Oak Ridge Reservation Annual Site 2015 Environmental Report

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Oak Ridge Reservation

Annual Site Environmental Report 2015

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Jamie Herold
Oak Ridge National Laboratory

Design
Alutiiq Graphics

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Project director
James Rochelle

Project coordinator
Ben Rogers, PhD

Department of Energy project manager and Oak Ridge Office coordinator
Katatra Vasquez

Technical coordinators

Paula R Roche
Y-12 National Security Complex

Joan Hughes
Oak Ridge National Laboratory

Mike Coffey
East Tennessee Technology Park

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Prepared by
UT-Battelle, LLC
P.O. Box 2008, Oak Ridge, TN 37831-2008
for the US Department of Energy under Contract DE-AC05-00OR22725
and by
Consolidated Nuclear Security LLC
Oak Ridge, TN 37831-8169
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and by
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Acronyms and Abbreviations

A	AAS	ambient air (monitoring) station
	ABC	aluminum beverage can (recycling)
	ACHP	Advisory Council on Historic Preservation
	ACO	Analytical Chemistry Organization (Y-12 Complex)
	ACM	asbestos-containing material
	AFV	alternative fuel vehicle
	AGL	above ground level
	ALARA	as low as reasonably achievable
	AMP	asset management program
	ANSI	American National Standards Institute
	ANSI/HPS	ANSI Health Physics Society (standard)
	AOC	area of concern
	AOEC	Agent Operations Eastern Command (NNSA OST)
	ARAP	Aquatic Resource Alteration Permit
	ARAR	applicable or relevant and appropriate requirement
	ASER	*Oak Ridge Reservation Annual Site Environmental Report*
	ATSDR	Agency for Toxic Substances and Disease Registry
	AWQC	ambient water quality criterion
B	BCG	biota concentration guide
	BCK	Bear Creek kilometer
	BFK	Brushy Fork kilometer
	BMAP	Biological Monitoring and Abatement Program
	BRW	bedrock well
C	C&D	construction and demolition
	CAA	Clean Air Act
	CAP-88	Clean Air Assessment Package (software)
	CAS	condition assessment survey
	CCA	chromated copper arsenate (as in CCA Type C pressure-treated wood)
	CCR	climate change resiliency
	CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
	CEUSP	Consolidated Edison Uranium Solidification Project
	CFL	Computers for Learning
	CFR	*Code of Federal Regulations*
	CFTF	Carbon Fiber Technology Facility
	CH	contact-handled
	CNF	Central Neutralization Facility
	CNS	Consolidated Nuclear Security, LLC

CO_2e	CO_2 equivalent
COC	contaminant of concern
COR	City of Oak Ridge
CPU	central processing unit
CRK	Clinch River kilometer
CROET	Community Reuse Organization of East Tennessee
CRT	cathode ray tube (also display devices, especially computers incorporating cathode ray tubes)
CWA	Clean Water Act
CWTS	Chromium Water Treatment System (ETTP)
CX	categorical exclusion
CY	calendar year

D

D&D	decontamination and decommissioning
DAC	derived air concentration
DCA	dichloroethane
DCE	dichloroethene/dichloroethylene
DCS	derived concentration standard
DNAPL	dense nonaqueous phase liquid
DOE	US Department of Energy
DOE ORO	DOE Oak Ridge Office

E

EA	environmental assessment
EC&P	environmental compliance and protection
ECD	Environmental Compliance Department (Y-12)
ECM	energy conservation measure
ED	effective dose
EFK	East Fork Poplar Creek kilometer
EFPC	East Fork Poplar Creek
EISA	Energy Independence and Security Act
EM	environmental management
EMMIS	Environmental Monitoring Management Information System (Y-12)
EMS	environmental management system
EMWMF	Environmental Management Waste Management Facility
ENIGMA	Ecosystems and Networks Integrated with Genes and Molecular Assemblies
EO	executive order
EOC	Emergency Operations Center
EPA	US Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPEAT	Electronic Product Environmental Assessment Tool
EPT	ephemeroptera, plecoptera, and trichoptera (taxa)
EPSD	Environmental Protection Services Division (UT-Battelle)
ES&H	environment, safety, and health

	ESPC	Energy Savings Performance Contract
	ESS	Environmental Surveillance System (ORNL)
	ETTP	East Tennessee Technology Park
	EV	electric vehicle
F	FAR	Federal Acquisition Regulation
	FCK	First Creek kilometer
	FEMP	Federal Energy Management Program
	FFA	Federal Facility Agreement (for the Oak Ridge Reservation)
	FFCA	Federal Facilities Compliance Agreement
	FFK	Fifth Creek kilometer
	FONSI	finding of no significant impact
	FWS	US Fish and Wildlife Service
	FY	fiscal year
	FYNSP	Future Years Nuclear Security Plan
G	GET	general employee training
	GHG	greenhouse gas
	GI	green infrastructure
	GI/LID	green infrastructure/low impact development
	GM	Geiger–Müller tube for detection of ionizing radiation
	GP	guiding principle
	GSA	General Services Administration
	GSF	gross square feet
H	HAP	hazardous air pollutant
	HCN	hydrogen cyanide
	HEMSF	high-energy mission-specific facility
	HEPA	high-efficiency particulate air
	HEU	highly enriched uranium
	HFIR	High Flux Isotope Reactor
	HPSB	high-performance sustainable building
	HQ	hazard quotient
	HVAC	heating, ventilation, and air conditioning
	HVC	Hardin Valley Campus
I	IC_{25}	inhibition concentration (the concentration of effluent that causes a 25% reduction in survival, reproduction, and/or growth of monitored species)
	ID	identification (number)
	IDMS	Integrated Document Management System (UT-Battelle)
	ILA	industrial, landscaping, and agricultural
	ISMS	Integrated Safety Management System
	ISO	International Organization for Standardization

	Isotek	Isotek Systems LLC
J	JCI	Johnson Controls, Inc.
L	LCD	liquid crystal display
	LEDP	Laboratory Equipment Donation Program
	LEED	Leadership in Energy and Environmental Design
	LEP	life extension program
	LID	low impact development
	LIMS	Laboratory Information Management System (Y-12 Complex)
	LLW	low-level waste
M	M&E	material and equipment
	M&TE	measurement and test equipment
	MACT	Maximum Achievable Control Technology
	MARSAME	*Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual*
	MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*
	MCK	McCoy Branch kilometer
	MCL	maximum contaminant level
	MDA	minimum detectable activity
	MDF	Manufacturing Demonstration Facility
	MEI	maximally exposed individual
	MEK	Melton Branch kilometer
	MIK	Mitchell Branch kilometer
	MOA	memorandum of agreement
	MSL	mean sea level
	MT	meteorological tower (when followed by a numeral as in “MT2”)
	MTF	Mercury Treatment Facility
N	NAAQS	National Ambient Air Quality Standards
	NEPA	National Environmental Policy Act
	NESHAPs	National Emission Standards for Hazardous Air Pollutants
	NHPA	National Historic Preservation Act
	NIST	National Institute of Standards and Technology
	NNSA	National Nuclear Security Administration
	NNSS	Nevada National Security Site
	NOV	notice of violation
	NPDES	National Pollutant Discharge Elimination System
	NPL	National Priorities List (EPA)
	NPO	NNSA Production Office
	NPS	US National Park Service
	NRHP	National Register of Historic Places
	NSC	National Security Complex

	NSF-ISR	NSF International Strategic Registrations, Ltd.
	NTRC	National Transportation Research Center
	NWSol	North Wind Solutions, LLC
O	ODS	ozone-depleting substance
	O&M	operations and maintenance
	OMP	operational monitoring plan
	ORAU	Oak Ridge Associated Universities
	OREIS	Oak Ridge Environmental Information System (ORNL)
	ORGDP	Oak Ridge Gaseous Diffusion Plant
	ORISE	Oak Ridge Institute for Science and Education
	ORNL	Oak Ridge National Laboratory
	ORO	Oak Ridge Office (DOE)
	ORPS	Occurrence Reporting and Processing System (Y-12 Complex)
	ORR	Oak Ridge Reservation
	ORR-PCB-FFCA	Oak Ridge Reservation Polychlorinated Biphenyl Federal Facilities Compliance Agreement
	ORSSAB	Oak Ridge Site Specific Advisory Board
	ORWMA	Oak Ridge Wildlife Management Area
	OS	Office of Science (DOE)
P	P2/WMin	pollution prevention/waste minimization
	PAM	perimeter air monitoring (station)
	Pantex	Pantex Plant
	PCB	polychlorinated biphenyl
	PCE	tetrachloroethene
	PEMS	Predictive Emissions Monitoring System
	PHEV	plug-in hybrid electric vehicle
	PM	particulate matter
	PM_{10}	particulate matter with an aerodynamic diameter $\leq$ 10 µm
	$PM_{2.5}$	fine particulate matter with an aerodynamic diameter $\leq$ 2.5 µm
	PSS	plant shift superintendent
	PUE	power usage effectiveness
	PWTC	Process Waste Treatment Complex
Q	QA	quality assurance
	QAS	quality assurance system
	QC	quality control
	QMS	quality management system
R	R2	responsible recycling
	RA	remedial action

	R&D	research and development
	rad-NESHAPs	National Emission Standards for Hazardous Air Pollutants for radionuclides
	RATA	relative accuracy test audit
	RCRA	Resource Conservation and Recovery Act
	RCW	recirculating cooling water
	REC	renewable energy credit (also renewable energy certificate)
	REDC	Radiochemical Engineering Development Center
	RESRAD	residual radioactivity
	RH	remote-handled
	RI	remedial investigation
	RI/FS	remedial investigation/feasibility study
	RICE	reciprocating internal combustion engine
	RMP	risk management plan
	ROD	record of decision
	RQ	reportable quantity (CERCLA)
	RSI	Restoration Services, Inc.
S	S&M	surveillance and maintenance
	SAP	sampling and analysis plan
	SARA	Superfund Amendments and Reauthorization Act
	SBMS	Standards-Based Management System (UT-Battelle)
	SCP	standards and calibration program
	SD	storm water outfall/storm drain
	SDWA	Safe Drinking Water Act
	SHPO	State Historic Preservation Office (Tennessee)
	SIC	Standard Industrial Classification (code)
	SNAP	Significant New Alternatives Program (EPA)
	SNS	Spallation Neutron Source
	SODAR	sonic detection and ranging
	SOF	sum of fractions
	SPCC	spill prevention, control, and countermeasures (plan)
	SPMD	semipermeable membrane device
	SSP	site sustainability plan
	SSPP	Strategic Sustainability Performance Plan (DOE)
	STP	sewage treatment plant
	SVOC	semivolatile organic compound
	SWEIS	sitewide environmental impact statement
	SWHISS	Surface Water Hydrological Information Support System (Y-12 Complex)
	SWMU	solid waste management unit
	SWPP	storm water pollution prevention
	SWPPP	Storm Water Pollution Prevention Plan
	SWSA	solid waste storage area

T	T&D	transmission and distribution
	TCA	trichloroethane
	TCE	trichloroethene/trichloroethylene
	TDEC	Tennessee Department of Environment and Conservation
	TEMA	Tennessee Emergency Management Agency
	TMDL	total maximum daily load
	TMSP	Tennessee Stormwater Multi-Sector General Permit
	TOA	Tennessee Oversight Agreement
	TRI	toxic (chemical) release inventory
	TRO	total residual oxidant
	TRU	transuranic
	TSC	Technical Support Center
	TSCA	Toxic Substances Control Act
	TSS	total suspended solids
	TVA	Tennessee Valley Authority
	TWA	time-weighted average
	TWPC	Transuranic Waste Processing Center
	TWRA	Tennessee Wildlife Resources Agency
U	UCOR	URS | CH2M Oak Ridge LLC
	UMC	unneeded materials and chemicals
	UMS	Utilities Management System (Y-12 Complex)
	UNW	unconsolidated well
	UPF	Uranium Processing Facility (Y-12 Complex)
	USDA	US Department of Agriculture
	UST	underground storage tank
	UT-Battelle	UT-Battelle, LLC (partnership between University of Tennessee and Battelle Memorial Institute formed to manage ORNL for DOE)
V	VOC	volatile organic compound
W	WAI	Wastren Advantage, Inc.
	WCK	White Oak Creek kilometer
	WEMA	west end mercury-use area (Y-12)
	WOC	White Oak Creek
	WOD	White Oak Dam
	WPB	waste-processing building
	WQC	water quality criterion
	WQPP	water quality protection plan
	WRRP	Water Resources Restoration Program
	WSR	waste services represenatives
Y	Y-12/Y-12 Complex	Y-12 National Security Complex

Units of Measure and Conversion Factors*

Units of measure and their abbreviations

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

Quantitative prefixes

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

*Due to differing permit reporting requirements and instrument capabilities, various units of measurement are used in this report. The provided 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 (US liquid)	× 0.946	L	L	× 1.057	qt (US liquid)
gal	× 3.7854118	L	L	× 0.264172051	gal
Concentration					
ppb					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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ENVIRONMENTAL MANAGEMENT
Carrie Barber
Betsy Brucken
Mark Cleveland
Kevin Crow
Christa Davis
Katie Davis
Howell Estes
Steve Foster
Justin Frazer
Glen Galen
Sherry Gibson
Stephen Goodpasture
Kevin Ironside
Charles Justice
Richard Ketelle
Rodney Kingrea
Jeff Maddox
Bruce McElhoe
Jeff Murphy
Tony Poole
Gill Salade
Cheryl Sayler
Eileen Shea
Adam Smith
Wesley White
Steven Wood

ORSSAB
Spencer Gross

ORNL
Kevin Birdwell
Terry Bonine
Jason Case
Gary Chadwick
Jerry Cunningham
Jim Eaton
Rich Franco
Neil Giffen
Wes Goddard
Mark Greeley
Scott Gregory
Julia Hancock
Jamie Herold
Joan Hughes
Trent Jett
Regis Loffman
Diane Maddox
Terry Mathews
Lori Muhs
Don Naab
Teresa Nichols
Todd North
Anne Ostergaard
Mark Peterson
Kelly Roy
Kyle Rutherford
Ernest Ryan
Denise Saunders
Pat Scofield
Jeff Sickau
John Smith
Linda Smith
George Stephens
Sam Thomas—WAI
Charlie Valentine

Y-12 COMPLEX
Mike Arendale
Gary Beck
Ellen Boatner
Vickie Brumback
Jeff Bruner
Astrid Brynestad
Mark Burdette
Durand Carmany
Sara Cornwell
Terry Cothron
Laura Cunningham
Jennifer Dixon
Stan Duke
Beth Eckerman
Steve Field
Sheila Finney
Kim Hanzelka
Clarence Hill
William Hurst
Steve Jones
Wesley Long
Wayne McMahon
Stacey McNamara
Jane Nations
Terry Nore
Aprell Patterson
Jim Placke
Randy Redmond
Larry Rose
Beth Schultz
Mark Shedden
Brad Skaggs
Johnny Skinner
Lynn Taylor
Tim Tharp
Brenda Vann
Lance Voss

Executive Summary

Overview

The Oak Ridge Reservation (ORR), managed by the US Department of Energy (DOE), is located in Roane and Anderson counties in East Tennessee about 40 km (25 mi) from Knoxville. The ORR is one of DOE's most unusual and complex sites. It encompasses three major facilities and thousands of employees who perform 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. The ORR was established in the early 1940s as part of the Manhattan Project for the purposes of enriching uranium and pioneering methods for producing and separating plutonium. Today scientists at the Oak Ridge National Laboratory (ORNL), DOE's largest multipurpose national laboratory, conduct leading-edge research in advanced materials, alternative fuels, climate change, and supercomputing. 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 East Tennessee Technology Park (ETTP), a former uranium enrichment complex, is being transitioned to a clean, revitalized industrial park.

DOE's signature integrated safety management system (ISMS) integrates safety in all aspects of work at its facilities. Safety, as defined in ISMS, encompasses protection of the public, the worker, and the environment and includes all safety, health, and environmental disciplines (i.e., radiation protection, fire protection, nuclear safety, environmental protection, waste management, and environmental management).

The ORR is managed by three DOE Program Secretarial Offices and their management and operating contractors and support contractors. This 2015 *Oak Ridge Reservation Annual Site Environmental Report* (ASER) contains detailed and complex information provided to the DOE ORR integrating contractor by contractors including UT-Battelle, LLC; Consolidated Nuclear Security, LLC; URS | CH2M Oak Ridge LLC; Northwind/Wastren Advantage, Inc.; Oak Ridge Associated Universities; and Isotek Systems LLC. Three key chapters were prepared as follows: Chapter 3 by URS | CH2M Oak Ridge LLC (UCOR), the lead environmental management contractor for ETTP; Chapter 4 by Consolidated Nuclear Security, LLC, which manages and operates the Y-12 National Security Complex; and Chapter 5 by UT-Battelle, LLC, which manages the Oak Ridge National Laboratory. In addition, the aforementioned contractors are responsible for independently carrying out the various DOE missions at the three major ORR facilities. These contractors manage and implement environmental protection programs through environmental management systems that adhere to International Organization for Standardization standard 14001:2004, *Environmental Management Systems*, and are integrated with ISMS to provide unified strategies for managing resources. Detailed information on contractors' environmental management systems is provided in Chapters 3, 4, and 5.

DOE operations on the ORR have the potential to release a variety of constituents into 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 while others, such as radionuclides, are unique to specialized research and production activities like those conducted on the ORR. Any releases are highly regulated and carefully monitored. DOE is committed to enhancing environmental stewardship and managing the impacts its operations may have on the environment, and it encourages the public to participate in matters related to the ORR's environmental impact on the community by soliciting citizens' input on matters of significant public interest and through various communications. DOE also provides public access to information on all of its Oak Ridge environmental, safety, and health activities.

The ASER is prepared for DOE according to the requirements of DOE O 231.1B, *Environment, Safety, and Health Reporting*. The ASER includes data on the environmental performance of each of the major DOE ORR contractors and describes significant accomplishments in pollution prevention and sustainability programs that serve to reduce all types of waste and pollutant releases to the environment. An environmental report for the ORR that provides consolidated data on overall reservation performance and status has been published annually since the mid-1970s. The ASER continues to be a key component of the DOE effort to keep the public informed about environmental conditions across DOE and National Nuclear Security Administration sites. The report is prepared for readability, and frequent references to other sections, chapters, and reports are made throughout to avoid redundancy.

2015 Impacts

DOE ORR operations in 2015 continued to result in minimal impact to the public and the environment. Permitted discharges to air and water were well below regulatory standards, and potential radiation doses to the public from activities on the reservation were significantly less than the 100 mrem standard established for DOE sites in DOE O 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 the ORR in 2015 was estimated to be 0.4 mrem from air pathways, 1 mrem from water pathways (drinking water, fish consumption, swimming, recreation, and other uses), and 1 mrem from consumption of wildlife harvested on the ORR. This is about 3% of the DOE 100 mrem standard for all pathways and is significantly less than the 300 mrem annual average dose to people in the United States from natural or background radiation. The 2015 maximum hypothetical dose is consistent with those calculated for the previous 5 years (2010–2014).

Environmental Monitoring

Extensive environmental monitoring is conducted across the ORR each year. Site-specific environmental protection programs are carried out at ORNL, the Y-12 Complex, and ETTP. The ORR-wide environmental surveillance programs, which include locations and media both on and off the reservation, are conducted to enhance and supplement data from site-specific efforts. In 2015 thousands of samples and measurements of air, water, direct radiation, vegetation, fish, and wildlife collected from across the reservation were analyzed for both radioactive and nonradioactive contaminants. Sample media, locations, frequencies, and parameters were selected based on environmental regulations and standards, public and environmental exposure pathways, public concerns, and measurement capabilities. Chapters 2 through 7 of this report provide detailed summaries of the environmental protection and surveillance programs on the ORR. These extensive sampling and monitoring efforts demonstrate DOE's commitment to ensuring safety; protecting human health; complying with regulations, standards, DOE orders, and "as low as reasonably achievable" principles; 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 (TDEC), monitor the ORR for compliance with applicable environmental regulations. These agencies issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and/or oversee compliance with regulations. Continued compliance with environmental regulations and DOE orders assures on-site processes do not adversely impact the public or the environment.

During 2015 there were only a few instances of noncompliance with regulations, permits, and DOE orders. These were promptly addressed to ensure minimal adverse environmental or public health effects resulted. Noncompliances and notifications made to regulatory agencies during the year are summarized below, and detailed information is provided in Chapters 2 through 5 of this report.

- The Y-12 Complex had one unplanned release of a hazardous substance which required notification of the regulatory agencies. On June 9, 2015 during the demolition of Building 9808, 2,117 pounds of mercury and mercury-containing sludge were spilled, which exceeded a hazardous substance reportable quantity. This event was reported to the appropriate agencies in accordance with regulatory requirements.

- ETTP received one environmental violation in 2015. This violation occurred at ETTP during a routine inspection for a missing used oil drum label on a drum in the facility’s garage. The condition was immediately corrected and documented in UCOR’s quality assurance tracking system. No penalties were assessed in 2015.

- Although a notice of violation was issued by TDEC on August 5, 2015 for a drinking water monitoring deficiency, the Y-12 Plant Water System retains the state’s “Approved” designation.

- A notice of violation issued to UT-Battelle by TDEC was received on January 20, 2015 for failure to include two emergency generators in a timely manner in the ORNL site air permit. This was self-reported to TDEC on November 11, 2014 and the omission has since been corrected. The two generators are now included in a permit issued January 23, 2015.

Chapter 2 provides a detailed summary of ORR environmental compliance during 2015, and Chapters 3, 4, and 5 discuss each facility’s compliance status for the year.

Pollution Prevention and Site Sustainability

Numerous pollution prevention and sustainability programs across the ORR embody efforts to achieve enduring sustainability in facilities, operations, and organizational culture. These programs promote energy and water conservation, building efficiency, sustainable landscaping, green transportation, sustainable acquisition, and waste minimization, which in turn reduce life-cycle costs of programs and projects and reduce risks to the environment. In 2015, ORR contractors were recognized for excellence in pollution prevention and sustainability programs with multiple awards, which are described in Chapters 3, 4, and 5.

Cleanup Operations in 2015

The ORR has played key roles in US defense and energy research. However, past waste disposal practices, operational and industrial practices, changing standards, and unintentional releases have left land and facilities contaminated. Contaminants include radioactive elements, mercury, asbestos, polychlorinated biphenyls, and industrial wastes. The DOE Environmental Management (EM) program is responsible for cleaning up these sites, and numerous cleanup projects are under way at the reservation’s three main facilities.

In 2015 the most notable EM accomplishment on the ORR was completion of the 750,000-square-foot K-31 Building Demolition Project at ETTP. Demolition was completed on the K-861 Switch House, which was the power distribution and electrical switching station for the K-31 Building. With the demolition of K-31, only one gaseous diffusion building remains at ETTP—the K-27 Building. The removal of transite paneling on the outer skin of the K-27 Building began in 2015, and building demolition is anticipated to be completed in 2016. Historic preservation of the K-25 Site continued in 2015 with the completion of the conceptual design of the Equipment Building, Viewing Tower, K-25 History Center, Wayside Exhibit, and K-25 slab delineation. EM also continued planning activities for capital asset projects that will further advance ORR cleanup objectives. These include a mercury treatment facility at Y-12, a new disposal facility that will accept debris from future cleanup at Y-12 and ORNL, and a sludge treatment facility at the Transuranic Waste Processing Center.

1. Introduction to the Oak Ridge Reservation

The Oak Ridge Reservation (ORR) is a federally owned 13,547 ha (33,476-acre) site located in Anderson and Roane counties in eastern Tennessee. The ORR is home to two major US Department of Energy (DOE) operating components, the Oak Ridge National Laboratory (ORNL) and the Y-12 National Security Complex (Y-12 Complex or Y-12). A number of other facilities are located on ORR, including the East Tennessee Technology Park (ETTP), site of a former gaseous diffusion plant that is undergoing environmental cleanup and transition to a private sector business and industrial park; the Oak Ridge Institute for Science and Education (ORISE) South Campus, which includes training facilities, laboratories, and support facilities; a variety of smaller government-owned, contractor-operated facilities involved in environmental cleanup; and the government-owned, government-operated Agent Operations Eastern Command of the National Nuclear Security Administration (NNSA) Office of Secure Transportation.

The ORR was established in the early 1940s as part of the Manhattan Project for the purposes of enriching uranium, pioneering methods for producing and separating plutonium, and administering the nationwide World War II effort. ORR missions are continuing to evolve as it adapts to meet the changing basic and applied research and national security needs of the United States.

Due to differing permit reporting requirements and instrument capabilities, various units of measurement are used in this report. The list of units of measure and conversion factors provided on pages xxvi and xxvii is intended to help readers convert numeric values presented here as needed for specific calculations and comparisons. Appendix A contains a glossary of technical terms that may be useful for understanding the terminology used in this report.

1.1 Background

The Oak Ridge Reservation Annual Site Environmental Report (ASER) is prepared annually and presents summary environmental data to (1) characterize environmental performance, (2) summarize environmental occurrences reported during the year, (3) confirm compliance with environmental standards and requirements, and (4) highlight significant program activities. The report fulfills the requirement contained in DOE O 231.1B, *Environment, Safety, and Health Reporting* (DOE 2012) that an integrated annual site environmental report be prepared.

The results summarized in this report are based on data collected before and continuing through 2015. This report is not intended to, nor does it, present the results of all environmental monitoring associated with the ORR. 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/or guidance and are referenced here as appropriate. Environmental monitoring on the ORR consists primarily of two major activities: 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 release to the environment; these measurements allow the 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 measurements and collection and analysis of samples taken from the site and its environs exclusive of effluents; these activities provide information on contaminant concentrations in air, water, groundwater, soil, foods, biota, and other media. Environmental surveillance data support determinations regarding environmental compliance and, when combined with data from effluent monitoring, support chemical and radiation dose and exposure assessments of the potential effects of ORR operations, if any, on the local environment.

1.2 History of the Oak Ridge Reservation

The ORR area was first occupied by Native Americans more than 10,000 years ago, and members of the Overhill Cherokee tribe still lived in the East Tennessee region when European settlers arrived in the late 1700s. These settlers lived on farms or in four small communities called Elza, Robertsville, Scarboro, and Wheat. All but Elza were founded shortly after the Revolutionary War. In the early 1940s about 1,000 families inhabited the area.

In 1942, the area that was to become the ORR was selected for use in the Manhattan Project in part because the Clinch River provided ample supplies of water, the terrain featured linear and partitioned ridges, nearby Knoxville was a good source of labor, and the Tennessee Valley Authority (TVA) could supply ample amounts of needed electricity. About 3,000 residents received orders to vacate within weeks the homes and farms that their families had occupied for generations. The site's wartime name was "Clinton Engineering Works."

The workers' city, named Oak Ridge, was established on the reservation's northern edge. The city grew to a population of 75,000 and was the fifth largest in Tennessee; however, it was not shown on any map. At the Y-12 Complex south of the residential area, an electromagnetic separation method was used to separate uranium-235 (^{235}U) from natural uranium. A gaseous diffusion plant, later known as K-25, was built on the reservation's western edge. Near the reservation's southwest corner, about 16 km (10 mi) from the Y-12 Complex, was a third facility known as X-10 or Clinton Laboratories where the Graphite Reactor was built. The X-10 facility was a pilot scale facility for the larger plutonium production facilities built at Hanford, Washington. Two years after World War II ended, Oak Ridge was shifted to civilian control under the authority of the US Atomic Energy Commission. In 1959, the city was incorporated and a city manager and city council form of government was adopted by the community.

Since that time, the missions of the three major ORR installations have continued to evolve and operations have adapted to meet the changing defense, energy, and research needs of the United States. Their current missions, as well as the missions of several smaller DOE facilities and activities on the ORR, are described in Section 1.4 of this document.

1.3 Site Description

1.3.1 Location and Population

The ORR lies within the Great Valley of East Tennessee between the Cumberland and Great Smoky Mountains and is bordered by the Clinch River (Fig. 1.1). The Cumberland Mountains are 16 km (10 mi) to the northwest; the Great Smoky Mountains are 51 km (31.6 mi) to the southeast. The ORR encompasses about 13,547 ha (33,476 acres) of mostly contiguous land in Anderson and Roane counties that is owned by the federal government and under the management of DOE (Fig. 1.2). The population of the 10-county region surrounding the ORR is about 1,096,961, and about 2% of its labor force is employed on the ORR. The 2015 US Census population estimate for the official nine-county Knoxville metropolitan statistical area is 857,585. Other municipalities within about 30 km (18.6 mi) of the reservation include Oliver Springs, Clinton, Rocky Top, Lenoir City, Farragut, Kingston, and Harriman.

Knoxville, the major metropolitan area nearest Oak Ridge, is located about 40 km (25 mi) to the east and, as of 2015, had a population of about 185,291. Except for the city of Oak Ridge, the land within 8 km (5 mi) of the 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 in the area.

Fig. 1.1. Location of the Oak Ridge Reservation.

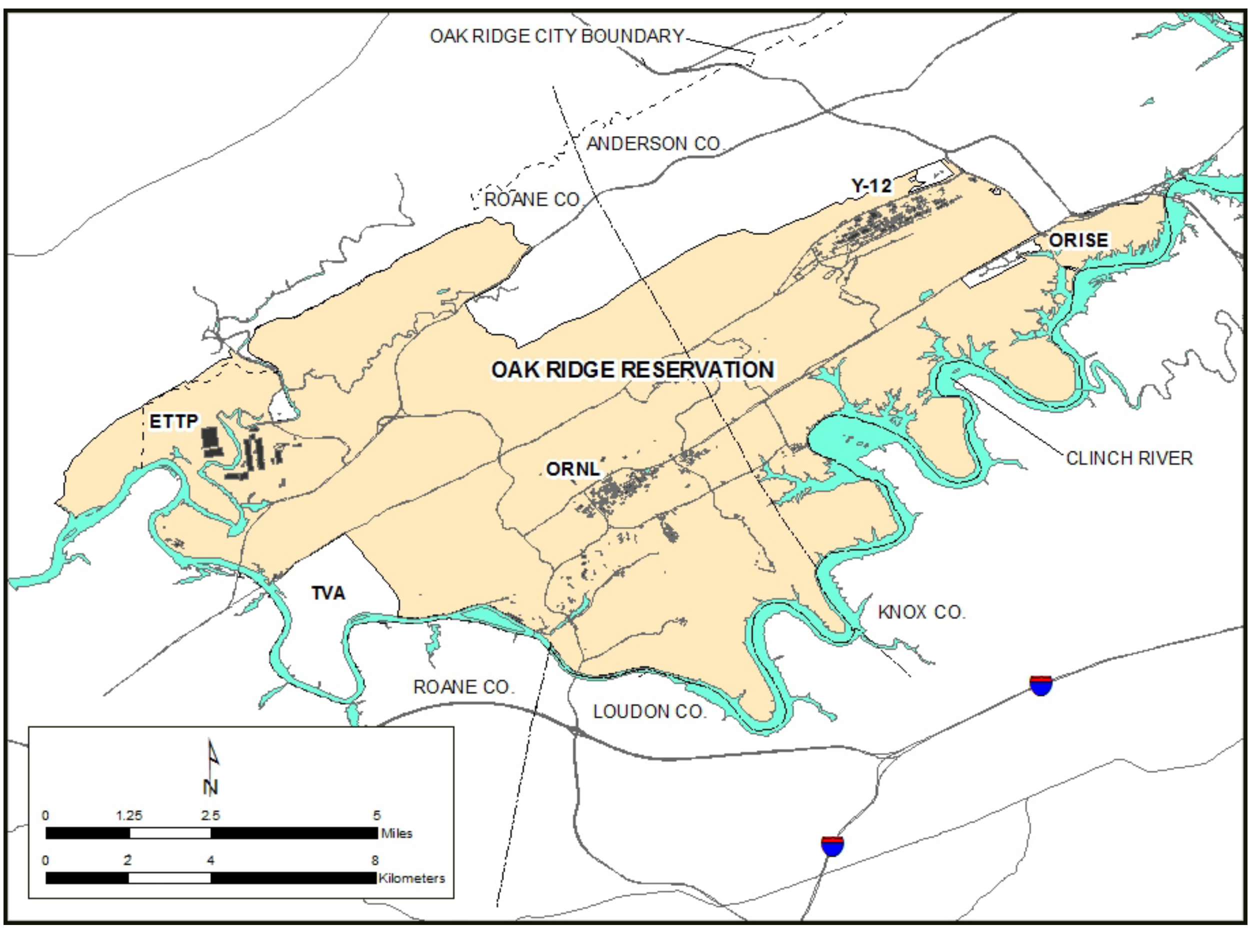

Fig. 1.2. The Oak Ridge Reservation.

1.3.2 Climate

The climate of the Oak Ridge region may be broadly classified as humid subtropical and is characterized by significant temperature changes between summer and winter. The 30-year mean temperature for 1981–2010 was 14.7°C (58.5°F). The average temperature for the Oak Ridge area in 2015 was 16.0°C (60.8°F). The coldest month is usually January, when temperatures average about 3.1°C (37.5°F). During 2015, February temperatures were coldest, averaging 0.6°C (33.08°F). July tends to be the warmest month, with average temperatures of 25.6°C (78.1°F). July 2015 temperatures averaged 26.2°C (79.2°F), slightly above the 30-year average. Monthly summaries of temperature averages, extremes, and 2015 values are provided in Appendix B, Table B.1.

Average annual precipitation in the Oak Ridge area for the 30-year period from 1981 to 2010 was 1,337.5 mm (52.64 in.), including about 26.9 cm (10.6 in.) of snowfall annually (NOAA 2011). Total precipitation during 2015 as measured at meteorological tower (MT)2 was 1,449 mm (57.08 in.), which was more than 10% above the 30-year average. Monthly summaries of precipitation averages, extremes, and 2015 values are provided in Appendix B, Table B.1.

The average annual wind data recovery rates (a measure of acceptable data) across locations used for modeling during 2015 were greater than 97% for wind sensors at the ORNL sites (towers MT2, MT3, MT4, and MT10) with the exception of the 10/15 m MT4 wind sensor (41%) due to the destruction of the instrument during an ice storm in February 2015 and associated damage to the tower boom (which required significant time to procure and repair). All other MT2, MT3, and MT4 instrument recoveries were well above 90% for both quarterly and annual values.

In 2015 wind speeds at ORNL Tower C/D (MT2), measured at 15 m (49 ft) above ground level (AGL), averaged 0.94 m/s (2.2 mph). This value remained unchanged for winds at 60 m (198 ft) AGL. 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. Wind direction frequencies with respect to 2015 precipitation hours for the ORR towers may be reviewed at http://www.ornl.gov/adm/fo/lp/orrm/page7.htm under the header "2015 Annual Precipitation Wind Roses—Oak Ridge Reservation."

More 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 document. A detailed analysis of wind patterns for the ORR was conducted from 2009 to 2011 and is documented in "Wind Regimes in Complex Terrain in the Great Valley of Eastern Tennessee" (Birdwell 2011), which may be reviewed online at http://www.ornl.gov/~das/met/MT/KRB_ORNL.pdf.

1.3.3 Regional Air Quality

The US Environmental Protection Agency (EPA) Office of Air Quality Planning and Standards has set National Ambient Air Quality Standards (NAAQS) for key principal pollutants, which are called "criteria" pollutants. These pollutants are sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), lead (Pb), ozone (O_3), particulate matter (PM) with an aerodynamic diameter less than or equal to 10 µm (PM_{10}), and fine PM with an aerodynamic diameter less than or equal to 2.5 µm ($PM_{2.5}$). EPA evaluates NAAQS based on ambient (outdoor) levels of the criteria pollutants. Areas that satisfy NAAQS are classified as attainment areas, whereas areas that exceed NAAQS for a particular pollutant are classified as nonattainment areas for that pollutant.

The ORR is located in Anderson and Roane counties. EPA has designated Anderson, Knox, and Blount counties as a nonattainment area for the $PM_{2.5}$ air quality standard. EPA also designated the portion of

Roane County surrounding the Kingston Steam Plant as a nonattainment area for $PM_{2.5}$. The greater Knoxville and Oak Ridge area is classified as a NAAQS attainment area for all other criteria pollutants for which EPA has made attainment designations.

1.3.4 Surface Water

The ORR lies within the Valley and Ridge Physiographic Province, which is composed of a series of drainage basins or troughs containing many small streams feeding the Clinch River. Surface water on the ORR drains into a tributary or series of tributaries, streams, or creeks within different watersheds. Each of these watersheds drains into the Clinch River which, in turn, flows into the Tennessee River.

The largest of the drainage basins is Poplar Creek, which receives drainage from a 352 km^2 (136 mi^2) area including the northwestern sector of the ORR. It flows from northeast to southwest, roughly through the center of ETTP, and discharges directly into the Clinch River.

East Fork Poplar Creek (EFPC), which discharges into Poplar Creek east of ETTP, originates within the Y-12 Complex and flows northeast along the south side of the Y-12 Complex. Bear Creek also originates within the Y-12 Complex but flows southwest. Bear Creek is mostly affected by storm water 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 has an area of 16.5 km^2 (6.4 mi^2). WOC headwaters originate on Chestnut Ridge, north of ORNL and near the Spallation Neutron Source (SNS) site. At the ORNL site, the creek flows west along the southern boundary of the developed area and then flows southwest through a gap in Haw Ridge to the western portion of Melton Valley, where it forms a confluence with Melton Branch. The headwaters of Melton Branch originate in Melton Valley east of the High Flux Isotope Reactor (HFIR) complex. It has a drainage basin area of about 3.8 km^2 (1.47 mi^2). The waters of WOC enter White Oak Lake, which is an impoundment formed by White Oak Dam (WOD). Water flowing over WOD enters the Clinch River after passing through the WOC embayment area.

1.3.5 Geological Setting

The ORR is located in the Tennessee portion of the Valley and Ridge Physiographic Province, which is part of the southern Appalachian fold-and-thrust belt. As a result of thrust faulting, associated fracturing of the rock, and differential erosion rates, a series of parallel valleys and ridges have formed that trend southwest–northeast.

Two geologic units on the ORR, designated as the Knox Group and the Maynardville Limestone of the Upper Conasauga Group and consisting of dolostone and limestone, respectively, make up the most significant water-bearing hydrostratigraphic units in the Valley and Ridge Province (Zurawski 1978) and on the ORR. Composed of fairly soluble minerals, these bedrock formations 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 form caverns and extensive solution conduit networks under some circumstances. This hydrostratigraphic unit is referred to locally as the Knox Aquifer. A combination of fractures and solution conduits in the aquifer control flow 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 for many streams (base flow), and most large springs on the ORR receive discharge from the Knox Aquifer. Yields of some wells penetrating larger solution conduits are reported to exceed

3,785.4 L/min (1,000 gal/min). The high productivity of the Knox Aquifer is attributed to the combination of its abundant and sometimes large solution conduit systems and frequently thick overburden soils that promote recharge and storage of groundwater.

The remaining geologic units on the 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 predominantly composed of insoluble minerals such as clays and quartz that were derived from ancient continental erosion. Groundwater occurs in and moves through fractures in those bedrock units. Groundwater availability in such settings is dependent on the abundance and interconnectedness of fractures and the connection of fractures to sources of recharge, such as alluvial soils along streams that 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 Historic Resources

The ORR contains a unique variety of natural, cultural, and historic resources. Ongoing efforts continue to focus on preserving the rich diversity of these resources.

1.3.6.1 Wetlands

About 243 ha (600 acres) of wetlands have been identified on the ORR; most are classified as forested palustrine, scrub/shrub, and emergent wetlands. Wetlands occur across the ORR at low elevations, primarily in riparian zones of headwater streams and receiving streams and in the Clinch River embayments (Fig. 1.3). Wetlands identified to date range in size from several square meters at small seeps and springs to about 10 ha (25 acres) at White Oak Lake.

In May 2015, vegetation parameters were measured at the ORNL parking structure wetland approximately four years after the 2011 mitigation. The percentage of cover by species was measured for each plot. Information was also taken on any fauna present at the time of the survey. Five years of data, including the data collected during the year of mitigation, have shown excellent overall vegetation coverage providing good quality habitat. Vegetation growing in the wetland in 2015 included both planted and volunteer plant species. There was a noted increase in black willow, sycamore, and green ash saplings. Climbing hempweed, an invasive species, continues to infiltrate the west end of the wetland; however, the spread is being controlled by the UT-Battelle grounds crew. A good variety of fauna was noted in and around the wetland including birds, frogs, and benthic macroinvertebrates.

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. In addition, wetland maps have been developed for selected areas of the ORR in response to project-specific requirements. These are also consulted and verified by site inspections when appropriate. See Chapter 5, Section 5.3.12 for additional details.

Monitoring restored or created mitigation sites for five years is a standard requirement of the Tennessee Department of Environment and Conservation's (TDEC's) wetland mitigation Aquatic Resource Alteration Permits (ARAPs) required by Section 401 of the Clean Water Act (CWA).

In 2014, as part of the Uranium Processing Facility (UPF) project at the Y-12 Complex, construction was completed on the Bear Creek Road bypass phase II and a haul road extension that modified wetlands on the north side of Bear Creek Road. Details of this activity are provided in Chapter 4, Section 4.5.9.4. The work was performed under an approved US Army Corps of Engineers Section 404 permit and an ARAP issued by TDEC. The wetland mitigation work performed under these permits will result in a more than 3:1 net increase in total wetland area when the multiyear project is complete. Monitoring mitigation in accordance with the permits has been initiated. Annual monitoring of wetland sites in 2015 revealed that, in general, the wetlands are responding as intended and have shown remarkable wetland plant coverage in the first year.

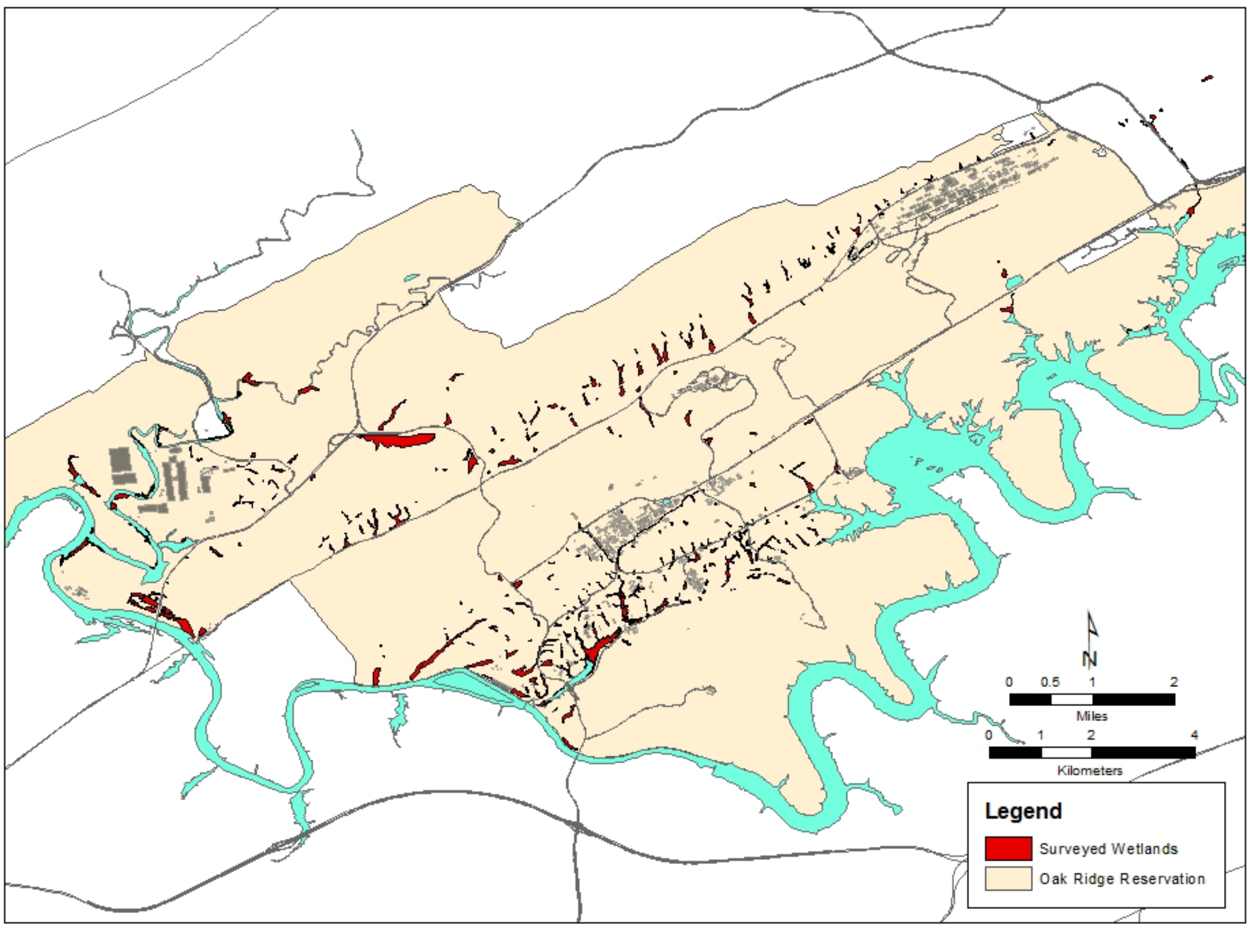

Fig. 1.3. Oak Ridge Reservation wetlands.

1.3.6.2 Wildlife/Endangered Species

Animals listed as species of concern by state, federal, or international organizations and known to have occurred on the reservation (excluding the Clinch River bordering the reservation) are listed along with their status in Table 1.1. Some of these (e.g., anhinga) have been seen only once or a few times; others (e.g., sharp-shinned hawk and southeastern shrew) are comparatively common and widespread on the reservation.

Table 1.1. Animal species of special concern reported on the Oak Ridge Reservation[a]

Scientific name	Common name	Status[b]		
		Federal	State	PIF[c]
	FISH			
Phoxinus tennesseensis	Tennessee dace		NM	
	AMPHIBIANS AND REPTILES			
Crytobranchus alleganiensis	Hellbender	MC	NM	
Hemidactylium scutatum	Four-toed salamander		NM	
	BIRDS			
	Darters			
Anhinga anhinga	Anhinga		NM	
	Bitterns and Herons			
Ixobrychus exilis	Least bittern	MC	NM	
Ardea alba	Great egret		NM	
Egretta caerulea	Little blue heron	MC	NM	
Egretta thula	Snowy egret	MC	NM	
	Kites, Hawks, Eagles, and Allies			
Haliaeetus leucocephalus	Bald eagle	MC[d]	NM	
Circus cyaneus	Northern harrier		NM	
Accipiter striatus	Sharp-shinned hawk	MC	NM	
Buteo lineatus	Red-shouldered hawk			RI
Buteo platypterus	Broad-winged hawk			RI
	Falcons			
Falco peregrinus	Peregrine falcon	MC[e]	E	RI
Falco sparverius	American kestrel	MC		RI
	Grouse, Turkey, and Quail			
Bonasa umbellus	Ruffed grouse			RI
Colinus virginianus	Northern bobwhite			RI
	Rails, Gallinules, and Coots			
Rallus limicola	Virginia rail	MC		
Porzana Carolina	Sora	MC		
Gallinula galeata	Common gallinule		NM	
	Owls			
Aegolius acadicus	Northern saw-whet owl	MC	T	RI
Tyto alba	Barn owl		NM	
	Goatsuckers			
Caprimulgus carolinensis	Chuck-will's-widow	MC		RI
Caprimulgus vociferus	Eastern whip-poor-will			RI
	Swifts			
Chaetura pelagica	Chimney swift			RI
	Kingfishers			
Megaceryle alcyon	Belted kingfisher			RI

Table 1.1 Animal species of special concern reported on the Oak Ridge Reservation[a] (Continued)

Scientific name	Common name	Status[b]		
		Federal	State	PIF[c]
	Woodpeckers			
Melanerpes erythrocephalus	Red-headed woodpecker	MC		RI
Sphyrapicus varius	Yellow-bellied sapsucker	MC	NM	
Picoides pubescens	Downy woodpecker			RI
Colaptes auratus	Northern flicker			RI
	Tyrant Flycatchers			
Contopus cooperi	Olive-sided flycatcher	MC	NM	RI
Contopus virens	Eastern wood-pewee			RI
Empidonax virescens	Acadian flycatcher			RI
Empidonax trailii	Willow flycatcher			RI
	Swallows			
Progne subis	Purple martin			RI
Riparia riparia	Bank swallow			RI
Hirundo rustica	Barn swallow			RI
	Titmice and Chickadees			
Poecile atricapillus	Black-capped chickadee	MC	NM	
Poecile carolinensis	Carolina chickadee			RI
	Nuthatches			
Sitta pusilla	Brown-headed nuthatch	MC		RI
	Wrens			
Troglodytes troglodytes	Winter wren			RI
Thryothorus ludovicianus	Carolina wren			RI
	Kinglets, Gnatcatchers, and Thrushes			
Hylocichla mustelina	Wood thrush	MC		RI
	Thrashers and Mockingbirds			
Toxostoma rufum	Brown thrasher			RI
	Waxwings			
Bombycilla cedrorum	Cedar waxwing			RI
	Shrikes			
Lanius ludovicianus	Loggerhead shrike	MC	NM	RI
	Vireos			
Vireo flavifrons	Yellow-throated vireo			RI
Vireo solitaries	Blue-headed vireo			RI
Vireo griseus	White-eyed vireo			RI
	Wood Warblers			
Vermivora chrysoptera	Golden-winged warbler	MC	NM	RI
Vermivora cyanoptera	Blue-winged warbler	MC		RI
Setophaga cerulea	Cerulean warbler	MC	NM	RI
Setophaga discolor	Prairie warbler	MC		RI

Table 1.1 Animal species of special concern reported on the Oak Ridge Reservation[a] (Continued)

Scientific name	Common name	Status[b]		
		Federal	State	PIF[c]
Setophaga dominica	Yellow-throated warbler			RI
Mniotilta varia	Black-and-white warbler			RI
Helmitheros vermivorum	Worm-eating warbler	MC		RI
Parkesia motacilla	Louisiana waterthrush	MC		RI
Protonotaria citrea	Prothonotary warbler	MC		RI
Geothlypis formosa	Kentucky warbler	MC		RI
Cardellina canadensis	Canada warbler	MC		RI
Setophaga citrina	Hooded warbler			RI
Icteria virens	Yellow-breasted chat			RI
Setophaga pinus	Pine warbler			RI
Cardellina pusilla	Wilson's warbler			RI
Setophaga magnolia	Magnolia warbler			RI
Setophaga fusca	Blackburnian warbler			RI
Setophaga pennsylvanica	Chestnut-sided warbler			RI
Setophaga virens	Black-throated green warbler			RI
	Tanagers			
Piranga olivacea	Scarlet tanager			RI
Piranga rubra	Summer tanager			RI
	Cardinals, Grosbeaks, and Allies			
Passerina cyanea	Indigo bunting			RI
	Towhees, Sparrows, and Allies			
Pipilo erythrophthalmus	Eastern towhee			RI
Spizella pusilla	Field sparrow			RI
Ammodramus savannarum	Grasshopper sparrow			RI
Pooecetes gramineus	Vesper sparrow		NM	
Ammodramus henslowii	Henslow's sparrow	MC	NM	RI
Melospiza Georgiana	Swamp sparrow			RI
	Blackbirds and Allies			
Dolichonyx oryzivorus	Bobolink			RI
Sturnella magna	Eastern meadowlark			RI
	Finches and Allies			
Spinus tristis	American goldfinch			RI
	MAMMALS			
Myotis grisescens	Gray bat	E	E	
Myotis sodalist	Indiana bat[f]	E	E	
Myotis septentrionalis	Northern long-eared bat	T		
Sorex longirostris	Southeastern shrew		NM	
Sorex cinereus	Masked shrew		NM	
Zapus hudsonius	Meadow jumping mouse		NM	

Table 1.1 Animal species of special concern reported on the Oak Ridge Reservation[a] (Continued)

[a]Land and surface waters of the Oak Ridge Reservation (ORR) exclusive of the Clinch River, which borders the ORR.
[b]Status codes:
E = endangered
T = threatened
MC = of management concern
NM = in need of management
ORR = Oak Ridge Reservation
RI = regional importance
[c]Partners in Flight (PIF)—an international organization devoted to conserving bird populations in the Western Hemisphere.
[d]The bald eagle was federally delisted effective August 8, 2007.
[e]The peregrine falcon was federally delisted effective August 25, 1999.
[f]A single specimen was captured in a mist net bordering the Clinch River in June 2013.

Birds, fish, and aquatic invertebrates are the most thoroughly surveyed animal groups on the ORR. Nevertheless, the only federally listed animal species that have been observed on the ORR in recent years have been mammals. Gray bats were observed over the Clinch River bordering the ORR in 2003 and over a pond on the ORR in 2004. Three gray bats were mist-netted outside a cave on the ORR in 2006. Several gray bats and one Indiana bat were also captured in mist nets bordering the Clinch River in June–July 2013. Northern long-eared bats, recently federally listed as threatened, are known to be present on the ORR: their calls have been identified in various acoustic surveys of the reservation, and in 2013 their presence was confirmed when a number were captured in mist nets (McCracken et al. 2015).

Two-hundred twenty-nine species of birds have been recorded on the ORR and its boundary waters. These are the 228 species documented by Roy et al. (2014) and the cackling goose (Branta hutchinsii), which was recorded in eBird (Sullivan et al. 2009) at the ORNL Swan Pond in November 2014. Most of these species are afforded protection under the Migratory Bird Treaty Act and Executive Order (EO) 13186, Responsibilities of Federal Agencies to Protect Migratory Birds. DOE's 2013 updated memorandum of understanding on migratory birds with the US Fish and Wildlife Service (FWS) strengthens migratory bird conservation on the ORR through enhanced collaboration between DOE and FWS (DOE-FWS 2013). Breeding bird surveys were conducted at 79 points along nine routes on the ORR in 2014 for the Partners in Flight Program. Multiple public nature walks were held on the ORR in 2015, including a bird-specific American Woodcock and Falconry walk. ORR work on early succession habitat was selected to represent DOE in the 2015 Presidential Migratory Bird Federal Stewardship Award nominations. All known ORR bird records since 1950, as well as population trends for 32 species of birds, were documented in the technical manuscript *Oak Ridge Reservation Bird Records and Population Trends* (Roy et al. 2014).

Several state-listed bird species such as the anhinga, olive-sided flycatcher, and little blue heron are uncommon migrants or visitors to the reservation. The cerulean warbler, listed by the state as in need of management, has been recorded during the breeding season on the ORR but is currently listed as a potential breeding bird on the ORR (Roy et al. 2014) as its actual breeding status is still uncertain. The bald eagle (Fig. 1.4), also listed by the state as in need of management, is a year-round resident in Tennessee, though it can be difficult to find on the reservation from September through November. One bald eagle nest was confirmed on the reservation in 2011, and this pair nested again in 2012, 2013, and 2014. A second bald eagle nest, with an eaglet, was discovered in 2013. Adult eagles were observed at this nest in 2014, and eaglets were successfully fledged from the Poplar Creek nesting location in 2015. Other species such as the northern harrier, great egret, and yellow-bellied sapsucker are migrants, winter residents, or casual visitors and are not known to nest on the reservation. The golden-winged warbler, listed by the state as in need of management, was sighted once (in May 1998) on the reservation, as was the Lincoln's sparrow (*Melospiza lincolnii*, in May 2014, no listed status). Barn owls have been known to nest on the reservation in the past and are still occasionally seen on the reservation.

ORNL 2012-P01070

Fig. 1.4. Bald eagle nest on the Oak Ridge Reservation.
[Source: Jason Richards, ORNL photographer.]

With many northern lakes freezing solid during the winter of 2013–2014, white-winged scoters (*Melanitta fusca*) and red-necked grebes (*Podiceps grisegena*) made rare appearances in East Tennessee in February and March of 2014, though they were only recorded locally on boundary waters of the reservation. Other uncommon birds for the ORR have been recorded in recent years, including several species associated with wetland habitats. The sora, least bittern, and Virginia rail (Fig. 1.5) were all observed at the K1007 P1 pond at ETTP in 2013, where high quality wildlife habitat has been established as a result of recent restoration efforts. The sora, seen as recently as December 2013, is considered to be a fairly common migrant throughout Tennessee but it is seldom seen on the ORR. The least bittern, heard in July 2012 and then again in May and July of 2013, is an uncommon migrant and summer resident in Tennessee. The Virginia rail, most recently observed in October 2013, was previously known only from historic (early 1950s) records on the ORR (Roy et al. 2014). All three species have been listed by FWS as “of management concern,” and the least bittern is also deemed in need of management by the State of Tennessee (Table 1.1).

ORNL 2015-G00408/chj

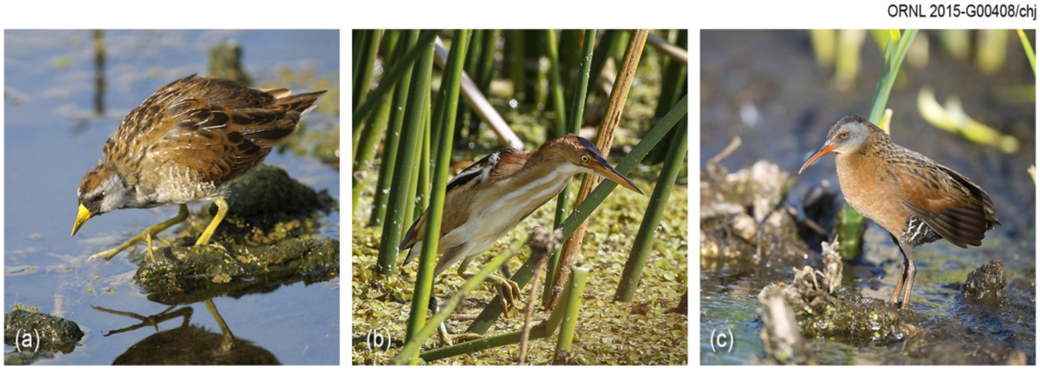

Fig. 1.5. Interesting bird species sighted on the Oak Ridge Reservation in recent years: (a) sora, (b) least bittern, and (c) Virginia rail.
[Source: Stock images courtesy of iStock.]

One species of fish, the spotfin chub (*Erimonax monachus*), which is listed as threatened by both the state and the federal government, has been sighted and collected in the city of Oak Ridge and may be present on the ORR. The tangerine darter (*Percina aurantiaca*), a species listed by the state as in need of management, has also been recorded in close proximity to the 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 being in need of management, has been found in the Bear Creek watershed, tributaries to the lower East Fork watershed, and Ish Creek and may occur in some sections of Grassy Creek upstream of Scientific Ecology Group, Inc., and International Technology Corporation at Clinch River kilometer 23 (e.g., south of west Bear Creek Road near Grassy Creek sampling point 1.9).

1.3.6.3 Threatened and Endangered Plants

Four plant species currently known to be on the ORR (spreading false foxglove, Appalachian bugbane, tall larkspur, and butternut) have been under review for listing at the federal level and were listed under the formerly used “C2” candidate designation. These species are now informally referred to as “special concern” species by the US Fish and Wildlife Service. (Note: Appalachian bugbane is no longer listed by Tennessee and does not have official federal status; therefore, it does not appear in Table 1.2.)

Seventeen plant species occurring on the ORR are listed by the state as endangered, threatened, or of special concern and are listed in Table 1.2. An additional 10 threatened, endangered, or special concern species are known to occur in the area and, although currently unconfirmed on the ORR, have the potential to be present; these are also included in Table 1.2. Other plant populations are currently under study on the ORR, which may lead to additions to the table below.

The Tennessee Heritage Program scientific advisory committee met in 2012 to revise the state’s Rare Plant List. Those changes are now official. This has reduced the number of state-protected species on the ORR by six. The protection of these six species on the ORR was a factor in their delisting.

Table 1.2. Vascular plant species listed by state or federal agencies and sighted/reported on or near the Oak Ridge Reservation, 2015

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

[a]Status codes:
- CE = Status due to commercial exploitation.
- E = Endangered in Tennessee.
- FSC = Federal Special Concern; formerly designated as C2. See *Federal Register*, February 28, 1996.
- S = Special concern in Tennessee.
- T = Threatened in Tennessee.

[b]Ramps have been reported near the 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. Both species of ramps have the same state status.

Acronyms

ORR = Oak Ridge Reservation

1.3.6.4 Historical and Cultural Resources

Efforts continue to preserve the ORR's rich prehistoric and historic cultural resources. Compliance with the National Historic Preservation Act (NHPA) at ETTP is achieved and maintained in conjunction with National Environmental Policy Act (NEPA) compliance. The scope of proposed actions is reviewed in accordance with the ORR cultural resource management plan (Souza et al. 2001). ETTP has 135 facilities that were eligible for inclusion on the National Register of Historic Places (NRHP), a National Park Service (NPS) program to identify, evaluate, and protect historic and archeological resources in the US, as well as numerous facilities that were not eligible for inclusion on the NRHP. To date, more than 800 facilities have been demolished. Artifacts of historical and/or cultural significance are identified before demolition and are catalogued in a database to aid in the historic interpretation of ETTP. The reservation contains more than 45 known prehistoric sites (primarily burial mounds and archeological evidence of former structures), more than 250 historic pre-World War II structures, 32 cemeteries, and several historically significant Manhattan Project-era structures.

The National Defense Authorization Act of 2015, passed by Congress and signed into law December 19, 2014, included provisions authorizing the Manhattan Project National Historical Park. On November 10, 2015, the Manhattan Project National Historical Park was established with the execution of an agreement by the Secretaries of Energy and Interior. On the Oak Ridge Reservation, the boundaries of the National Park include the X-10 Graphite Reactor, buildings 9731 and 9204-3 at the Y-12 National Security Complex, and the K-25 Building Site at the East Tennessee Technology Park. The Park also includes facilities and lands in Los Alamos, New Mexico and Hanford, Washington.

- X-10 Graphite Reactor – The building has been registered with the National Register of Historic Places since 1966, and has been open for public access in varying fashions since that time. Enhancing access and the visitor experience are part of DOE's objectives moving forward in implementing the National Park.

- Y-12 National Security Complex – Buildings 9731 and 9204-3 were eligible for listing on the National Register of Historic Places, and both are currently unavailable for regular public access. Irregular public access to both facilities has occurred as recently as Nov. 12, 2015, when DOE facilitated public tours to both buildings in celebration of the establishment of the National Park. Enhancing safe access while protecting DOE's mission capabilities is part of DOE's objectives moving forward in implementing the National Park.

- K-25 Building Site – The K-25 Building site is already undergoing extensive historic interpretation activities implemented separately and independently of the National Park. Enabling safe access to the former site of the K-25 Building is part of DOE's objectives in moving forward with the implementation of the National Park. As part of the activities to establish the Park, DOE released the K-25 Virtual Museum, which details the history of the K-25 Gaseous Diffusion Plant through narrative and photographs and can be found at http://www.k-25virtualmuseum.org/.

In addition, seven historic ORR properties are individually listed in the NRHP:

- Freels Bend Cabin
- Graphite Reactor
- 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 not yet listed in the NRHP, an area known as the Wheat Community African Burial Grounds was dedicated in June 2000, and a memorial monument was erected.

A memorandum of agreement (MOA) for the interpretation of historical properties at ETTP was signed in 2012 by DOE Oak Ridge Office (ORO), the State Historic Preservation Officer (SHPO), the Advisory Council on Historic Preservation (ACHP), the City of Oak Ridge, and the East Tennessee Preservation Alliance. The MOA is being implemented through planning for a museum that will highlight the historic aspects of ETTP and of the communities that were displaced during the construction of the site. Details are provided in Chapter 3, Sections 3.3.4 and 3.8.2. A final MOA was signed in August 2012 finalizing the aspects set forth in the mitigation plan. During 2013, a request for proposal was issued for a Professional Design Team and Museum Professional as specified in the MOA. Nine firms were prequalified, and the selection and award were executed April 1, 2014. The procurement process for the K-25 Virtual Museum web design firm was also begun in 2013 and awarded September 2, 2014. An MOA was signed by the US Department of Interior and DOE on November 10, 2015 creating the new Manhattan Project Historic National Park. The K-25 Virtual Museum website (K-25 Virtual Museum 2015) was launched in conjunction with the signing of the MOA.

Two site-wide programmatic agreements among DOE ORO, SHPO, and ACHP concerning management of historical and cultural properties at ORNL and at Y-12 have been enforced since their respective approvals.

1.4 Oak Ridge Sites

1.4.1 Oak Ridge National Laboratory

ORNL, managed for DOE by UT-Battelle, LLC, a partnership of the University of Tennessee and Battelle Memorial Institute, is the largest science and energy national laboratory in the DOE system (Fig. 1.6), conducting 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 SNS and HFIR. ORNL hosts a DOE leadership computing facility, home of the Titan supercomputer; one of DOE's nanoscience centers, the Center for Nanophase Materials Sciences; one of DOE's energy research centers, the BioEnergy Science Center; and a DOE innovation hub, the Consortium for Advanced Simulation of Light-Water Reactors. UT-Battelle also manages the US ITER project for DOE.

ORNL 2011-P02352

Fig. 1.6. The Oak Ridge National Laboratory.

ORNL, formerly called X-10, was established in 1943 to support the Manhattan Project. From an early focus on chemical technology and reactor development, ORNL's research and development (R&D) portfolio broadened to include programs supporting DOE missions in scientific discovery and innovation, clean energy, and nuclear security. Today there are about 4,400 workers at ORNL, and the laboratory's extensive capabilities for scientific discovery and innovation are applied to the delivery of mission outcomes for DOE and other sponsors.

The Transuranic Waste Processing Center (TWPC) is located on a tract of land about 10.5 ha (26 acres) in size in the Melton Valley area of ORNL about 120 ft west of the existing Melton Valley Storage Tanks. TWPC is managed by North Wind Solutions, LLC (NWSol) for DOE. TWPC's mission is to receive transuranic (TRU) waste for processing, treatment, repackaging, and shipment to designated facilities for final disposal. Waste that is determined to be non-TRU (e.g., low-level radioactive waste, mixed low-level waste) is shipped to the Nevada National Security Site (NNSS) or other approved facilities.

DOE remains focused on disposing of a significant inventory of uranium-233 (^{233}U) stored in Building 3019 at ORNL. This special nuclear material requires strict safeguards and security controls to protect against access. The ^{233}U Project's objective is to address safeguards and security requirements, eliminate safety and nuclear criticality concerns, and safely dispose of the material. In 2015, DOE successfully resolved the concerns associated with the disposition of the Consolidated Edison Uranium Solidification Project (CEUSP) material. CEUSP originated from a 1960s research and development test of thorium and uranium fuel at Consolidated Edison's Indian Point 1 Nuclear Plant in New York. Isotek Systems LLC (Isotek) manages activities at the Building 3019 complex for DOE and is responsible for activities associated with processing, down-blending, and packaging the DOE inventory of ^{233}U stored in the complex.

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

1.4.2 The Y-12 National Security Complex

The original Y-12 Complex was 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 site.

Today, as part of the NNSA Nuclear Security Enterprise, the Y-12 Complex (Fig. 1.7) 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 is a leader in materials science and precision manufacturing and serves as the main storage facility for the nation's supply of enriched uranium. The Y-12 Complex also supports efforts to reduce the risk of nuclear proliferation and performs complementary work for other government agencies.

UCOR is the DOE ORR cleanup contractor responsible for mercury remediation at the Y-12 Complex. In 2015, DOE headquarters approved the Outfall 200 Mercury Treatment Facility (MTF) Conceptual Design Report, as well as plans to proceed with MTF design. The goal of the MTF is to reduce the mercury concentration in water exiting the Y-12 Complex. Outfall 200 is the point at which the west end Y-12 storm drain system discharges to Upper East Fork Poplar Creek. Mercury from historical operations is present in the Outfall 200 storm water entering Poplar Creek. Also in 2015, eight pre-design studies to evaluate storm water chemistry, optimal treatment parameters, potential water diversion strategies, storm impacts on mercury levels, and other parameters were completed to provide information to support MTF siting and design.

In support of mercury clean-up efforts, research and technology development activities focused on the major factors influencing the accumulation of mercury in fish (fish are the major route of both human and wildlife exposure). Three lines of investigation for East Fork Poplar Creek were developed to (1) examine potential downstream sources, such as bank soil and sediment control, (2) study the ecology and how differences in food chain processes may influence the uptake of mercury in fish, and (3) investigate the water chemistry and flow characteristics of the creek and its influence.

The MTF is being designed to treat up to 3,000 gallons of storm water per minute and includes a 2-million-gallon storage tank to collect storm water during peak flow conditions of up to 40,000 gallons per minute and then treat the stored water after storm flow subsides. Captured storm water will be piped to a treatment facility located on an available site east of Outfall 200. Mercury treatment will be accomplished using chemical precipitation, clarification, and media filtration. Treated water will be discharged back into Upper East Fork Poplar Creek. The Outfall 200 MTF design incorporates flexibility and expandability of treatment processes for mercury if required in the future.

Understanding the movement of mercury in the East Fork Poplar Creek system was deemed essential to the development of new technologies and ultimately to the development of remedial options and strategies for the creek. Early studies have pointed to the importance of bank soils and sediments as a source of mercury to the creek, especially during high-flow events. Research is under way to examine potential technologies that may limit mercury erosion. Stream management changes—such as controlling nutrients or algae growth or managing fish populations—are also under investigation. In March 2015, scientists issued a report titled *Mercury Remediation Technology Development for Lower East Fork Poplar Creek* (ORNL/SPR-2014/645). This report offers science-based approaches and ideas for research and technology development activities that may lead to new mercury remediation projects.

ORNL 2012-G00348/ch

Fig. 1.7. Y-12 National Security Complex.

1.4.3 East Tennessee Technology Park

What is now known as ETTP (Fig. 1.8) was originally named the K-25 Site, where the nation's first gaseous diffusion plant for enriching uranium as part of the Manhattan Project was located.

During the Cold War additional uranium enrichment facilities were built adjacent to K-25, forming a complex officially known as the Oak Ridge Gaseous Diffusion Plant. Uranium enrichment operations at the site ceased in 1987, and restoration and decontamination and decommissioning (D&D) 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. Restoration of the environment, D&D of facilities, disposition of wastes, and reindustrialization are the major activities at the site. During 2015, ETTP landlord contractor functions and the majority of the ETTP cleanup program actions were managed by UCOR.

In 2015 three new businesses began operations at ETTP. Powerhouse Six, the third and largest solar array on site, was also constructed in 2015. Powerhouse Six is a 1 megawatt solar array on 5 acres of former DOE land that provides electricity to TVA through the City of Oak Ridge.

Fig. 1.8. East Tennessee Technology Park.

1.4.4 Environmental Management Waste Management Facility

EMWMF is located in eastern Bear Creek Valley near the Y-12 Complex and is managed by UCOR. EMWMF was built for the disposal of waste resulting from Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) cleanup actions on the 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 (ROD). The facility currently consists of six disposal cells.

EMWMF is an engineered landfill that accepts low-level, mixed low-level, and hazardous wastes from CERCLA cleanup activities on the DOE 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, EMWMF operates a leachate collection system. The leachate is treated at the ORNL Liquids and Gaseous Treatment Facility, which is operated by UCOR.

1.4.5 Oak Ridge Environmental Research Park

In 1980, DOE established the Oak Ridge Environmental Research Park (Fig. 1.9). The research park serves as an outdoor laboratory to evaluate the environmental consequences of energy use and development and the strategies to mitigate those effects. It contains large blocks of forest and diverse communities of vegetation that 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, sustainable development, tropospheric air quality, global climate change, innovative power conductors, solar radiation monitoring, ecological recovery, and monitoring and remediation.

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 precisely and accurately measure environmental factors for extended periods of time. Because the park is under the jurisdiction of the federal government, public access is restricted and experimental sites and associated equipment are therefore not disturbed.

National recognition of the value of the research park has led to its use as a component of both regional- and continental-scale research projects. Various 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.

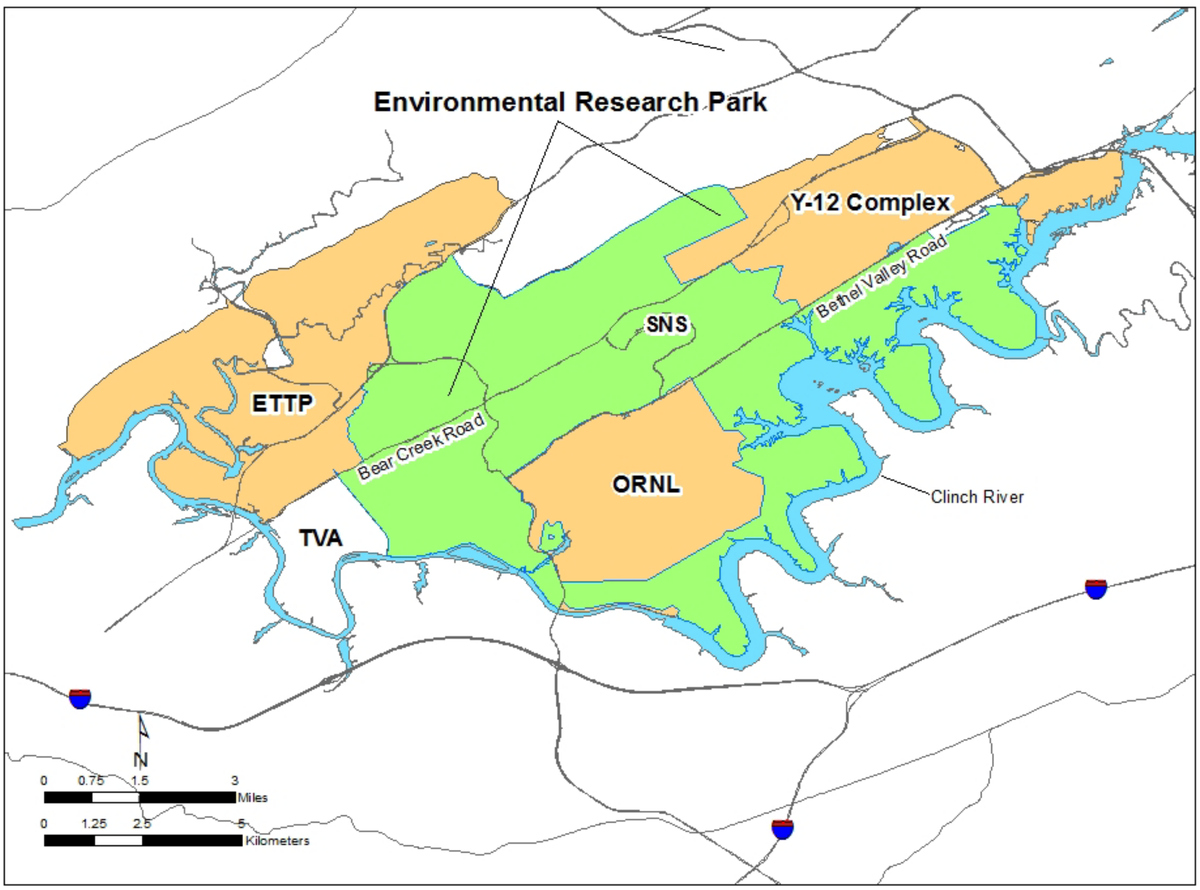

Fig. 1.9. The Oak Ridge Environmental Research Park.

1.4.6 Oak Ridge Institute for Science and Education

ORISE is managed by Oak Ridge Associated Universities (ORAU). ORISE addresses national needs in assessing and analyzing environmental and health effects of radiation, beryllium, and other hazardous materials; developing and operating medical and national security radiation emergency management and response capabilities; and managing education programs to help ensure a robust supply of scientists, engineers, and technicians to meet future science and technology needs. ORISE creates opportunities for collaboration through partnerships with other DOE facilities, federal agencies, academia, and industry in a manner consistent with DOE objectives and the ORISE mission.

ORISE is located in an area on the southeastern border of the ORR that from the late 1940s to the mid-1980s was part of an agricultural experiment station owned by the federal government and, until 1981, operated by the University of Tennessee. The site houses offices, laboratories, and storage areas for the ORISE program offices and support departments.

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

Since 1947, DOE and its predecessor agencies have moved nuclear weapons, weapons components, special nuclear materials, and other important national security assets by commercial and government transportation modes. 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. Thus, 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 within DOE NNSA responsible for this mission is the Office of Secure Transportation (OST).

The NNSA OST Agent Operations Eastern Command (AOEC) Secure Transportation Center and Training Facility is located on the ORR. NNSA OST AOEC is situated on about 723 ha (1,786 acres) of the ORR and operates under a user permit agreement with DOE ORO. NNSA OST AOEC implements its assigned mission transportation operations, maintains applicable fleet and escort vehicles, and continues extensive training activities for its federal agents.

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2. Compliance Summary and Community Involvement

DOE operations on the ORR are required to be in conformance with environmental standards established by a number of federal and state statutes and regulations, EOs, DOE orders, contract-based standards, and compliance and settlement agreements. Principal among the regulating agencies are EPA and TDEC. These agencies issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable regulations.

When environmental concerns or problems are identified during routine operations or during ongoing self-assessments of compliance status, the issues are discussed with the respective regulatory agencies. The following sections summarize the major environmental statutes and 2015 status for DOE operations on the ORR. Several facilities at ETTP and the Oak Ridge Science and Technology Park sites have been leased to private entities over the past several years through the DOE Reindustrialization Program. The compliance status of these lessee operations is not discussed in this report.

Because of different permit reporting requirements and instrument capabilities, various units of measure are used in this report. The list of units of measure and conversion factors provided on pages xxvi and xxvii is intended to help readers convert numeric values presented in this document as needed for specific calculations and comparisons.

2.1 Laws and Regulations

Table 2.1 summarizes the principal environmental standards applicable to DOE activities on the reservation, the 2015 status, and references to the report sections that provide more detailed information.

2.2 External Oversight and Assessments

Inspections of ORR environmental activities conducted by regulatory agencies during 2015 are summarized in Table 2.2. This table does not include internal DOE or DOE contractor assessments, audits, or evaluations.

The State of Tennessee also conducts a program of independent monitoring and oversight of DOE activities on the ORR through the Tennessee Oversight Agreement (TOA). TOA is a voluntary agreement between DOE and the State of Tennessee and is designed to assure the citizens of Tennessee that their health, safety, and environment are being protected through existing programs and substantial new commitments by DOE. More information on TOA and reporting of monitoring conducted under TOA is available at http://www.tennessee.gov/environment/topic/rem-oak-ridge-reservation-clean-up.

Table 2.1. Applicable environmental laws/regulations and 2015 status

Regulatory program description	2015 status	Report sections
CAA and corollary State of Tennessee requirements regulate the release of air pollutants through permits and air quality limits. Emissions of airborne radionuclides are regulated by EPA via rad-NESHAPs authorization. Greenhouse gas emissions inventory tracking and reporting are regulated by EPA and DOE internal oversight.	In 2015, all activities on the ORR were conducted in accordance with CAA requirements. One NOV was issued to UT-Battelle, LLC, by TDEC for failure to permit two emergency generators in a timely manner. These two generators were inadvertently omitted from an application submitted previously. The permit for these two generators was issued by TDEC on January 23, 2015.	3.3.5 4.3.3 5.3.3
CERCLA provides a regulatory framework for remediation of the release or threat of release of hazardous substances from past practices on the ORR.	The ORR has been on the EPA NPL since 1989. The ORR FFA, initiated in 1992 among EPA, TDEC, and DOE, establishes the framework and schedule for developing, implementing, and monitoring remedial actions on the ORR. The on-site CERCLA Environmental Management Waste Management Facility (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 the ORR, including ORNL. EMWMF is an engineered landfill that accepts low-level radioactive, hazardous, asbestos, and PCB wastes and combinations of the aforementioned wastes in accordance with specific waste acceptance criteria under an agreement with state and federal regulators. No NOVs were issued for CERCLA-related ORR actions during 2015.	3.3.11 4.3.7 5.3.8
CWA seeks to protect and improve surface water quality by establishing surface water standards enabled by a system of permits. Wastewater discharges are regulated by NPDES permits issued by TDEC.	Discharges to surface water at each of the three major ORR sites are governed by NPDES permits. A compliance rate of >99% was achieved by all three major ORR sites in 2015. Four effluent limit exceedances occurred at the ORNL STP in May 2015. Corrective actions including sludge-management system improvements were completed before the end of May 2015. See Appendix D for more information.	3.3.6 4.3.4 5.3.4
EISA § 438 establishes requirements for federal agencies to reduce storm water runoff from development projects to protect water resources.	To comply with EISA, a variety of storm water management techniques referred to as GI or LID practices have been implemented on the ORR. The site sustainability plans and associated reporting provide data on sustainability projects and support EISA § 438 compliance.	4.2.6.8 5.2.1.4.2
EPCRA, also referred to as SARA Title III, requires reporting emergency planning information, hazardous chemical inventories, and environmental releases of certain toxic chemicals to federal, state, and local authorities.	In 2015, DOE facilities on the ORR were operated in accordance with emergency planning and reporting requirements.	3.3.14 4.3.9 5.3.10

Table 2.1. Applicable environmental laws/regulations and 2015 status (Continued)

Regulatory program description	2015 status	Report sections
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 NEPA documents.	During 2015, DOE planning and decision making activities on the ORR were conducted in accordance with NEPA requirements.	3.3.4 4.3.2 5.3.2
NHPA provides protection for the nation's historic resources by establishing a comprehensive national historic preservation policy.	The ORR has several facilities eligible for inclusion in the NRHP. Proposed activities are reviewed to determine potential adverse effects on these properties, and methods to avoid or minimize harm are identified. During 2015, activities on the ORR were in compliance with NHPA requirements.	3.3.4 4.3.2 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 for the presence of wetlands are conducted on a project or program as-needed basis through NEPA and other reviews. Wetland protection on the ORR is conducted in accordance with 10 CFR 1022 and EO 11990, *Protection of Wetlands*.	1.3.6.1 4.2.6.1 5.3.12
RCRA governs the generation, storage, handling, and disposal of hazardous wastes. RCRA also regulates USTs containing petroleum and hazardous substances, universal waste, and recyclable used oil.	The Y-12 Complex, 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 the ORR.	3.3.9 4.3.6 5.3.6
SDWA establishes minimum drinking water standards and monitoring requirements.	The City of Oak Ridge supplies potable water to the facilities on the ORR and is responsible for meeting all regulatory requirements for drinking water. In 2015, sampling results for ORNL's water system residual chlorine levels, lead and copper levels, bacterial constituents, and disinfectant by-products were all within acceptable limits.	3.3.8 4.3.5 5.3.5
TSCA regulates the manufacture, use, and distribution of a number of toxic chemicals.	In 2015, UT-Battelle operated 16 PCB waste storage areas in generator buildings. ORR facilities manage TSCA-regulated materials, including PCBs. The ORR PCB FFCA between EPA and DOE continues to provide a mechanism to address legacy PCB-use issues across the ORR. The agreement specifically addresses the unauthorized use of PCBs, storage and disposal of PCB waste, PCB spill cleanup and/or decontamination, PCBs mixed with radioactive materials, PCB research and development, and records and reporting requirements for the ORR. EPA is updated annually on the status of DOE actions with regard to management and disposition of legacy PCBs covered under the ORR PCB FFCA. One unauthorized use of PCBs was discovered and reported in pipe-coating material in the 7900 area.	3.3.13 4.3.8 5.3.9

Table 2.1. Applicable environmental laws/regulations and 2015 status (Continued)

Regulatory program description	2015 status	Report sections
Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d) protects bald and golden eagles by prohibiting, except under certain 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 the ORR year-round. Currently there are two active bald eagle nests on the ORR that are protected in accordance with this act. Eaglets were successfully fledged from a Poplar Creek nesting location in 2015.	1.3.6.2
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.	The ORR is host to several plant and animal species that are categorized as endangered, threatened, or of special concern and that are protected in accordance with this act.	1.3.6.2
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.	The ORR hosts numerous migratory birds that are protected under this act.	1.3.6.2
DOE O 231.1B, *Environment, Safety and Health Reporting,* ensures timely collection, reporting, analysis, and dissemination of information on environment, safety, and health issues.	The *Oak Ridge Reservation Annual Site Environmental Report for 2015* summarizes ORR environmental activities during 2015 and characterizes environmental performance.	All chapters
DOE O 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 the ORR to ensure compliance with this DOE order.	
DOE O 436.1, *Department Sustainability,* provides requirements and responsibilities for managing sustainability within DOE to ensure the department carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges and advances sustainable, efficient, and reliable energy for the future.	DOE contractors on the ORR have developed SSPs and have implemented EMSs that are incorporated with the contractors' ISMSs to promote sound stewardship practices and to ensure compliance with this DOE order.	3.2 4.2 5.2

Table 2.1. Applicable environmental laws/regulations and 2015 status (Continued)

Regulatory program description	2015 status	Report sections
DOE O 458.1, ***Radiation Protection of the Public and the Environment,*** issued in June 2011, canceled DOE O 5400.5 and 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.	In 2015, DOE O 458.1 was the primary contractual obligation for radiation protection programs for UT-Battelle, LLC and CNS, and for all UCOR work scope areas where existing CERCLA Decision Documents do not specifically identify DOE O 5400.5 requirements. A dose assessment, 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, estimated the maximum 2015 dose to a hypothetically exposed member of the public from all ORR potential exposure pathways combined would be about 3 mrem. The 2015 maximum ED was about 3% of the limit given in DOE O 458.1. Clearance of property from ORNL, ETTP and the Y-12 Complex was conducted in accordance with approved procedures that comply with DOE O 458.1.	4.3.13 4.3.13 Chap. 7
DOE O 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 O 5400.5 is the primary environmental surveillance radiological ARAR for most CERCLA activities across the ORR and will remain in force until the individual CERCLA decision documents are reissued or revised to incorporate DOE O 458.1. A dose assessment, 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, estimated the maximum 2015 dose to a hypothetically exposed member of the public from all ORR potential exposure pathways combined would be about 3 mrem.	Chap. 7
EO 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds,* identifies the responsibilities of federal agencies to promote the conservation of migratory bird populations.	An MOU was entered into by DOE and FWS that meets the requirements under Section 3 of EO 13186. The ORR hosts numerous migratory birds that are present either seasonally or year-round. This MOU, which was updated in September 2013, strengthens migratory bird conservation on the ORR through enhanced collaboration between DOE and FWS.	1.3.6.2
EO 13693, *Executive Order -- Planning for Federal Sustainability in the Next Decade,* instructs federal agencies to increase efficiency and improve their environmental performance, which will protect our planet for future generations and save taxpayer dollars through avoided energy costs.	In 2015, EO 13693, Planning for Federal Sustainability in the Next Decade, superseded EO 13514 and established a new Scope 1 and Scope 2 total reduction target of 40% by 2025. Progress toward achieving DOE sustainability goals is summarized in this report. ORR activities complied with the planning and reporting requirements of these executive orders in 2015.	3.2.4 4.2.3.4 5.2.1.4

[a]DOE. 2015. *2015 Strategic Sustainability Performance Plan*. US Department of Energy, Washington, DC.

Table 2.1. Applicable environmental laws/regulations and 2015 status (Continued)

Acronyms

ARAR = applicable, relevant, and appropriate requirement
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
EISA = Energy Independence and Security Act
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
ETTP = East Tennessee Technology Park
FFA = Federal Facility Agreement
FFCA = Federal Facilities Compliance Agreement
FWS = US Fish and Wildlife Service
GI = green infrastructure
ISMS = integrated safety management system
LID = low impact development
MOU = memorandum of understanding
NEPA = National Environmental Policy Act
NESHAPs = National Emission Standards for Hazardous Air Pollutants
NHPA = National Historic Preservation Act
NOV = notice of violation
NPDES = National Pollutant Discharge Elimination System
NPL = National Priorities List
NRHP = National Register of Historic Places
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
PCB = polychlorinated biphenyl
rad-NESHAPs = National Emission Standards for Hazardous Air Pollutants for radionuclides
RCRA = Resource Conservation and Recovery Act
SARA = Superfund Amendments and Reauthorization Act
SDWA = Safe Drinking Water Act
SSP = site sustainability plan
STP = sewage treatment plant
TDEC = Tennessee Department of Environment and Conservation
TSCA = Toxic Substances Control Act
UCOR = URS | CH2M Oak Ridge LLC
UST = underground storage tank
Y-12 Complex = Y-12 National Security Complex

Table 2.2. Summary of regulatory environmental evaluations, audits, inspections, and assessments conducted at Oak Ridge Reservation, 2015

Date	Reviewer	Subject	Issues
		***ORNL* (including UT-Battelle, LLC; UCOR; Isotek; and WAI activities)**	
January 14	TDEC	Annual CAA Inspection for ORNL and CFTF	0
February 19	City of Oak Ridge	CFTF Wastewater Inspection	0
April 27–29	TDEC	Annual RCRA Inspection for ORNL (including TWPC)	1
April 29	1916-T2 Warehouse	1916-T2 Warehouse RCRA Inspection	0
August 3	City of Oak Ridge	CFTF Wastewater Inspection	0
October 21–22	TDEC	Annual CAA Inspection for ORNL and CFTF	0
October 28–29	City of Oak Ridge	CFTF Wastewater Inspection	0
		ETTP	
March 9	TDEC	Annual RCRA Compliance Inspection	1
June 2	TDEC	RCRA TNHW-117 Permit Renewal	0
June 24	TDEC	D&D Waste Shipment Audit	0
June 15	TDEC	TDEC NPDES Permit Writer	0
September 24 and 28	TDEC	NPDES Compliance Evaluation Inspection	0
		Y-12 Complex	
February 12	COR	Semiannual Industrial Pretreatment Compliance Inspection	0
March 9–10	TDEC	Annual CAA Inspection	0
September 16	COR	Semiannual Industrial Pretreatment Compliance Inspection	0
November 17–19	TDEC	Annual CAA Inspection	0

Acronyms:
CAA = Clean Air Act
CFTF = Carbon Fiber Technology Facility
COR = City of Oak Ridge
D&D = decontamination and decommissioning
ETTP = East Tennessee Technology Park
Isotek = Isotek Systems LLC
NPDES = National Pollutant Discharge Elimination System
ORNL = Oak Ridge National Laboratory
RCRA = Resource Conservation and Recovery Act
TDEC = Tennessee Department of Environment and Conservation
TNHW = Tennessee Hazardous Waste Permit
TWPC = Transuranic Waste Processing Center
UCOR = URS | CH2M Oak Ridge LLC
WAI = Wastren Advantage, Inc.
Y-12 Complex = Y-12 National Security Complex

2.3 Reporting of Oak Ridge Reservation Spills and Releases

CERCLA hazardous substances are substances considered to be harmful to human health and the environment. Many are commonly used substances that are harmless in normal uses but can be dangerous when released. CERCLA establishes reportable quantities (RQ) for hazardous substance releases. Any hazardous substance release exceeding an RQ triggers reports to the National Response Center, the State Emergency Response Center, and community coordinators. Discharges 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 CFR 110.3[b]).

The Y-12 Complex had one unplanned release of a hazardous substance which required notification of the regulatory agencies. On June 9, 2015 during the demolition of Building 9808, 2,117 pounds of mercury and mercury-containing sludge were spilled, which exceeded a hazardous substance reportable quantity. This event was reported to the appropriate agencies in accordance with regulatory requirements. See Section 4.3.11 for more information.

2.4 Notices of Violations and Penalties

ETTP received one environmental violation in 2015. This violation occurred at ETTP during a routine inspection for a missing used oil drum label on a drum in the facility's garage. The condition was immediately corrected and documented in UCOR's QAS tracking system. No penalties were assessed in 2015.

Although a notice of violation was issued by TDEC on August 5, 2015 for a drinking water monitoring deficiency, the Y-12 Plant Water System retains the state's "Approved" designation.

A notice of violation (NOV) issued to UT-Battelle by TDEC was received on January 20, 2015 for failure to include two emergency generators in a timely manner in the ORNL site air permit. This was self-reported to TDEC on November 11, 2014 and the omission has since been corrected. The two generators are now included in a permit issued January 23, 2015.

No other environmental NOVs, penalties, or consent orders were issued on the reservation during 2015.

2.5 Community Involvement

Many community involvement activities were provided by and/or supported by the DOE and its contractors in 2015 across a diverse range of subjects and activities. These included, but were not limited to, ETTP historic interpretation efforts, Manhattan Project National Historical Park public meetings and engagement, American Museum of Science and Energy community meetings hosted by the City of Oak Ridge, ETTP airport public meetings, public comment periods for draft environmental assessments, and Community Relations Council meetings. During 2015 organizations such as Great Smoky Mountains National Park, the East Tennessee Foundation, Oak Ridge Associated Universities Science Bowl, America Recycles Day activities, and local charities benefited from DOE and its contractors' efforts.

2.5.1 Public Comments Solicited

To keep the public informed of comment periods and other matters related to cleanup activities on the ORR, DOE publishes online notices (http://energy.gov/orem/services/community-engagement), conducts public meetings, and issues notices in local newspapers as appropriate. Information regarding environmental policy and DOE's commitment to providing sound environmental stewardship practices and keeping the public informed is available to the public via sponsored forums and public documents such as this report.

2.5.2 Oak Ridge Site Specific Advisory Board

The Oak Ridge Site Specific Advisory Board (ORSSAB) is a federally appointed citizens' panel that provides independent advice and recommendations to the DOE Oak Ridge Environmental Management (EM) Program. The board was formed in 1995 and is composed of up to 22 members chosen to reflect the diversity of gender, race, occupation, views, and interests of persons living near the DOE 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 on the ORSSAB website at http://www.energy.gov/ORSSAB.

Videos of the first hour of recent board meetings are posted on YouTube at http://www.youtube.com/user/ORSSAB.

Additional information may be obtained by calling 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 40,000 documents describing environmental activities in Oak Ridge. The center is open Monday through Friday, 8 a.m. to 5 p.m. An online catalog that can be used to search for DOE documents by author, title, date, and other fields is available at http://doeic.science.energy.gov.

2.5.3.1 Telephone Contacts

- Agency for Toxic Substances and Disease Registry: 1-800-232-4636
- DOE Information Center: 865-241-4780; toll free 1-800-382-6938 (option 6)
- DOE Public Affairs Office: 865-576-0885
- DOE ORO Public Information Line: 1-800-382-6938
- EPA Region 4: 1-800-241-1754
- ORSSAB: 865-241-4583, 865-241-4584, 1-800-382-6938 (option 4)
- TDEC, DOE Oversight Division: 865-481-0995

2.5.3.2 Internet Sites

- Agency for Toxic Substances and Disease Registry: http://www.atsdr.cdc.gov
- American Recovery and Reinvestment Act: http://www.energy.gov/recovery-act
- DOE Main Website: http://www.energy.gov
- DOE Information Center: http://doeic.science.energy.gov
- EPA Region 4: http://www.epa.gov/region4
- ETTP: http://www.ettpreuse.com/default.htm
- ORNL: https://www.ornl.gov/
- ORSSAB: http://www.energy.gov/ORSSAB
- TDEC: http://www.tennessee.gov/environment/
- TDEC, DOE Oversight Division: http://www.tn.gov/environment/section/rem-remediation/energy-oversight.shtml
- Y-12 National Security Complex: http://www.y12.doe.gov/

2.6 References

DOE 2015. *2015 Strategic Sustainability Performance Plan*. US Department of Energy, Washington, DC.

3. East Tennessee Technology Park

East Tennessee Technology Park (ETTP) was originally 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 was changed to include the enrichment of uranium for nuclear reactor fuel elements and recycling of uranium recovered from spent fuel, and the name was changed to the “Oak Ridge Gaseous Diffusion Plant” (ORGDP). In the 1980s, a reduction in the demand for nuclear fuel resulted in the shutdown of the enrichment process, and production ceased. The emphasis of the mission then changed to environmental management and restoration operations, and the name was changed to the “East Tennessee Technology Park.”

Environmental management and remediation operations consist of operations such as waste management, the cleanup of outdoor storage and disposal areas, the demolition and/or cleanup of facilities, land restoration, and environmental monitoring. Proper disposal of huge quantities of waste that were generated over the course of production operations is also a major task. Beginning in the 1990s, reindustrialization (the conversion of underused government facilities for use by the private sector) also became a major mission at ETTP. Reindustrialization allows private industry to lease underused facilities, thus providing both jobs and a new use for facilities that otherwise would have to be demolished. State and federally mandated effluent monitoring and environmental surveillance at ETTP involve the collection and analysis of samples of air, water, soil, sediment, and vegetation from ETTP and the surrounding area. Monitoring results are used to assess exposures to members of the public and the environment, to assess the performance of treatment systems, to help identify areas of concern, to plan remediation efforts, and to evaluate the efficacy of remediation efforts. In 2015, there was 100% compliance with permit standards for emissions/discharges from ETTP operations.

On November 10, 2015, the US Department of Energy (DOE) and the US Department of Interior signed a memorandum of agreement (MOA) establishing the Manhattan Project National Historic Park. The MOA defines the respective roles and responsibilities of the departments in administering the park and includes provisions for enhanced public access, management, interpretation, and historic preservation. The K-25 Building Site, formerly the K-25 Gaseous Diffusion Building, is within the boundary of the newly established National Park. As part of the activities to establish the park, DOE released the K-25 Virtual Museum, which details the history of the K-25 Gaseous Diffusion Plant through narrative and photographs and can be found at http://www.k-25virtualmuseum.org/.

3.1 Description of Site and Operations

Construction of the K-25 Site (Fig. 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 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 the ORGDP.

After military production of highly enriched uranium (HEU) was concluded in 1964, the two original process buildings were shut down. For the next 20 years, the plant’s primary missions were 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.

Fig. 3.1. East Tennessee Technology Park.

By 1985, the demand for enriched uranium had 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 East Tennessee Technology Park (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. Figure 3.3 shows the ETTP areas designated for D&D activities through 2015.

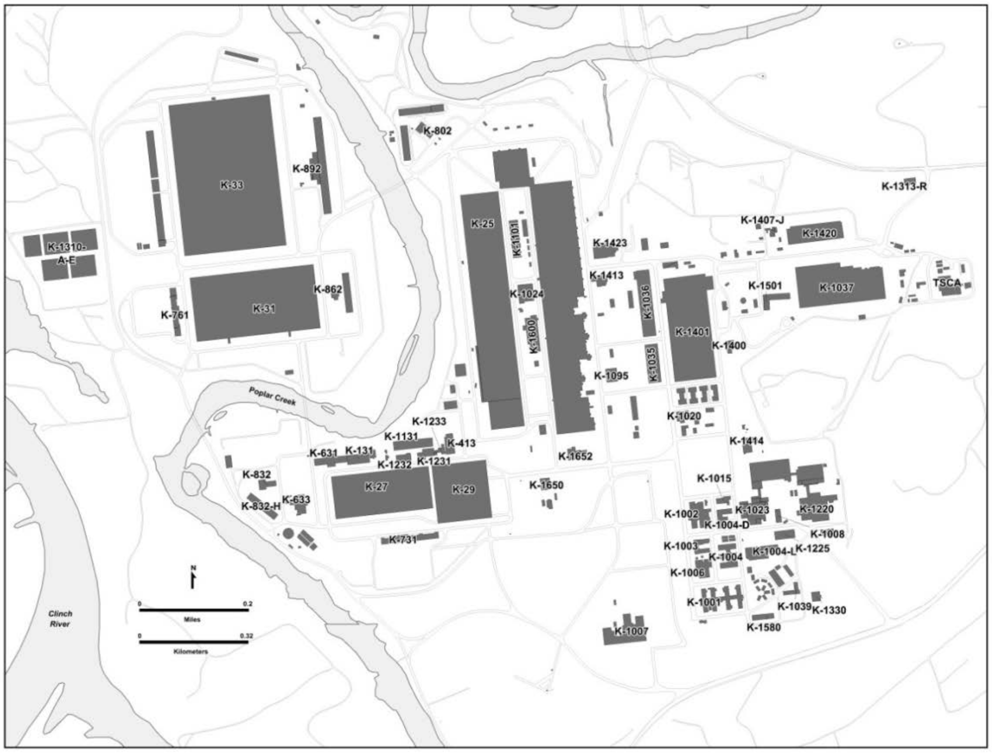


Fig. 3.2. East Tennessee Technology Park before the start of decontamination and decommissioning activities in 1991.

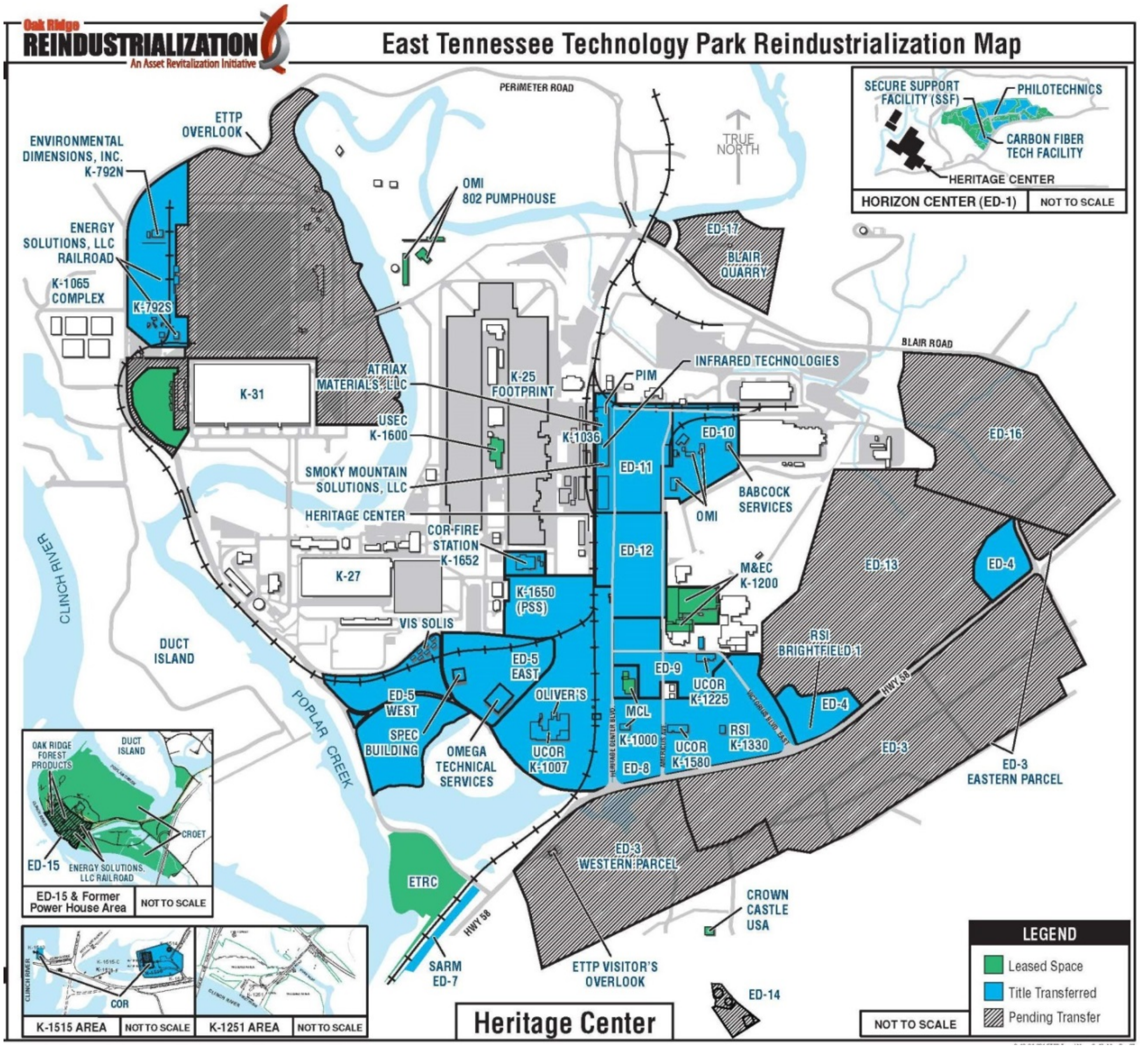


Fig. 3.3. East Tennessee Technology Park in 2015, showing progress in reindustrialization.

The ETTP mission is to reindustrialize and reuse site assets through leasing or transferring excess or underutilized land and facilities and through incorporating commercial industrial organizations as partners in the ongoing environmental restoration, D&D, and waste treatment and disposal.

The long-term goal of the US Department of Energy (DOE) for ETTP is to transfer as much of the site as practicable out of DOE ownership and control for the development of a private business and industrial park. The site is undergoing environmental cleanup of its land, as well as D&D of most of its buildings. The reuse of key facilities through title transfer is part of the site's closure plan. 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 entities such as the City of Oak Ridge. The facilities may then be subleased or sold, with the goal of stimulating private industry and recruiting business to the area. These transfers also reduce maintenance costs for DOE, which frees up additional money for environmental cleanup.

URS | CH2M Oak Ridge LLC (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. Unless otherwise noted, information on non-DOE entities located on the ETTP site is not provided in this document.

3.2 Environmental Management System

The UCOR Environmental Management System (EMS) is integrated with the UCOR Integrated Safety Management System (ISMS). UCOR's EMS is based on a graded approach for a closure and remediation contract and reflects the elements and framework contained in International Organization for Standardization (ISO) Standard 14001:2004 (ISO 2004), *Environmental management systems—Requirements with guidance for use*. UCOR is committed to incorporating sound environmental management, protection, and sustainability practices in all work processes and activities that are part of the DOE Environmental Management (EM) program in Oak Ridge, Tennessee. UCOR's environmental policy states in part, "Our commitment to protect and sustain human, natural, and cultural resources is inherent in our mission 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.

Management Commitment—Integrate responsible environmental practices into project operations.

Environmental Compliance and Protection (EC&P)—Comply with all environmental regulations and standards.

Sustainable 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.

Partnership/Stakeholder Involvement—Maintain partnerships through effective two-way communications with our customers and other stakeholders.

3.2.1 Environmental Stewardship Scorecard

The Environmental Stewardship Scorecard is used to track and measure site-level EMS performance. During 2015, UCOR received "green scores" for EMS performance. As an example, Fig. 3.4 presents information on UCOR's 2015 pollution prevention recycling activities related to solid waste reduction at ETTP. UCOR recycles office and mixed paper, cardboard, phone books, newspapers, magazines, aluminum cans, antifreeze, engine oils, batteries (lead acid, universal waste, and alkaline), universal waste bulbs, plastic bottles, all types of #1 and #2 plastics, and surplus electronic assets, such as computers (CPUs and laptops) and monitors (CRTs and LCDs). Other recycling opportunities include unique structural steel, stainless-steel structural members, transformers, and electrical breakers.

UCOR's exceptional electronics stewardship earned it an award in 2015 from the Green Electronics Council for its use of Electronic Product Environmental Assessment Tool (EPEAT) methods. UCOR also received a data driven award from participating in the US Environmental Protection Agency (EPA)'s Federal Green Challenge to reduce federal government impact on the environment and make operations more sustainable.

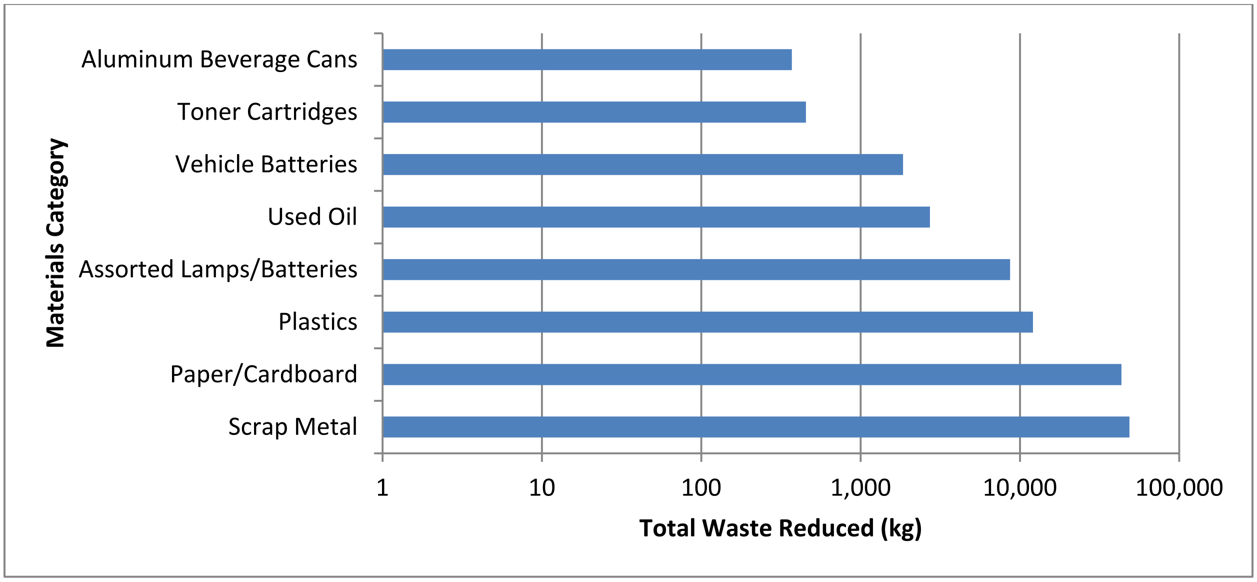


Fig. 3.4. Pollution prevention recycling activities related to solid waste reduction at East Tennessee Technology Park in CY 2015.

Additionally, UCOR internally recognized six projects for their pollution prevention/waste minimization (P2/WMin) accomplishments in 2015. This included the reuse of 1,100 yd^3 of concrete waste as fill material in the K-832 basin, the use of an enhanced waste cover and water conditioning at the Environmental Management Waste Management Facility (EMWMF), which avoided the treatment of thousands of gallons of water, and the construction and initiation of a second 1-megawatt (MW) solar farm on the west end of the park. All together, these and other projects saved in excess of $3 million and promoted sustainability goals by reducing waste, avoiding greenhouse gas production, and preserve valuable landfill space.

In the area of alternative energy, Restoration Services, Inc. (RSI), in concert with UCOR, continued operation of ETTP's first solar farm on the east end of the plant property. Brightfield 1 (Fig. 3.5), as it is known, is a 200-kW solar array located on a 0.405 ha (1-acre) tract purchased from CROET and built by RSI as part of UCOR's commitment to the revitalization of the former K-25 Site.

Fig. 3.5. Brightfield 1 Solar Farm.

RSI self-financed the project, using solar panels manufactured in Tennessee, and partnering with other local small businesses for the installation. Power generated from Brightfield 1 is being sold to the Tennessee Valley Authority (TVA) through the City of Oak Ridge Electric Department using a TVA Generation Partners contract. The completed project was commissioned in April 2012 and is part of RSI's Brownfields to Brightfields (B2B) initiative that works to develop restricted use properties into solar farms. Brightfield 1 energy production in its first year was 110% more than projected, with no downtime due to maintenance issues. In Calendar Year (CY) 2015, Brightfield 1 produced 231,140 kWh of energy.

As mentioned above, through the cooperative efforts of DOE, UCOR, RSI, Vis Solis, Inc., CROET, and the City of Oak Ridge, a second solar farm—the Powerhouse 6 Solar Farm—was constructed on the west end of the park. It is a 1-MW solar farm that became operational in April 2015 and provides renewable energy, long-term lease income to CROET and boosters development at ETTP. This project provides numerous benefits to the environment and the community at large, and includes the following:

- Generates enough clean energy to power more than 100 homes.
- Prevents pollution by removing the equivalent of 240 cars from the road annually (1,141 metric tons of carbon dioxide).
- Provides brownfield reuse/redevelopment at ETTP.
- Supports the City of Oak Ridge renewable energy goals.
- Supports the TVA renewable energy initiative.
- Offers community economic development jobs and property tax income to the City of Oak Ridge.
- Demonstrates benefits of ETTP reindustrialization.
- Supports DOE renewable energy goals.
- Demonstrates collaborative success between DOE and a public utility for renewable energy development.

UCOR also continued to use green products whenever possible and evaluated large quantity purchases for less toxic alternatives. In addition, UCOR maintained its extensive recycling program and benefitted the local community through donations of proceeds to local charities from its aluminum beverage can (ABC) recycling efforts.

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, management assessments conducted by functional or project organizations, and routine field walk downs conducted by a variety of functional and project personnel. Management and independent assessments are performed in accordance with *Management Assessment*, PROC-PQ-1420, and *Independent Assessment*, PROC-PQ-1401. Assessments are scheduled on the UCOR Quality Assurance System (QAS) in accordance with PROC-PQ-1420. Records are maintained for all formal assessments and audits. Issues identified in assessments are handled, as required, by ISO 14001:2004, Section 4.5.3, "Nonconformity, Corrective Action, and Preventive Action" (ISO 2004).

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 environment, safety, and health (ES&H) goals. UCOR works continuously to improve EMS to reduce impacts from 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 an enabling EMS into the daily conduct of business; fostering a spirit of cooperation with federal, state, and local regulatory agencies; and using appropriate waste management, treatment, storage, and disposal methods.

The environmental performance objectives are to achieve zero unpermitted discharges to the environment; comply with all conditions of environmental permits, laws, regulations, and DOE orders; integrate EMS and environmental considerations as part of ISMS; and, to the extent practicable, reduce waste generation, prevent pollution, maximize recycle and reuse potential, and encourage environmentally preferable procurement of materials with recycled and biobased content.

UCOR has established a set of core EMS objectives that remain relatively unchanged from year to year. These objectives are generally applicable to all operations and activities throughout UCOR’s work scope. The core environmental objectives are based on complying with applicable legal requirements and sustainable environmental practices contained in DOE O 436.1, *Departmental Sustainability* (DOE 2011a), and include the following:

- Comply with all environmental regulations, permits, and regulatory agreements.
- Reduce or eliminate the acquisition, use, storage, generation, and/or release of toxic, hazardous, and radioactive materials; waste; and greenhouse gas emissions through acquisition of environmentally preferable products, conduct of operations, waste shipment, and pollution prevention and waste minimization (P2/WMin) and sustainable practices.
- Reduce degradation and depletion of environmental resources through postconsumer material recycling; energy, fuel, and water conservation efforts; and use or promotion of renewable energy, and transfer for reuse valuable real estate assets.

3.2.5 Implementation and Operations

UCOR protects the safety and health of workers and the public by identifying, analyzing, and mitigating aspects, hazards, and impacts from ETTP operations, and by implementing sound work practices. All UCOR 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 management assessments also provide a measure of how well EMS attributes are integrated into work activities through ISMS. UCOR has embodied its program for EC&P of natural resources in a companywide EM and protection policy. The policy is UCOR’s fundamental commitment to incorporating sound EM practices into all work processes and activities.

3.2.6 Pollution Prevention/Waste Minimization (P2/WMin)

UCOR'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 possible. The reuse or recycling of building debris or other wastes generated is evaluated in all cases.

- The ETTP EMS program fosters pollution prevention at every level of its operations, from routine office recycling to more esoteric reuse and recycling at the project field level. UCOR's pollution prevention program is successful because it is tightly bound to its work control process. Thus many unique applications of material reuse and recycling have resulted, many of which have been captured through its internal P2 awards program. Some recent examples are: The reuse of 1,100 yd^3 of concrete waste as fill material in the K-832 basin and the reuse of rock from the K-31 berm in fill material for a total savings of $89,000.

- The innovative water conditioning at the EMWMF contact water ponds (CWPs) to chemically reduce hexavalent chromium to the less toxic trivalent chromium. The cost avoidance associated with water shipment and treatment was estimated at $3.2 million.

- The reuse of various UCOR properties through the Government Services Administration's property reuse program, which included 38 printers, 34 monitors, and 638 shoring jacks. This avoided disposal and saved valuable landfill space.

- The disposition of approximately $50,000 of unused office supplies through the ORNL's property sales. The UCOR Local Safety Improvement Team (LSIT) sponsored a cleanout of the K-1007 building, which was responsible for the success of this project.

- The reuse of 400 yd^3 of clean soil at the Nuclear High Hazard Operations (NHHO) Y-12 National Security Complex (Y-12), which resulted in a $20,000 savings. The NHHO Oak Ridge National Laboratory (ORNL) group also recycled 20 yd^3 of unused metal pipe, which resulted in a cost savings of $4,000, in addition to saving valuable landfill space.

- Through the cooperative efforts of DOE, UCOR, RSI, Vis Solis, Inc., CROET, and the City of Oak Ridge, a second solar farm was built and made operational in April 2015. It is a 1-MW solar farm that provides renewable energy, provides long-term lease income to CROET, and boosts development at ETTP.

Total savings of the winning projects were in excess of $3.3 million and in many cases, valuable landfill space and virgin materials were conserved. The internal awards will be evaluated for possible nomination for national levels awards (e.g., the DOE Headquarters Annual Award Program).

3.2.7 Competence, Training, and Awareness

The UCOR training and qualification process ensures that needed skills for the workforce are identified and developed. The process also documents knowledge, experience, abilities, and competencies of the workforce for key positions requiring qualification. This process is described in PROC-TC-0702, *Training Program*. 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, which includes a link to its environmental policy statement, POL-UCOR-007; a list of environmental aspects; and a link to the *Integrated Safety Management System Description*, PPD-EH-1400. A number of other documents and reports that address environmental aspects and cleanup progress are also published and made available to the public [e.g., ASER and the annual cleanup progress report (UCOR 2015a)]. UCOR participates 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, permit review public meetings, and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 decision document public meetings]. 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 Do-Act-Check, it provides a framework by which work incorporates environmental hazards into its work control and planning. This translates into many returns to the organization. UCOR uses EMS objectives and targets, an internal pollution prevention recognition program, environmentally preferable purchasing, work control processes, and a recycle program to meet sustainability and 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 2016, UCOR-4127/R4). In 2015, the UCOR EMS program underwent the independent program verification required triennially by EO 13423 (CEQ 2007, EO 13423), which resulted in zero findings, two observations, and four proficiencies.

3.2.10 Management Review

Senior management review of EMS is performed at several layers and frequencies. A formal review/presentation with UCOR senior management that addresses the requirement elements contained in this section is conducted at least once per year. At least two of the senior managers are present for management reviews. The ISMS description is updated annually to address improvements and lessons learned and to update objectives and targets as necessary and signed by the UCOR president and project manager. The environmental policy is also reviewed during the management review annually and revised as necessary.

3.3 Compliance Programs and Status

During 2015, ETTP operations were conducted in compliance with contractual and regulatory environmental requirements, and there were no National Pollutant Discharge Elimination System (NPDES) permits or Clean Air Act (CAA) noncompliances. Figure 3.6 shows the trend of NPDES compliance at ETTP since 1999. One environmental violation was issued at the ETTP during a routine inspection for a missing used oil drum label on a drum in the facility's garage. The condition was immediately corrected and documented in UCOR's QAS tracking system. The following sections provide more detail on each compliance program and the related activities in 2015.

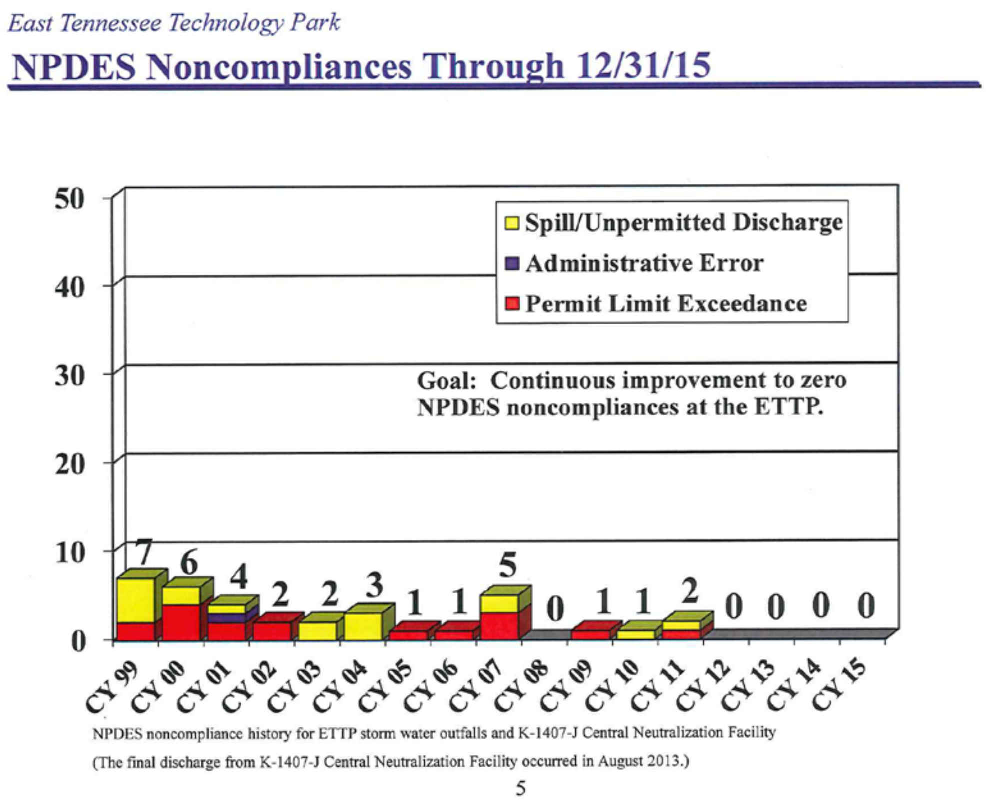


Fig. 3.6. East Tennessee Technology Park (ETTP) National Pollutant Discharge Elimination System (NPDES) permit compliance since 1999.

3.3.1 Environmental Permits

Table 3.1 contains a list of environmental permits that were in effect at ETTP in 2015.

3.3.2 Notices of Violation and Penalties

ETTP received one environmental violation in 2015. This violation occurred at ETTP during a routine inspection for a missing used oil drum label on a drum in the facility's garage. The condition was immediately corrected and documented in UCOR's QAS tracking system. There were no penalties assessed in 2015.

3.3.3 Audits and Oversight

Table 3.2 presents a summary of environmental audits and oversight visits conducted at ETTP in 2015.

Table 3.1. East Tennessee Technology Park Environmental Permits, 2015

Regulatory driver	Permit title/description	Permit number	Issue date	Expiration date	Owner	Operator	Responsible contractor
CAA	State permit to operate an air contaminant source—internal combustion engine–powered emergency generators and fire water pump	069346P	03-03-2015 Amended 04-21-2015	10-01-2024	DOE[a]	UCOR	UCOR
CWA	NPDES permit for storm water discharges	TN0002950	2-01-15	3-31-20	DOE	UCOR	UCOR
CWA	State operating permit—waste transportation project; Blair Road and Portal 6 sewage pump and haul permit	SOP-05068	07-01-14	02-28-19	DOE	TFE	TFE
CWA	State operating permit—ETTP holding tank/haul system for domestic wastewater	SOP-99033	07-01-15	06-30-20	UCOR	UCOR	UCOR
UST	Authorized/certified USTs at K-1414 Garage	Customer ID 30166 Facility ID 073008	03-20-89	Ongoing	DOE	UCOR	UCOR
RCRA	ETTP container storage and treatment units	TNHW-165	09-15-15	09-15-25	DOE	UCOR	UCOR
RCRA	Hazardous waste corrective action document (encompasses entire ORR)	TNHW-164	09-15-15	09-15-25	DOE	DOE/All[a]	DOE/All[a]

[a]DOE and all ORR are co-operators of hazardous waste permits.

Acronyms

CAA = Clean Air Act
CWA = Clean Water Act
DOE = US Department of Energy
ETTP = East Tennessee Technology Park
ID = identification (number)
NPDES = National Pollutant Discharge Elimination System
ORR = Oak Ridge Reservation
RCRA = Resource Conservation and Recovery Act
SOP = state operating permit
TFE = Technical and Field Engineering, Inc.
UCOR = URS | CH2M Oak Ridge LLC
UST = underground storage tank

Table 3.2. Regulatory oversight, assessments, inspections, and site visits at East Tennessee Technology Park, 2015

Date	Reviewer	Subject	Issues
March 9	TDEC	Annual RCRA Compliance Inspection	1
June 2	TDEC	RCRA TNHW-117 Permit Renewal	0
June 24	TDEC	D&D Waste Shipment Audit	0
June 15	TDEC	TDEC NPDES Permit Writer	0
September 24 and 28	TDEC	NPDES Compliance Evaluation Inspection	0
October 21, 2015	TDEC	Asbestos NESHAP Compliance Inspection	0

Acronyms
NPDES=National Pollutant Discharge Elimination System
RCRA = Resource Conservation and Recovery Act
TDEC = Tennessee Department of Environment & Conservation
NESHAP =National Emission Standards for Hazardous Air Pollutants

3.3.4 National Environmental Policy Act/National Historic Preservation 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. Many of the current operations at ETTP are conducted under CERCLA. NEPA reviews are part of the CERCLA planning process to ensure that NEPA values are incorporated into CERCLA projects and documentation.

During 2015, ETTP continued to operate under site-level, site-specific procedures that provide requirements for project reviews and NEPA compliance. These 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 Oak Ridge Office (ORO) has approved generic categorical exclusion (CX) determinations that cover certain proposed activities (i.e., maintenance activities, facilities upgrades, personnel safety enhancements). A CX 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. UCOR activities on ORR are in full compliance with NEPA requirements, and procedures for implementing NEPA requirements have been fully developed and implemented. At ETTP, a checklist incorporating NEPA and EMS requirements has been developed as an aid for project planners. For routine, recurring activities, DOE generic CX determinations are used. During 2015, no new CX determinations for activities at ETTP were issued by DOE.

Compliance with the National Historic Preservation Act (NHPA) at ETTP is achieved and maintained in conjunction with NEPA compliance. The scope of proposed actions is reviewed in accordance with the ORR cultural resource management plan (Souza et al. 2001). At ETTP, there were 135 facilities eligible for inclusion on the National Register of Historic Places (NRHP), a National Park Service program to identify, evaluate, and protect historic and archeological resources in the US, as well as numerous facilities that were not eligible for inclusion on the NRHP. To date, more than 800 facilities have been demolished. Artifacts of historical and/or cultural significance are identified before demolition and are catalogued in a database to aid in the historic interpretation of ETTP.

Consultation for the development of a Memorandum of Agreement (MOA) for D&D of the K-25 and K-27 buildings started in 2001; the document, approved in 2003, required a third-party analysis of the preservation and interpretive strategies for those two buildings. In 2005, DOE, the Tennessee State Historic Preservation Office (SHPO), and the Advisory Council on Historic Preservation (ACHP) entered into an MOA that included the retention of the north end tower (also known as north wing and north end) of the K-25 building and Portal 4 (K-1028-45), among other features, as the "best and most cost-effective mitigation to permanently commemorate, interpret, and preserve the significance" of ETTP. Another series of consultation meetings ensued in 2009 and DOE advised that prohibitive costs and safety considerations precluded fulfillment of three stipulations in the 2005 MOA, including the preservation of the north end tower. The parties offered a wide array of potential mitigation measures and, in the absence of consensus on how best to commemorate Building K-25, DOE, SHPO, and ACHP entered into a bridge MOA until the parties could reach a final agreement. After completing an evaluation of the structural integrity of the K-25 building and interpretative approaches for the site, DOE distributed a preferred mitigation plan to the consulting parties in October 2011. The DOE final mitigation plan, which addressed comments submitted by consulting parties in November 2011, permitted demolition of the entire K-25 building and called for, among other mitigation measures, the designation of a commemorative area around the building's perimeter from which future surface development would largely be restricted; the retention, if possible, of the entire concrete slab or the demarcation of the building's footprint; the construction of a viewing tower and structure for equipment display; and the development of a history center within the ETTP Fire Station. A final MOA was signed in August 2012, finalizing the aspects set forth in the mitigation plan. During 2013, a request for proposal was issued for a "Professional Design Team and Museum Professional," as specified in the MOA. Nine firms were prequalified, and the selection and awards were executed April 1, 2014. The procurement process for the K-25 "virtual museum" web design firm was also begun in 2013 and awarded September 2, 2014.

On December 14, 2014, Congress authorized the establishment of the Manhattan Project Historical Park to commemorate the history of the Manhattan Project. It will comprise the three major sites: Los Alamos, New Mexico; Oak Ridge, Tennessee; and Hanford, Washington, which were dedicated to accomplishing the Manhattan Project mission.

The Final Conceptual Design Report, Final Conceptual Site Exhibit Plan, and the Final Conceptual Design Museum Plan were completed and provided to the Consulting Parties in January 2015. The Consulting Parties reviewed the report and plans and provided comments.

An MOA was signed by the US Department of Interior and DOE on November 10, 2015 (DOE 2015d), creating the new Manhattan Project Historic National Park. The K-25 Virtual Museum website (K-25 Virtual Museum 2015) was launched in conjunction with the signing of the MOA.

3.3.5 Clean Air Act Compliance Status

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 (SIPs), New Source Performance Standards (NSPSs), Prevention of Significant Deterioration permitting programs, and National Emission Standards for Hazardous Air Pollutants (NESHAPs). 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 and permit conditions was demonstrated in 2015. The ETTP ambient air monitoring program permitted source operations tracking and record keeping provided documentation fully supporting a 100% compliance rate.

3.3.6 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 CWA was EPA establishment of limits on specific pollutants allowed to be discharged in US waters by municipal sewage treatment plants (STPs) 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 2015, ETTP discharged to the waters of the state of Tennessee under the individual NPDES permit TN0002950, which regulates storm water discharges.

3.3.7 National Pollutant Discharge Elimination System Permit Noncompliances

In 2015, compliance with ETTP NPDES storm water permit TN0002950 was determined by more than 150 laboratory analyses, field measurements, and flow estimates. The NPDES permit compliance rate for all discharge points for 2015 was 100%.

3.3.8 Safe Drinking Water Act Compliance Status

Since October 1, 2014, all water at the ETTP site is supplied by the City of Oak Ridge drinking water plant, located north of the DOE Y-12 Complex in Oak Ridge, Tennessee.

3.3.9 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. This amount includes hazardous waste generated under permitted activities (including repackaging or treatment residuals). At the end of 2015, ETTP had three generator accumulation areas for hazardous or mixed waste.

In addition, ETTP is permitted to store and treat hazardous and mixed waste under Resource Conservation and Recovery Act (RCRA) Part B Permit TNHW-165. Hazardous waste may be treated and stored at permitted locations in Building K-1423 and at the K-1065 complex. This hazardous waste permit was reissued on September 15, 2015, as a replacement for TNHW-117. The hazardous waste corrective action document, TNHW-164, which covers the ORR CERCLA areas of concern and solid waste management units was also reissued on September 15, 2015, as a replacement for TNHW-121.

There was one RCRA generator or permit noncompliance in 2015. During the annual TDEC RCRA inspection, a used oil drum was observed at the K-1414 garage without the required "used oil" label. The label was immediately placed on the drum.

ETTP prepared and submitted to the TDEC Division of Solid Waste Management the 2015 annual report of hazardous waste activities. This report identifies the type and amount of hazardous waste that was generated, shipped off-site, or is currently in storage.

3.3.10 Resource Conservation and Recovery Act Underground Storage Tanks

Underground storage tanks (USTs) containing petroleum and hazardous substances are regulated under RCRA Subtitle I (40 CFR Part 280). EPA granted TDEC authority to regulate USTs containing petroleum under TDEC Rule 0400-18-01, *Underground Storage Tank Program*; however, EPA still regulates hazardous substance USTs. During 2015, operations of USTs at ETTP were in complete regulatory compliance.

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

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

3.3.12 East Tennessee Technology Park RCRA-CERCLA Coordination

The *Federal Facility Agreement for the Oak Ridge Reservation* (FFA, DOE 2015a, DOE/OR-1014) is intended to coordinate the corrective action processes of RCRA required under the Hazardous and Solid Waste Amendments permit with CERCLA response actions.

3.3.13 Toxic Substances Control Act Compliance Status—Polychlorinated Biphenyls

On April 3, 1990, DOE notified EPA headquarters (as required by 40 CFR Part 761.205) that ETTP is a generator with on-site storage, a transporter, and an approved disposer of polychlorinated biphenyl (PCB) wastes.

PCB waste generation, transportation, disposal, and storage at ETTP is regulated under EPA ID number TN0890090004. In 2015, ETTP operated eight PCB waste storage areas in ETTP generator buildings, and when longer term storage of PCB/radioactive wastes were necessary, RCRA-permitted storage buildings were used. ETTP operated one long-term PCB waste storage area at ETTP where non-radioactive PCB waste was stored in a facility that was not a RCRA-permitted storage facility. The continued use of authorized polychlorinated biphenyl (PCBs) in electrical systems and/or equipment (e.g., transformers, capacitors, rectifiers) is regulated at ETTP. At this time, no PCB-contaminated electrical equipment is in service at ETTP. Most Toxic Substances Control Act (TSCA)-regulated equipment at ETTP has been disposed of. However, some ETTP facilities continue to use or store nonelectrical PCB-contaminated equipment for future reuse.

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, DOE ORO and EPA Region 4 consummated a major compliance agreement known as the *Oak Ridge Reservation Polychlorinated Biphenyl Federal Facilities Compliance Agreement* (DOE 2012, ORR-PCB-FFCA), which became effective December 16, 1996, and was last revised on May 23, 2012. The modification in 2012 incorporated institutional controls at the TSCA Incinerator where limited areas of contamination remain in place at the facility after the facility closure actions were completed. The institutional controls will remain in place until future PCB cleanup actions, which will be addressed during CERCLA demolition actions.

The 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 tile, 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) each year per 40 CFR 761.180(a). 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.

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

The Emergency Planning and Community Right-to-Know Act (EPCRA) that is also identified as Title III of SARA require that facilities report inventories that exceed threshold planning quantities and releases of hazardous and toxic chemicals. The reports are submitted to the local emergency planning committee, and the state emergency response commission, and the local fire department. ETTP complied with these requirements in 2015 through the submittal of required reports as applicable under EPCRA Sections 302, 311, 312, and 313. ETTP had no reportable releases of hazardous substances or extremely hazardous substances, as defined by CERCLA and EPCRA, in 2015.

3.3.14.1 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 2015, 12 were located at ETTP. These chemicals were nickel metal, lead metal (including large lead acid batteries), sodium metal, diesel fuel, sulfuric acid (including large lead acid batteries), Chemical Specialties Ultrapoles, creosote-treated wood, unleaded gasoline, Sakrete Type S or N mortar mix, CCA Type C pressure-treated wood, Flexterra F6M Erosion Control Agent, and sodium chloride.

3.3.14.2 Toxic Chemical Release Reporting (EPCRA Section 313)

Section 313 requires facilities to complete and submit a toxic chemical 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. A Form R for each chemical must be submitted by July 1 of each year. DOE electronically submits annual TRI reports to EPA on or before July 1 of each year. The reports address releases of certain toxic chemicals to air, water, land, and waste management, recycling, and pollution prevention 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 2015, the only chemicals that met the reporting requirements were diisocyanates associated with foaming activity to stabilize deposits in pipes undergoing remediation actions.

3.4 Quality Assurance Program

3.4.1 Integrated Assessment and Oversight Program

Quality assurance (QA) program implementation and procedural and subcontract compliance are verified through the UCOR integrated assessment and oversight 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: (1) external assessments conducted by organizations external to UCOR, (2) independent assessments conducted by teams independently of the project/function being assessed, and (3) management assessments and surveillances conducted as self-assessments and surveillances by the organization or on behalf of the organization manager.

Self-assessments are performed by the organization/function with primary responsibility for the work, process, or system being assessed. Organizations and functions within the company plan and schedule self-assessments. Self-assessments encompass both formal and informal assessments. The formal self-assessments include management assessments and surveillances and subcontractor oversight. Informal self-assessments include weekly inspections and routine walkthroughs conducted by subcontractor coordinators, ES&H and QA representatives, quality engineers, and line managers.

Conditions adverse to quality identified from internal and external assessments are documented, causal analyses are performed, and corrective actions are developed and tracked to closure. Analyses are conducted periodically to identify trends for management action. Senior management evaluates data from those processes to identify opportunities for improvement.

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 2015, ETTP DOE EM operations were under UCOR responsibility for regulatory compliance.

3.5.1 Construction and Operating Permits

UCOR ETTP operations are subject to amended CAA regulations and permitting under TDEC Air Pollution Control rules that are specific to stationary fossil-fueled reciprocating internal combustion engines (RICE) for emergency use. UCOR initially had responsibility for five RICE units subject to permitting and therefore prepared and submitted permit applications. TDEC issued a Permit to Construct or Modify (967220P) with an effective date of August 22, 2013. The permit covered compliance demonstration requirements for four emergency generators and one fire water booster pump system. Due to installation issues associated with a new unit, a request to extend the expiration date of the permit was requested and granted by TDEC on June 26, 2014. Prior to the expiration date of the amended permit a second fire water booster pump system was to be transitioned from another contractor to UCOR. That contractor had not obtained the required permit for this unit. To assure full compliance by UCOR, a request for an operating permit was prepared and submitted to TDEC prior to the transition of this unit. The operating permit request included the addition of this fire water booster pump system. TDEC issued an operating permit (069346P) covering six RICE units on March 3, 2015. The current permit covers the six units through October 1, 2024.

Compliance for all units is demonstrated by following specified maintenance schedules, limiting hours of operations for nonemergencies to 100 h per year, and record keeping. Regulations exempt any operating hours of these units during nonscheduled (emergency) power outages. 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.

3.5.1.1.1 Control of Asbestos

ETTP's asbestos management program ensures all activities involving demolition and all other actions impacting asbestos-containing materials (ACMs) are fully compliant with 40 CFR Part 61, Subpart M. This includes using approved engineering controls and work practices, inspections, and monitoring for proper removal and waste disposal of ACMs. ETTP has numerous buildings and equipment that contain ACMs. Major demolition activities during 2015 involved the abatement of significant quantities of ACMs that were subject to the requirements of 40 CFR Part 61, Subpart M. Most demolition and ACM abatement activities are governed under CERCLA. Under this act, notifications of asbestos demolition or renovations, as specified in 40 CFR Part 61.145(b), are incorporated into CERCLA document regulatory notifications. All other non-CERCLA planned demolition or renovation activities were individually reviewed for applicability of the TDEC notification requirements of the rule. During 2015, no individual non-CERCLA ETTP activity required a notification submittal. 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 2015, 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 ACMs occurred at ETTP during 2015.

3.5.1.1.2 Stratospheric Ozone Protection

The management of ODSs at ETTP is subject to regulations in 40 CFR Part 82, Subpart F, Recycling and Emissions Reduction; 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, including motor vehicle air conditioners. In addition, the regulations apply to refrigerant reclamation activities, appliance owners, manufacturers of appliances, and recycling and recovery equipment. Figure 3.7 illustrates the historical on-site ODS inventory at ETTP.

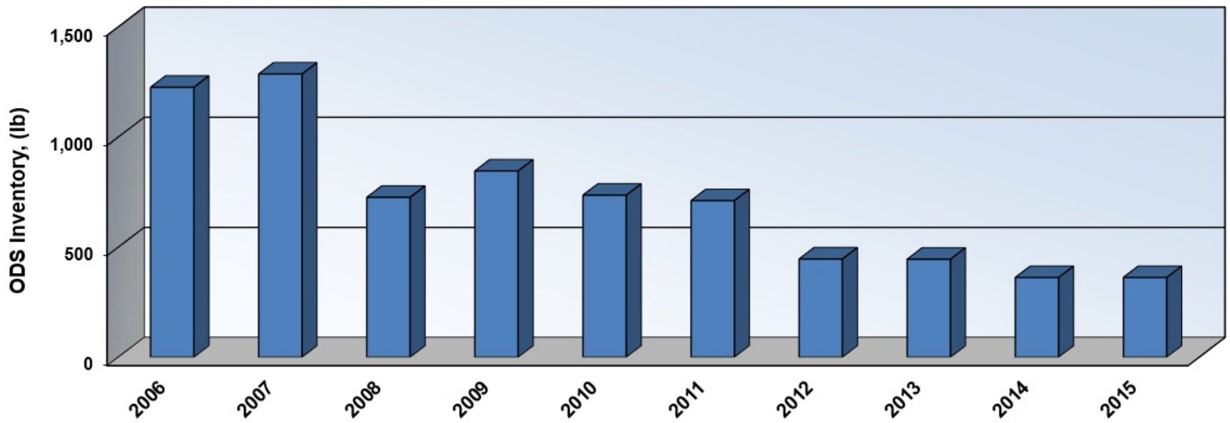


Fig. 3.7. East Tennessee Technology Park total on-site ozone-depleting substances inventory, 10-year history.

3.5.1.2 Fugitive Particulate Emissions

ETTP has been the location of major building demolition 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, 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 (Rad-NESHAPs). 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 (CAP-88) computer codes, which were developed under EPA sponsorship for use in demonstrating compliance with the 10 mrem/year effective dose (ED) Rad-NESHAP emission standard for the entire DOE 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 not less than 0.1 mrem per year to any member of the public. ETTP Rad-NESHAP sources—the K-1200 Building South Bay, the K-1407 Chromium Water Treatment System (CWTS) Volatile Organic Compound (VOC) Air Stripper, and K-2500-H Segmentation Shops A, B, C, and D—are 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. Figure 3.8 provides a historical dose trend for the most impacted on-site member of the public. The increased dose impact during the fourth quarter of 2013 was coincidental to nearby major demolition activities. Over 80% of the dose during that period was due to ^{99}Tc (^{99}technetium). The isotopes (atoms of an element having the same number of protons in their nuclei but differing in the number of neutrons) of uranium dose contributions during this same period were consistent with historical variations. The results are based on actual ambient air sampling in a location conservatively representative of the on-site location.

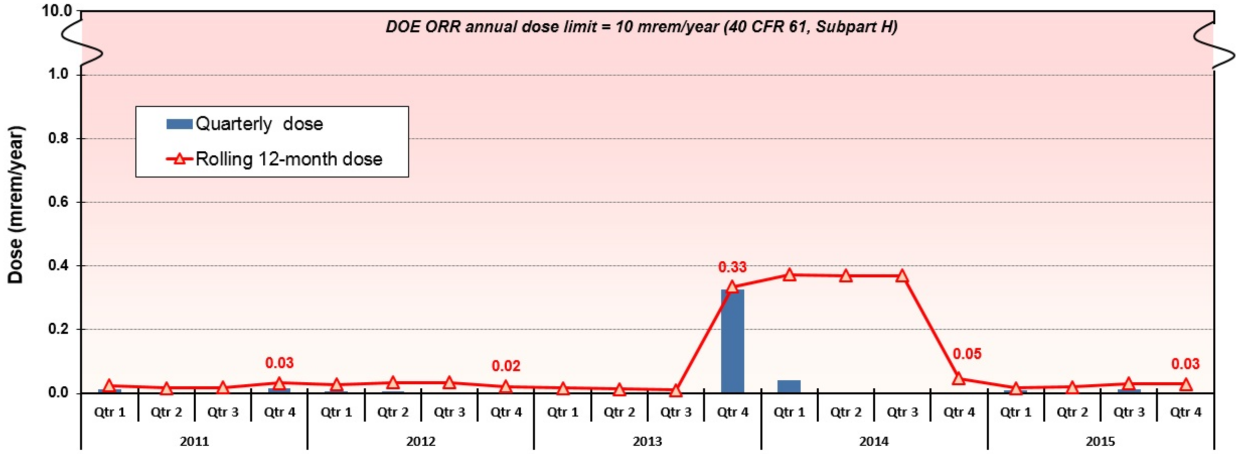


Fig. 3.8. East Tennessee Technology Park ambient air station K11 radionuclide monitoring results: 5-year rolling 12-month dose history up through 2015.
(DOE = US Department of Energy and ORR = Oak Ridge Reservation)

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 2015b, UCOR-4257). The plan satisfies the QA requirements in 40 CFR Part 61, Method 114, 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*. 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 2005a).

3.5.1.5 Greenhouse Gas Emissions

The EPA rule for mandatory reporting of Greenhouse Gases (GHGs) (also referred to as the “Greenhouse Gas Reporting Program”) was enacted October 30, 2009, under 40 CFR Part 98. According to the rule in general, the stationary source emissions threshold for reporting is 25,000 metric tons or more of GHGs per year, reported as metric tons of CO_2 equivalent (CO_2e) per year. The rule defines GHGs as:

- carbon dioxide (CO_2),
- methane (CH_4),
- nitrous oxide (N_2O),
- hydrofluorocarbons,
- perfluorocarbons, and
- sulfur hexafluoride (SF_6).

A 2015 review was performed of ETTP processes and equipment categorically identified under 40 CFR Part 98.2, whose emissions must be included as part of a facility annual GHG report starting with the CY 2010 reporting period. Based on total GHG emissions from all ETTP stationary sources during 2015, 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 metric tons 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 small comfort heating systems, hot water systems, and power generators. Figure 3.9 shows the 5-year trend up through 2015 of ETTP total GHG stationary emissions. For the 2015 CY period, GHG emissions totaled only 118 metric tons.

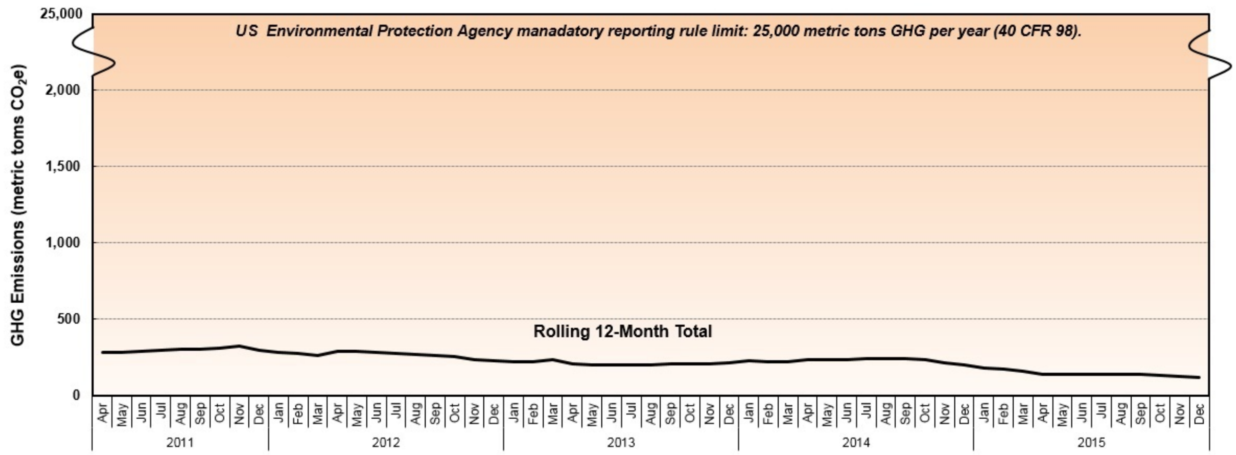


Fig. 3.9. East Tennessee Technology Park stationary source greenhouse gas (GHG) emissions tracking history *[in carbon dioxide equivalent (CO_2e)].*

Executive Order (EO) 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*, was signed by President Barak Obama on October 5, 2009. The purpose of this order was to establish policies for federal facilities that will increase energy efficiency; measure, report, and reduce GHG emissions from direct and indirect activities; conserve and protect water resources through efficiency, reuse, and storm water management; eliminate waste; recycle; and prevent pollution at all such facilities. While the order deals with a number of environmental media, only its applicability to GHG is considered here. The EO defines three distinct scopes for purposes of reporting. Scope 1 is essentially direct GHG emissions from sources that are owned or controlled by a federal agency; Scope 2 encompasses GHG emissions resulting from the generation of electricity, heat, or steam purchased by a federal agency; and Scope 3 involves GHG emissions from sources not owned or directly controlled by a federal agency, but related to agency activities, such as vendor supply chains, delivery services, and employee business travel and commuting. One goal of this order was to establish a FY 2020 Scope 1 and Scope 2 reduction target of 28%, as compared to the 2008 baseline year.

EO 13693, *Planning for Federal Sustainability in the Next Decade*, was signed and issued on March 25, 2015. This order supersedes EO 13514 and established a new Scope 1 and Scope 2 total reduction target of 40% by 2025, as compared to the 2008 baseline year. For reporting purposes, GHG emission data are compared to both goals.

The information reported here includes GHG emissions from the industrial landfills at Y-12 that are managed by UCOR. The landfills are not part of the contiguous ETTP site; however, DOE requested that UCOR 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. Figure 3.10 shows the trend toward meeting both the 28% total Scope 1 and 2 GHG emissions reduction target by FY 2020 and the 40% goal by FY 2025.

With respect to EO 13514, emissions for FY 2015 totaled 20,821 metric tons CO_2e, roughly 44% below the FY 2020 target level of 37,478 metric tons CO_2e and a 60% reduction to date compared to the 2008 baseline year level of 52,053 metric tons. When compared to the EO 13693 target, FY 2015 data show that the targeted 40% reduction has already been achieved by comparing the FY 2015 total of 20,821 metric tons to the 40% target level of 31,232 metric tons.

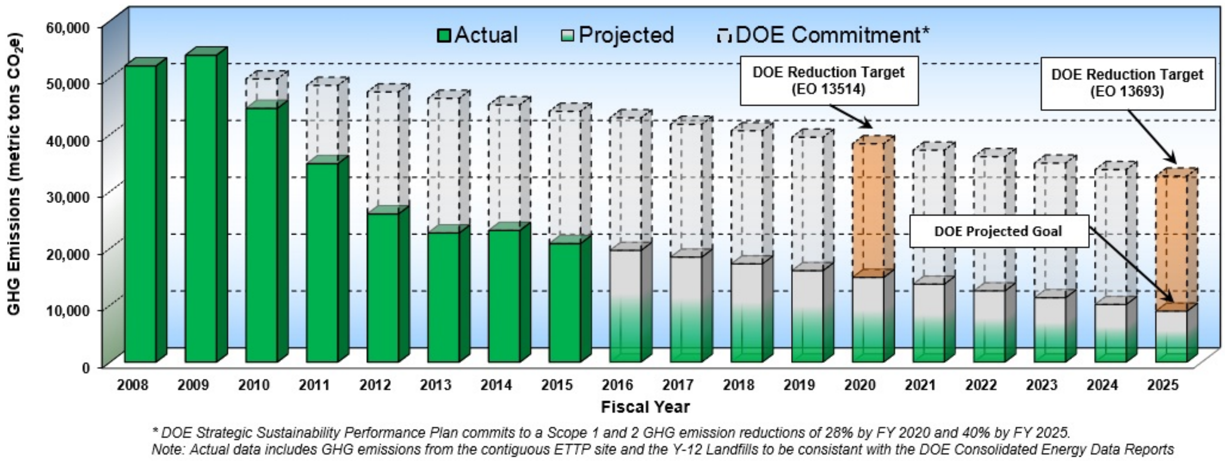
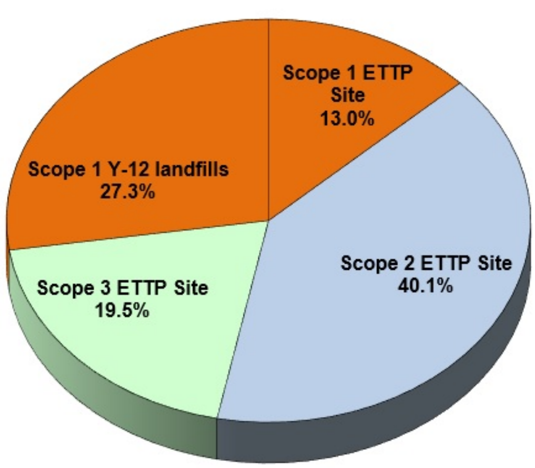


Fig. 3.10. East Tennessee Technology Park (ETTP) greenhouse gas (GHG) emissions trend and targeted reduction commitment *[in metric tons carbon dioxide equivalent (CO_2e)].*

Figure 3.11 shows the relative distribution and amounts of all ETTP FY 2015 GHG emissions for Scopes 1, 2, and 3. 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 total amount of GHG emissions for FY 2015 was 25,867 tons, as compared to the 30,662 tons for FY 2014.



ETTP CY 2015 Greenhouse Gas Emissions: 25,867 tons

Scope 1: ETTP Site Releases
Onsite stationary fossil fuel combustion, 137 tons
Onsite releases of freons and SF6, 106 tons
Onsite mobile source fuel combustion, 3,130 tons

Scope 1: Y-12 Industrial Landfills
Y-12 Industrial Landfills, 7,073 tons

Scope 2: Indirect GHG Releases
Electricity purchase, 10,375 tons

Scope 3: Indirect GHG Releases
Business alr travel, 52 tons
Business ground travel, 58 tons
Employee commuting, 4,928 tons
Contracted wastewater treatment, 8 tons

Fig. 3.11. CY 2015 East Tennessee Technology Park (ETTP) greenhouse gas (GHG) emissions by scope, as defined in Executive Order 13514.
(Y-12 = Y-12 National Security Complex ***and*** *SF6 = sulfur hexafluoride)*

3.5.1.6 Source-Specific Criteria Pollutants

Until July 1, 2011, ETTP operations included only one functioning stationary source with permit restrictions for any form of criteria air pollutant emissions: the Central Neutralization Facility (CNF) VOC air stripper. This permit was surrendered following an updated potential to emit review that identified air pollutant emissions to be below any regulatory requirement for permitting. During December 2011, the new CWTS began operations. This unit is equipped with an air stripper to remove VOCs from the effluent stream. All process data records and the calculated potential maximum VOC emission rates for the CWTS air stripper were below levels that would require permitting. The calculated VOC annual emissions during 2015 for CWTS was only 0.012 ton/year as compared to an emission limit of 5 ton/year. The annual potential emissions for this facility would be well below the 5 ton/year limit, assuming it operated at the maximum hourly emission rate continuously for the entire year.

Federal regulations amended in January 2013 require permitting for existing and new stationary emergency generators powered by RICEs (i.e., emergency or e-RICEs). These amendments apply only to non-CERCLA e-RICEs. TDEC originally issued an amended construction permit for six on-site units. Four of the units are emergency generator engines (K-1007, K-1039, K-1095, and K-1652) and the remaining two units are the fire water booster pump engines (K-802 and K-1310-RW). The effective date of the permit was August 22, 2013, with a new expiration date of August 23, 2015. An application for an operating permit was prepared and submitted to TDEC dated September 26, 2014. TDEC issued an operating permit for the six e-RICE units with an effective date of March 3, 2015. The operating permit supersedes the construction permit with an expiration date of October 1, 2024.

Regulations limit e-RICE nonemergency and maintenance operations to 100 h of operations per 12-month rolling total (i.e., 100 h of running the engines for testing and maintenance purposes per year). Additionally, nonemergency operations are limited to 50 h of the 100 h annual limit. The current permit specifies conditions that must be met to demonstrate compliance. These requirements include performing scheduled maintenance, record keeping, and tracking the runtimes of each of the five permitted units. Copies of all maintenance activities are provided for permit compliance review, and the runtimes are entered into spreadsheets to track against annual limits. Table 3.3 provides the number of hours of operations for each unit, up through December 31, 2015.

Table 3.3. East Tennessee Technology Park UCOR emergency reciprocating internal combustion engine air permit compliance demonstration, 2015

e-RICE Unit	Permit limits: Total hours/year = 100 Nonemergency hours/year = 50			
	PM Testing (hours/year)	**Nonemergency (hours/year)**	**Total (hours/year)**	**Emergency (hours/year)**
K-802	21.4	36.3	57.7	0
K-1007	6.1	23.0	29.1	0.5
K-1039	5.4	4.4	9.8	0.0
K-1095	6.0	0.5	6.5	0.0
K-1310-RW	0.0	0.0	0.0	0.0
K-1407[a]	5.9	0.2	6.1	3.8
K-1652	6.0	0.4	6.4	0.0

[a]K-1407 e-RICE operating under CERCLA and exempt from TDEC air emission permitting.

Acronyms

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
e-RICE = emergency reciprocating internal combustion engine
PM = particulate matter
TDEC = Tennessee Department of Environment and Conservation
UCOR = URS | CH2M Oak Ridge LLC

ETTP operations released airborne pollutants from a variety of minor pollutant-emitting sources, such as stacks, 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. To ensure compliance, periodic inventory reviews of ETTP operations were performed that used monthly data obtained through the ECPRA 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 ECPRA 311 monthly HMIS chemical inventories at ETTP with the risk management plan (RMP) threshold quantities listed in 40 CFR Part 68.130 was conducted. This is an ongoing action that documents the potential applicability for maintaining and distributing an RMP and to ensure 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, Sect. 112(r), “Prevention of Accidental Releases.” The results of this review indicated that all RMP-listed chemicals were less than 1% of their specific trigger thresholds. Therefore, activities at ETTP are not subject to the rule. Procedures are in place 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 of long-term trends of airborne concentration levels of selected air contaminant species.
- Measurement of the highest concentrations of the selected air contaminant species that occur in the vicinity of ETTP operations.
- Evaluation of the potential impact of air contaminant emissions from ETTP operations on ambient air quality.

The sampling stations in the ETTP area are designated as base, supplemental, or ORR perimeter air monitoring (PAM) stations. Figure 3.12 shows the locations of all ambient air sampling stations in and around ETTP that were active during the 2015 reporting period. Figure 3.13 shows an example of a typical ETTP air monitoring station.

The base program consists of two locations using high-volume, ambient air samplers. Supplemental locations are typically temporary, project-specific stations that use sampler’s specific to a particular type of potential emissions. Historically, the project-specific samplers are the same high-volume systems used for the base program. All base, supplemental, and PAM samplers operate continuously with exposed filters collected weekly. The radiological monitoring results for samples collected at the two ETTP area PAM stations were provided by UT-Battelle staff and are included in the ETTP network for comparative purposes.

The analytical parameters were chosen with regard to existing and proposed regulations and with respect to activities at ETTP. Supplemental station K11 has originally deployed to demonstrate that radiological emissions from K-25 building demolition and remediation activities are in compliance with DOE dose limits to on-site members of the public. All K-25 demolition and debris removal was completed by the end of March 2014. The demolition and debris removal of the K-31 building began during October 2014 and was completed during August 2015. K11 remained a key sampling location regarding the potential

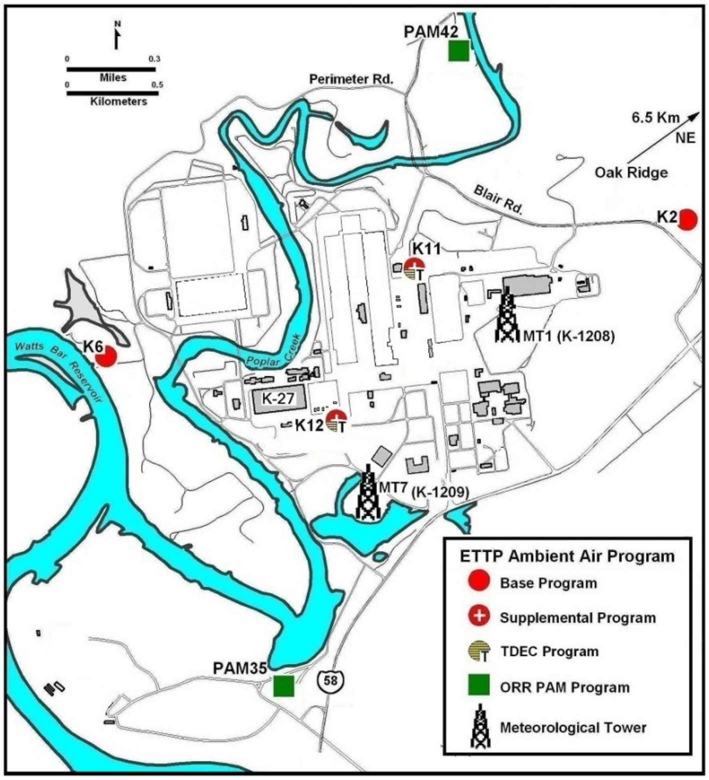


Fig. 3.12. East Tennessee Technology Park ambient air monitoring station locations.
(ETTP = East Tennessee Technology Park, MT = meteorological tower, ORR = Oak Ridge Reservation, PAM = perimeter air monitoring, TDEC = Tennessee Department of Environment & Conservation, and TSCAI = Toxic Substances Control Act Incinerator)

dose impact on the maximally exposed individual (MEI) that is a member of the public during the K-31 project. In preparation for the demolition of the K-27 building, a potential fugitive radionuclide emissions release was modeled to evaluate the dose impact on members of the public. This evaluation indicated that the MEI was in a direction and distance that was not within the current coverage by the ambient air program. To assure obtaining an applicable measurement of the dose impact on the MEI, a new supplemental sampling location (K12) was established. Station K12 began operating during October 2015 and K-27 demolition was started as planned in early 2016. The sampling results prior to the demolition will establish a baseline for tracking any measurable contribution during this project.

Changes of emissions from ETTP will warrant periodic re-evaluation 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 emissions controls, a survey of all on-site tenants is reviewed every six months through a request for the most recent ETTP reindustrialization map.

Fig. 3.13. East Tennessee Technology Park ambient air monitoring station.

All base and supplemental stations collected continuous samples for radiological and selected metals analyses during 2015. Inorganic analytical techniques were used to test samples for chromium and lead. Radiological analyses of samples from the ETTP stations test for the isotopes ^{99}Tc, ^{234}uranium (^{234}U), ^{235}U, and ^{238}U; ORR station sampling results for ^{234}U, ^{235}U, and ^{238}U provided by UT-Battelle are included with the ETTP results.

Figures 3.14 and 3.15 illustrate the ambient air concentrations of chromium and lead for the past five years, based on quarterly composites of weekly continuous samples. All samples were analyzed by the inductively coupled plasma-mass spectrometer (ICP-MS) analytical technique. The results are compared with applicable air quality standards for each pollutant. The annualized levels of chromium and lead during 2015 were well below the indicated annual standards. Stations K6 and K11 are in the prevailing topography influenced directions to the major demolition and remediation activities on the site and generally showed slightly higher annual chromium and lead ambient air concentrations during 2015, as compared to the other sampling locations. Following the completion of the K-31 project, the downward trend for chromium during the fourth quarter of 2015 is approaching typical background levels for this pollutant. All chromium results are compared to the more conservative hexavalent chromium annual risk-specific dose standard. K11 sampling results for lead have historically trended higher and have been more variable compared to the other stations due to its close proximity to major demolition sites and the service roads for transport and other demolition machinery.

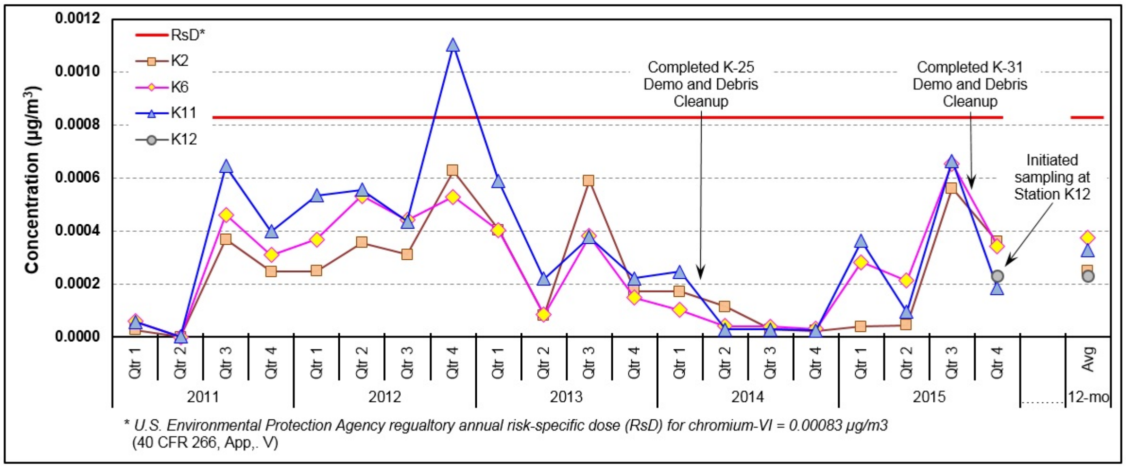


Fig. 3.14. Chromium monitoring results: 5-year history through December 2015.

(Demo = demolition)

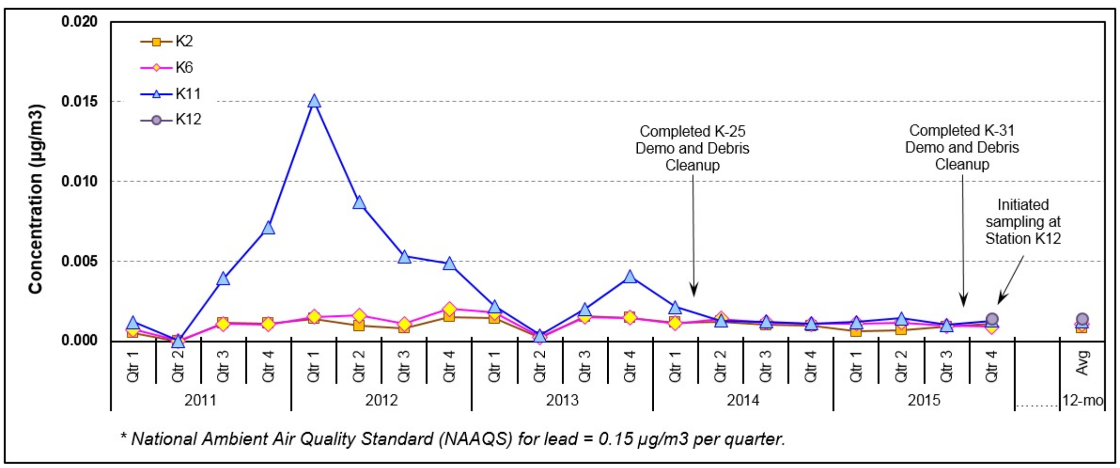


Fig. 3.15. Lead monitoring results: 5-year history through December 2015.

(Demo = demolition)

Quarterly radiochemical analyses are performed on composite samples collected at all stations. The selected isotopes of interest were ^{99}Tc, ^{234}U, ^{235}U, and ^{238}U. The concentration and dose results for each of the nuclides are presented in Table 3.4 for the 2015 reporting period.

Table 3.4. Radionuclides in ambient air at East Tennessee Technology Park, January 2015 through December 2015

Station	Concentration (μCi/mL)				
	^{99}Tc	^{234}U	^{235}U	^{238}U	Total
K2	9.10E-16	3.63E-18	6.44E-20	2.43E-19	9.13E-16
K6	1.10E-15	5.34E-18	6.72E-19	7.60E-19	1.10E-15
K11	1.07E-15	1.92E-18	7.36E-19	1.57E-18	1.07E-15
K12	6.39E-16	ND[a]	6.58E-19	ND	6.40E-16
40 CFR Part 61, Effective Dose (mrem/year)					
K2	0.027	<0.001	<0.001	<0.001	0.027
K6	0.033	<0.001	<0.001	<0.001	0.033
K11[b]	0.029	<0.001	<0.001	<0.001	0.029
K12[c]	0.002	ND	<0.001	ND	0.002

[a]ND = Not detected.
[b]On-site business receptor location.
[c]Station K12 began operating during October 2015.

The annual dose impact, as listed in Fig. 3.16, shows that Stations K2, K6, and K11 have equivalent results in 2015. The dose based on Station K12 data is only for the fourth quarter of 2015 and would represent an exposure only during that period of time. Overall, the highest dose impact on the hypothetically MEI of the public was approximately 0.03 mrem, as compared to the annual limit of 10 mrem. This exposure assumes a person resides or abides at the location of the sampling locations. The most significant dose-contributing isotope was ^{99}Tc.

Figure 3.16 is a historical summary chart of dose calculation results. Each data point represents the accumulated dose over the previous four quarterly sampling periods. The highest potential dose impact for an individual over the most recent five years and working in the vicinity of Station K11 would only be 0.37 mrem, as compared to the annual limit of 10 mrem. The on-site location of Station K11 was in close proximity to major demolition and debris removal activities that impacted radiologically contaminated materials. The primary dose contributing isotope during that time was ^{99}Tc. All data continue to show potential exposures, which are all well below the 10 mrem annual dose limit.

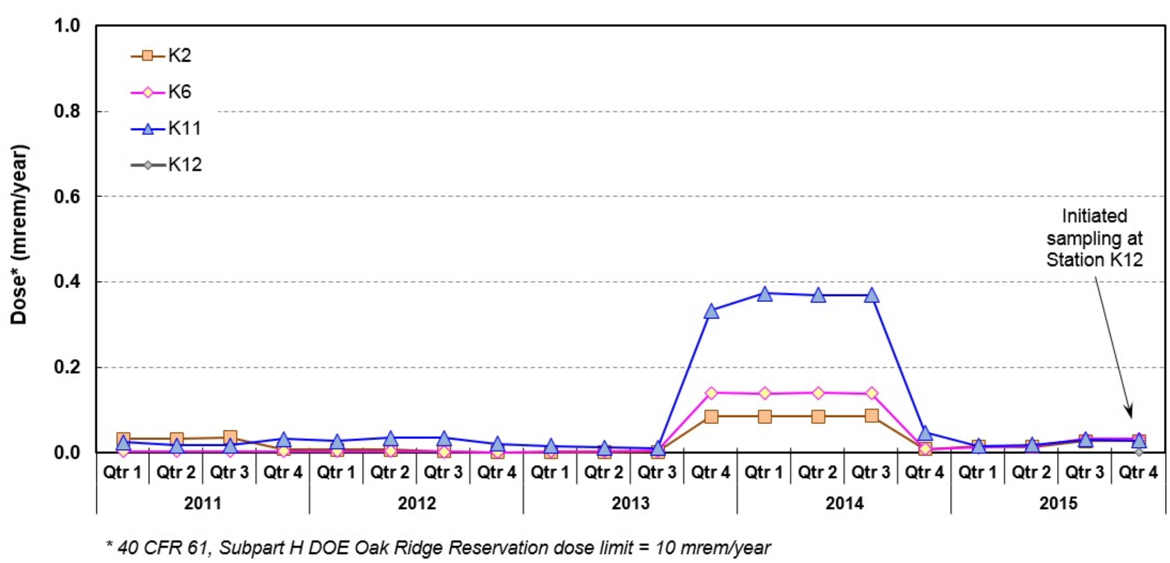


Fig. 3.16. Dose impact results: 5-year history through December 2015.

3.6 Water Quality Program

3.6.1 NPDES Permit Description

From January through March of CY 2015, ETTP was covered by an NPDES permit that was issued on April 1, 2010. This NPDES permit expired on March 31, 2015. On April 1, 2015, a new NPDES permit became effective at ETTP. The new permit will expire on March 30, 2020.

Under the permit that was in effect during January through March 31, 2015, there were 108 NPDES-permitted storm water outfalls at ETTP. As part of the NPDES permit in effect during that time period, these storm water outfalls were listed in two groups based on the types of flows being discharged through the outfalls. A total of 32 storm water outfalls were sampled as being representative of these groups.

The Group I storm water outfalls flow on an intermittent basis. These outfalls receive storm water runoff from minor site industrial operation areas that do not have a significant potential to contain contaminants. Effluent from Group I outfalls was considered to pose little or no threat of containing significant pollutants. Representative Group I outfalls were sampled on a semiannual basis for TSS, pH, and flow.

Many of the Group II storm water outfalls flow on a continuous basis. These outfalls receive storm water runoff from site industrial operations where there is a higher potential for contamination. These areas include storage areas, outside radiological areas, and other areas that pose a risk of potential contamination. These outfalls may also receive effluents described for Group I storm water outfalls. Representative Group II outfalls were sampled on a semiannual basis for oil and grease (O&G), TSS, pH, and flow.

In addition to the routine sampling of Group I and Group II outfalls, several outfalls were also sampled for mercury on a quarterly basis. The outfalls that were sampled for mercury included outfalls 170, 180, 190, and 05A. In addition, outfall 170 was also sampled on a quarterly basis for total chromium and hexavalent chromium. A Storm Water Pollution Prevention (SWPP) program was also required by this NPDES permit, but very few specific guidelines for conducting this program were included in the permit.

As part of the requirements of the current NPDES permit, storm water outfalls were no longer divided into two groups based on the types of flows being discharged through the outfalls. All outfalls were combined into a single group. A total of 27 representative outfalls are monitored on an annual basis for O&G, TSS, pH, and flow. Outfall 170 is monitored on a quarterly basis for total chromium and hexavalent chromium. Screening levels for many parameters are set at a fraction of the NPDES permit limits or AWQC, and are used by the laboratory to flag data that indicate additional scrutiny may be warranted.

The current NPDES permit also contains very specific language in relation to activities to be conducted as part of the ETTP SWPP Program. Sampling to be performed under the SWPP Program include the following:

> For bioaccumulative pollutants such as mercury that are found at ETTP, a long-term monitoring of pollutant loadings (known as flux) will be conducted as part of the current NPDES permit. This flux monitoring includes:
>
> a. Flow Monitoring
> Selected outfalls to include outfalls 100, 170, 180, and 190, will utilize field installed flow meters to gauge flows for three ranges of rainfall events at least once during the permit term at each outfall:

i. 0.1 – 0.5 inch rain event
ii. 0.5 – 1.5 inch rain event
iii. 1.5 inch or greater rain event

These flows will be utilized to compare against flows generated using the Natural Resources Conservation Service (NRCS) Technical Report-55 (TR-55), which is the current flow modeling technique utilized at ETTP. These compared values will be utilized to increase the accuracy of the TR-55 flow modeling process. Given that the flow monitoring will occur over a variety of rain events and multiple field variables can pose problems in collecting usable data, this monitoring shall be completed anytime during the permit period.

b. Mercury Monitoring
Mercury will be sampled at outfalls 180 and 190 using the flow weighted sampling technique. Specific guidelines on how these samples will be collected will be included as part of upcoming SWPP Program Sampling and Analysis Plans (SAP).

c. Flux calculation
Flow monitoring results will be used to calibrate the variable inputs to the TR-55 flow modeling process employed at ETTP. This calibrated flow model will be used with the flow paced mercury sampling results to determine mercury flux at the respective outfalls.

Also included as part of this ETTP NPDES permit, bioaccumulation monitoring will be utilized at selected locations. The bioaccumulation task will include monitoring of caged clams (*Corbicula fluminea*) placed at selected locations around ETTP and the collection and analysis of fish from Mitchell Branch (a small creek that runs roughly east to west along the northern part of ETTP) and the three major pond sites on ETTP. Both clams and fish from uncontaminated off-site locations are also analyzed as points of reference. The primary contaminants of concern (COC) for bioaccumulation monitoring at ETTP will be PCBs and mercury.

In addition, semi-permeable membrane devices (SPMDs) may also be utilized to determine the bioaccumulation of PCBs. SPMDs are used as bioaccumulators of lipophilic environmental contaminants in aqueous media. These devices mimic biological systems to provide a measure of bioavailable pollutants in water. Its passive transport mechanism is similar to that of chemical transport through fish gills. Data from these investigations will be provided to the CERCLA cleanup program for use in making decisions on-site cleanup activities.

Storm water samples will be collected at locations that will be affected by remedial action activities prior to the initiation of these activities in order to determine the conditions present before remediation begins. In addition, storm water samples will be collected at potentially affected outfalls and storm water catch basins after remedial activities have been undertaken, and after they have been completed to help gauge the potential effectiveness of the remediation efforts.

a. The results of the monitoring effort at the D&D sites will be utilized in determining the effectiveness of best management practices (BMP) developed by the DOE Environmental Management program to control off-site releases of legacy pollutants.

b. Periodic monitoring will be performed as part of the ETTP SWPP Program to monitor the continued effectiveness of the chromium collection system.

Sampling required for the completion of the NPDES permit application will be conducted as part of the ETTP SWPP Program. The application for this permit renewal is required to be submitted to TDEC by October 2019, to allow TDEC 180 days to review it prior to permit expiration on March 31, 2020. Additionally, DOE will require time to review the permit application before it is submitted to TDEC. Based on previous TDEC guidance, composite samples will be collected as time-weighted composites due to the short travel time and site conditions within the watersheds. Monitoring will be conducted to ensure all required samples are collected to complete the EPA Form 2E and EPA Form 2F. The following sampling will be conducted:

i. Representative outfalls meeting the requirements to complete an EPA Form 2E will be sampled as follows. Parameters that are required to be collected by grab sample per analytical method or regulatory guidance, will be collected as a grab sample only. All other parameters required to be sampled will be collected as time weighted composites only.

ii. Representative outfalls will be sampled to ensure completion of EPA Form 2F Section VII. Discharge Information, Parts A, B, and C as follows:

   a) Part A – Parameters required to be sampled for Part A will be collected as required. Oil & grease, total nitrogen, total phosphorus, and pH will be sampled as grab samples per EPA guidance. Biochemical oxygen demand, chemical oxygen demand, and TSS will be collected as either grabs or time weighted composites.

   b) Part B – At ETTP, all facilities generating process wastewater have been closed and the respective NPDES permits are expired. Therefore, ETTP is no longer subject to any effluent guidelines and there are no sampling requirements under part B at any stormwater outfall at ETTP.

   c) Part C – Each representative stormwater outfall will be sampled only for pollutants that could potentially be present based on the characteristics and uses of the drainage area for that outfall and are shown in Tables 2F-2, 2F-3, and 2F-4. Based upon historical site knowledge and analytical monitoring results, metals, mercury, and PCBs will be collected from all representative outfalls. In addition, each representative outfall will be evaluated, and volatile organic compounds (VOC), radionuclides, and other select parameters will be collected from the representative outfalls as required.

   d) Parameters selected to be sampled for Part C that are required to be collected by grab sample per analytical method or regulatory guidance, will be collected as a grab sample only. All other parameters selected to be sampled for Part C will be collected as time weighted composites only.

Investigative sampling will be performed as part of the ETTP SWPP Program. This includes sampling of storm drain networks for bioaccumulative parameters and investigations triggered by analytical results, CERCLA requirements, changes in site conditions, etc.

Storm water sampling results will be reviewed and evaluated to provide feedback for the next round of investigative sampling, generate suggested modifications and improvements to storm water runoff controls, and provide input for CERCLA project cleanup decisions.

3.6.2 East Tennessee Technology Park Storm Water Pollution Prevention Program

All storm water samples collected as part of the ETTP SWPP Program sampling effort were collected according to guidelines stated in the Sampling and Analysis Plan (SAP), *East Tennessee Technology Park Storm Water Pollution Prevention Program Sampling and Analysis Plan, Oak Ridge, Tennessee* (UCOR-4028, UCOR 2015).

3.6.2.1 Radiological Monitoring of Storm Water Discharges

ETTP conducts radiological monitoring of storm water discharges to determine compliance with applicable dose standards. ETTP also applies the as low as reasonably achievable process to minimize potential exposures to the public. Sampling for gross alpha and gross beta radioactivity, as well as specific radionuclides, is conducted as part of the SWPP Program sampling efforts. Analytical results are used to estimate the total discharge of each radionuclide from ETTP via the storm water discharge system.

As part of the ETTP SWPP SAP, storm water samples were collected from discharges resulting from a storm event greater than 0.1 in. that occurred within a time period of 24 h or less and that occurred at least 72 h after any previous rainfall greater than 0.1 in. in 24 h. Composite samples were collected at each outfall using Isco™-automated sampling equipment. The composite samples consisted of at least three aliquots taken during the first 60 min of a storm event discharge. Samples composited by time (equal volume aliquots collected at a constant interval) were used. Outfalls 292 and 380 were sampled under these conditions.

Changes were made in the ETTP SWPP SAP regarding the conditions in which radiological monitoring samples are collected. Specified samples are to be collected from discharges resulting from a storm event greater than 0.1 in. that occurred within a time period of 24 h. No specified dry period is required before the samples may be taken. A series of at least three manual grab samples of equal volume will be collected during the first 60 min of a storm event discharge and combined into a composite sample.

Table 3.5 contains information on the outfalls that were sampled for radiological discharges. Table 3.6 contains the results of this sampling effort. Table 3.7 lists the activity levels of each of the major isotopes that were discharged from the ETTP storm water system in 2015.

Table 3.5. Storm water composite sampling for radiological discharges

Storm water outfall	Gross alpha/ gross beta (composite sample)	U isotopic (composite sample)	^{99}Tc (composite sample)
150	X	X	X
195	X	X	X
198	X	X	X
250	X	X	X
280	X	X	X
292	X	X	X
294	X	X	X
350	X	X	X
360	X	X	X
380	X	X	X
660	X	X	X
930	X	X	X

Table 3.6. Analytical results for radiological monitoring at ETTP storm water outfalls in 2015

Parameter	Screening Level	Outfall 150	Outfall 195	Outfall 198	Outfall 250	Outfall 280	Outfall 292	Outfall 294	Outfall 350	Outfall 360	Outfall 380	Outfall 660	Outfall 930
Alpha activity (pCi/L)	10	0.255 U	3.74 U	-0.663 U	-0.911 U	6.28	**92.8**	**21.8**	**18.6**	**46.8**	**30.35**	1.49 U	-1.52 U
Beta activity (pCi/L)	30	1.44 U	22.6	0.13 U	5.23 U	7.44	**40.5**	19.6	9.74	25.7	25	3.43	1.34 U
^{99}technetium (pCi/L)	1760	-1.84 U	28.8	1.36 U	-0.321 U	4.82 U	46.2	21	0.096 U	12.4	19.8	0.503 U	1.64 U
Total uranium (µg/L)	none	0.607 U	6.76	0.87 U	0.378 U	3.57	211	21.8	14.2	39.7	32.45	3.29	1.24 U
$^{233/234}$uranium (pCi/L)	28	0.305 U	3.94	0.271 U	0.128 U	2.61	**102**	10.2	9.06	23.9	12.7	1.27	0.264 U
$^{235/236}$uranium- (pCi/L)	29	0.0269 U	0.171 U	0.142 U	0.0437 U	0.243 U	7.75	0.84	0.579	1.54	0.578	0.155 U	0.066 U
^{238}uranium (pCi/L)	30	0.2 U	2.25	0.271 U	0.12 U	1.16	**69.8**	7.21	4.67	13.1	10.8	1.08	0.406 U

BOLD indicates screening level exceeded.

Table 3.7. Radionuclides released to off-site waters from the ETTP storm water system in 2015 (Ci)

Isotope	U-234	U-235	U-238	^{99}Tc
Activity level	0.0048	0.00039	0.0024	0.83

Screening criteria for gross alpha and gross beta radiation and for $^{233/234}U$ and ^{238}U were exceeded at outfall 292. Screening criterion for gross alpha radiation was exceeded at outfall 294. Outfalls 292 and 294 receive storm water runoff from a radiologically-contaminated area on the K-1064 peninsula where uranium hexafluoride (UF_6) converter shells were once stored. The converter shells were removed from this area several years ago as part of the K-1064 peninsula D&D program. Discharges from this outfall have historically contained radiological contaminants at levels above screening criteria.

At outfalls 360, 350 and 380, screening criteria for gross alpha radiation were exceeded. Outfall 350 receives runoff from the former K-1066-D yard, where UF_6 cylinders were once stored. Outfall 360 once received runoff from the K-1031 building, which was demolished several years ago. Building K-1031 served as a storage facility for equipment utilized in the removal and recovery of uranium from contaminated equipment. Outfall 380 receives storm water runoff from the north side of the K-27 building, as well as from the former K-1231 and K-1232 areas. These facilities were utilized in the production and/or handling of UF_6, so the presence of elevated gross alpha radiation in storm water runoff from these areas was likely.

No screening criteria were exceeded at outfalls 150, 195, 198, 250, 280, 660, or 930.

3.6.2.2 Decontamination and Decommissioning of the K-25 Building

Final D&D activities were completed for the K-25 building in July 2014. To assess any ongoing impacts the remaining building slab will have on the quality of the storm water runoff, monitoring will be performed on an annual basis. Runoff samples were collected at outfall 490 to monitor east wing slab runoff; runoff from Outfall 334 was sampled to monitor west wing slab runoff, and Outfall 230 was sampled to monitor north end slab runoff.

Because sampling of the K-25 building slab runoff required a fairly heavy and intense downpour, samples were collected when runoff was sufficient to allow all of the samples for the given analytical parameters to be collected, regardless of the amount or intensity of the rainfall event. All of the samples collected as part of this effort were taken using the manual grab sampling method. Manual grab samples were collected according to the guidelines specified in Sections 3.1.2 and 3.3.1 of the EPA’s *NPDES Storm Water Sampling Guidance Document* (EPA 1992) and applicable procedures that have been developed by the sampling subcontractor.

Table 3.8 provides information on the locations and parameters that were sampled.

Table 3.8. Storm water sampling for the K-25 Building slab runoff

Sampling Events for all locations	Sampling location	Gross alpha/beta	U Isotopic, ^{99}Tc[a]	PCBs[b]	Metals[c]/ Mercury	TSS
Annually	West wing (outfall 334)	X	X	X	X	X
	East wing (outfall 490)	X	X	X	X	X
	North tower (outfall 230)	X	X	X	X	X

[a] U Isotopic analysis includes: $^{233/234}$U, $^{235/236}$U, and ^{238}U.
[b] PCB analysis includes: Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268.
[c] Metals analysis includes: Al, Ag, As, Ba, Be, B, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, Se, Tl, V, and Zn.
PCBs = polychlorinated biphenyls
TSS = total suspended solids

Samples were collected at outfalls 230 and 490 in September 2015. Samples were collected at outfall 334 in November 2015. Results over screening levels are shown in Table 3.9.

Table 3.9. Analytical results over screening levels for Building K-25 D&D annual slab runoff monitoring in 2015

Sampling location	PCB-1260 (µg/L)	Lead (µg/L)
SCREENING LEVEL	**Detectable**	**1.8**
Outfall 230	0.87	
Outfall 490		3.57

D&D = decontamination and decommissioning
PCBs = polychlorinated biphenyls

In order to collect data for trend graphs to be reported in the Remediation Effectiveness Report (RER) and the ASER, and to collect data comparable to information that is being gathered by TDEC on an ongoing basis, concurrent samples were collected in June and August 2015 at outfall 490 and at the K-1007-B weir and analyzed for ^{99}Tc. The June 2015 samples were collected during a rain event of 0.86 in. The August 2015 samples were collected during dry weather conditions. Data from these sampling events are shown in Table 3.10.

Table 3.10. Concurrent ^{99}Tc sampling at outfall 490 and the K-1007-P1 pond

Sampling location	^{99}Tc* (pCi/L) 5/11/15	^{99}Tc* (pCi/L) 6/1/15	^{99}Tc* (pCi/L) 8/13/15
SCREENING LEVEL	**1760**	**1760**	**1760**
Outfall 490	687	443	396
K-1007-P1 pond	Not Sampled	29.1	Not Sampled

*^{99}Tc results are provided as a reference. They do not exceed screening criteria.
^{99}Tc = ^{99}technetium

The data indicate that discharges from outfall 490 containing elevated levels of ^{99}Tc are greatly attenuated by the K-1007-P1 pond. Therefore, discharges from the K-1007-P1 pond to Poplar Creek contain only a small amount of ^{99}Tc.

In the future, the concurrent sampling for ^{99}Tc at outfall 490 will be conducted each time samples are collected at the P1 pond.

In addition to the routine ^{99}Tc sample to be collected at outfall 490, a sample for ^{99}Tc will be collected at outfall 190 each time a quarterly mercury sample is collected at this outfall (see Section 2.3.1). The analytical data from this sample will assist in determining if groundwater contaminated with ^{99}Tc from the K-25 D&D project could be migrating toward the outfall 190 drainage area and discharging into Mitchell Branch via outfall 190. Table 3.11 contains information on this monitoring effort.

Table 3.11. Quarterly ^{99}Tc sampling at outfall 190

Sampling location	^{99}Tc* (pCi/L) 5/11/15	^{99}Tc* (pCi/L) 8/3/15	^{99}Tc* (pCi/L) 11/2/15
SCREENING LEVEL	**1760**	**1760**	**1760**
Outfall 190	27.7	14.4	15.9

*^{99}Tc results are provided as a reference. They do not exceed screening criteria.
^{99}Tc = ^{99}technetium

From this data, it does not appear that ^{99}Tc contaminated groundwater is discharging into Mitchell Branch via storm water outfall 190.

3.6.2.3 Decontamination and Decommissioning of the K-31 Building

The K-31 building was placed in operation in 1951 for the isotopic enrichment of uranium by gaseous diffusion and was shut down in 1985. The two-story building was approximately 1200 × 622 ft and stood 67-ft tall. The building spanned a 17-acre footprint. It was comprised of six building units (K-602-1 through K-602-6) and was built of steel with cement/asbestos composite siding, concrete floors, steel structural supports, and a built-up roof. Building K-31 was used to enrich uranium for defense and power generation purposes until it was shut down in 1985. After 1985, all process and non-process equipment, with the exception of 12 overhead cranes, was removed and portions of the facility decontaminated. In 2005, most of the hazardous materials were removed from the building's interior.

Demolition of the K-31 building at ETTP began October 8, 2014. This demolition marked the removal of the fourth of five gaseous diffusion buildings at ETTP. The decontamination and decommissioning (D&D) of K-31 included several SWPP controls in addition to or supplementing the general controls identified in UCOR-4255, *East Tennessee Technology Park Storm Water Pollution Prevention Program Baseline Document* (UCOR 2016a). These controls were best management practices developed to minimize pollutant loading in storm water runoff.

- The demolition area utilized berms around the demolition area to control runoff/run on.
- Berms utilizing liner material were constructed with a liner made of high-density polyethylene with a minimum thickness of 10 mil; liner sections were overlapped approximately 12 in. and adhered with manufacturer/supplier-recommended adhesive.
- Certain portions of bermed areas were constructed of earthen materials, such as gravel or crusher run.

Several storm water catch basins in the Building K-31 drainage area were protected with sediment filtration and oil-absorbent control devices and coir matting. Sediment control measures were modified as D&D activities were conducted based on monitoring results and inspections.

In order to closely monitor the storm water runoff from the K-31 building demolition activities, sampling has been performed throughout the demolition process, as shown in Table 3.12. On April 7, 2014, pre-demolition samples were collected to provide baseline data for conditions present before demolition began. Outfalls 510 and 560, which discharge to the south into Poplar Creek, and Outfall 610, which discharges to the east into Poplar Creek, were sampled as part of this effort. Samples have also been collected at outfalls 510, 560, and 610 after each rainfall event of 1 in. or more. Table 3.13 indicates the dates these samples were collected and the parameters that were detected above screening levels.

In addition to storm water runoff sampling at outfalls 510, 560, and 610, samples were collected in Poplar Creek at the K-1250-2 and K-1250-4 bridges, which are downstream of the K-31 D&D activities. The K-1250-2 Bridge was utilized as a sampling location for Poplar Creek for the K-31 D&D project on January 12, 2015. Subsequent sampling of Poplar Creek for the K-31 D&D project were collected at the K-1250-4 Bridge. No results over screening criteria were detected in samples from Poplar Creek that were collected at the K-1250-2 Bridge. Mercury results from samples from Poplar Creek that were collected at the K-1250-4 Bridge exceeded screening criteria (25 ng/L) on several occasions. The mercury detected at these locations is believed to be due to historical releases of mercury from past Y-12 Plant operations into East Fork Poplar Creek, which discharges into Poplar Creek north of ETTP. None of the other analytical data collected as part of this sampling effort exceeded screening levels.

All storm water samples collected as part of this SWPP Program sampling effort were manual grab samples. Manual grab samples were collected according to the guidelines specified in Sections 3.1.2 and 3.3.1 of the EPA's *NPDES Storm Water Sampling Guidance Document* (EPA 1992) and applicable procedures that have been developed by the sampling subcontractor.

Demolition of the last portion of the K-31 building was completed in June 2015. Sampling performed upon completion of the D&D activities was conducted in July 2015. Analytical results from this sampling effort are shown in Table 3.13. No additional sampling will be performed as part of the D&D of the K-31 building.

Table 3.12. Storm water sampling to support D&D of the K-31 building

Sampling location	Sampling frequency	pH	Gross alpha /beta	U Isotopic, ^{99}Tc	PCBs[a] (individual aroclors and total PCBs)	Metals[b]/ Mercury	Hexavalent chromium
Outfall 510*	After each rainfall event of 1″ or greater in a 24-h period. Upon completion of D&D activities	X	X	X	X	X	X
Outfall 560	After each rainfall event of 1″ or greater in a 24-h period. Upon completion of D&D activities	X	X	X	X	X	X
Outfall 610	After each rainfall event of 1″ or greater in a 24-h period. Upon completion of D&D activities	X	X	X	X	X	X
Poplar Creek at K-1250-2 bridge	After each rainfall event of 1″ or greater in a 24-h period. Upon completion of D&D activities	X	X	X	X	X	X
Poplar Creek at K-1250-4 bridge	After each rainfall event of 1″ or greater in a 24-h period. Upon completion of D&D activities	X	X	X	X	X	X

[a] PCB analysis includes: Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268. Total PCBs will also be reported as part of the analytical data package.
[b] Metals analysis includes: Al, Ag, As, Ba, Be, B, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, Se, Tl, V, and Zn.
*As described in Section 2.2.3, analytical results from samples collected at outfall 510 will be utilized for both the K-31 building D&D and the K-761 Switch House D&D.
D&D = decontamination and decommissioning
PCBs = polychlorinated biphenyls

Table 3.13. Results over screening levels for Building K-31 D&D monitoring

Sampling Location	pH	Gross Alpha	Gross Beta	^{99}Tc*	Arsenic	Copper	Lead	Selenium	Zinc	PCB-1254	PCB-1260	PCB-1268	Total Chromium	Hexavalent Chromium	Mercury
		(pCi/L)	(pCi/L)	(pCi/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(ng/L)
Screening Level	**>8.5, <6.5**	**10**	**30**	**1760**	**7.5**	**7**	**1.8**	**3.8**	**75**	**Detectable**	**Detectable**	**Detectable**	**75**	**8**	**25**
OUTFALL 510**															
4/7/2014						8.32									
3/4/2015	8.8		86.5	95.6		10.8				0.0765	0.0931	0.084	186	170	
4/15/2015			30.5	39.1		9.48	4.95				0.0683		76.9	60	
6/2/2015			35	39.4		8.78	3.82								
7/14/15		14	34.2	19.5		12.8	10.1		112						
7/21/15		11.7													
OUTFALL 560															
4/7/2014															
1/12/2015		12.7	62.7	83.6	10.1	24.3	30.8		236	0.157	0.235	0.371	95.7	51	43.6
3/4/2015		16.5	103	136		19.7				0.0733	0.0792	0.0534	258	230	
4/15/2015	8.9		49.2	65.7		17.7	9.54		83.8	0.251	0.228	0.119	121	101	
7/15/15															30.4
OUTFALL 610															
4/7/2014															
11/17/2014			39.2	58.5		21	8.74	11.2	107		0.0469	0.361	452	440	
1/12/2015										0.0599	0.0818	0.115		26	
3/4/2015							3.45					0.06		15	
4/15/2015												0.0836			
K-1250-2 Bridge															
1/12/15															
K-1250-4 Bridge															
3/4/15															248
4/15/15															172
6/2/15															54.7
7/14/15															45.8
7/21/15															46.2

Except for ^{99}Tc, only results exceeding screening criteria are shown. All ^{99}Tc results are below screening criteria and are shown as a reference for gross beta radiation levels. Non-detect results for ^{99}Tc are not shown.
**As described in Section 2.2.3, analytical results from samples collected at outfall 510 will be utilized for both the K-31 building D&D and the K-761 Switch House.
D&D = decontamination and decommissioning   PCBs = polychlorinated biphenyls ^{99}Tc = ^{99}technetium

3.6.2.4 Decontamination and Decommissioning of the K-761 Switch House

The K-761 building, also known as the K-31 substation, operated from 1952 through 1985. It transferred electrical power from overhead transmission lines to the K-31 cascade. K-761 was a multistory building that included a basement, first floor, mezzanine, and a second floor. The building measured approximately 306 ft by 57 ft with an 8-ft basement and was made of brick, tile wall, and reinforced concrete. Runoff from the K-761 area discharges to Poplar Creek via storm water outfall 510.

Since the K-761 Switch House and the K-31 building were demolished concurrently in 2015, samples collected at outfall 510 provided analytical data for both D&D projects. The analytical parameters collected as part of the K-761 Switch House sampling effort are presented in Table 3.14. These parameters are the same as those collected for the K-31 D&D sampling effort.

Pre-demolition monitoring was conducted at outfall 510. Monitoring and samples have been collected at that location after each rainfall event of 1 in. or more, as D&D activities were being conducted in order to closely monitor the storm water runoff from the K-761 Switch House building demolition activities. Additional sampling will be conducted at outfall 510 after all building debris from the K-761 demolition area and the remaining building slab has been removed.

3.6.2.5 Decontamination and Decommissioning of the K-892 Pumphouse

The K-892 Pumphouse was built in 1954 to pump treated water for the K-33 recirculating cooling water (RCW) system. The building consisted of three sections. One section contained water treatment chemical tanks and feed equipment. A second section contained RCW pumps, piping, and valves. A third section contained electrical transformers, diesel fuel, and chemical storage tanks. D&D activities were completed at the K-892 Pumphouse in 2015.

As shown in Table 3.19, initial sampling was performed on January 12, 2015, to provide baseline data for conditions present before demolition began. Sampling was also performed on May 4, 2015, during demolition activities after a rainfall event of more than 1 in. in a 24-h period. Additionally, sampling was performed on April 15, 2015, after D&D activities were completed.

Table 3.14. Storm water sampling for the D&D of the K-892 Pumphouse

Sampling location	Sampling frequency	pH	Gross alpha/beta	U Isotopic, ^{99}Tc, transuranics[a]	PCBs[b]	Metals[c]/ Mercury	Hexavalent chromium
Outfall 690	Prior to initiation of building demolition activities. After each rainfall event of 1″ or greater in a 24-h period. Upon completion of D&D activities.	X	X	X	X	X	X

[a] Transuranics analysis includes: ^{237}Np, ^{238}Pu, and $^{239/240}$Pu.
[b] PCB analysis includes: Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268.
[c] Metals analysis includes: Al, Ag, As, Ba, Be, B, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, Se, Tl, V, and Zn.
D&D = decontamination and decommissioning PCBs = polychlorinated biphenyls ^{99}Tc = ^{99}technetium

Table 3.15. K-892 Pumphouse D&D - analytical results that exceeded screening levels

Sampling Location	Lead (μg/L)	PCB-1254 (μg/L)
SCREENING LEVEL	**1.8**	**Detectable**
Outfall 690 1/12/15	3.99	
Outfall 690 3/4/15		0.0492

Post-demolition samples were collected from outfall 690 on April 15, 2015. None of the parameters that were sampled on this date exceeded screening criteria. No additional monitoring in association with the D&D of the K-892 Pumphouse will be performed.

3.6.2.6 Pre-Demolition Monitoring for the K-27 Building D&D

Building K-27 is the last remaining gaseous diffusion building at ETTP. Similar in structure to the already demolished K-25 building, the K-27 building spans more than 8 acres and is about 900-ft long, 400-ft wide, and 58-ft high.

Demolition of the K-27 building is a high priority at ETTP due to its severely deteriorated state. In 2014, workers completed inventory management and nondestructive assay measurements; characterized process equipment; performed vent, purge, and drain operations on process equipment; and prepared necessary regulatory documents. Transite was removed from outside the building in late 2015. Building demolition activities began in early 2016 and are expected to be completed in late 2016 or early 2017. Completing this project will mark the end of all gaseous diffusion buildings at ETTP.

As shown in Table 3.16, initial sampling was performed to provide baseline data for conditions present before demolition begins. This initial sampling effort was performed before the time demolition work is scheduled to begin. Sampling will also be performed during demolition activities after rainfall events of 1 in. or more in a 24-h period. Additionally, sampling will be performed after D&D activities have been completed.

Table 3.16. Storm water sampling for the D&D of the K-27 Building

Sampling location	Sampling frequency	pH	Gross alpha/beta	U Isotopic, ^{99}Tc, transuranics[a]	PCBs[b]	Metals[c]/ Mercury	Hexavalent chromium
Outfall 380	Prior to initiation of building demolition activities	X	X	X	X	X	X
Outfall 430	Prior to initiation of building demolition activities	X	X	X	X	X	X
Poplar Creek instream at Outfall 460	Prior to initiation of building demolition activities	X	X	X	X	X	X

[a] Transuranics analysis includes: Np-237, Pu-238, and Pu-239/240.
[b] PCB analysis includes: Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268.
[c] Metals analysis includes: Al, Ag, As, Ba, Be, B, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, Se, Tl, V, and Zn.
NOTE: Outfall 382 drains the K-131/K-631 complex rather than K-27. Since this outfall will not provide direct information pertaining to the D&D of K-27, it will not be sampled as part of the K-27 D&D sampling effort.
D&D = decontamination and decommissioning PCBs = polychlorinated biphenyls ^{99}Tc = ^{99}technetium

Prior to the initiation of demolition activities, pre-demolition samples were collected at storm water outfalls 382 and 430 and at the Poplar Creek instream location near outfall 460. Results from these sampling efforts that exceeded screening levels are shown in Table 3.17.

Table 3.17. Analytical results over screening levels for K-27 D&D sampling (prior to demolition)

Sampling Location	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	^{99}Tc* (pCi/L)	Mercury (ng/L)
SCREENING LEVEL	**10 pCi/L**	**30 pCi/L**	**1760 pCi/L**	**25 ng/L**
Outfall 380 6/30/15	29.1			
Outfall 430 6/2/15		106	177	
Poplar Creek at Outfall 460 6/2/15				164

* ^{99}Tc results are below screening criteria and are shown as a reference for gross beta radiation levels.
D&D = decontamination and decommissioning ^{99}Tc = ^{99}technetium

3.6.2.7 Pre-Demolition Monitoring for the K-731 Switch House D&D

The K-732 Switchyard is a level, gravel-covered yard, approximately 4 acres in size, that is fenced on three sides and bounded by the K-731 Switch House to the north. The gravel layer is approximately 18-in. thick, having been placed as a containment measure for any spills. The switchyard was originally constructed in 1944 to provide electrical power to Building K-27. It later became the receiving point for TVA power at 161 kV and supplying 13.8 kV power to the ETTP site. The adjacent K-731 Switch House received power from K-732 via underground conduits. The site contains a number of below-grade vaults and pits with conduits for electrical and communication cables. Use of the switchyard was phased out over the years and the yard was completely shut down in 2011. Electricity to ETTP is now provided by the City of Oak Ridge.

Demolition of the K-732 Switchyard has been contracted to CTI and Associates of Kansas City, Missouri. The project includes the demolition of the K-732 Switchyard with recovery and recycling of metals and material assets. Demolition of the K-732 Switchyard structures began in late 2015 and are expected to be completed in early 2016. Demolition of the K-731 Switch House will begin as a UCOR work scope after demolition work at the K-732 Switchyard has been completed by CTI and Associates.

Two sumps are located in the basement of K-731. Sump S-053 discharges to sump S-054. Sump S-054 discharges to storm water outfall 430. An additional five sumps (sumps S-055, S-056, S-057, S-058, and S-059) are located in the K-732 Switchyard. Sump S-055 collects water from Valve Vault 2 in the K-732 switchyard. Sump S-056 collects water from Valve Vault 3 in the K-732 switchyard. Sump S-057 collects water from Synchronous Condenser 101. Sump S-058 collects water from Synchronous Condenser 102. Sump S-059 collects water from Synchronous Condenser 103. All of these sumps discharge to outfall 440. A portion of the south side of the switchyard discharges to storm water outfall 440, as well. This discharge to outfall 440 includes surface runoff from paved sections of the switchyard area, as well as infiltration through the gravel portion of the switchyard area. The K-731/K-732 sumps and the drainage system from this area to outfalls 430 and 440 are shown in Fig. 3.17.

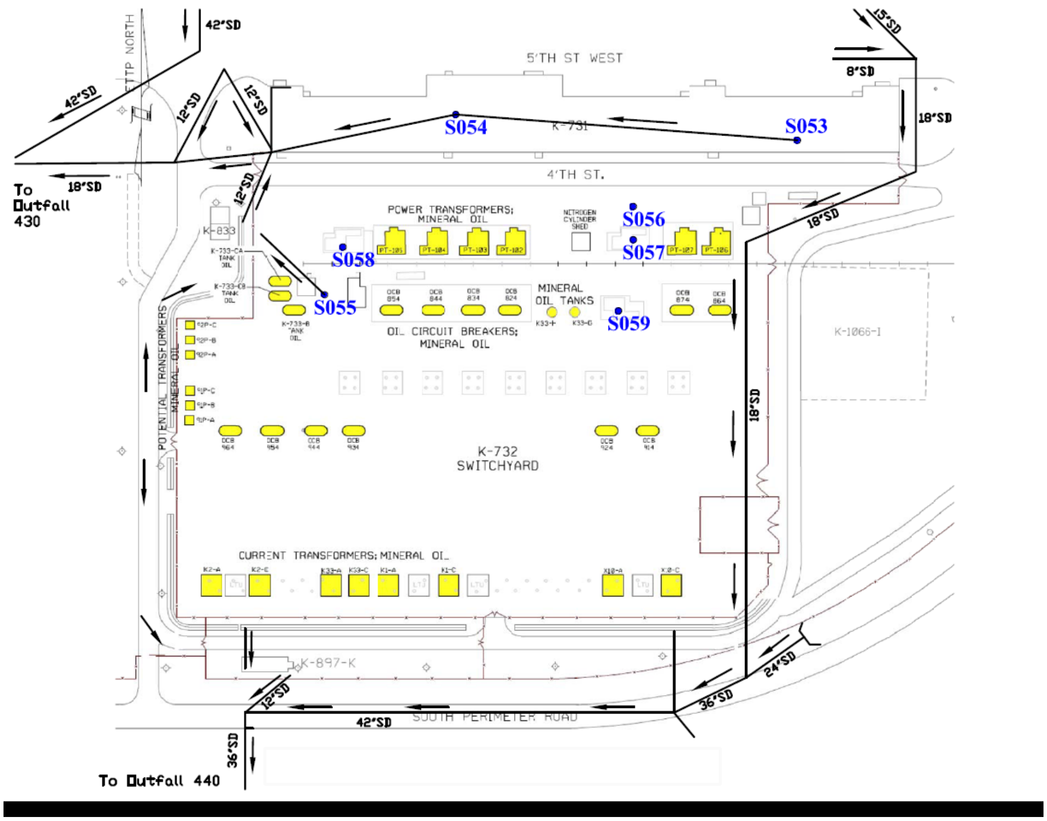


Fig. 3.17. K-731 Switch House and K-732 Switchyard Drainage System.

Because the sumps in Building K-731 are not currently in operation, water has accumulated in the basement of the building. As an initial pre-demolition action, the water that has accumulated in the basement of the K-731 Switch House must be removed and disposed. On August 27, 2015, a sample of the water in the K-731 basement was collected from a stairwell that provides access to the basement. The results from this sampling effort are shown in Table 3.18.

Table 3.18. Analytical results over screening levels for samples collected from the K-731 basement

Sampling location	PCB-1260 (µg/L)	Zinc (µg/L)
SCREENING LEVEL	**detectable**	**75**
K-731 basement (stairwell)	0.169	108

A decision on the disposition of the water in the K-731 basement will be made in CY 2016. Options for disposal of this water include discharging it into a bermed area and allowing it to infiltrate into the soil or discharging it to the storm drain system using appropriate best management practices.

In October 2015, samples were collected from outfall 440 to determine if water from sumps S-055, S-056, S-057, S-058, and S-059 or other portions of the K-732 switchyard area could be adversely affecting the discharge from the outfall. Table 3.19 indicates the parameters that were sampled as part of this effort. No results over screening levels were detected in samples collected from outfall 440.

Table 3.19. Storm water composite sampling for radiological discharges

Storm water outfall	Gross alpha/ gross beta	^{99}Tc	VOCs	PCBs/pesticides*
440	X	X	X	X

*PCB analysis includes: Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268.
PCBs = polychlorinated biphenyls ^{99}Tc = ^{99}technetium VOCs = volatile organic compound

3.6.2.8 Monitoring of Operational Building Sumps

As part of the ETTP SWPP Program monitoring, samples were collected from each of the remaining building sumps. These sumps accumulate storm water during wet weather conditions. This sampling was performed to identify contaminants that could be discharged during the normal operation of the sumps. These sumps will be sampled at least once during each NPDES permit cycle. However, the sumps will be evaluated each year to determine if changing conditions (D&D activities, etc.) may warrant more frequent sampling.

There are no specific requirements (rainfall, specific discharge rate, etc.) for sampling the sumps. They can be sampled as long as there is adequate water present in them to allow the samples to be collected. All water samples taken as part of this investigation shall be collected as manual grab samples. Manual grab samples will be collected according to the guidelines specified in Sections 3.1.2 and 3.3.1 of the EPA's *NPDES Storm Water Sampling Guidance Document* (EPA 1992) and applicable procedures that have been developed by the sampling subcontractor.

Preliminary activities leading to the D&D of the K-1037 building are underway. Walkdowns of the building have been conducted to identify RCRA universal waste materials such as light bulbs, spent batteries, etc., that must be collected and disposed before additional D&D actions can occur. Also, surveys of the building have been performed to identify chemicals, flammable materials, etc., that must be removed from the building. In addition to these activities, the water from the K-1037 basement must be removed.

As part of the ETTP SWPP Program sampling effort, sampling of the water in the K-1037 basement was conducted in July 2015. Accumulated water from two representative locations were sampled as part of this effort. Sump S-093 was sampled as part of this monitoring effort. Sump S-094 was also planned to be included as part of this sampling effort. However, because the sump pumps in the K-1037 basement are not currently operational, the area where sump S-094 is located was flooded and was not accessible for sampling. Therefore, a sample was collected from a flooded stairwell near columns F8 and G8 of the K-1037 building. This location is as close to sump S-094 as possible and is representative of the water in the area of the basement served by the sump. Monitoring requirements for this sampling effort are included in Table 3.20.

Table 3.20. Sampling of accumulated water in Building K-1037 basement

Sampling location	Sampling frequency	pH	Gross alpha/beta	PCBs[a]	Metals[b]/ Mercury	TSS
Sump S-093	Prior to initiation of building demolition activities.	X	X	X	X	X
Stairwell at Columns F8/G8	Prior to initiation of building demolition activities.	X	X	X	X	X

[a] PCB analysis includes: Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268.
[b] Metals analysis includes: Al, Ag, As, Ba, Be, B, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, Se, Tl, V, and Zn.
PCBs = polychlorinated biphenyls TSS = total suspended solids

Parameters that were detected at levels exceeding screening criteria are shown in Table 3.21.

Table 3.21. Analytical results above screening criteria from the sampling of accumulated water in Building K-1037 basement in 2015

Sampling location	Cadmium (μg/L)	Lead (μg/L)	Gross alpha radiation (pCi/L)	Gross beta radiation (pCi/L)	PCB-1254 (μg/L)	PCB-1260 (μg/L)
SCREENING LEVEL	**Detect-able**	**1.8**	**10**	**30**	**Detect-able**	**Detect-able**
Sump S-093			630	930		
Stairwell at Columns F8/G8	0.82	3.6	190	440	1.4	3

PCBs = polychlorinated biphenyls

Uranium and ^{99}Tc samples were also collected and analytical results were non-detectable. Additional sampling may be performed to determine why gross alpha and gross beta levels were elevated while the uranium and ^{99}TC results were non-detectable.

Personnel working on the D&D of the K-1037 building planned to install portable pumps in the basement to pump the water to the environment if it met the criteria for accumulated water discharges stated in the ETTP SWPP Program Baseline Document. However, because of the exceedances for metals, PCBs, and gross alpha/gross beta radiation, this water will not be suitable for discharge to the environment. An alternate means of disposal of this water has not yet been determined but on-site treatment as a CERCLA action is being considered.

Sump S-073A, which is located in the basement of Building K-1006, was also sampled as part of the ETTP SWPP Program. This sump is a 30-in.-diameter, 36-in.-deep concrete structure. It is located in the northeast corner basement of the K-1006 laboratory building, beneath the interior stairwell. The sump receives groundwater flow that is periodically pumped to the sanitary sewer system by a float-controlled pump. This water is then treated at the Rarity Ridge Sewage Treatment Plant. The *Baseline*

Environmental Analysis Report for the K-1006 Material and Chemistry Laboratory (K/EM-543/R1, LMES 1997) states that the sump located in the northeast corner of the basement accumulates rainwater from a drain in the concrete floor area adjacent to the outside door of the basement. Monitoring requirements for this sampling effort are included in Table 3.22.

Table 3.22. Sampling of Building K-1006 sump

Sampling location	pH	Gross alpha/beta	PCBs[a]	Metals[c]/ Mercury	TSS
Sump S-073-A	X	X	X	X	X

[a] PCB analysis includes aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268. Total PCBs will also be reported as part of the analytical data package.
[b] Metals analysis includes: Al, Ag, As, Ba, Be, B, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, Se, Tl, V, and Zn.
PCBs = polychlorinated biphenyls TSS = total suspended solids

Parameters that were detected at levels exceeding screening criteria in 2015 are shown in Table 3.23.

Table 3.23. Analytical results over screening levels for Sump S-073A in 2015

Sampling location	Copper (µg/L)	Lead (µg/L)	Zinc (µg/L)	Cadmium (µg/L)
SCREENING LEVEL	**7**	**1.8**	**75**	**Detectable**
Sump S-073A	21.2	12.5	89.3	2.04

3.6.2.9 Monitoring Runoff from Oak Ridge Forest Products Area

Oak Ridge Forest Products, LLC (ORFP) operates a wood yard and chipping facility at the K-722 site, which is located at the former Powerhouse area. The primary operation being conducted is the conversion of low-grade forest products (pulpwood) into wood chips. These wood chips are used as a biomass fuel, in paper production, and for mulching and landscaping. Wood from local logging and clearing activities is purchased on-site. The wood is then processed into wood chips by a chipper.

One source of potential impact to storm water runoff from this facility is fuel storage. Double-walled aboveground storage tanks with a total storage capacity of approximately 2,500 gal have been installed on-site to contain both on-road and off-road diesel fuel. Secondary containment was constructed around the above-ground tanks. Above-ground storage tanks also store water used for fire suppression and equipment cleaning. Portable restrooms are used for the handling of sanitary waste.

Sampling was performed in order to assess any potential impact that the operation of this facility may be having on the quality of the storm water runoff from the area. Guidance found in the Tennessee Storm Water Multi-Sector Permit (TMSP) for Industrial Activities was utilized in choosing the parameters to be sampled as part of this effort. Parameters required to be sampled under the TMSP for Standard Industrial Classification (SIC) code 2411 (log storage and handling areas) and SIC code 2421 (general sawmills and planing mills) were selected to be representative of the storm water discharges that may originate at ORFP.

As shown in Table 3.24, storm water runoff from outfalls 780, 810, and 820 were sampled as part of this effort. (Outfall 810 was not originally designated to be sampled as part of this effort. However, because it receives drainage from the ORFP area and because flow was present at the outfall when outfalls 780 and 820 were sampled, a sample was collected at outfall 810 to provide additional information about this area.) These samples were collected at a time when storm water runoff was observable from the ORFP facility. The analytical results from this sampling effort will be used to determine if additional sampling of these storm water outfalls will be necessary on a more frequent basis (i.e., quarterly, annually).

Field observations were also made at each of the outfalls when sampling of the storm water runoff from the ORFP facility was conducted. The discharge from these outfalls was observed for visible sheen, discoloration, foam, floating materials, suspended materials, and debris. If any debris was noted in the discharge from the outfall that does not appear as if it would fit through a 1-in.-diameter round opening, EC&P personnel were contacted.

Samples were collected from these outfalls in December 2014 and January 2015. The only parameter that exceeded screening criteria was copper at outfall 810. Copper was detected at 7.31 µg /L, which exceeds the screening criteria of 7 µg/L. None of the other parameters were present at levels that exceeded screening criteria. In addition, no adverse conditions were noted as part of the field observations conducted at the time the sampling was being performed. Therefore, it is believed that storm water discharges from the area of the ORFP facility are not creating an adverse impact on receiving waters.

Table 3.24. Storm water sampling at the Oak Ridge Forest Products facility

Sampling location	Oil and grease	TSS	COD	Metals[a]	pH
Outfall 780	**X**	**X**	**X**	**X**	**X**
Outfall 810	**X**	**X**	**X**	**X**	**X**
Outfall 820	**X**	**X**	**X**	**X**	**X**

[a] Metals analysis includes: Al, Ag, As, Ba, Be, B, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sb, Se, Tl, V, and Zn.
COD = chemical oxygen demand TSS = total suspended solids

3.6.2.10 Legacy Mercury Investigation Sampling

Activities involving mercury that were conducted at ETTP included usage, handling, and recovery operations. Mercury usage and handling were common in such equipment as manometers, switches, mass spectrometers, mercury diffusion pumps, mercury traps, and laboratory operations. Large quantities of mercury-bearing wastes from the on-site gaseous diffusion plant operations and support buildings, ORNL, and Y-12, were processed and stored at ETTP. Mercury from soils and spill cleanups was processed on-site, as well. Mercury recovery operations were conducted in a number of buildings. Many buildings were located in watersheds that discharged primarily into Mitchell Branch.

Mercury levels that exceed the ambient water quality criterion (AWQC) of 51 ng/L at ETTP have been identified in the Mitchell Branch watershed, as well as in a number of storm water outfalls, surface water locations, and groundwater monitoring wells at ETTP. Improved analytical techniques for mercury have resulted in much lower detection limits than previously possible. In addition, knowledge of known historical mercury processes at the facility has increased substantially. These factors have led to an ongoing facility investigation to more precisely detect and quantify the extent of any mercury contamination that may exist.

Factors considered as part of the mercury investigation include weather conditions (wet vs. dry), remedial action activities (before, during, and after demolition of ETTP facilities), and types of monitoring locations chosen for sampling (in-stream, outfall, ambient, catch basin). For the purpose of the investigation activities, a dry weather period was defined as being at least 72 h after a storm event of 0.1 in. or more. Wet weather conditions were defined as a storm event greater than 0.1 in. that occurs within a time period of 24 h or less and at least 72 h after any previous rainfall greater than 0.1 in. in 24 h. In addition, manual grab samples were defined as samples collected according to the guidelines specified in Sections 3.1.2 and 3.3.1 of the EPA *NPDES Storm Water Sampling Guidance Document* (EPA 1992) and applicable procedures that have been developed by the sampling subcontractor.

Two monitoring programs collected mercury data across ETTP at various locations during CY 2015. Samples were collected as specifically defined in the NPDES permit and as part of the SWPP Program.

3.6.2.11 Mercury Sampling Conducted as Part of the Previous NPDES Permit

As part of the NPDES permit compliance program for the previous ETTP NPDES permit that was in effect until March 31, 2015, mercury was sampled on a quarterly basis at outfalls 05A, 170, 180, and 190. These four locations were selected because information gathered as part of the permit application process indicated that mercury levels at these outfalls occasionally exceeded the AWQC level of 51 ng/L. Outfalls 170, 180, and 190 collect storm water from large areas on the north side of ETTP and discharge to Mitchell Branch. Outfall 05A is the discharge point for the former sewage treatment plant drainage basin into Poplar Creek on the east side of ETTP. The NPDES permit that took effect on April 1, 2015, no longer requires quarterly mercury monitoring. However, in order to continue collecting data for the analysis of trends in mercury discharges from these outfalls, quarterly mercury sampling will be conducted as part of the ETTP SWPP Program, as indicated in Table 3.25. Since mercury has not been detected at outfall 170 at levels over the AWQC of 51 ng/L for several years, outfall 170 will not be sampled as part of this SWPP Program effort. Data from this sampling effort will be utilized as part of the RER and may provide information that will be used in upcoming CERCLA cleanup decisions.

Table 3.25. Mercury sampling at storm water outfalls

Sampling Location	Parameter	Measurement frequency	Sample type
Outfall 05A	Mercury	1/quarter	Grab
Outfall 180	Mercury	1/quarter	Grab
Outfall 190	Mercury	1/quarter	Grab

Table 3.26 contains analytical data from mercury sampling performed at outfalls 170, 180, 190, and 05A in CY 2015. Samples collected during the first quarter of CY 2015 were collected as part of the requirements of the ETTP NPDES permit, which was in effect at that time. Mercury samples collected during the second, third, and fourth quarters of CY 2015 were taken as part of the requirements of the ETTP SWPP Program.

Table 3.26. Quarterly NPDES/SWPP Program mercury monitoring results – CY 2015

Sampling location	1st Quarter CY 2015 (ng/L)	2nd Quarter CY 2015 (ng/L)	3rd Quarter CY 2015 (ng/L)	4th Quarter CY 2015 (ng/L)
Outfall 170**	4.1	-----	-----	-----
Outfall 180	**219**	**53.1**	50.8	**99.3**
Outfall 190	20.3	11.1	16.7	**55.6**
Outfall 05A	**67.4**	**132**	**148**	**185**

*Results in **bold** exceed the AWQC for mercury (51 ng/L).
NPDES = National Pollutant Discharge Elimination System
SWPP = Storm Water Pollution Prevention

Figures 3.18–3.21 indicate the mercury levels at outfalls 170, 180, 190, and 05A from CY 2010–present. These graphs contain mercury information from quarterly sampling performed as part of the quarterly NPDES permit compliance/quarterly SWPP Program sampling, NPDES permit renewal sampling, D&D sampling, and other mercury sampling performed at these outfalls. Results from outfalls 180, 190, and 05A were frequently above the AQWQC of 51 ng/L.

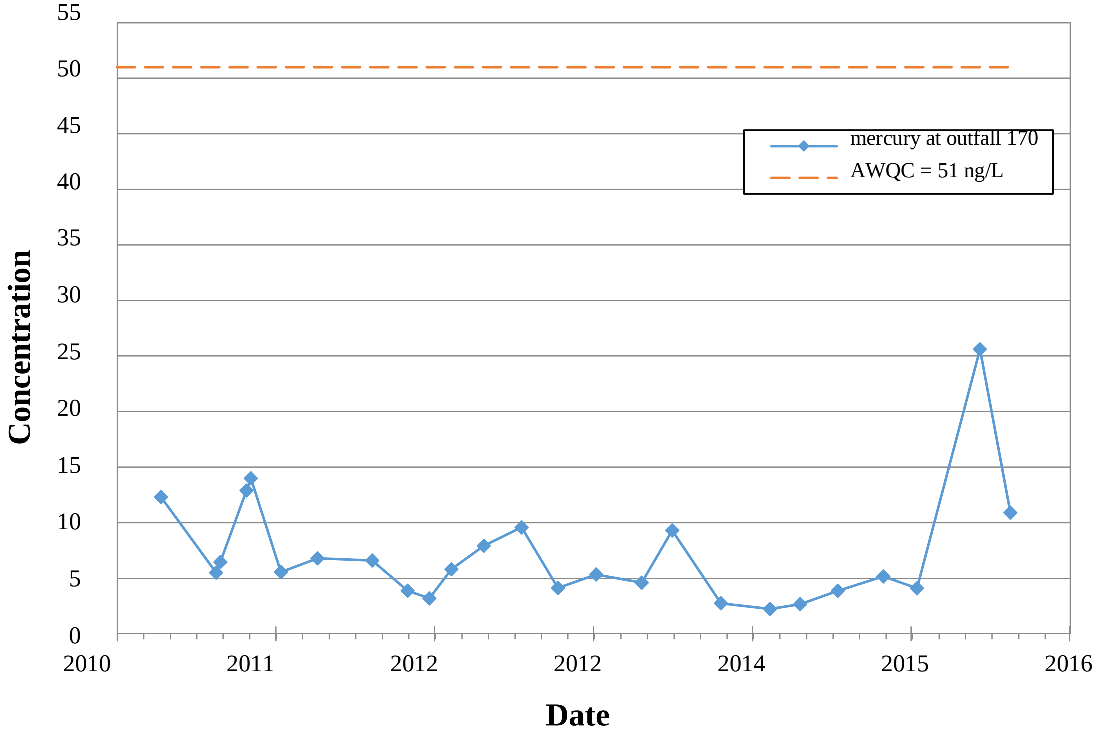


Fig. 3.18. Mercury concentrations at outfall 170. *(AWQC = ambient water quality criterion)*

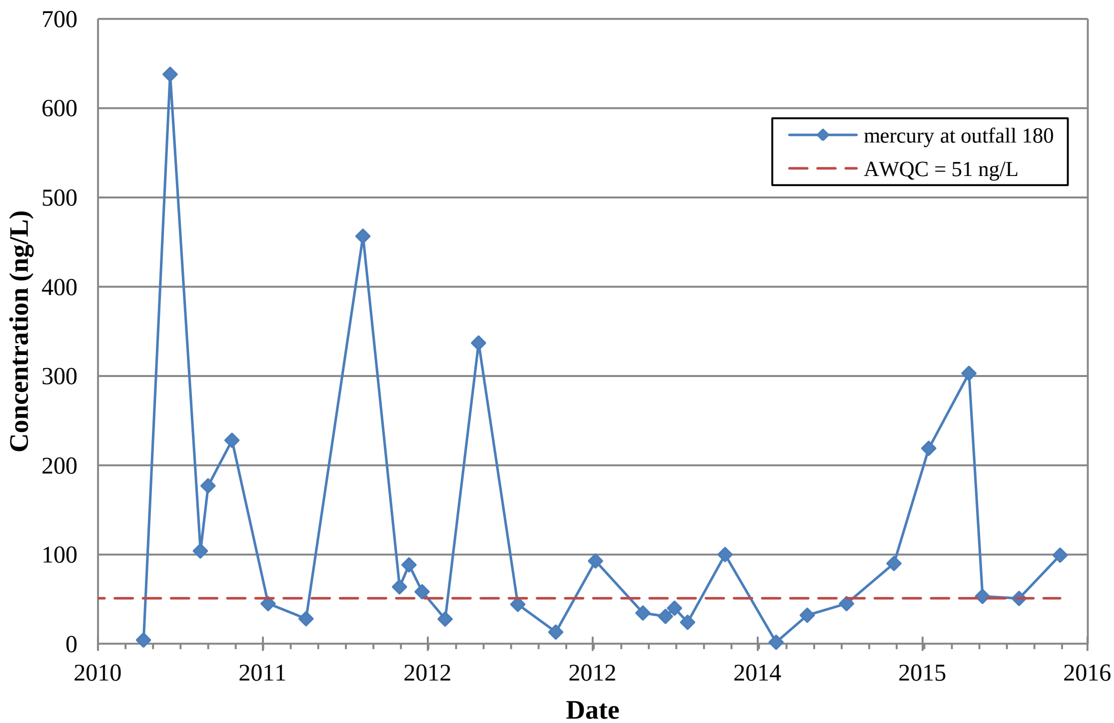


Fig. 3.19. Mercury concentrations at outfall 180. *(AWQC = ambient water quality criterion)*

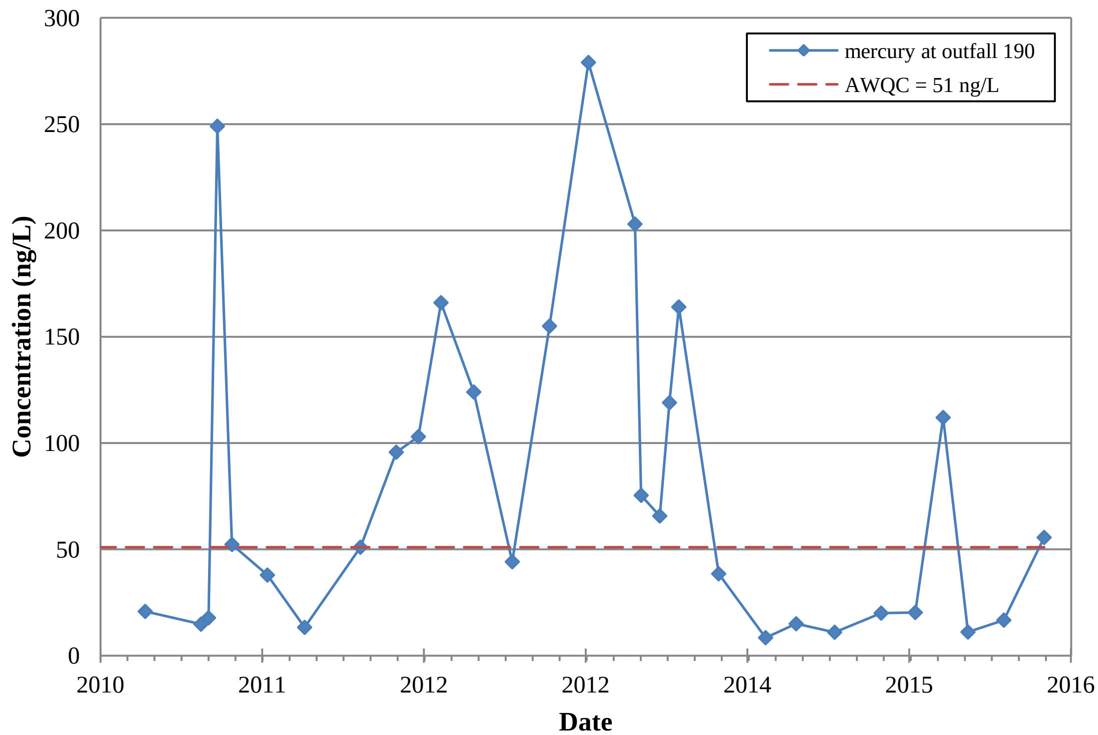


Fig. 3.20. Mercury concentrations at outfall 190. *(AWQC = ambient water quality criterion)*

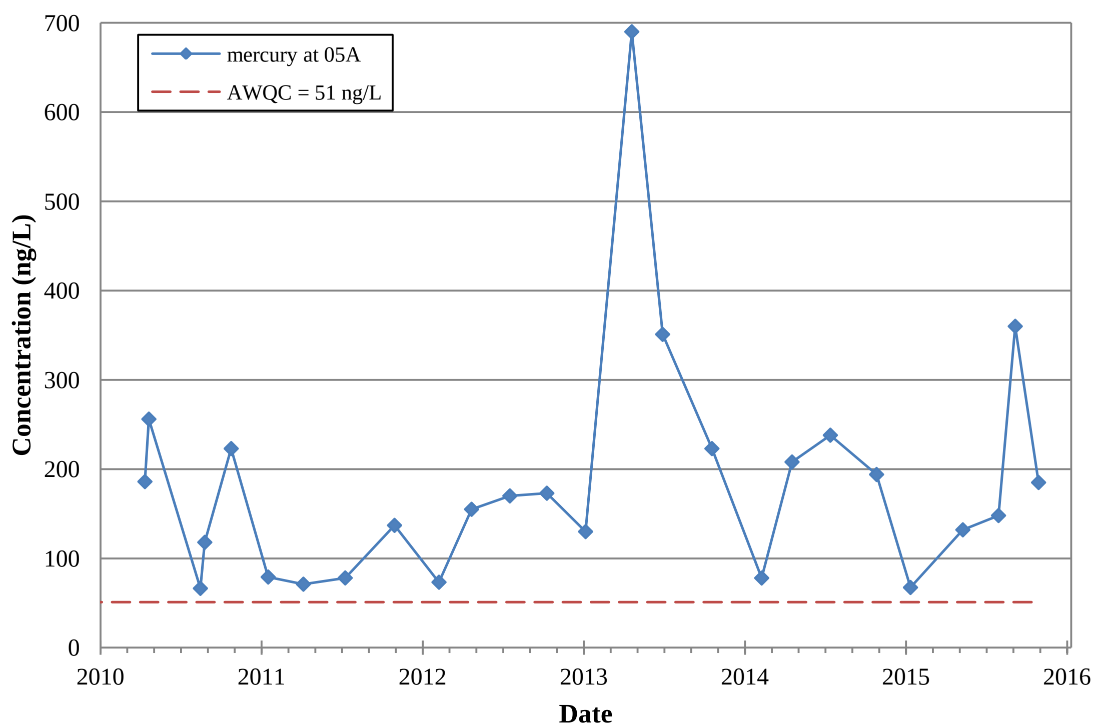


Fig. 3.21. Mercury concentrations at outfall 05A. *(AWQC = ambient water quality criterion)*

3.6.2.12 Investigation of Mercury in Selected ETTP Storm Water Outfalls

The K-1024 Dilution Pit was used during the K-1024 instrument shop operations (1945-1963) and centrifuge development laboratory operations (1970–1985) and was located on the northwest corner of Building K-1024. During 1946-1947, the K-1024 building operations cleaned mercury from line recorder chemical traps. The electronics shop frequently experienced mercury spills and elevated levels of mercury vapors. The Building K-1024 sanitary flow and acid/solvent flow were each handled by independent drain lines. A 4-in. acid waste line flowed through a dilution pit before discharging into the K-25 Site storm drain system. The dilution pit was placed in standby in 1985. In the early 1990s, it was filled and covered with asphalt.

The storm drain networks for outfalls 230 and 240 drain the former K-1024 building area. In addition to sampling at the 230 and 240 outfalls, samples were collected from selected storm drain catchment basins in the outfall 230 and 240 networks as part of the ETTP SWPP Program. The analytical results from this sampling effort will allow an assessment of the levels of mercury that may be continuing to enter the storm water drainage system.

The total mercury samples were collected during both wet weather and dry weather conditions. Flow was not present at all locations during dry weather conditions. The absence of flow was noted at each applicable location. All reasonable efforts were made to collect the wet weather or dry weather samples from a selected network within a single day.

Since water samples may inadvertently pick up sediment from the bottom of the storm drain system, both a filtered and an unfiltered sample were collected for total mercury analysis. The filtering was done in the field utilizing a 0.45 micron filter and a portable peristaltic pump.

Samples were collected as indicated in Table 3.27. Locations that were inaccessible or cannot be sampled for other reasons were noted.

Table 3.27. Sampling of outfall 230 and 240 networks

Storm Water Outfall Network	Associated manholes to be sampled	Sampling event	Total Mercury (unfiltered)	Total Mercury (filtered in the field)
230	2003, 3040, 3035, 7011, 7012, 7013, 7014	Wet and dry weather	X	X
240	2008, 2014, 2050, 7053, 7054, 7056, 7059	Wet and dry weather	X	X

Dry weather sampling of outfall 230 and its associated drainage network was performed in February 2015. As part of the monitoring of the outfall 230 network, samples were collected at manholes 2003, 3035, 3040, 7011, 7012, 7013, and 7014. Both filtered and unfiltered samples were collected at each location. Table 3.28 contains the results of the dry weather sampling performed in the outfall 230 network. Results in bold exceed the AWQC for mercury (51 ng/L).

Table 3.28. Mercury results from dry weather sampling at storm water outfall 230 and associated piping network

Sampling Location	Mercury (ng/L)*	
	Unfiltered	Filtered (Field)
Outfall 230	2.07	1.54
Manhole 2003	23.1	**69.8**
Manhole 3035	11.9	3.45
Manhole 3040	47.7	17.8
Manhole 7011	2.77	45.6
Manhole 7012	27.3	35.1
Manhole 7013	46.4	31.4
Manhole 7014	**60.1**	39.3

*Results in **bold** exceed the AWQC for mercury (51 ng/L).

Dry weather sampling of outfall 240 and its associated drainage network was completed on March 26, 2015. At the time of sampling, only manholes 2008 and 2014 were flowing; outfall 240 and manholes 2050, 7053, 7054, 7056, and 7059 were dry. These results are presented in Table 3.29.

Table 3.29. Mercury results from dry weather sampling at outfall 240 and associated piping network

Sampling Location	Mercury Result (ng/L)	
	Unfiltered	Filtered (Field)
Manhole 2008	**447**	9.33
Manhole 2014	9.88	7.9

*Results in **bold** exceed the AWQC for mercury (51 ng/L).

Wet weather sampling of outfall 230 and its associated drainage network was performed on April 20, 2015. As part of the monitoring of the outfall 230 network, samples were collected at manholes 2003, 3035, 3040, 7011, 7012, 7013, and 7014. Both filtered and unfiltered samples were collected at each location. Table 3.30 contains the results of the wet weather sampling performed in the outfall 230 network.

Table 3.30. Mercury results from wet weather sampling at outfall 230 and associated piping network

Sampling Location	Mercury Result (ng/L)	
	Unfiltered	Filtered (Field)
Outfall 230	36.1	14.2
Manhole 2003	**76.8**	34.7
Manhole 3035	43.2	14.4
Manhole 3040	38.6	16.4
Manhole 7011	**162**	**82.6**
Manhole 7012	**211**	**103**
Manhole 7013	**334**	**160**
Manhole 7014	**963**	**123**

*Results in **bold** exceed the AWQC for mercury (51 ng/L).

Wet weather sampling of outfall 240 and its associated drainage network was completed on September 10, 2015. Both filtered and unfiltered samples were collected at each location. Table 3.31 contains the results of the wet weather sampling performed in the outfall 240 network.

Table 3.31. Mercury results from wet weather sampling at outfall 240 and associated piping network

Location ID	Mercury Result (ng/L)	
	Unfiltered	Filtered (Field)
Outfall 240	**116**	28.1
Manhole 2008	**141**	**87.3**
Manhole 2014	**92.2**	45.6
Manhole 7053	**580**	**415**
Manhole 7054	**706**	**642**
Manhole 7056	**534**	19.2
Manhole 7059	8.34	10.1

*Results in **bold** exceed AWQC for mercury (51 ng/L).

Manholes 7053, 7054, and 7056, which contained the highest levels of mercury detected in the outfall 240 drainage system, are located south of the former Building K-1024 and associated K-1024 Dilution Pit locations. Building K-1024 once housed an instrument maintenance operation, which serviced various types of instruments that may have contained mercury. Instrument cleaning wastes drained into the K-1024 Dilution Pit and onto the storm drain system. It is believed that this operation may be a primary source of the mercury detected in both the outfall 230 and 240 storm water drainage systems. The dilution pit was filled and covered with asphalt several years ago. Building K-1024 was demolished as part of the Building K-25 D&D project.

Mercury at levels above the screening criteria has been identified at each of the outfalls in Table 3.32 during past sampling events. In order to evaluate whether the discharge of mercury from these outfalls is part of an ongoing trend or whether it is an isolated occurrence, additional sampling at the outfalls was conducted in CY 2015 to allow for a sufficient number of data points for trend analysis.

Table 3.32. ETTP outfalls selected for mercury investigation sampling

Sampling location	Sampling event(s)	Mercury (manual grab)
Outfall 100	Wet weather	X
Outfall 195	Wet weather	X
Outfall 230	Wet weather	X
Outfall 240	Wet weather	X
Outfall 280	Wet weather	X

Table 3.33. Analytical results for mercury investigation sampling

Sampling Location	Hg Result (ng/L)
Outfall 100	8.78
Outfall 195	10.3
Outfall 230	15.6
Outfall 240	22.3

As part of the sitewide mercury investigation, a mercury sample was collected at outfall 694 on September 4, 2014. The mercury result from this sample was 910 ng/L. Because the mercury level in this sample was quite elevated, follow-up samples were collected from outfall 694 and from a catch basin in the drainage system of the outfall on July 23, 2015. The mercury results from these samples are indicated in Table 3.34.

Table 3.34. Analytical results for mercury investigation sampling at outfall 694

Sampling Location	Hg Result (ng/L)
Outfall 694 (9/4/14)	**910**
Outfall 694 (7/23/15)	30.5
Catch Basin 1B017	15.4

*Results in **bold** exceed the AWQC for mercury (51 ng/L).

It is believed that the elevated mercury results from the September 2014 sample may have been related to sediment that was present in Poplar Creek water that had historically been pumped into the K-892 Pumphouse and may have been discharged through outfall 694. There is no clear explanation of why the detected mercury level in the follow-up sample differed so greatly from the original sample. Catch basin 1B017 is located upstream of the point where the K-892 Pumphouse discharge enters the outfall 694 network, which may explain why mercury levels in the basin were lower than mercury levels at the outfall.

3.6.2.13 Mercury Sampling Conducted as Part of the NPDES Permit Renewal

Mercury has been sampled at several outfalls as part of the NPDES permit renewal process during CY 2015. Mercury results for these NPDES permit renewal samples exceeded the AWQC of 51 ng/L at outfalls 05A, 180, and 190. The results of the NPDES permit renewal mercury sampling are included in Table 3.35.

Table 3.35. NPDES Permit Renewal - Mercury Monitoring Results – CY 2015

Sampling location	Mercury (ng/L)
Outfall 05A	**360**
Outfall 100	50.1
Outfall 142	3.84
Outfall 170	25.6
Outfall 180	**303**
Outfall 190	**112**
Outfall 195	40
Outfall 198	7.23
Outfall 334	3.24
Outfall 510	10.8

*Results in **bold** exceed the AWQC for mercury (51 ng/L).
NPDES = National Pollutant Discharge Elimination System

3.6.2.14 Sampling of Legacy Chromium Groundwater Plume Discharge

The release of hexavalent chromium into Mitchell Branch from storm water outfall 170 and from seeps at the headwall of outfall 170 resulted in levels of hexavalent chromium that exceeded the AWQC. Immediately below outfall 170, hexavalent chromium levels were measured at levels as high as 0.78 mg/L, which exceeded the state of Tennessee hexavalent chromium water quality chronic criterion of 0.011 mg/L for the protection of fish and aquatic life. The levels of total chromium were at approximately the same value, indicating that the chromium was almost completely hexavalent chromium at the release point. The reason that the chromium was still in a hexavalent state is unknown, considering that hexavalent chromium has not been used in ETTP operations for over 30 years.

On November 5, 2007, DOE notified EPA and TDEC of their intent to conduct a CERCLA time-critical removal action to install a grout barrier wall and groundwater collection system to intercept the chromium-contaminated water discharging from the storm drain 170 outfall and headwall seeps into Mitchell Branch. The action reduced the level of hexavalent chromium in Mitchell Branch by approximately 98%, from 0.78 mg/L to levels as low as 0.014 mg/L, during worst-case dry-weather base flow periods. During wet-weather periods, the level of hexavalent chromium in Mitchell Branch was reduced from 0.025 mg/L to levels that are below method detection thresholds of 0.012 mg/L. The time-critical removal action is documented in the *Removal Action Report for the Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE 2008).

In 2012, the treatment of the chromium collection system water was transitioned from CNF to CWTS. To monitor both the continued effectiveness of the collection system, as well as the effectiveness of the new CWTS, periodic monitoring is performed as part of the ETTP SWPP Program. Samples are collected at monitoring well-289, the chromium collection system wells, storm drain 170, and Mitchell Branch Kilometer (MIK) 0.79. Samples are also collected at monitoring well-289 to monitor the concentrations of chromium in the contaminated groundwater plume. Samples are collected from the chromium collection system wells to monitor the chromium in the water recovered by the groundwater collection system. Samples collected at storm drain 170 monitor the concentrations of the chromium and hexavalent chromium plume being discharged directly to Mitchell Branch. Samples are collected at MIK 0.79 to monitor chromium and hexavalent chromium concentrations in Mitchell Branch. Requirements for this sampling effort are listed in Table 3.36.

Samples at these locations are collected on a quarterly basis during varying wet and dry weather conditions. All of the samples collected as part of this effort are taken using the manual grab sampling method. Manual grab samples are collected according to the guidelines specified in Sections 3.1.2 and 3.3.1 of the EPA's *NPDES Storm Water Sampling Guidance Document* (EPA 1992) and applicable procedures that have been developed by the sampling subcontractor. All guidelines in the *East Tennessee Technology Park Storm Water Pollution Prevention Program Sampling and Analysis Plan* (UCOR-4028, UCOR 2015) were followed as part of this sampling effort. Figures 3.22 and 3.23 are graphs of the analytical data from this sampling effort.

Table 3.36. Monitoring requirements - Mitchell Branch subwatershed total and hexavalent chromium sampling locations

Sampling Location	Parameter	Measurement frequency	Sample type
MIK 0.79	Total chromium	1/quarter	Grab
MIK 0.79	Hexavalent chromium	1/quarter	Grab
Storm Drain-170	Total chromium	1/quarter	Grab
Storm Drain-170	Hexavalent chromium	1/quarter	Grab
Monitoring Well-289 (TP-289)	Total chromium	1/quarter	Grab
Monitoring Well-289 (TP-289)	Hexavalent chromium	1/quarter	Grab
Cr collection system wells (CWTS-INF)	Total chromium	1/quarter	Grab
Cr collection system wells (CWTS-INF)	Hexavalent chromium	1/quarter	Grab

NOTE: Total chromium and hexavalent chromium will be collected during varying weather conditions (for example, samples will be collected during wet-weather conditions one quarter and during dry-weather conditions the following quarter).

MIK = Mitchell Branch kilometer
TP = temporary piezometer
CWTS-INF = Chromium Water Treatment System-Influent

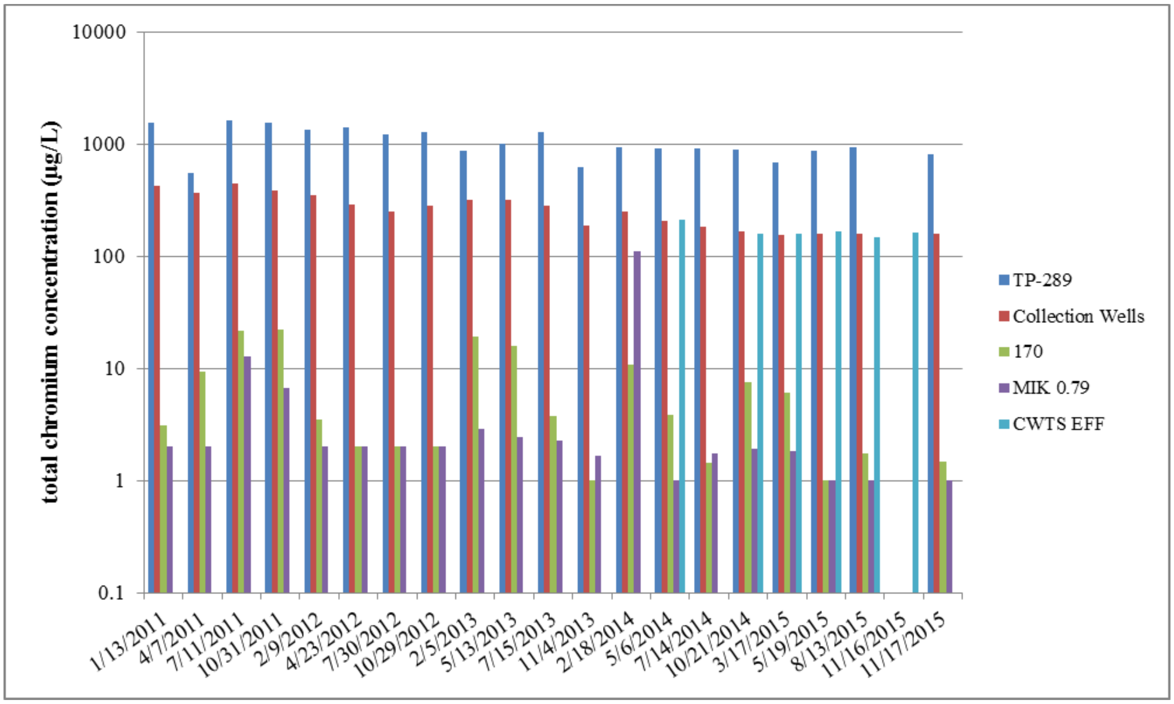


Fig. 3.22. Total chromium sample results for the chromium collection system.
(CWTS EFF = Chromium Water Treatment System Effluent, MIK = Mitchell Branch kilometer, and TP = temporary piezometer)

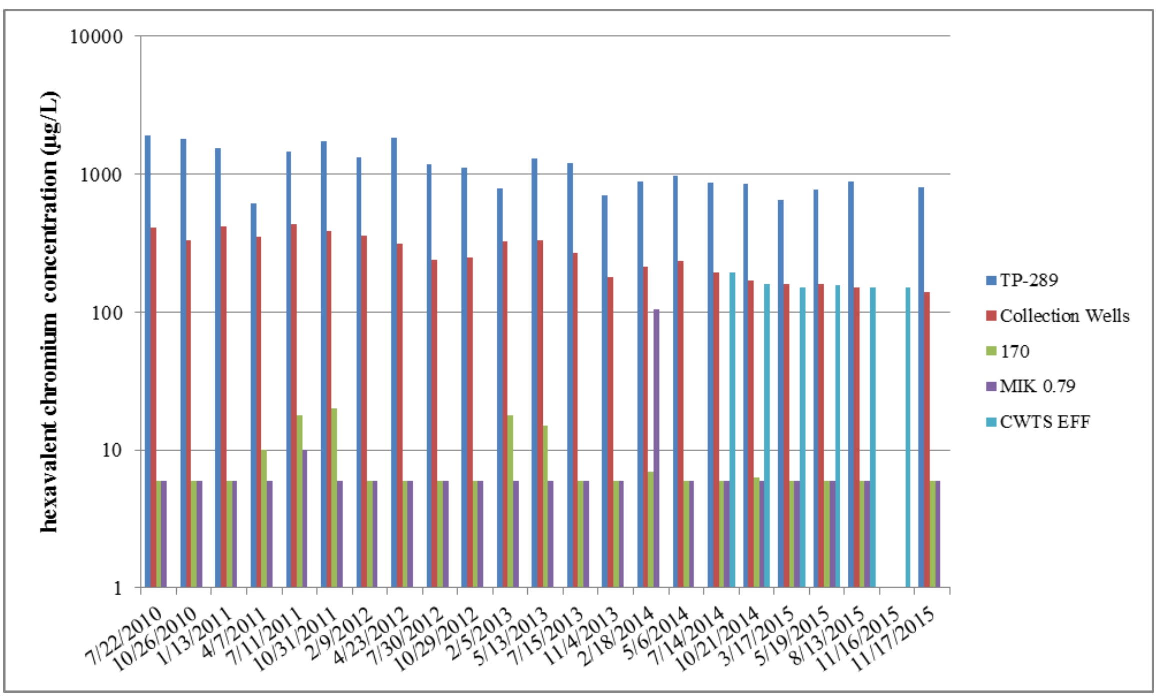


Fig. 3.23. Hexavalent chromium sample results for the chromium collection system.
(CWTS EFF = Chromium Water Treatment System Effluent, MIK = Mitchell Branch kilometer, and TP = temporary piezometer)

The analytical data indicate that chromium levels may fluctuate slightly at temporary piezometer (TP)-289, but are relatively consistent over the long term. Chromium values at outfall 170 and MIK 0.79 have much more variability. This is most likely due to the greater variability in flow rates at these two locations.

Additional monitoring of the CWTS will be performed, as indicated in the *East Tennessee Technology Park Chromium Water Treatment System Sampling and Analysis Plan* (UCOR-4259, UCOR 2014).

3.6.2.15 PCB Monitoring at ETTP Storm Water Outfalls

An evaluation of PCB data collected as part of the ETTP SWPP Program from CY 2000 to the present was performed to identify locations where PCBs have been detected at storm water outfall locations. Many of these locations are representative outfalls under the current ETTP NPDES permit and will be sampled for PCBs as part of the permit renewal sampling effort for the next ETTP NPDES permit application. Therefore, none of the outfalls that will be sampled for PCBs as part of this PCB monitoring program will be sampled during the same year as NPDES permit renewal samples are collected from them. In addition, outfalls that are to be sampled as part of ongoing D&D activities will be sampled the year after D&D activities are expected to be completed. Also, outfalls that are to be sampled as part of upcoming D&D activities will be sampled during the year before D&D activities are expected to begin. Table 3.37 indicates the storm water outfalls that were sampled for PCBs as part of the ETTP SWPP Program sampling effort.

Table 3.37. PCB samples collected during CY 2015

Sampling Location	Parameter[a]	Sample type
Outfall 100	Total PCBs and individual PCB aroclors	Grab
Outfall 210	Total PCBs and individual PCB aroclors	Grab
Outfall 230	Total PCBs and individual PCB aroclors	Grab
Outfall 240	Total PCBs and individual PCB aroclors	Grab
Outfall 360	Total PCBs and individual PCB aroclors	Grab
Outfall 390	Total PCBs and individual PCB aroclors	Grab
Outfall 490	Total PCBs and individual PCB aroclors	Grab
Outfall 700	Total PCBs and individual PCB aroclors	Grab
Outfall 710	Total PCBs and individual PCB aroclors	Grab
Outfall 890	Total PCBs and individual PCB aroclors	Grab

[a] PCB analysis includes: Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268. Total PCBs will also be reported as part of the analytical data package.
PCB = polychlorinated biphenyl

Table 3.38 indicates the analytical results from storm water outfall samples for PCBs collected as part of the ETTP SWPP Program sampling effort.

Table 3.38. PCB samples collected as part of the ETTP SWPP Program sampling effort

Sampling Location	Parameter[a]	Date Sampled	Results Above Detection Limit
Outfall 100	Total PCBs and individual PCB aroclors	8/18/15	PCB-1248 - **0.112 µg/L**
Outfall 210	Total PCBs and individual PCB aroclors	9/10/15	No PCBs detected
Outfall 230	Total PCBs and individual PCB aroclors	8/18/15	No PCBs detected
Outfall 240	Total PCBs and individual PCB aroclors	9/10/15	No PCBs detected
Outfall 360	Total PCBs and individual PCB aroclors	11/30/15	No PCBs detected
Outfall 390	Total PCBs and individual PCB aroclors	8/20/15	No PCBs detected
Outfall 490	Total PCBs and individual PCB aroclors	8/18/15	No PCBs detected
Outfall 700	Total PCBs and individual PCB aroclors	8/20/15	No PCBs detected
Outfall 710	Total PCBs and individual PCB aroclors	8/20/15	No PCBs detected
Outfall 890	Total PCBs and individual PCB aroclors	12/14/15	No PCBs detected

Acronyms
ETTP = East Tennessee Technology Park
PCBs = polychlorinated biphenyls
SWPP = Storm Water Prevention Program

Analytical data collected as part of this storm water monitoring effort will be utilized to provide information for evaluating cleanup decisions and to measure the effectiveness of remedial actions.

The PCB monitoring task will also include monitoring of PCB bioaccumulation in caged clams (*Corbicula fluminea*), which will be placed at selected locations around the ETTP. Additionally, the collection and analysis of fish from Mitchell Branch and three major ponds on the site will also be performed. Both clams and fish from uncontaminated off-site locations are also analyzed as points of reference. The primary contaminants of concern (COC) for these bioaccumulation monitoring tasks at ETTP will be PCBs and mercury. Additional information on these monitoring tasks is provided in the ETTP Biological Monitoring and Abatement Program (BMAP) SAP.

3.6.2.16 NPDES Permit Renewal Monitoring

Preparations for the NPDES permit application that will be submitted to the TDEC in CY 2019 are being made. Additionally, DOE will require time to review the permit application before it is submitted to TDEC. In order for all of the required monitoring to be conducted in time for the permit application to be prepared and submitted, sampling required for the completion of the permit application was initiated as part of the ETTP SWPP Program SAP in CY 2015. Table 3.39 indicates the dates when samples were collected at representative outfalls during CY 2015.

Table 3.39. NPDES permit renewal sampling conducted in CY 2015

Sampling Location	Manual Grab Samples - Date Collected	Manual Grab or Grab-by-Compositor Samples - Date Collected	Composite Samples - Date Collected
05A	8/6/2015	8/6/2015	9/10/2015
100	8/6/2015	8/6/2015	8/18/15
142	8/6/2015	8/6/2015	9/10/2015
150	7/14/2015	7/14/2015	8/6/2015
170	3/19/2015	3/19/2015	6/9/2015
180	3/19/2015	3/19/2015	4/14/2015
190	3/19/2015	3/19/2015	3/19/2015
195	3/19/2015	3/19/2015	11/19/2015
198	9/9/2015	9/9/2015	11/19/2015
230	9/9/2015	9/9/2015	
430	11/18/2015		
510	11/18/2015		

NPDES = National Pollutant Discharge Elimination System

Table 3.40 indicates results from these NPDES permit renewal sampling efforts that exceeded screening criteria. Mercury results that exceeded screening criteria are discussed in Section 3.6.2.12.

Table 3.40. Analytical results exceeding screening levels for NPDES permit renewal sampling in 2015

Sampling Location	Copper (µg/L)
SCREENING LEVEL	**7**
Outfall 150	29.3
Outfall 190	11.8
Outfall 195	7.04

NPDES = National Pollutant Discharge Elimination System

3.6.3 Surface Water Monitoring

During 2015, the ETTP Environmental Monitoring Program (EMP) personnel conducted environmental surveillance activities at 12 surface water locations (Fig. 3.24) to monitor groundwater and storm water runoff at watershed exit pathway locations (K-1700, K-1007-B, and K-901-A) or ambient stream conditions (CRKs 16 and 23; K-1710; K-716; the K-702-A slough; and MIKs 0.45, 0.59, 0.71, and 1.4). As part of monitoring the ambient stream conditions, K-1700 and MIKs 0.45, 0.59, 0.71, and 1.4 were sampled and analyzed quarterly for radionuclides, and CRKs 16 and 23, K-716, and the K-702-A slough were sampled semiannually.

At MIKs 0.45, 0.59, and 0.71, quarterly monitoring is only conducted for ^{99}Tc only. Results of radiological monitoring were compared with the Derived Concentration Standards (DCS) values in DOE Standard 1196 (DOE 2011). 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 become available. If the average SOF for a location exceeds the DCS requirement of remaining below 1.0 (100%) for the year, a source investigation is required. Sources exceeding DCS requirements would need an analysis of the best available technology to reduce the SOF of the radionuclide concentrations to less than 1.0 (100%). At the majority of locations, the monitoring results yielded SOF values of less than 0.01 (1% of the allowable DCS) (Fig. 3.25). The exception was K-1700 with an SOF of 0.015 (1.5% of the allowable DCS).

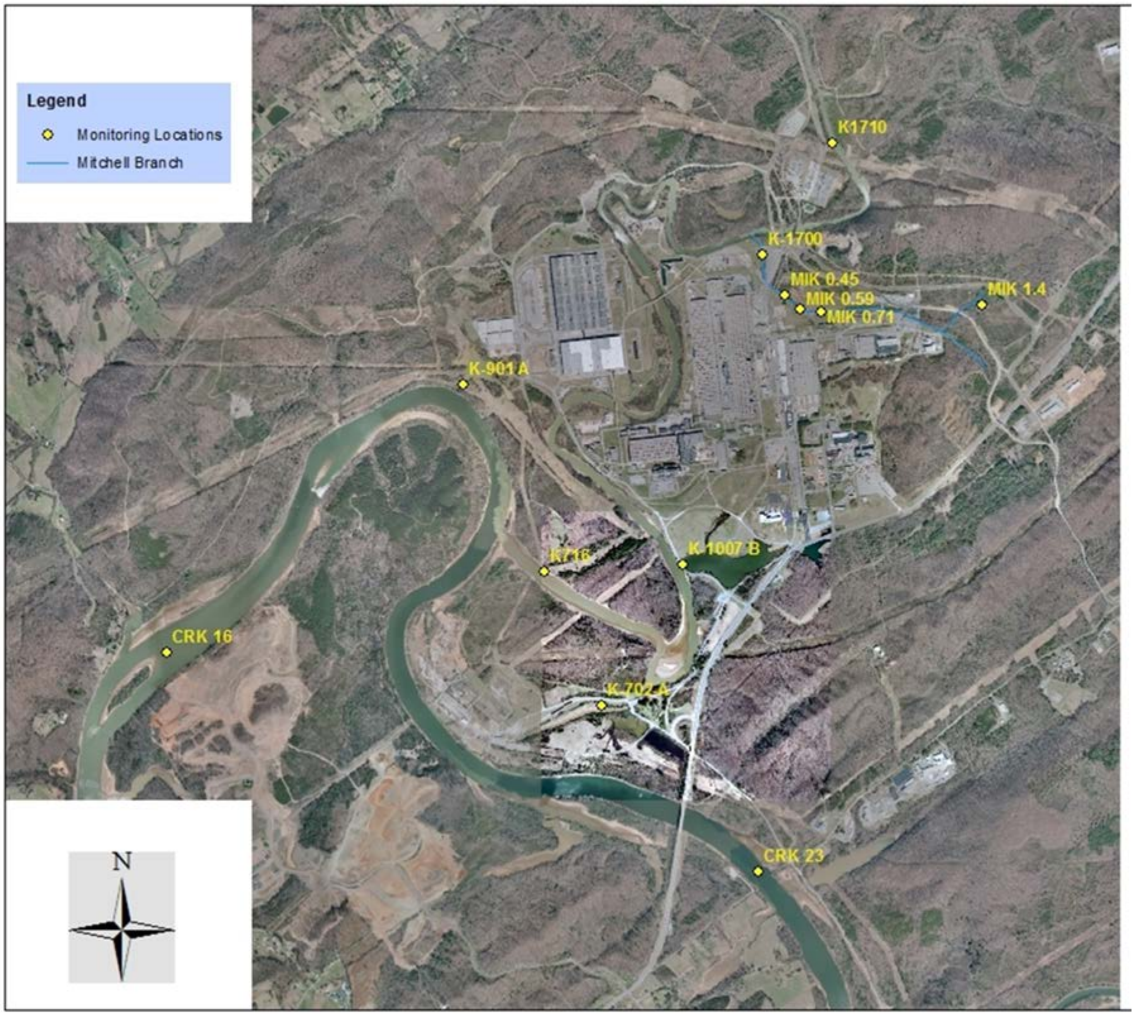


Fig. 3.24. East Tennessee Technology Park Environmental Monitoring Program surface water monitoring locations. *(CRK = Clinch River kilometer and MIK = Mitchell Branch kilometer)*

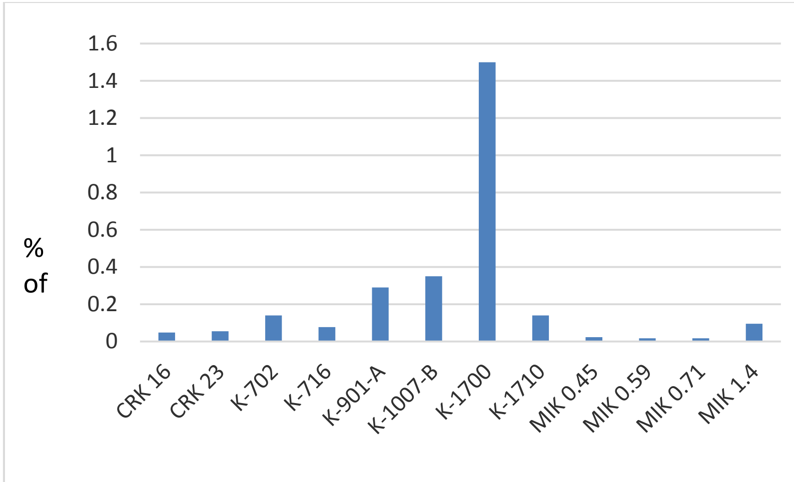


Fig. 3.25. Annual average percentage of derived concentration standards (DCSs) at surface water monitoring locations, 2015. *(CRK = Clinch River kilometer and MIK = Mitchell Branch kilometer)*

Depending on the monitoring location, water samples may be analyzed for pH, selected metals, and VOCs. In 2015, results for most of these parameters were well within the appropriate AWQC. The two exceptions were an exceedance of mercury at K-1710 during the second quarter and an exceedance of lead at K-901-A during the third quarter of 2015. The level of mercury during the second quarter at K-1710 was measured at 96.6 ng/L, which exceeded the AWQC of 51 ng/L. This location is in Poplar Creek upstream from the ETTP surface water influence, so it is doubtful that ETTP operations were the source. The level of lead in the water at the K-901-A monitoring location during the third quarter was measured at 4.5 µg/L, which slightly exceeded the hardness dependent AWQC of 4.4 µg/L. This level of lead is not typical at this location, and no operations were ongoing in the vicinity that might have caused the exceedance. No obvious signs of distress (e.g., dead fish) were observed to be associated with any of these exceedances in 2015.

Figures 3.26 and 3.27 illustrate the concentrations of TCE (trichloroethene) and cis-1,2-dichloroethene (cis-1,2-DCE) from the K-1700 weir (which is used to monitor Mitchell Branch), the only surface water monitoring location where VOCs are regularly detected. Concentrations of TCE and total 1,2-DCE are below the AWQCs for recreation, organisms only (300 µg/L for TCE and 10,000 µg/L for trans-1,2-DCE), which are appropriate standards for Mitchell Branch. Moreover, the standards for 1,2-DCE apply only to the "trans" form of 1,2-DCE; almost all of the 1,2-DCE is in the cis isomer. In addition, vinyl chloride has sometimes been detected in Mitchell Branch water (Fig. 3.28). 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; however, storm drain network monitoring generally has not detected these compounds in the storm water discharges. When detected, the concentrations are lower than in the stream. Therefore, it appears that the primary source of these compounds is contaminated groundwater.

Since 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 (Fig. 3.29). In 2015, hexavalent chromium levels in Mitchell Branch were all below the detection limit of 6 µg/L.

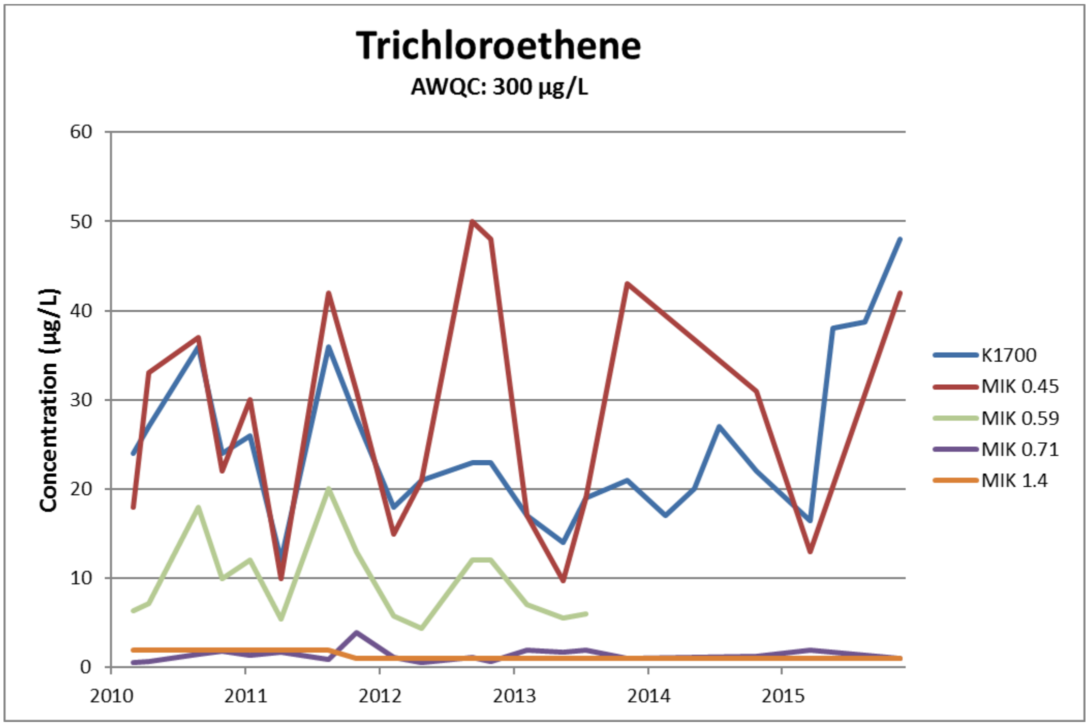


Fig. 3.26. Trichloroethene concentrations in Mitchell Branch.
(MIK = Mitchell Branch kilometer and AWQC = ambient water quality criterion)

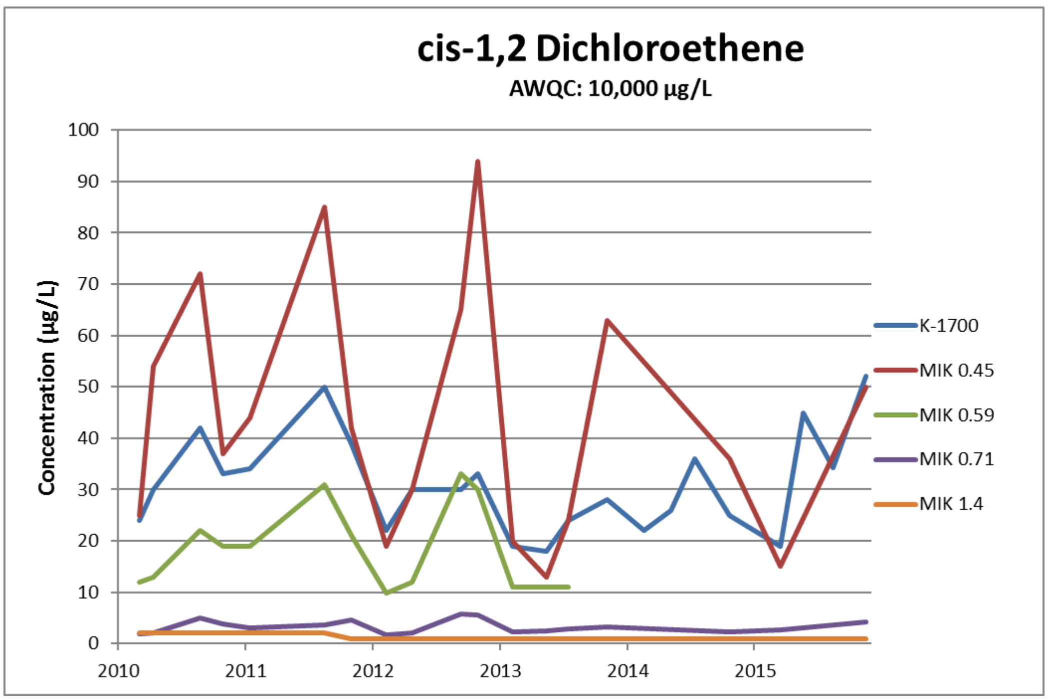


Fig. 3.27. Concentrations of cis-1,2-dichloroethene in Mitchell Branch.
(MIK = Mitchell Branch kilometer and AWQC = ambient water quality criterion)

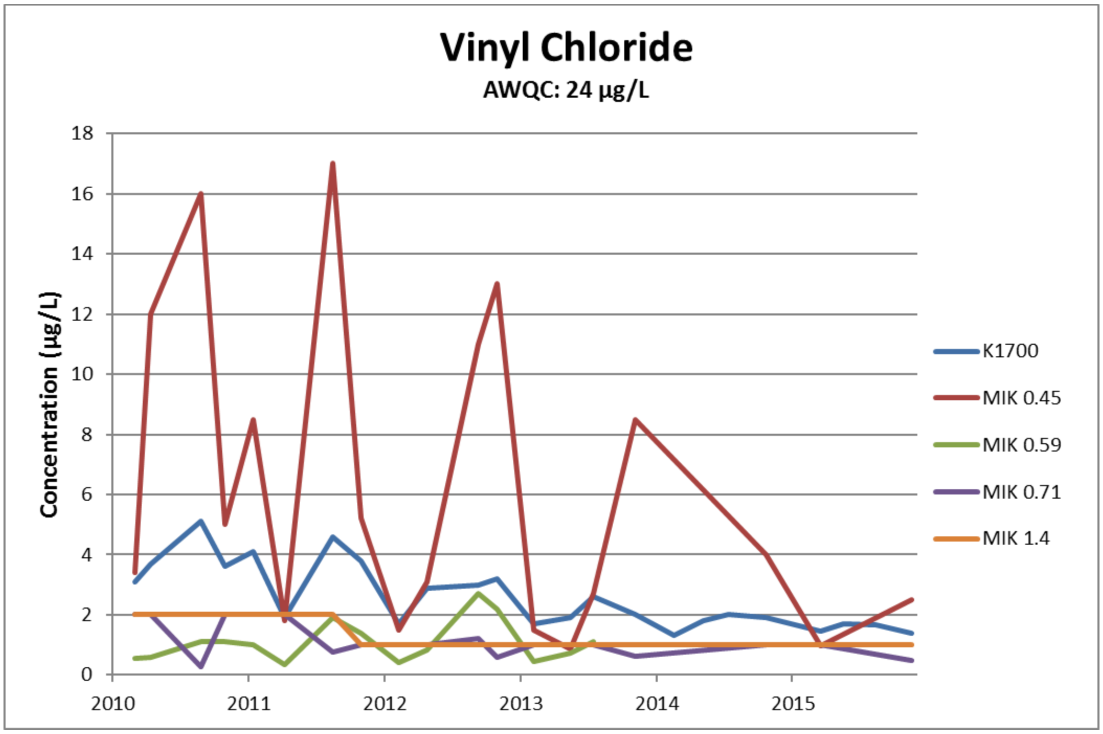


Fig. 3.28. Vinyl chloride concentrations in Mitchell Branch.
(MIK = Mitchell Branch kilometer and AWQC = ambient water quality criterion)

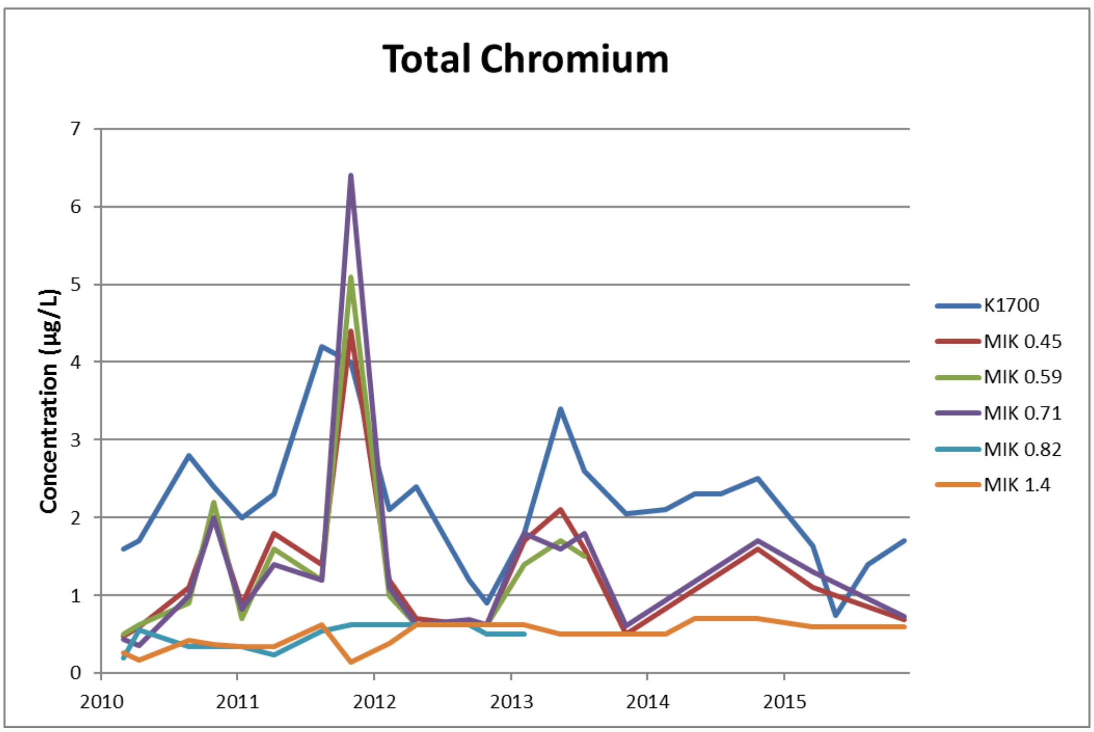


Fig. 3.29. Total chromium concentrations at K-1700.
[The AWQC for Cr(III), which is hardness dependent, is 74 µg/L, based on a hardness of 100 mg/L. The AWQC for Cr(IV) is 11 µg/L. (AWQC = ambient water quality criterion, MIK = Mitchell Branch kilometer)]

3.6.4 Groundwater Monitoring

3.6.4.1 Performance Monitoring Goals and Objectives

Major components of the *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2161&D2, DOE 2005) selected remedy are:

- Assess data sufficiency for each exposure unit (EU) and supplement data as necessary to determine if remediation levels are exceeded.
- Remove soil up to 10 ft in depth that exceeds remediation levels set to protect a future industrial worker.
- Remove soil to water table, bedrock, or acceptable levels of contamination, whichever is the shallowest, to protect underlying groundwater to maximum contaminant level (MCLs) and to protect human health and the environment.
- Remove or decontaminate the contaminated portions of slabs, vaults, basements, pits, tanks, pipelines, or any other subsurface structure that exceed the remediation levels to protect a future industrial worker to a depth no more than 10 ft. Use soil or concrete debris that meets Zone 2 remediation levels as backfill material in basements and deep excavations.
- Remove the debris in the K-1070-B Burial Ground, regardless of depth to minimize potential future impact to surface water and soil that exceeds remediation levels for protection of workers (upper 10 ft) or protection of groundwater (water table or bedrock surface).
- Remove the debris and soil in the K-1070-C/D Burial Ground that exceeds remediation levels for the protection of workers (upper 10 ft) or protection of groundwater (water table or bedrock surface).
- Verify all acreage in Zone 2 as compliant with soil remediation levels established by the record of decision (ROD).
- Implement land use controls (LUCs) to prevent exposure to residual solid contamination left on-site and/or to prevent residential use of the land.

Zone 2 was divided into 44 EUs for planning and evaluation purposes. Final status assessments and associated data gap sampling efforts for EUs in Zone 2 are being conducted using a Dynamic Verification Strategy (DVS) in accordance with the *Remedial Design Report/Remedial Action Work Plan for the Zone 2 Soils, Slabs, and Subsurface Structures, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2224&D4, DOE 2015c). Successful completion of the Zone 2 cleanup requires that each of these 44 EUs be characterized, evaluated against the Zone 2 risk criteria, and remediated if necessary.

The Remediation Action Objectives for Zone 2 are to:

- Protect human health under an industrial land use to an excess cancer risk level at or below 1×10^{-4} and non-cancer risk levels at or below an HI [Hazard Index] of 1, and
- Protect groundwater to levels at or below MCLs.

Drinking water MCLs are used as screening criteria for evaluating the effectiveness of soil, buried waste, and subsurface structure cleanup. The ROD, however, specifically defers groundwater and surface water cleanup to a later CERCLA action and does not include ARAR-based performance objectives for groundwater cleanup.

The monitoring requirements are monitoring of groundwater adjacent to potential sources of groundwater contamination, including the K-1070-C/D Burial Ground (DOE/OR/01-2161&D2, DOE 2005). This monitoring will continue until the sitewide ROD is approved.

Figure 3.30 shows watershed scale and CERCLA performance monitoring locations at ETTP (groundwater monitoring locations are shown on separate figures as indicated). Table 3.41 lists performance monitoring conducted for the Zone 2 ROD and other CERCLA actions at ETTP. ETTP does not have a sole surface water integration point at which all upstream contaminant releases converge to exit the watershed, but has several subwatersheds. Therefore, there are several surface water integration points.

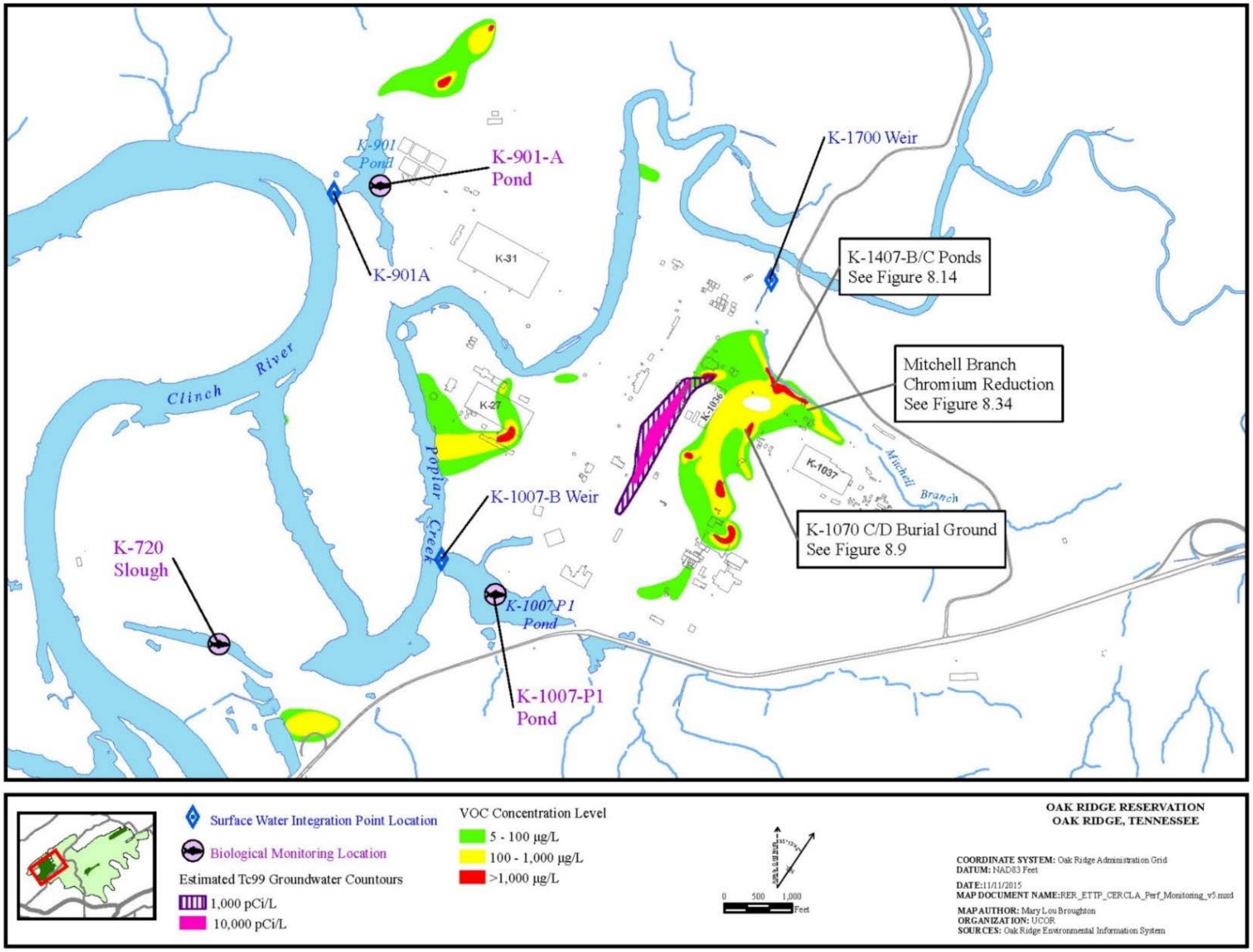


Fig. 3.30. Watershed scale and CERCLA performance monitoring locations at ETTP.*(CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act and VOC = volatile organic compound)*

Table 3.41. CERCLA action performance monitoring in the ETTP administrative watershed[a]

CERCLA action	Performance goal	**Performance standard**	**Monitoring location(s)**	**General schedule and monitored parameters**
		Performance Monitoring		
Zone 2 Soil, Buried Waste, and Subsurface Structure RAs (includes K-1070-C/D Burial Ground)	Protect human health under an industrial land use to an ELCR at or below 1×10^{-4} and non-cancer risk levels at or below a HI of 1 Protect groundwater to levels at or below MCLs for drinking water	Drinking water MCLs	*Groundwater* TMW-011 UNW-064 UNW-114	Semiannual sampling (seasonally wet and dry conditions) Laboratory analyses for VOCs and water quality parameters
Long-term Reduction of Hexavalent Chromium Releases to Mitchell Branch (Non-TC RmA)	Collect and treat hexavalent chromium-contaminated groundwater to reduce its toxicity prior to discharge into Mitchell Branch Protect water quality in Mitchell Branch at levels consistent with AWQC	Hexavalent chromium concentrations below 0.011 mg/L AWQC in Mitchell Branch immediately downstream of SD-170 discharge	*Surface water* MIK-0.79 SD-170 *Groundwater* TP-289 IW-416 and IW-417 *Treatment System Discharge*	Quarterly sampling of all monitoring locations Laboratory analyses (unfiltered samples) for total and hexavalent chromium in surface water, groundwater, and treatment system discharge samples Treatment system discharge samples also analyzed for pH, total uranium, VOCs, gross alpha and beta, and select radionuclides
K-1407-B/C ponds RA	Reduce potential threats to human health and the environment posed by residual contamination in pond soils by providing isolation and shielding with rock fill and intact soil cover	Remediation target concentrations were not established in the CERCLA decision or post-decision documents	*Surface water* K-1700 weir *Groundwater* UNW-003 UNW-009	Semiannual sampling Laboratory analyses for nitrate, field parameters, VOCs, metals, gross alpha and beta, ^{99}Tc, ^{90}strontium (^{90}Sr), ^{137}cesium (^{137}Cs), $^{230/232}$thorium (^{230,232}Th), and $^{234/238}$U

[a]Changes to performance monitoring for RAs require prior approval from the EPA and TDEC.

Table 3.41 (continued)

CERCLA action	Performance goal	Performance standard	Monitoring location(s)	General schedule and monitored parameters
K-901-A and K-1007-P1 holding ponds and K-720 slough RA	The goal of the ecological enhancement performed at the K-1007-P1 holding pond is to establish a new steady-state condition within the pond that reduces risks from PCBs by enhancing components of the ecology that minimize PCB uptake, which will reduce risks to human and piscivorous wildlife by interdicting contaminant exposure pathways associated with these receptors	PCB concentration of 1 mg/kg in fish fillets (2.3 mg/kg whole body)	Operational Monitoring at K-1007-P1 pond only:	
			1. Presence of original fish	1. Once, after fish removal
			2. PCBs in fish	2. Annually
			3. Condition of vegetation	3. 2×/yr during growing season
			4. Species of fish	4. Annually
			5. Water quality	5. 3×/yr during growing season
			6. PCBs in clams	6. Four locations annually for a four week exposure
			7. Geese/waterfowl population	7. Monthly identification and enumeration of all waterfowl in and around pond
			Performance Monitoring at K-1007-P1 & K-901-A holding ponds, and K-720 slough:	
			1. PCBs in fish	1. Annually for four years, then reassess for every other year until acceptable risk documented for each pond
			2. Species of fish in K-1007-P1 only	2. Annually for four years (reassess after four years, as above)
			3. PCBs in clams in K-1007-P1 only	3. Four locations annually for a four week exposure (reassessed after four years, as above)

[a]Changes to performance monitoring for RAs require prior approval from the EPA and TDEC.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
ELCR = excess lifetime cancer risk
HI = hazard index
MCL = maximum contaminant level
RA = remedial action
RmA = Removal Action
TC = time critical
VOC = volatile organic compound

3.6.4.2 Evaluation of Performance Monitoring Data

Monitoring locations, analytical parameters, and cleanup levels were not specified for groundwater monitoring at the K-1070-C/D Burial Ground (Fig. 3.31), although the primary COCs in that area are VOCs. Semiannual samples are analyzed for VOCs and general water quality parameters in wells and surface water locations outside the perimeter of the burial ground. Monitoring at the site is focused on providing data for evaluating changes in contaminant concentrations near the source units or potentially discharging to surface water within the boundaries of the ETTP. Approximately 9,000 gal of mixed volatile organic liquids were disposed in G-Pit. Historic data showed that 1,1,1-TCA was present at very high concentrations in wells monitored near the site. 1,1,1-TCA is amenable to biodegradation to 1,1-DCA by microbes in the *Dehalobacter* genus. Although 1,1-DCA is also amenable to degradation by some species of *Dehalobacter*, the presence of cis-1,2-DCE and vinyl chloride (VC) tend to inhibit the biodegradation of 1,1-DCA. Cis-1,2-DCE and VC are common biodegradation products of tetrachloroethene (PCE) and TCE, which are also present in groundwater at the site, along with 1,1-DCE, another biodegradation product of PCE and TCE.

Following remediation of G-Pit, monitoring wells UNW-114, TMW-011, and UNW-064 (Fig. 3.31) were selected to monitor the VOC plume leaving the K-1070-C/D Burial Grounds, because they were located in the principal known downgradient groundwater pathway. Results of monitoring at these wells show elevated VOC concentrations. VOC concentrations at these three wells were decreasing prior to the excavation of the G-Pit contents (during FY 2000) and continue to decrease. Although 1,1,1-TCA was formerly present at concentrations far greater than its 200 µg/L MCL, natural biodegradation has reduced its concentrations to less than the drinking water standard. Several direct push monitoring points were installed to the west of UNW-114 during investigations conducted in support of a Sitewide Groundwater Remedial Investigation in 2005 (*Final Sitewide Remedial Investigation and Feasibility Study for East Tennessee Technology Park, Oak Ridge Tennessee*. DOE/OR/01-2279&D3, DOE 2007). 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 two of these points (DPT-K1070-5 and DPT-K1070-6) to measure VOC concentrations and their fluctuations.

Of the three wells monitored at this site, well UNW-114 is closest to the source area. Monitoring data for well UNW-114 (Fig. 3.32) show that concentrations of most VOCs have been variable since 2005 and exhibit no trend or a stable trend. Concentrations of 1,1-DCA have gradually increased from a minimum of about 140 µg/L in 2007 to a recent concentration of 890 µg/L. 1,1,1-TCA was not detected in the March 2015 sample, but was detected at 0.3 J µg/L in an August 2015 sample from well UNW-114 during FY 2015. The lingering 1,1-DCA residual in groundwater is evidence of the former presence of high concentrations of 1,1,1-TCA in the area. Recent concentrations of most chlorinated VOCs in well UNW-114 are within factors of about two to five times their MCLs.

Well UNW-064 is located slightly further downgradient from the contaminant source area than UNW-114 and its monitoring data exhibit a slightly different behavior. Similar to the overall trend observed at UNW-114, the majority of VOC concentrations at UNW-064 (Fig. 3.33) decreased from about 2002 through 2005. Concentrations remained relatively low through the drought years of 2006 into 2008, and increased between 2008 and 2010. Since 2010, VOCs in well UNW-064 have exhibited stable to gradually decreasing concentrations with fairly strong seasonal fluctuations. At UNW-064 the 1,1-DCA, 1,1-DCE, cis-1,2-DCE, and TCE show a seasonal concentration fluctuation with higher concentration during winter than during summer. This seasonal fluctuation suggests that contaminant mass transport responds to increased groundwater recharge and seepage through the plume. DOE suspects that increased seasonal recharge drives mass transfer in the plume through two combined mechanisms. One mechanism is a rise in groundwater elevation in the source area (residual liquid waste beneath "G-Pit"), which allows groundwater seepage through fractures of higher permeability at a somewhat shallower depth. The second mechanism is simply a higher flow volume through the source area and downgradient fractures caused by the higher head imposed on the whole saturated zone. Cis-1,2-DCE, PCE, and VC have decreased to concentrations less than their respective MCLs in well UNW-064. TCE continues to fluctuate at concentrations approximately two to five times its MCL and 1,1-DCE concentrations are about five to ten times the MCL.

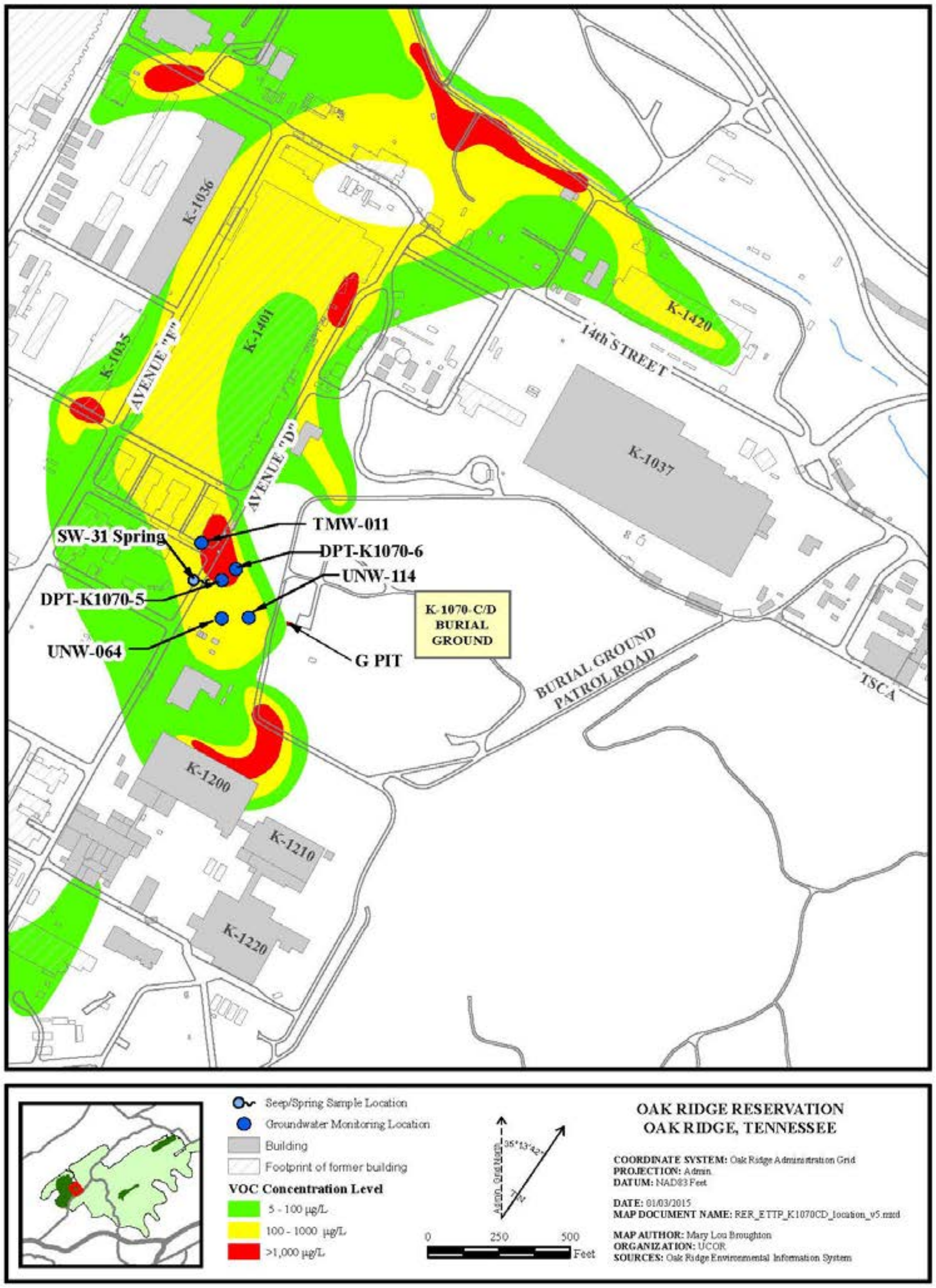


Fig. 3.31. Location map for K-1070-C/D Burial Ground.
(VOC = volatile organic compound)

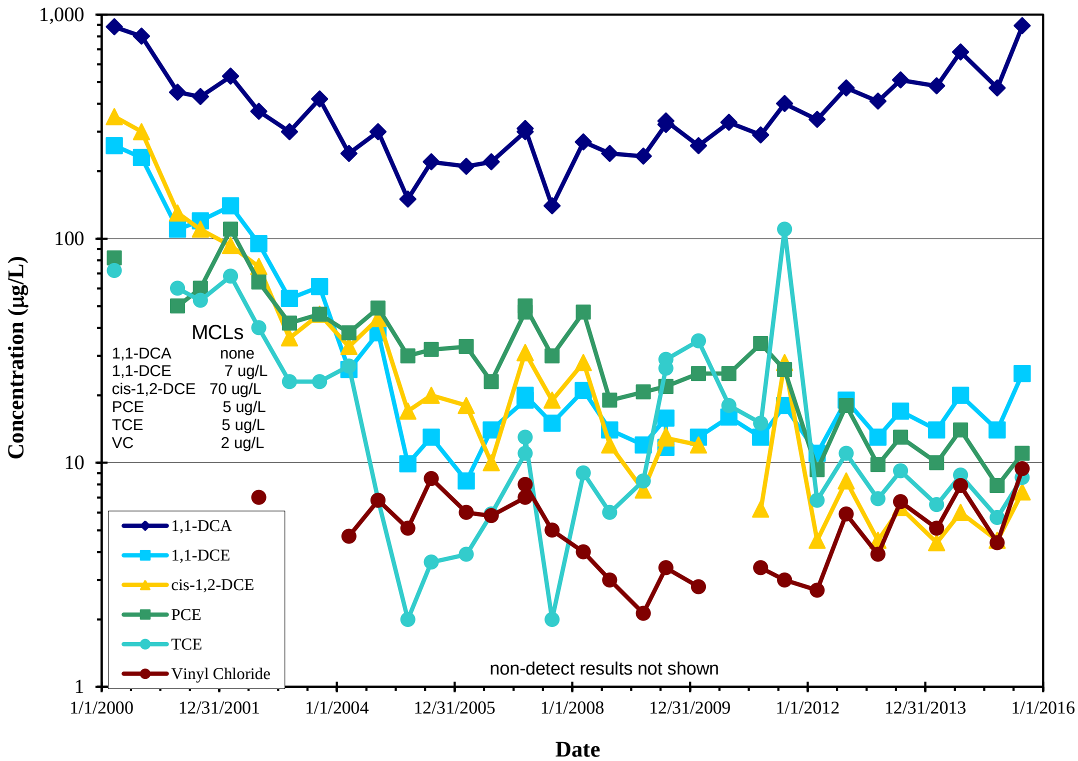


Fig. 3.32. VOC concentrations in well UNW-114 2002-2015.
(MCL = maximum contaminant level)

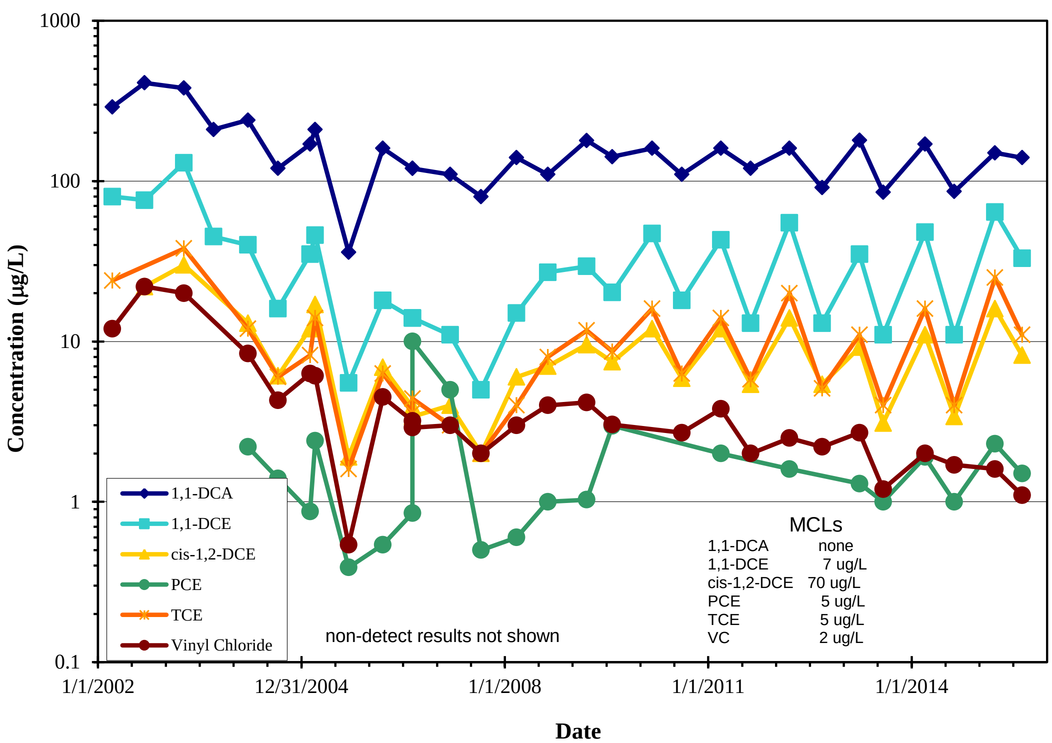


Fig. 3.33. VOC concentrations in well UNW-064 2000–2015.
(MCL = maximum contaminant level)

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 that the seasonal signature is reversed with higher concentrations in summer than during winter. This relationship suggests that 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. Like the other two wells, VOC concentrations (Fig. 3.34) decreased from 2000 until early 2005, after which concentrations have fluctuated seasonally within a gradual downward trend through about 2011. Since the summer of 2012, concentrations have experienced another step-like decrease. Cis-1,2-DCE and PCE have remained below their respective MCLs since the winter of 2012. Since the winter sampling event in 2012, VC concentrations have fluctuated with winter concentrations being below the MCL and summer concentrations exceeding the MCL by factors of two to three. TCE and 1,1-DCE concentrations fluctuate at concentrations about five to 15 times their respective MCLs.

Monitoring locations DPT-K1070-5 and DPT-K1070-6 (Fig. 3.31) were installed using direct-push technology and therefore they sample groundwater just at, and somewhat above the top of bedrock. At these locations very high concentrations of 1,1,1-TCA, 1,1-DCE, and TCE persist (Fig. 3.35). Overall decreasing trends for TCE, 1,1,1-TCA and its degradation product 1,1-DCE are apparent at well DPT-K1070-5, while 1,1,1-TCA in DPT K-1070-6 fluctuates in a concentration range well above its MCL. High concentrations (500–1,000 µg/L) of cis-1,2-DCE are present in addition to some values for 1,1,1-TCA, 1,1-DCA, 1,1-DCE, and TCE in this concentration range. Other VOCs that were found in the excavated material from G-Pit, such as 1,1,2-TCA, 1,2-dimethylbenzene and chloroform, continue to be detected in these monitoring points.

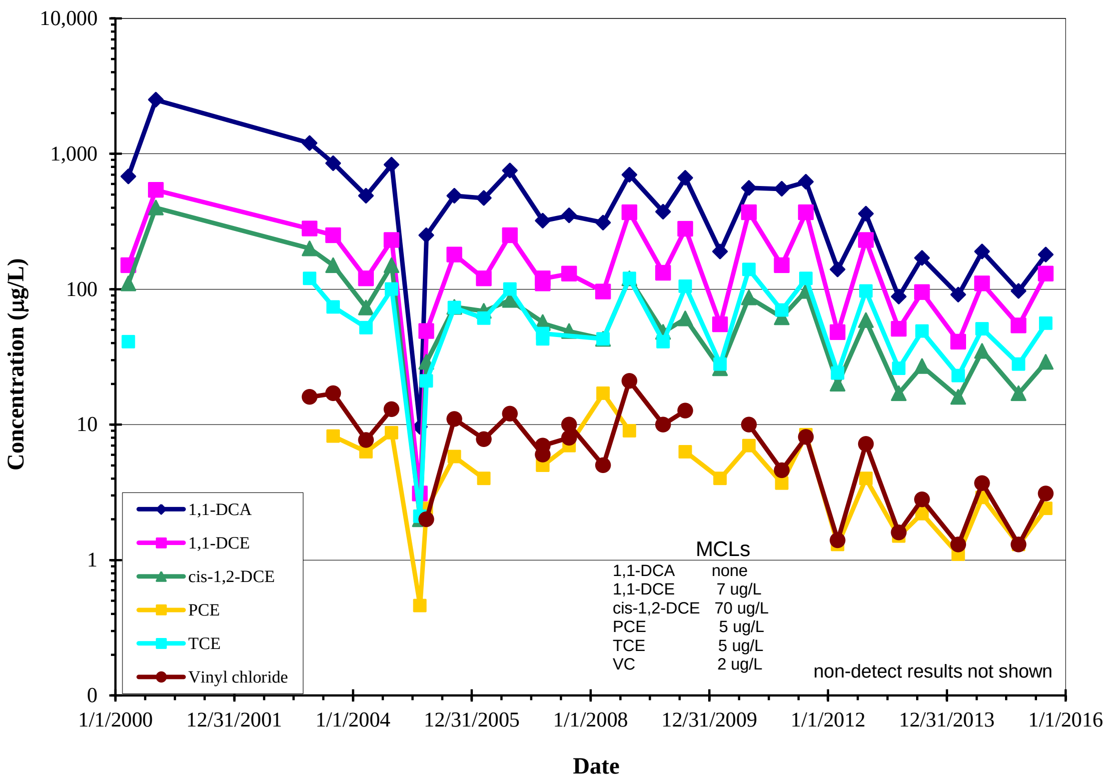


Fig. 3.34. VOC concentrations in well TMW-011 2000–2015.
(MCL = maximum contaminant level)

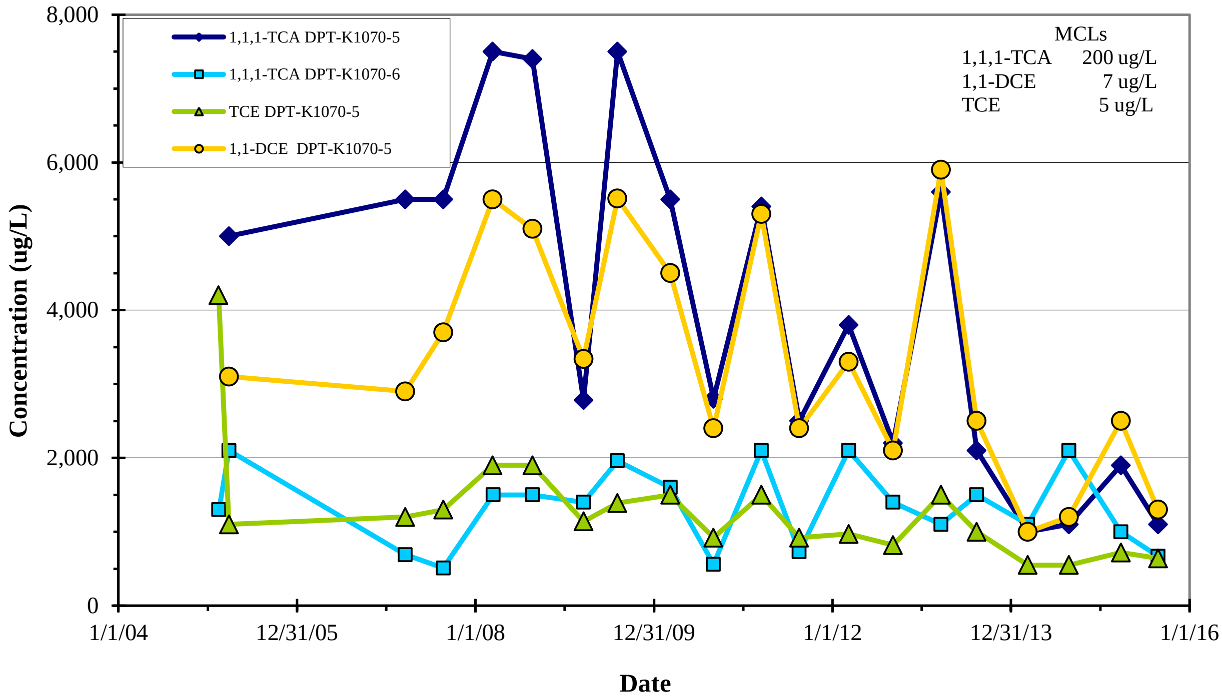


Fig. 3.35. Concentrations of selected VOCs in DPT-K1070-5 and DPT-K1070-6.
(MCL = maximum contaminant level)

3.6.4.3 Performance Summary

VOC concentrations in wells monitored downgradient of K-1070-C/D show that a broad area is affected by the releases from the G-Pit liquid VOC disposals. While concentrations along one portion of the impacted area continue to decrease, there remains a known area with very high concentrations of the contaminants disposed at the site. The persistent, very high concentrations of these VOCs suggest that a dense nonaqueous phase liquid (DNAPL) source beneath and/or downgradient of the G-Pit continues to release mass into the plume.

3.6.5 Other Long-Term Stewardship Requirements

Other long-term stewardship (LTS) requirements for the Zone 2 ROD are described below.

3.6.5.1 Requirements

The R*ecord of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2161&D2, DOE 2005) establishes "industrial" as the land use to a depth of 10 ft. To implement restrictions that prohibit residential or agricultural use of this area under the ROD and to restrict access to this area until that end use has been achieved, seven LUCs will be implemented: (1) property record restrictions, (2) property record notices, (3) zoning notices, (4) the excavation/penetration permit (EPP) program, (5) access controls, (6) signs, and (7) surveillance patrols. The objectives of these Zone 2 LUCs follow:

- Control land use to prevent exposure to contamination by controlling excavations or soil penetrations below 10 ft and prevent uses of the land involving exposures to human receptors greater than those from industrial use. Significant accumulations of material with residual contamination above unrestricted use levels will also be monitored and controlled. This will avoid accumulation of contamination placed in an area not currently designated for disposal that could reestablish a risk to a future industrial user.

- Prohibit the development and use of property for residential housing, elementary or secondary schools, childcare facilities, children's playgrounds, other prohibited commercial uses, or agricultural use.

- Maintain the integrity of any existing or future monitoring systems until the ETTP sitewide residual contamination RA is implemented.

- Control and restrict access to workers and the public to prevent unauthorized uses and maintain signs to provide notice or warning to prevent unauthorized access.

- Maintain the integrity of access controls and signs at the K-1070-C/D Burial Ground for as long as the residual debris represents a concern.

Until remediation is complete and the industrial land use is achieved, the seven LUCs mentioned above will be implemented to restrict residential or agricultural use of the land. Reliance will be primarily on property record and zoning notices, the EPP program, access controls, and surveillance patrols. Once remediation is complete, property record restrictions, property record and other public notices, zoning notices, excavation permits, and less intensive surveillance patrols and fences for the short-term at the K-1070-C/D Burial Grounds will be used. In addition, when an area within Zone 2 is transferred, property record restrictions and notices will be implemented.

The PCCRs completed under the *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2161&D2, DOE 2005) state that the No Further Action (NFA) decision means that an EU is available for unrestricted industrial use to a depth of 10 ft below ground surface (bgs) and NFA is required beyond the LUCs specified in the Zone 2 ROD.

3.6.5.2 Status of Requirements

General LUCs for Zone 2 remained in place during FY 2015. Signs were maintained to control access and surveillance patrols were conducted as part of routine surveillance and maintenance (S&M) inspections. The EPP program functioned according to established procedures and plans for the site. Required mowing was performed. Additionally, signs and access controls at the K-1070-C/D Burial Ground were inspected annually by the ETTP S&M Program.

3.6.6 K-1407-B/C Ponds

The *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, DOE 1993) addressed potential risks associated with residual wastes and soils remaining in the K-1407-B/C ponds from the initial removal of sludge conducted as a previous RCRA closure action. The location of the K-1407-B/C ponds at ETTP is shown in Fig. 3.36.

Components of the selected remedy include the following activities:

- Placement of clean soil and rock fill for isolation and shielding,

- Maintenance of institutional controls, and
- Groundwater monitoring to assess performance of the action and develop information for use in reviewing the effectiveness of the remedy.

3.6.6.1 Performance Monitoring

3.6.6.1.1 *Performance Monitoring Goals and Objectives*

The objective of the K-1407-B/C ponds remediation was to reduce potential threats to human health and the environment posed by residual metal, radiological, and VOC contamination within the pond soils (DOE/OR/01-1125&D3, DOE 1993).

The *Remedial Action Report for the K-1407-B Holding Pond and the K-1407-C Retention Basin, Oak Ridge, Tennessee* (DOE/OR/01-1371&D1, DOE 1995) proposes semiannual groundwater monitoring for nitrate, metals, and selected radionuclides, including gross alpha and beta activity, ^{99}Tc, ^{90}strontium (^{90}Sr), ^{137}cesium (^{137}Cs), $^{230/232}$thorium ($^{230/232}$Th), and $^{234/238}$U. Target concentrations for these parameters were not established in the CERCLA documents (DOE 1993, DOE 1995) for use in post-remediation monitoring to evaluate effectiveness. Performance monitoring is conducted in wells UNW-003, UNW-009, and the Mitchell Branch weir (K-1700 weir).

3.6.6.1.2 *Evaluation of Performance Monitoring Data*

The primary groundwater contaminants in the K-1407-B/C ponds area are VOCs. VOCs are widespread in this portion of ETTP, including contaminant sources upgradient of the ponds. Groundwater samples were collected at UNW-003 and UNW-009 in March and August/September 2015. VOCs are not detected in shallow groundwater north of Mitchell Branch in well UNW-009. VOC concentration data for well UNW-003 for the time span 2001 through 2015 are shown on Fig. 3.37. Monitoring results for FY 2015 at the wells are generally consistent with results from previous years although concentrations of PCE and TCE have increased during FYs 2014 and 2015 compared to levels measured during the preceding several years. The detection of VOCs at concentrations well above 1,000 µg/L and the steady concentrations over recent years suggest the presence of DNAPLs in the vicinity of well UNW-003. The sitewide ROD will address groundwater contamination present in the area of the former ponds.

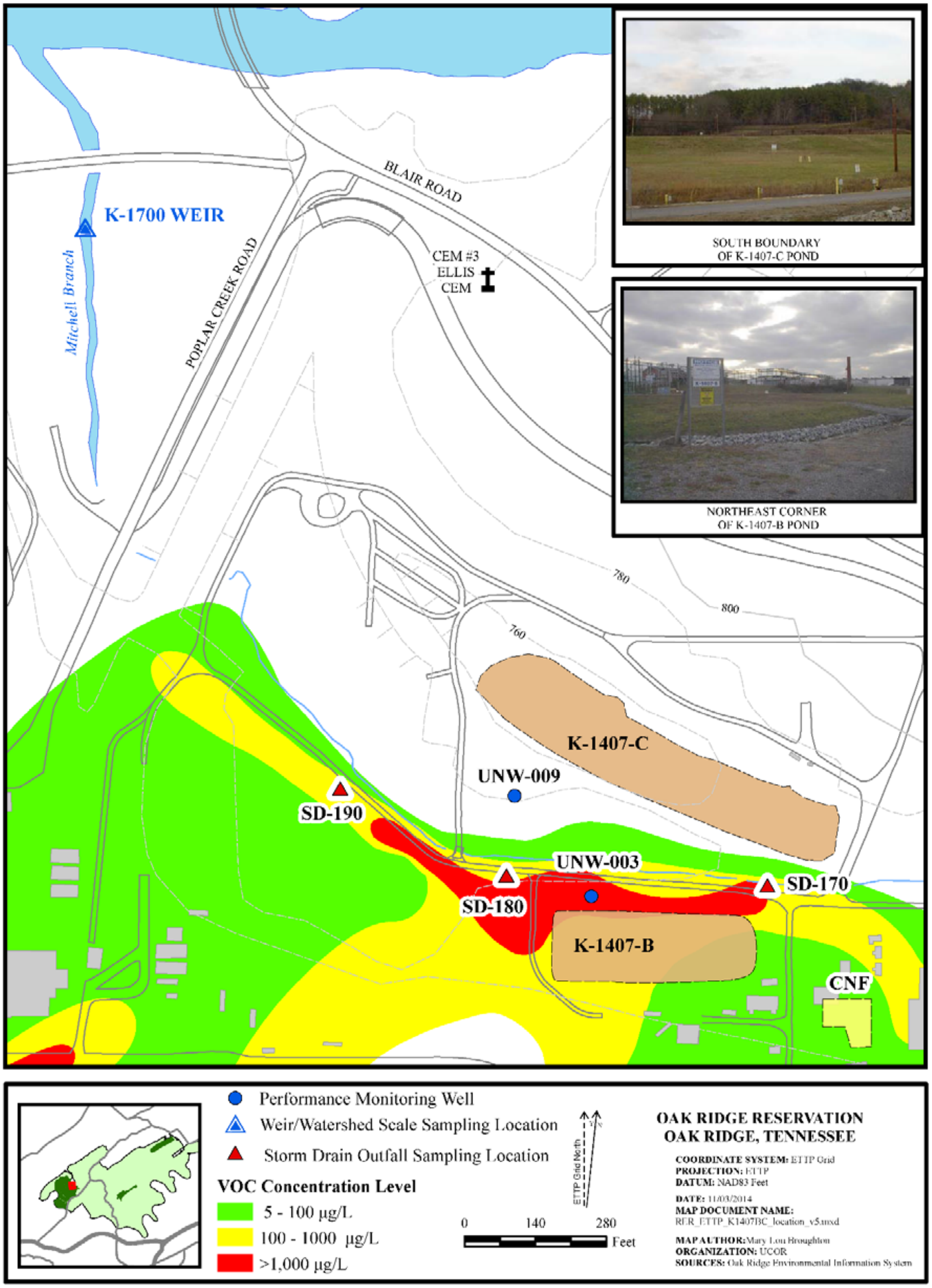


Fig. 3.36. Location of K-1407-B/C ponds.
(SD = storm water outfall and VOC = volatile organic compound)

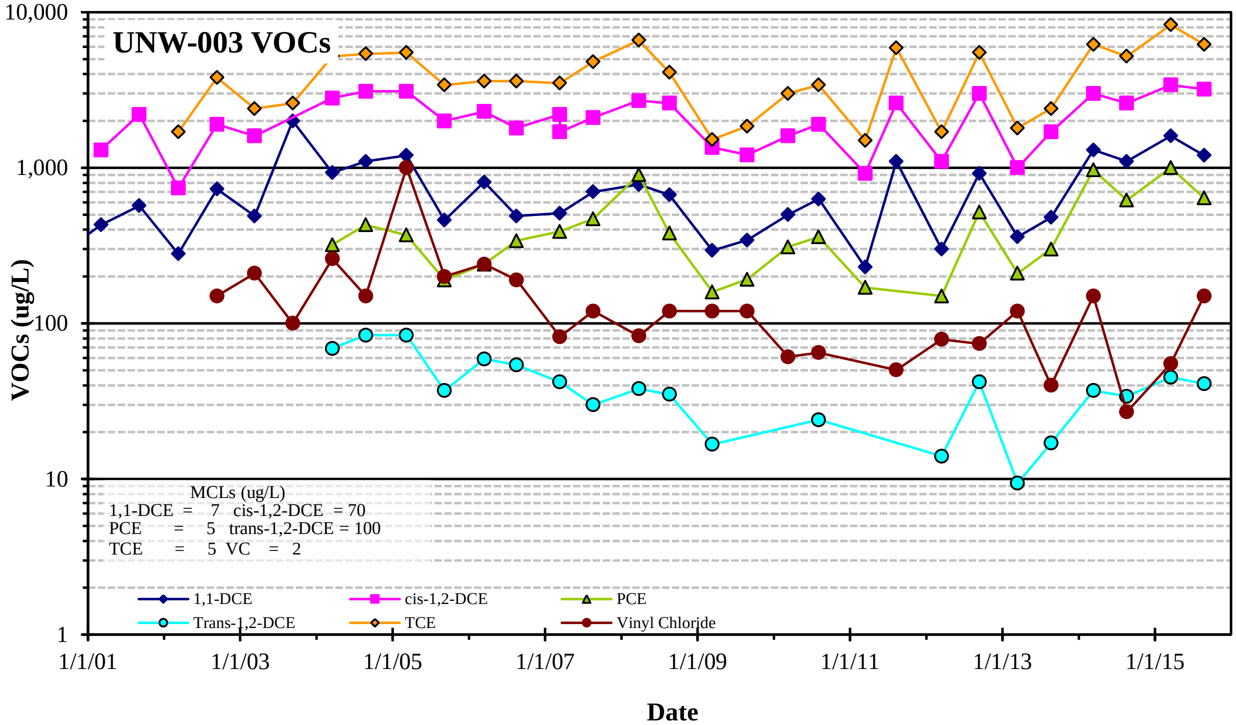


Fig. 3.37. VOC concentrations in well UNW-003, 2001–2015.
(MCL = maximum contaminant level; VOC = volatile organic compound)

3.6.6.2 Other Long-Term Stewardship Requirements

3.6.6.2.1 Requirements

LTS requirements specified in the *Remedial Action Report for the K-1407-B Holding Pond and the K-1407-C Retention Basin* (DOE/OR/01-1371&D1, DOE 1995) were clarified in an erratum approved in May 2015 and included maintenance of institutional controls.

The erratum states, "*Conduct annual inspections and perform radiological and industrial hygiene surveillance and other assessment activities only as needed if activities are conducted at the site that are necessary to keep the remediated ponds in compliance with environmental, safety, and health requirements and maintain records of all related activities.*"

3.6.6.2.2 Status of Requirements

All components of the K-1407-B/C ponds site were inspected in FY 2015 by the ETTP S&M Program, including access controls and sign conditions; condition of vegetation including dead spots, excessive weeds or deep rooted vegetation, grass mowing, discoloration or withering of vegetation; soil/surface condition, including evidence of soil erosion, gullies or rills, staining, debris or trash. The site underwent routine mowing. Minor maintenance included removing vegetation from signs.

3.6.7 K-1070-C/D G-Pit and Concrete Pad

The K-1070-C/D G-Pit is the primary source of organic contaminant releases to soil and groundwater in the 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/OR/02-1486&D4, DOE 1998). The location of the area at ETTP is shown in Figs. 3.31 and 3.38. Components of the remedy included:

- Excavation of the G-Pit contents, interim storage of the material, treatment, and disposal, and
- Placement of an interim 2 ft soil cover over the Concrete Pad until remediated.

3.6.7.1 Other LTS Requirements

3.6.7.1.1 Requirements

The *Record of Decision for the K-1070-C/D Operable Unit, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/02-1486&D4, DOE 1998) and *Remedial Action Report for the K-1070-C/D G-Pit and K-1071 Concrete Pad, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-1964&D2, DOE 2002) require interim LTS activities including maintaining institutional controls. An *Erratum to the Remedial Action Report for the K-1070-C/D G-Pit and K-1071 Concrete Pad, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-1964&D2, DT, DOE 2015) approved in May 2015 contains revised frequencies. Specifically, annual inspections of the soil cover over the pad are to be conducted to look for erosion; the grass on the cover is to be mowed as needed, but not less than annually; radiological walkover surveys are to be conducted only if there is activity in the area to confirm the effectiveness of the K-1071 Concrete Pad soil cover in preventing exposure to ionizing radiation; and inspections of the fence are to be performed as needed, but no less than annually. Existing institutional controls will continue to ensure the existing EPP program remains in place.

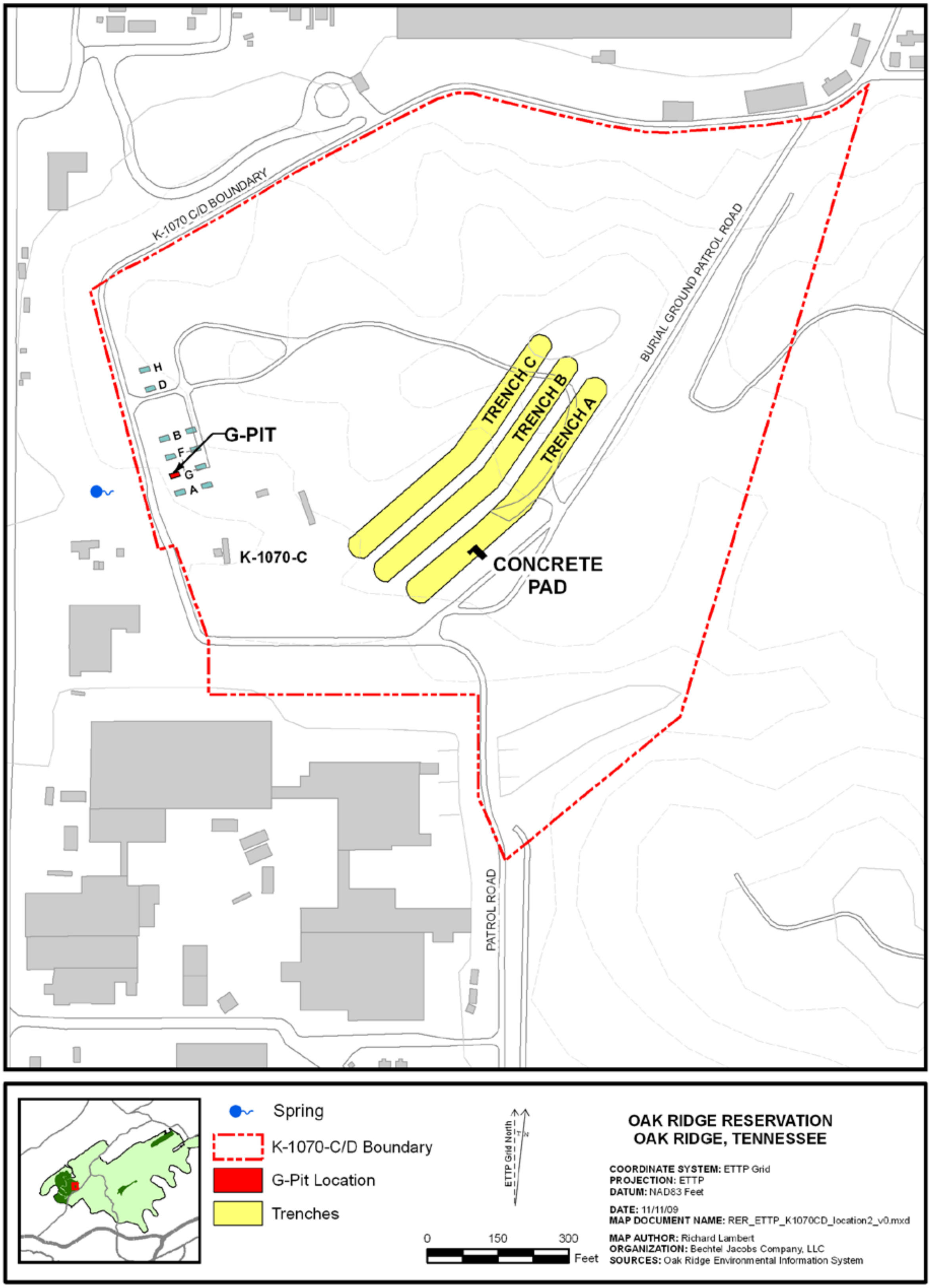


Fig. 3.38. Location of K-1070-C/D G-Pit and Concrete Pad.

3.6.7.1.2 Status of Requirements

The site was inspected by the ETTP S&M Program in FY 2015 for items including condition of the warning signs, condition of fencing and locked gate, condition of the K-1071 Concrete Pad soil cover and maintenance of vegetation including the presence of excessive weeds or deep-rooted vegetation, need for grass mowing, or discoloration or withering of vegetation. No maintenance was required.

3.6.8 Groundwater Plumes

This section provides a summary of ETTP sitewide groundwater, surface water, and aquatic biology monitoring.

Extensive groundwater monitoring at the ETTP site, using Safe Drinking Water Act (SDWA) MCLs as groundwater screening values, has identified VOCs as the most significant groundwater contaminant on-site. The principal chlorinated hydrocarbon chemicals that were used at ETTP were PCE, TCE, and 1,1,1-TCA.

Figure 3.39 shows the distribution and generalized concentrations of the sum of the primary chlorinated hydrocarbon chemicals and their transformation products, respectively, at ETTP. Specific compounds in the summation of chlorinated VOCs include chloroethenes (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCA, and VC), chloroethanes (1,1,1-TCA, 1,1,2-TCA, 1,2-DCA, 1,1-DCA, and chloroethane), and chloromethanes (carbon tetrachloride, chloroform, and methylene chloride). Several plume source areas are identified within the regions of the highest VOC concentrations. In these areas, the primary chlorinated hydrocarbons have been present for decades and mature contaminant plumes have evolved. The degree of transformation or degradation of the primary chlorinated hydrocarbon compounds is highly variable across the site. In the vicinity of the K-1070-C/D source, a high degree of degradation has occurred, although a strong source of contamination still remains in the vicinity of the G-Pit, where approximately 9,000 gal of chlorinated hydrocarbon liquids were disposed in an unlined pit. Other areas where transformation is significant include the K-1401 Acid Line leak site, and the K-1407-B pond area. Transformation processes are weak or inconsistent at the K-1004 and K-1200 area, K-1035, K-1413, and K-1070-A Burial Ground; and little transformation of TCE is observed in the K-27/K-29 source and plume area.

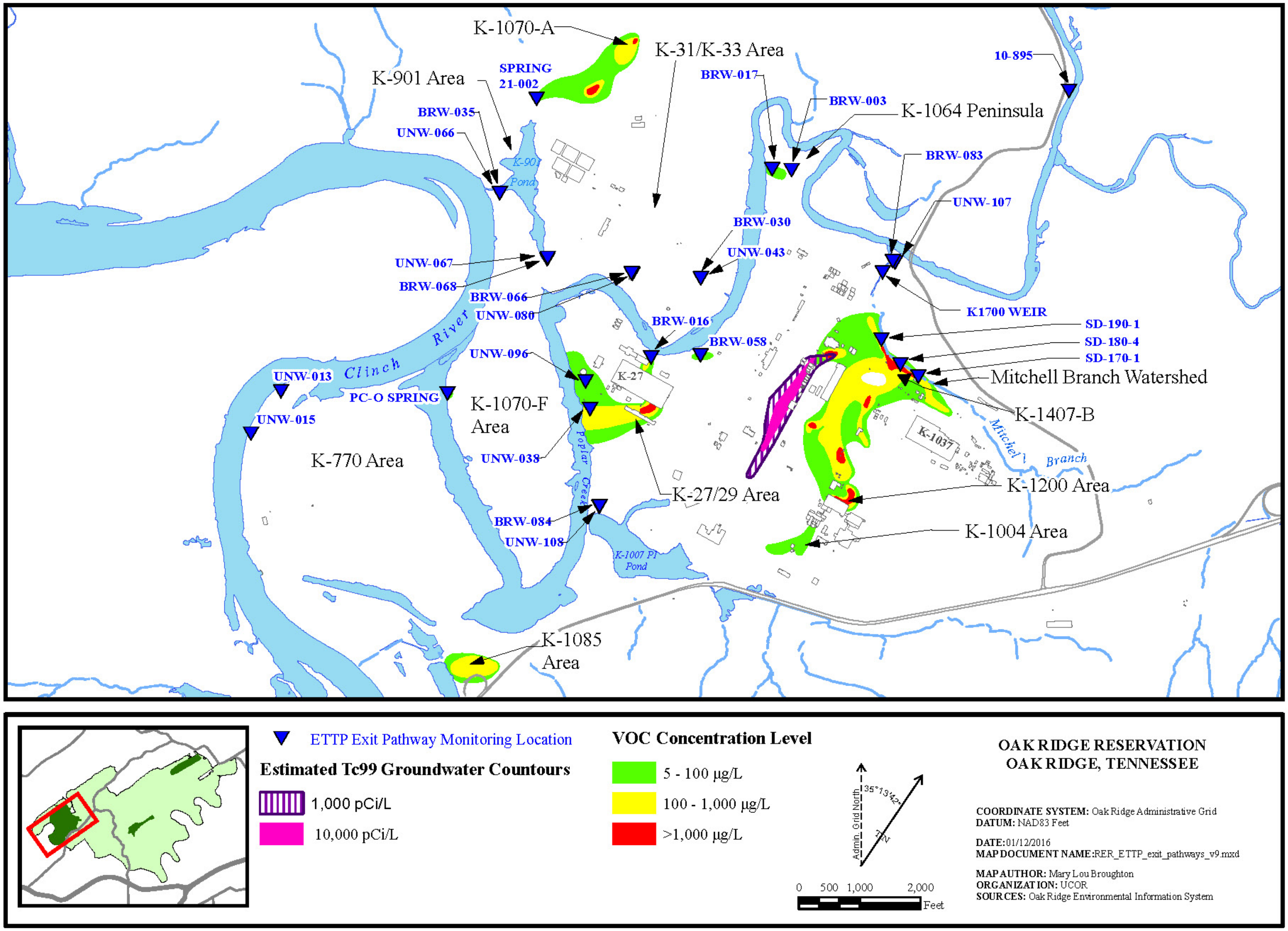


Fig. 3.39. ETTP exit pathways monitoring locations. *(VOC = volatile organic compound)*

3.6.9 Groundwater Exit Pathways

Groundwater exit pathway monitoring sites are shown in Fig. 3.36. Groundwater monitoring results for the exit pathways are discussed below.

Mitchell Branch – The Mitchell Branch groundwater exit pathway is monitored using surface water data from the K-1700 weir on Mitchell Branch and wells BRW-083 and UNW-107.

Wells BRW-083 and UNW-107, located near the mouth of Mitchell Branch, have been monitored since 1994. Table 3.42 shows the history and concentrations of detected VOCs in groundwater. 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. During FY 2015, no chlorinated VOCs were detected in BRW-083 and TCE was detected at an estimated concentration of 0.53 J µg/L in the August sample from UNW-107.

Table 3.42. VOCs detected in groundwater in the Mitchell Branch Exit Pathway

Well	Date	cis-1,2-DCE	PCE	TCE	VC
BRW-083	8/29/2002	ND	**5**	**28**	ND
	3/16/2004	0.69	2.2	**9.9**	ND
	8/26/2004	2	4.7	**20**	ND
	3/14/2007	5	**9**	**28**	ND
	3/20/2008	ND	ND	ND	ND
	8/21/2008	ND	ND	ND	ND
	3/12/2009	ND	ND	1.31 J	ND
	8/3/2009	ND	2.66	**14.2**	ND
	3/3/2010	ND	ND	ND	ND
	8/30/2010	3.6	**5.1**	**18**	ND
	3/15/2011	2.8	**6.7**	**22**	ND
	8/10/2011	ND	ND	ND	ND
	3/1/2012	ND	ND	ND	ND
	8/16/2012	ND	ND	ND	ND
	8/6/2013	ND	ND	ND	ND
	3/13/2013	ND	ND	ND	ND
	3/13/2014	ND	ND	ND	ND
	8/7/2014	ND	ND	ND	ND
	3/30/2015	ND	ND	ND	ND
	8/20/2015	ND	ND	ND	ND
UNW-107	8/3/1998	ND	ND	3	ND
	8/26/2004	4.7	ND	3.6	ND
	8/21/2006	3.4	**14**	2	1.2
	3/13/2007	25	2 J	**23**	2[a]
	8/21/2007	17	ND	**30**	0.3 J

Table 3.41 (continued)

Well	Date	cis-1,2-DCE	PCE	TCE	VC
	3/5/2008	ND	ND	ND	ND
	8/18/2008	ND	ND	ND	ND
	3/12/2009	ND	ND	ND	ND
	7/30/2009	ND	ND	ND	ND
	3/4/2010	ND	ND	ND	ND
	7/28/2010	ND	ND	ND	ND
	3/16/2011	ND	ND	ND	ND
	8/11/2011	ND	ND	ND	ND
	3/30/2012	ND	ND	ND	ND
	9/12/2012	ND	ND	ND	ND
	8/8/2013	ND	ND	ND	ND
	3/20/2013	ND	ND	ND	ND
	3/18/2014	ND	ND	ND	ND
	8/20/2014	ND	ND	ND	ND
	3/16/2015	ND	ND	ND	ND
	8/25/2015	ND	ND	0.53 J	ND

[a]Detection occurred in a field replicate. Constituent not detected in regular sample.

Bold table entries exceed SDWA MCL screening values (PCE, TCE = 5 µg/L, cis-1,2-DCE = 70 µg/L, VC = 2 µg/L). All concentrations µg/L.

Acronyms

BRW = bedrock well
DCE = dichloroethene
J = estimated value
ND = Not Detected
PCE = tetrachloroethene
TCE = trichloroethene
VC = vinyl chloride

K-1064 Peninsula area – Wells BRW-003 and BRW-017 monitor groundwater at the K-1064 Peninsula burn area. Figure 3.40 shows the history of VOC concentrations in groundwater from FY 1994 through FY 2015. TCE concentrations have declined in both wells over that period of time. TCE was present at concentrations less than the MCL during FY 2015 at well BRW-017 and was detected at an estimated concentration of 0.66 J µg/L in the August sample from well BRW-003. In the August 2015 sample from well BRW-003 1,1,1-TCA was detected at an estimated concentration of 0.47 J µg/L following several years of non-detect results at the 1 µg/L detection limit. Cis-1,2-DCE was detected at concentrations much less than its MCL in both semiannual samples in well BRW-017.

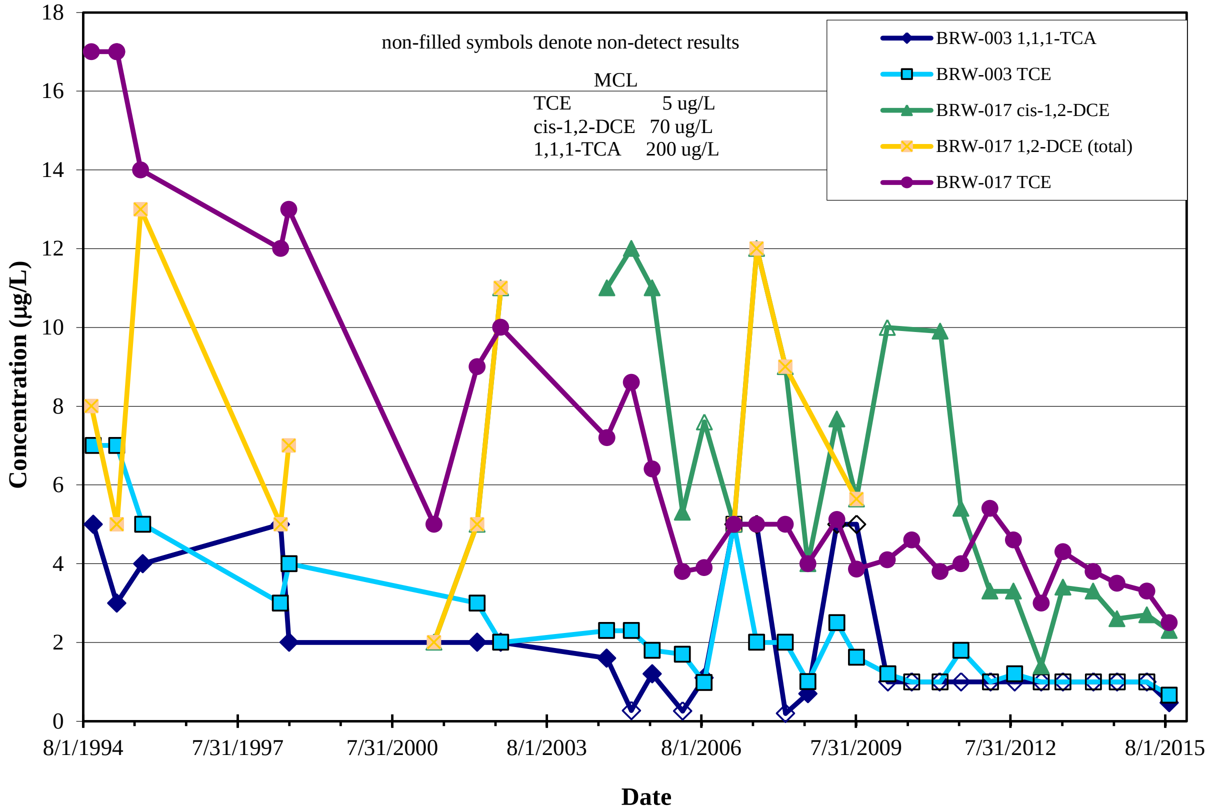


Fig. 3.40. VOC concentrations in groundwater at K-1064 Peninsula area.
(MCL = maximum contaminant level and VOC = volatile organic compound)

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. VOCs are not COCs in this area; however, leaks of recirculated cooling water in the past have left residual subsurface chromium contamination. Figure 3.41 shows the history of chromium detection in wells at K-31/K-33. Well UNW-043 exhibits the highest residual chromium concentrations of any in the area. Chromium concentrations in well UNW-043 correlate with the turbidity of samples, and acidification of unfiltered samples. These samples contain suspended solids, often causing detection of high-metal content because the addition of acid preservative, which releases metals that are adsorbed into the solid particles at the normal groundwater pH. During FY 2006, an investigation was conducted to determine if groundwater in the vicinity of the K-31/K-33 buildings contained residual hexavalent chromium from recirculated cooling water leaks. The data indicated the chromium in groundwater near the leak sites was essentially of the less toxic trivalent species. During FY 2008 through FY 2015, field-filtered (i.e., dissolved) and unfiltered samples were collected from UNW-043. Chromium concentrations in the field-filtered samples are consistently much lower than the MCL and during FY 2015 the chromium concentration in filtered aliquots was less than the 0.011 mg/L AWQC level for hexavalent chromium. During FY 2015, both field-filtered and unfiltered samples were collected from wells BRW-066, UNW-030 and UNW-080. Chromium was non-detect in all samples from well BRW-066 during FY 2015.

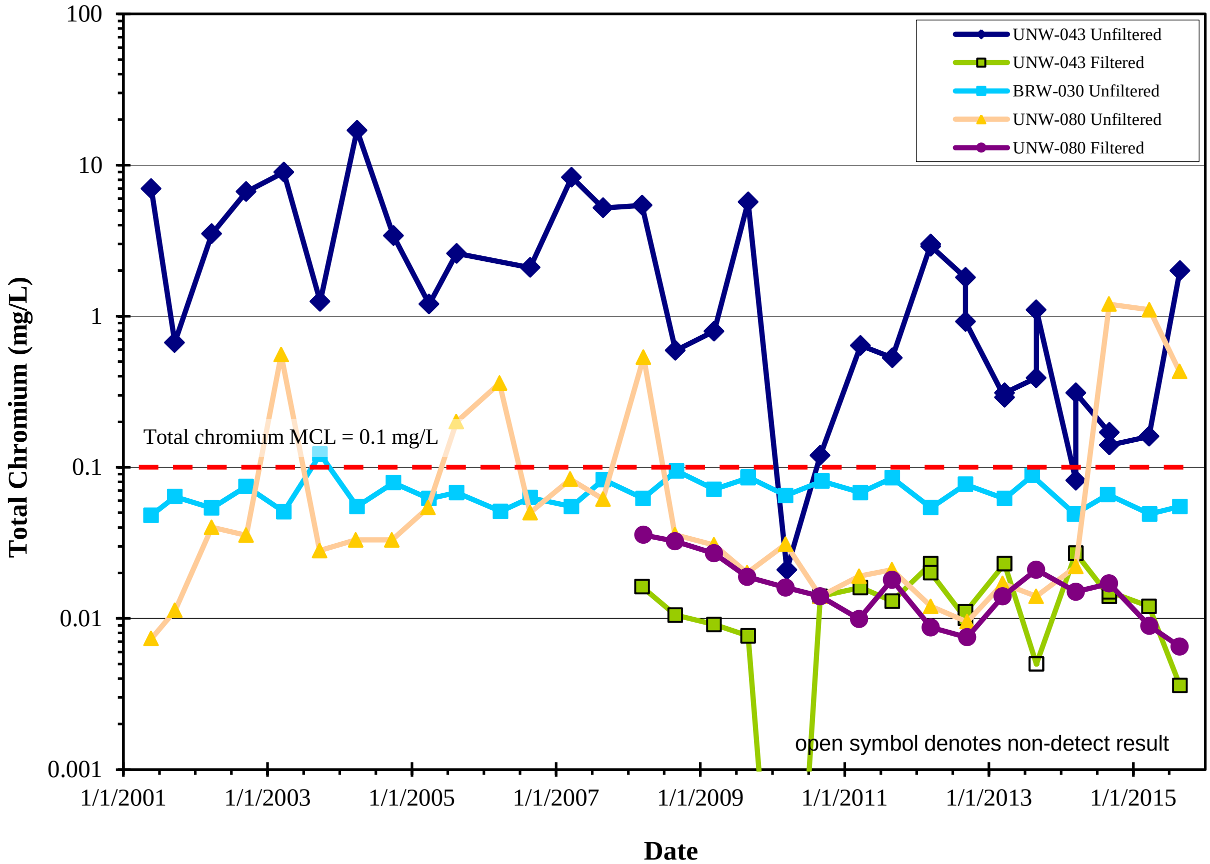


Fig. 3.41. Chromium concentrations in groundwater in the K-31/K-33 area.
(MCL = maximum contaminant level)

K-27/K-29 area – Several exit pathway wells are monitored in the K-27/K-29 area. Figure 3.42 provides concentrations of detected VOCs in wells both north and south of K-27 and K-29 through FY 2015. The source of VOC contamination in well BRW-058 is not suspected to be from K-27/K-29 area operations but is more likely associated with groundwater contamination that originates in the K-25 area. Well BRW-058 VC continues to slightly exceed the MCL, while cis-1,2-DCE remains at concentrations slightly lower than the MCL. The VOC concentrations in well BRW-016 appear to be gradually decreasing and do not exceed MCLs. TCE levels in well UNW-038 fluctuate between 10 to 20 times the MCL and appear to be in a nearly stable fluctuation range since about 2011, with higher concentrations during the wet season and lower concentrations during the dry season. At BRW-016, cis-1,2-DCE levels show a decreasing trend and VC has decreased to < 1 µg/L, which is lower than the MCL.

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 (as shown earlier in Fig. 3.24). These wells were monitored intermittently from 1994 through 1998 and semiannually from FY 2001 through FY 2015. The first detections of VOCs in these wells occurred during FY 2006 with detection of low (~10 µg/L or less) concentrations of TCE and cis-1,2-DCE. The source area for these VOCs is not known. During FY 2015 TCE was detected at 7 µg/L and cis-1,2-DCE was detected at 0.83 J µg/L in the August sample from well BRW-084. No VOCs were detected in either sample from well UNW-108. Metals have been detected in the past associated with the presence of turbidity in the samples. Very low concentrations of antimony (0.31 J µg/L in well UNW-108 in March) and selenium (0.46 J µg/L in BRW-084 in March and

0.52 J µg/L in well UNW-108 in September) were detected on filtered samples. Potential sources of these metals in this area are unknown and the detected concentrations are far below any criterion level.

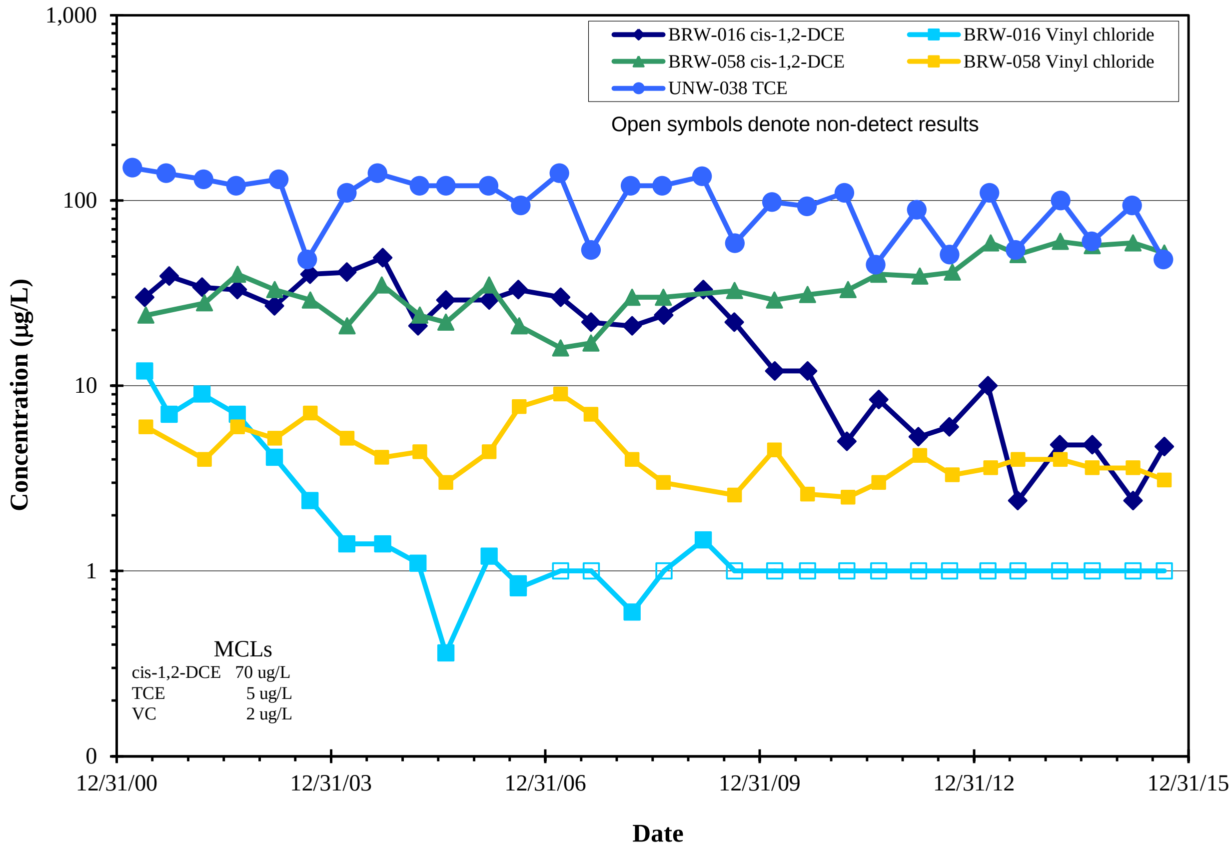


Fig. 3.42. Detected VOC concentrations in groundwater exit pathway wells near K-27 and K-29.
(MCL = maximum contaminant level)

K-901-A holding pond area – Exit pathway groundwater in the K-901-A holding pond area (also shown earlier in Fig. 3.24) is monitored by four wells (BRW-035, BRW-068, UNW-066, and UNW-067) and two springs (21-002 and PC-0). Very low concentrations (< 5 µg/L) of VOCs are occasionally detected in wells adjacent to the K-901-A holding pond. However, these contaminants are not persistent in groundwater west and south of the pond. The only VOC detected in the K-901-A holding pond exit pathway wells during FY 2015 was cis-1,2-DCE at 0.38 J µg/L in both the March and August samples from well BRW-035. Alpha activity was detected at 28.2 and 68.7 pCi/L in well UNW-066 in the March and August samples, respectively, and at 52.8 pCi/L in the August sample from well UNW-068. Beta activity was detected at 84.1 pCi/L and 81.5 pCi/L in the August samples from well UNW-06 and UNW-067. Based on the increases in detected alpha and beta activity, additional radiological analyses will be conducted in these wells during FY 2016.

TCE is the most significant groundwater contaminant detected in the springs and the historic TCE concentrations are shown in Fig. 3.43. Spring PC-0 was added to the sampling program in 2004. During April through October each year, spring PC-0 is submerged beneath the Watts Bar lake level. In late winter 2012, DOE installed a sampling pump in the mouth of the spring to allow year-round sampling. The contaminant source for the PC-0 spring is presumed to be disposed waste at the former Construction Spoil Area (K-1070-F) located on Duct Island. The TCE concentrations in PC-0 spring have varied between non-detectable levels and 26 µg/L and have decreased from their highest measured value in 2006 to concentrations less than or several times the drinking water standard. During FY 2015, cis-1,2-DCE was detected at and below about 1 µg/L in PC-0 samples collected in March and June 2015.

Although TCE is the principal contaminant detected at spring 21-002, 1,1-DCE, and carbon tetrachloride, were present at concentrations less than 2 and 3.2 µg/L, respectively. The TCE concentration at spring 21-002 tends to vary between less than 5 and 25 µg/L and this variation appears to be related to variability in rainfall, which affects groundwater discharge from the K-1070-A VOC plume. During FY 2015, TCE was detected at its MCL in a January sample and at slightly over three times the MCL in June. Alpha activity was detected at 1.14 pCi/L in the June sample and the highest detected beta activity was 6.45 pCi/L, measured in the June sample. Technetium-99 was detected in the sample collected during June 2015, at a measured activity of 8.65 pCi/L, which is much lower than the 900 pCi/L drinking water standard for this radionuclide. Uranium-234, ^{235}U, and ^{238}U were detected at less than 1 pCi/L.

TCE concentrations measured in samples from spring 10-895, which is located along Poplar Creek by Blair Road, are also shown on Fig. 3.43. This spring was added to the ETTP monitoring program during FY 2015. The highest TCE concentration measured was 5.8 µg/L. Carbon tetrachloride was detected at 0.32 J µg/L in the June 2015 sample.

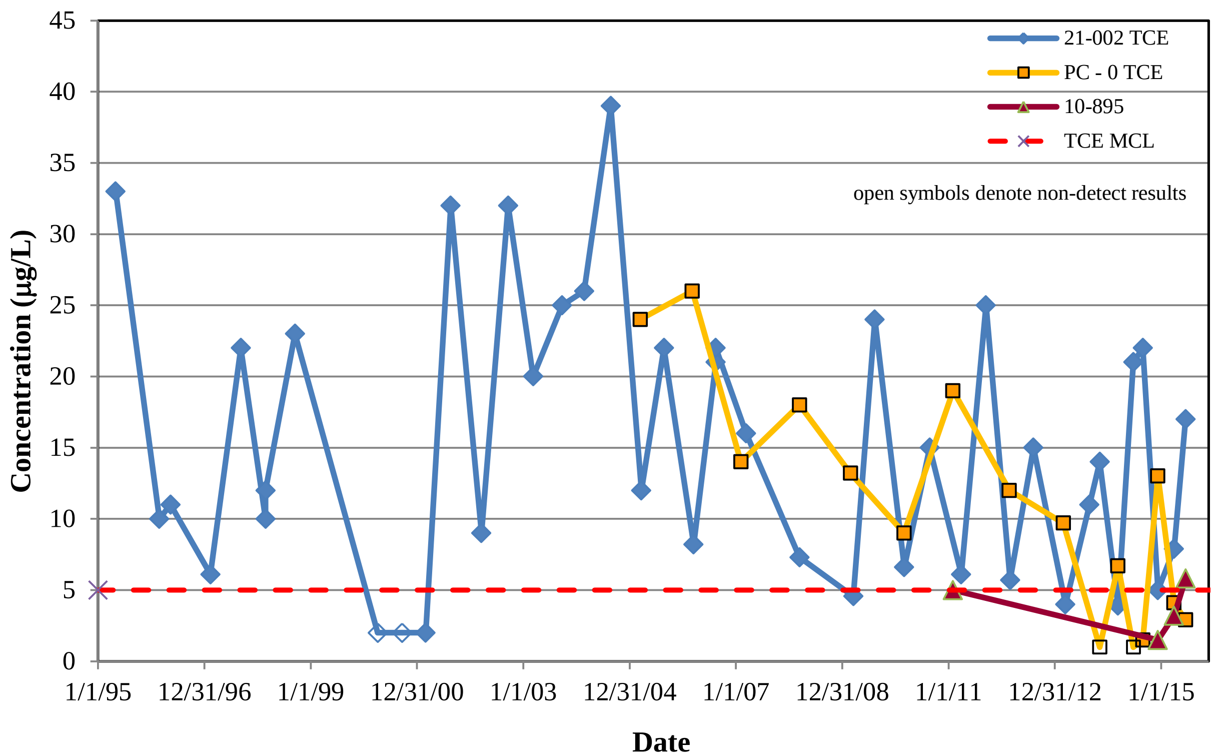


Fig. 3.43. TCE concentrations in selected ETTP K-901 area springs.
(MCL = maximum contaminant level)

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 (Fig. 3.44). Measured alpha and beta activity levels were below screening levels during FY 2015. Figure 8.41 shows the history of measured alpha and beta activity in this area. Historic analytical results indicate that the alpha activity is largely attributable to uranium isotopes. The beta activity levels in well UNW-013 are attributable to ^{99}Tc. Much lower alpha and beta activity levels have been measured in well UNW-015 since sampling was resumed in FY 2013, following an interruption in sampling during site remediation activities.

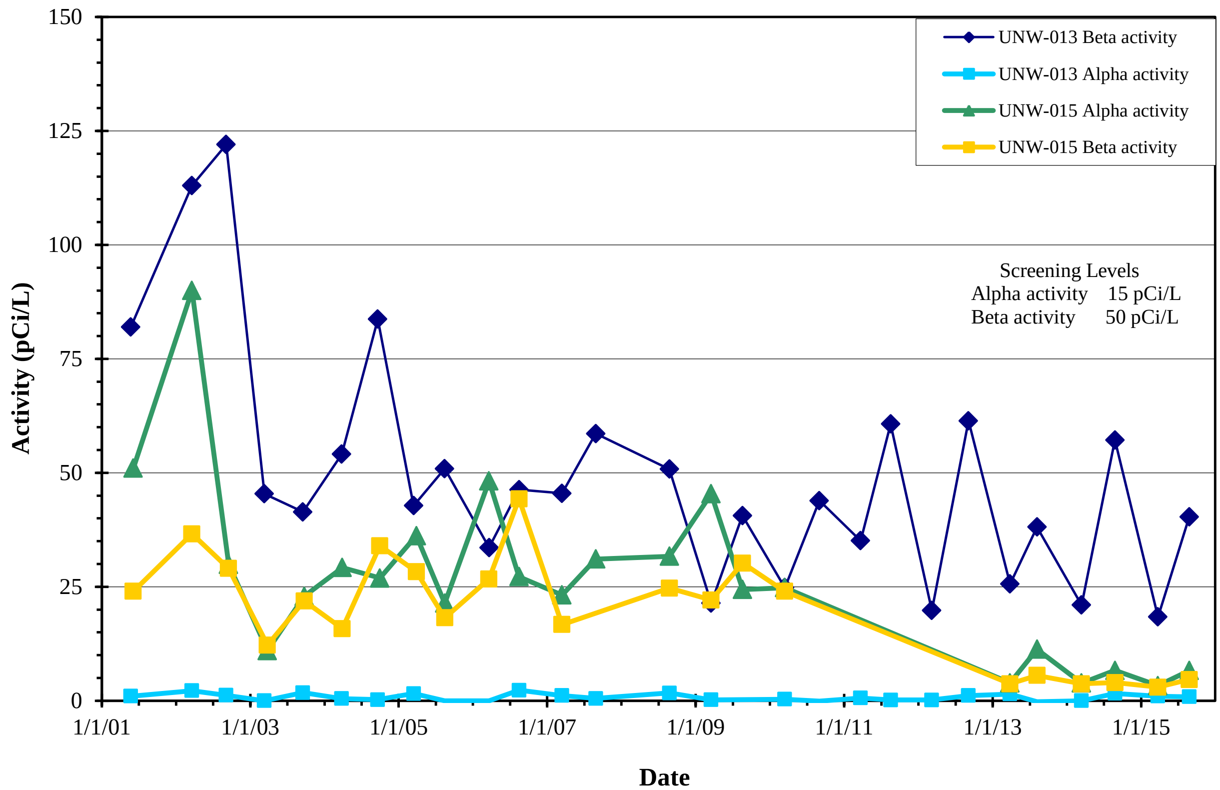


Fig. 3.44. History of measured alpha and beta activity in the K-770 area.

3.6.10 Technetium-99 in ETTP Site Groundwater

Technetium-99 is a beta particle-emitting radionuclide. There is not a specific drinking water MCL for ^{99}Tc, but its MCL-DC concentration is 900 pCi/L. Technetium-99 has been a known groundwater contaminant at the ETTP site for many years. Past CERCLA investigations have sampled and analyzed for ^{99}Tc in groundwater. In the past, the highest ^{99}Tc activity levels (as high as 6,000+ pCi/L) have been observed beneath the K-1070-A burial ground, where concentrations at a couple of wells remain in the 200–500 pCi/L range. The area along Mitchell Branch near the former K-1407 ponds has residual ^{99}Tc contaminated groundwater from the operational era of the ponds, and possibly from K-1420, with much lower activity levels (< 100 pCi/L).

3.6.10.1 Background

Environmental fate of some metal contaminants in groundwater is strongly dependent on the pH and oxidation-reduction potential of the water. A summary review of the environmental behavior of ^{99}Tc in the environment was published by Pacific Northwest National Laboratory (PNNL 2005) related to tank wastes at Hanford. Background information from that report is used in preparation of the following interpretation of potential ^{99}Tc mobility in groundwater at the ETTP site.

Under electrochemically oxidizing conditions, technetium forms the negatively-charged pertechnetate ion (TcO_4^-) with technetium assuming a valence of 7^+. The pertechnetate ion is quite mobile in aqueous settings since negatively charged ions do not tend to adsorb to mineral surfaces in soil or rock, which inherently tend to have negatively charged to neutrally charged surfaces. Under electrochemically reducing conditions, the pertechnetate ion is not stable and technetium may assume a 4^+ valence. In the 4^+ valence state technetium may form ionic combinations with oxygen and hydroxyl groups, which may be amorphous solids with lower solubilities than the pertechnetate ion. In the 4^+ valence, in the absence of complexing ligands, technetium may adsorb to mineral and organic matter surfaces, and may become bound in low solubility technetium oxyhydroxides. In the 4^+ valence, technetium may also form soluble complexes with carbonate/bicarbonate ions as well as sulfate. Thermodynamic and directly measured speciation and solubility relationships for technetium carbonate and sulfate complexes have not been established, although these complexes may be important to technetium mobility in reducing electrochemical environments.

In addition to standard physical chemical conditions, microbial processes are important as potential mediators that can lead to reduction of technetium from the highly soluble and mobile 7^+ valence in the pertechnetate ion to the 4^+ valence in the lower solubility forms. Microbial processes often occur in very localized regions in the subsurface where chemical conditions are favorable. This fact is evident in groundwater at the ETTP site, where intrinsic microbial communities are known to slowly degrade chlorinated organic compounds in some areas, but not in other areas. Factors that may favor microbial reduction of dissolved compounds include relatively slow groundwater movement, which limits influx of dissolved oxygen via groundwater recharge; presence of organic carbon that can serve as electron donor material; and presence of microbes capable of affecting the required molecular transformations.

3.6.10.2 ETTP Site Groundwater Electrochemistry and General Chemistry

Data from groundwater, spring, and surface water sampling and analyses conducted at the ETTP site as part of the ETTP Water Quality Program (EWQP) during FY 2015 have been reviewed for parameters pertinent to understanding the potential for ^{99}Tc mobility in site groundwater. During collection of all groundwater samples at ETTP, field measurement of pH and redox potential are made and recorded. The field measurements of pH and redox potential from all groundwater, spring, and surface water samples collected in FY 2015 have been plotted and superimposed over the technetium Eh-pH diagram in Fig. 8.42 of the PNNL report (PNNL 2005). Individual data points are posted for samples analyzed for ^{99}Tc and the detection/non-detection status is indicated by symbol color. The data shown on Fig. 3.45 suggest that ^{99}Tc is quite mobile under the physicochemical conditions present in site groundwater.

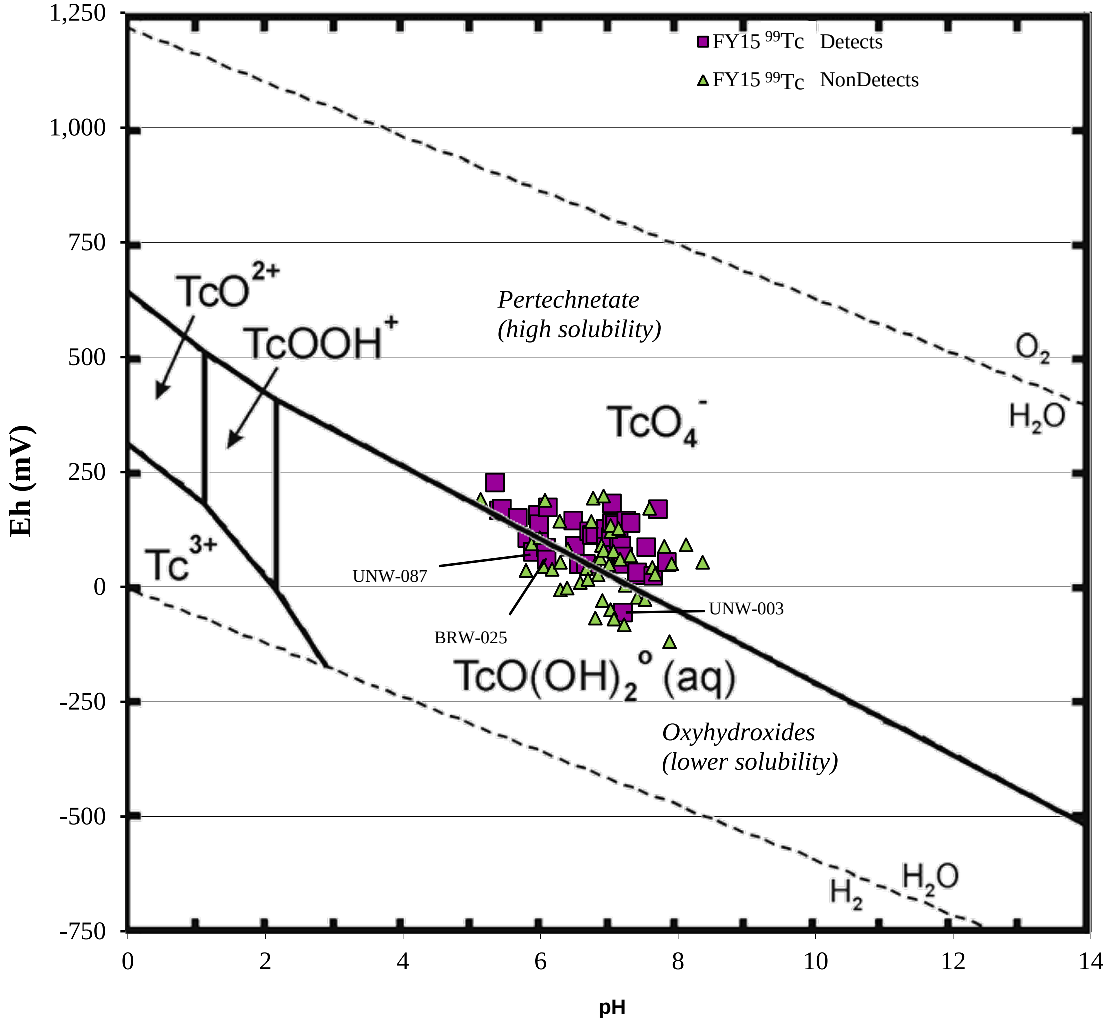


Fig. 3.45. Eh-pH region in which ETTP groundwater, spring water, and surface waters lie in relation to the technetium Eh-pH speciation regions at 25ºC and 900 pCi/L ^{99}Tc.
(ETTP =East Tennessee Technology Park and Tc = technetium)

In addition to physicochemical data, major dissolved anions, including bicarbonate, carbonate, and sulfate are measured on a subset of groundwater samples. Bicarbonate concentrations ranged from a low of 7 mg/L in well UNW-118, which monitors groundwater in the siliceous bedrock of the lower Rome Formation near State Route 58 (also known as Highway 58), to a high of 320 mg/L in well BRW-003, which monitors groundwater in the limestone-rich Chickamauga Group within Zone 2. The bicarbonate concentration in site groundwater samples averaged about 110 mg/L. Sulfate concentrations ranged from a low of about 0.6 mg/L at well UNW-121 that monitors groundwater in the soils at the K-1070-A site, to a high of 85 mg/L at well BRW-017 that monitors groundwater in bedrock in a portion of the Chickamauga Group. Sulfate concentrations averaged about 12 mg/L in site groundwater. These data indicate that ^{99}Tc could form soluble complexes with bicarbonate and sulfate ions under some conditions that would allow contaminant mobility via groundwater transport.

Much of the ETTP physicochemical data suggest that ^{99}Tc mobility would be fairly high. Under this condition, dilution and dispersion processes during groundwater transport would be the only concentration reduction processes that would reduce ^{99}Tc activities since adsorption of pertechnetate ion is negligible. Site groundwater chemical and microbial conditions in some areas may provide attenuation processes that will reduce ^{99}Tc geochemical mobility in the groundwater system. If ^{99}Tc is present where these conditions occur, these processes would be additive to dilution and dispersion processes expected to reduce contaminant levels with increasing transport distances.

3.6.10.3 FY 2015 Distribution of ^{99}Tc in ETTP Site Groundwater

During demolition of the K-25 east wing in the winter of 2014, fugitive dust suppression misting and rainfall carried ^{99}Tc off the work area. Contaminated runoff apparently percolated through soil and into subsurface utility lines and probably into backfill surrounding the buried utilities. Groundwater sampling for ^{99}Tc was increased in wells in the general vicinity of the east wing and where wells were available along potential groundwater transport pathways. During FY 2015, two phases of subsurface investigation work were completed under a Removal Site Evaluation (RmSE) (DOE/OR/01-2663&D1/A1; DOE 2015b) to assess the potential threat to human health and the environment from the elevated ^{99}Tc levels observed in groundwater, storm water, and sanitary sewage during demolition of the K-25 building. Background information about the behavior of ^{99}Tc in the environment and a summary of groundwater sampling to evaluate levels at ETTP are provided below.

The scope of investigations conducted in the ^{99}Tc RmSE focused on understanding the role of site subsurface infrastructure in migration of ^{99}Tc away from the K-25 east wing source area and the involvement of groundwater. The investigations used push technology to sample soil along and beneath portions of storm water outfall/storm drains (SDs), sanitary sewer pipes, and the abandoned electrical ductbank that formerly carried electrical cables along the east side of the K-25 building. Continuous soil cores were obtained from the ground surface to target depths of refusal on the bedrock surface. Soils were visually logged and field classified to determine soil types and textures, and all recovered soil cores were field scanned using a photoionization detector (PID) and beta gamma radiation detector. The RmSE Work Plan established criteria for collection of at least two samples per boring for analysis of VOCs and ^{99}Tc. A temporary PVC piezometer was installed in each borehole to allow observation of groundwater levels and to provide groundwater samples for ^{99}Tc and /or VOC analyses. The investigations determined that although ^{99}Tc entered and traveled through the sanitary sewer and the storm water outfall/storm drain (SD) that discharges to the K-1007-P1 pond, the amount of ^{99}Tc transport in backfill outside those pipes was minimal. The investigation found that ^{99}Tc transport through the abandoned underground electrical ductbank was an important transport pathway along the east side of the K-25 building as far south as ductbank manhole row 21. RAs conducted in Zone 1 included plugging the ductbank manholes with cement grout from row 21 to the south and west to the former steam plant located near the Clinch River in the K-770 Area. VOCs were found to not be significant contaminants in any of the borehole soils. Groundwater was sampled where available in the temporary piezometers in July 2015. The resulting ^{99}Tc-contaminated groundwater area is shown on Fig. 3.46, along with summer 2015 ^{99}Tc concentration ranges in groundwater throughout the ETTP site.

The area where detected ^{99}Tc is highest along the eastern side of the K-25 east wing. The highest concentrations occur in well temporary piezometers near ductbank manholes in row 22 – DB22LD and DB22M (25,900 pCi/L and 19,500 pCi/L, respectively). The second most highly contaminated wells are along the ductbank corridor to the north, at wells UNW-137 (9,750 pCi/L) and in wells near the K-1413 facility (UNP-008 = 10,600 pCi/L, BRW-015 = 7,430 pCi/L, and UNW-026 = 3,890 pCi/L). The conceptual model that was advanced in the previous RER was essentially confirmed by the ^{99}Tc RmSE investigations. Percolation water from the contaminated slab area probably entered the backfill around the electrical duct bank that runs north-south along the east side of the building. Rapid transport along this utility corridor carried the high concentrations of ^{99}Tc into the areas where the high concentrations are currently detected.

The plume trajectory for ^{99}Tc is to the south/southwest from the ductbank manhole rows 21 and 22 area, and to the northeast from the K-1413 area through well UNW-089, and toward Mitchell Branch. At well UNW-089, the ^{99}Tc activities apparently reached their maximum during the winter or spring of 2015 since the highest observed result of 428 pCi/L was recorded in March; by September, the result had decreased to 341 pCi/L. As indicated by the piezometric surface shown on Fig. 3.46, there is a trough in the water table surface that is formed in a now-filled valley that leads from the K-1413 area northward, toward Mitchell Branch. The inset box in Fig. 3.46 shows an inferred plume trajectory arrow from the contaminated area near K-1413 toward UNP-005. At well UNP-005 low levels of ^{99}Tc have been detected intermittently with previous results of 12.8 pCi/L in August 2010 and 7.6 pCi/L in September 2013 and 8.33 and 12.7 pCi/L in March and September 2015, respectively. Technetium-99 has also been detected intermittently in groundwater in wells UNW-003 and BRW-047 further east along Mitchell Branch. The levels in well UNW-003 have fluctuated in the range of about 10–50 pCi/L since reliable ^{99}Tc analytical data became available in 1998 and 2015 results were 13.1 and 21.5 pCi/L in March and August, respectively. A single sample result is available from well BRW-047, which contained about 45 pCi/L of ^{99}Tc. It is also noted that during construction activities in the 1940s and 1950s the culverts for the SD-190 network were laid in the pre-existing valley beneath the contour fill. Infiltration of ^{99}Tc plume water into the SD-190 culvert is expected. Groundwater sampling and analysis for ^{99}Tc in all the wells where it has been detected, as shown on Fig. 3.46 will continue.

DOE is conducting a third and final phase of investigation under the ^{99}Tc RmSE, which includes push probe sampling of areas slightly further east than the currently documented ductbank contamination, further north of the K-1413 area. Two bedrock wells are being installed to the west of the contaminated area to assess potential bedrock contaminant transport. The results of that phase of work will be included in the 2017 RER.

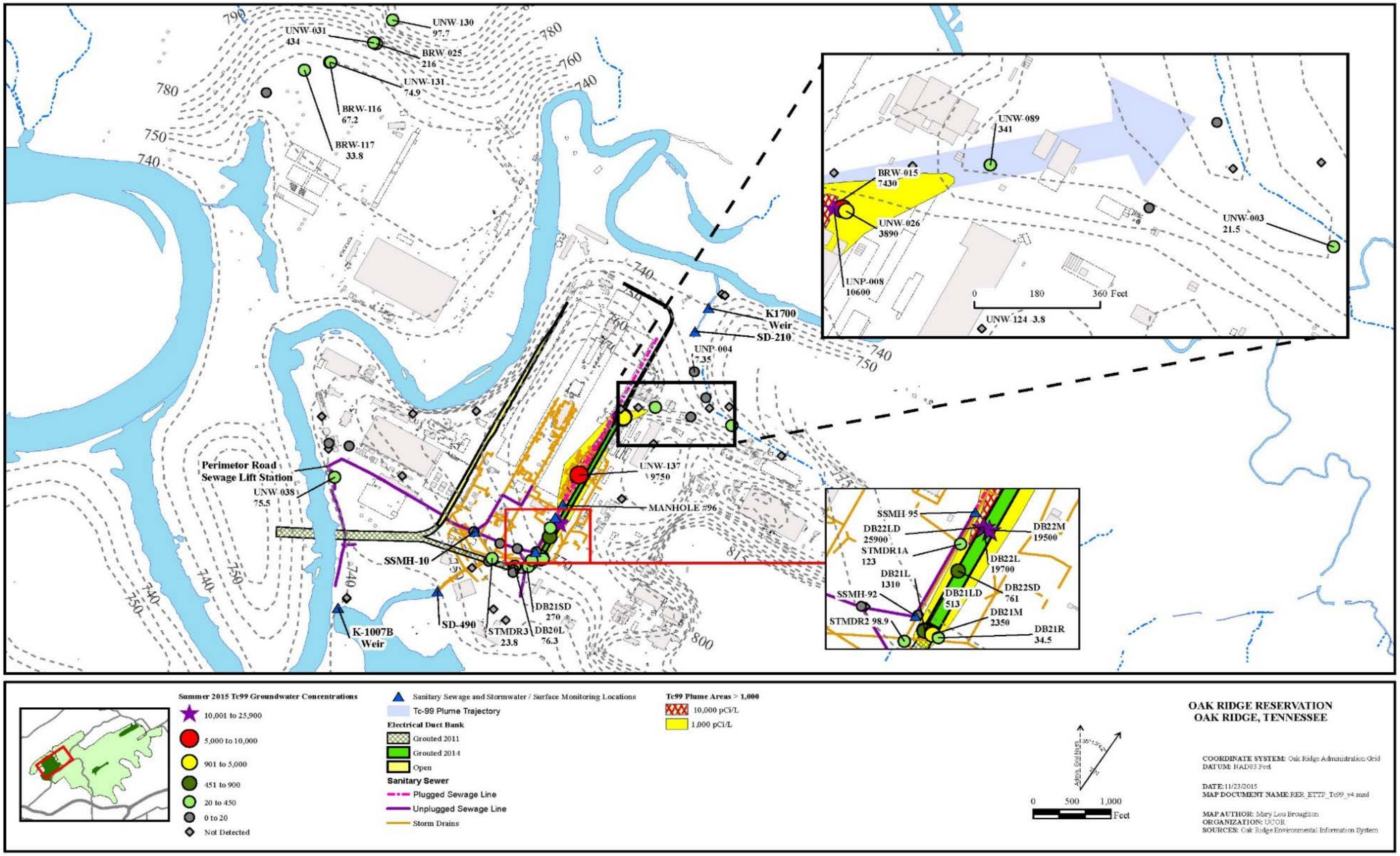


Fig. 3.46. Sample locations and maximum detected ^{99}Tc in ETTP groundwater. *(ETTP =East Tennessee Technology Park and Tc = technetium)*

3.7 Biological Monitoring

The ETTP Biological Monitoring and Abatement Program (BMAP) consists of two tasks designed to evaluate the effects of ETTP historical legacy operations on the local environment, identify areas where abatement measures would be most effective, and test the efficacy of the measures. The results from this program will support future CERCLA cleanup actions. These tasks are: (1) bioaccumulation studies, and (2) instream monitoring of biological communities. Figure 3.47 shows the major water bodies at ETTP and Fig. 3.48 shows the BMAP monitoring locations along Mitchell Branch.

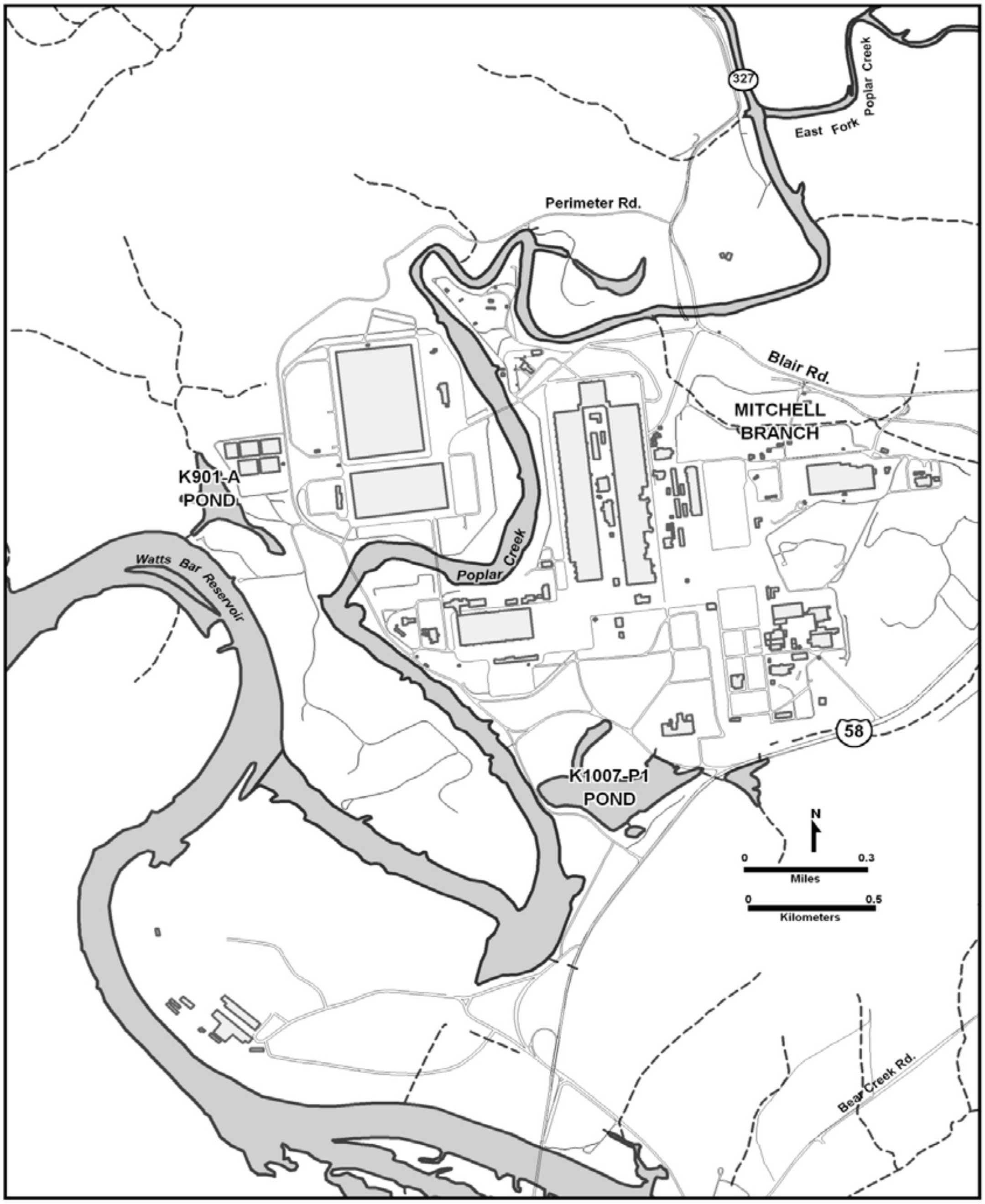


Fig. 3.47. Water bodies at the East Tennessee Technology Park.

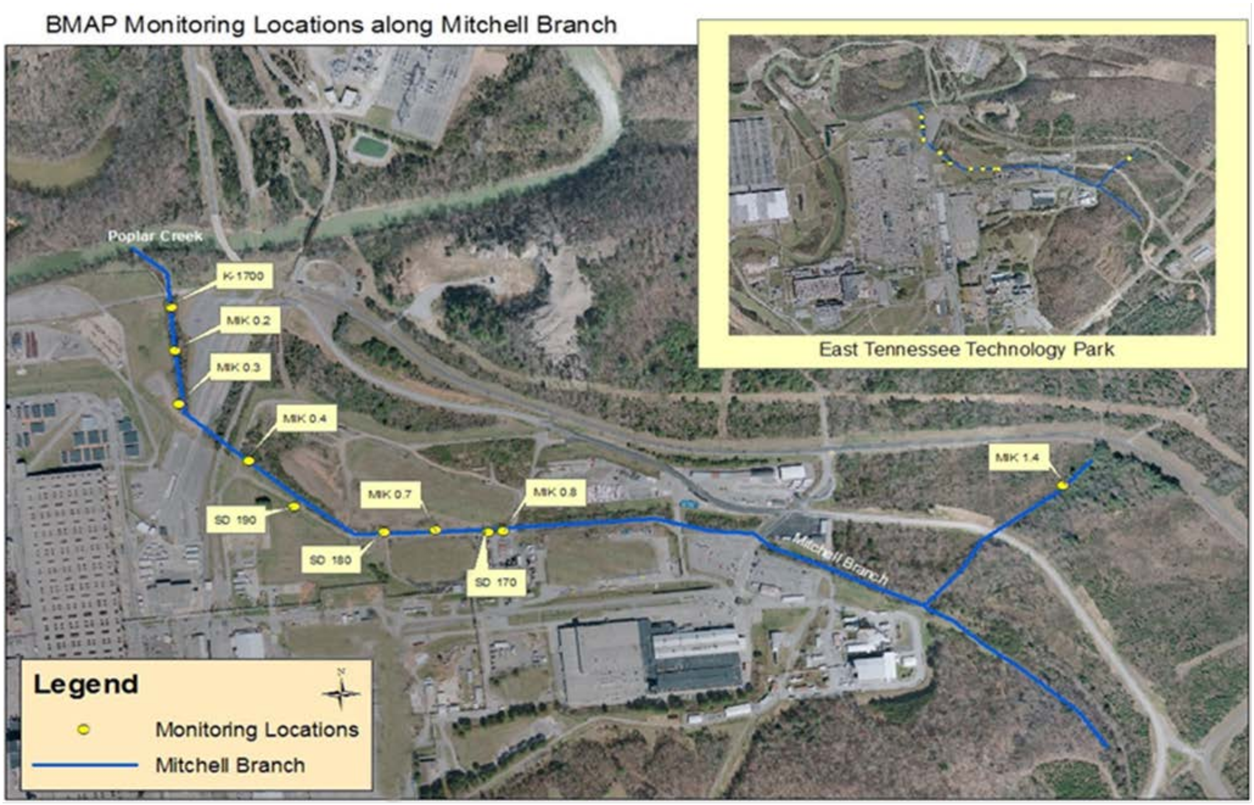


Fig. 3.48. Major storm water outfalls and biological monitoring locations on Mitchell Branch. *(BMAP = Biological Monitoring and Abatement Program, MIK = Mitchell Branch kilometer, and SD = storm water outfall/storm drain)*

The bioaccumulation task includes monitoring of caged clams (*Corbicula fluminea*) placed at selected locations around ETTP and the collection and analysis of fish from Mitchell Branch and three major ponds on the site. Both clams and fish from uncontaminated off-site locations are also analyzed as points of reference. While historically the primary COC for the bioaccumulation task at ETTP has been PCBs, in recent years mercury has been added to the list of legacy COCs at selected locations.

In 2015, the clams (Fig. 3.49) were allowed to remain in place for four weeks and were then analyzed for total PCBs (Table 3.43 and Fig. 3.50) and, in a subset of clams, for total mercury (Table 3.44 and Fig. 3.51). In general, there is a significant amount of variability in the PCB concentrations in clams from year to year, although there are some overall trends of note. In 2015, the greatest concentrations of PCBs were found in the clams from storm water outfall SD 190 and downstream of that location in Mitchell Branch, as has been seen in recent years. The concentrations in PCBs in the clams from the K-1007-P1 pond were significantly lower in the 2015 monitoring, as compared to the levels seen in the 2014 monitoring, which continues an overall trend of decreasing PCB concentrations at this location.

Fig. 3.49. Asiatic clam (Corbicula fluminea).

Table 3.43. Compiled data for PCB concentrations in caged Asiatic clams (Corbicula fluminea), 2009 to 2015

(µg/g, wet weight)

Location	Basket[a]	2009	2010	2011	2012	2013	2014	2015
MIK 0.8 (above SD 170)	A	0.09	0.12	0.11	0.04	0.05	0.079	0.046
	B	0.11	0.13	0.15	0.04	0.04	0.081	0.063
SD 170	A	0.27	0.21	0.16	0.08	0.12	0.121	0.055
	B	0.25	0.28	0.16	0.15	0.13	0.16	0.053
MIK 0.7 (below SD 170)	A	0.18	0.15	0.13	0.08	0.07	0.081	0.066
	B	0.15	0.13	0.17	0.07	0.09	0.088	0.062
SD 180	A						0.099	0.282
	B						0.096	0.242
MIK 0.5 (below SD 180)	A	0.25	0.15	0.13	*b*	0.09	0.099	
	B	0.2	0.17	0.16	*b*	0.11	0.096	
SD 190	A	2.07	1.22	2.36	0.84	2.13	1.329	1.824
	B	1.98	1.09	1.7	*b*	2.51	1.633	2.044
MIK 0.4 (below SD 190)	A	0.9	1.28	1.71	0.41	1.7	0.92	0.766
	B	0.78	2.69	1.82	0.5	2	0.929	0.820
SD 195	A				0.37			
	B				0.31			
MIK 0.3	A		2.93	6.74	2.52	1.8	1.56	1.525.
	B		3.42	4.56	2.74	2.2	1.43	1.125

Acronyms

MIK = Mitchel Branch kilometer
PCB = polychlorinated biphenyls
SD = storm water outfall/storm drain

Table 3.43 (continued)

Location	Basket[a]	2009	2010	2011	2012	2013	2014	2015
MIK 0.27	A			4.42				
	B			4.94				
MIK 0.2	A	2.43	2.15	5.33	0.96	2.2	1.61	1.104
	B	2.42	2.13	4.82	1.41	2.4	1.899	NA[b]
K-1700	A					2.1		
	B					2.3		
SD 992	A		2.93					
	B		3.42					
K-1203 sump	A				0.34	0.2	0.148	
	B				0.29	0.23	0.149	
SD 100 (upper)	A	0.96	0.29	2.25	1.69	0.1	0.181	
	B	0.69	0.22	1.75	1.7	0.09	0.136	
SD 100 (lower)	A	1.32	0.72	5.95	*b*	0.42	0.408	
	B	1.72	0.8	4.5	1.92	1.35	0.239	
SD 120	A	0.34	3.06	0.75	0.11	0.28	0.356	
	B	0.57	1.18	0.97	0.16	0.34	0.353	
SD 490	A	0.4	0.37	0.39	0.19	0.18	0.191	
	B	0.46	0.47	0.46	0.17	0.18	0.181	
K-1007-P1 outfall	A	0.91				1.29	1.264	0.359
	B	0.85				1.3	1.424	0.383
P1	A	0.86	0.99	1.38	1.48			
	B	1.17	0.91	1.68	1.57			
K-901-A outfall	A	0.14	0.06	0.3	0.07	0.11	0.208	0.190
	B	0.16	0.05	0.2	0.07	0.16	0.239	0.172
SD 710	A						0.282	
	B						0.321	
K-897-E	A							0.033
	B							0.078
K-897-J	A							0.057
	B							0.056
Sewee Creek	A	0.02	0.01	0	0.01	0.004	ND	ND
	B	0.02	0.01	0.01	0.003	0.002	ND	ND

[a]Sample result is the reported concentration in the composited clam sample from each cage, where A and B denote replicates. Data were extracted from tables within the 2009–2014 East Tennessee Technology Park Biological Monitoring and Abatement Program fiscal year reports.
[b]Insufficient numbers of clams survived to provide a suitable sample size for analysis.

Acronyms
MIK = Mitchell Branch kilometer
SD = storm water outfall/storm drain
ND = non-detect

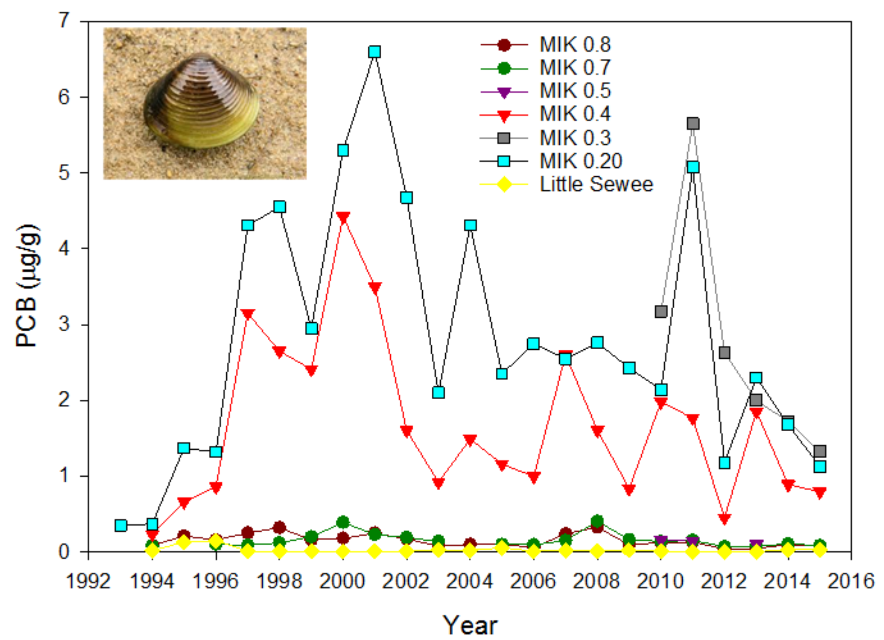


Fig. 3.50. Trend of PCBs in caged clams.
(MIK = Mitchell Branch kilometer and PCBs = polychlorinated biphenyls)

Table 3.44. Compiled data for mercury concentrations in caged Asiatic clams (*Corbicula fluminea*), 2011 to 2015
(ng/g, wet weight)

Location	Basket	2011	2012	2013	2014	2015
MIK 0.8 (above SD 170)	A	37	31.9	33.5	34.4	25
	B	46.9	32.2	32.1	44.1	22
SD 170	A	67.2	88.7	34.2	36.5	28
	B	80.7	62.3	38.9	43.2	38
MIK 0.7 (below SD 170)	A	37.7	46.2	33.5	34.8	28
	B	64.8	48.8	33.3	38	78
SD-180	A					103
	B					106
MIK 0.5 (below SD 180)	A	97.2	51.4	48.7		
	B	154.8	*B*	49.6		
SD 190	A	109.9	127.8	187.8	93.7	58
	B	80.7	270	210.7	103	107
MIK 0.4 (below SD 190)	A	114	85	113.1	46.3	47
	B	102.3	104.8	107.1	56	40
SD 195	A		88.1			
	B		79.5			
MIK 0.3	A		311.7	116.6	148	64
	B		322.6	125.8	132	53
MIK 0.2	A	166.3	115.9	100.1	88.4	38
	B	187.9	136.6	105.9	83.4	---
K-1700	A			87.7		
	B			88.3		
K-1203-10 sump	A	—	472.3	298.8	392	
	B	—	336.2	337.8	455	
P1	A	23	25.6	19	19.5	34

Table 3.44 (continued)

Location	Basket	2011	2012	2013	2014	2015
	B	22.6	14.5	22.4	17	20
K-901-A outfall	A	33.1	17.4	18.9	16.9	19
	B	46.4	27.6	25.8	18.5	67
SD 05A	A		472.3			
	B		336.2			
K-897-E	A					24
	B					22
K-897-J	A					26
	B					31
Little Sewee Creek	A	19.6	25.2	24.4	18.6	21
	B	27.2	19.1	26.7	17.4	26

Acronyms
MIK = Mitchell Branch kilometer
SD = storm water outfall/storm drain

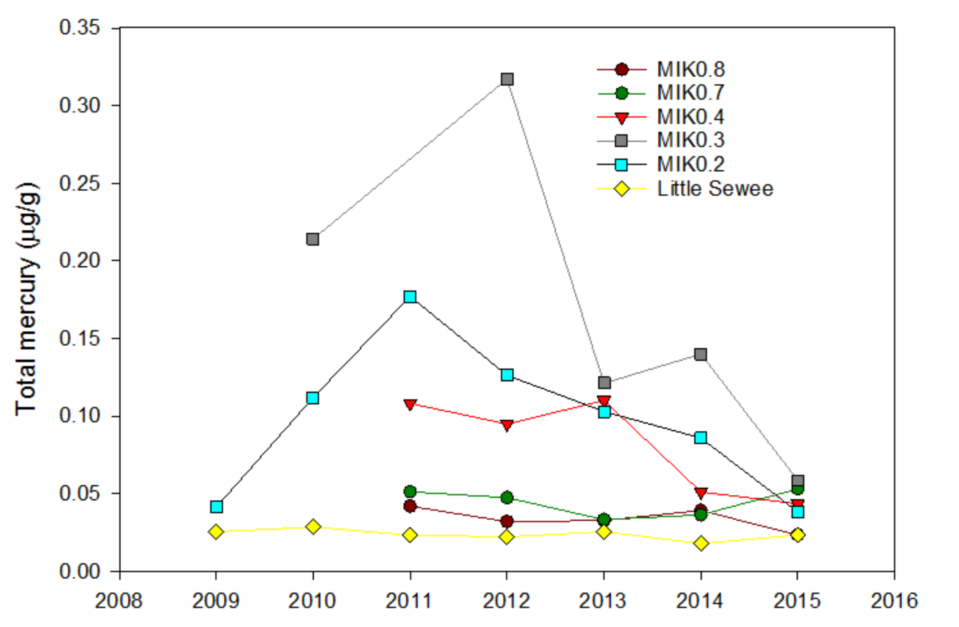


Fig. 3.51. Trend of mercury in caged clams. *(MIK = Mitchell Branch kilometer)*

Clams from the Mitchell Branch watershed, the K-901-A and K-1007-P1 ponds, storm water outfall 710, and the sump at the former K-1203 STP were analyzed for mercury (both total mercury and methyl mercury) in 2015. The highest mean total mercury concentrations were found in the clams from storm water outfall 180 (104.5 ng/g). Clams from the section between K-1700 and storm water outfall SD 190 also had higher levels, with concentrations of total mercury in the caged clam composite samples ranging from a low of 38 ng/g to a high of 107 ng/g. At other sites, mercury concentrations in clams ranged from at or near reference values to fourfold higher (19 to 78 ng/g). Clams were also analyzed for methyl mercury, which typically makes up a small fraction of the total mercury in clams. Levels of methyl mercury in the clams in the 2015 monitoring ranged from a high of 23 ng/g in the clams from the K-1007-P1 pond to a low of 6 ng/g in the clams from MIK 0.8. In most instances, the levels of methyl mercury were very close to the levels seen in the clams from the reference locations (an average of 11 ng/g).

Bioaccumulation monitoring in the K-1007-P1 pond, K-901-A pond, K-720 slough, and Mitchell Branch involves sampling of fish (Fig 3.52) and analyzing the tissues for PCB concentrations (Table 3.45 and Fig. 3.53). Typically, fillets of game fish are used as a monitoring tool to assess human health risks, while whole body composites of forage fish are used to assess ecological risks associated with exposure to PCBs. Target species vary from site to site, depending upon the ecological conditions and, thus, the available species. The target species for bioaccumulation monitoring in 2015 in the K-1007-P1 pond was bluegill sunfish (*Lepomis macrochirus*) (Fig. 3.54) and largemouth bass (*Micropterus salmoides*). In Mitchell Branch, the target species was the redbreast sunfish (*Lepomis auritus*). In the K-901-A pond and the K-720 slough, the target species were the gizzard shad (*Dorosoma cepedianum*) and largemouth bass (*Micropterus salmoides*). As there were not enough largemouth bass, carp (*Cyprinus carpio*) and smallmouth buffalo (*Ictiobus bubalus*) were also collected.

Fig. 3.52. Fish bioaccumulation sampling at K-1007-P1 pond.

Table 3.45. Polychlorinated biphenyl levels in fish samples at East Tennessee Technology Park, 2009 to 2015*(µg/g)*

Fish	Sampling location	2009	2010	2011	2012	2013	2014	2015
Redbreast sunfish	Mitchell Branch	0.99	1.17	1.12	1.67	1.29	1.54	2.71
Stoneroller minnows	Mitchell Branch							7.54
Largemouth bass	K-901-A pond	0.48		0.5	0.72	1.4	0.45	0.66
Common carp	K-901-A pond		0.71	2.06	3.08	2.94	1.41	1.77
Gizzard shad	K-901-A pond				4.82	8.86	6.52	5.41
Largemouth bass	K-1007-P1 pond	14.85	0.3					5.33
Bluegill sunfish	K-1007-P1 pond		2.13	1.85	2.16	0.7	0.62	0.45
Bluegill sunfish (whole body composites)	K-1007-P1 pond				9.25	4.45	3.21	2.03
Redbreast sunfish	Hinds Creek	0.0007	0.09	0.06	0.06	0.06	0.03	0.03
Stoneroller minnows	Hinds Creek							0.03
Largemouth bass	K-720 slough			0.24	0.22	0.14	0.15	0.08
Smallmouth buffalo	K-720 slough			0.77	0.68	0.44	0.14	
Common carp	K-720 slough			0.96	0.31	0.45	0.27	0.35
Gizzard shad (whole body composites)	K-720 slough					0.57	0.29	0.39

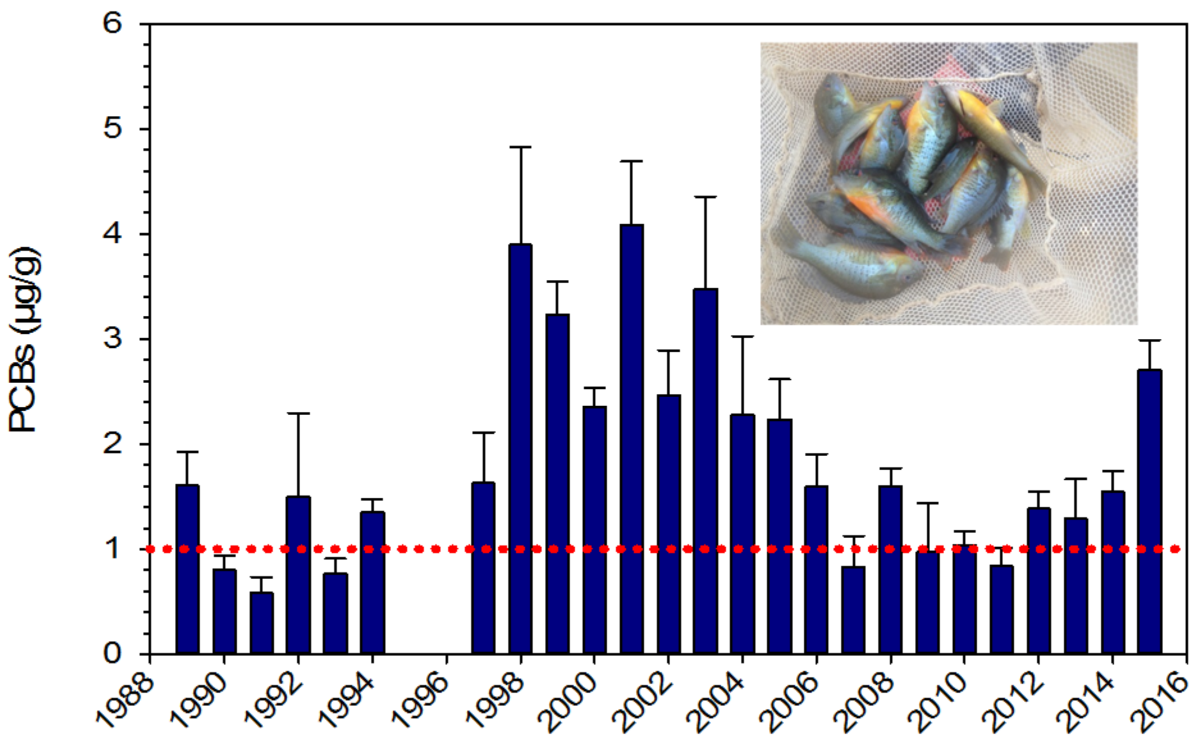


Fig. 3.53. Trend of polychlorinated biphenyls in fish from Mitchell Branch (blue bars show average values, T-bars show the range of results from individual fish).

ORNL 2011-G00782/chj

Fig. 3.54. Bluegill sunfish (*Lepomis macrochirus).*

Whole body composites (six composites of 10 bluegills per composite) and fillets from 20 individual bluegills were analyzed for PCBs to assess the ecological and human health risks associated with PCB contamination in the K-1007-P1 pond. Average PCB levels in bluegill whole body composites from the K-1007-P1 pond averaged 2.03 µg/g, down from 3.21 µg/g in 2014. Fillets averaged 0.45 µg/g total PCBs, a slight decrease compared to levels seen in 2014 (0.62 µg/g). Fillets of largemouth bass averaged 5.33 µg/g total PCBs (bass were not sampled in 2014). Average PCB concentrations in sunfish fillets collected in Mitchell Branch were 2.71 µg/g, slightly higher than the levels seen in 2014 (1.59 µg/g). The concentrations observed in fillets of largemouth bass from the K-901-A pond (0.66µg/g) increased slightly from the concentrations seen in the 2014 monitoring, 0.45 µg/g. Fillets of carp from the K-901-A pond averaged 1.77µg/g. Gizzard shad whole body composite samples from K-901-A pond (5.41 g/g) decreased from the concentrations seen in the 2014 monitoring (6.52 µg/g). Levels of PCBs in bass, gizzard shad, and carp from the K-720 slough (0.08 µg/g, 0.39 µg/g, and 0.35 µg/g, respectively) were considerably lower than for the same species from the K-901-A pond.

In addition to being analyzed for PCBs, selected species collected from several locations were analyzed for total mercury (Table 3.46 and Fig. 3.55). Previous studies have shown that methyl mercury accounts for more than 95% of the total mercury in fish, so a separate analysis for methyl mercury was not conducted. The EPA’s recommended limit for mercury in fish fillets is 0.3 µg/g. In 2015, whole body composite samples of gizzard shad from the K-720 slough averaged 0.07 µg/g of mercury, while those from the K-901-A pond averaged 0.05 of mercury. The mean mercury concentration in largemouth bass fillets collected from the K-1007-P1 pond was 0.12 µg/g in 2015, while whole body composite samples of bluegill from K-1007-P1 pond averaged 0.08 µg/g of mercury. The mean mercury concentration in sunfish fillets collected at MIK 0.2 was 0.41 µg/g in 2015, little changed from 2014 (0.46 µg/g). However, mercury concentrations in fish in Mitchell Branch in recent years have averaged about 0.3 to 0.5 µg/g, with about 10 to 20% variability within the annual collection (Table 3.45). Fillets of sunfish from the reference site, Hinds Creek, averaged 0.06 µg/g of mercury in 2015, while whole body composite samples of stonerollers (*Campostoma oligolepis*) averaged 0.03 µg/g of mercury.

Table 3.46. Mercury levels in fish fillets and whole body samples at East Tennessee Technology Park, 2009 to 2015
(µg/g)

Fish	Sampling location	2009	2010	2011	2012	2013	2014	2015
Redbreast sunfish	Mitchell Branch	0.49	0.35	0.34	0.37	0.52	0.46	0.41
Stoneroller minnows								0.06
Gizzard shad (whole body)	K-901-A pond		0.086					0.05
Paddlefish (1 sample)	K-1007-P1 pond		0.07					
Largemouth bass	K-1007-P1 pond							0.12
Bluegill sunfish	K-1007-P1 pond		0.085					0.08
Stoneroller minnows	Hinds Creek							0.06
Redbreast sunfish	Hinds Creek		0.08	0.07	0.058	0.07	0.09	0.06
Gizzard shad (whole body)	K-720 slough		0.067					0.07

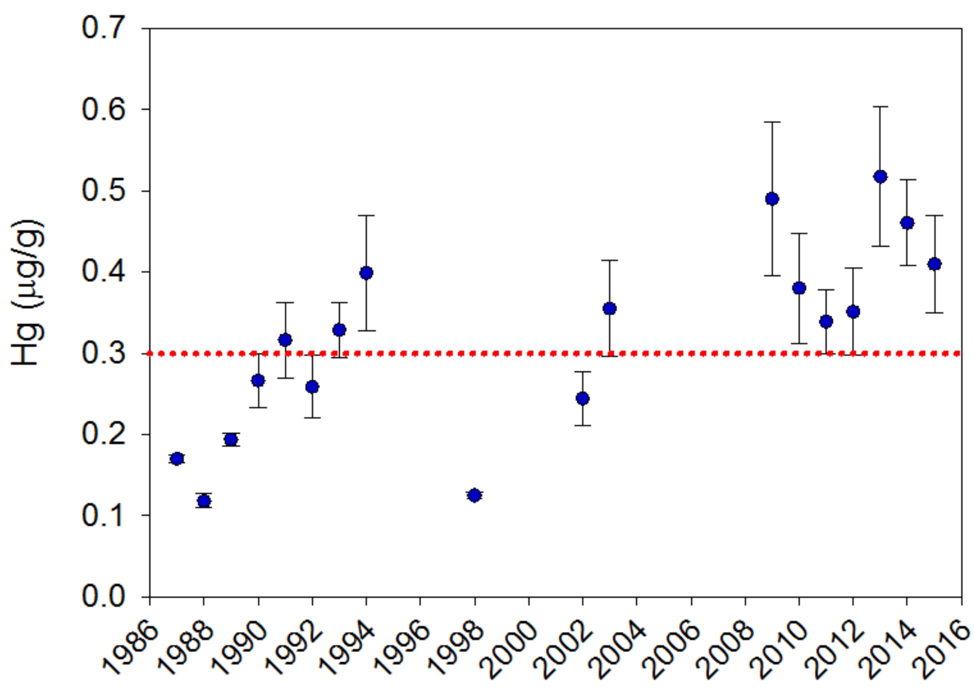


Fig. 3.55. Trend of mercury in fish in Mitchell Branch.

In April 2015, the benthic macroinvertebrate community at four Mitchell Branch locations (MIKs 0.4, 0.7, 0.8, and 1.4) was sampled using standard quantitative techniques (Fig. 3.56); MIK 1.4 was the reference location. Results of monitoring in 2015 using the ORNL protocols show little change at the three uppermost locations (MIKs 1.4, 0.8, and 0.7). The number of pollution-intolerant species is highest at MIK 1.4 (Fig. 3.57). The number of pollution-tolerant species makes up a much larger percentage of the total fauna at MIK 0.4 than at any of the other locations. Otherwise, except for the period from 2010-2012, trends in change at MIK 0.4 have generally mirrored those at MIKs 0.7 and 0.8. In recent years, the benthic macroinvertebrate community at MIK 0.7 and MIK 0.8 has shown no major persistent change in trends of either the mean number of taxa (taxonomic richness of all taxa) or the mean number of pollution-intolerant taxa [i.e., the taxonomic richness of the Ephemeroptera, Plecoptera, and Trichoptera (EPT)]. These results show that the benthic community at MIK 0.4 continues to be negatively impacted while the results for MIKs 0.7 and 0.8 suggest that the macroinvertebrate community at those sites is also impacted to a lesser degree.

Fig. 3.56. Benthic macroinvertebrate sampling in Mitchell Branch.

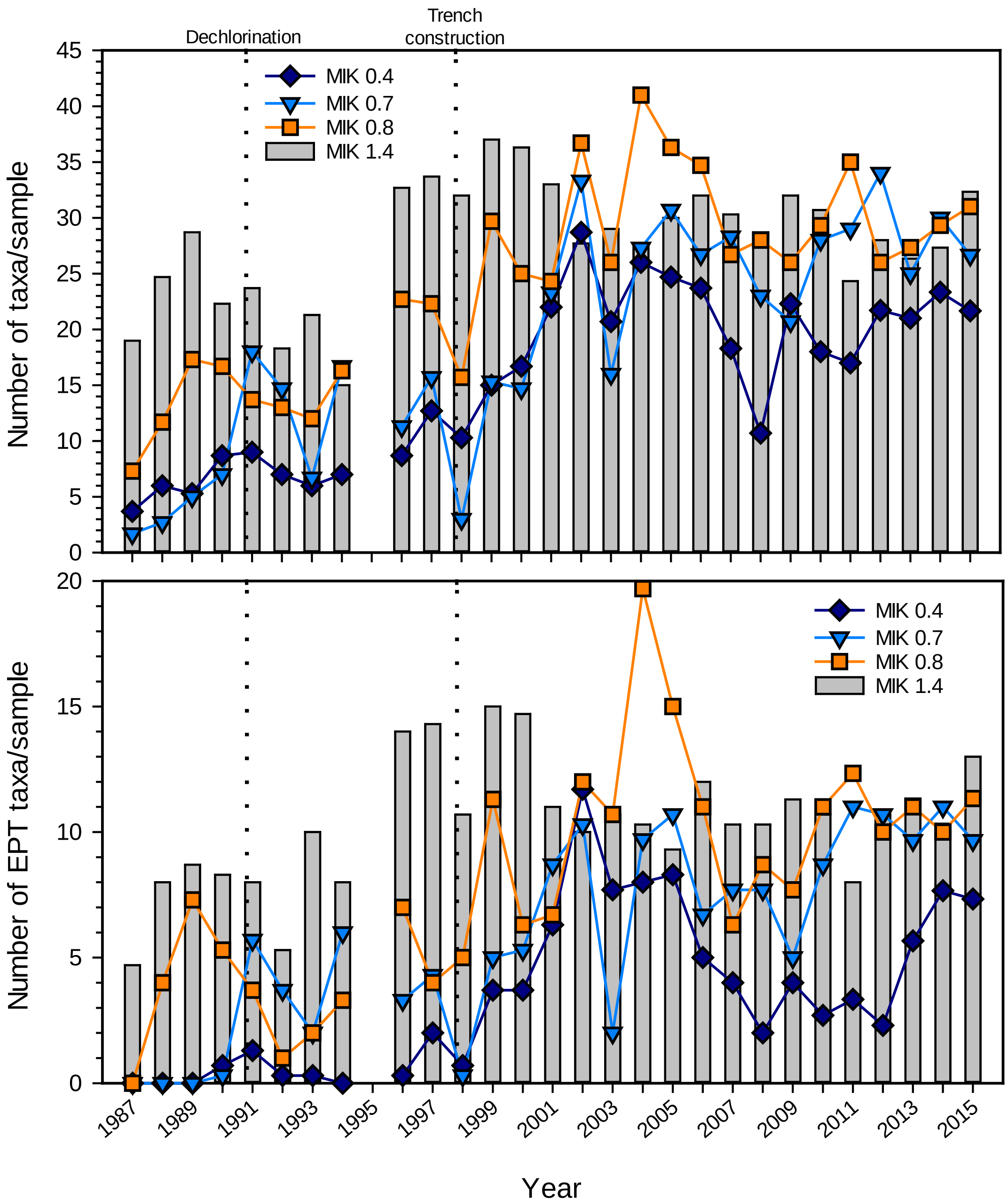
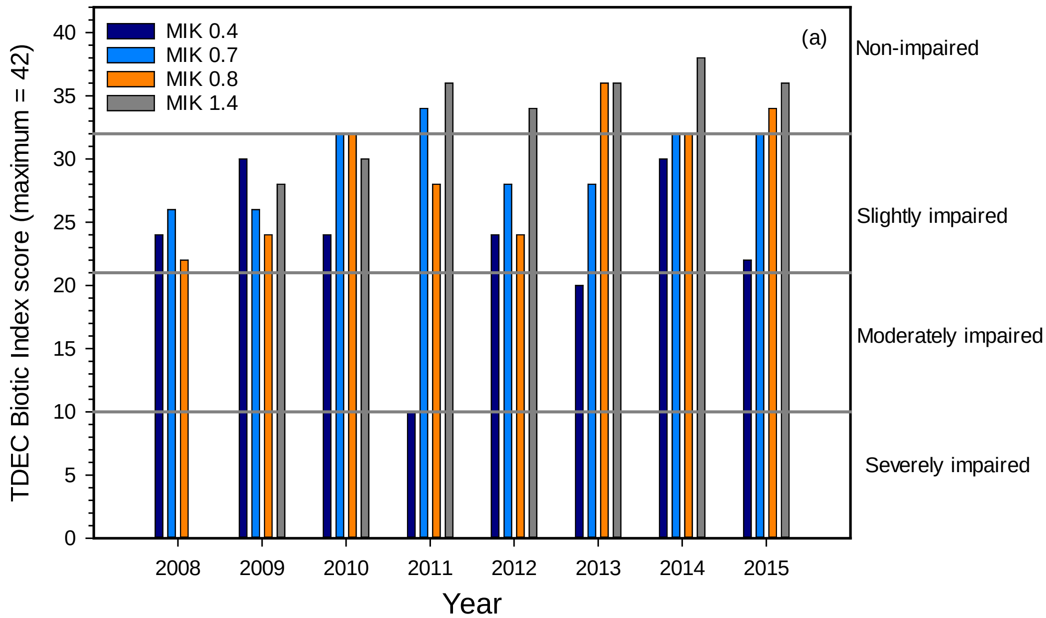


Fig. 3.57. Mean taxonomic richness in Mitchell Branch, 1987–2015*:*
(a) number of all taxa, and (b) number of pollution-intolerant Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, and caddisflies, or EPT) taxa per sample. Samples were not collected in April 1995, as indicated by the gap in the lines. (MIK = Mitchell Branch kilometer)

Since August 2008, TDEC protocols, which assess both community and habitat characteristics, have also been used at the MIK 0.4, 0.7, and 0.8 monitoring locations. Beginning in August 2009, the use of TDEC protocols was expanded to include MIK 1.4 as well (Fig. 3.58). The biotic index indicated that the community at MIK 0.4 was slightly impaired, and the communities at MIKs 0.7, 0.8, and 1.4 were unimpaired. The habitat assessment (which primarily considers the physical aspects of the stream to



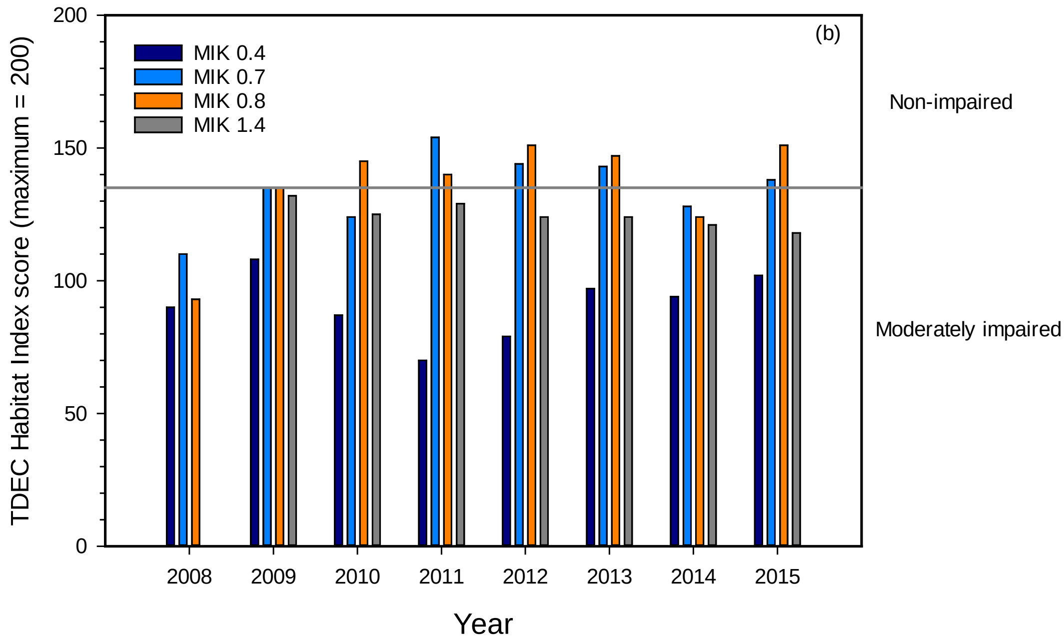


Fig. 3.58. Temporal trends in Tennessee Department of Environment and Conservation (TDEC) Benthic Macroinvertebrate Biotic Index (a) and Stream Habitat Index (b) scores for Mitchell Branch, August 2008 to 2015.

Horizontal lines in both graphs show the lower thresholds for narrative index ratings; respective narrative ratings for each threshold are shown on the right side of each graph.
(MIK = Mitchell Branch kilometer)

determine its suitability to support biological communities) in 2015 indicated habitat impairment at MIKs 0.4 and 1.4, while the habitat at MIKs 0.7 and 0.8 were rated as unimpaired. Overall, results using TDEC's semiquantitative protocols and ORNL's quantitative protocols since 2008 have been in general agreement that the macroinvertebrate community at MIK 0.4 scores from slightly to moderately impaired, and the communities at MIKs 0.7 and 0.8 score from slightly impaired to unimpaired. Habitat assessments show evidence of some impairment at all sites.

Fish communities in Mitchell Branch (MIKs 0.4 and 0.7) and at local reference sites were sampled in 2015. In Mitchell Branch, species richness (number of species), density (fish/m²) (Figs. 3.59 and 3.60), and biomass were assessed for comparison with area reference streams. Results for 2015 showed changes within the normal range of variation for species richness. However, most of the species found during the community studies sampling tend to be more tolerant of less than optimal conditions. At the most downstream site (MIK 0.4), all three metrics [species richness (Fig. 3.59), density (Fig. 3.60), and biomass] increased with a noticeable increase in biomass and density. MIK 0.7 had a slight decrease in species richness, while biomass and density still remain over two times higher than in the other reference streams. Overall, variations in these three parameters are typical of streams that have been severely impacted and are still recovering. While the condition of the fish communities over the last several years has been relatively stable, they have yet to reach conditions typical of less impacted streams in the area, and the stream is still dominated by more tolerant fish species.

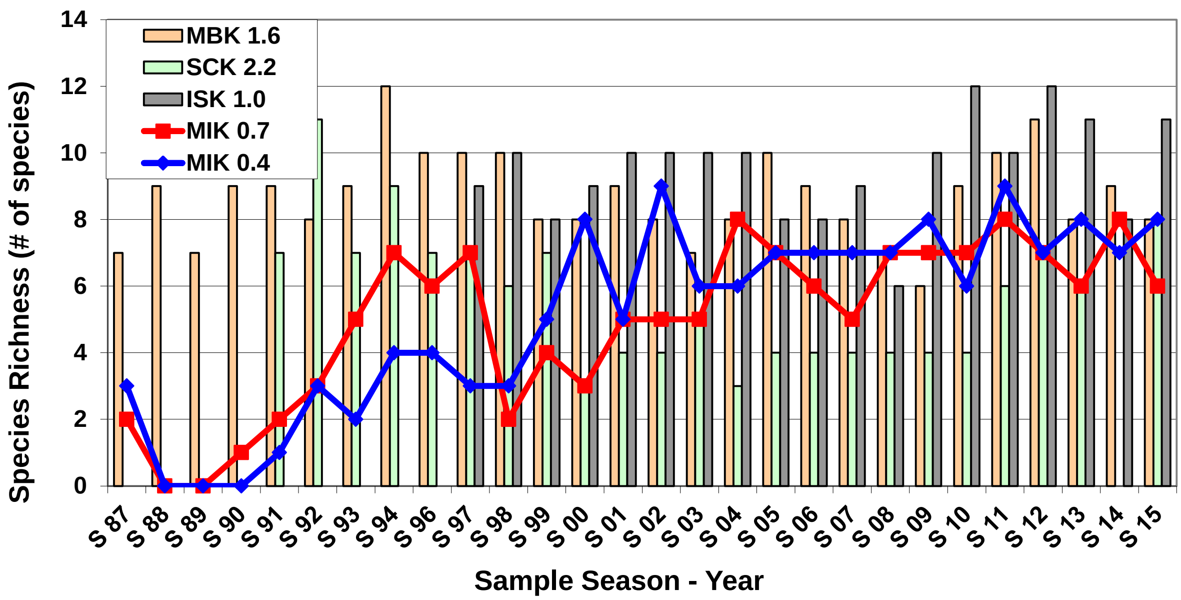


Fig. 3.59. Species richness for fish communities at sites in Mitchell Branch and in reference streams. *(ISK = Ish Creek kilometer, MBK = Mill Branch kilometer, MIK = Mitchell Branch kilometer, and SCK = Scarboro Creek kilometer)*

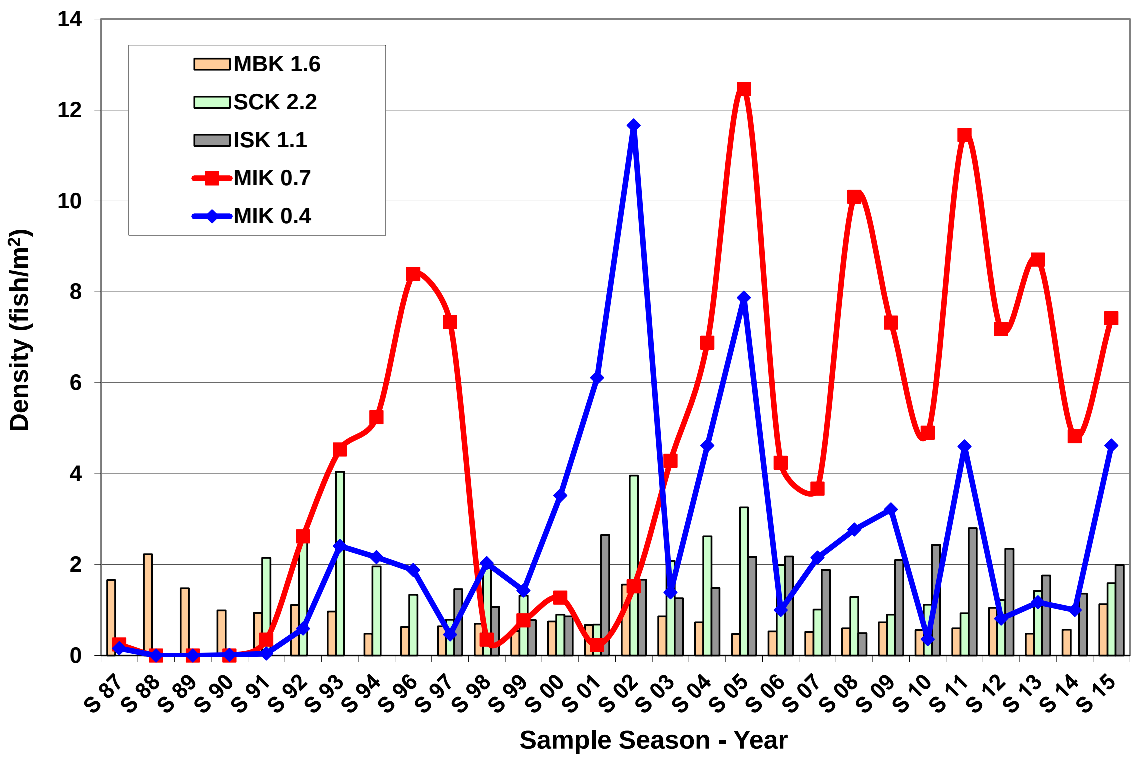


Fig. 3.60. Density for fish communities at sites in Mitchell Branch, and in reference streams.
(ISK = Ish Creek kilometer, MBK = Mill Branch kilometer, MIK = Mitchell Branch kilometer, and SCK = Scarboro Creek kilometer)

Similar to stream sampling, the K-1007-P1 pond is sampled annually to assess the diversity and density of resident fish populations. The pond is isolated from Poplar Creek by a weir grate at the outfall, preventing migration of fish into or out of the pond. Remediation efforts in 2007 focused on creating a fish community dominated by short-lived sunfish. Before remediation activities, the fish community contained high densities of predatory fish, as well as grazers, which fed on phytoplankton. In 2015, the fish community was comprised of sunfish (~50%), grazers (~40%), and predators (~7%). These numbers continue to vary from year to year, indicating that the population has not reached a state of balance yet, but they do continue to indicate a movement towards the goal of a sunfish-dominated community.

3.8 Environmental Management and Waste Management Activities

Waste Management Activities

Restoration of the environment, D&D of facilities, and management of legacy wastes constitute the major operations at ETTP.

CWTS is a smaller water treatment unit for chromium-contaminated groundwater that sits within the existing CNF footprint. CWTS came online in late 2012 and handles purge water from groundwater monitoring, as well as the chromium collection system water. Effluent from CWTS discharges into the Clinch River through an existing CNF discharge line. Section 3.6.2.14 provides a more detailed discussion of CWTS operations.

3.8.1 Environmental Remediation Activities

EM continued remediation activities to reduce ETTP soil contamination in 2015. The site is divided into two cleanup regions: Zone 1, a 1,400-acre area outside the main plant area, and Zone 2, the 800-acre area that comprises the main plant area.

3.8.1.1 Zone 1

The interim ROD, which documents the cleanup method for the site, required Environmental Management (EM) to remediate soil to a depth of 10 ft (suitable for the protection of an industrial work force) and remove sources of groundwater contamination. EM prepared a remedial investigation/feasibility study (RI/FS) to address groundwater, surface water, ecological protection, and final LUCs. EPA and TDEC provided comments on the RI/FS, and the agencies reached an agreement to initiate a Zone 1 final soils ROD and defer Zone 1 surface water and groundwater to a future decision. In FY 2014, TDEC prepared and approved a revised RI/FS. The initial draft of the Zone 1 final soils proposed plan was also prepared and transmitted to EPA and TDEC for review. Upcoming work includes addressing EPA and TDEC comments and finalizing the Zone 1 final soils proposed plan, conducting a public meeting on the proposed plan, and preparing the Zone 1 final soils ROD.

3.8.1.2 Zone 2

Remediating Zone 2 involves removing some contaminated soil so that the site is safe for industrial use and removing sources of groundwater contamination.

In FY 2015, EM completed characterization of the footprints of Building K-25 and Building K-31. In 2016, this characterization data will be evaluated to determine if remediation is required under the Zone 2 Soils ROD. The roughly 40-acre footprint of Building K-25 has been declared the K-25 Preservation Footprint and is designated for historical commemoration and interpretation activities. The characterization results are also being used to support preservation of the area and evaluation of potential end states of the slab.

3.8.1.3 Tc-99 GW Investigation

Elevated levels of ^{99}Tc, a slowly decaying isotope, were observed in groundwater, storm water, and sanitary sewage during the demolition of the K-25 building. In 2014, an RmSE was prepared to assess the potential threat to human health and the environment from the elevated ^{99}Tc levels, discuss mitigative measures taken, and determine if further action was needed. The evaluation concluded that the levels of ^{99}Tc do not pose a threat to human health and the environment and recommended a shallow groundwater investigation south of the K-25 building slab to evaluate the potential migration of ^{99}Tc.

In 2015, the shallow groundwater investigation was implemented in phases. The results of Phase 1 and Phase 2 are documented in *Addendum to the Technetium-99 Removal Site Evaluation of the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2663&D1/A1, DOE 2015b). This document was submitted to DOE on December 21, 2015. The RmSE document will be revised to update the results of the Phase 3 investigation, which are scheduled to be completed in 2016.

3.8.1.4 Building K-31 Demolition

Demolition of the K-31 building at ETTP was completed in June 2015, marking the removal of the fourth of five gaseous diffusion buildings at the former uranium enrichment site. ETTP—once called the Oak

Ridge Gaseous Diffusion Plant (ORGDP), as well as the K-25 Site—was built as part of the Manhattan Project in the 1940s to enrich uranium for the atomic bombs that would end World War II. The site later produced enriched uranium for commercial and defense purposes. Operations ceased in 1985 and the site was permanently shut down in 1987. DOE then began cleanup operations, which included demolition of many of the buildings at the site.

The 750,000 ft^2 K-31 building was built in 1951. As part of a cleanup project in 2005, most of the hazardous materials were removed from the facility, leaving its shell to be demolished. UCOR, DOEs cleanup contractor, began demolishing the building in October 2014 and completed demolition ahead of schedule and under budget.

3.8.1.5 Building K-27 Demolition

Demolition of the K-27 building will mark the first-ever complete cleanup of a gaseous diffusion complex.

In FY 2015, transite paneling on the structure’s outer skin was removed. Building demolition began and is expected to be completed in 2016.

The building is one of EMs highest priorities at the site due to its risk and deteriorated state. The K-27 building is similar in structure to the already demolished K-25 building. It spans more than 8 acres and is approximately 900-ft long, 400-ft wide, and 58-ft in height.

Characterization of the building structure, equipment, and piping was completed for the purposes of waste disposal. A total of 105 samples of the building structure and 184 samples of equipment and piping were collected. Oil and other fluids were drained from various equipment. The application of polyurethane foam in process gas equipment, the off-site shipment of sodium fluoride (NaF) traps, the removal of ^{99}Tc-contaminated cylinders, and the removal of high risk equipment were completed. Removal of process gas equipment from the cell floor in two units of the building was completed. Other project activities completed in FY 2015 included sealing slab penetrations, installing storm water berms, and preparing waste disposal documents.

3.8.1.6 Buildings K-31 and K-33 Ancillary Facilities Demolition

In addition to completing the K-31 building demolition, buildings that supported the gaseous diffusion operations at K-31 and K-33 were also removed, creating an additional 200-acre tract of land for use by the private sector.

Demolition of four support pedestals remaining from the tear down of Building K-791 in the late 1990s was safely completed in February 2015. The pedestals were built as part of Building K-791 in the early 1950s to support equipment that regulated power to the K-33 building during gaseous diffusion operations. The pedestals were constructed of formed concrete and rebar. Each pedestal was 30 ft × 18 ft × 18 ft with a wall thickness varying from 40 to 52 in.

Demolition was completed on the K-761 Switch House, which was the power distribution and electrical switching station for the K-31 gaseous diffusion building at ETTP. The 14,640 ft^2, five-story building was built in the early 1950s, and after K-31 ceased operations in 1985, K-761 was shut down. Activities were then limited to routine S&M, storage of various types of waste containers, and the occasional removal of process equipment items for shipment to other gaseous diffusion plants.

Other ancillary buildings that were demolished included the K-892 fire and raw cooling water pumphouse and the K-892-Y RCW sludge softener.

3.8.1.7 Building K-1037 Demolition Preparation Begins

After almost 10 years of being placed in standby condition, the K-1037 Building has had revised security measures approved by DOE to allow for the removal of materials in preparation for deactivation and demolition of the facility. The building was used to produce barrier material for the gaseous diffusion process.

Initial planning walkdowns for the building have been conducted, which identified issues with the building's electrical service and combustibles storage. The original electrical distribution has been isolated, and a new temporary lighting service has been installed. Workers also began removing combustibles from the building.

Preliminary planning and engineering walkdowns have been conducted to allow for future asbestos and hazardous materials abatement.

3.8.1.8 Commemoration of the K-25 Site

Historic preservation of the K-25 Site continued in FY 2015 with the completion of the conceptual design of the Equipment Building, Viewing Tower, K-25 History Center, Wayside Exhibits, and K-25 slab delineation. A consultation meeting was held in January 2015, where representative from the Professional Site Design Team and Museum Professional (Smee and Busby Architects and Hilferty and Associates) presented the conceptual design to a group of 12 consulting parties, made up of historic preservation agencies and other interested agencies. Following review of the conceptual design documents, preliminary design activities started in 2015.

Development of the K-25 Virtual Museum website proceeded throughout FY 2015, and the website was previewed by the consulting parties in May 2015. Their comments were incorporated into the website, which is now available online at www.K-25virtualmuseum.org. The designer of the web-based K-25 Virtual Museum is Westside Media; historical content was provided by UCOR staff.

The National Defense Authorization Act of 2015, passed by Congress and signed into law December 19, 2014, by President Barak Obama, included provisions authorizing a Manhattan Project National Historical Park. Although the historic preservation activities at the K-25 Site are being implemented separately and independently of the National Historical Park, the passage of the Park legislation may provide opportunities to benefit from the experience of the National Park Service (NPS).

In August 2015, NPS officials, accompanied by an interpretive team from the NPS Harpers Ferry Center, toured Oak Ridge historic properties and held preliminary discussions with DOE headquarters and local officials about launching the park. The visit included a tour of the K-25 Site and discussions on the status of K-25 historic preservation activities.

3.8.2 Reindustrialization

As cleanup has progressed extensively at ETTP, more large parcels are becoming available for transfer (Fig. 3.61). The completion of K-31 demolition allows for the first parcel of over 200 contiguous acres that can be developed for large-scale, heavy industrial projects at Heritage Center Industrial Park. This area has been approved for transfer by the EPA and TDEC. Transfer of the land is expected to take place in 2016. This will be the second largest transfer in the history of the program. Additionally, a large area of 170 acres at the southeast corner of ETTP has been approved for transfer to Metropolitan Knoxville Airport Authority for a potential airport project. The general aviation airport runway will accommodate small corporate jets, private airplanes, and EMS aircraft. DOE completed an Environmental Assessment to support the property transfer and potential construction and operation of the airport. In 2015, DOE began draft documentation for future property transfers of large industrial parcels at the former Powerhouse area and Duct Island, both located at the western end of the site.

In the past year, three new businesses have begun operations at ETTP. This year also saw the construction of the Powerhouse 6 Solar Farm, the third and largest solar array on-site. Powerhouse 6 is a 1-MW solar array on five acres of former DOE land, providing electricity to TVA through the City of Oak Ridge. Heritage Center has also established numerous greenway areas, as well as an arboretum certified by the Tennessee Urban Forestry Council.

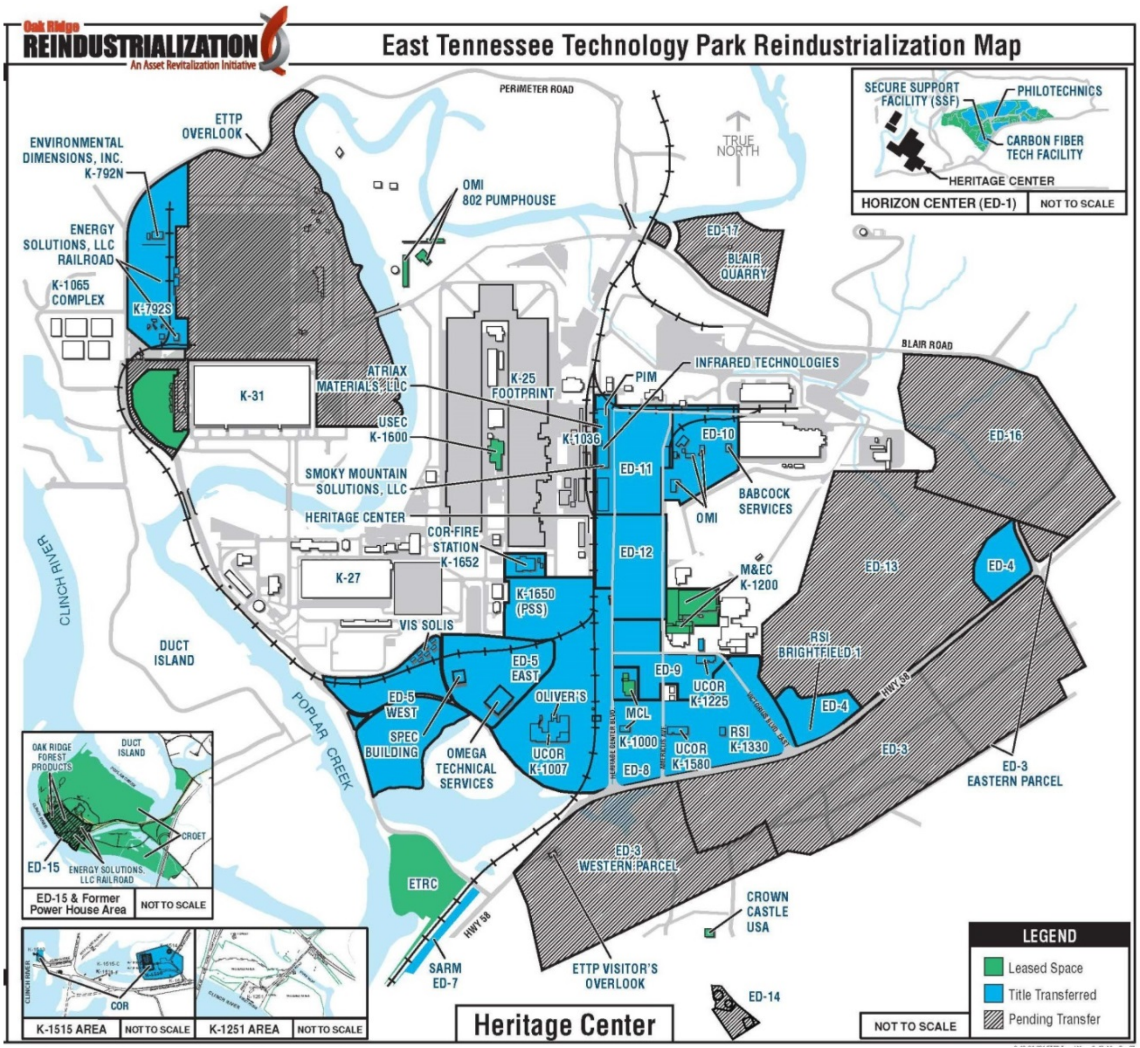


Fig. 3.61. East Tennessee Technology Park reindustrialization status, 2015.

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4. The Y-12 National Security Complex

The Y-12 National Security Complex, a premier manufacturing facility operated by Consolidated Nuclear Security, LLC, for the National Nuclear Security Administration, plays a vital role in the US Department of Energy Nuclear Security Enterprise. Drawing on more than 60 years of manufacturing excellence, the Y 12 Complex helps ensure a safe and reliable US nuclear weapons deterrent.

The Y-12 Complex also retrieves and stores nuclear materials, fuels the nation's naval reactors, and performs complementary work for other government and private-sector entities.

Today's environment requires that the Y-12 Complex have a new level of flexibility and versatility, so while continuing its key role, the Y-12 Complex has evolved to become the resource that the nation looks to for support in protecting America's future by developing innovative solutions in manufacturing technologies, prototyping, safeguards and security, technical computing, and environmental stewardship.

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

4.1 Description of Site and Operations

4.1.1 Mission

Consolidated Nuclear Security, LLC (CNS) manages and operates the Pantex Plant (Pantex) and Y-12 National Security Complex (Y-12) on behalf of the National Nuclear Security Administration (NNSA). Together, these two sites are a core element of a sustainable and robust national nuclear deterrent.

Charged with maintaining the safety, security, and effectiveness of the US nuclear weapons stockpile, the Y-12 Complex is a one-of-a-kind manufacturing facility that plays an important role in US national security. Y-12's core mission is to ensure a safe, secure, and reliable US nuclear deterrent, which is essential to national security. Every weapon in the US nuclear stockpile has components manufactured, maintained, or ultimately dismantled by Y-12. Through Life Extension Program (LEP) activities, Y-12 produces refurbished, replaced, and/or upgraded weapon components to modernize the enduring stockpile. As the nation reduces the size of its arsenal, Y-12 has a central role in decommissioning weapons systems and providing weapons material for nonexplosive, peaceful uses. Y-12 provides the expertise to secure highly enriched uranium (HEU), store it with the highest security, and make material available for nonweapons uses (e.g., in research reactors that produce cancer-fighting medical isotopes and commercial power). Y-12 also processes HEU from weapons removed from the nation's nuclear weapons stockpile for use by the Naval Reactors program to fuel nuclear-powered submarines and aircraft carriers.

Located within the city limits of Oak Ridge, the Y-12 Complex covers more than 328 ha (810 acres) in the Bear Creek Valley, stretching 4.0 km (2.5 miles) in length down the valley and nearly 2.4 km (1.5 miles) in width across it. NNSA-related facilities located off the Y-12 Complex site but in Oak Ridge include the Central Training Facility, the Uranium Processing Facility (UPF) project offices, a records storage facility, Y-12 Shipping and Receiving, and an analytical laboratory.

4.1.2 Modernization

Government-owned facilities and operations are being challenged to become smaller, more efficient, and more responsive to changing national and global challenges. NNSA's vision for a smaller, safer, more secure and less expensive nuclear weapons complex must leverage the scientific and technical capabilities of its workforce while continuing to meet national security requirements.

Nowhere in the National Security Enterprise is this more important than at the Y-12 Complex.

Most Y-12 Complex mission-critical facilities are more than 70 years old (Fig. 4.1). To address this situation, Y-12 has been consolidating operations, modernizing facilities and infrastructure, and reducing the legacy footprint for more than a decade. These actions are consistent with and supportive of NNSA enterprise transformation planning. Through modernization projects, deferred maintenance reduction, and infrastructure reduction, the Y-12 Complex will continue to strive toward becoming a more responsive, sustainable enterprise. As evidenced by the performance achievements presented in this year's ASER, Y-12 continues to meet the challenges of declining budgets through enhanced security measures, enhanced technology, and innovative business practices.

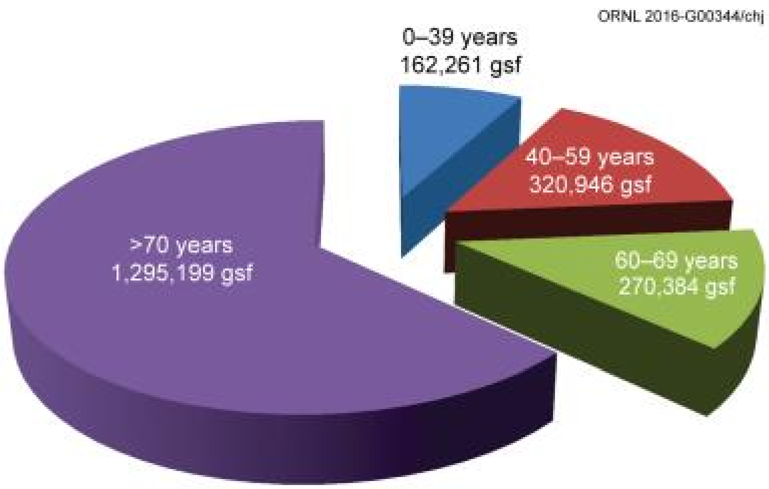

Fig. 4.1. Gross square footage by age of mission-critical facilities at the Y-12 National Security Complex.
(gsf = gross square feet.)

Replacement and revitalization are key elements of the modernization strategy at Y-12. A significant number of facilities at Y-12 are at or beyond design life. At present, several facilities are in the early construction or critical design process.

Enriched Uranium 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.

UPF is an integral part of the Y-12 Complex transformation efforts and a key component of the NNSA Uranium Center of Excellence. UPF will be a modern manufacturing facility designed and constructed for health, safety, security, and operations efficiency. In FY 2014, NNSA commissioned a Project Peer

Review Team to assess the progress and opportunities for the UPF project. This evaluation produced a number of recommendations to refocus the project to a smaller footprint and to relocate various processes to existing facilities. This effort is vital to the long-term mission for Y-12. Efforts are under way to implement the revised strategy and to incorporate bridging plans to maintain the integrity of the aged infrastructure.

When UPF is complete, it will replace a portion of HEU production functions. The remaining HEU production capability will be transitioned to Buildings 9215 and 9204 02E, which must be sustained to achieve the HEU mission strategy. The strategy includes

- accelerating transition out of Building 9212 by 2025 to reduce nuclear safety and operational risk while maintaining enriched-uranium capabilities;
- integrating evaluation of alternatives for delivery of UPF that prioritizes replacement capabilities by risk to nuclear safety, security, and mission continuity;
- substantially improving the needed Y-12 infrastructure over the next decade at a risk-based annual funding level that supports safe and secure operations; and
- prioritizing replacement capabilities by risk-to-mission continuity, nuclear safety, and security.

Lithium Production Capability

To ensure continued mission availability and to reduce annual operating costs, the lithium capability must be replaced; the equipment and facility degradation have gone beyond the option of repair. Building 9204-2, built in 1943, performs production work for lithium and related materials vital to nuclear weapons production. The facility, at approximately 325,000 ft^2, is oversized for today’s mission and has both internal and external concrete deterioration. The roof, walls, and ceilings have been exposed to decades of corrosive liquids and processing fumes, requiring restricted access and protective equipment (hard hats) in many areas. The facility, currently carrying approximately $21.7M in deferred maintenance, could be replaced by a new facility less than one-fourth its size. Site production risk assessments rate two of the lithium processes as the highest equipment risk at Y-12. Critical process equipment (hydraulic press) failures caused high-priority repair efforts to minimize the negative impact on delivery schedules of directed stockpile work components. The inability to control humidity due to aged and inoperable heating, ventilation, and air-conditioning (HVAC) equipment has caused recurrent lost work days, negatively impacting directed stockpile work costs and LEP schedules. An Analysis of Alternatives is currently underway to determine the path forward for replacement of the capability.

Support Facilities

Emergency response capabilities at Y-12 reside in four primary facilities: three located on site (Buildings 9706-2, 9105 and 9710-2) with the third located off site (K-1650) near the Y-12 campus at the East Tennessee Technology Park. Building 9706-2 houses the Plant Shift Superintendent (PSS) and the Emergency Control Center (ECC). The Technical Support Center (TSC) was relocated to 9105 due to a flood event in 2014. Building 9710-2 houses the Fire Station and the Fire Department Alarm Room (FDAR). Building K-1650 houses the command center/alternate Emergency Operations Center (EOC). A proposed EOC facility line-item project is scheduled to begin in 2018. The scope of this line-item project includes the replacement of the PSS/TSC and the emergency operations center. The proposed emergency response facility will more effectively and efficiently support the Y-12 National Security Complex (NSC) missions by consolidating the aforementioned capability functions into a habitable, survivable facility that also provides space for a Technical Support Team.

The principal facility housing Fire Protection Operations (FPO) is Building 9710-2. Built in 1948, 9710-02 is located within the most highly protected area of the plant and is close to Y-12's most hazardous operations. Seismic, tornado, hazardous material release, and security events could render the fire station inaccessible. Access to the facility by off-duty personnel is critical because those personnel augment the duty staff. Although upgrades have been performed over the years, Building 9710-2 has exceeded its useful life and needs to be replaced so that long-term emergency management response to the site is ensured. Relocation of the fire station away from Y-12 hazardous material facilities is necessary to ensure that the Fire Department can respond safely and effectively to all emergencies at Y-12.

Over the next 10 years and beyond, Y 12 will continue to consolidate personnel and processes in support of the long-range footprint reduction and modernization vision. The proposed, smaller Y-12 will eliminate many of the World War II–vintage operations buildings that currently house the nuclear operations. The plan envisions a smaller future site and proposes the following new capable, responsive, and sustainable facilities:

- Projects initiated during Future Years Nuclear Security Plan (FYNSP) period:
  - EOC
  - Fire Hall
  - Lithium Capability Project
  - UPF and Bridging Strategy for 9215 and 9204-02E
- Projects planned for beyond FYNSP:
  - West End Change House
  - Applied Technologies Laboratory
  - Consolidated Manufacturing Capability
  - Maintenance Complex
  - Material Storage and Staging Facility
  - Waste Management Complex

Excess Facility Disposition

Since 2002, Y-12 has demolished more than 1.4 million ft^2 of excess facilities. The NNSA Facilities Disposition Program is under development and will continue to evaluate excess assets, prioritize their disposition, and propose the budget resources required for their disposition. Without a defined program to eliminate excess facilities, the NNSA sites will continue to use limited resources to safely maintain those facilities that no longer have a mission use.

Currently, more than 80 excess US Department of Energy (DOE) facilities are located on the Y-12 site. The facilities are owned by NNSA and DOE's Office of Environmental Management (EM), Office of Science (SC), and Office of Nuclear Energy (NE). Process-contaminated excess facilities contain radiological or chemical contamination resulting from their mission operations during the Manhattan Project and the Cold War. Process-contaminated excess facilities are expected to be managed by NNSA and its prime contractor, CNS, until facility conditions meet the criteria for transfer to EM. EM, through its contractors, will then be responsible for decommissioning and demolishing the facilities. Nonprocess contaminated excess facilities generally do not contain radiological or chemical contamination from mission operations but may contain hazardous industrial materials associated with their construction materials [e.g., asbestos insulation, lead-containing paint, or polychlorinated biphenyl (PCB)-contaminated oil]. The nonprocess contaminated excess facilities will be deactivated by NNSA and decommissioned by NNSA or EM, depending on the cost and complexity.

During FY 2015, the secretary of energy established the Laboratory Operations Board to complete the first comprehensive complex-wide assessment of DOE's infrastructure. As a subset of the Laboratory

Operations Board, the Excess Contaminated Facilities Working Group was formed with representatives from NNSA, EM, and SC. The working group is consolidating information from throughout the DOE enterprise and is developing priorities and budgetary requirements. Y-12 will work with the Excess Contaminated Facilities Working Group to ensure that there is a continued focus on both the risks presented by the excess facilities at Y-12 and the actions required to safely and effectively mitigate those risks.

4.2 Environmental Management System

As part of CNS's commitment to environmentally responsible operations, the Y-12 Complex has implemented an EMS based on the rigorous requirements of the globally recognized ISO 14001-2004 (ISO 2004).

DOE O 436.1, *Departmental Sustainability*, (DOE 2011) provides requirements and responsibilities for managing sustainability within DOE in accordance with applicable Executive Orders. The order further requires implementation of an Environmental Management System (EMS) that is either certified to the requirements of ISO 14001 by an accredited ISO 14001 registrar or self-declared to be in conformance to the standard in accordance with instructions issued by the Office of the Federal Environmental Executive, a chartered task force under the White House Council on Environmental Quality.

The EMS requirements taken from DOE O 436.1 have been incorporated in the Environmental Protection Functional Area of the Y-12 Complex Standards/Requirements Identification Document.

4.2.1 Integration with Integrated Safety Management System

The Integrated Safety Management System (ISMS) is the DOE umbrella of environment, safety, and health (ES&H) programs and systems that provides the necessary structure for any work activity that could potentially affect the public, a worker, or the environment. At Y-12, the elements of the ISO 14001 EMS are incorporated in ISMS for environmental compliance, pollution prevention, waste minimization, and resource conservation.

4.2.2 Policy

The Y-12 environmental policy and commitment to providing sound environmental stewardship practices through the implementation of an EMS have been defined, are endorsed by top management, and have been made available to the public via company-sponsored forums and public documents such as this one. The Y-12 ES&H policy is presented in Fig. 4.2.

ORNL 2010-G00475/chj

Y-12 Environment, Safety, and Health Policy

Policy: As we work to achieve the Y-12 mission and our vision of a modernized Y-12 Complex, we will do so by ensuring the safety and health of every worker, the public, and the environment. Every employee, contractor, and visitor is expected to take personal responsibility for their actions.

- Environmental Policy: We protect the environment, prevent pollution, comply with applicable requirements, and continually improve our environment.
- Safety and Health Policy: The safety and health of our workers and the protection of public health and safety are paramount in all that we do. We maintain a safe work place and plan and conduct our work to ensure hazard prevention and control methods are in place and effective.

In support of this policy, we are committed to:

- Integration of Environment, Safety and Health (ES&H) into our business processes for w ork planning, budgeting, authorization, execution, and change control in accordance with our Integrated Safety Management System.
- Continuously improving our processes and systems by establishing, tracking, and achieving goals that drive performance excellence.
- Direct, open, and truthful communication of this policy and our ES&H performance to our employees, contractors, customers, and stakeholders.
- Strive to minimize the impact of our operations on the environment in a safe, compliant, and cost-effective manner using sustainable practices for energy efficiency, fleet management, water consumption, pollution prevention, recycling/reuse, source reduction, resource conservation, and environmentally preferable purchasing.
- Incorporate sustainable design principles into the design and construction of facility upgrades, new facilities, and infrastructure considering life-cycle costs and savings.
- Incorporate the use of engineering controls to reduce or eliminate hazards whenever possible into the design and construction of facility upgrades, new facilities, and infrastructure.
- Strive to provide a clean and efficient workplace free of occupational injuries and illnesses (Target Zero).
- Foster and maintain a work environment of mutual respect and teamwork that encourages free and open expression of ES&H concerns.

Fig. 4.2. Y-12 National Security Complex environment, safety, and health policy.

The Y-12 ES&H policy has been communicated to all employees; incorporated into General Employee Training (GET) for every employee, guest, and contractor; and made available for viewing on the Y-12 external website and the internal Y-12 Complex website. Y-12 Complex personnel are made aware of the commitments stated in the policies and how the commitments relate to Y-12 Complex work activities.

4.2.3 Planning

4.2.3.1 Environmental Aspects

Environmental aspects may be thought of as potential environmental hazards associated with a facility operation, maintenance job, or work activity. Aspects and impacts are evaluated to ensure that the significant aspects and potential impacts continue to reflect stakeholder concerns and changes in regulatory requirements. The EMS provides the system to ensure that environmental aspects are systematically identified, monitored, and controlled to mitigate or eliminate potential impacts to the environment.

The FY 2015 analysis identified the following as significant environmental aspects:

- air emissions
- greenhouse gas (GHG) emissions (scopes 1 and 3)
- wastewater/groundwater
- excess facilities and unneeded materials and chemicals
- hazardous or mixed wastes
- radiological waste
- potable water usage
- surface water and storm water
- aging infrastructure and equipment
- legacy contamination and disturbance
- storage or use of chemicals and radioactive materials
- energy consumption (scope 2 GHGs)
- clearing, grading, or excavation (nonquarantined soil)

4.2.3.2 Legal 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 documented each year in this report (see Section 4.3).

4.2.3.3 Objectives, Targets, and Environmental Action Plans

CNS responds to change and pursues sustainability initiatives by establishing and maintaining environmental objectives, targets (goals), and action plans at Y-12. Goals and commitments are established annually; are agreed to by the National Nuclear Security Administration Production Office (NPO) and CNS; and are consistent with the Y-12 Complex's mission, budget guidance, ES&H work scope, site incentive plans, and continuous improvement 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 2015 environmental targets achieved at the Y-12 Complex are presented in Section 4.2.6.1.

4.2.3.4 Programs

NNSA has developed and funded several important programs to integrate environmental stewardship into all facets of Y-12 Complex missions. The programs also address the DOE order requirements for protecting various environmental media, reducing pollution, conserving resources, and helping to promote compliance with all applicable environmental regulatory requirements and permits.

Environmental Compliance

The Y-12 Environmental Compliance Department (ECD) provides environmental technical support services and oversight for Y-12 Complex 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. ECD serves as the Y-12 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 US Environmental Protection Agency (EPA). ECD administers compliance programs aligned with the major environmental legislation that affects Y-12

Complex activities. Compliance status and results of monitoring and measurements conducted for these compliance programs are presented in this document.

ECD also maintains and ensures implementation of the Y-12 Complex EMS and spearheads initiatives to proactively address environmental concerns to continually improve environmental performance and go beyond compliance

Waste Management

The CNS Y-12 Waste Management Program supports the full life cycle of all waste streams within the Y-12 Complex. While ensuring compliance with federal and state regulations, DOE orders, waste acceptance criteria, and Y-12 Complex procedures and policies, the waste management 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/disposal. The program also provides technical support to Y-12 operations for waste planning, characterization, packaging, tracking, reporting, and managing waste treatment/disposal subcontracts.

Sustainability and Stewardship

The Sustainability and Stewardship Program has two major missions. The first is to establish and maintain companywide programs and services to support sustainable waste management operations. These sustainable operations include pollution prevention and recycling programs, excess materials programs, generator services programs, facility destruction and recycling operations, and PrYde. The Y-12 PrYde program incorporates an inspection and rating system related to the cleanliness of facilities, materials, and hazardous/unsafe conditions to help personnel maintain work areas in a clean, safe, environmentally sound, and professional manner.

The second mission is stewardship practices, the programs that manage legacy issues and assist in preventing the development of new problematic issues. Stewardship programs include Clean Sweep and Unneeded Materials and Chemicals (UMC).

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

Additionally, the implementation of these programs directly supports EMS objectives and targets to disposition UMC, continually improve recycle programs by adding new recycle streams as applicable, improve sustainable acquisition (i.e., promote the purchase of products made with recycled content and biobased products, including alternative fuels such as E85), meet sustainable design requirements, and adhere to pollution prevention reporting requirements.

Energy Management

Energy management is an ongoing and comprehensive effort with key strategies to reduce consumption of energy, water, and fuel (electricity, coal, natural gas, and gasoline/diesel). As part of Facility Management and programs in Facilities Services, the energy management effort tracks federally mandated conservation initiatives at the Y-12 Complex and informs personnel about sustainability issues, particularly in relation to energy, water, and fuel conservation and efficiency.

The Y-12 energy management effort and the sustainability and stewardship programs support the DOE and NNSA visions for a commitment to energy efficiency and sustainability and achievement of the guiding principles. Specifically, the Y-12 vision is to support the DOE ES&H policy and the *Strategic Sustainability Performance Plan* (DOE 2015) (SSPP) while promoting overall sustainability and reduction of greenhouse gas (GHG) emissions. The mission of the Y-12 Energy Management program is to incorporate energy-efficient technologies site wide and to position Y-12 to meet NNSA energy requirement needs through 2025 and beyond. Sustainability goals, goal performance, and goal achievement are defined in the SSP issued in December 2015.

4.2.4 Implementation and Operation

4.2.4.1 Roles, Responsibility, and Authority

The safe, secure, efficient, and environmentally responsible operation of the Y-12 Complex requires the commitment of all personnel. All personnel share the responsibility for successful day-to-day accomplishment of work and the environmentally responsible operation of the Y-12 Complex. Environmental and Waste Management technical support personnel assist the line organizations with identifying and carrying out their environmental responsibilities. Additionally, an Environmental Officer Program is in place to facilitate communication of environmental regulatory requirements and to promote EMS as a tool to drive continual environmental improvement at the Y-12 Complex. Environmental officers coordinate their organizations' efforts to maintain environmental regulatory compliance and promote other proactive improvement activities.

4.2.4.2 Communication and Community Involvement

The Y-12 Complex is committed to keeping the community informed on operations, environmental concerns, safety, and emergency preparedness. The Community Relations Council, composed of 20 members from a cross section of the community, including environmental advocates, neighborhood residents, Y-12 Complex retirees, and business and government leaders, serves to facilitate communication between Y-12 and the community. The council provides feedback to Y-12 regarding its operations and ways to enhance community and public communications. Y-12 sponsored the Great Smoky Mountains National Park, the East Tennessee Foundation, and the Oak Ridge Associated Universities Science Bowl in 2015.

As part of the Y-12 Complex America Recycles Day activities, four local charities received $200 donations from funds raised by the Y-12 Complex employee aluminum beverage can (ABC) recycling efforts. Since the ABC recycling program began in 1994, more than $85,600 has been donated to various local charities.

Y-12 continues to promote sustainable behaviors for environmental improvements at the site and within the community. As a part of Earth Day Activities, LiveWise personnel again collected gently used athletic shoes to support the Modular Organic Regenerative Environments Foundation Group. A United Way Coat and Toiletries Drive is conducted annually to provide coats and other needed items for the Volunteer Ministry Center for the Homeless. These activities reflect Y-12 employees' commitment to reduce landfill waste and support community outreach.

4.2.4.3 Emergency Preparedness and Response

Local, state, and federal emergency response organizations are fully involved in the Y-12 National Security Complex 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 National Security Complex emergency response exercises.

Five exercises and seven drills were conducted at the Y-12 Complex during FY 2015. The drills and exercises focused on topics such as responding to a hazardous chemical release, natural disaster, radiological release, active shooter event, security condition change, and severe event (multiple hazards, multiple buildings). Six building evacuation and accountability drills were also conducted.

Y-12 National Security Complex expertise in emergency management continues to be recognized within DOE. Members of the Emergency Management Program Office staff participated in the DOE Emergency Management Issues Special Interest Group Conference held in Shepherdstown, West Virginia, in July 2015. The Y-12 National Security Complex staff made presentations, participated in steering committee meetings, and distributed Y-12 National Security Complex Emergency Management Program information to other DOE facility emergency management professionals.

4.2.5 Checking

4.2.5.1 Monitoring and Measurement

The Y-12 Complex maintains procedures to monitor overall environmental performance and to monitor 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 2015 program activities are described throughout this chapter. Progress in achieving environmental goals is reported as a monthly metric on Performance Track, the senior management web portal that consolidates and maintains Y-12 Complex site–level performance measures. Progress is reviewed in periodic meetings with senior management and NPO.

4.2.5.2 Environmental Management System Assessments

To periodically verify that EMS is operating as intended, assessments are conducted as part of the Y-12 Complex internal assessment program. The assessments are designed to ensure that nonconformities with the ISO 14001:2004 standard (ISO 2004) are identified and addressed.

The environmental assessment program comprises 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.

To self-declare conformance to the ISO 14001:2004 standard in accordance with instructions issued by the Federal Environmental Executive and adhere to DOE O 436.1 (DOE 2011) requirements, EMS must be audited by a qualified party outside of the control or scope of EMS at least every 3 years. To fulfill this requirement, a four-person audit team from The University of Tennessee Center for Industrial Services evaluated the Y-12 EMS May 11–14, 2015. The Y-12 EMS was found to fully conform, and no issues were identified. The next external verification audit is scheduled for spring 2018.

4.2.6 Performance

The EMS objectives and targets and other plans, initiatives, and successes that work together to accomplish DOE goals and reduce environmental impacts are discussed in this section. The Y-12 Complex used a number of DOE reporting systems, including the following, to report performance.

- Pollution Prevention Tracking and Reporting System, which collects environmental, sustainable acquisition and product purchases, and best practices data.
- Federal Automotive Statistical Tool, which collects fleet inventory and fuel use.

- Consolidated Energy Data Report, which collects additional data on metering requirements, water use, renewable energy generation and purchases, training, and sustainable buildings.

- *Site Sustainability Plan* Performance Reporting, which collects data on site-identified sustainability projects and supports Energy Independence and Security Act (EISA) Section 432 compliance.

The DOE Office of Health, Safety, and Security annual environmental progress reports on implementation of EMS requirements and sustainability goals driven by executive orders, and the Office of Management and Budget's Environmental Stewardship Scorecard gave the Y-12 Complex an EMS scorecard rating for FY 2015 of green, indicating full implementation of EMS requirements.

4.2.6.1 Environmental Management System Objectives and Targets

At the end of FY 2015 Y-12 had achieved 3 of 10 targets that had been established. Seven of the targets were established with long-term time frames and were carried into future years. Overall, 33 actions were completed through September. Highlights included the following, with additional details and successes presented in other sections of this report.

- Clean Air—Y-12 completed annual boiler tune-ups and energy assessments by qualified energy assessors on the Y-12 Steam Plant, meeting new compliance requirements of the final maximum achievable control technology standards for industrial, commercial, and institutional boilers issued by the EPA (2013).

- Energy Efficiency—Implementation of five Energy Savings Performance Contract (ESPC) energy conservation measures (ECMs) began in FY 2014 for projects to improve lighting, chilled water, air compressors, and steam. Significant progress was made in many areas, and the ECM for air compressor upgrades was substantially completed by the end of FY 2015. The final completion date for this ECM was planned by the end of CY 2015.

- Hazardous Materials—Projects for legacy and excess unneeded material/equipment removal in several facilities, including 9201-1, 9215, and 9204-2, were developed and implemented. Completed actions included disposition of cooling trays, forklifts, vacuums, and several pieces of equipment in Development and Materials Management. A project to improve controls for Sealand storage containers was developed and substantially implemented in FY 2015, with controls added to the online property management system, procurement restriction for Sealands implemented, and applicable procedures changed.

- Land/Water Conservation—A project to reduce inflow and infiltration into the sanitary sewer system were substantially completed with the installation of fiberglass liner in 1000 feet of sanitary sewer, and repairing eleven manholes to eliminate inflow. Stream restoration and wetlands expansion efforts continued, and the Y-12 Environmental Sampling Services completed a multiyear effort to improve the instrument calibration program to meet requirements of the International Standard, ISO 17025 (2015).

- Reduce/Reuse/Recycle/Buy Green—Y-12 continued efforts to increase use of remanufactured toner cartridges, substantially completing revisions to applicable procedures. In addition, Y-12 added one new recycle stream to their award-winning recycling program.

4.2.6.2 Sustainability and Stewardship

Numerous efforts at the Y-12 Complex have reduced its impact on the environment. Efforts include increased use of environmentally friendly products and processes and reductions in waste and emissions. During the past few years, these efforts have been recognized by our customers, our community, and other stakeholders (see Section 4.2.7). Pollution prevention efforts at the Y-12 Complex have not only benefited the environment but have also resulted in cost efficiencies (Fig. 4.3).

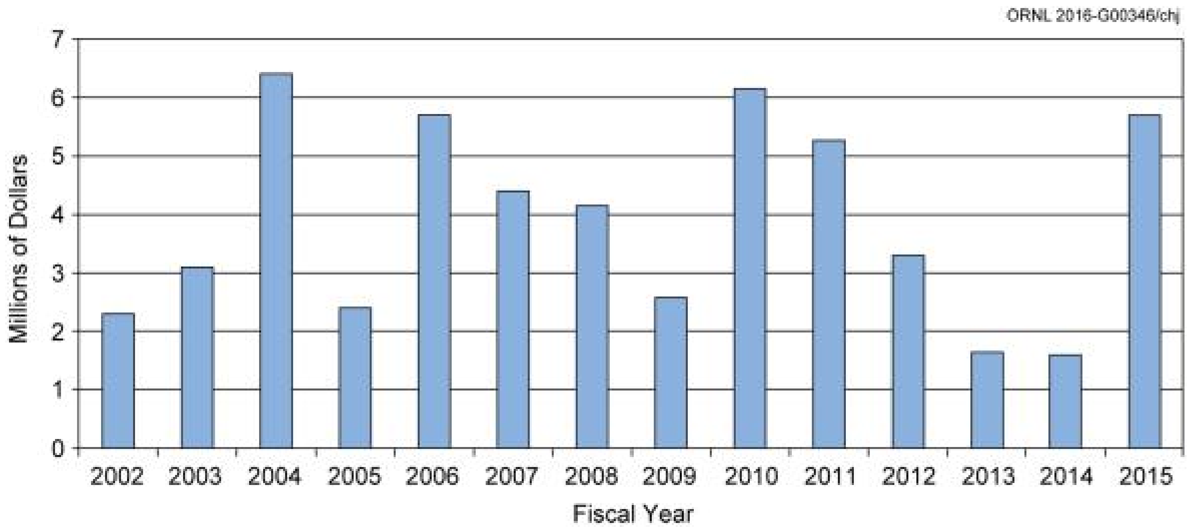

Fig. 4.3. Cost efficiencies from Y-12 National Security Complex pollution prevention activities.

In FY 2015 the Y-12 Complex implemented 94 pollution prevention initiatives (Fig. 4.4), with a reduction of more than 39.9 million kg of waste and cost efficiencies of more than $5.7 million. The completed projects include the activities described below.

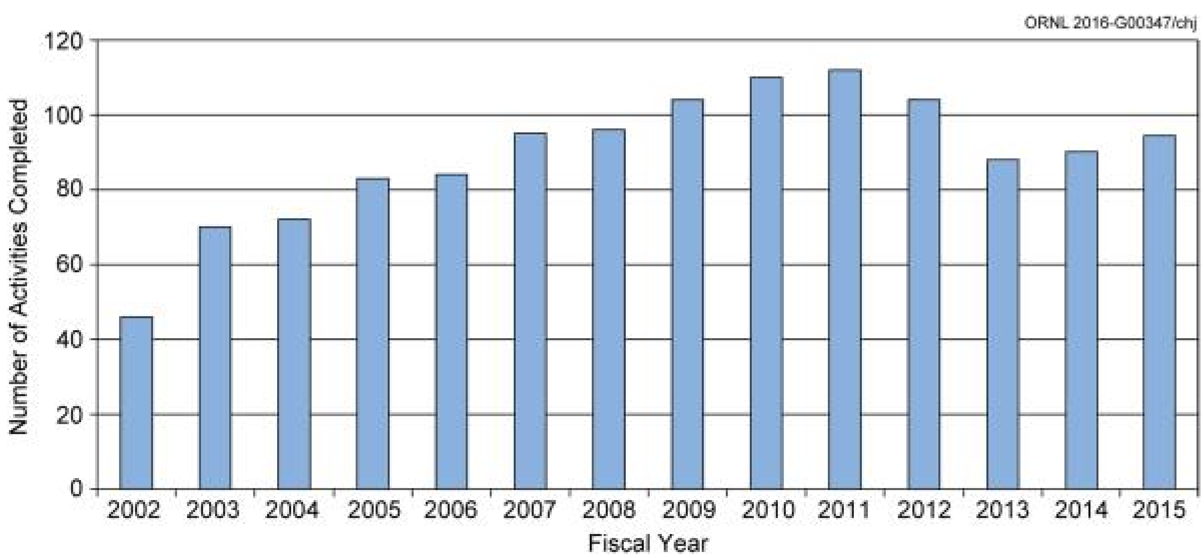

Fig. 4.4. Y-12 National Security Complex pollution prevention initiatives.

Pollution Prevention/Source Reduction

Sustainable initiatives have been embraced across the Y-12 Complex to reduce the impact of pollution on the environment and to increase operational efficiency. Many of the Y-12 Complex sustainable initiatives have pollution prevention benefits or targets eliminating the source of pollution, including the 2015 activities highlighted in this section.

Sustainable Acquisition—Environmentally Preferable Purchasing

Sustainable products, including recycled-content materials, are procured for use across the Y-12 Complex. In 2015, Y-12 procured recycled-content materials valued at more than $1.4 million for use at the site.

Solid Waste Reduction

In 2015, Y-12 diverted 60.8% of municipal and 95.9% of construction and demolition waste from landfill disposal through reuse and recycle. The Clean Sweep Program provides turnkey services to material generators, including segregation, staging and pickup of materials for excess, recycle, and disposal. Clean Sweep Specialists ensure that materials are reused or recycled to the maximum extent possible. The UPF Project recycled or reused over 74.4 million lb of materials in 2015, including brush, asphalt, and scrap metal. More 62 million lb of asphalt removed from obsolete roads and parking lots were ground into base course material that was subsequently used to maintain unpaved roads at Y-12 and on the Oak Ridge Reservation (Fig. 4.5).

Hazardous Chemical Minimization

The Y-12 Complex is committed to reducing the use of toxic and hazardous chemicals and minimizing the volume of hazardous waste generated by site operations. In 2015, Y-12 Utilities implemented a standard automated cooling tower treatment/blowdown process to maintain tower water chemistry more efficiently. The new process prevented the use of more than 28,000 lb of water treatment chemicals and over 24 million gal of water each year. Waste Management modified the operation of the West End Treatment Facility such that pretreatment operations eliminated the need for a portion of the Effluent Polishing System while ensuring that discharge permit requirements were met. This modification prevented the use of more than 147,000 lb of treatment chemicals and the generation of over 1870 ft^3 of associated low-level waste sludge.

Recycling

Y-12 has a well-established recycling program and 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 Fig. 4.6, more than 1.2 million kg of materials was diverted from landfills and into viable recycle processes during 2015. Currently recycled materials range from office-related materials 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. Ultraviolet lamps were added in FY 2015 to broaden waste diversion efforts.

Fig. 4.5. UPF Asphalt Reuse.*[Source: Brett Pate, Y-12 photographer.]*

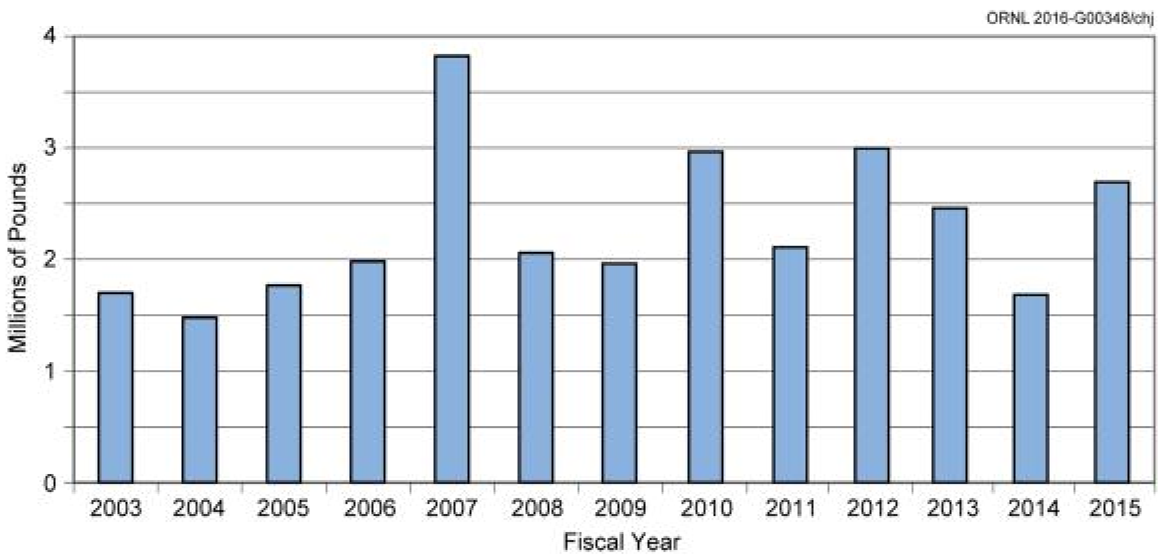

Fig. 4.6. Y-12 National Security Complex recycling results.

4.2.6.3 Energy Management

The mission of the Y-12 Energy Management program is to incorporate energy-efficient technologies site wide and to position Y-12 to meet NNSA energy requirement needs through 2025 and beyond. The program identifies improvements in energy efficiency in facilities, coordinates energy-related efforts across the site, and promotes employee awareness of energy conservation programs and opportunities. Y-12 is committed to achieving the sustainable energy and transportation goals established in Executive Order 13693.

The Energy Policy Act of 2005 established a goal of reducing building energy intensity by 30% by FY 2015 from an FY 2003 baseline. Y-12 exceeded the FY 2015 goal by achieving a 39.9% reduction in energy intensity (Fig. 4.7). A new goal has been established to achieve a 25% reduction in energy intensity by FY 2025 based on an FY 2015 baseline.

Specific initiatives that aided in the reduction of electricity consumption at Y-12 during FY 2015 included

- installing light-emitting diode and T-8 fluorescent lighting;
- improving meter readings via the Utilities Management System (UMS);
- improving employee awareness;
- achieving utility efficiencies, including reductions in steam pressure, chilled water production, and condensate return.

Additional energy reductions will be required in numerous areas to fully reduce energy use across the plant. Both facility management and utilities management are diligently focusing on improvements to achieve the goal. Efforts that are fully incorporated into planning activities for facilities include the following.

- EISA assessments are included in annual reporting.
- ECMs from both EISA and the ESPC process are included in budgeting reviews.
- Low-cost/no-cost efforts, including component replacements, are incorporated into routine activities.
- EISA assessments and condition assessment surveys (CASs) share resources, including personnel and database support.

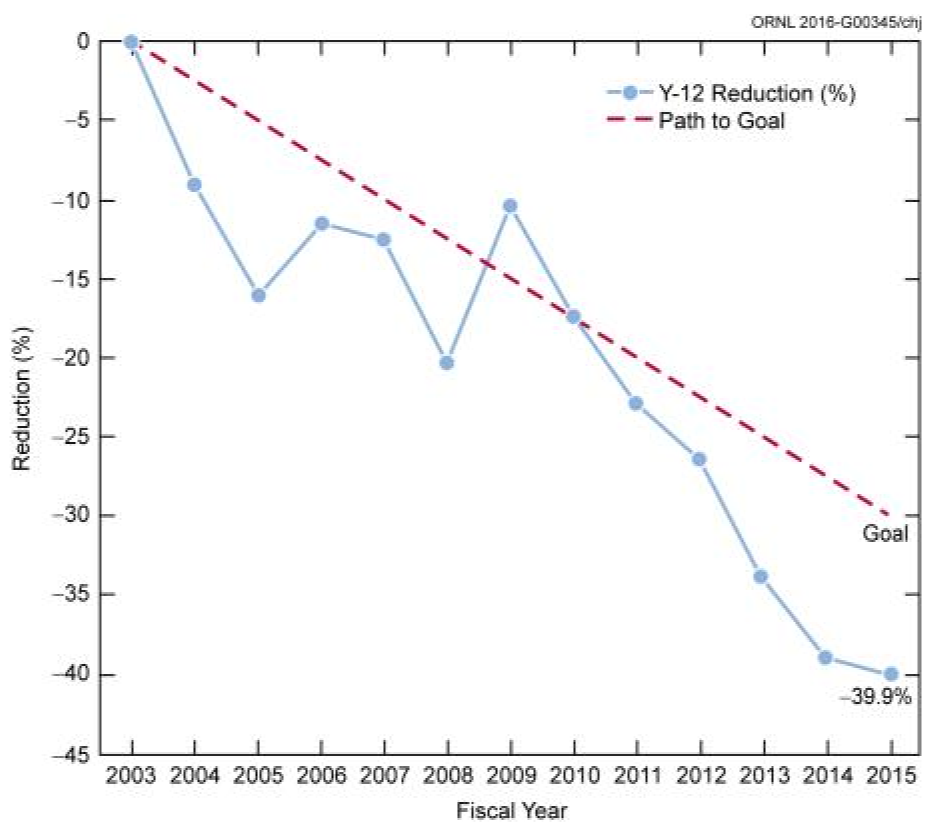

Fig. 4.7. Y-12 has achieved a 39.9% reduction in energy intensity compared to the baseline year, 2003.

As shown in Fig. 4.8, future reductions may be challenging due to a projected increase in the site's energy intensity. Current projections indicate increases once UPF goes on line, but those may be partially offset by an accelerated demolition program.

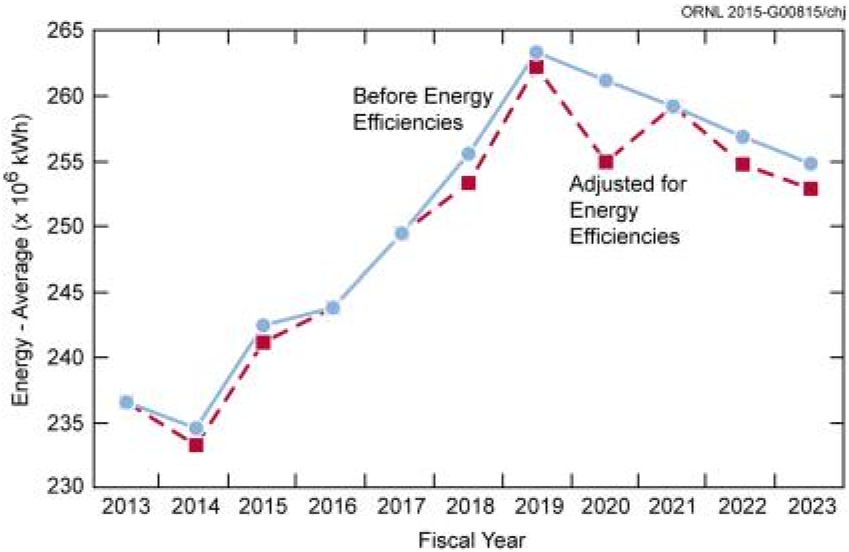

Fig. 4.8. Y-12 National Security Complex electricity load forecast.

The following efforts are planned to ensure continued site success for energy reduction.

- Complete implementation of ESPC Delivery Order 3 and additional modifications (lighting, chilled water, steam, natural gas, compressed air).
- Consolidate data centers, per Office of Management and Budget definition, and install electric meters.
- Continue installation of advanced metering.
- Continue facility upgrades for high-performance sustainable building (HPSB) compliance and implement building retro-commissioning.
- Continue implementation of cool roof applications.
- Encourage energy reduction through tenant awareness, including training and monthly meter reporting.

Energy Monitoring

Comprehensive water and energy audits at Y-12 are performed to meet EISA Section 432. The audits evaluate energy and water use and identify opportunities to reduce use. The audits are performed by a certified energy auditor. The implementation costs for the ECMs are developed using the Condition Assessment Information System database. Based on the requirement to assess 100% of the covered facilities at the site, Y-12 successfully completed the first 4-year assessment cycle in FY 2012 and began the second assessment or reassessment cycle in FY 2013, and continued through FY 2015. Additional assessments were completed during FY 2014 and FY 2015 as part of the ESPC Investment Grade Audit for Delivery Order 3. Energy projects are included in out-year planning for the site and where possible and with adequate return on investment, will be funded. Specific examples include heating, ventilating, and air-conditioning (HVAC) replacements, lighting upgrades, and occupancy sensors in HPSB candidate facilities.

Y-12 currently has numerous standard and advanced electrical meters located on various facilities throughout the plant. Efforts to read meters and monitor commodity information have improved significantly due to the connection of several additional meters to the Utilities Management System (UMS). The actual electricity costs for the plant are based on total energy consumption as defined by the Tennessee Valley Authority (TVA) revenue meters in the ELZA 1 substation. Y-12 does not use a space chargeback system, and individual building metering is not currently used for such purposes. The ELZA 1 substation electricity use is monitored to ensure accurate billing from TVA and to develop the annual utilities budget.

Btu meters were installed on components of the chilled water system as part of the ESPC project, and these meters, along with newly installed cooling tower meters, have been added to the automatic output from UMS. Natural gas meters are located at the steam plant on each of the boilers.

Recent focus has been on installation of new meters and connectivity to UMS. As these connections have progressed, data have been migrated to the energy management module for eventual use in site metrics, data reporting, and ECMs. Meter data are also entered into the EPA Portfolio Manager for benchmarking and reporting purposes.

Minimal funding was available for dedicated metering during FY 2015. Efforts will continue on establishing communications with the UMS. Metering for HPSB candidates is still a concern for the plant. This issue prevents adequate monitoring of energy for the required 20% reduction. It is also impacting required reporting of power usage effectiveness (PUE) at the plant data centers. Efforts will continue to identify funding to install electric meters for HPSB candidates as well as electric, chilled water, and steam metering for the data centers.

Y-12 began entering facilities into the EPA Portfolio Manager in FY 2011. Y-12 enters and tracks data for both covered and non-covered facilities. Data from the Portfolio Manager is shared with NNSA sustainability contacts and is automatically migrated to DOE’s web-based EISA Section 432 Compliance Tracking System (CTS) for annual reporting in June. Meter data are also entered into Portfolio Manager for benchmarking and reporting purposes.

Energy Savings Performance Contracts

Dedicated funding for energy and water projects is provided via the ESPC mechanism. Y-12 has taken advantage of the energy saving opportunities provided by the ESPCs. ESPC delivery order 2 is in the fourth period of performance at Y-12. This contract included chiller plant improvements, steam condensate return system modifications, steam trap improvements, and demineralized water production facility replacement. Efforts from delivery order 2 have greatly contributed toward both energy reduction and efficiency gains for the projects implemented.

Y-12 entered into its third ESPC contract in September 2013. Delivery order 3 is in the construction phase, which will continue through FY 2017. Delivery order 3 will result in an estimated annual energy and water cost savings of $2.9 million and estimated energy-related operations and maintenance (O&M) annual energy and water cost savings of $2.4 million. The site will continue to work with NNSA for successful accomplishment of these efforts. Delivery order 3 includes the following ECMs.

- Steam System Decentralization
- Chiller Plant Upgrades

- Energy Efficient Lighting Upgrades
- Steam and Condensate System Improvements
- Compressed Air System Upgrades

Y-12 entered into its first modification to Delivery Order 3 in September 2014 which is in the construction phase, will continue through FY 2016, and will result in an estimated annual energy and water cost savings of $240K and an estimated energy-related O&M annual energy and water cost savings of $100K. Delivery Order 3, Modification 1 includes the following ECMs.

- Chiller Plant Upgrades

- Energy Efficient Lighting Upgrades (because lighting sensors were omitted in ESPC Delivery Order 3, the energy and cost savings were adjusted in this modification.)

Y-12 entered into its second modification to Delivery Order 3 in September 2015. Modification 2 adds 160 buildings to the lighting scope, 9 buildings to the steam decentralization scope, and replaces 1 more cooling tower. Modification 2 is in the construction phase, will continue through FY 2017 and will result in an estimated annual energy and water cost savings of $240K with no other energy-related O&M annual energy and water cost savings. Delivery Order 3, Modification 2, includes the following ECMs.

- Chiller Plant Upgrades
- Energy Efficient Lighting Upgrades
- Steam System Decentralization

Site Sustainability Plan

The DOE SSPs are an annual reporting requirement and are prepared in accordance with the Department of Energy's (DOE's) Guidance for the Site Sustainability Plans (SSP) (CNS.2015) and supplemental NNSA guidance from the Associate Administrator for Infrastructure and Operations, and supports the requirements of DOE O 436.1 Departmental Sustainability. The Y-12 and Pantex SSPs were combined into a single CNS SSP to fulfill the planning and reporting requirements for FY 2016. The DOE sustainability goals and Y-12 status and plans for these goals are summarized in Table 4.1.

Table 4.1. FY 2015 sustainability goals and status

SSPP Goal	DOE Goal	Performance Status	Planned Actions and Contribution	Risk of Non-attainment
		Goal 1: GHG Reduction		
1.1	50% Scope 1 & 2 GHG reduction by FY 2025 from an FY 2008 baseline (2015 target: 19%)	Goal Met for FY 2015 – Scope 1 & 2 emissions have decreased by 41% for FY 2015. Surpassed FY 2015 interim goal of 19%. At Risk - It is uncertain if the 2025 goal can be met due to UPF construction.	Continue to identify methods for reduction of GHG; further emphasize energy reductions.	Medium
1.2	25% Scope 3 GHG reduction by FY 2025 from a FY 2008 baseline (2015 target: 6%)	At Risk – Site Scope 3 emissions have decreased by 4.9% which did not meet the FY 2015 interim goal of 6%. It is uncertain if this goal will be achievable due to increased travel between Pantex and Y-12 and increased commuting due to the UPF 9/80 work schedule.	Y-12 will continue to promote alternative commuting methods.	High
		GOAL 2: Sustainable Buildings and Regional & Local Planning		
2.1	25% energy intensity reduction in goal-subject buildings, achieving 2.5% reductions annually, by FY 2025 from a FY 2015 baseline	Goal Met – The site met the 2015 goal by achieving a 39.9% reduction from the 2003 baseline. The new goal will be compared to the FY 2015 baseline. It is unlikely this goal can be met during UPF construction.	Continue implementation of planned energy reduction initiatives, including ESPC Delivery Order 3, as well as Mod. 1 and Mod. 2.	High
2.2	EISA Section 432 energy and water evaluations	Goal Met – Y-12 completed all required EISA-covered assessments during FY 2015.	Assessments will continue to meet a 3-year cycle.	Low
2.3	Meter all individual buildings for electricity, natural gas, steam and water, where cost-effective and appropriate	On Track – Currently 88% of electricity is metered; 100% of natural gas; 5% of steam; 100% of chilled water are metered.	Continue procurement and installation of meters as funding is allocated.	Electricity: Low Steam: Medium Natural Gas: Low Chilled Water: Low

Table 4.1. (continued)

SSPP Goal	DOE Goal	Performance Status	Planned Actions and Contribution	Risk of Non-attainment
2.4	At least 15% (by building count or gross square feet) of existing buildings greater than 5,000 gross square feet (GSF) to be compliant with the revised Guiding Principles for HPSB by FY 2025, with progress to 100% thereafter	On Track – Y-12 has achieved, for GSF, an 11% compliance with HPSB Guiding Principles.	Y-12 will continue to implement initiatives to meet HPSB compliance as funding and resources allow.	Medium
2.5	Efforts to increase regional and local planning coordination and involvement	Goal Met – Y-12 is actively involved in local and regional efforts on transportation planning, ecosystem, watershed, and environmental management.	Continue to participate in existing activities and look for new opportunities to leverage regional and local resources.	N/A
2.6a	Net Zero Buildings: Percentage of the site's existing buildings above 5,000 gross square feet intended to be energy, waste, or water net-zero buildings by FY 2025.	At Risk – An assessment for the installation of renewable energy projects for both solar and wind technologies found neither to be feasible for Y-12.	Y-12 will continue to evaluate opportunities as market advances bring payback within reasonable timeframes.	High
2.6b	Net Zero Buildings: Percentage of new buildings (> 5,000 GSF) entering the planning process designed to achieve energy net-zero beginning in FY 2020.	On Track – The UPF project is currently seeking a waiver for Leader- ship in Energy and Environmental Design (LEED) Gold certification.	If waiver is granted, Project will review and implement LEED scorecard credit and Guiding Principles by building, where feasible-now six buildings.	Medium
2.7	Data Center Efficiency. Establish a power usage effectiveness (PUE) target in the range of 1.2-1.4 for new data centers and less than 1.5 for existing data centers.	At Risk – The PUE is currently estimated at lower than 1.4, since the current PUE rating for Y-12 data centers in unknown. However, this value is based solely on electricity usage and does not account for energy intensity.	Chilled water and electrical metering are planned for Building 9117 in FY 2016. This data will allow the measurement of the PUE.	Medium
		Goal 3: Clean & Renewable Energy		
3.1	"Clean Energy" requires that the percentage of an agency's total electric and thermal energy ac- counted for by renewable and alternative energy shall be not less than: 10% in FY 2016-2017, working towards 25% by FY 2025.	On Track – See 3.2 below.	See 3.2 below.	Low

Table 4.1. (continued)

SSPP Goal	DOE Goal	Performance Status	Planned Actions and Contribution	Risk of Non-attainment
3.2	"Renewable Electric Energy" requires that renewable electric energy account for not less than 10% of a total agency electric consumption in FY16-17, working towards 30% of total agency electric consumption by FY 2025.	On Track – Due to sharing the Wind RECs with Pantex, Y-12 achieved 9.5% renewable energy consumption, exceeding the 7.5% interim goal for FY 2015 and is on track to meet the 10% goal in FY 2016.	Y-12 plans to renew the shared credits for FY 2016 and beyond.	Low
		Goal 4: Water Use Efficiency and Management		
4.1	36% potable water intensity reduction by FY 2025 from a FY 2007 baseline. (2015 target: 16%)	Goal Met – Y-12 achieved a 61.6% reduction from the baseline, surpassing, not only the interim goal of 16%, but the 2025 goal of 36%.	Water conservation measures will continue to be implemented as practicable in support of the HPSB initiative.	Low
4.2	30% water consumption reduction of industrial, landscaping, and agricultural (ILA) water by FY 2025 from a FY 2010 baseline. (2015 target: 10%)	Y-12 no longer consumes ILA and baseline ILA water is accounted for in Goal 4.1.	All water used at Y-12 is potable water and included in the potable water category.	N/A
		Goal 5: Fleet Management		
5.1	20% reduction in annual petroleum consumption by FY 2015 relative to a FY 2005 baseline; maintain 20% reduction thereafter. (2015 target: 20%)	Goal Not Met – Petroleum fuel consumption increased from FY 2014 as E85 was unavailable due to a fuel tank rupture. For FY 2015 Y-12 had a 1.5% decrease in petroleum usage as compared to the FY 2005 baseline whereas there was a 40% reduction in FY 2014.	New tanks will be installed during FY 2016, including an E85 tank. Older vehicles are being replaced by newer, alternative fuel vehicles (AFV) when available by GSA.	High for FY 2016 Low for FY 2017 and beyond
5.2	10% increase in annual alternative fuel consumption by FY 2015 relative to a FY 2005 baseline; maintain 10% increase thereafter. (2015 target: 10%)	Goal Not Met – Since E85 fuel was unavailable due to a fuel tank rupture, alternative fuel consumption was minimal for FY 2015 with a 93% reduction in consumption as compared to the FY 2005 baseline. In FY 2014, there was a 77.7% increase in alternative fuel consumption as compared to the FY 2005 baseline.	New tanks will be installed during FY 2016, including an E85 tank. Older vehicles are being replaced by newer, alternative fuel (when available) vehicles by GSA.	High for FY 2016 Low for FY 2017 and beyond

Table 4.1. (continued)

SSPP Goal	DOE Goal	Performance Status	Planned Actions and Contribution	Risk of Non-attainment
5.3	30% reduction in fleet-wide per-mile greenhouse gas emissions reduction by FY 2025 from a FY 2014 baseline. (2015 target: N/A; 2017 target: 4%)	N/A	Future vehicle purchases and leases will include AFVs, including E85, hybrid, and electric vehicles where possible.	Low
5.4	75% of light duty vehicle acquisitions must consist of alternative fuel vehicles (AFV). (2015 target: 75%)	Goal Met – There were no passenger vehicle purchases made during FY 2015. All passenger vehicles are being leased from GSA.	Passenger vehicles will continue to be leased through GSA with more availability of AFVs.	Low
5.5	50% of passenger vehicle acquisitions consist of zero emission or plug-in hybrid electric vehicles by FY 2025. (2015 target: N/A)	N/A	Future vehicle purchases and leases will include hybrid and electric vehicles where possible.	Low
		Goal 6: Sustainable Acquisition		
6.1	Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring Bio-Preferred and bio-based provisions and clauses are included in 95% of applicable contracts.	Goal Met – The sustainable acquisition clause 952.223-78 was incorporated into Y-12 procurement clauses in FY 2011. The terms and conditions were revised in 2012 to include Federal Acquisition Regulation clause 52.223-15. In April 2013 and July 2014 Y-12's terms and conditions were modeled after sustainable acquisition DEAR Clause 952.223-78, which includes the requirements for considering recycled content, bio-based content, energy efficient, water efficient, and other environmentally preferable products. Therefore, all contracts issued after October 1, 2013 contain the sustainable acquisition clauses.	Y-12 will incorporate additional clauses as requested and will continue to evaluate sustainable products for use at the site.	
		Goal 7: Pollution Prevention & Waste Reduction		
7.1	Divert at least 50% of non-hazardous solid waste, excluding construction and demolition debris.	Goal Met – Over 60.8% of non-hazardous waste diverted from landfill.	At least one new recycle material stream is added to the recycling program each fiscal year to further increase the diversion rate.	Low

Table 4.1. (continued)

SSPP Goal	DOE Goal	Performance Status	Planned Actions and Contribution	Risk of Non-attainment
7.2	Divert at least 50% of construction and demolition materials and debris.	Goal Met – Over 95.0% (38,588.5 metric tons/ 40,222.5 metric tons) of construction and demolition (C&D) waste diverted from landfill.	Systematic disposition evaluation method will continue to be used for C&D materials to ensure maximum waste diversion is achieved.	Low
		Goal 8: Energy Performance Contracts		
8.1	Annual targets for performance contracting to be implemented in FY 2017 and annually thereafter as part of the planning of section 14 of E.O. 13693.	Goal Met – Y-12 has taken advantage of the energy saving opportunities provided by the ESPCs. ESPC Delivery Order #2 is in the fourth period of performance at Y-12. Delivery Order #3, Mod #1, is in the construction phase which will continue through FY 2016. Delivery Order #3, Mod #2, is in the construction phase which will continue through FY 2017.	Y-12 will continue to leverage ESPCs to help achieve sustainability goals.	Low
		Goal 9: Electronic Stewardship		
9.1	Purchases – 95% of eligible acquisitions each year are EPEAT-registered products.	Goal Met – 100% of all computer desktops, laptops, monitors, tablets and thin clients purchased or leased during FY 2015 were EPEAT-registered or Energy Star-qualified products and more than 96% were EPEAT Gold registered.	Y-12 has a standard desktop configuration that specifies the procurement of EPEAT-registered and Energy Star-qualified products.	Low
9.2	Power management – 100% of eligible PCs, laptops, and monitors have power management enabled.	At Risk – Y-12 has implemented power management to feasible CPUs and laptops; power management features are enabled on all monitors not deemed mission critical.	100% implementation of PCs and laptops is not currently feasible with existing network security features. The site will continue active implementation of power management by replacing PCs with thin clients where feasible.	High

Table 4.1. (continued)

SSPP Goal	DOE Goal	Performance Status	Planned Actions and Contribution	Risk of Non-attainment
9.3	Automatic duplexing – 100% of eligible computers and imaging equipment have automatic duplexing enabled.	At Risk – During FY 2015, 20% of the printers, copiers, and multi- function devices were set to automatically duplex.	Recommended default for all networked printers with duplexers was "duplex" instead of "simplex." Included sustainable acquisition for communication services equipment evaluation and repair. The number of non-networked printers that either don't have duplex capability or can be changed by the user to a simplex default will make this goal difficult to achieve.	Medium
9.4	End of Life – 100% of used electronics are reused or recycled using environmentally sound disposition options each year.	On Track – Y-12's approved electronics recycling vendor achieved Responsible Recycling© (R2) certification in May 2015. Therefore, the last two shipments of electronics were made to an R2 certified recycler.	With the certification of Y-12's approved electronics recycling vendor as an R2 certified recycler, all used electronics will be recycled using environmentally sound disposition options in FY 2016 and beyond.	Low
		Goal 10: Climate Change Resilience		
10.1	Update policies to incentivize planning for, and addressing the impacts of climate change.	On Track – Policies for planning and addressing climate change impacts are reviewed and updated as needed, particularly with regard to severe winter weather and heat stress.	Continue to track trends and information on climate change and is engaged in numerous organizations dedicated to future planning and impacts.	N/A
10.2	Update emergency response procedures and protocols to account for projected climate change, including extreme weather events.	On Track – The Y-12 National Security Complex Severe Event Emergency Response Plan addresses severe natural phenomena events such as tornadoes, earthquakes, snow and ice, extended loss of power events and events that result in the loss of mutual aid.	Continue to review and update Emergency Response procedures as needed.	N/A

Table 4.1. (continued)

SSPP Goal	DOE Goal	Performance Status	Planned Actions and Contribution	Risk of Non-attainment
10.3	Ensure workforce protocols and policies reflect projected human health and safety impacts of climate change.	On Track – Y-12 has a robust Building/Facility Emergency Program to protect personnel during severe weather emergencies, including earthquakes, tornados, and floods. The Inclement Winter Weather procedure is designed to protect personnel during winter weather events. The Temperature Extreme procedure is designed to protect personnel during both extreme cold and hot events.	Protocols, processes and procedures will continue to be reviewed and revised as needed based on improved understanding/lessons learned regarding climate change impact.	N/A
10.4	Ensure site/lab management demonstrates commitment to adaptation efforts through internal communications and policies.	On Track – Management communications include procedures, texts/pages, emergency call-in number, and safety messages as applicable.	Communications will continue to be evaluated to ensure a good understanding by plant personnel of climate adaptation policies.	N/A
10.5	Ensure that site/lab climate adaptation and resilience policies and programs reflect best available current climate change science, updated as necessary.	On track – The current climate change discussion does not present any new scenarios at Y-12 that have not been planned for already therefore no changes to policies or programs were needed based on advancements in climate change science or on-site analysis.	Y-12 will continue to partner with Oak Ridge National Laboratory (ORNL), TVA, and others to remain current on climate change science and will update on-site policies and programs as needed.	N/A

Acronyms

AFV = alternative fuel vehicle
E85 = Ethanol fuel blend up to 85% Ethanol and 15% gasoline or other hydrocarbon
EISA = Energy Independence and Security Act
EPEAT = Electronic Product Environmental Assessment Tool
ESPC = Energy Savings Performance Contract
GHG = greenhouse gas
GSF = gross square feet
REC = renewable energy certificate
SSPP = *Strategic Sustainability Performance Plan* (DOE)
UPF = Uranium Processing Facility

4.2.6.4 Water Conservation

In FY 2015 Y-12 achieved a 61.6% water intensity reduction from the FY 2007 baseline, surpassing not only the FY 2015 interim goal of 16%, but the 2025 goal of 36% (Fig. 4.9). Actions that have contributed to the overall reduction in potable water use include the following:

- steam trap repairs and improvements,
- condensate return repairs and reroutes,
- replacement of once-through air handling units, and
- low-flow fixture installation.

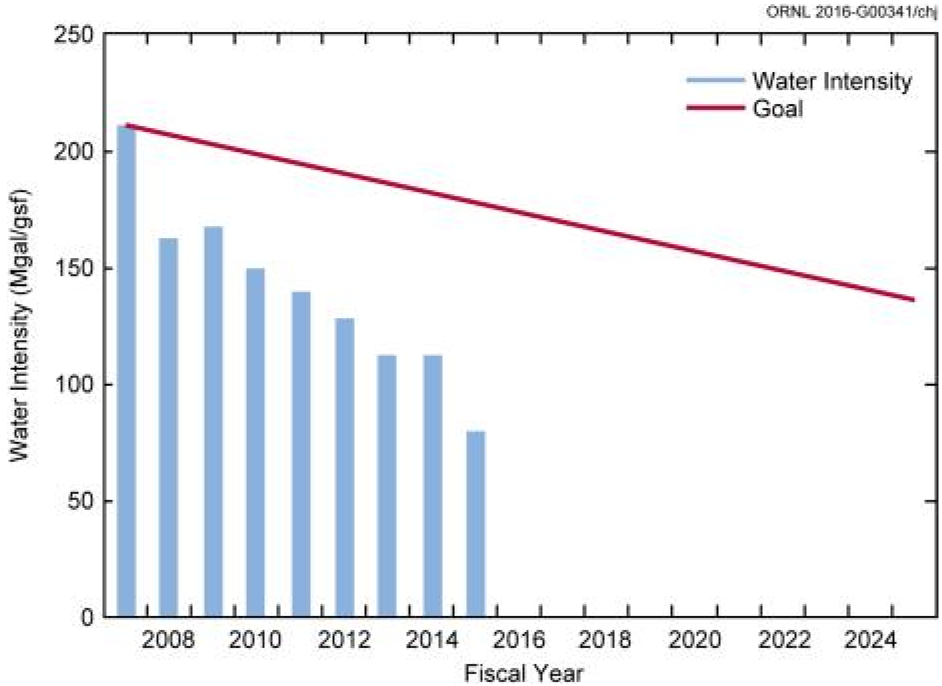

Fig. 4.9. Y-12 National Security Complex water intensity goals.*(Mgal = millions of gallons, gsf = gross square foot)*

Meters are installed on the potable water tanks and on various facilities within the plant. Future metering will include advanced meter installations for all enduring facilities, as applicable, to comply with the 2016 goal. Additionally, new advanced meters will be installed on the potable water tanks as the existing meters are flow meters rather than totalizing meters.

Although Y-12 is currently exceeding the FEMP water use reduction goal, significant reductions in water consumption can still be achieved. This can be accomplished through continuing water saving improvement projects within the facilities as funding becomes available. These improvements include: replacing or modifying HVAC units that use once through cooling water so they no longer discharge the cooling water into the storm drain; upgrading plumbing fixtures to new water saving fixtures; and replacing steam heating with natural gas heating which will save the steam condensate that is usually not returned to the steam plant.

Y-12 was selected to participate in the FY 2016 pilot for the new HVAC Asset Management Program (HVAC AMP). The HVAC AMP will replace a 30 Ton and a 15 Ton HVAC unit which will, in turn, eliminate the need for a 60 Ton water cooled chiller. These two HVAC units will be replaced with energy efficient heat pumps that don't use water. This project has been postponed until 2017 by the HVAC AMP.

Y-12 is also in the process of having a second plant wide water assessment completed by the Federal Energy Management Program with engineers from Pacific Northwest National Laboratory (PNNL). This is being done not only to identify water saving projects but also to qualify Y-12 for the new Water Asset Management Program (Water AMP). This program may help Y-12 in the future with implementing water saving projects.

These efforts, which were recommended by the Federal Energy Management Program/Pacific Northwest National Laboratory water assessment, will include

- upgrading toilets and urinals to low-flow, hands-free units;
- installing flow restrictors on faucets and shower heads;
- repairing condenser loop connections to the cooling towers;
- replacing once-through water-cooled air conditioning systems with air-cooled equivalents;
- installing advanced potable water meters; and
- repairing system to allow Building 9212 condensate to be returned to the steam plant.

4.2.6.5 Fleet Management

The Y-12 fleet is composed of agency-owned and General Services Administration (GSA) sedans, light-duty trucks/vans, medium-duty trucks/vans, and heavy-duty trucks. During the last quarter of FY 2015, 242 sedans and light-duty and medium-duty vehicles from theY-12 agency-owned fleet were transferred to the GSA. The GSA replaced 64 of those vehicles with newer, alternative-fuel vehicles (AFVs) where available, during CY 2015. The remaining 178 are to be replaced in CY 2016. This consolidation will decrease the average age of Y-12's vehicle fleet from 15 years to between 3 to 5 years of age. By replacing the older, less-fuel-efficient vehicles with the AFVs, Y-12 will greatly reduce its consumption of petroleum fuels and emissions of GHGs and will increase its use of alternative fuels. Fleet Management is working closely with vehicle custodians during the replacement process to ensure that replacement vehicles are appropriately assigned to meet mission requirements. Areas where electric vehicles could meet mission requirements will also be evaluated. Y-12 continues to operate a taxi service as one of the strategies for fleet optimization.

Y-12 had surpassed both FY 2015 goals regarding alternative fuel use and petroleum use at the end of FY 2014 with a 40% reduction in petroleum usage and a 77.7% increase in alternative fuel usage compared to the FY 2005 baseline. The rupture of an on-site fuel tank at the subcontractor-operated fuel station, and subsequent concerns that surfaced during the investigation resulted in the fuel station being placed out of service, effectively eliminating availability of E85 fuel for Y-12 vehicles. Therefore, Y-12 was not able to meet its goals for FY 2015 of decreasing alternative fuel usage by 93% and reducing petroleum use by 1.5%.

A project is under way to install new above-ground fuel storage tanks, including one for E85 fuel, on site. When completed, the new fueling station will enable Y-12 to meet both the petroleum reduction and the alternative fuel consumption goals. The new station is not expected to be operational until the end of FY 2016, which will placeY-12's ability to meet the alternative fuel consumption goal at risk in FY 2016. It is uncertain at this time if the reduction in petroleum usage from the replacement of the older vehicles with new, more-fuel-efficient vehicles will be sufficient to meet the petroleum reduction goal in FY 2016. Y-12 will continue to monitor vehicle usage and will redistribute or remove vehicles from the fleet as needed. Y-12 currently owns and operates four low-speed electric vehicles and a 25-

passenger diesel-electric hybrid bus. Actions taken since FY 2013 to improve the fleet and planned actions through FY 2017 are shown in Fig. 4.10.

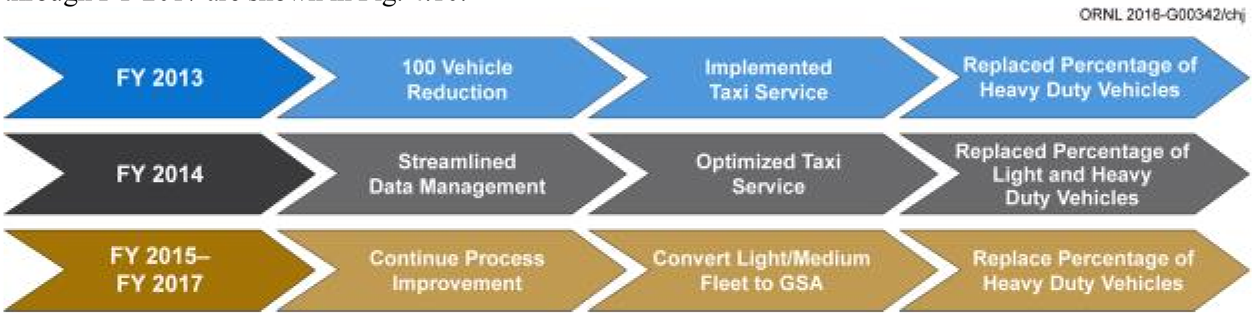

Fig. 4.10. Fleet management roadmap.

4.2.6.6 Electronic Stewardship

Y-12 has implemented a variety of electronic stewardship activities, including server virtualization, virtual desktop infrastructure, procurement of energy-efficient computing equipment, reuse and recycle of computing equipment, replacement of aging computing equipment with more energy-efficient equipment, and reconfiguration of data centers to achieve more energy-efficient operations. All desktop computers, laptops, monitors, and thin clients purchased or leased during FY 2015 were registered Electronic Product Environmental Assessment Tool (EPEAT) products. Y-12's standard desktop configuration specifies the procurement of EPEAT-registered and Energy Star–qualified products.

4.2.6.7 Greenhouse Gases

Table 4.2 provides a summary of Y-12 Complex GHG emissions for FY 2008 (the baseline year as required by EO 13514) and FY 2015. The Y-12 Complex has reduced Scopes 1 and 2 GHG emissions by 41% since the 2008 baseline year, primarily due to decreased Scope 1 emissions from steam generation and industrial fugitive emissions and decreased Scope 2 emissions from energy efficiency projects, renewable energy certificate credits from the Pantex Renewable Energy Project, and HPSB improvements. Scope 3 GHG emissions have been reduced by 4.9% since the 2008 baseline year. This reduction is due primarily to renewable energy certificates and reductions in business travel and transmission and distribution losses.

Employee commuting GHG emissions account for 65% of the Scope 3 emissions. Y-12's four day per week (10 hours per day) work schedule is critical to Y-12's Scope 3 emissions reduction efforts. It will be difficult for the Y-12 Complex to meet the reduction goal for Scope 3 GHG emissions without the addition of public transit to the Oak Ridge area and/or a telecommuting program. To further reduce employee commuting emissions, the Y-12 Complex will continue to encourage use of the Y-12 Complex carpooling and rideshare programs.

Table 4.2. Y-12 National Security Complex greenhouse gas emissions summary

GHG emission source	FY 2008 baseline (metric ton CO_2e/year)	FY 2015 (metric ton CO_2e/year)
	Scope 1[a]	
Steam (coal, natural gas, fuel oil)	129,021	57,010
Industrial fugitive emissions	22,542	9,399
On-site wastewater treatment	6.9	8.0
	1,063	-

Table 4.2. (continued)

GHG emission source	FY 2008 baseline (metric ton CO_2e/year)	FY 2015 (metric ton CO_2e/year)
	Scope 2 [a]	
Renewable energy certificates		(14,376)[b]
	184,995	147,129
Total Scopes 1 and 2	**337,627.9**	**199,170**
	Scope 3 [a]	
T&D losses	12,185.8	9,691.6
Off-site municipal wastewater treatment	25.3	26.4
Employee commute	17,447	19,707.3
Business ground and air travel	2,251	1,865.9
Renewable energy certificates	N/A	(946.9)
Total Scope 3	**31,909.1**	**30,344.3**
TOTAL GHG emissions	**369,537**	**229,514**

[a] Greenhouse gas (GHG) emissions are classified as Scope 1, 2, or 3. Scope 1 includes GHG emissions occurring directly on site, such as heating or air conditioning in DOE buildings or the combustion of fuel in vehicles owned or operated by DOE. Scope 2 includes indirect emissions that are produced by an outside source as part of the productions process, such as electricity consumed in DOE buildings.

[b] With the agreement of the NPO for the Y-12 and Pantex sites, the Y-12 Complex GHG inventory was credited with renewable energy produced by the Pantex Renewable Energy Project as part of the Pantex–Y-12 integration effort. This renewable energy strategy was supported by the fact that CNS Pantex meets the DOE renewable energy goal requirement through purchase of renewable energy credits.

Acronyms

CNS = Consolidated Nuclear Security, LLC
CO_2e = CO_2 equivalent
FY = fiscal year
GHG = greenhouse gas
NPO = National Nuclear Security Administration Production Office
T&D = transmission and distribution

4.2.6.8 Storm Water Management and the Energy Independence and Security Act of 2007

EISA Section 438 requires federal agencies to reduce storm water runoff from development and redevelopment projects to protect water resources. The Y-12 Complex complies with these requirements using a variety of storm water management practices, often referred to as "green infrastructure" or "low-impact development" practices. During the last few years several green infrastructure initiatives have been implemented to reduce the size and number of impervious surfaces through the use of sustainable vegetative practices and porous pavements. Actions that have contributed to the overall prevention of storm water runoff during FY 2015 include the following.

- There has not been a significant change (up or down) in green space during FY 2015 due to UPF site readiness activities. The planned paved areas for UPF should be offset by the constructed sediment ponds with the Faircloth skimmers (Fig. 4.11) that mitigate the rate of the storm water leaving the area.

- UPF site readiness construction used a mulcher/chipper (Fig. 4.12) to produce mulch that was used as erosion control along the haul road.

- UPF established vegetative cover (grass) on the previously disturbed area along the new Bear Creek Road and new haul road extension corridors, improving storm water quality.

Fig. 4.11. Faircloth skimmer previously installed at Sediment Basin 1.

Fig. 4.12. Uranium Processing Facility site readiness construction used a mulcher/chipper to produce mulch that was used as erosion control along the haul road.

In all, about 3.5 acres have been added to the green bank to offset future projects within the Y-12 Complex.

4.2.7 Awards and Recognition

Since November 2000, the Y-12 Complex commitment to environmentally responsible operations has been recognized with more than 125 external environmental awards from local, state, and national agencies. The awards received in 2015 are summarized in the following sections.

Tennessee Chamber of Commerce and Industry Awards

Y-12 was recognized in two areas at the 33rd Annual Tennessee Chamber of Commerce and Industry Environment and Energy Conference in an awards ceremony on October 14, 2015, at Montgomery Bell State Park. Y-12 received the Solid and Hazardous Waste Award for “UPF Sustainable Practices.” Additionally, Y-12 received a Water Quality Award for “Y-12 Reduced Water Usage and Improved Water Quality.”

Electronic Product Environmental Assessment Tool Award

Y-12 received an EPEAT Purchaser 3 Star Level Award for Excellence in Green Procurement of Electronics in a ceremony in Washington, DC, on April 22, 2015. Y-12 was recognized by the Green Electronics Council at the 3 Star Level for purchasing EPEAT electronics in the following categories: PCs and Displays; Imaging Equipment (e.g., copiers, scanners, multifunction devices); and Televisions.

Federal Energy Management Program Award

Y-12 received a FEMP Federal Energy and Water Management Award for “Y-12 Steams Ahead with Wise Utilities Management” on October 14, 2015, in a ceremony in Washington, D. C.

4.3 Compliance Status

4.3.1 Environmental Permits

Table 4.3 lists environmental permits in force at the Y-12 Complex during 2015. More detailed information can be found in the following sections.

Table 4.3. Y-12 National Security Complex environmental permits, 2015

Regulatory driver	Title/description	Permit number	Issue date	Expiration date	Owner	Operator	Responsible contractor
CAA	Title V Major Source Operating Permit	562767	1/8/2012	1/8/2017	DOE	DOE	CNS
CAA	UPF Construction Permit	967550P	3/01/2014	3/01/2017	DOE	DOE	CNS
CWA	Industrial & Commercial User Wastewater Discharge (Sanitary Sewer) Permit	1-91	4/1/2010	3/30/2015[a]	DOE	DOE	CNS
CWA	NPDES Permit	TN0002968	10/31/2011	11/30/2016	DOE	DOE	CNS
CWA	UPF 401 Water Quality Certification/ ARAP Access/Haul Road	NRS10.083	6/10/2010	6/09/2015[b]	DOE	DOE	CNS
CWA	UPF Department of Army Section 404 Clean Water Act Permit	2010-00366	9/02/2010	9/02/2020	DOE	DOE	CNS
CWA	UPF General Storm Water Permit Y-12 Complex (41.7 hectares/103 acres)	TNR 134022	10/27/2011	5/23/2016	DOE	CNS	CNS
RCRA	Hazardous Waste Transporter Permit	TN3890090001	1/7/2016	1/31/2017	DOE	DOE	CNS
RCRA	Hazardous Waste Corrective Action Permit	TNHW-164	9/15/2015	9/15/2025	DOE	DOE, NNSA, and all ORR co-operators of hazardous waste permits	UCOR
RCRA	Hazardous Waste Container Storage Units	TNHW-122	8/31/2005	8/31/2015[a]	DOE	DOE/CNS	CNS/ Navarro co-operator
RCRA	Hazardous Waste Container Storage and Treatment Units	TNHW-127	10/06/2005	10/06/2015[a]	DOE	DOE/CNS	CNS co-operator

Table 4.3. (continued)

Regulatory driver	Title/description	Permit number	Issue date	Expiration date	Owner	Operator	Responsible contractor
RCRA	RCRA Post closure Permit for the Chestnut Ridge Hydrogeologic Regime	TNHW-128	9/29/2006	9/29/2016	DOE	DOE/UCOR	UCOR
RCRA	RCRA Postclosure Permit for the Bear Creek Hydrogeologic Regime	TNHW-116	12/10/2003 Permit reapplication submitted to TDEC on 1/31/13	12/10/2013[a]	DOE	DOE/UCOR	UCOR
RCRA	RCRA Postclosure Permit for the Upper East Fork Poplar Creek Hydrogeologic Regime	TNHW-113	9/23/2003 Permit reapplication submitted to TDEC on 1/31/13	9/23/2013[a]	DOE	DOE/UCOR	UCOR
Solid Waste	Industrial Landfill IV (Operating, Class II)	IDL-01-103-0075	Permitted in 1988—most recent modification approved 1/13/1994	N/A	DOE	DOE/UCOR	UCOR
Solid Waste	Industrial Landfill V (Operating, Class II)	IDL-01-103-0083	Initial permit 4/26/1993	N/A	DOE	DOE/UCOR	UCOR
Solid Waste	Construction and Demolition Landfill (Overfilled, Class IV subject to CERCLA ROD)	DML-01-103-0012	Initial permit 1/15/1986	N/A	DOE	DOE/UCOR	UCOR
Solid Waste	Construction and Demolition Landfill VI (Postclosure care and maintenance)	DML-01-103-0036	Permit terminated by TDEC 3/15/2007	N/A	DOE	DOE/UCOR	UCOR
Solid Waste	Construction and Demolition Landfill VII (Operating, Class IV)	DML-01-103-0045	Initial permit 12/13/1993	N/A	DOE	DOE/UCOR	UCOR
Solid Waste	Centralized Industrial Landfill II (Postclosure care and maintenance)	IDL-01-103-0189	Most recent modification approved 5/8/1992	N/A	DOE	DOE/UCOR	UCOR

Table 4.3. (continued)

[a] Continue to operate in compliance pending TDEC action on renewal and reissuance.

[b] Monitoring and maintenance phase.

Acronyms

ARAP = Aquatic Resource Alteration Permit
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
Navarro = Navarro Research and Engineering, Inc.
NNSA = National Nuclear Security Administration
NPDES = National Pollutant Discharge Elimination System
ORR = Oak Ridge Reservation
RCRA = Resource Conservation and Recovery Act
ROD = record of decision
TDEC = Tennessee Department of Environment and Conservation
UCOR = URS | CH2M Oak Ridge LLC
Y-12 Complex = Y-12 National Security Complex

4.3.2 National Environmental Policy Act/National Historic Preservation Act

As federal agencies, DOE and NNSA comply with the National Environmental Policy Act (NEPA) requirements (procedural provisions, 40 CFR 1500 thru 1508), as outlined in the DOE's Implementing Procedures for NEPA (Title 10 CFR 1021). CNS fully supports NNSA's commitment to NEPA by evaluating proposed federal actions for potential impacts that affect the quality of the environment at Y-12. CNS ensures that reasonable alternatives for implementing such actions have been considered in the decisionmaking process and that such decisions are documented in accordance with the DOE/NNSA and the Council on Environmental Quality (CEQ) regulations. Such a prescribed evaluation process ensures that the proper level of environmental review is performed before an irreversible commitment of resources is made.

During CY 2015, environmental evaluations were completed for 39 proposed actions, and 38 proposed actions were determined to be covered by a categorical exclusion (CX), as listed in Appendix B for facility operations to Subpart D of Part 1021 in *National Environmental Policy Act General Categorical Exclusion* (Y/TS-2312). This included the evaluation of a new Y-12 Fire Station, the continuation of the Energy Conservation Measure project, and several projects to replace/upgrade existing equipment and facility infrastructure at Y-12. An Environmental Assessment was conducted for NNSA's proposed action to design and build a new on-site Emergency Operations Center (EOC) at Y-12 to support the future Y-12 mission. The proposed action consolidates the Plant Shift Superintendent's office, the Emergency Control Center, the Technical Support Center, and the Fire Department Alarm Room from their present locations to a single facility. This facility will meet current DOE orders, is survivable and sustainable for 72 hours, and would achieve the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Gold Certification.*Environmental Assessment of the Emergency Operations Center Project* (DOE/EA-2014a) was issued September, 2015. *Finding of No Significant Impact (FONSI) for the Emergency Operation Center Project* (DOE/EA-2014b) was issued October, 2015.

The *Final Site-Wide Environmental Impact Statement (SWEIS) for the Y-12 National Security Complex* (DOE 2011a) was issued in March, 2011. This final SWEIS is available on the Internet at http://nnsa.energy.gov/content/y12sweis2011. The SWEIS evaluated the modernization proposals for Y-12, including the UPF, and updated the analyses presented in the original Y-12 Complex SWEIS, issued in November 2001. The final SWEIS and the notice of availability were published March 4, 2011. NNSA issued a record of decision (ROD) in July 2011 for the *Continued Operation of the Y-12 National Security Complex*, based on the SWEIS. The DOE's NEPA implementing procedures, 10 CFR 1021, requires a 5-year evaluation of the final SWEIS, beginning in 2016.

Since the publication of the ROD, NNSA updated the strategy and design approach for UPF. Under the updated strategy, NNSA would use a hybrid approach of upgrading existing Y-12 facilities and building new UPF facilities. The updated strategy is consistent with recommendations from a project peer review of the UPF, *Final Report of the Committee to Recommend Alternatives to the Uranium Processing Facility Plan in Meeting the Nation's Enriched Uranium Strategy* (the Red Team Report, issued April, 2014). The single-structure UPF concept would be separated into multiple buildings, with each constructed to safety and security requirements appropriate to the building's function. The UPF strategy is addressed in detail in a *Supplement Analysis Final Site-Wide Environmental Impact Statement* (EIS-0387-SA-01). See http://energy.gov/nepa/downloads/eis-0387-sa-01-supplement-analysis.

In accordance with the National Historic Preservation Act of 1966 (NHPA), NNSA is committed to identifying, preserving, enhancing, and protecting its cultural resources. The prescribed evaluation process ensures that the proper level of environmental review is performed before an irreversible commitment of resources is made. Compliance activities in 2015 included completing Section 106 reviews of ongoing and new projects, collecting and storing historic artifacts, conducting tours, maintaining the Y-12 History Center, and participating in various outreach projects with local organizations and school

Thirty-nine proposed projects were evaluated to determine whether any historic properties eligible for inclusion in the *National Register of Historic Places* would be adversely impacted. It was determined that none of the 39 projects would have an adverse effect on historic properties eligible for listing in the *National Register* and that no further Section 106 documentation was required. The Y-12 Oral History Program continues efforts to conduct oral interviews to document the knowledge and experience of those who worked at the Y-12 Complex during World War II and the Cold War era. The interviews provide information on day-to-day operations of the Y-12 Complex, the use and operation of significant components and machinery, and how technological innovations occurred over time. Some of the information collected from the interviews will be available in various media, including DVDs shown in the Y-12 History Center.

The Y-12 History Center, located in The New Hope Center, continues to be a work in progress. The Y-12 History Center features many historical photographs and artifacts, a history library, and a video viewing area. More interactive and video-based exhibits are planned for the future. The Y-12 History Center is open to the public Monday through Thursday from 8:00 a.m. to 5:00 p.m. and on Fridays by special request. A selection of materials, including documentary DVDs, books, pamphlets, postcards, and fact sheets are available free to the public.

Congress passed the National Defense Authorization Act of 2015, which included provisions authorizing a park to be located at three sites: Oak Ridge, Tennessee; Hanford, Washington; and Los Alamos, New Mexico. President Obama signed the National Defense Authorization Act into law on December 19, 2014.

On November 10, 2015, the secretary of the interior and the secretary of energy signed a memorandum of agreement between the two agencies defining the respective roles in creating and managing the park. The agreement included provisions for enhanced public access, management, interpretation, and historic preservation. With the signing, the Manhattan Project National Historical Park officially was established.

Outreach activities in 2015 consisted of partnering with the City of Oak Ridge, the Oak Ridge Convention and Visitor's Bureau, and the Arts Council of Oak Ridge, which sponsor the annual Secret City Festival. In June, The Secret City Festival promoted the history of the Manhattan Project by providing information to visitors regarding the History of Y-12 and directions for them to visit the Y-12 History Center.

Y-12 also partnered with the American Museum of Science and Energy by providing guided public tours of the Y-12 History Center from March through November. Other outreach activities included providing tours and conducting presentations on the history of the Y-12 Complex and Oak Ridge to local and visiting schools, agencies, and organizations.

4.3.3 Clean Air Act Compliance Status

Permits issued by the State of Tennessee are the primary vehicle used to convey the clean air requirements that are applicable to the Y-12 Complex. 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. The Y-12 Complex is currently governed by Title V Major Source Operating Permit 562767.

The permit requires annual and semiannual reports. More than 3000 data points are obtained and reported each year. All reporting requirements were met during CY 2015, and there were no permit violations or exceedances during the report period.

The TDEC–Knoxville Office, Clean Air Compliance, completed the Y-12 annual Clean Air Compliance inspection on March 9 and 10, 2015, and on November 17 and 19, 2015. No noncompliance findings were identified.

Ambient air monitoring, while not specifically required by any permit condition, is conducted at the Y-12 Complex to satisfy DOE order requirements, as a best management practice, and/or to provide evidence of sufficient programmatic control of certain emissions. Ambient air monitoring conducted specifically for the Y-12 Complex (i.e., mercury monitoring) is supplemented by additional monitoring conducted for the Oak Ridge Reservation (ORR) and by both on-site and off-site monitoring conducted by TDEC.

Section 4.4 provides detailed information on 2015 activities conducted at Y-12 in support of CAA.

4.3.4 Clean Water Act Compliance Status

During 2015 the Y-12 Complex continued its excellent record for compliance with the National Pollutant Discharge Elimination System (NPDES) water discharge permit. 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 2015 was almost 100%.

About 2500 data points were obtained from sampling required by the NPDES permit; no noncompliances were reported. The Y-12 NPDES permit in effect during 2015 (TN0002968) was issued on October 31, 2011, and became effective on December 1, 2011. A modification was effective in May 2014. It will expire on November 30, 2016.

The effluent limitations contained in the permit are based on the protection of water quality in the receiving streams. The permit emphasizes biological, toxicological, and radiological monitoring of storm water runoff.

Some of the key requirements and changes incorporated in the modified permit are summarized below.

- The requirement to manage the flow of East Fork Poplar Creek (EFPC) such that a minimum of 5 million gal/day is guaranteed by adding raw water from the Clinch River to the headwaters of EFPC was removed.
- Flow and mercury monitoring and reporting requirements were removed for outfall 200.
- Monitoring and reporting requirements for Kjeldahl nitrogen and phosphorus at outfall 200 were added.
- Flow and mercury monitoring and reporting requirements were removed for outfall C11.
- Flow and mercury monitoring and reporting requirements were removed for station EFP.
- Requirements for monitoring and reporting of ammonia, phosphorus, and Kjeldahl nitrogen were added for station EFP.

4.3.5 Safe Drinking Water Act Compliance Status

The City of Oak Ridge supplies potable water to the Y-12 Complex and meets all federal, state, and local standards for drinking water. The water treatment plant, located north of the Y-12 Complex, is operated by the City of Oak Ridge.

Tennessee Regulations for Public Water Systems and Drinking Water Quality, Chap. 0400-45-01, set limits for biological contaminants, chemical activities, and chemical contaminants. Sampling for total coliform, chlorine residuals, lead, copper, and disinfectant by-product is conducted by the Y-12 Environmental Compliance Division.

In 2015 the Y-12 Complex potable water system retained its approved status for potable water with TDEC. All total coliform samples collected during 2015 were analyzed by the State of Tennessee laboratory, and the results were negative. Analytical results for disinfectant by-products (total trihalomethanes and haloacetic acids) for Y-12 Complex water systems were below TDEC and Safe Drinking Water Act (SDWA) limits. The Y-12 Complex potable water system is currently sampled triennially for lead and copper, and the system sampling was last completed in 2014. These results were below TDEC and SDWA limits and met the established requirements.

Although a notice of violation was issued by TDEC on August 5, 2015 for a drinking water monitoring deficiency, the Y-12 Plant Water System retains the State's "Approved" category.

Two required water samples were not taken in accordance with the schedule stated in the Stage 2 Disinfection Byproduct monitoring plan. The samples were taken 19 days late due to a shipping error by a subcontracted analytical laboratory. The analytical results for these samples were well within regulatory limits. Process modifications were implemented to ensure that future compliance samples are taken in accordance with the monitoring plan. A public notification was issued to inform all Y-12 NSC employees about the delayed monitoring.

4.3.6 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. The Y-12 Complex is considered a large-quantity generator because it may generate more than 1000 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 the site to licensed treatment and disposal facilities. The Y 12 Complex also has a number of satellite accumulation areas (SAAs) and 90-day waste storage areas.

Mixed wastes are materials that are both hazardous (under RCRA guidelines) and radioactive. The Federal Facilities Compliance Act (1992) requires that DOE work with local regulators to develop a site treatment plan to manage mixed waste. Development of the plan has two purposes: to identify available treatment technologies and disposal facilities (federal or commercial) that are able to manage mixed waste produced at federal facilities and to develop a schedule for treating and disposing of the waste streams.

The ORR site treatment plan is updated annually and submitted to TDEC for review. The current plan (TDEC 2015) documents the mixed-waste inventory and describes efforts undertaken 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 and update the plan as a reporting mechanism as progress is made. The Y-12 Complex has developed new disposition milestones to address its remaining inventory of legacy mixed waste. Disposition milestones for this final inventory are in fiscal years from 2013 through 2018 (see Fig.4.13).

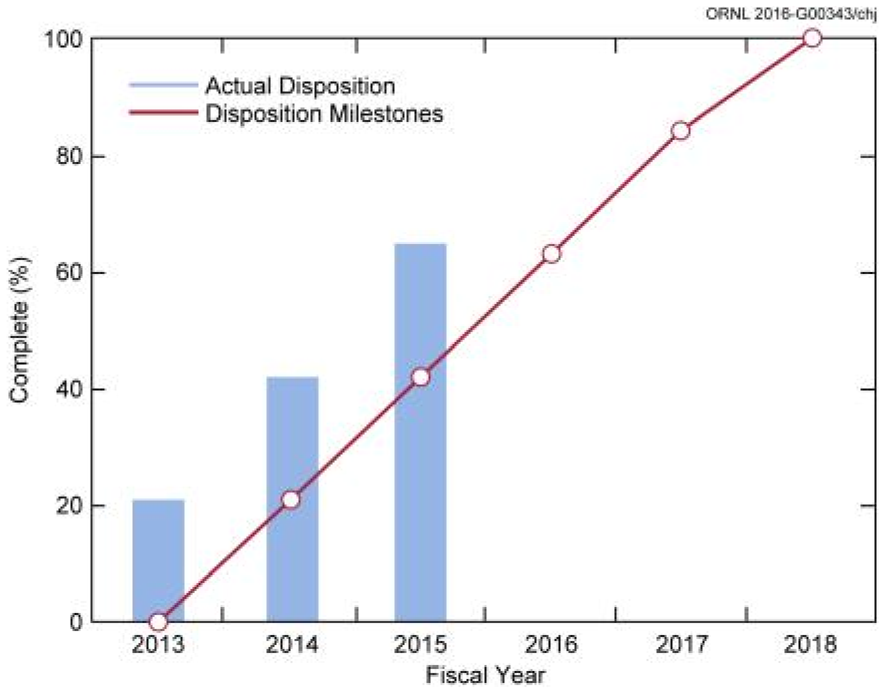

Fig. 4.13. Y-12 National Security Complex path to elimination of its inventory of legacy mixed waste as part of the Oak Ridge Reservation site treatment plan.

The quantity of hazardous and mixed wastes generated by the Y-12 Complex increased in 2015 (Fig. 4.14). This increase was primarily due to an increase in contaminated leachate from legacy operations, which made up 97% of the total hazardous and mixed waste generated in 2015. The Y-12 Complex currently reports waste on 77 active waste streams. The Y-12 Complex is a state-permitted treatment, storage, and disposal facility. Under its permits, the Y-12 Complex received 1473 kg of hazardous and mixed waste from the off-site Union Valley analytical chemistry laboratory in 2015. In addition, 126,761 kg of hazardous and mixed waste was shipped to DOE-owned and commercial treatment, storage, and disposal facilities. More than 9 million kg of hazardous and mixed wastewater was treated at on-site wastewater treatment facilities.

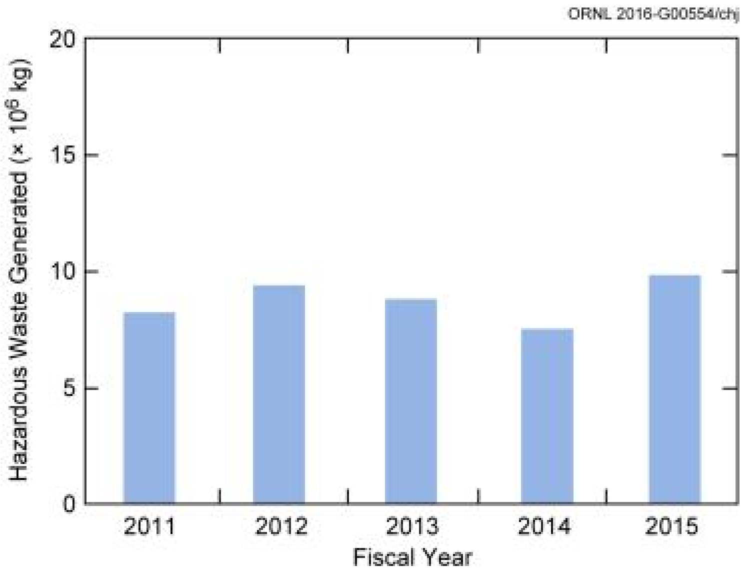

Fig. 4.14. Hazardous waste generation, 2010–2015.

4.3.6.1 Resource Conservation and Recovery Act Underground Storage Tanks

TDEC regulates the active petroleum underground storage tanks (USTs) at the Y-12 Complex. Existing UST systems that are to remain in service at the Y-12 Complex must comply with performance requirements described in TDEC UST regulations (TN 0400-18-01).

Closure and removal of two petroleum USTs at the East End Fuel Station was completed in August 2012. There are no petroleum USTs remaining at Y-12.

4.3.6.2 Resource Conservation and Recovery Act Subtitle D Solid Waste

The ORR landfills operated by the DOE EM program are located within the boundary of the Y-12 Complex. 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 the ORR. In addition, one Class IV facility (Spoil Area 1) is overfilled by 8945 m^3 and has been the subject of a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remedial investigation/feasibility study (RI/FS. A CERCLA ROD for Spoil Area 1 was signed in 1997. One Class II facility (Landfill II) has been closed and is subject to postclosure care and maintenance. Associated TDEC permit numbers are noted in Table 4.3. Additional information about the operation of these landfills is addressed in Section 4.8.3, “Waste Management.”

4.3.7 Resource Conservation and Recovery Act–Comprehensive Environmental Response, Compensation, and Liability Act Coordination

The ORR Federal Facility Agreement (DOE 2014b) is intended to coordinate the corrective action processes of RCRA required under the Hazardous Waste Corrective Action permit (formerly known as the Hazardous and Solid Waste Amendments permit) with CERCLA response actions.

During CY 2015 several actions were taken to facilitate TDEC's renewal of TNHW-121 ORR Hazardous Waste Corrective Action document. The TNHW-121 document was dated for a period from 2004 through September 28, 2014. The annual solid waste management unit/area of concern Table A-1 and A-2 update lists were submitted to TDEC on January 22, 2015. A public notice on the renewal of the TNHW-121 document was issued on July 15, 2015, in coordination with a public notice with renewal information for the ETTP Site RCRA Part B TNHW-117 Permit. Based on the timely renewal submittals that met TDEC expectations for the TNWH-121 document, ORR operations continue to operate in compliance with the TNHW-121 document through the middle of September 2015. On September 15, 2015, the renewal of the Oak Ridge Reservation Corrective Action document TNHW-164 was issued with a ten year period from September 15, 2015, through September 15, 2025.

Three RCRA postclosure permits, one for each of the three hydrogeologic regimes at the Y-12 Complex, have been issued to address the eight major closed waste disposal areas at the Y-12 Complex. Because it falls under the jurisdiction of two postclosure permits, the S-3 pond site is described as having two parts, eastern and former S-3 (Table 4.4). Groundwater corrective actions required under the postclosure permits have been deferred to CERCLA. RCRA groundwater monitoring data were reported to TDEC and EPA in the annual groundwater monitoring report for the Y-12 Complex (UCOR 2015).

Periodic updates of proposed construction and demolition (C&D) activities at the Y-12 Complex (including alternative financing projects) have been provided to managers and project personnel from the TDEC DOE Oversight Division and EPA Region 4. A CERCLA screening process is used to identify proposed C&D projects that warrant CERCLA oversight. The goal is to ensure that modernization efforts do not diminish the effectiveness of previously completed CERCLA environmental remediation actions and that they do not adversely impact future CERCLA environmental remediation actions.

Table 4.4. Y-12 National Security Complex Resource Conservation and Recovery Act postclosure status for former treatment, storage, and disposal units on the Oak Ridge Reservation

Unit	Major components of closure	Major postclosure requirements
Upper East Fork Poplar Creek Hydrogeologic Regime (RCRA Postclosure Permit TNHW-113)		
New Hope Pond	Engineered cap, upper East Fork Poplar Creek distribution channel	Cap inspection and maintenance. No current groundwater monitoring requirements in lieu of ongoing CERCLA actions in the eastern portion of Y-12 Complex
Eastern S-3 ponds groundwater plume	None for groundwater plume; see former S-3 Ponds (S-3 Site) for source area closure	Postclosure corrective action monitoring. Inspection and maintenance of monitoring network
Chestnut Ridge Hydrogeologic Regime (RCRA Postclosure Permit TNHW-128)		
Chestnut Ridge security pits	Engineered cap	Cap inspection and maintenance. Postclosure corrective action monitoring. Inspection and maintenance of monitoring network and survey benchmarks
Kerr Hollow Quarry	Waste removal, access controls	Access controls inspection and maintenance. Postclosure detection monitoring. Inspection and maintenance of monitoring network and survey benchmarks
Chestnut Ridge sediment disposal basin	Engineered cap	Cap inspection and maintenance. Postclosure detection monitoring. Inspection and maintenance of monitoring network and survey benchmarks
East Chestnut Ridge Waste Pile	Engineered cap	Cap inspection and maintenance. Postclosure detection monitoring. Inspection and maintenance of monitoring network, leachate collection sump, and survey benchmarks. Management of leachate
Bear Creek Hydrogeologic Regime (RCRA Postclosure Permit TNHW-116)		
Former S-3 ponds (S-3 pond site)	Neutralization and stabilization of wastes, engineered cap, asphalt cover	Cap inspection and maintenance. Postclosure corrective action monitoring. Inspection and maintenance of monitoring network and survey benchmarks
Oil landfarm	Engineered cap	Cap inspection and maintenance. Postclosure corrective action monitoring. Inspection and maintenance of monitoring network and survey benchmarks
Bear Creek Burial Grounds: A-North, A-South, and C-West and the walk-in pits	Engineered cap, seep collection system specific to the burial grounds	Cap inspection and maintenance. Postclosure corrective action monitoring. Inspection and maintenance of monitoring network and survey benchmarks

Acronyms

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
ORR = Oak Ridge Reservation
RCRA = Resource Conservation and Recovery Act
Y-12 Complex = Y-12 National Security Complex

4.3.8 Toxic Substances Control Act Compliance Status

The storage, handling, and use of PCBs are regulated under the Toxic Substances Control Act (TSCA). Capacitors manufactured before 1970 that are believed to be oil-filled are handled as though they contained 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 June 12, 2015

Given the widespread historical uses of PCBs at the Y-12 Complex and fissionable material requirements that must be met, an agreement between EPA and DOE was negotiated to assist ORR facilities in becoming compliant with TSCA regulations. This agreement, the ORR PCB Federal Facility Compliance Agreement (FFCA), which became effective in 1996, provides a forum with which to address PCB compliance issues that are truly unique to these facilities. Y-12 Complex operations involving TSCA-regulated materials were conducted in accordance with TSCA regulations and ORR PCB FFCA.

The removal of legacy PCB waste, some of which had been stored since 1997, in accordance with the terms of ORR PCB FFCA, was completed in 2011.

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

The Emergency Planning and Community Right-to-Know Act (EPCRA) requires that facilities 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. The Y-12 Complex submitted reports in 2015 in accordance with requirements under EPCRA Sections 302, 303, 311, 312, and 313.

The Y-12 Complex had one unplanned release of a hazardous substance which required notification of the regulatory agencies. On June 9, 2015 during the demolition of Building 9808, 2,117 pounds of mercury and mercury-containing sludge were spilled which exceeded a hazardous substance reportable quantity. This event was reported to the appropriate agencies in accordance with regulatory requirements. See section 4.3.11 for more information.

Section 311 notifications were sent to TEMA and local emergency responders in 2015 because chemicals newly exceeded the reporting thresholds or new information was identified about previously reported chemicals. Those chemicals included coal tar pitch (CAS No. 65996-93-2) and asphalt oxidized (CAS No. 64742-93-4) from roofing projects, ferric sulfate (CAS No. 10028-22-5) used in wastewater treatment, and ammonia (CAS No. 7664-41-7) used in various facility and laboratory operations. 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 also 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 52 chemicals that were over Section 312 inventory thresholds in 2015.

Y-12 Complex operations are evaluated annually to determine the applicability for submittal of a toxic release inventory report to TEMA and EPA in accordance with EPCRA 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 TRI-ME (Toxics Release Inventory-Made Easy) web-based reporting system operated by EPA.

Total 2015 reportable toxic releases to air, water, and land and waste transferred off-site for treatment, disposal, and recycling were 20,823 kg (45,907 lb). Table 4.6 lists the reported chemicals for the Y-12 Complex for 2014 and 2015 and summarizes releases and off-site waste transfers for those chemicals.

Table 4.5. Emergency Planning and Community Right-to-Know Act Section 313 toxic chemical release and off-site transfer summary for the Y-12 National Security Complex, 2014 and 2015

Chemical	Year	Quantity[a] (lb)[b]
Chromium	2014	3,312
	2015	3,474
Copper	2014	4,494
	2015	3,605
Lead compounds	2014	19,324
	2015	14,914
Manganese	2014	--[c]
	2015	3,763
Mercury	2014	436
	2015	179
Methanol	2014	20,274
	2015	16,350
Nickel	2014	5,356
	2015	3,622
Silver	2014	--[c]
	2015	Form A[d]
Total	2014	53,196
	2015	45,907

[a]Represents total releases to air, land, and water and includes off-site waste transfers. Also includes quantities released to the environment as a result of remedial actions, catastrophic events, or one-time events not associated with production processes.
[b]1 lb = 0.4536 kg.
[c]Not reported in previous year.
[d]Form A – less than 500 lbs. released.

4.3.10 Spill Prevention, Control, and Countermeasures

The Clean Water Act (CWA), Section 311, regulates the discharge of oils or petroleum products to waters of the United States and requires the development and implementation of spill prevention, control, and countermeasures (SPCC) plans to minimize the potential for oil discharges. The major requirements for SPCC plans are contained in Title 40 CFR Part 112. These regulations require that SPCC plans be reviewed, evaluated, and amended at least once every 5 years or earlier if significant changes occur. The SPCC rule includes requirements for oil spill prevention, preparedness, and response to prevent oil discharges to navigable waters and adjoining shorelines. The rule requires specific facilities to prepare, amend, and implement SPCC plans.

The Y-12 Complex SPCC plan (B&W Y-12 2010) was revised in September 2015 to update general Y-12 Complex changing site infrastructure. This plan presents the SPCC to be implemented by the Y-12 Complex to prevent spills of oil and hazardous constituents 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 PSS. Spill response materials and equipment are stored near tanks and drum storage areas and other strategic areas of the Y-12 Complex to facilitate spill response. All Y-12 Complex personnel and subcontractors are required to have initial spill and emergency response training before they can work on the site. This training is received as part of the GET program.

SPCC-related improvements have been made at Y-12 by reducing the amount of oil stored on site, particularly electrical transformer oil. The revised Y-12 SPCC Plan (CNS Y-12 2015a) was completed in September 2015, meeting the regulatory requirement to review and update the SPCC Plan every 5 years.

4.3.11 Unplanned Releases

The Y-12 Complex has procedures for notifying off-site authorities for categorized events at the Y-12 Complex. Off-site notifications are required for specified events according to federal statutes, DOE orders, and Tennessee Oversight Agreement. As an example, any observable oil sheen on EFPC and any release impacting surface water must be reported to the EPA National Response Center in addition to other reporting requirements. Spills of CERCLA reportable quantity (RQ) limits must be reported to the EPA National Response Center, DOE, TEMA, and the Anderson County Local Emergency Planning Committee.

In addition, the Y-12 occurrence reporting program provides timely notification to the DOE community of Y-12 Complex events and site conditions that could adversely affect the public or worker health and safety, the environment, national security, DOE safeguards and security interests, functioning of DOE facilities, or the reputation of DOE.

Y-12 Complex occurrences are categorized and reported through the Occurrence Reporting and Processing System (ORPS). ORPS 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 CY 2015 there was one release of a hazardous substance exceeding an RQ.

There was a release of a hazardous substance exceeding an RQ on June 9, 2015, when a mercury spill occurred at Building 9808. This building was being prepared for demolition. The appropriate authorities were notified of the release, and the mercury was cleaned up.

Additionally, there was one reportable occurrence related to the Water Program.

The Central Mercury Treatment Facility experienced a bypass on March 7, 2015. The event was reported to the TDEC (NA--NPO-CNS-Y12NSC-2015-0013). A high level alarm automatically shut down the treatment system, but failed to notify the appropriate personnel. It is estimated that between 0.052 and 0.070 grams of mercury were discharged during the approximately 3 hour event.

4.3.12 Audits and Oversight

A number of federal, state, and local agencies oversee Y-12 Complex activities. In 2015, the Y-12 Complex was inspected by federal, state, or local regulators on four occasions. Table 4.6 summarizes the results, and additional details follow.

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 twice yearly compliance inspections. No issues were identified in 2015.

Personnel from the TDEC Knoxville Field Office completed two clean air compliance inspections on March 10 and November 19, 2015. The inspections covered 33 air emission sources, several emergency generators, and included facility walkthroughs and records reviews. There were no findings or deficiencies identified.

Table 4.6. Summary of external regulatory audits and reviews, 2015

Date	Reviewer	Subject	Issues
February 12	COR	Semiannual Industrial Pretreatment Compliance Inspection	0
March 9-10	TDEC	Annual CAA Inspection	0
September 16	COR	Semiannual Industrial Pretreatment Compliance Inspection	0
November 17–19	TDEC	Annual CAA Inspection	0

Acronyms
CAA = Clean Air Act
COR = City of Oak Ridge
TDEC = Tennessee Department of Environment and Conservation

4.3.13 Radiological Release of Property

Clearance of property from the Y-12 National Security Complex is conducted in accordance with approved procedures that comply with DOE O 458.1, *Radiation Protection of the Public and the Environment* (DOE 2011c). Property consists of real property (i.e., land and structures), personal property, and material and equipment (M&E). At the Y-12 National Security Complex there are three paths for releasing property to the public based on the potential for radiological contamination:

- survey and release of property potentially contaminated on the surface (using preapproved authorized limits for releasing property),
- evaluation of materials with a potential to be contaminated in volume (volumetric contamination) to ensure no radioactivity has been added, and
- evaluation using process knowledge (surface and volumetric).

These three release paths are discussed in the following sections. Table 4.7 summarizes some examples of the quantities of property released in 2015. During FY 2015, Y-12 recycled more than 2.67 million lb of materials off the site for reuse, including but not limited to computers, electronic office equipment, used oil, scrap metal, tires, batteries, lamps, and pallets.

Table 4.7. Summary of materials released in 2015

Category	Amount released
Real property (land and structures) computer equipment recycle	None
– Computers, monitors, printers, & mainframes	81,973 lb
Electronic office equipment recycle[a]	
– used office & telecommunications equipment	2,027 lb
Recycling examples	
– Used oils	2,295 gal
– Used tires	21,120 lb
– Scrap metal	1,315,122 lb
– Lead acid batteries	85,443 lb
Public sales[b]	
– Copper	10,268 lb
– miscellaneous furniture	138,372 lb
– vehicles and miscellaneous equipment	100,484 lb
External transfers[c]	109,065 lb

[a] Items such as typewriters, telephones, shredders, calculators, laminators, and overhead projectors.
[b] Sales during FY 2015.
[c] Vehicles; miscellaneous equipment; and materials transferred to various federal, state, and local agencies for reuse during FY 2015.

4.3.13.1 Property Potentially Contaminated on the Surface

Property that is potentially contaminated on the surface is subject to a complete survey unless it can be released based on process knowledge or via a survey plan that provides survey instructions along with ~~the~~ technical (process knowledge) justification for the survey plan based on *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (NRC 2000) and *Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual* (MARSAME) (NRC 2009) [1]. The surface contamination limits used at the Y-12 National Security Complex to determine whether M&E are suitable for release to the public are provided in Table 4.8.

Y-12 uses an administrative limit for total activity of 2400 dpm/100 cm² for radionuclides in groups 3 and 4 (see Table 4.8). The use of the more restrictive administrative limits ensures that M&E do not enter into commerce exceeding the definition of contamination found in 49 CFR 173, "Shippers—General Requirements for Shipments and Packagings."

[1] The *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) provides guidance on how to demonstrate that a site is in compliance with a radiation dose or risk-based regulation, otherwise known as a release criterion. The *Multi-Agency Radiation Survey and Assessment of Materials and Equipment* anual is a supplement to MARSSIM that provides technical information on approaches for determining proper disposition of materials and equipment.

Table 4.8. DOE O 458.1 preapproved authorized limits[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	1000	3,000	200
Group 3—U-Natural, ^{235}U, ^{238}U, associated decay products, alpha emitters	5000	15,000	1000
Group 4—Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr and others noted above[g]	5000	15,000	1000
Tritium (applicable to surface and subsurface)[h]	Not applicable	Not applicable	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. No generic concentration guidelines have been approved for release of material that has been contaminated in depth, such as activated material or smelted contaminated metals (e.g., radioactivity per unit volume or per unit mass). Authorized limits for residual radioactive material in volume must be approved separately.
[b]As used in this table, dpm (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-emitting and beta-gamma-emitting radionuclides exists, the limits established for alpha-emitting 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 of 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 millirad per hour (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. It is not necessary to use wiping techniques to measure removable contamination levels 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 the ^{90}Sr that is present in them. It does not apply to ^{90}Sr that has been separated from the other fission products or mixtures where the ^{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
DOE = US Department of Energy

Source: Vázquez 2011.

4.3.13.2 Property Potentially Contaminated in Volume (Volumetric Contamination)

Materials such as activated materials smelted contaminated metals, liquids, and powders are subject to volumetric contamination (e.g., radioactivity per unit volume or per unit mass) and are treated separately from surface-contaminated objects. No authorized volumetric contamination limits have been approved for material released from the Y-12 National Security Complex. Materials that are subject to volumetric contamination are evaluated for release by the following three methods.

1. Unopened, Sealed Containers—Material is still in an original commercial manufacturer's sealed, unopened container. A seal can be a visible manufacturer's seal (i.e., lock tabs, heat shrink) or a manufacturer's seal that cannot be seen (e.g., unbroken fluorescent bulbs, sealed capacitors) as long as the container remains unopened once received from the manufacturer.

2. Process Knowledge—If it can be determined that there is no likelihood of contamination being able to enter a system then this is documented and used to justify release; then the basis for release is documented. Often this is accompanied by confirmatory surveys.

3. Analytical—The material is sampled, and the analytical results are evaluated against measurement-method critical levels or background levels from materials that have not been impacted by Y-12 National Security Complex activities. If the results meet defined criteria, then they are documented and the material is released.

4.3.13.3 Process Knowledge

Process knowledge is used to release property from the Y-12 National Security Complex without monitoring or analytical data and to implement a graded approach (less than 100% monitoring) for monitoring of some M&E (MARSAME Classes II and III) (NRC 2009). A conservative approach (nearly 100% monitoring) is used to release older M&E for which a complete and accurate history is difficult to compile and verify (MARSAME Class I). The process knowledge evaluation processes are described in Y-12 Complex procedures.

The following M&E are released without monitoring based on process knowledge; this does not preclude conducting verification monitoring, for example, before sale.

- All M&E from buildings evaluated and designated as "RAD-Free Zones."
- Pallets generated from administrative buildings.
- Pallets that are returned to shipping during the same delivery trip.
- Lamps from administrative buildings.
- Drinking water filters.
- M&E approved for release by Radiological Engineering Technical Review.
- Portable restrooms used in nonradiological areas.
- Documents, mail, diskettes, compact disks, and other office media; personal M&E; paper, plastic products, water bottles, ABCs, and toner cartridges; office trash, house-keeping materials, and associated waste; breakroom, cafeteria, and medical wastes; and medical and bioassay samples generated in nonradiological areas.
- Subcontractor/vendor/privately owned vehicles, tools, and equipment used in nonradiological areas.
- M&E that are administratively released.

- M&E misdelivered to Stores that has not been distributed to other Y-12 National Security Complex locations.
- New computer equipment distributed from Building 9103 subcontractor/vendor/privately owned vehicles, tools, and equipment that has not been used in contaminated areas or for excavation activities.

4.4 Air Quality Program

Sections of the Y-12 Complex Title V permit 562767 contain requirements that are generally applicable to most industrial sites. Examples include requirements associated with asbestos controls, control of stratospheric ozone–depleting chemicals, control of fugitive emissions, and general administration of the permit. The Title V permit also contains a section of specific requirements directly applicable to individual sources of air emissions at the Y-12 Complex. Major requirements in that section include the Radiological National Emission Standards for Hazardous Air Pollutants (Rad-NESHAP) (40 CFR 61) requirements and the numerous requirements associated with emissions of criteria pollutants and other, nonradiological hazardous air pollutants (HAPs). 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 State of Tennessee.

4.4.1 Construction and Operating Permits

In 2015 the Y-12 Complex received an extension to the construction air permit for UPF, amended by TDEC on January 26, 2015. There were no modifications to the Y-12's Title V Operating Air Permit in 2015.

Permit administration fees are paid to TDEC annually in support of the Title V program. CNS has chosen to pay the fees based on a combination of actual emissions [steam plant, methanol, solvent 140/142 volatile organic compounds (VOCs)] and allowable emissions (balance of plant). In 2015, emissions categorized as actual emissions totaled 37,703 kg, and emissions calculated by the allowable method totaled 590,342 kg. The total emissions fee paid was $27,713.23.

Demonstrating compliance with the conditions of air permits is a significant effort at the Y-12 Complex. Key elements of maintaining compliance are maintenance and operation of control devices, monitoring, record keeping, and reporting. High-efficiency particulate air (HEPA) filters and scrubbers are control devices used at the Y-12 Complex. HEPA filters are found throughout the complex, and in-place testing of HEPA filters to verify the integrity of the filters is routinely performed. Scrubbers are operated and maintained in accordance with source-specific procedures. Monitoring consists of tasks such as continuous stack sampling, one-time stack sampling, and monitoring the operation of control devices. Examples of continuous stack sampling are the radiological stack monitoring systems on numerous sources throughout the complex.

The Y-12 Complex sitewide permit requires annual and semiannual reports. One report is the overall annual ORR Rad-NESHAPs report (DOE 2015a), which includes specific information regarding Y-12 Complex radiological emissions; the second is an annual Title V compliance certification report indicating compliance status with all conditions of the permit. The third is a Title V semiannual report, which covers a 6-month period for some specific emission sources. It consists of monitoring and record-keeping requirements for the sources. Table 4.9 gives the actual emissions versus allowable emissions for the Y-12 Complex Steam Plant.

Table 4.9. Actual versus allowable air emissions from the Y-12 National Security Complex Steam Plant, 2015

Pollutant	Emissions (tons/year)[a]		Percentage of allowable
	Actual	Allowable	
Particulate	3.55	41	8.7
Sulfur dioxide	0.28	39	0.7
Nitrogen oxides[b]	14.73	81	18.2
Volatile organic compounds[b]	2.43	9.4	25.9
Carbon monoxide[b]	37.42	139	26.9

NOTE: The emissions are based on fuel usage data for January through December 2015. The emissions also included the fuel used during testing.
[a]1 ton = 907.2 kg.
[b]When there is no applicable standard or enforceable permit condition for a pollutant, the allowable emissions are based on the maximum actual emissions calculation as defined in Tennessee Department of Environment and Conservation Rule 1200-3-26-.02(2)(d)3 (maximum design capacity for 8,760 h/year). Both actual and allowable emissions were calculated based on the latest US Environmental Protection Agency compilation of air pollutant emission factors (EPA 1995 and 1998).

4.4.1.1 Generally Applicable Permit Requirements

The Y-12 Complex, like many industrial sites, has a number of generally applicable requirements that require management and control. Asbestos, ozone-depleting substances (ODS) and fugitive particulate emissions are notable examples.

4.4.1.1.1 Control of Asbestos

The Y-12 Complex has numerous buildings and equipment that contain asbestos-containing materials. The compliance program for management of removal and disposal of asbestos-containing materials includes demolition and renovation notifications to TDEC and inspections, monitoring, and prescribed work practices for abatement and disposal of asbestos materials. There was no reportable release of asbestos in 2015. There were five notifications of asbestos demolition or renovation, five revisions of notification of asbestos demolition or renovation, two records of oral regulatory communication, one revised annual estimate for CY 2015, one annual estimate for CY 2016, and one notification of change in the management and operating contractor for the Y-12 Complex submitted to TDEC in 2015 for its review and records.

An internal surveillance of the asbestos NESHAP reporting process was conducted on November 24, 2015. The scope of this surveillance was focused on compliance with applicable state and federal environmental regulations, specifically reporting and record-keeping requirements for on-site demolition and renovation activities for buildings. There were no findings or deficiencies identified as a result of this surveillance.

4.4.1.1.2 Stratospheric Ozone Protection

The *Y-12 Complex Ozone Depleting Substances (ODS) Phase-Out and Management Plan* (B&W Y-12 2014) provides a complete discussion of requirements and compliance activities at the Y-12 Complex. Past ODS-reduction initiatives that began in the early 1980s focused on elimination of Class I ODS use in refrigerants and solvent- cleaning operations. In 2012, the last remaining chiller system at the Y-12

Complex with Class I ODSs was taken out of service. The refrigerant from that system was sent to the Defense Logistics Agency.

Y-12 Complex initiatives have also involved elimination of ODS solvents in cleaning processes. Operations personnel developed and implemented changes in one process that eliminated ODS solvents from that process. Evaluation of ODS reduction opportunities continue for another solvent-cleaning operation. Future actions related to this process will be dependent on ongoing efforts to identify a safe and viable replacement chemical or to identify practical and cost-effective modifications to process equipment.

All Class I and Class II substitutions are made in accordance with EPA's Significant New Alternatives Program (SNAP). Y-12 Complex personnel are notified as EPA issues regulations detailing SNAP replacement chemicals that may be applicable to Y-12 Complex operations. To prevent ODSs from coming on site, procurement documents are written to ensure that no additional equipment or processes using Class I ODSs are brought on site, and Class II ODS usage is limited wherever possible.

Site procedures are in place for disposition of excess refrigerant or refrigerant-containing equipment. Recovered refrigerant is recycled/reused in equipment in the Y-12 Complex whenever feasible. Refrigerant is recovered from refrigerant-containing equipment before disposal of the equipment. Class I ODSs that cannot be used on-site are first made available to the Defense Logistics Agency. Remaining refrigerants, including Class I and Class II ODSs, are sold to refrigerant reclamation facilities or properly disposed.

4.4.1.1.3 Fugitive Particulate Emissions

As modernization and infrastructure reduction efforts increase at the Y-12 Complex, the need also increases for good work practices and controls to minimize fugitive dust emissions from C&D activities. Y-12 Complex personnel continue to use a mature project planning process to review, recommend, and implement appropriate work practices and controls to minimize fugitive dust emissions. Precautions used to prevent particulate matter from becoming airborne include but are not be limited to (1) use, where possible, of water or chemicals for control of dust in demolition of existing buildings or structures, construction operations, grading of roads, or the clearing of land; (2) application of asphalt, oil, water, or suitable chemicals on dirt roads, material stockpiles, and other surfaces that can create airborne dusts; and (3) installation and use of hoods, fans, and fabric filters to enclose and vent the handling of 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 the Y-12 Complex occurs almost exclusively as a result of plant production, maintenance, and waste management activities. The major radionuclide emissions contributing to the dose from the Y-12 Complex are ^{234}U, ^{235}U, ^{236}U, and ^{238}U, which are emitted as particulates. The particle size and solubility class of the emissions are determined 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 four categories of processes or operations that are considered when calculating the total uranium emissions are

- those that exhaust through monitored stacks;
- unmonitored processes for which calculations are performed per Appendix D of 40 CFR 61;

- processes or operations exhausting through laboratory hoods, also involving 40 CFR 61Appendix D calculations; and
- 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 the Y-12 Complex. In addition, a probe-cleaning program is in place, and the results from the probe cleaning at each source are incorporated into the respective emission point source terms. In 2015, 34 process exhaust stacks were continuously monitored, 25 of which were major sources; the remaining 9 were minor sources. The Nuclear Facilities Risk Reduction (NFRR) Project was completed in early 2015 and resulted in two major stacks being removed from the sampling program (Stacks UB-027 and UB-043). Additionally, an increase in mission-related activities resulted in three stacks being brought on line, and sampling was reinstated for Stacks US-009, -010, and -011. Because of activities associated with the startup of these processes, the total amount of increased uranium emissions increased at the Y-12 NSC, which is provided below. The sampling systems on the stacks have been approved by EPA Region 4.

During 2015, unmonitored uranium emissions at the Y-12 Complex occurred from 31emission points associated with on-site, unmonitored processes and laboratories operated by CNS. Emission estimates for these processes and laboratory stacks were made using inventory data with emission factors provided in 40 CFR Part 61, Appendix D. The Y-12 Complex source term includes an estimate of these emissions.

The Y-12 Analytical Chemistry Organization operates out of two main laboratories. One is located on the site in Building 9995. The other is located in a leased facility on Union Valley Road, about 0.3 miles east of the Y-12 Complex, and is not within the ORR boundary. In 2015, 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% of the derived air concentration (DAC) as defined in the ORR radionuclide compliance plan (DOE 2013) are included in the annual source term. Annual average concentrations and design ventilation rates are used to arrive at the annual emission estimate for those areas. Two emission points from room ventilation exhausts were identified in 2015 where emissions exceeded 10% of DAC. These emission points feed to monitored stacks, and any radionuclide emissions are accounted for as noted for monitored emission points.

The Y-12 Complex Title V Major Source Operating Permits contain a sitewide, streamlined alternate emission limit for enriched and depleted uranium process emission units. A limit of 907 kg per year of particulate 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 Rad-NESHAPs compliance. An estimated 0.0204 Ci (13.5 kg) of uranium was released into the atmosphere in 2015 as a result of Y-12 Complex process and operational activities (Figs. 4.15 and 4.16).

A UPF is presently being designed. It is intended that this facility house some of the processes that are currently in existing production buildings. The UPF project was issued a Construction Air Permit, 967550P. The current strategy, with concurrence from the TDEC Air Division, is to include the UPF in the 2017 update of the Y-12 Site Title V Operating Permit and to maintain the facility on the permit as inactive until operations commence in about 2025.

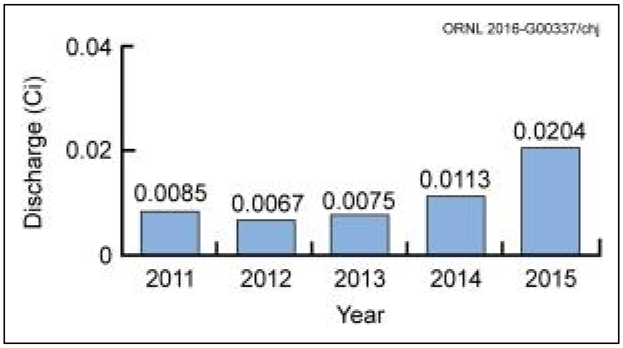

Fig. 4.15 Total curies of uranium discharged from the Y-12 National Security Complex to the atmosphere, 2011–2015

The calculated radiation dose to the maximally exposed off-site individual from airborne radiological release points at the Y-12 Complex during 2015 was 0.114 mrem. This dose is well below the NESHAP standard of 10 mrem and is less than 0.04% of the roughly 300 mrem that the average individual receives from natural sources of radiation. (See Chapter 7 for an explanation of how the airborne radionuclide dose was determined.)

4.4.1.3 Quality Assurance

QA activities for the Rad-NESHAPs program are documented in *Y-12 National Security Complex Quality Assurance Project Plan for National Emission Standards for Hazardous Air Pollutants (NESHAP) for Radionuclide Emission Measurements* (B&W Y-12 2010). The plan satisfies the QA requirements in 40 CFR Part 61, Method 114, for ensuring that the radionuclide air emission measurements from the Y-12 Complex 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. The requirements are also referenced in TDEC regulation 1200-3-11-.08. The plan ensures the quality of the Y-12 Complex radionuclide emission measurements data from the continuous samplers, breakthrough monitors, and minor radionuclide release points. It specifies the procedures for management of activities affecting the quality of data. 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 a number of control devices (e.g., HEPA filters and scrubbers) are key to controlling emissions of criteria pollutants. The primary source of criteria pollutants at the Y-12 Complex is the steam plant, where only natural gas and Number 2 fuel oil are permitted to be burned. Information regarding actual vs. allowable emissions from the steam plant is provided in Table 4.9.

Particulate emissions from point sources result from many operations throughout the Y-12 Complex. Compliance demonstration is achieved via several activities, including monitoring the operations of control devices, limiting process input materials, and using certified readers to conduct stack-visible emission evaluations.

Use of Solvent 140/142 and methanol throughout the complex and use of acetonitrile at a single source 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 CY 2015 are 2,313 lb (1.16 tons) and 25,641 lb (12.82 tons), respectively. The highest calculated amount of acetonitrile emitted to the atmosphere for CY 2015 was 5 tons, which was less than the permitted value of 9 tons/year.

4.4.1.5 Mandatory Reporting of Greenhouse Gas Emissions under 40 CFR 98

Title 40 of the Code of Federal Regulations Part 98, *Mandatory Greenhouse Gas Reporting*, establishes mandatory GHG 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 mandatory reporting of GHGs rule requires reporting of annual emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons, perfluorochemicals, and other fluorinated gases (e.g., nitrogen trifluoride and hydrofluorinated ethers). These gases are often expressed in metric tons of CO_2e.

The Y-12 Complex is subject only to the 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 that sources emitting above the 25,000 CO_2e threshold level monitor and report emissions.

The Y-12 Complex Steam Plant is subjected to this rule. The steam plant consists of four boilers. The maximum heat input capacity of each boiler shall not exceed 99 MM Btu/h. Natural gas is the primary fuel source for the boilers; Number 2 fuel oil as a backup source of fuel. 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 9204-2, 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 Calculation Method was used to calculate GHGs from the Y-12 Complex. The amount of natural gas supplied to the site, along with the fuel usage logs provides the basic information for calculation of the GHG emissions.

The emission report is submitted electronically in a format specified by the EPA administrator. 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 the Y-12 Complex is shown in Table 4.10. The decrease in emissions from 2010 to2015 is associated with the fact that coal is no longer burned since the natural-gas-fired steam plant came on line.

Table 4.10. Greenhouse gas emissions from Y-12 National Security Complex stationary fuel combustion sources

Year	GHG emissions (metric tons CO_2e)
2010	97,610
2011	70,187
2012	63,177
2013	61,650
2014	58,509
2015	51,706.9

Acronyms
CO_{2e} = CO_2 equivalent
GHG = greenhouse gas

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 one-time stack test and through monitoring of control device operations. Hydrogen fluoride is used at one emission source, and emissions are controlled through the use of scrubber systems. The beryllium control devices and the scrubber systems were monitored during 2015 and were found to be operating properly.

Methanol is released as fugitive emissions (e.g., pump and valve leaks) as part of the brine/methanol system. Methanol is subject to state air permit requirements; however, due to the nature of its release (fugitive emissions only), there are no specific emission limits or mandated controls. Mercury is a significant legacy contaminant at the Y-12 Complex, and cleanup is being addressed under the environmental remediation program. 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 and is discussed under Section 4.4.2, “Ambient Air.”

In 2007 EPA vacated a proposed Maximum Achievable Control Technology Standards (MACT) standard that was intended to minimize hazardous air pollution emissions. At that time a case-by-case MACT review was conducted as part of the construction permitting process for the Y-12 Complex replacement steam plant. The new natural-gas-fired steam plant came on line on April 20, 2010, and coal is no longer combusted. Specific conditions aimed at minimizing hazardous air pollutant (HAP) emissions from the new steam plant were incorporated into the operating permit issued January 9, 2012 (see Section 4.4.1). In addition, the boiler MACT 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 MACT requirements. The steam plant must comply with the new requirements no later than January 31, 2016. The new requirements (work practice standards) include conducting annual tune-ups and a one-time energy assessment of the boilers to meet these requirements. There are no numeric emission limit requirements for the steam plant.

Unplanned releases of HAPs are regulated through the Risk Management Planning regulations. Y-12 Complex personnel have determined there are no processes or facilities containing inventories of chemicals in quantities exceeding thresholds specified in rules pursuant to CAA, Title III, Sect.112(r), “Prevention of Accidental Releases.” Therefore, the Y-12 Complex is not subject to that rule. Procedures are in place to continually review new processes and/or process changes against the rule thresholds.

4.4.1.7 Reciprocating Internal Combustion Engine Standards for New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants

Reciprocating internal-combustion engines (RICEs) use reciprocating motion to convert heat energy into mechanical work. A number of stationary emergency-use RICEs (which power generators) are located throughout the Y-12 Complex. The emergency engines/generators are used to provide power for critical systems in the event of electrical power failures/outages at the Y-12 Complex. Emergency RICEs are defined as stationary RICEs whose operations are limited to emergency situations and require testing and maintenance activities to ensure operation during emergencies. A stationary RICE used for peak shaving is not considered an emergency stationary RICE, although such a RICE may be used for periods of emergency demand response, subject to restriction.

EPA has created multiple national air pollution regulations to reduce air emissions from RICEs. Two types of federal air standards are applicable to RICEs: (1) New Source Performance Standards (Title 40 CFR Part 60, Subpart IIII) and (2) NESHAPs (Title 40 CFR Part 63, Subpart ZZZZ). The compression ignition engines/generators located at Y-12 are subject to these rules. EPA is concerned about how RICEs are used and also the emissions generated from these engines in the form of both HAPs and criteria pollutants.

All previous stationary emergency engines/generators were listed in the Y-12 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 HAPs. Regardless of engine size, the rules apply to any existing, new, or reconstructed stationary RICE located at a major source of HAP emissions.

To comply with the rules, the Y-12 Complex prepared a significant permit modification to the Y-12 Major Source (Title V) Operating Air Permit to add numerous stationary, emergency-use engines/generators located throughout the Y-12 Complex. The permit application was submitted to TDEC on May 6, 2013, for review and approval. TDEC downgraded the significant modification to a minor modification per EPA’s review and request. In a prior, updated permit application for renewal of the Y-12 Major Source (Title V) Operating Air Permit dated March 9, 2011, Y-12 Complex staff identified Title 40 CFR, Part 60, Subpart IIII, and “Standards of Performance for Stationary Compression Ignition Internal Combustion Engines,” as a requirement applicable to the stationary emergency use engines located at the Y-12 Complex. TDEC issued Y-12 a minor permit modification to the Title V air permit on March 3, 2014, for the emergency engines/generators. Compliance for the engines/generators is determined through monthly records of the operation of the engines/generators that are recorded through a nonresettable hour meter on each engine/generator. Documentation must be maintained of how many hours are spent for (1) emergency operation, (2) maintenance checks and readiness testing, and (3) nonemergency operation. Each engine/generator must use only diesel fuel with low sulfur content (15 ppm) and a cetane index of 40.

4.4.2 Ambient Air

To understand the complete picture of ambient air monitoring in and around the Y-12 Complex, data from on- and off-site monitoring conducted specifically for the Y-12 Complex, DOE reservationwide monitoring, and on- and off-site monitoring conducted by EPA and TDEC personnel must be considered.

No federal regulations, state regulations, or DOE orders require ambient air monitoring within the Y-12 Complex 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 during the past several years. In addition, major processes that result in emission of enriched and depleted uranium are equipped with stack samplers that have been reviewed and approved by EPA to meet requirements of the NESHAP regulations.

4.4.2.1 Mercury

The Y-12 Complex 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 at the Y-12 Complex. Originally four monitoring stations were operated at the Y-12 Complex, including two within the West End Mercury –Use Area WEMA (i.e., the former west end mercury-use area at Y-12). The two atmospheric mercury monitoring stations currently operating at the Y-12 Complex, ambient air station (AAS) 2 and AAS8, are located near the east and west boundaries of the Y-12 Complex, respectively (Fig. 4.16). Since their establishment in 1986, AAS2 and AAS8 have monitored mercury in ambient air continuously with the exception of short intervals of downtime because of electrical or equipment outages. In addition to the monitoring stations located at the Y-12 Complex, two additional monitoring sites were operated: a reference site (rain gauge 2) was operated 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 the 25-month period from August 1987 to September 1989.

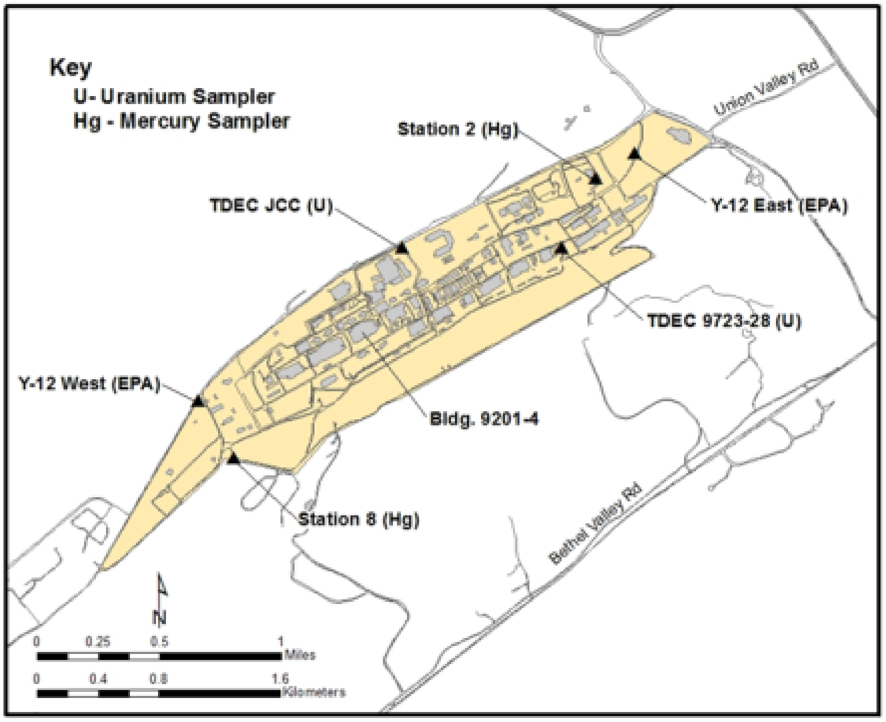

Fig. 4.16. Locations of ambient air monitoring stations at the Y-12 Complex. *[EPA = US Environmental Protection Agency (sampler) TDEC = Tennessee Department of Environment and Conservation, and JCC = Jack Case Center.]*

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 ~1 L/min. Actual flows are measured biweekly with a calibrated Gilmont flowmeter in conjunction with the biweekly change-out of 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.

The 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 4.11). Average mercury concentration at the AAS2 site for 2015 is 0.0026 μg/m^3 (N = 24), comparable to averages measured since 2003. After an increase in the average concentration at AAS8 for the period of 2005 through 2007, thought to be possibly due to increased decontamination and decommissioning D&D work on the west end, the average concentration at AAS8 for 2015 was 0.0035 μg/m^3 (N = 23), similar to levels reported for 2008 and the early 2000s. Based on the decreased mercury concentrations, the sampling schedule was changed from a weekly to biweekly duration last year. The sampling schedule will revert back to a weekly basis if the data suggest an increase in ambient air mercury concentrations or if breakthrough of the charcoal traps is observed.

Table 4.11 summarizes the 2015 mercury results with results from the 1986 through 1988 period included for comparison. Figure 4.17, Parts a, b, and c, illustrate temporal trends in mercury concentration for the two active mercury-monitoring sites for the period since the inception of the program in 1986 through 2015 [parts (a) and (b)] and seasonal trends at AAS8 from 1994 through 2015 [part (c)]. The dashed line superimposed on the plots in Figs. 4.18(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 the Perimeter Intrusion Detection Assessment System installation and storm drain restoration projects under way at that time within WEMA. In 4.21(c), a monthly moving average has been superimposed over the AAS8 data to highlight seasonal trends in mercury at AAS8 from January 1994 through 2015.

Table 4.11. Summary of data for the Y-12 National Security Complex ambient air monitoring program for mercury for CY 2015

Ambient air monitoring stations	Mercury vapor concentration (µg/m^3)			
	2015 Minimum	2015 Maximum	2015 Average	1986–1988[a] Average
AAS2 (east end of the Y-12 Complex)	0.0013	0.0055	0.0026	0.010
AAS8 (west end of the Y-12 Complex)	0.0015	0.0074	0.0035	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 ’80s 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.

Acronyms
AAS = ambient air (monitoring) station
CY = calendar year
Y-12 Complex = Y-12 National Security Complex

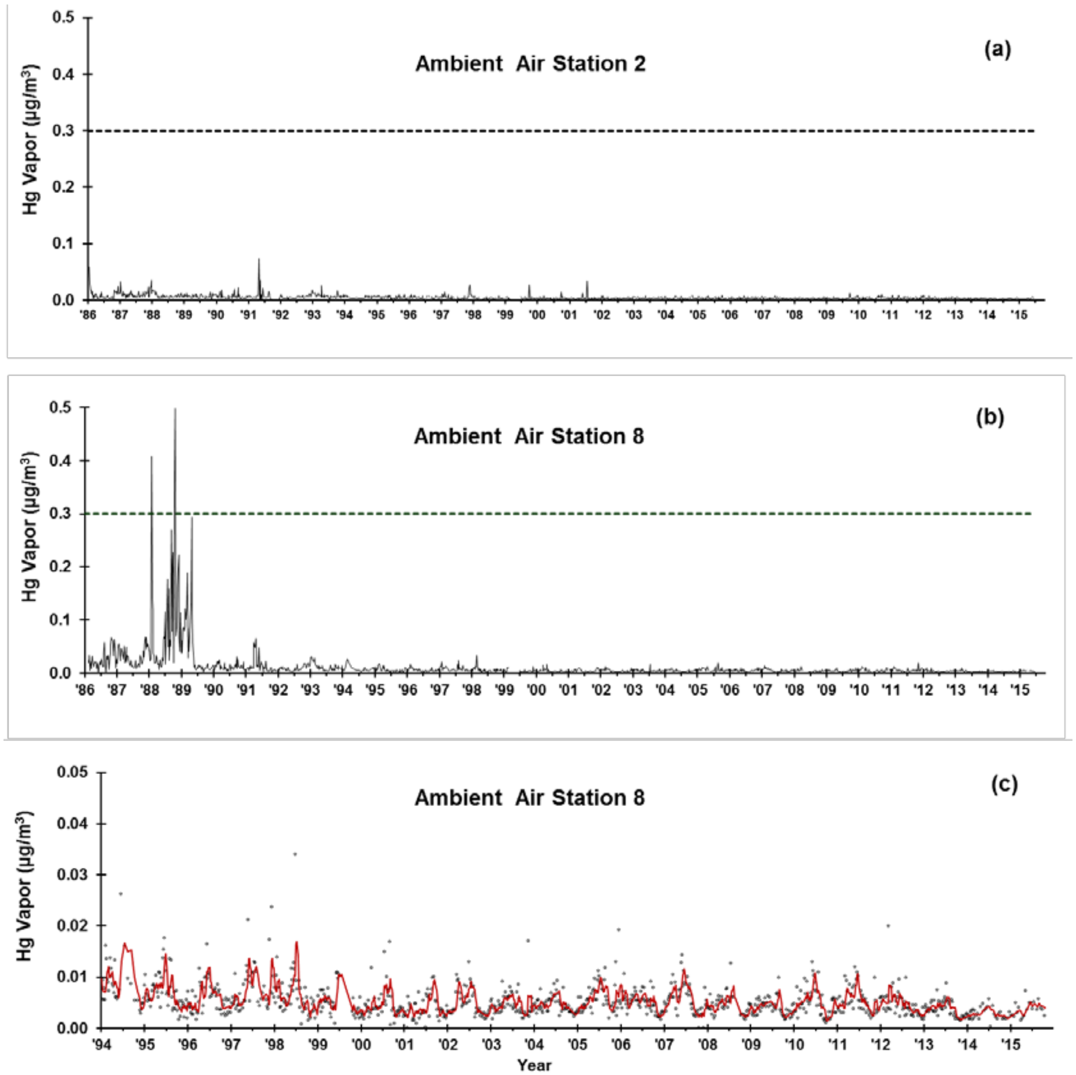

Fig. 4.17. Temporal trends in mercury vapor concentration for the boundary monitoring stations at the Y-12 Complex, July 1986 to January 2016 [(a) and (b)] and January 1994 to January 2016 for ambient air station 8 [(c)].

The dashed lines superimposed on (a) and (b) represent the US Environmental Protection Agency reference concentration of 0.3 µg/m^3 for chronic inhalation exposure. In (c) (note different concentration scale), a monthly moving average has been superimposed over the data to highlight seasonal trends in mercury at ambient air station 8 from January 1993 to January 2016, with higher concentrations generally measured during the warm weather months.

In conclusion, 2015 average mercury concentrations at the two mercury-monitoring sites 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 [i.e., the National Institute for Occupational Safety and Health recommended exposure limit of 50 µg/m^3, time-weighted average (TWA) for up to a 10 h workday, 40 h workweek; the American Conference of Governmental Industrial Hygienists workplace threshold limit value of 25 µg/m^3 as a TWA for a normal 8 h workday and 40 h workweek; and the current EPA reference concentration of 0.3 µg/m^3 for elemental mercury for a continuous inhalation exposure to the human population without appreciable risk of harmful effects during a lifetime].

4.4.2.2 Quality Control

A number of QA/quality control (QC) steps are taken to ensure the quality of the data for the Y-12 Complex mercury in 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.

The Gilmont correlated flowmeter, used for measuring flows through the sampling train, is purchased annually or, if not new, shipped back to the manufacturer annually for calibration in accordance with standards set by the National Institute of Standards and Technology (NIST).

Each batch of samples submitted to the analytical laboratory contains a minimum of 5% 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% to 10% 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 all the way to the analytical laboratory.

The project manager conducts a field performance evaluation annually to ensure that proper procedures are followed by the sampling technicians. No issues were identified in the last evaluation conducted, May 14, 2015.

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% at five or more times the detection limit are to be rerun (third duplicate) to resolve the discrepancy], and
- archiving all primary laboratory records for at least 1 year.

4.4.2.3 Ambient Air Monitoring Complementary to the Y-12 Complex Ambient Air Monitoring

Ambient air monitoring is conducted at multiple locations near ORR to measure radiological and other selected parameters directly in the ambient air. These monitors are operated in accordance with DOE orders. Their locations were selected so that areas of potentially high exposure to the public are monitored continuously for parameters of concern. This monitoring provides direct measurement of airborne concentrations of radionuclides and other HAPs, 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 AAS located in the Scarboro Community of Oak Ridge (Station 46) measures off-site impacts of Y-12 Complex operations. This station is located near the theoretical area of maximum public pollutant concentrations as calculated by air-quality modeling. ORR network stations are also located at the east end of the Y-12 Complex (Station 40) and just south of the Country Club Estates neighborhood (Station 37).

In addition to the monitoring described above, the State of Tennessee (i.e., TDEC) and EPA perform ambient air monitoring to characterize the region in general and to characterize and monitor DOE operations locally. Specific to Y-12 Complex operations, three uranium ambient air monitors within the Y-12 Complex boundary, used by TDEC since 1999, were phased out of service in 2012. TDEC is now using two additional high-volume samplers (Fig. 4.17) to provide isotopic uranium monitoring capability. These are located on the east side of the Jack Case Center and on the south side of the Building 9723-28 change house. EPA performs ambient air monitoring on the east end of the plant near the intersection of Scarboro Road and Bear Creek Road and on the west end of the plant near the intersection of Bear Creek Road and Old Bear Creek Road.

The TDEC DOE Oversight Division air quality monitoring includes several other types of monitoring on ORR, for example,

- RADNet[2] air monitoring,
- fugitive radioactive air emission monitoring,
- ambient VOC air monitoring,
- perimeter air monitoring,
- real-time monitoring of gamma radiation,
- ambient gamma radiation monitoring using external dosimetry, and
- program-specific monitoring associated with infrastructure-reduction activities.

Results of these activities are summarized in annual status reports, which are issued by the TDEC DOE Oversight Division.

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

4.5.1 National Pollutant Discharge Elimination System Permit and Compliance Monitoring

The current Y-12 Complex NPDES permit (TN0002968) requires sampling, analysis, and reporting for about 56 outfalls. Major outfalls are depicted in Fig. 4.18. The number is subject to change as outfalls are eliminated or consolidated or if permitted discharges are added. Currently, the Y-12 Complex has outfalls and monitoring points in the following water drainage areas: EFPC, Bear Creek, and several tributaries on the south side of Chestnut Ridge, all of which eventually drain to the Clinch River.

[2] The US Environmental Protection Agency's nationwide radiological monitoring program for air, precipation, and drinking water.

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 the sampling and analysis of 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 in the vicinity of the Y-12 Complex is affected by current and legacy operations. Discharges from Y-12 Complex processes flow into EFPC before the water exits the Y-12 Complex. EFPC eventually flows through the City of Oak Ridge to Poplar Creek and into the 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.

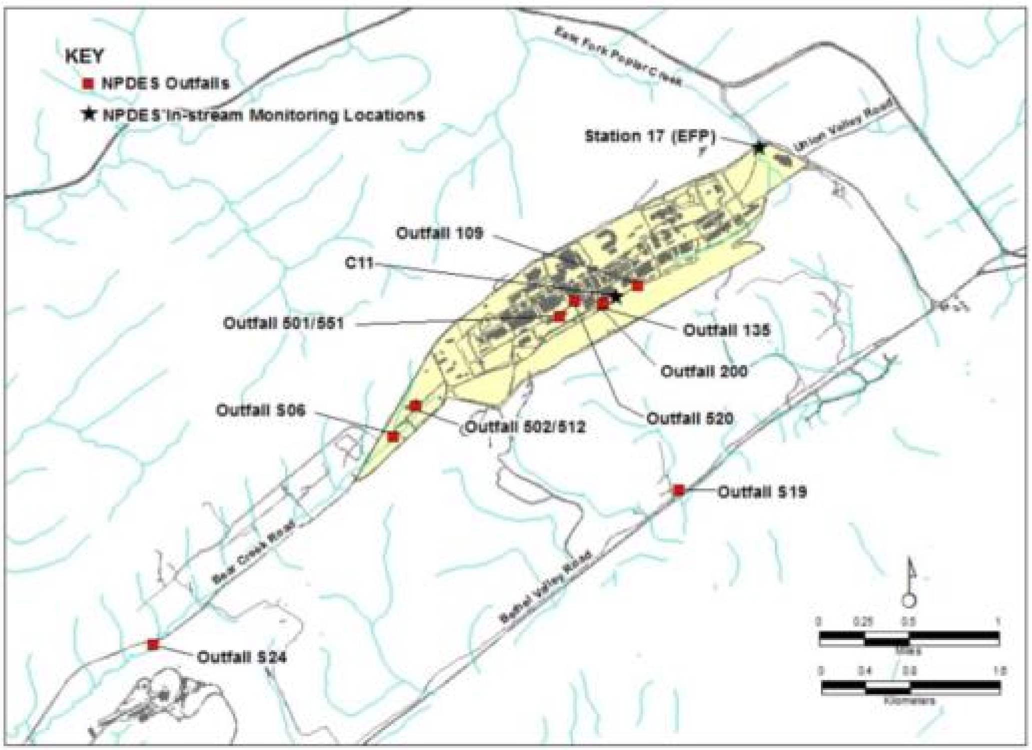

Fig. 4.18. Major Y-12 National Security Complex National Pollutant Discharge Elimination System (NPDES) outfalls and monitoring locations.

Requirements of the NPDES permit for 2015 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 2015 was almost 100%.

Table 4.12. National Pollutant Discharge Elimination System compliance monitoring requirements and record for the Y-12 National Security Complex, January through December 2015

Discharge point	Effluent parameter	Daily average (lb)	Daily maximum (lb)	Monthly average (mg/L)	Daily maximum (mg/L)	Percentage of compliance	Number of samples
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
	Polychlorinated biphenyl (PCB)				0.001	*b*	0
Outfall 502 (West End Treatment Facility)	pH, standard units			*A*	9.0	100	2
	Total suspended solids		31		40	100	3
	Total toxic organic				2.13	100	2
	Hexane extractables			10	15	100	2
	Cadmium		0.4		0.15	100	3
	Chromium		1.7		1.0	100	3
	Copper		2.0		1.0	100	3
	Lead		0.4		0.2	100	3
	Nickel		2.4		3.98	100	3
	Nitrate/Nitrite				100	100	3

Table 4.12. (continued)

Discharge point	Effluent parameter	Daily average (lb)	Daily maximum (lb)	Monthly average (mg/L)	Daily maximum (mg/L)	Percentage of compliance	Number of samples
	Silver		0.26		0.05	100	3
	Zinc		0.9		1.48	100	3
	Cyanide		0.72		1.20	100	2
	PCB				0.001	100	2
Outfall 512 (Groundwater Treatment Facility)	pH, standard units			*A*	9.0	100	13
	PCB				0.001	100	1
Outfall 520	pH, standard units			*A*	9.0	100	0
Outfall 200 (North/South pipes)	pH, standard units			*A*	9.0	100	54
	Hexane extractables			10	15	100	14
	Cadmium			0.001	0.023	95	19
	IC_{25} *Ceriodaphnia*			37% Minimum		100	1
	IC_{25} *Pimephales*			37% Minimum		100	1
	Total residual chlorine			0.024	0.042	100	13
Outfall 551	pH, standard units			*A*	9.0	100	52
	Mercury			0.002	0.004	96	51
Outfall C11	pH, standard units			*A*	9.0	100	14
Outfall 135	pH, standard units			*A*	9.0	100	14
	IC_{25} *Ceriodaphnia*			9% Minimum		100	1
	IC_{25} *Pimephales*			9% Minimum		100	1
Outfall 109	pH, standard units			*A*	9.0	100	6
	Total residual chlorine			0.010	0.017	100	49
Outfall S19	pH, standard units			*A*	9.0	100	1
Outfall S06	pH, standard units			*A*	9.0	100	3
Outfall S24	pH, standard units			*A*	9.0	100	2
Outfall EFP	pH, standard units			*A*	9.0	100	14
Category I outfalls	pH, standard units			*A*	9.0	100	58
Category II outfalls	pH, standard units			*A*	9.0	100	23
	Total residual chlorine				0.5	100	24
Category III outfalls	pH, standard units			*A*	9.0	100	9
	Total residual chlorine			*A*	0.5	100	7

[a]Not applicable.
[b]No discharge.

4.5.2 Mercury Removal from Storm Drain Catch Basins

Mercury tends to collect in low spots in the storm drain system following heavy rains. During 2015, spill response and waste services personnel continued to inspect the Y-12 storm drain system for visible mercury.

During CY 2015, 0.25 lb of mercury was collected from the storm system. See Section 4.8.2 for additional discussion of the DOE EM mercury remediation strategy (DOE 2014d).

4.5.3 Radiological Monitoring Plan and Results

A radiological monitoring plan is in place at the Y-12 Complex to address compliance with DOE orders and NPDES permit TN0002968. The permit requires the Y-12 Complex to submit 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. 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 three types of locations: (1) treatment facilities, (2) other point-source and area-source discharges, and (3) instream locations. Operational history and past monitoring results provide a basis for parameters routinely monitored under the plan (Table 4.13). The current radiological monitoring plan for the Y-12 Complex (B&W Y-12 2012) was last revised and reissued in January 2012.

Table 4.13. Radiological parameters monitored at the Y-12 National Security Complex, 2015

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 the Y-12 Complex and are the dominant detectable radiological parameters in surface water
Fission and activation products	^{90}Sr, ^{3}H, ^{99}Tc, ^{137}Cs	These parameters reflect a minor activity at the Y-12 Complex, 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
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

Acronyms
Y-12 Complex = Y-12 National Security Complex

Radiological monitoring during storm water events is accomplished as 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. Results of storm event monitoring during 2015 were reported in the annual storm water report (T/TS-2035/R9), issued in November 2015. In addition, the monthly 7-day composite sample for radiological parameters taken at Station 17 on EFPC likely includes rain events.

Radiological monitoring plan locations sampled in 2015 are noted on Fig. 4.19. Table 4.14 identifies the monitored locations, the frequency of monitoring, and the sum of the percentages of the DCSs for radionuclides measured in 2015. Radiological data were well below the allowable DCSs.

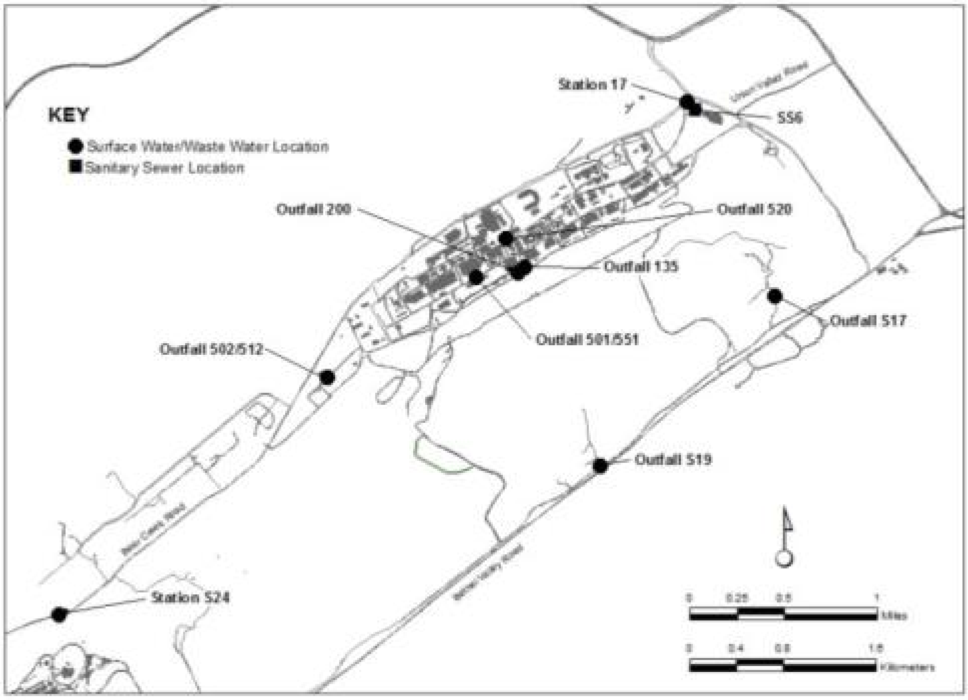

Fig. 4.19. Surface water and sanitary sewer radiological sampling locations at the Y-12 National Security Complex.

Table 4.14. Summary of Y-12 National Security Complex radiological monitoring plan sample requirements and 2015 results

Location	Sample frequency	Sample type	Sum of DCS percentages
Y-12 Complex wastewater treatment facilities			
Central Pollution Control Facility	1/batch	Composite during batch operation	No flow
West End Treatment Facility	1/batch	24 h composite	64
Groundwater Treatment Facility	4/year	24 h composite	5.8
Steam condensate	1/year	Grab	No Flow
Central Mercury Treatment Facility	4/year	24 h composite	2.0
Other Y-12 Complex point and area source discharges			
Outfall 135	4/year	24 h composite	3.1
Kerr Hollow Quarry	1/year	24 h composite	8.3
Rogers Quarry	1/year	24 h composite	0.19
Y-12 Complex instream locations			
Outfall S24	1/year	7-day composite	8.2
East Fork Poplar Creek, complex exit (east)	1/month	7-day composite	2.5
North/south pipes	1/month	24 h composite	6.7
Y-12 Complex Sanitary Sewer			
East End Sanitary Sewer Monitoring Station	1/year	7-day composite	44

Acronyms
DCS = derived concentration standard
Y-12 Complex = Y-12 National Security Complex

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In 2015, the total mass of uranium and associated curies released from the Y-12 Complex at the easternmost monitoring station, station 17 on upper EFPC, was 116 kg or 0.068 Ci (Table 4.15). Figure 4.20 illustrates a 5-year trend of these releases. The total release is calculated by multiplying the average concentration (grams per liter) by the average flow (million gallons per day). Converting units and multiplying by 365 days per year yields the calculated discharge.

The Y-12 Complex 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 of Oak Ridge, although there are no city-established radiological limits. Alpha and beta levels are measured weekly, and subsequent uranium analyses are performed if the alpha or beta levels are above prescribed levels. Potential sources of radionuclides discharging to the sanitary sewer have been identified in previous studies at the Y-12 Complex as part of an initiative to meet ALARA goals. Results of radiological monitoring were reported to the City of Oak Ridge in 2015 quarterly monitoring reports.

Table 4.15. Release of uranium from the Y-12 National Security Complex to the off-site environment as a liquid effluent, 2011–2015

Year	Quantity released	
	Ci[a]	Kg
	Station 17	
2011	0.104	124
2012	0.039	121
2013	0.055	140
2014	0.061	90
2015	0.068	116

[a]1 Ci = 3.7E+10 Bq.

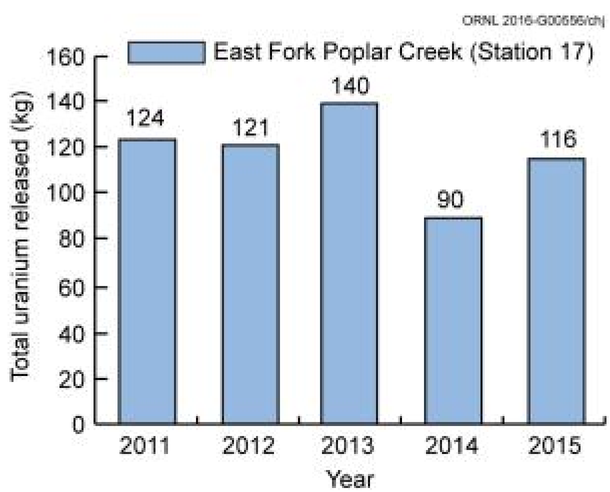

Fig. 4.20. Five-year trend of Y-12 National Security Complex releases of uranium to East Fork Poplar Creek.

4.5.4 Storm Water Pollution Prevention

The SWPPP at the Y-12 Complex is designed to minimize the discharge of pollutants in storm water runoff. The plan identifies areas that can reasonably be expected to contribute contaminants to surface water bodies via storm water runoff and describes the development and implementation of storm water management controls to reduce or eliminate the discharge of such pollutants. This plan requires (1) characterization of storm water by sampling during storm events, (2) implementation of measures to reduce storm water pollution, (3) facility inspections, and (4) employee training.

The Y-12 SWPPP underwent a significant rewrite in September 2012. This was due to issuance of a modified NPDES permit in November 2011. Significant changes included the elimination of two instream monitoring locations (C05 and C08) and the removal of the requirement to perform instream base-load sediment sampling. Other requirements remained essentially the same, with the exception of the lowering of a few benchmark values for certain sector outfalls. The NPDES permit defines the primary function of the Y-12 Complex to be a fabricated metal products industry. However, it also requires that storm water monitoring be conducted for three additional sectors: scrap/waste recycling activities; landfill and land application activities; and discharges associated with treatment, storage, and disposal facilities as they are defined in the Tennessee Storm Water Multi Sector General Permit for Industrial Activities (TNR050000). Each sector has prescribed benchmark values and some have defined sector mean values. The "rationale" portion of the NPDES permit for the Y-12 Complex states "These benchmark values were developed by the EPA and the State of Tennessee and are based on data submitted by similar industries for the development of the multi-sector general storm water permit. The benchmark concentrations are target values and should not be construed to represent permit limits."

Storm water sampling was conducted in 2015 during rain events that occurred on March 19 and June 8. Results were published in the annual storm water report (CNS 2015b), which was submitted to the TDEC Division of Water Pollution Control in December 2015. Consistent with permit requirements, storm water monitoring is performed each year for sector outfalls, three major outfalls that drain large areas of the Y-12 Complex, and two instream monitoring locations on EFPC (Fig. 4.21). The permit no longer calls for sampling of stream base load sediment that is being transported as a result of the heavy flow.

A significant change from 2013 to 2014 was the elimination of flow augmentation in EFPC. This discharge of raw water into EFPC was discontinued on April 30, 2014; thus, raw water is no longer required to be sampled. This has reduced the flow in EFPC by about 3.3 million gal per day, a significant amount (about 60%).

In general, the quality of storm water exiting the Y-12 Complex via EFPC remained relatively stable from 2014 to 2015. The one area of concern is the concentration of mercury being measured in the discharge from outfall 014. Since the first unexpected elevated result in 2013 (7.12 μg/L) this sector outfall has been on an annual monitoring schedule. The result in 2014 (0.892 μg/L) showed some improvement. However, in 2015, the result was 9.11 μg/L which is the highest measurement to date. This has garnered the attention of TDEC Division of Water Resources personnel. This has resulted in some discussion of including discharges from this outfall to be routed to the planned mercury treatment system which is to be located nearby. A final decision on this issue is still pending.

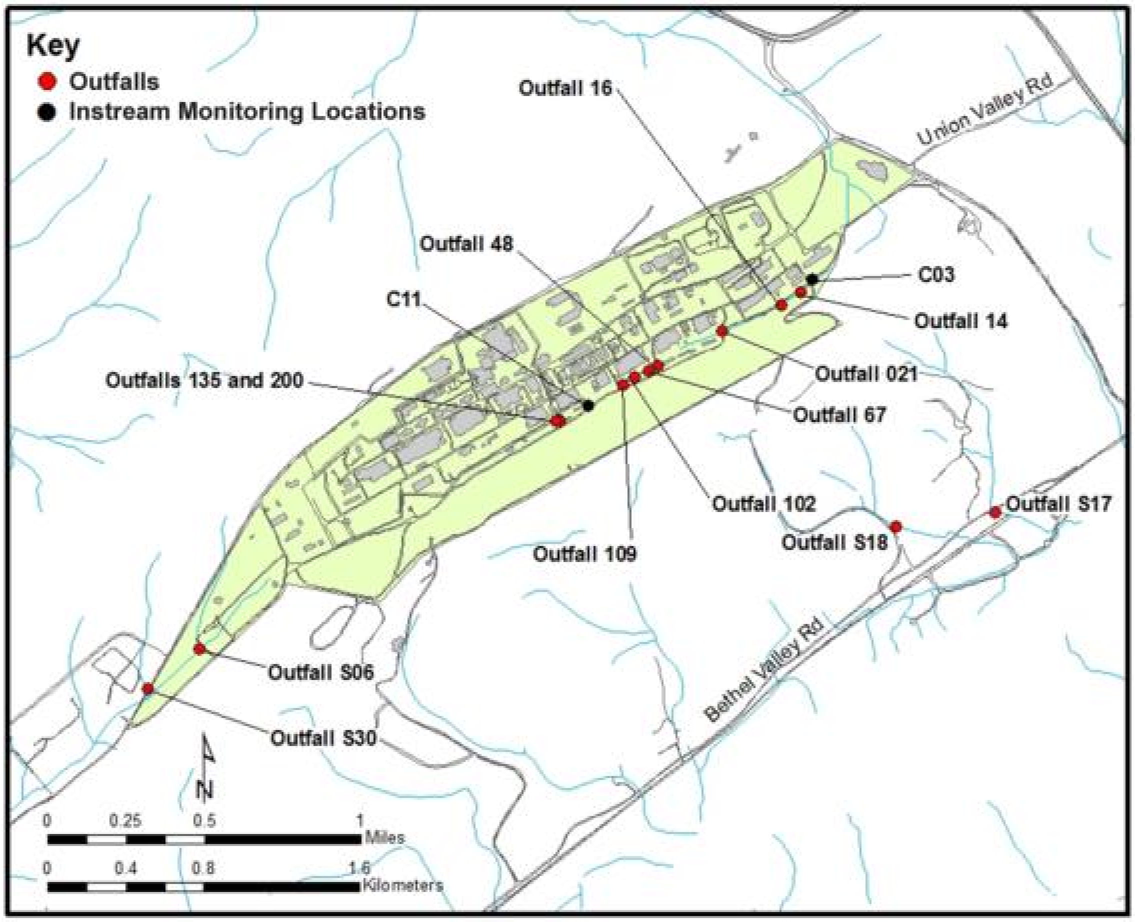

Fig. 4.21. Y-12 National Security Complex storm water monitoring locations.

4.5.5 Y-12 Complex Ambient Surface Water Quality

To monitor key indicators of water quality, a network of real-time monitors located at three instream locations along upper EFPC is used. The Surface Water Hydrological Information Support System (SWHISS) is available for real-time water quality measurements such as pH, temperature, dissolved oxygen, conductivity, and chlorine. The locations are shown in Fig. 4.22. The primary function of SWHISS is to provide an indication of potential adverse conditions that could be causing an impact on the quality of water in upper EFPC. It is operated as a best management practice.

Additional sampling of springs and tributaries is conducted in accordance with the Y-12 Groundwater Protection Program (GWPP) to monitor trends throughout the three hydrogeologic regimes (see Section 4.6).

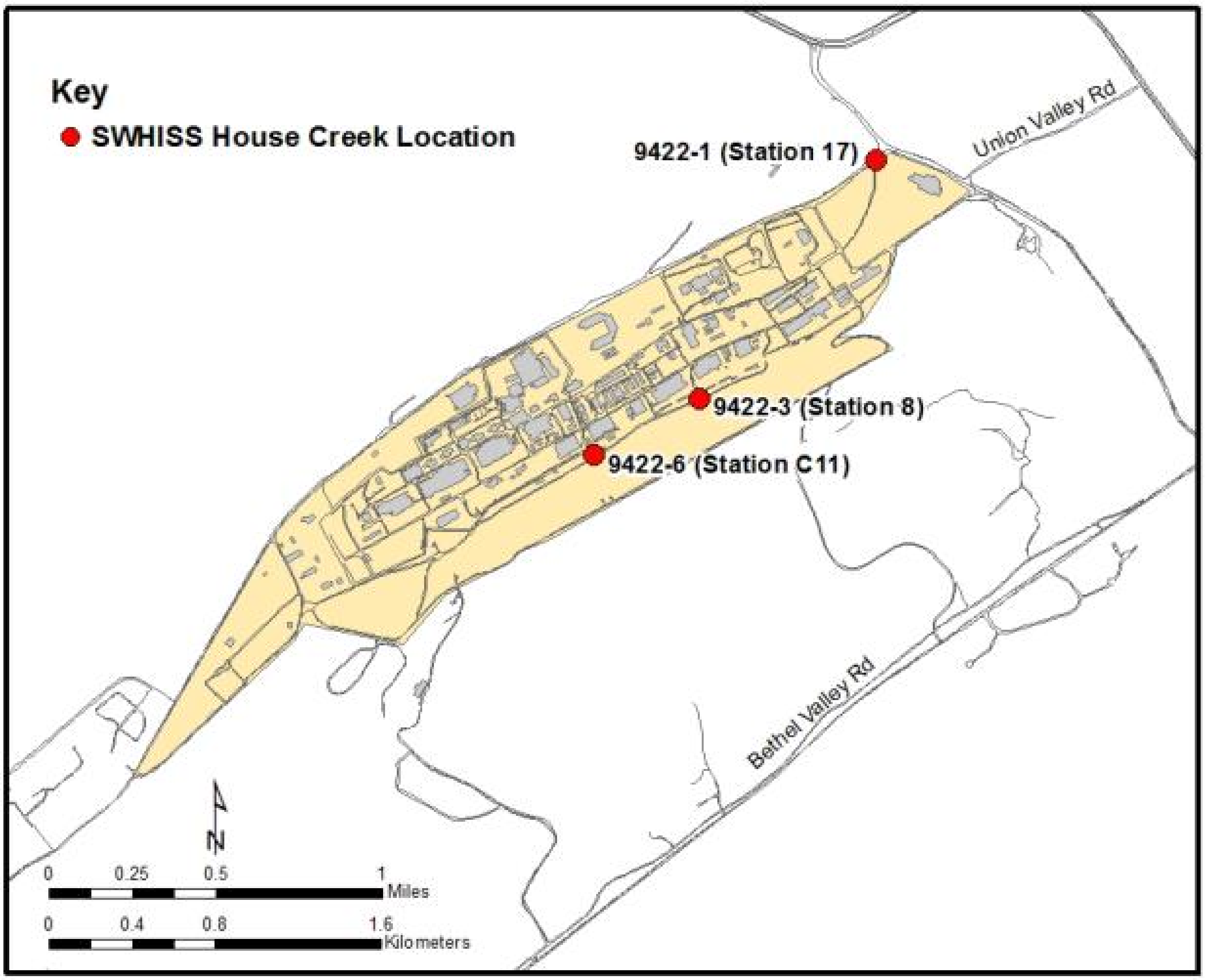

Fig. 4.22. Surface Water Hydrological Information Support System (SWHISS) monitoring locations.

4.5.6 Industrial Wastewater Discharge Permit

The Industrial and Commercial User Wastewater Discharge Permit 1-91 defines requirements for the discharge of 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, gross beta and uranium are taken in a weekly 24 hour composite sample. The sample is analyzed for uranium if the alpha and beta values exceed certain levels. Other parameters (including metals, oil and grease, solids, and biological oxygen demand) are monitored on a monthly basis. 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 also use the east end monitoring station (also known as SS6, see Fig. 4.20) to conduct compliance monitoring as required by the pretreatment regulations. City personnel also conduct twice yearly compliance inspections. Monitoring results during 2015 (Table 4.16) indicate two exceedances of the permit. These were for two exceedances of the daily flow limit which occurred on November 30 and December 1, 2015.

Table 4.16. Y-12 National Security Complex discharge point SS6, Sanitary Sewer Station 6, January through December 2015
(all units are mg/L unless noted otherwise)

Effluent parameter	Number of samples	Average value	Daily maximum (effluent limit)[a]	Monthly average (effluent limit)[a]	Number of limit exceedances
Flow (gal/day)	365	383,000	1,400,000	1,400,000	2
pH (standard units)	13	7.5	9/6[b]	9/6[b]	0
Biochemical oxygen demand	13	<74	300	200	0
Kjeldahl nitrogen	13	18.8	90	45	0
Phenols—total recoverable	13	<0.025	0.3	0.15	0
Oil and grease	13	<8.1	50	25	0
Suspended solids	34	77	300	200	0
Cyanide	13	<0.006	0.062	0.041	0
Arsenic	18	<0.01	0.025	0.010	0
Cadmium	18	<0.0009	0.005	0.0033	0
Chromium	18	<0.004	0.075	0.05	0
Copper	18	0.0365	0.21	0.14	0
Iron	18	0.682	30	10	0
Lead	18	<0.007	0.074	0.049	0
Mercury	33	0.0022	0.035	0.023	0
Nickel	18	<0.007	0.032	0.021	0
Silver	18	<0.01	0.10	0.05	0
Zinc	18	0.155	0.75	0.35	0
Molybdenum	18	0.067	0.05[c]	0.05[c]	Not Applicable
Selenium	18	<0.02	0.01[c]	0.01[c]	Not Applicable
Toluene	4	0.005U	0.005[c]	0.005[c]	Not Applicable
Benzene	4	0.005U	0.005[c]	0.005[c]	Not Applicable
1,1,1-trichloroethane	4	0.005U	0.005[c]	0.005[c]	Not Applicable
Ethylbenzene	4	0.005U	0.005[c]	0.005[c]	Not Applicable
Carbon tetrachloride	4	0.005U	0.005[c]	0.005[c]	Not Applicable
Chloroform	4	0.004JU	0.005[c]	0.005[c]	Not Applicable
Tetrachloroethylene	4	0.003JU	0.005[c]	0.005[c]	Not Applicable
Trichloroethene	4	0.005U	0.005[c]	0.005[c]	Not Applicable
Trans-1,2-dichloroethylene	4	0.005U	0.005[c]	0.005[c]	Not Applicable
Methylene chloride	4	0.005U	0.005[c]	0.005[c]	Not Applicable

[a]Industrial and commercial users wastewater permit limits.
[b]Maximum value/minimum value.
[c]There is not a permit limit for this parameter. This value is the required detection limit.

4.5.7 Quality Assurance/Quality Control

The Environmental Monitoring Management Information System (EMMIS) is used to manage surface water monitoring data. EMMIS 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:

- use of standard operating procedures for sample collection and analysis;
- use of chain-of-custody and sample identification, customized chain-of-custody documents, and sample labels provided by EMMIS;
- instrument standardization, calibration, and verification;
- sample technician training;
- sample preservation, handling, and decontamination; and
- use of 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 (LIMS) on the day of approval. EMMIS routinely accesses LIMS electronically to capture pertinent data. Generally, the system will store the data in the form of concentrations.

A number of electronic data management tools enable automatic flagging of data points and allow for monitoring and trending data over time. Field information on all routine samples taken for surface water monitoring is entered in EMMIS, which also retrieves data nightly from the analytical laboratory. The system then performs numerous checks on the data, including comparisons of the individual results against any applicable screening criteria, regulatory thresholds, compliance limits, best management standards, or other water quality indicators, and produces required reports.

4.5.8 Biomonitoring Program

In accordance with the requirements of the NPDES permit effective December 1, 2011, Part III-E, p. 31, two outfalls that discharge to the headwaters of EFPC (outfalls 200 and 135) were evaluated for toxicity during 2015 using fathead minnow (*Pimephales promelas*) larvae and water fleas (*Ceriodaphnia dubia)*. A third discharge, outfall 125, no longer has sufficient base flows for toxicity to be evaluated. Table 4.17 summarizes the results of the 2015 outfall biomonitoring tests in terms of the IC_{25}, the concentration of each outfall effluent that causes a 25% reduction in *C. dubia* survival or reproduction or fathead minnow survival or growth. The lower the value of the IC_{25}, the more toxic the effluent.

Table 4.17. Y-12 National Security Complex Biomonitoring Program summary information for outfalls 200 and 135 in 2015[a]

Site	Test start date	Species	IC_{25}[b] (%)
Outfall 200	7/08/15	*Ceriodaphnia dubia*	>100
Outfall 200	7/08/15	*Pimephales promelas*	>100
Outfall 135	7/09/15	*Ceriodaphnia dubia*	>36
Outfall 135	7/09/15	*Pimephales promelas*	>36

[a]Inhibition concentration (IC_{25}) is summarized for the discharge monitoring locations, outfalls 200 and 135.
[b]IC_{25} as a percentage of full-strength effluent from outfalls 200 and 135 diluted with laboratory control water. IC_{25} is the concentration that causes a 25% reduction in *C. dubia* survival or reproduction or fathead minnow survival or growth; 36% is the highest concentration of outfall 135 tested.

Acronyms
Y-12 Complex = Y-12 National Security Complex

Effluent from outfall 135 did not reduce fathead minnow survival or growth or *C. dubia* survival or reproduction by 25% or more at any of the tested concentrations. For both species, the IC_{25} for survival, growth, or reproduction was therefore >36% (the highest concentration of effluent tested). Toxicity is demonstrated according to the NPDES permit if the IC_{25} is less than or equal to the permit limit (9% whole effluent for outfall 135).

Effluent from outfall 200 also did not reduce fathead minnow survival or growth or *C. dubia* survival or reproduction by 25% or more at any of the tested concentrations. Therefore, the fathead minnow IC_{25} for survival, growth, or reproduction was >100% (the highest concentration of this effluent that was tested). Toxicity is demonstrated according to the NPDES permit if the IC_{25} is less than or equal to the permit limit (37% whole effluent for outfall 200).

4.5.9 Biological Monitoring and Abatement Programs

The NPDES permit issued for the Y-12 Complex mandates a BMAP with the objective of demonstrating that the effluent limitations established for the facility protect the classified uses of the receiving stream, EFPC. The 2015 BMAP sampling reported here follows the NPDES-required Y-12 BMAP plan (Peterson et al. 2013). BMAP, which has been monitoring the ecological health of EFPC since 1985, currently consists of three major tasks that reflect complementary approaches to evaluating the effects of the Y-12 Complex discharges on the aquatic integrity of EFPC. These tasks include (1) bioaccumulation monitoring, (2) benthic macroinvertebrate community monitoring, and (3) fish community monitoring. Data collected on contaminant bioaccumulation and the composition and abundance of communities of aquatic organisms provide a direct evaluation of the effectiveness of abatement and remedial measures in improving ecological conditions in the stream.

Monitoring is currently being conducted at five primary EFPC sites although sites may be excluded or added depending on the specific objectives of the various tasks. The primary sampling sites include upper EFPC at EFPC kilometers (EFKs) 24.4 and 23.4 (upstream and downstream of Lake Reality, respectively); EFK 18.7 (also EFK 18.2), located off ORR and below an area of intensive commercial and light industrial development; EFK 13.8 and EFK 13.0, located upstream and downstream of the Oak Ridge Wastewater Treatment Facility; and EFK 6.3, located about 1.4 km downstream of the ORR boundary (Fig. 4.23). Brushy Fork at Brushy Fork kilometer 7.6 is used as a reference stream in two BMAP tasks. Additional sites off

ORR are also occasionally used for reference, including Beaver Creek, Bull Run, Cox Creek, Hinds Creek, Paint Rock Creek, and Emory River in the Watts Bar Reservoir (Fig. 4.24).

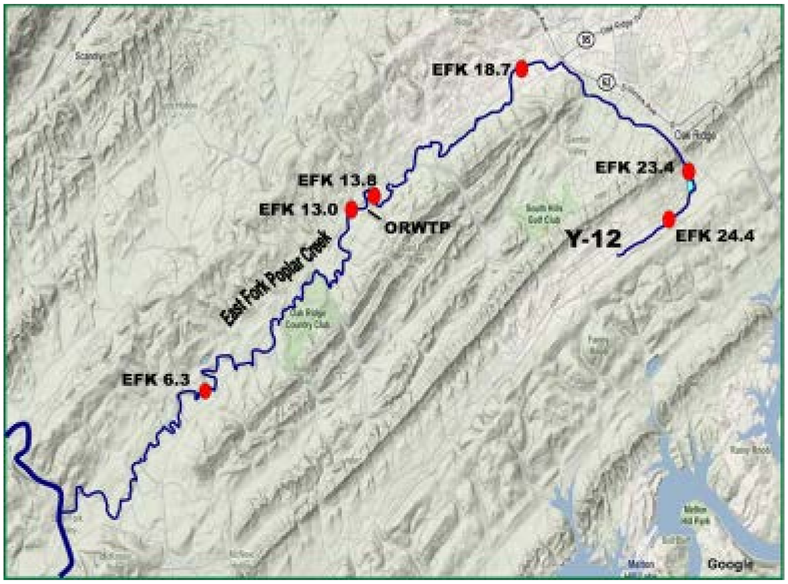

Fig. 4.23. Locations of biological monitoring sites on East Fork Poplar Creek in relation to the Y-12 National Security Complex. *(EFK = East Fork Poplar Creek kilometer and ORWTP = Oak Ridge Water Treatment Plant.)*

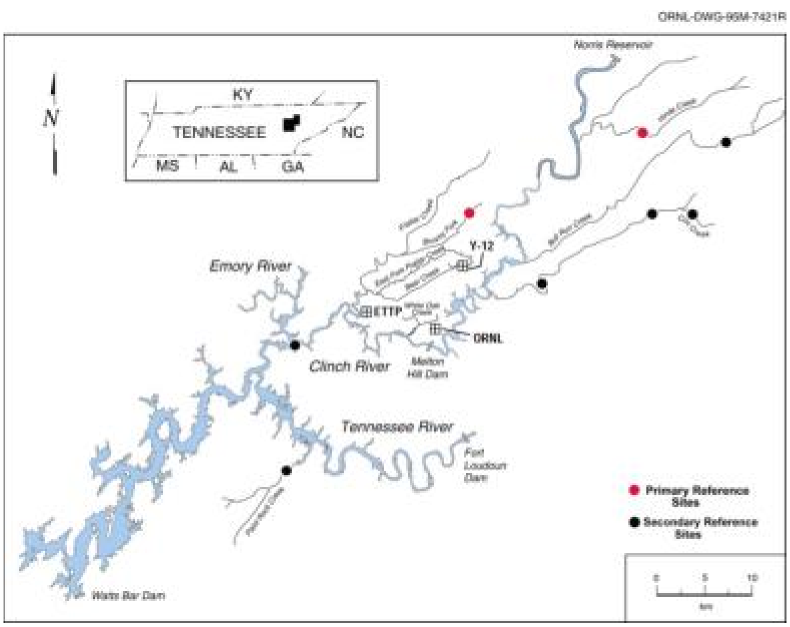

Fig. 4.24. Locations of biological monitoring reference sites in relation to the Y-12 National Security Complex. *(ETTP = East Tennessee Technology Park, ORNL = Oak Ridge National Laboratory, and Y-12 = Y-12 National Security Complex.)*

Significant increases in the number of invertebrate and fish species in EFPC over the last two decades demonstrate that the overall ecological health of the stream continues to improve. However, the pace of improvement in upper EFPC near the Y-12 Complex has slowed in recent years, and fish and invertebrate communities continue to have fewer species than the corresponding communities in reference streams. The impacts on stream ecology of recent remedial and abatement actions to address mercury releases at Y-12, including a major storm drain cleanout in WEMA (2011) and flow augmentation cessation (April 30, 2014), are still uncertain and, along with additional anticipated changes in stream conditions in upper EFPC with a planned mercury treatment facility in the EFPC headwaters, will be continue to be a focus of future monitoring and investigation.

4.5.9.1 Bioaccumulation Studies

Historically mercury and PCB levels 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 Complex operations.

As part of this monitoring effort, redbreast sunfish (*Lepomis auritus*) and rock bass (*Ambloplites rupestris*) are collected twice a year from five sites throughout the length of EFPC and are analyzed for tissue concentrations of mercury (twice yearly) and PCBs (annually) (Fig. 4.25). A new sampling site was added in 2013 at EFK 13.0, just downstream of the Oak Ridge STP. Mercury concentrations remained higher in fish from EFPC in 2015 than in fish from reference streams. Elevated mercury concentrations in fish from the upper reach of EFPC indicate that the Y-12 Complex remains a continuing source of mercury to fish in the stream.

Figure 4.25 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 RAs, first over the 1990s time period and then again in response to the Big Springs Treatment System in 2006. Although mercury concentrations in fish over time have not decreased commensurate with mercury levels in water in the lower sections of EFPC, mercury concentrations in fish at the uppermost sampling site (EFK 24.4) decreased steadily in the 1990s, consistent with decreased concentrations in water (Fig. 4.26). Significant fluctuations in aqueous mercury concentrations (thought to be the result of storm drain relining and cleanout) have been seen at EFK 23.4 since 2009. Redbreast collected from the EFK 24.4 sampling site, about 1 km upstream of Station 17, appears to have responded to the recent peak and decline in aqueous mercury concentrations. Mean concentrations at EFK 24.4 increased from ~0.6 μg/g in 2011 to above 1 μg/g in 2012 and dropped back down in 2013–2015 (~0.6 μg/g). These concentrations are above the EPA AWQC for mercury (0.3 μg/g mercury as methylmercury in fish fillet). That this species appears to have responded to changes in water mercury concentrations in the upper reaches of the creek is interesting, given it has not responded to decreases in aqueous total mercury concentrations at downstream sites throughout EFPC in the past 20 years. 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 ongoing investigations are being conducted to better understand mercury bioaccumulation dynamics in this creek and to better predict how remedial changes may impact mercury concentrations in fish in the future.

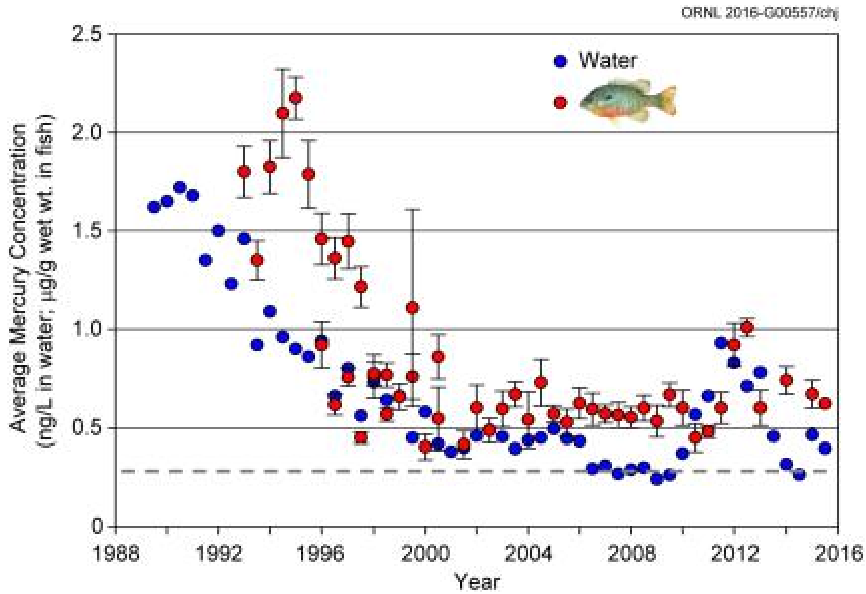

Fig. 4.25. Semiannual average mercury concentration in water from and muscle fillets of redbreast sunfish in East Fork Poplar Creek (EFPC) at EFPC kilometers 23.4 (water) and 24.4 (fish), FY 2015. *Dashed grey line represents the ambient water quality criterion for methylmercury in fish fillets (0.3 mg/kg).*

The mean total PCB concentration in sunfish fillets at EFK 23.4 was 0.56 µg/g in FY 2015, which was significantly lower than the concentration in FY 2014 (0.87 µg/g) (Fig. 4.26). Regulatory guidance and human health risk levels have varied 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 targets for PCB-focused Total Maximum Daily Loads (TMDLs), including for local reservoirs (Melton Hill, Watts Bar, and Fort Loudon; TDEC 2010a, b, c). 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, and then 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. The remediation goal for fish fillets at the ETTP K-1007-P1 pond on ORR is 1 µg/g PCBs. Most recently, the water quality criterion has been used to calculate the fish tissue concentration triggering impairment and a TMDL (TDEC 2007); this concentration is 0.02 mg/kg PCBs in fish fillets (TDEC 2010a, b, and c). The mean fish PCB concentration in upper EFPC, 0.56 µg/g in fish fillets, is well above this concentration.

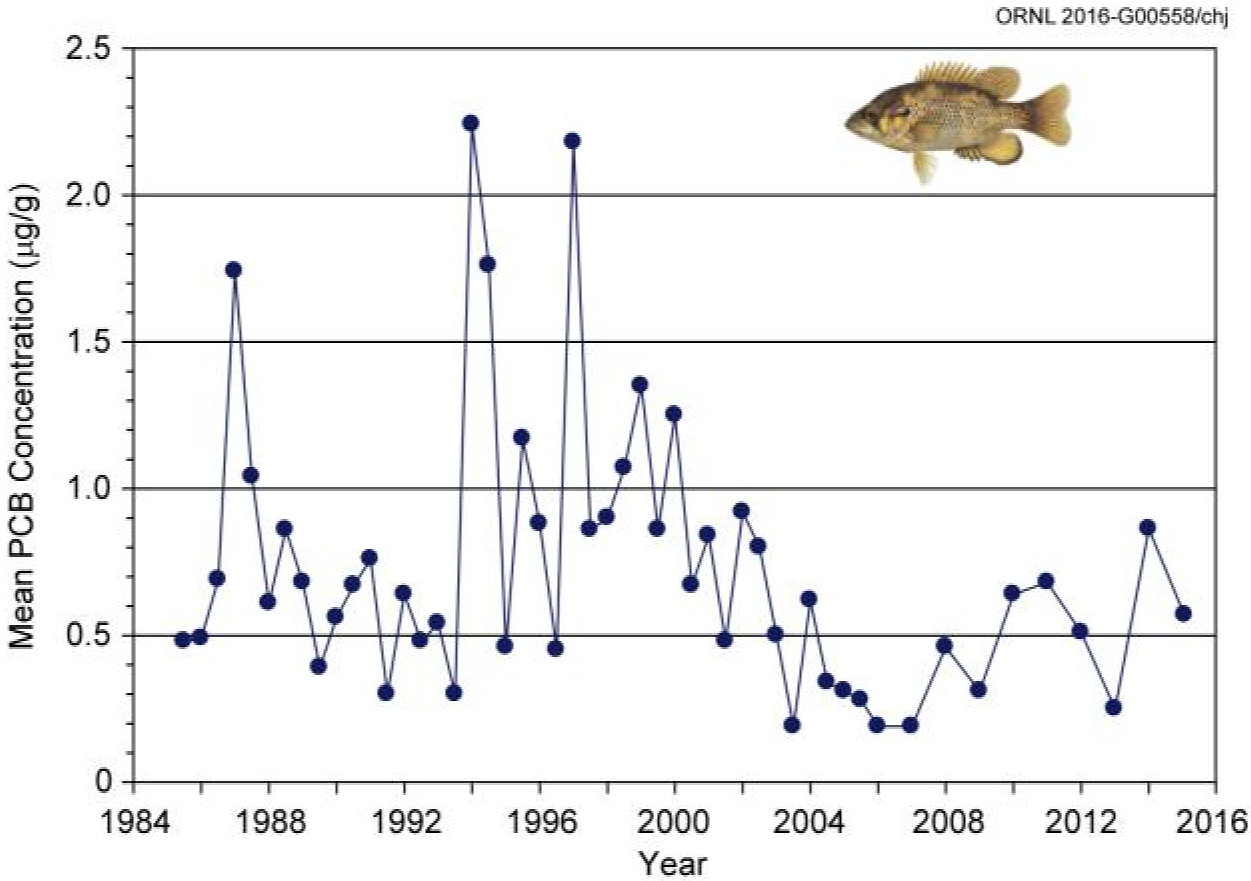

Fig. 4.26. Annual mean concentrations of polychlorinated biphenyls (PCBs) in rock bass muscle fillets at East Fork Poplar Creek kilometer 23.4., FY 2015.

4.5.9.2 Benthic Invertebrate Surveys

Monitoring of the benthic macroinvertebrate community continued at three sites in EFPC and two reference streams in the spring of 2015. The number of pollution-intolerant taxa at all three sites in EFPC and both reference sites was higher in 2014 than in 2015 (Fig. 4.27a), although densities of the pollution-intolerant taxa were higher at all sites in 2015, most notably at EFK 24.4 (Fig. 4.28b). This combination of results suggests that lower taxa richness but higher densities were widespread phenomena. Also of significance was that the mean densities of the pollution-intolerant taxa in 2015 exceeded the upper bound of the reference site confidence limits for the first time at EFK 23.4 and EFK 24.4 since monitoring began in 1985, which may indicate that cessation of flow management, may not be negatively affecting stream conditions for benthic macroinvertebrates in upper EFPC. Even with the notable increases in the densities of the pollution-intolerant taxa at EFK 23.4 and EFK 24.4, the number of pollution-intolerant taxa remain low relative to the reference sites, thus, indicating mild degraded conditions remain. The true effect of ending flow management on the invertebrate community will become more evident as more data become available.

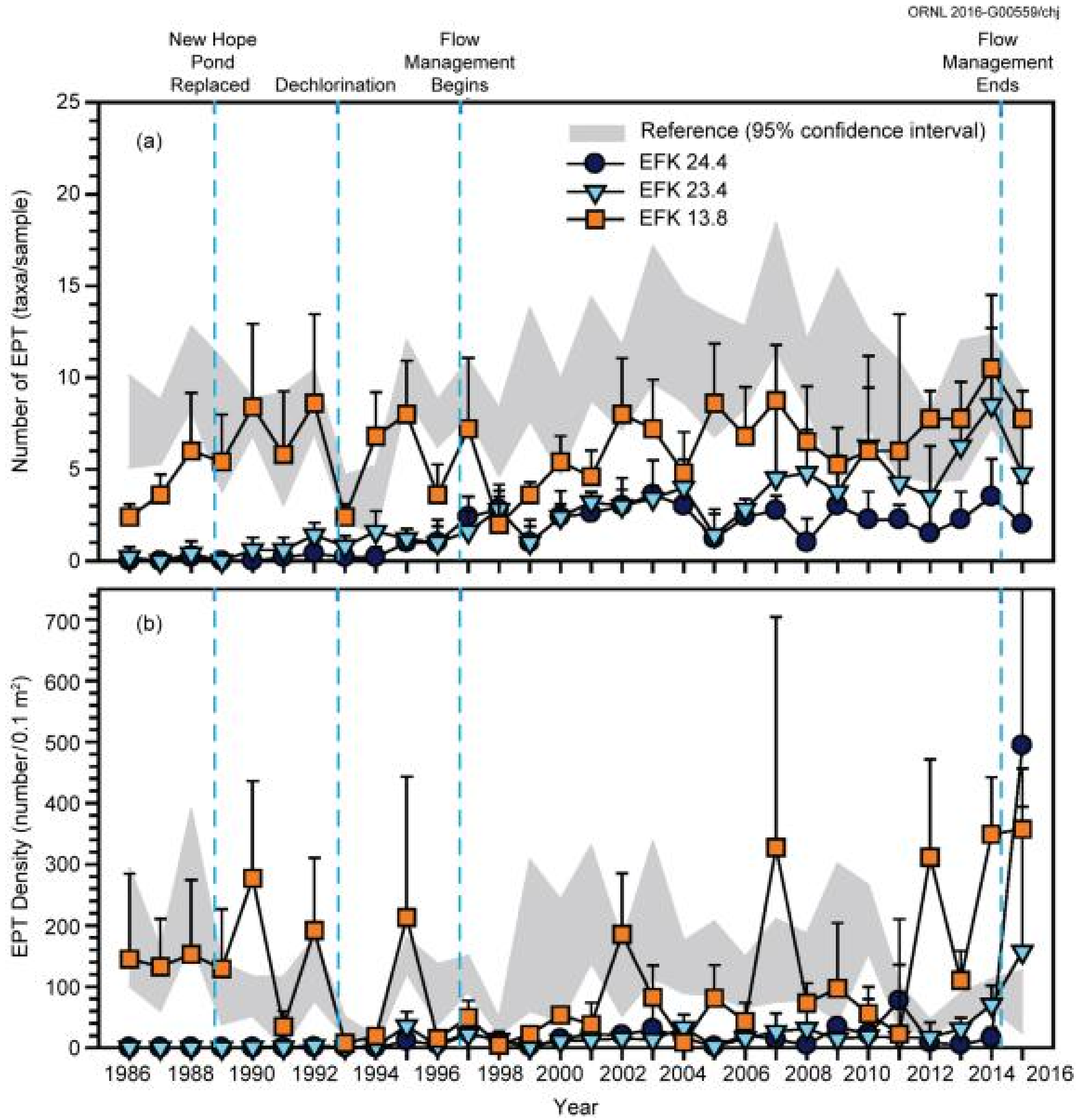

Fig. 4.27. (a) Taxonomic richness (mean number of taxa per sample) and (b) density (mean number of taxa per square meter) of the Ephemeroptera, Plecoptera, and Trichoptera (EPT) in the benthic macroinvertebrate communities sampled in the spring from East Fork Poplar Creek and two nearby reference streams (Brushy Fork and Hinds Creek), 1986–2015. *(EFK = East Fork Poplar Creek kilometer.)*

4.5.9.3 Fish Community Monitoring

Fish communities were monitored in the spring and fall of 2015 at five sites along EFPC and at a comparable reference stream (Brushy Fork). Over the past two decades, overall species richness, density, biomass, and number of pollution-sensitive fish species have improved at all sampling locations below Lake Reality. Some species of fish are considered sensitive and require very specific habitat conditions to survive and can only tolerate a narrow range of environmental disturbance. The mean number of sensitive species occurring at four sites in EFPC and a reference stream is shown in Fig. 4.28 and dramatically highlights the major improvements in the fish community in the middle to lower sections of the stream.

However, the EFPC fish community continues to lag behind the reference stream community in most important metrics of fish diversity and community structure. This is especially true at the monitoring sites closest to the Y-12 Complex where the sensitive species richness ranges from 0 to 33% of the reference value.

Fish communities appear to be stable in upper EFPC in 2015, even under reduced flows associated with the termination of flow augmentation from Melton Hill in April 2014. No fish kills were observed in 2015 in upper EFPC and in contrast fish densities were considerably higher at the uppermost sampling location (Fig. 4.29). Very high densities are not usually a positive indicator of fish health however, and continued monitoring will provide additional insight into these variabilities.

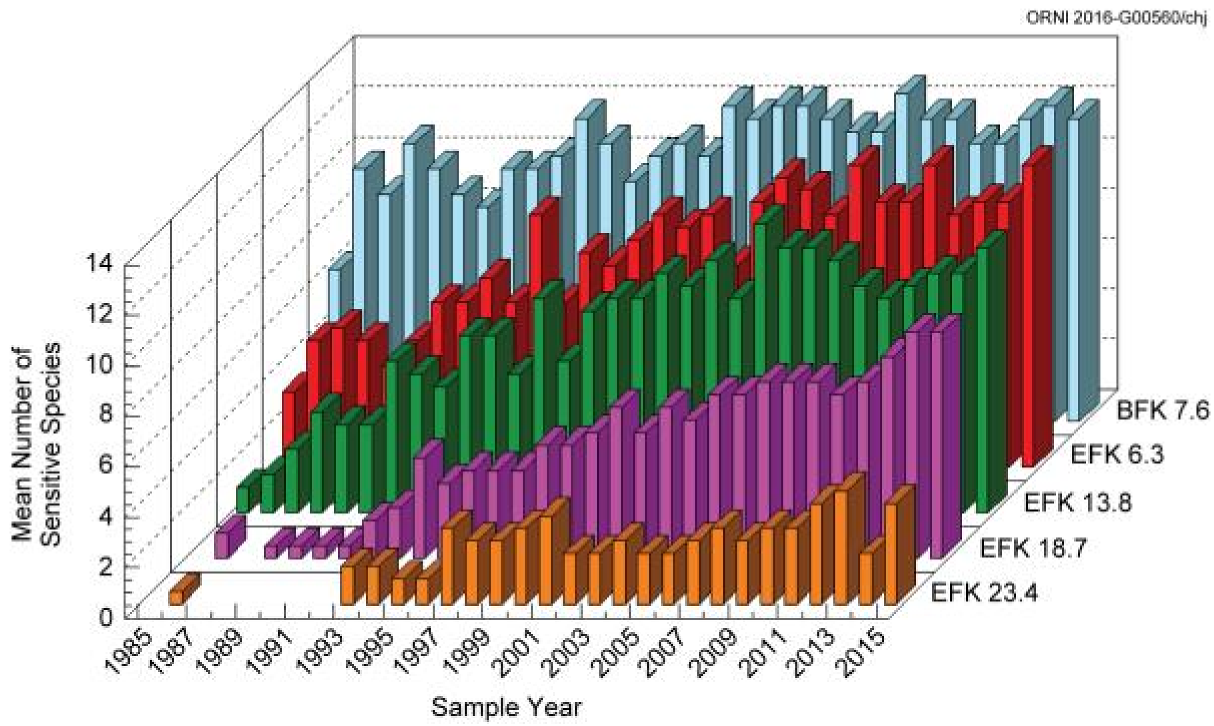

Fig. 4.28. Comparison of mean sensitive species richness (number of species) collected each year from 1985–2015 from four sites in East Fork Poplar Creek and a reference site (Brushy Fork). *(BFK = Brushy Fork kilometer and EFK = East Fork Poplar Creek kilometer.)*

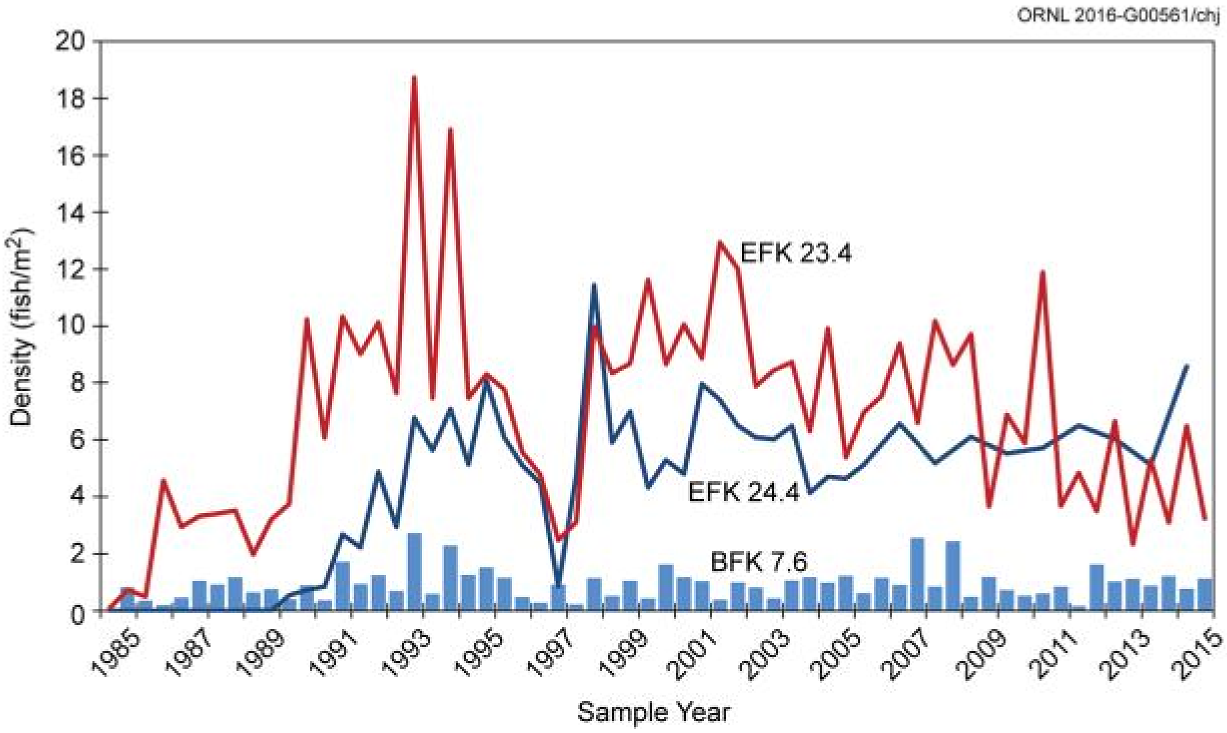

Fig. 4.29. Fish density (number of fish per square meter) for two sites in upper East Fork Poplar Creek and a reference site (Brushy Fork) from 1985–2015. *(BFK = Brushy Fork kilometer and EFK = East Fork Poplar Creek kilometer.)*

4.5.9.4 Upper Bear Creek Remediation

As part of the construction of the Uranium Processing Facility inside Y-12, Haul Road was expanded in 2013-2014 and several wetlands were negatively impacted. This resulted in the need for mitigations including the creation and expansion of wetlands in the Bear Creek watershed. All wetland mitigation sites were constructed during the Haul Road expansion except one which will be completed in the future. Wetland soils available after road construction, with their associated wetland plant seed banks, was used to support the establishment of hydric soils and wetland plant species in the mitigation areas. In all, 3.51 acres of wetlands will be constructed to compensate for the removal of 1 acre. The compensation ratios are intended to ensure that there is no net loss of resource value.

As part of haul road construction it was also necessary to culvert two sections of north tributary streams to Bear Creek. To mitigate the loss of natural streams a previously impacted section of Bear Creek was identified for restoration to more natural conditions. Approximately 300 feet of upper Bear Creek was remediated in 2014 by diverting the stream out of a channelized section and back into its original channel. This remediated section was lined extensively with erosion matting along both banks and various size river rocks were added to the channel to create pool/riffle complexes throughout the site. The natural meander of the channel was kept and only slight modifications were made. All disturbed soils were seeded and native plants were added to the site to stabilize sediments and reestablish the streams riparian zone post-construction.

Annual monitoring of these remediated wetland sites in 2015 revealed that, in general, the wetlands are responding as intended and have shown remarkable wetland plant coverage in the first year. The wetland soil bank was undoubtedly key to the restoration effort. There are some wetlands with extensive open water areas, and there are some areas with somewhat less wet conditions. However, this is not unusual at this stage of wetland restoration projects. It will be important to carefully monitor hydrologic conditions and wetland plant growth with time, and understand responses to annual precipitation patterns. Keeping invasive plants in check is also important, as these species can be aggressive shortly after soil disturbance.

Similarly, there have been positive developments associated with the stream mitigation site, in that the stream channel has a more natural meander and habitat appears to be much improved. Follow-up engineering actions have been applied to address some earlier challenges associated with a leak in the weir separating the two channels. Additional plantings were also needed to supplement the riparian plantings which experienced some plant mortality. Future monitoring will help determine whether the restoration and follow up action have been successful.

4.6 Groundwater at the Y-12 Complex

Groundwater monitoring at the Y-12 Complex is performed to comply with federal, state, and local requirements and DOE Orders to determine the degree of environmental impact from legacy and current operations. More than 150 known or potential sources of environmental contamination have been identified at the Y-12 Complex, some from plant operations and some from former waste management practices (DOE 2014b). Monitoring provides information on the nature and extent of contamination of groundwater, which is then used to determine what actions must be taken to protect the worker, public, and environment. Figure 4.30 depicts the major facilities or areas for which groundwater monitoring was performed during CY 2015.

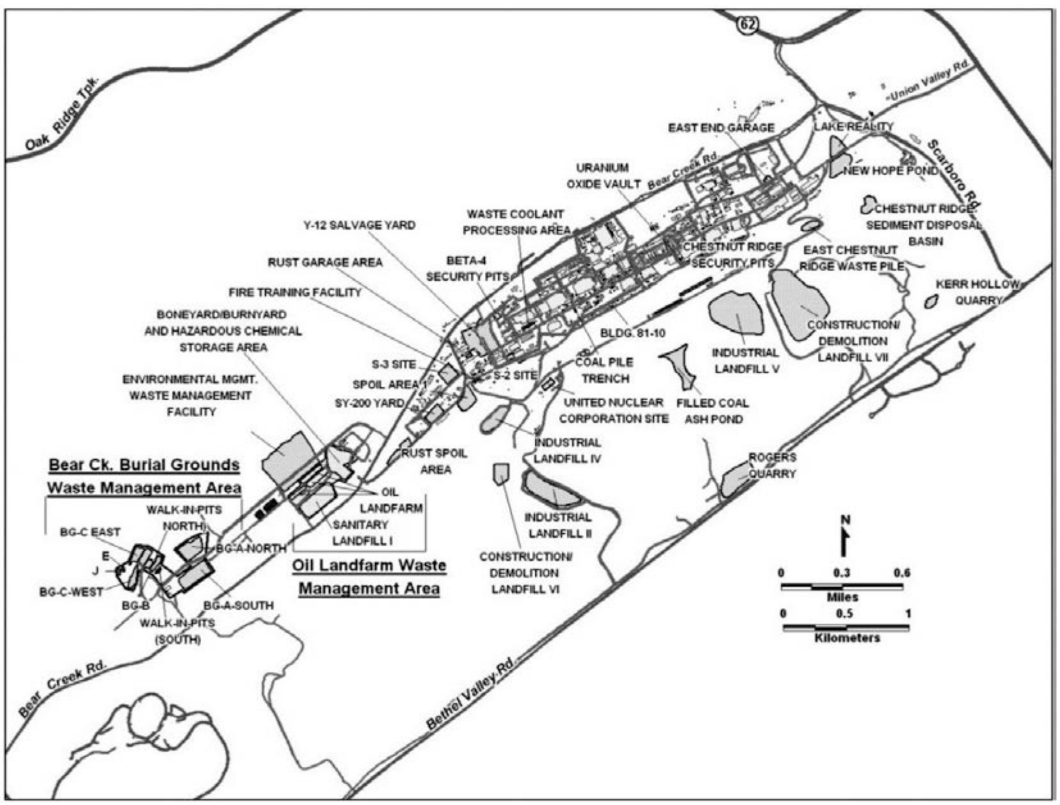

Fig. 4.30. Known or potential contaminant sources for which groundwater monitoring was performed at the Y-12 National Security Complex during CY 2015.

4.6.1 Hydrogeologic Setting

The Y-12 Complex is divided into three hydrogeologic regimes (Bear Creek, upper EFPC, and Chestnut Ridge), which are delineated by surface water drainage patterns, topography, and groundwater flow characteristics (Fig. 4.31). Most of the Bear Creek and upper EFPC regimes are underlain by the shales, siltstones, and sandstones with a subordinate and locally variable amount of carbonate bedrock mentioned in Section 1.3.5 and hydrostratigraphically referred to as aquitards. Aquitards are rock units that contain water but do not readily yield significant water to pumping wells. However, geologic units that are considered aquitards can often yield water in quantities sufficient for domestic or small farm use (Domenico and Schwartz 1990). The southern portion of the two regimes is underlain by the Maynardville Limestone, which is part of the Knox aquifer. The Chestnut Ridge regime is almost entirely underlain by the Knox aquifer. The southernmost portion near Bethel Valley Road consists of the lowest members of the Chickamauga Group. In general, groundwater flow in the water table interval follows the topography. Shallow groundwater flow in the Bear Creek and upper EFPC regimes is divergent from the topographic and groundwater divide located near the western end of the Y-12 Complex that defines the boundary between the two. In addition, flow converges on the primary surface streams (Bear Creek and upper EFPC) from Pine Ridge and Chestnut Ridge. In the Chestnut Ridge regime, a groundwater divide exists that nearly coincides with the crest of the ridge. Shallow groundwater flow tends to be toward either flank of the ridge, with discharge primarily to surface streams and springs located in Bethel Valley to the south and Bear Creek Valley to the north.

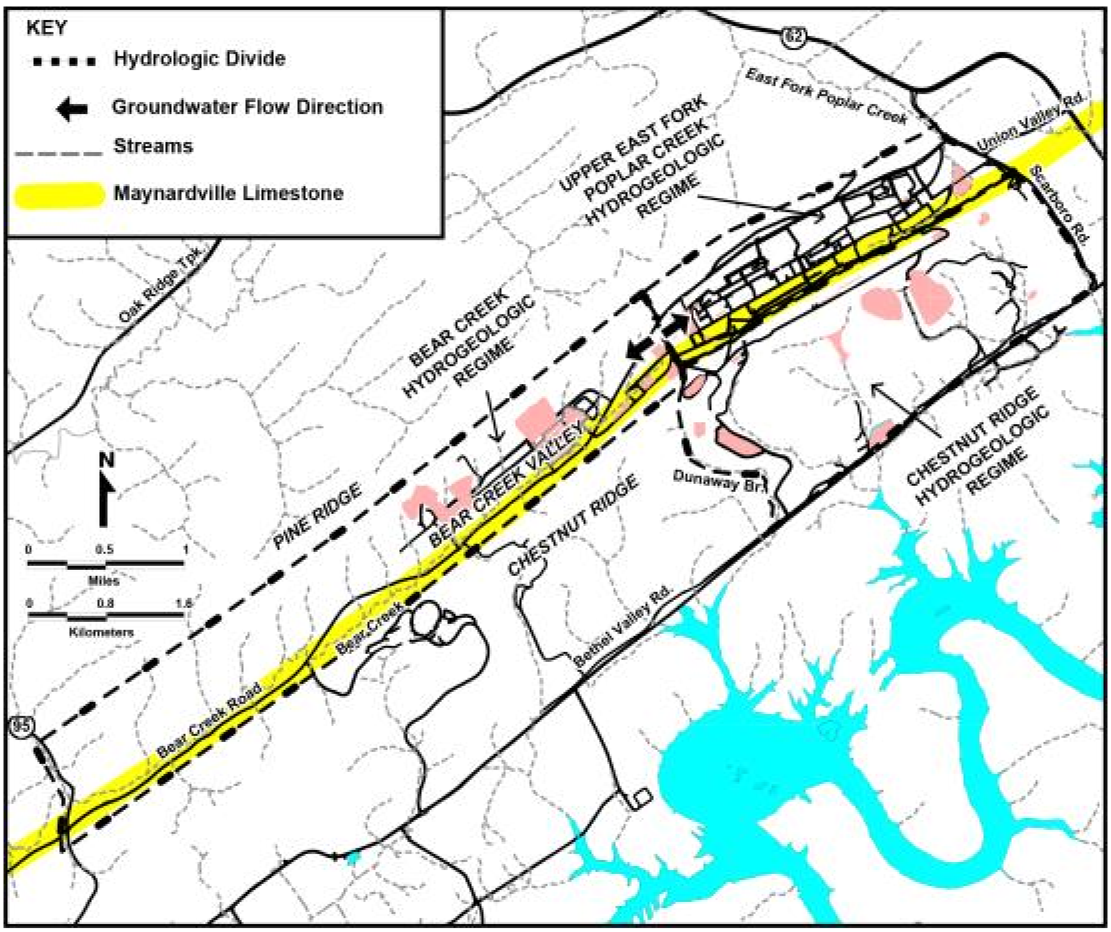

Fig. 4.31. Hydrogeologic regimes at the Y-12 National Security Complex and the position of the Maynardville Limestone in Bear Creek Valley.

In Bear Creek Valley, groundwater in the intermediate and deep intervals moves predominantly through fractures in the aquitard, converging on and then moving through fractures and solution conduits in the Maynardville Limestone (Fig. 4.32). Karst development in the Maynardville Limestone has a significant impact on groundwater flow paths in the water table and intermediate intervals. In general, groundwater flow parallels the valley and geologic strike. Groundwater flow rates in Bear Creek Valley vary widely; they are very slow within the deep interval of the fractured noncarbonate rock (less than 10 ft/year) but can be quite rapid within solution conduits in the Maynardville Limestone (tens to thousands of feet per day). The rate of groundwater flow perpendicular to geologic strike from the aquitard units of the lower Conasauga Group to the Maynardville Limestone is also very slow below the water table interval.

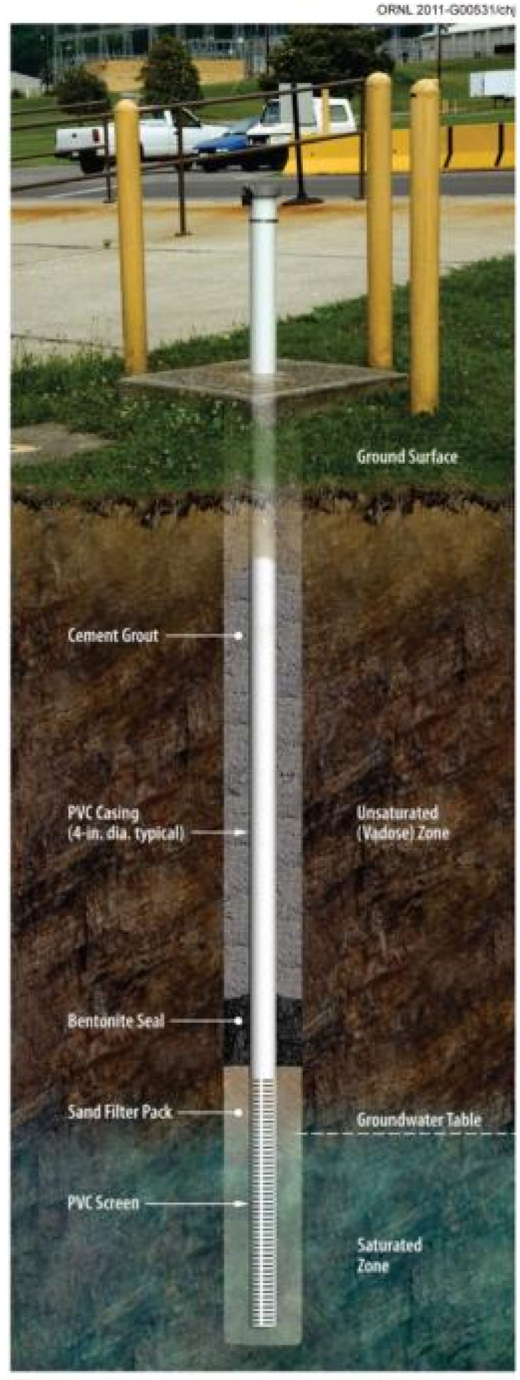

Fig. 4.32. Cross section of a typical groundwater monitoring well.

Contaminant migration is primarily advective (contaminants are transported along with flowing groundwater through the pore spaces, fractures, or conduits of the hydrogeologic system). Strike-parallel transport of some contaminants can occur within the aquitard units for significant distances, where they discharge to surface water tributaries or underground utility and storm water distribution systems in industrial areas. Continuous elevated levels of nitrate (a groundwater contaminant from legacy waste disposals) within the fractured bedrock of the aquitards are known to extend east and west from the S-2 and S-3 sites for thousands of feet. VOCs (e.g., petroleum products, coolants, and solvents) at source units over or in the fractured clastic dominated bedrock can remain close to source areas because they tend to adsorb to the bedrock matrix, diffuse into pore spaces within the matrix, and degrade before migrating to exit pathways where more rapid transport occurs for longer distances. However, extensive VOC contamination from multiple sources is observable throughout the groundwater system in both the Bear Creek and upper EFPC regimes.

Groundwater flow in the Chestnut Ridge regime is through fractures and solution conduits in the Knox Group. Discharge points for intermediate and deep flow are not well known. Groundwater is currently presumed to flow toward Bear Creek Valley to the north and Bethel Valley to the south. Groundwater from intermediate and deep zones may discharge at certain spring locations along the flanks of Chestnut Ridge. Following the crest of the ridge, water table elevations decrease from west to east, demonstrating an overall easterly trend in groundwater flow.

4.6.2 Well Installation and Plugging and Abandonment Activities

A number of monitoring devices have been used for groundwater data collection at the Y-12 Complex. Monitoring wells are permanent devices used for the collection of groundwater samples; they are installed according to established regulatory and industry standards. Figure 4.32 shows a cross section of a typical groundwater monitoring well. Other devices or techniques (e.g., drive points and direct push installations) are sometimes used to gather groundwater data.

In CY 2015, one well (FW-306) was installed as a background well at the DOE Oak Ridge Field Center and Enigma Site. This flush-mount well was installed to a depth of 19.9 ft. bgs. Ecosystems and Networks Integrated with Genes and Molecular Assemblies (ENIGMA), a Scientific Focus Area Program at Lawrence Berkeley National Laboratory, is supported by the Office of Science, Office of Biological and Environmental Research, of the U. S. Department of Energy.

Two surveillance monitoring wells were plugged and abandoned during the year. These wells, GW-777 and GW-778, were removed in support of UPF construction activities.

4.6.3 CY 2015 Groundwater Monitoring

Groundwater monitoring in CY 2015 was performed to comply with DOE orders and regulations as part of the Y-12 Groundwater Protection Program (GWPP), DOE EM programs such as the Water Resources Restoration Program (WRRP), and other projects. Compliance requirements were met by monitoring 210 wells and 52 surface water locations and springs (Table 4.18). Figure 4.33 shows the locations of Y-12 Complex perimeter/exit pathway groundwater monitoring stations.

Table 4.18. Summary groundwater monitoring at the Y-12 National Security Complex, 2015

	Purpose for which monitoring was performed				
	Restoration[a]	**Waste management**[b]	**Surveillance**[c]	**Other**[d]	**Total**
Number of active wells	63	33	114	71	281
Number of other monitoring stations (e.g., springs, seeps, surface water)	29	6	17	0	52
Number of samples taken[e]	195	78	135	216	624
Number of analyses performed	10,695	10,715	11,481	10,804	43,695
Percentage of analyses that are nondetects	69.2	91.5	81.6	50	73.2
Ranges of results for positive detections, VOCs (µg/L)[f]					
Chloroethenes	0.3-3,600	5.46-9.77	2–42,000	NA	
Chloroethanes	0.31-410	7.85-73.7	1-1,100	NA	
Chloromethanes	0.3-950	ND	2–3,600	NA	
Petroleum hydrocarbons	0.32-6,600	ND	1–690	NA	
Uranium (mg/L)	0.0042–0.48	ND	0.00053–0.716	0.01-1.1	
Nitrates (mg/L)	0.005–6,200	0.512–2.53	0.065–11,300	0.1-25.0	
Ranges of results for positive detections, radiological parameters (pCi/L)[g]					
Gross alpha activity	2.81-325	0.65–6.32	3.4–1,600	NA	
Gross beta activity	2.61–15,100	2.85–18.4	7.8–10,000	NA	

Table 4.18. (continued)

[a]Monitoring to comply with CERCLA requirements and with RCRA postclosure detection and corrective action monitoring.
[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 Enigma Project.
[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—include tetrachloroethene, trichloroethene, 1,2-dichloroethene (*cis* and *trans*) 1,1-dichloroethene, and vinyl chloride
- chloroethanes—include 1,1,1-trichloroethane, 1,2-dichloroethane, and 1,1-dichloroethane
- chloromethanes—include carbon tetrachloride, chloroform, and methylene chloride
- petroleum hydrocarbons—include benzene, toluene, ethylbenzene, and xylene

[g]1 pCi = 3.7×10^2 Bq.

Acronyms
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
NA = not analyzed
ND = not detected
RCRA = Resource Conservation and Recovery Act
VOC = volatile organic compound

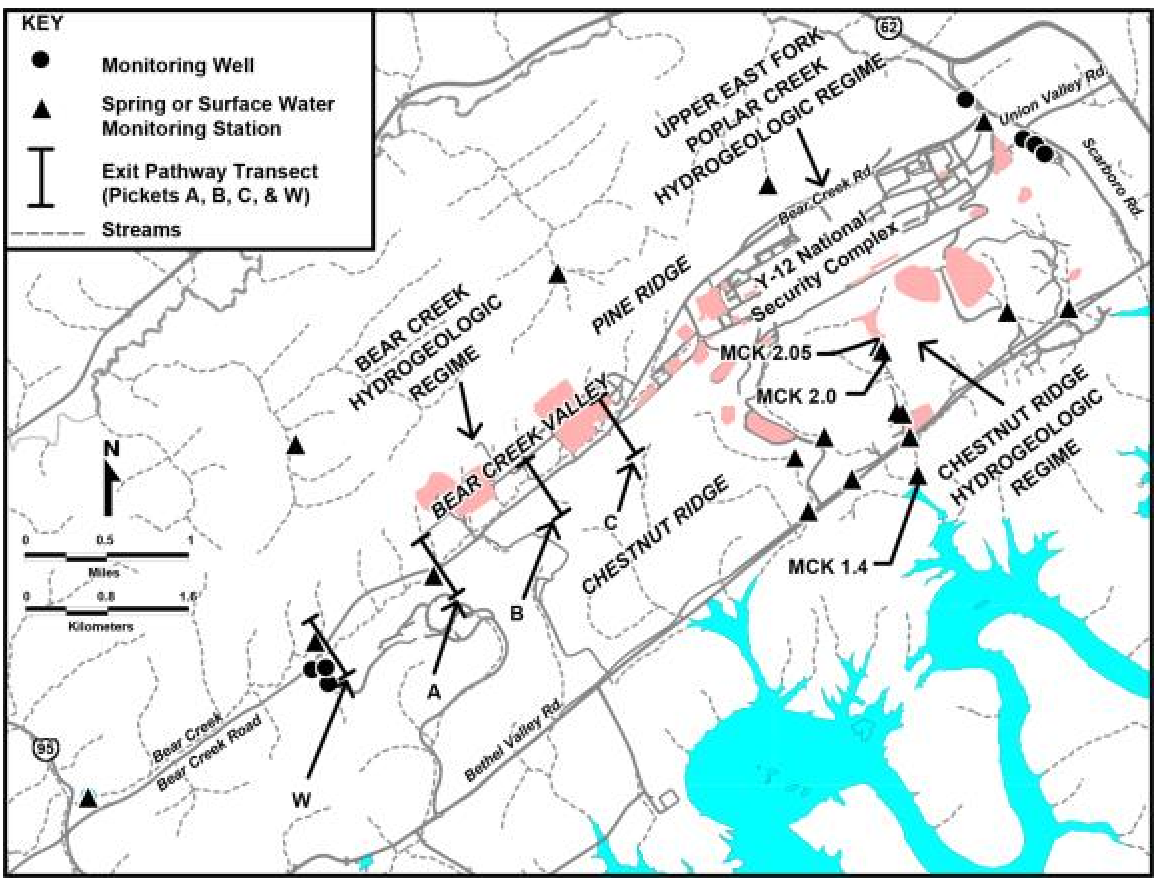

Fig. 4.33. Location of Y-12 National Security Complex perimeter/exit pathway well, spring, and surface water monitoring stations. *(MCK = McCoy Branch kilometer.)*

Most of the conventional monitoring wells at the Y-12 Complex were sampled using industry standard methods approved by TDEC and EPA (Fig. 4.34).

Fig. 4.34. Groundwater monitoring well sampling at the Y-12 National Security Complex. *[Source: Kathryn Fahey, Y-12 photographer.]*

Comprehensive water quality results of groundwater monitoring activities at the Y-12 Complex in CY 2015 are presented in the *Calendar Year 2015 Groundwater Monitoring Report* (CNS 2016).

Details of monitoring efforts performed specifically for CERCLA baseline and remediation evaluation are published in the FY 2015 and FY 2016 WRRP sampling and analysis plans (UCOR, 2014c, 2015) and the annual CERCLA remediation effectiveness reports (DOE 2016).

Groundwater monitoring compliance reporting to meet RCRA postclosure permit requirements can be found in the annual RCRA groundwater monitoring report (UCOR 2016).

4.6.4 Y-12 Complex Groundwater Quality

Historical monitoring efforts show that four primary contaminants impact groundwater quality at the Y-12 Complex: nitrate, VOCs, metals, and radionuclides. Of those, VOCs are the most widespread as a result of their common use and disposal at the site. Uranium and ^{99}Tc are the radionuclides of greatest concern. Trace metals (e.g., arsenic, barium, cadmium, chromium, mercury), the least extensive groundwater contaminants, generally occur close to source areas because of their generally high adsorption characteristics. Historical data show that plumes from multiple-source units have mixed with one another and that contaminants (other than nitrate and ^{99}Tc) are not always easily associated with a single source.

4.6.4.1 Upper East Fork Poplar Creek Hydrogeologic Regime

Among the three hydrogeologic regimes underlying the Y-12 Complex, the upper EFPC regime encompasses most of the known and potential sources of surface water and groundwater contamination. A brief description of waste management sites is given in Table 4.19. Chemical constituents from the S-3 site (primarily nitrate and ^{99}Tc) and VOCs from multiple source areas are observed in the groundwater in the western portion of the upper EFPC regime; groundwater in the eastern portion is predominantly contaminated with VOCs.

Table 4.19. Description of waste management units and underground storage tanks included in groundwater monitoring activities, upper East Fork Poplar Creek hydrogeologic regime, 2015

Site	Description
New Hope Pond	Built in 1963 and closed in 1988. Regulated flow of water in upper East Fork Poplar Creek before exiting the Y-12 Complex. Sediments include PCBs, mercury, and uranium. An oil skimmer basin was built as part of the pond when constructed. This basin collected oil and floating debris from upper East Fork Poplar Creek before discharge into the pond. A minor source of uranium in groundwater, the basin was closed under RCRA in 1990.
Salvage Yard Scrap Metal Storage Area	Used from 1950 to 1999 for scrap metal storage. Some metals contaminated with low levels of uranium. In 2011 a CERCLA action to characterize and remove the scrap was completed. Soil characterization and analysis performed in 2010 and 2011 determined that this facility is not a significant risk to groundwater.
Salvage Yard Oil/Solvent Drum Storage Area	Operated from 1976 to 1989. Primary wastes included waste oils, solvents, uranium, and beryllium. Closed under RCRA with all drums removed. Soil characterization and analysis performed in 2010 and 2011 determined that this facility is not a significant risk to groundwater.
Salvage Yard Oil Storage Tanks	Used from 1978 to 1986. Two tanks used to store PCB-contaminated oil, both within a diked area. Tanks were removed after 1993. Soil characterization and analysis performed in 2010 and 2011 determined that this facility is not a significant risk to groundwater.
Salvage Yard Drum Deheader	Used from 1959 to 1989. Sump tanks 2063-U, 2328-U, and 2329-U received residual drum contents. Tanks removed in 1989. Sump leakage was a likely release mechanism to groundwater. The facility was demolished and removed and the soils beneath this facility were excavated and replaced with clean fill and gravel to remediate the site in 2011.
Building 81-10 Area	Mercury recovery facility operated from 1957 to 1962. Historical releases to soil, groundwater and surface water from leaks and spills of liquid wastes or mercury. The building structure was demolished in 1995.
Rust Garage Area	Former vehicle and equipment maintenance area, including four former petroleum USTs. All tanks were removed by 1990. Petroleum product releases to groundwater are documented.
Building 9418-3 Uranium Oxide Vault	Originally contained an oil storage tank. Used from 1960 to 1964 to dispose of nonenriched uranium oxide. Leakage from the vault to groundwater is the likely release mechanism.
Fire Training Facility	Used for hands-on firefighting training. Sources of contamination to soil include flammable liquids and chlorinated solvents. Infiltration is the primary release mechanism to groundwater.
Beta-4 Security Pits	Used from 1968 to 1972 for disposal of classified materials, scrap metals, and liquid wastes. Site is closed and capped. Primary release mechanism to groundwater is infiltration.
S-2 Site	Used from 1945 to 1951. An unlined reservoir received liquid wastes. Infiltration is the primary release mechanism to groundwater.
Waste Coolant Processing Area	Used from 1977 to 1985. Former biodegradation facility used to treat waste coolants from various machining processes. Closed under RCRA in 1988.
East End Garage	Used from 1945 to 1989 as a vehicle fueling station. Five USTs used for petroleum fuel storage were excavated, 1989 to 1993. Petroleum releases to the groundwater are documented. The Bldg 9754 Fuel Station transfer lines and dispenser tanks were removed in October 1993.
Coal Pile Trench	Located beneath the former steam plant coal pile. Disposals included solid materials (primarily alloys). Trench leachate is a potential release mechanism to groundwater. In 2011, the coal pile overlying the coal pile trench was removed and the area resurfaced with gravel.

Acronyms

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
PCB = polychlorinated biphenyl
RCRA = Resource Conservation and Recovery Act
UST = underground storage tank
Y-12 Complex = Y-12 National Security Complex

4.6.4.1.1 Plume Delineation

Sources of groundwater contaminants monitored during CY 2015 include the S-2 site, the Fire Training Facility, the S-3 site, the Waste Coolant Processing Facility, former petroleum UST sites, New Hope Pond, the Beta-4 Security Pits, the Salvage Yard, and process/production buildings throughout the Y-12 Complex. Although the S-3 site, now closed under RCRA, is located west of the current hydrologic divide that separates the upper EFPC regime from the Bear Creek regime, it has contributed to groundwater contamination in the western part of the upper EFPC regime. As previously mentioned, contaminant plumes in the upper EFPC regime are elongated in shape as a result of preferential transport of the contaminants parallel to strike (parallel to the valley axis) in both the Knox aquifer and the fractured bedrock of the aquitard units.

The plumes depicted in this section reflect the average concentrations and radioactivity in groundwater between CYs 2008 and 2012. The circular icons presented on the plume maps (Figs. 4.35, 4.37-4.39) represent CY 2015 monitoring results.

In CY 2013, the Y-12 GWPP evaluated the extent of current groundwater contamination and updated the plume maps for a number of contaminants of concern (COCs), including the primary contaminants (B&W Y-12 2013). Plume maps in previous ASERs were developed from those presented in CERCLA RIs that took place in the late 1990s (DOE 1997, 1998). The RI plume maps were determined to be representative of groundwater contamination at Y-12 during the years subsequent to publication and were considered relevant for presentation in the ASERs. The updated maps are based on the more extensive and more recent sampling and analysis results, which include data not available for the RIs (e.g., existing or new wells being sampled subsequent to the RIs). These results were used to capture current groundwater conditions and in some areas reflect substantially different (higher or lower) contaminant concentrations than the data used during the RIs. These changes are due to improved data availability and/or changes within the hydrogeologic system (i.e., plume migration and/or degradation processes) either related to time and natural processes or as a result of actions taken to mitigate groundwater contamination (i.e., the east end VOC plume capture system, Section 4.6.4.1.4).

4.6.4.1.2 Nitrate

Unlike many groundwater contaminants, nitrate is highly soluble and moves easily with groundwater. Nitrate concentrations in groundwater at the Y-12 Complex exceed the 10 mg/L drinking water standard (a complete list of national drinking water standards is presented in Appendix C) in part of the western portion of the upper EFPC regime in the aquitard units and in the Maynardville Limestone unit of the Knox aquifer. The two primary sources of nitrate contamination are the S-2 and S-3 sites. The extent of the nitrate plume is essentially defined in the unconsolidated and shallow bedrock zones. In CY 2015, groundwater concentrations of nitrate as high as 9,300 mg/L (well GW-275) were observed in the shallow–intermediate bedrock intervals about 20 m (65 ft) below ground surface and about 396 m (1,300 ft) east of the S-3 site (Fig. 4.36). These results are consistent with results from previous years.

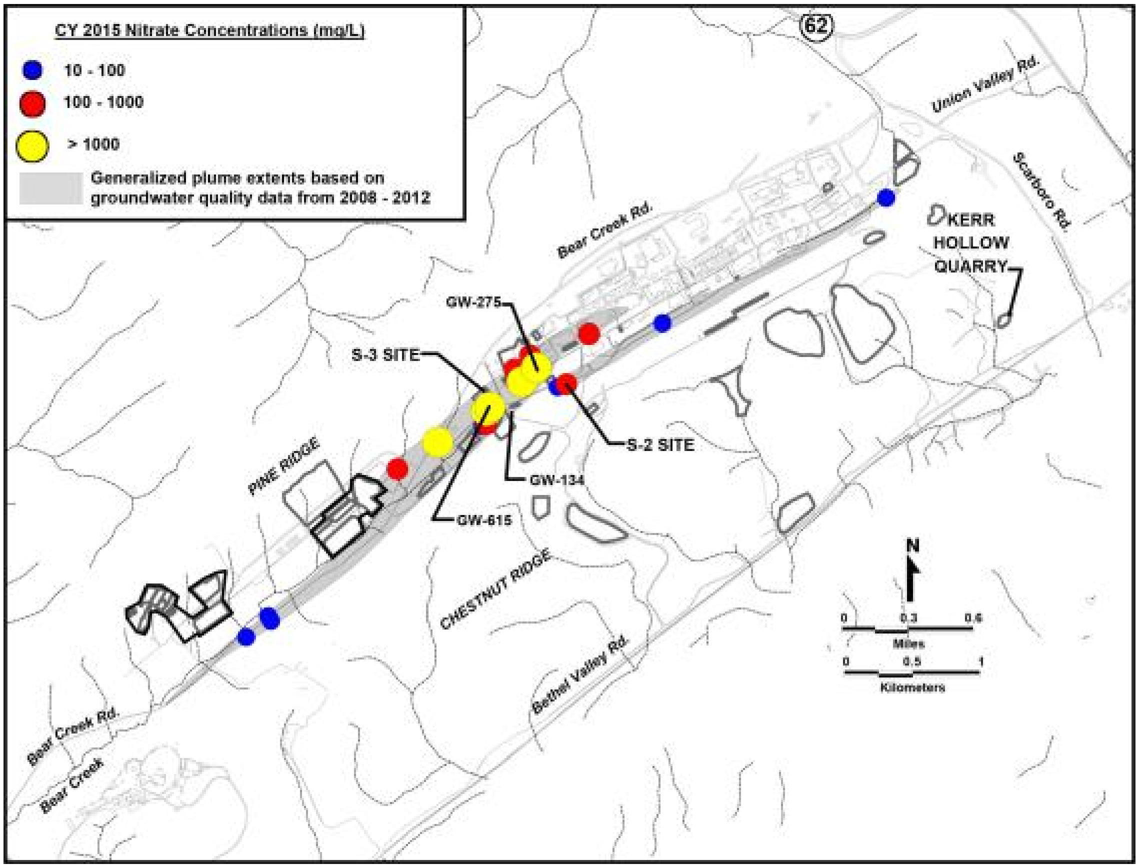

Fig. 4.35. Nitrate observed in groundwater at the Y-12 National Security Complex, 2015.

4.6.4.1.3 Trace Metals

Concentrations of arsenic, barium, beryllium, cadmium, chromium, copper, ~~lead~~, nickel, thallium, and uranium exceeded drinking water standards during CY 2015 in samples collected from various groundwater monitoring locations at or downgradient of the S-2 site, the S-3 site, and throughout the complex. Trace metal concentrations above standards tend to occur only adjacent to the source areas due to their low solubility in natural water systems and high adsorption to the clay-rich soils and bedrock underlying the Y-12 Complex.

Concentrations of uranium exceed the standard (0.03 mg/L) in a number of source areas (e.g., the S-3 site, the Uranium Oxide Vault, New Hope Pond and the former oil skimmer basin) and contribute to the uranium concentration in upper EFPC.

One trace metal absent from the list of those that exceed drinking water standards in groundwater in CY 2015 is mercury. Because mercury has similar characteristics as other trace metals (i.e., low solubility and high adsorption to clay-rich soils and bedrock), it exhibits little tendency for extensive transport in diffuse groundwater plumes. Additionally, the hydrogeologic complexities of the fracture-conduit flow system underlying the Y-12 Complex make it challenging to delineate the vertical and horizontal extents of any groundwater contamination. Elevated mercury concentrations (above the surveillance monitoring analytical detection limits) in groundwater have been consistently observed only near known source areas (Fig. 4.36).

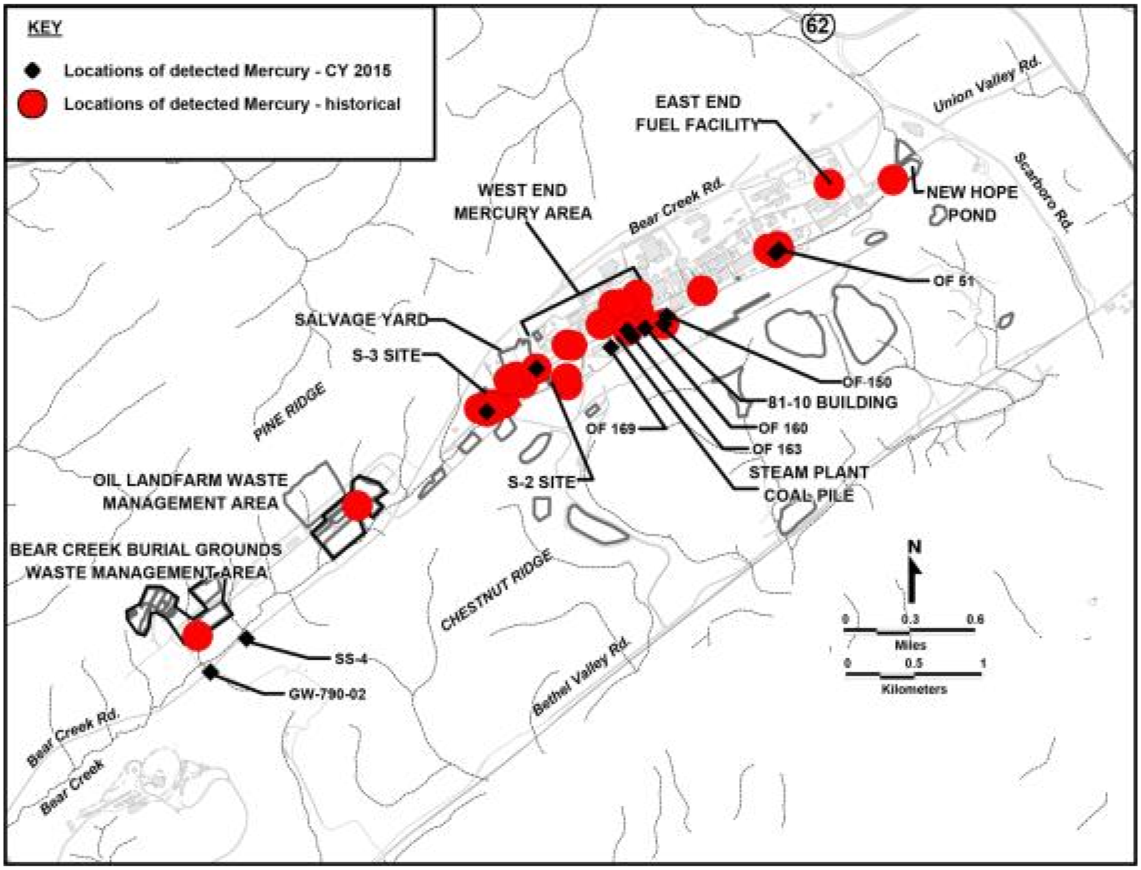

Fig. 4.36. Y-12 National Security Complex groundwater and surface water monitoring stations where mercury has been detected.

Because of past processes and disposal practices, mercury is a legacy contaminant at the Y-12 Complex. It is commonly found in the soils near specific areas where it was used in processes in the 1950s and 1960s. This metal is a COC in surface waters discharging from these areas. However, the transport mechanisms and connections between process buildings, soil contamination, storm drains, shallow groundwater, buried tributaries, and stream channels are not well understood. When mercury is discharged from the storm drain system into the open creek channel, it is rapidly captured by particulate materials, and sediment/particle transport becomes the primary mechanism of mobility. In an attempt to understand the fate and transport of mercury at the Y-12 Complex, researchers developed a conceptual model integrating known hydrologic, geochemical, and physical data (Peterson et al. 2011). More recently, UCOR and ORNL have teamed to develop a number of mercury remediation technology activities (see Section 4.8.1).

In tightly fractured shale with high clay content and other noncarbonate bedrock, the natural flow paths are such that significant advective transport of mercury through the groundwater is not likely. This is supported by extensive groundwater surveillance monitoring data. In industrialized areas of the Y-12 Complex where the shallow subsurface has been reworked extensively, some preferential transport along building foundations and underground utilities is apparent from elevated surface water concentrations of mercury. The actual mechanism of transport (e.g., advective, chemically diffusive, colloidal) is uncertain.

Interconnections between the surface water and groundwater systems have been demonstrated by tracer investigations (DOE 2001) and the discharge of elevated concentrations of mercury from a buried spring (i.e., outfall 51) adjacent to upper EFPC. This discharge is presently captured and treated to remove the mercury at the Big Springs Water Treatment System. Additionally, the regular observation of elemental mercury in storm drains in the western area of the Y-12 Complex has resulted in an increase in monitoring in recent years in several storm drain catch basins [e.g., outfall 169, outfall 163, outfall 160, and outfall 150 (Fig. 4.38)] by WRRP. In recent years, storm drain lines in this area have undergone extensive cleaning and lining.

4.6.4.1.4 Volatile Organic Compounds

Because of the many legacy source areas, VOCs are the most widespread groundwater contaminants in the upper EFPC regime. Dissolved VOCs in the regime primarily consist of chlorinated and petroleum hydrocarbons. In CY 2015, the highest summed concentration of dissolved chlorinated hydrocarbons (49,297 µg/L) was again found in groundwater at well 55-3B in the western portion of the Y-12 Complex adjacent to manufacturing facilities. The highest dissolved concentration of petroleum hydrocarbons (13,911 µg/L) was obtained from well GW-658 at the closed East End Garage.

These monitoring results are consistent with data from the previous years of monitoring. A continuous dissolved plume of VOCs in groundwater in the bedrock zone extends eastward from the S-3 site over the entire length of the regime (Fig. 4.37). The primary sources are the Waste Coolant Processing Facility, fuel facilities (Rust Garage and East End Garage), and other waste-disposal and production areas throughout the Y-12 Complex. Chloroethene compounds (PCE, TCE, DCE, and vinyl chloride) tend to dominate the volatile organic plume composition in the western and central portions of the Y-12 Complex. However, PCE is almost ubiquitous throughout the extent of the plume, indicating many source areas. Chloromethane compounds (carbon tetrachloride, chloroform, and methylene chloride) are the predominant VOCs in the eastern portion of the Y-12 Complex.

Variability in concentration trends of chlorinated and petroleum VOCs near source areas is seen within the upper EFPC regime. As seen in previous years, data from most of the monitoring wells have remained relatively constant (i.e., stable) or have decreased since 1988. Increasing trends have been observed in monitoring wells associated with the Rust Garage, Old Salvage Yard, and S-3 site in the western part of the Y-12 Complex; some legacy sources at production/process facilities in central areas; and the east end VOC plume, indicating that some portions of the plume are still showing activity.

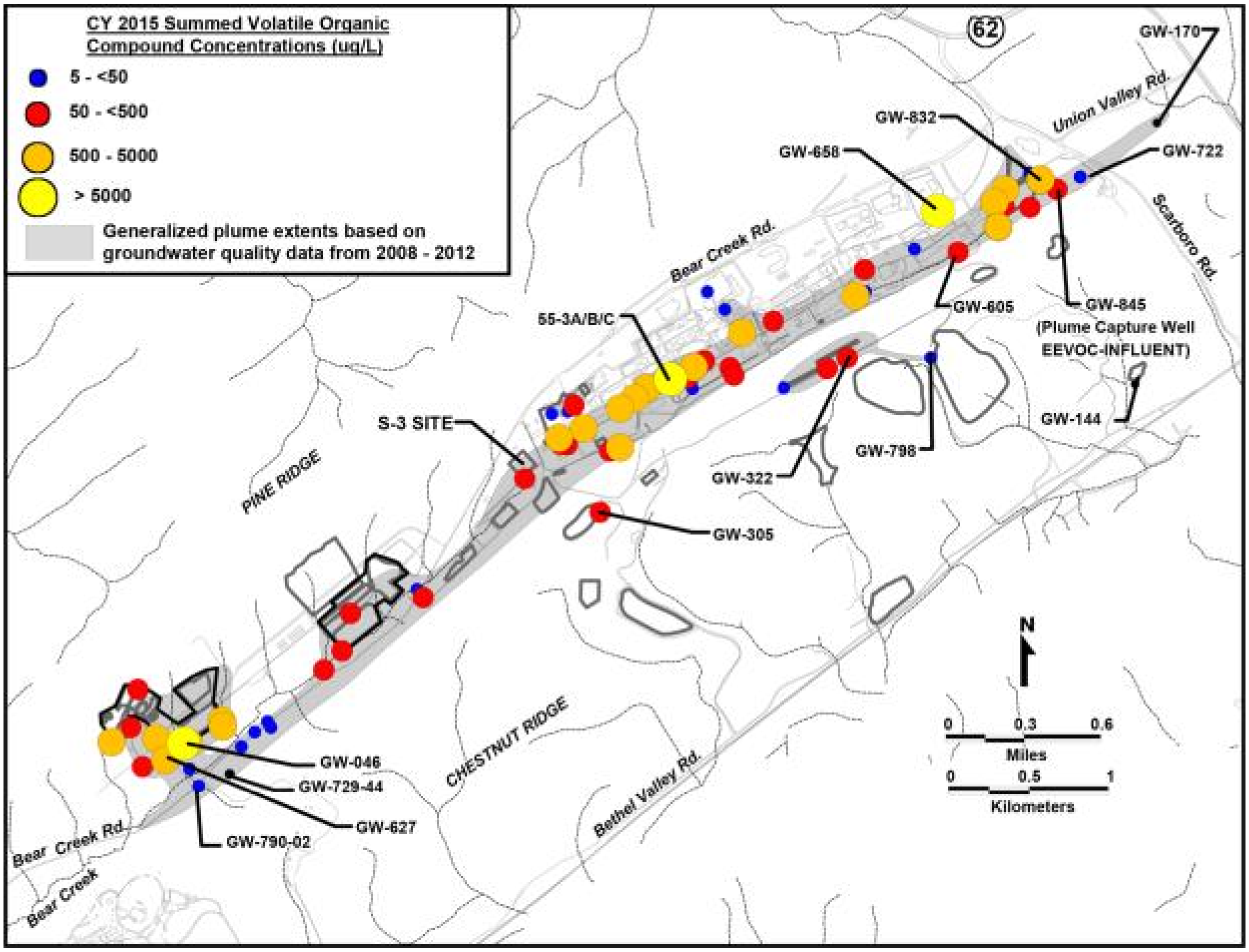

Fig. 4.37. Summed volatile organic compounds observed in groundwater at the Y-12 National Security Complex, 2015. *(EEVOC = east end volatile organic compound.)*

Within the exit pathway (the Maynardville Limestone underlying EFPC) the general trends are also stable or decreasing. One shallow well (GW-605) exhibits an increasing trend in chloroethenes, indicating active transport in this region of the groundwater plume. This well is west and upgradient of the pumping well (GW-845) operated to capture the east end VOC plume before it migrates off ORR into Union Valley. The pumping well may be influencing plume stability causing mobilization in the region of well GW-605. Other than well GW-605, the trends west of New Hope Pond are indicators that the contaminants from source areas are attenuating due to factors such as (1) dilution by surrounding uncontaminated groundwater, (2) dispersion through a complex network of fractures and conduits, (3) degradation by chemical or biological means, and/or (4) adsorption by surrounding bedrock and soil media. Wells to the southwest to southeast of New Hope Pond are displaying the effects of pumping well GW-845. Wells east of New Hope Pond and north of well GW-845 exhibit stable to increasing trends in VOC concentrations, indicating that little impact or attenuation from the plume capture system is apparent across lithologic units (perpendicular to strike). However, no subsequent downgradient detection of these compounds is apparent, so either migration is limited or some downgradient across-strike influence by the plume capture system is occurring.

4.6.4.1.5 Radionuclides

The primary alpha-emitting radionuclides found in the upper EFPC regime during CY 2015 are isotopes of uranium. Prior to 2014 most of the exceedances of the drinking water standard for gross alpha

(15 pCi/L) occurred in the western portion of the Y-12 Complex near the S-3 Site and Salvage Yard source areas. However, in CY 2014 and again in CY 2015 the highest gross alpha activity in groundwater (325 pCi/L) was observed on the east end of the Y-12 Complex in well GW-154, located at the former oil skimmer basin at the former inlet to the New Hope Pond which is now capped (Fig. 4.38).

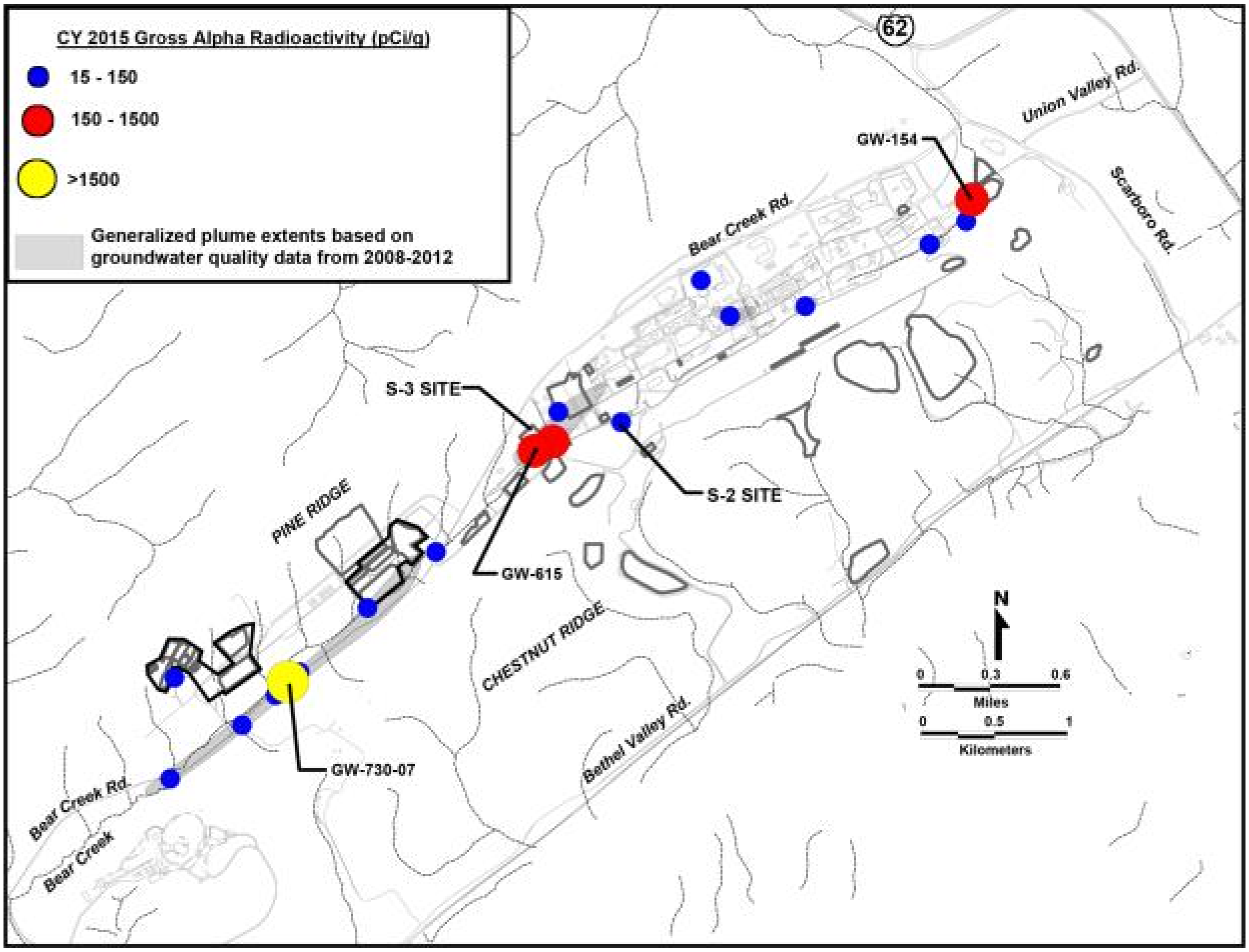

Fig. 4.38. Gross alpha activity observed in groundwater at the Y-12 National Security Complex, 2015.

The primary beta-emitting radionuclides observed in the upper EFPC regime are Technetium-99 (^{99}Tc) and isotopes of uranium. Elevated gross beta activity in groundwater in the upper EFPC regime shows a pattern similar to that observed for historical gross alpha activity. Technetium-99 is the primary contaminant exceeding the screening level of 50 pCi/L in groundwater in the western portion of the regime with the source being the S-3 site (Fig. 4.39). The highest gross beta activity in groundwater was observed during CY 2015 from well GW-108 (15,100 pCi/L), east of the S-3 site.

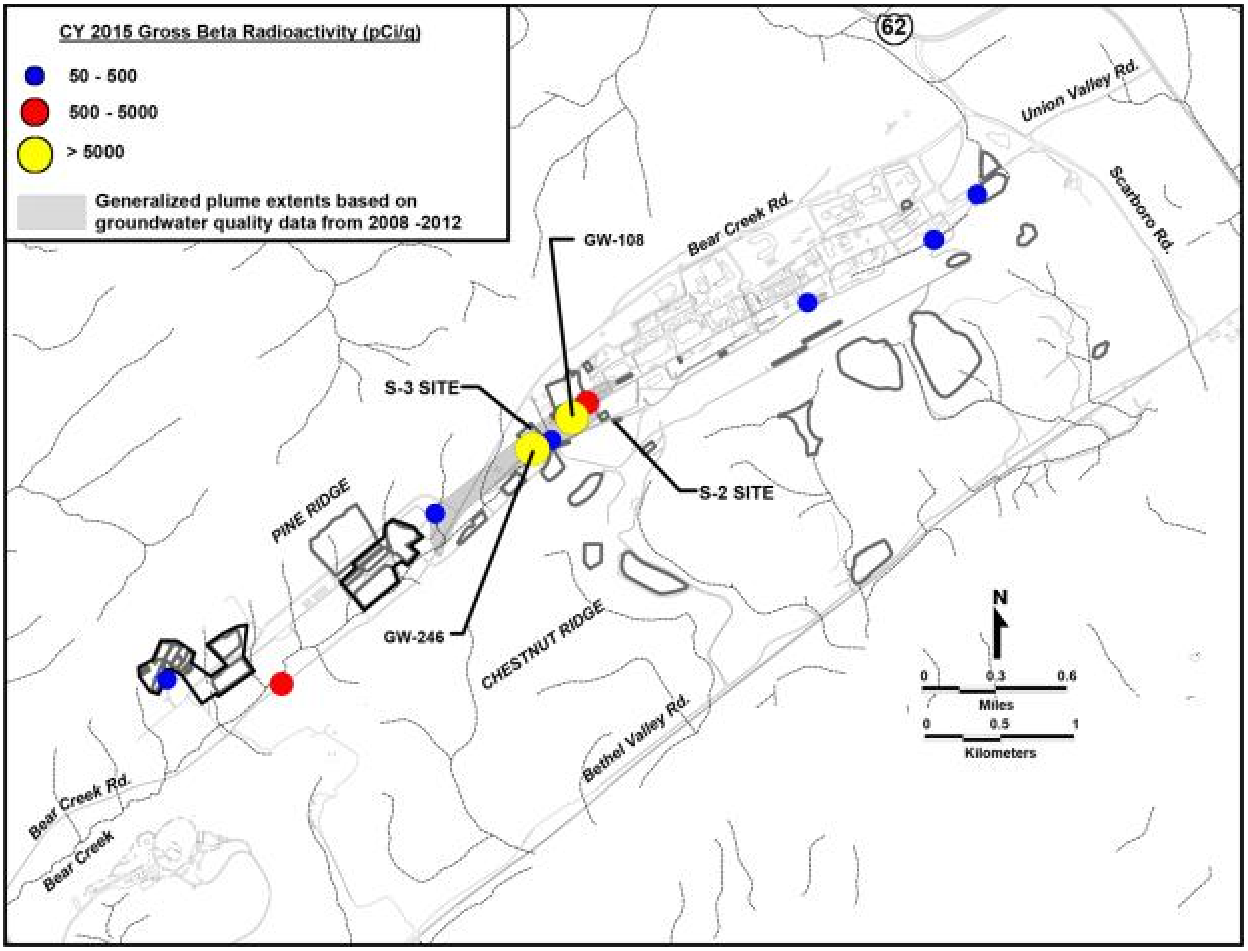

Fig. 4.39. Gross beta activity observed in groundwater at the Y-12 National Security Complex, 2015.

4.6.4.1.6 Exit Pathway and Perimeter Monitoring

Data collected to date indicate that VOCs are the primary class of contaminants migrating through the exit pathways in the upper EFPC regime. Historically, the compounds have been observed at depths of up to 500 ft below ground surface in the Maynardville Limestone, the primary exit pathway on the east end of the Y-12 Complex. The deep fractures and solution channels that constitute flow paths within the Maynardville Limestone appear to be well connected, resulting in contaminant migration for substantial distances off ORR into Union Valley to the east of the complex.

In addition to the intermediate-to-deep pathways within the Maynardville Limestone, shallow groundwater within the water table interval near New Hope Pond, Lake Reality, and upper EFPC are also monitored. Historically, VOCs have been observed near Lake Reality from monitoring wells, a dewatering sump, and the New Hope Pond distribution channel underdrain. In that area, shallow groundwater flows north-northeast through the water table interval east of New Hope Pond and Lake Reality, following the path of the distribution channel for upper EFPC.

During CY 2015, the observed concentrations of VOCs at the New Hope Pond distribution channel underdrain (GW-832) remained low (26.8 µg/L). This may be because the continued operation of the groundwater plume–capture system in well GW-845 southeast of New Hope Pond is effectively reducing the levels of VOCs in the area. The installation of the plume capture system (The East End Volatile

Organic Compound Treatment System [EEVOCTS]) was completed in June 2000. This system pumps groundwater from the intermediate bedrock 48 to 134 m (157 to 438 ft) below ground surface to mitigate off-site migration of VOCs. Groundwater is continuously 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.

Monitoring wells near well GW-845 continue to show an encouraging response to the EEVOCTS operations. The multiport system installed in well GW-722, about 153 m (500 ft) east and downgradient of well GW-845, permits sampling of vertically discrete zones within the Maynardville Limestone between 27 and 130 m (87 and 425 ft) below ground surface (Fig. 4.38). This well has been instrumental in characterizing the vertical extent of the east-end plume of VOCs and is critical in the evaluation of the effectiveness of the plume capture system. Monitoring results from the sampled zones in well GW-722 indicate reductions in VOCs due to groundwater pumping upgradient at well GW-845 [as shown in sample zone GW-722-17 (385 ft below ground surface), in Fig. 4.40]. Other wells also show decreases that may be attributable to the EEVOCTS operation. These indicators demonstrate that operation of the plume capture system is decreasing VOCs upgradient and downgradient of well GW-845, minimizing exposure to the public and the environment.

ORNL 2016-G00338/chj

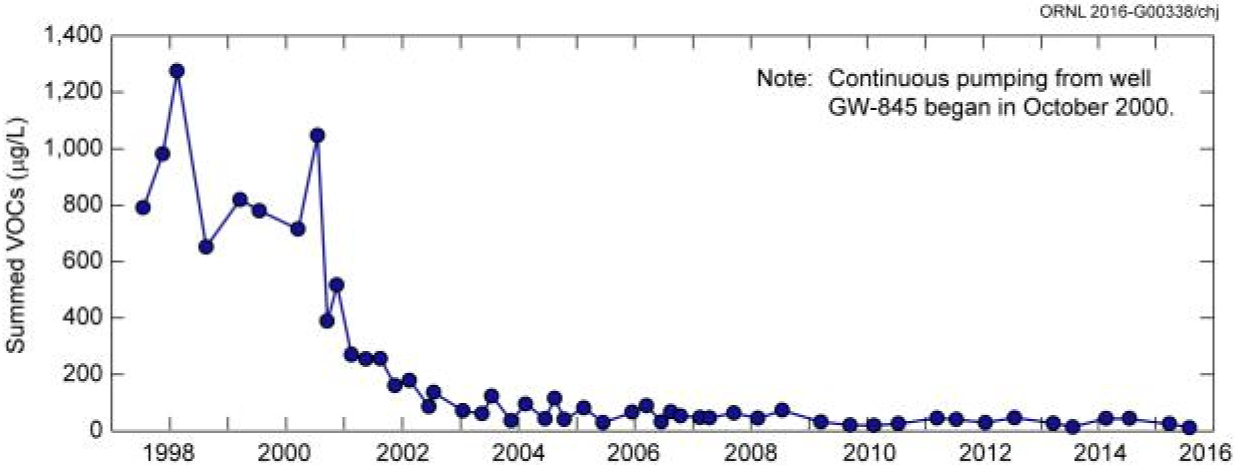

Fig. 4.40. Decreasing summed volatile organic compounds (VOCs) observed in exit pathway well GW-722-17 near the New Hope Pond, 2015. *Note: Continuous pumping from well GW-845 began in October 2000.*

Upper EFPC flows north from the Y-12 Complex through a large gap in Pine Ridge. Shallow groundwater moves through this exit pathway, and very strong upward vertical flow gradients exist. Continued monitoring of the wells in this pathway gap since about 1990 has shown no indication of any contaminants moving via that exit pathway (Fig. 4.33. One shallow well was monitored in CY 2015, and no groundwater contaminants were observed.

Three sampling locations continue to be monitored north and northwest of the Y-12 Complex to evaluate possible contaminant transport from the ORR. Those locations are considered unlikely groundwater or surface water contaminant exit pathways; however, monitoring continues to be performed to assess potential health impacts from Y-12 Complex operations to nearby residences. One of the stations monitored is a tributary that drains the north slope of Pine Ridge on the perimeter of the ORR and discharges into the adjacent Scarboro Community. One 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 discharges from the perimeter of the ORR and flows adjacent to the Country Club

Estates community. Samples were obtained and analyzed for metals, inorganic parameters, VOCs, and gross alpha and gross beta activities. No results exceeded a primary drinking water standard nor were there any indications that contaminants were being discharged from the ORR into those communities.
Union Valley Monitoring

Groundwater monitoring data obtained during the early 1990s provided the first strong indication that VOCs were being transported off ORR through the deep Maynardville Limestone exit pathway. The upper EFPC RI (DOE 1998) provided a discussion of the nature and extent of the VOCs.

In CY 2015, monitoring of locations in Union Valley continued, showing overall decreasing or very low concentration stable trends (less than primary drinking water standards) in the individual concentrations of contaminants forming the groundwater contaminant plume in Union Valley.

Under the terms of an interim ROD, administrative controls such as restrictions on potential future groundwater use have been established and maintained. Additionally, the previously discussed EEVOCTS (well GW-845) was installed, and operations were initiated to mitigate the migration of groundwater contaminated with VOCs into Union Valley (DOE 2015).

In July 2006, the Agency for Toxic Substances and Diseases Registry (ATSDR), the principal federal public health agency charged with evaluating the human health effects of exposure to hazardous substances in the environment, published a report in which groundwater contamination across the ORR was evaluated (ATSDR 2006). In the report, it was acknowledged that extensive groundwater contamination exists throughout the ORR, but the authors concluded that there is no public health hazard from exposure to contaminated groundwater originating on the ORR. The Y-12 Complex 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 the institutional and administrative controls established in the ROD do not provide for reduction in toxicity, mobility, or volume of COCs, but it concluded that the controls are protective of public health to the extent that they limit or prevent community exposure to contaminated groundwater in Union Valley.

4.6.4.2 Bear Creek Hydrogeologic Regime

Located west of the Y-12 Complex 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 the Y-12 Complex to State Highway 95. Table 4.20 describes each of the waste management sites within the Bear Creek regime.

Table 4.20. Description of waste management units included in calendar year 2015 groundwater monitoring activities, Bear Creek hydrogeologic regime

Site	Description
S-3 Site	Four unlined surface impoundments constructed in 1951. Received liquid nitric acid/uranium–bearing wastes via the nitric acid pipeline until 1983. Other disposals included ^{99}Tc. Closed and capped under RCRA in 1988. Infiltration was the primary release mechanism to groundwater.
Oil Landfarm	Operated from 1973 to 1982. Received waste oils and coolants tainted with metals and PCBs. Closed and capped under RCRA in 1989. Infiltration was the primary release mechanism to groundwater.
Boneyard	Used from 1943 to 1970. Unlined shallow trenches used to dispose of construction debris and to burn magnesium chips and wood. Excavated and restored in 2002–2003 as part of Boneyard-Burnyard remedial activities.

Table 4.20. (continued)

Site	Description
Burnyard	Used from 1943 to 1968. Wastes, metal shavings, solvents, oils, and laboratory chemicals were burned in two unlined trenches. Excavated and restored in 2002–2003 as part of the Boneyard-Burnyard remedial activities.
Hazardous Chemical Disposal Area	Used from 1975 to 1981. Built over the Burnyard. Handled compressed gas cylinders and reactive chemicals. Residues placed in a small, unlined pit. The northwest portion was excavated and restored in 2002–2003 as part of Boneyard-Burnyard remedial activities.
Sanitary Landfill I	Used from 1968 to 1982. Nonhazardous industrial landfill. May be a source of certain contaminants to groundwater. Closed and capped under TDEC requirements in 1985. Evaluation under CERCLA determined that no further action was need.
Bear Creek Burial Grounds A and C and Walk-In Pits	Burial grounds A and C received waste oils, coolants, beryllium, uranium, various metallic wastes, and asbestos into unlined trenches and standpipes. The walk-in pits received chemical wastes, shock-sensitive reagents, and uranium saw fines. Activities ceased in 1981. Final closure was certified for A (1989), C (1993), and the walk-in pits (1995). Infiltration is the primary release mechanism to groundwater.
Bear Creek Burial Grounds B, D, E, and J and Oil Retention Ponds 1 and 2	Burial grounds B, D, E, and J consisted of unlined trenches. These burial grounds received uranium chip, metal, and oxide wastes and uranium contaminated debris. Ponds 1 and 2, built in 1971 and 1972, respectively, captured waste oils seeping into two Bear Creek tributaries. The ponds were closed and capped under RCRA in 1989. Certification of closure and capping of burial ground B and part of C was granted in February 1995.
Rust Spoil Area	Used from 1975 to 1983 for disposal of construction debris but may have included materials bearing solvents, asbestos, mercury, and uranium. Closed under RCRA in 1984. Site is a source of VOCs to shallow groundwater according to CERCLA remedial investigation and current surveillance monitoring.
Spoil Area I	Used from 1980 to 1988 for disposal of construction debris and other stable, nonradioactive wastes. Permitted under TDEC solid waste management regulations in 1986; closure began shortly thereafter. Soil contamination is of primary concern. CERCLA ROD issued in 1997.
SY-200 Yard	Used from 1950 to 1986 for equipment and materials storage. No documented waste disposal at the site occurred. Leaks, spills, and soil contamination are concerns. CERCLA ROD issued in 1996.
Environmental Management Waste Management Facility	A CERCLA ROD defines the construction, operation, and closure of this on-site facility for disposal of radioactive, hazardous, and mixed wastes generated from CERCLA cleanup projects conducted on the ORR and associated sites. The facility began accepting wastes in 2002 with full capacity estimated to be reached in FY 2020.

Acronyms

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
ETTP = East Tennessee Technology Park
ORNL = Oak Ridge National Laboratory
ORR – Department of Energy Oak Ridge Reservation
PCB = polychlorinated biphenyl
RCRA = Resource Conservation and Recovery Act
ROD = record of decision
TDEC = Tennessee Department of Environment and Conservation
VOC = volatile organic compound
Y-12 Complex = Y-12 National Security Complex

4.6.4.2.1 Plume Delineation

The primary groundwater 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 the Oil Landfarm waste management areas are significant sources of uranium and other trace metals and VOCs. High concentrations of chlorinated hydrocarbons and PCBs have been observed as deep as 82 m (270 ft) below the Bear Creek Burial Grounds (MMES 1990).

Contaminant plume boundaries are essentially defined in the bedrock formations that directly underlie many waste disposal areas in the Bear Creek regime, particularly the Nolichucky Shale. This fractured aquitard unit is positioned north of and adjacent to the exit pathway unit, the Maynardville Limestone. The elongated shape of the contaminant plumes in the Bear Creek regime is the result of preferential transport of the contaminants parallel to strike (parallel to the valley axis) in the Maynardville Limestone and the aquitard units.

The plumes depicted in this section reflect the average concentrations and radioactivity in groundwater between CYs 2008 and 2012. The circular icons presented on the plume maps (Fig. 4.35, 4.37-4.39) represent CY 2015 monitoring results. (See Section 4.6.4.1.1 for more details.)

4.6.4.2.2 Nitrate

The limits of the nitrate plume probably define the maximum extent of groundwater contamination in the Bear Creek regime. The horizontal extent of the nitrate plume is essentially defined in groundwater in the upper to intermediate bedrock intervals of the aquitard units and Knox aquifer [less than 92 m (300 ft) below the ground surface].

Data obtained during CY 2015 indicate that nitrate concentrations in groundwater continue to exceed the drinking water standard in an area that extends west from the source area at the S-3 site. The highest nitrate concentration (11,300 mg/L) was observed at well GW-615 adjacent to the S-3 site at a depth of 68 m (223 ft) below ground surface (Fig. 4.35), indicating that high concentrations persist deeper in the subsurface groundwater system. A multiport monitoring well, GW-134, was sampled in CY 2011 and continues to show elevated concentrations of nitrate (1,420 mg/L) as deep as 226 m (740 ft) below ground surface.

4.6.4.2.3 Trace Metals

During CY 2015, barium, beryllium, cadmium, lead, manganese, nickel, and uranium were identified from groundwater monitoring as the trace metal contaminants in the Bear Creek regime that exceeded drinking water standards. Historically, elevated concentrations of many of the trace metals were observed at shallow depths near the S-3 site. In 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 (see Section 4.6.4.1.3). Disposal of acidic liquid wastes at the S-3 site reduced the pH of the groundwater, which allows the metals to remain in solution longer and migrate further from the source area.

The most prevalent trace metal contaminant observed within the Bear Creek regime is uranium, indicating that geochemical conditions are favorable for its migration. Early characterization indicated that the Boneyard-Burnyard site was the primary source of uranium contamination of surface water and groundwater. Historically, uranium has been observed at concentrations exceeding the drinking water standard of 0.03 mg/L in shallow monitoring wells, springs, and surface water locations downgradient from all of the waste areas. In 2003, the final RAs at the Boneyard-Burnyard were performed with the objective of removing materials contributing to surface water and groundwater contamination to meet existing ROD goals. About 65,752 m^3 (86,000 yd^3) of waste materials was excavated and placed in the EMWMF (DOE 2007). There were significant decreases in uranium concentration and flux in the surface water tributary immediately downstream of the Boneyard-Burnyard (NT-3), which indicate that RAs performed from 2002 to 2003 were successful in removing much of a primary source of uranium in Bear Creek Valley. There has been an overall decrease in uranium concentrations since 1990 (Table 4.21); however, in CY 2014 and again in CY 2015 slight increases were observed in the upper reaches of Bear Creek, indicating that this contaminant still presents a significant impact.

Table 4.21. Nitrate and uranium concentrations in Bear Creek

Bear Creek Monitoring Station (distance from S-3 site)	Contaminant	Average concentration[a] (mg/L)					
		1990–1994	1995–1999	2000–2004	2005–2009	2010–2014	2015
BCK[b]-11.84 to 11.97	Nitrate	116	65.7	89.5	43.3	53.3	31.8
(~0.5 miles downstream)	Uranium	0.203	0.112	0.129	0.112	0.172	0.247
BCK-09.20 to 09.47	Nitrate	16.1	7.8	12.1	8.4	4.4	4.38
(~2 miles downstream)	Uranium	0.098	0.093	0.135	0.060	0.051	0.055
BCK-04.55	Nitrate	4.7	2.3	3.5	1.1	0.8	0.79
(~5 miles downstream)	Uranium	0.034	0.030	0.033	0.020	0.016	0.021

[a]Excludes results that do not meet data quality objectives.
[b]BCK = Bear Creek kilometer

Additional monitoring is ongoing in an attempt to determine uranium inputs to the stream from source areas and the karst groundwater system underlying Bear Creek. Other trace metals observed in the Bear Creek regime are arsenic, boron, chromium, copper, lead, mercury, nickel, selenium, strontium, thallium, and zinc. Concentrations have commonly exceeded background values in groundwater near contaminant source areas. One exception to this is the detection of mercury in the bottom zone (1026 ft bgs) of Westbay™ well GW-790 in CY 2015. Due to the depth of the location and the hydrologic and geochemical characteristics of the groundwater from this zone (total dissolved solids analysis from this sample was 179,000 mg/L) it is unlikely that the detected result indicates a Y-12 source. Follow-up monitoring in 2016 will be performed to further evaluate this mercury result.

In recent years some investigators have been applying very sensitive analytical methods for the extremely low level detection of mercury in water samples. These detection limits are below surveillance monitoring detection limits. As a result, mercury was again observed at slightly above the background concentration in natural spring SS-4 along Bear Creek this year (Fig. 4.37). This location is not near known source areas of mercury contamination. The source of the mercury is uncertain; however, it could be from upstream/upgradient locations where mercury is a known Y-12 legacy contaminant, or other off-site anthropogenic sources (i.e., coal-fired power generation plants) unrelated to DOE operations.

4.6.4.2.4 Volatile Organic Compounds

VOCs are widespread in groundwater in the Bear Creek regime. The primary compounds are PCE, TCE, 1,2-DCE, vinyl chloride, and 1,1-DCA. In most areas, they are dissolved in the groundwater and can occur in bedrock at depths up to 92 m (300 ft) below ground surface. Groundwater in the fractured bedrock of the aquitard units that contain detectable levels of VOCs occurs within about 305 m (1,000 ft) laterally of the source areas. The highest concentrations observed in CY 2015 in the Bear Creek regime occurred in the Nolichucky shale bedrock unit (an aquitard) at the Bear Creek Burial Ground waste management area, with a maximum summed VOC concentration of 5,683 µg/L in well GW-046 (Fig. 4.38).

High concentrations of VOCs like this and in other near source wells, coupled with increasing trends observed downgradient of the Bear Creek Burial Ground waste management area in the clastic (noncarbonated) dominated fractured bedrock of the aquitard units (Fig. 4.41), indicate that a considerable mass of dense nonaqueous phase organic compounds is still present at a depth below the Bear Creek Burial Grounds, providing a source for dissolved phase migration of VOCs. This migration parallel to the valley axis and toward the exit pathway (Maynardville Limestone) is occurring in both the unconsolidated and bedrock intervals.

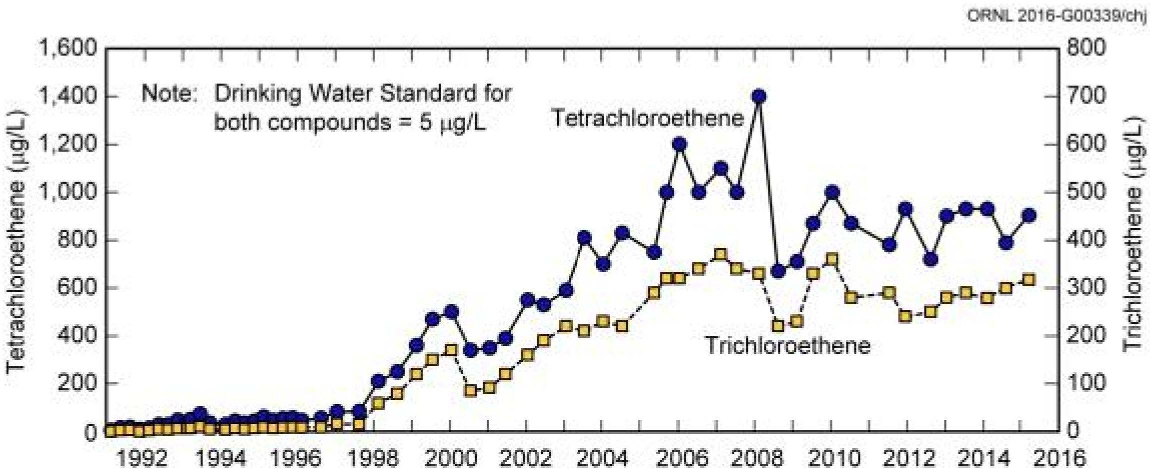

Fig. 4.41. Increasing volatile organic compounds observed in groundwater at well GW-627 west and downgradient of the Bear Creek Burial Grounds, 2015.
Drinking water standard for both compounds = 5 mg/L

Significant transport of VOCs has occurred in the Maynardville Limestone. Data obtained from monitoring well GW-729-44 in 2014 shows that in the intermediate–deep groundwater interval [98 m (320 ft) below the ground surface], an apparently continuous dissolved plume extends at least 2,591 m (8,500 ft) westward from the S-3 site to just south of the Bear Creek Burial Ground waste management area.

4.6.4.2.5 Radionuclides

The primary radionuclides identified in the Bear Creek regime are isotopes of uranium and ^{99}Tc. Neptunium, americium, radium, strontium, thorium, plutonium, and tritium are secondary and less widespread radionuclides which historically have been observed in groundwater near the S-3 site. Evaluations of the extents of radionuclides in groundwater in the Bear Creek regime during CY 2015 were based primarily on measurements of gross alpha activity and gross beta activity. If the annual average gross alpha activity in groundwater samples from 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) was assumed to be present at elevated levels in the groundwater monitored by the well. A similar rationale was used for annual average gross beta activity that exceeded 50 pCi/L. Technetium-99, a more volatile radionuclide, is qualitatively screened by gross beta activity analysis and, at certain monitoring locations, is evaluated isotopically.

Groundwater with elevated levels of gross alpha activity occurs near the S-3 site and the Oil Landfarm waste management area. In the bedrock interval, gross alpha activity has historically exceeded 15 pCi/L in groundwater in the fractured bedrock of the aquitard units only near source areas (Fig. 4.38. However, in CY 2015 in a deep zone of GW-730, an anomalous gross alpha activity of 1,600 pCi/L was observed. Monitoring well GW-730 is a multiport Westbay™ well located downgradient of the Oil Landfarm waste management area. This sample is considered anomalous because: 1) uranium, the primary alpha-emitting radionuclide in the Bear Creek regime, was not detected in this sample, 2) this zone (GW-730-07) is over 1,200 ft deep and is unlikely to be hydrologically active, and 3) this sample had an extremely high Total Dissolved Solids (TDS) concentration which can have a significant impact on the analytical determination of both gross alpha and gross beta activity. Additional sampling will be performed in CY 2016 for further evaluation.

Data obtained from exit pathway monitoring stations during CY 2015 show that gross alpha activity in groundwater in the Maynardville Limestone and in the surface waters of Bear Creek exceeds the drinking water standard for over 2,438 m (8,000 ft) west of the S-3 site. The highest gross alpha activity observed in groundwater located adjacent to the S-3 Site in CY 2015 was 200 pCi/L in well GW-246.

In CY 2015, the highest gross beta activity in groundwater in the Bear Creek regime was 10,000 pCi/L at well GW-246 located adjacent to the S-3 site.

4.6.4.2.6 Exit Pathway and Perimeter Monitoring

Exit pathway monitoring began in 1990 to provide data on the quality of groundwater and surface water exiting the Bear Creek regime. The Maynardville Limestone is the primary exit pathway for groundwater. Bear Creek, which flows across the Maynardville Limestone in much of the Bear Creek regime, is the principal exit pathway for surface water. Various studies have shown that the surface water in Bear Creek, the springs along the valley floor, and the groundwater in the Maynardville Limestone are hydraulically connected. Surveys have been performed that identify gaining (groundwater discharging into surface waters) and losing (surface water discharging into a groundwater system) reaches of Bear Creek. The western exit pathway well transect (Picket W) serves as the perimeter well location for the Bear Creek regime (Fig. 4.34).

Exit pathway monitoring consists of continued monitoring at four well transects (pickets) and selected springs and surface water stations. Groundwater quality data obtained during CY 2015 from the exit pathway monitoring wells indicate that groundwater is contaminated above drinking water standards in the Maynardville Limestone between Pickets A and C, and trends continue to be generally stable to decreasing (Fig. 4.42).

Surface water samples collected during CY 2015 indicate that water in Bear Creek contains many of the 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. The concentrations in the creek generally decrease with distance downstream of the waste disposal sites; however, an increase in these chemicals has been observed in upper reaches (Table 4.21; see Section 4.6.4.2.3).

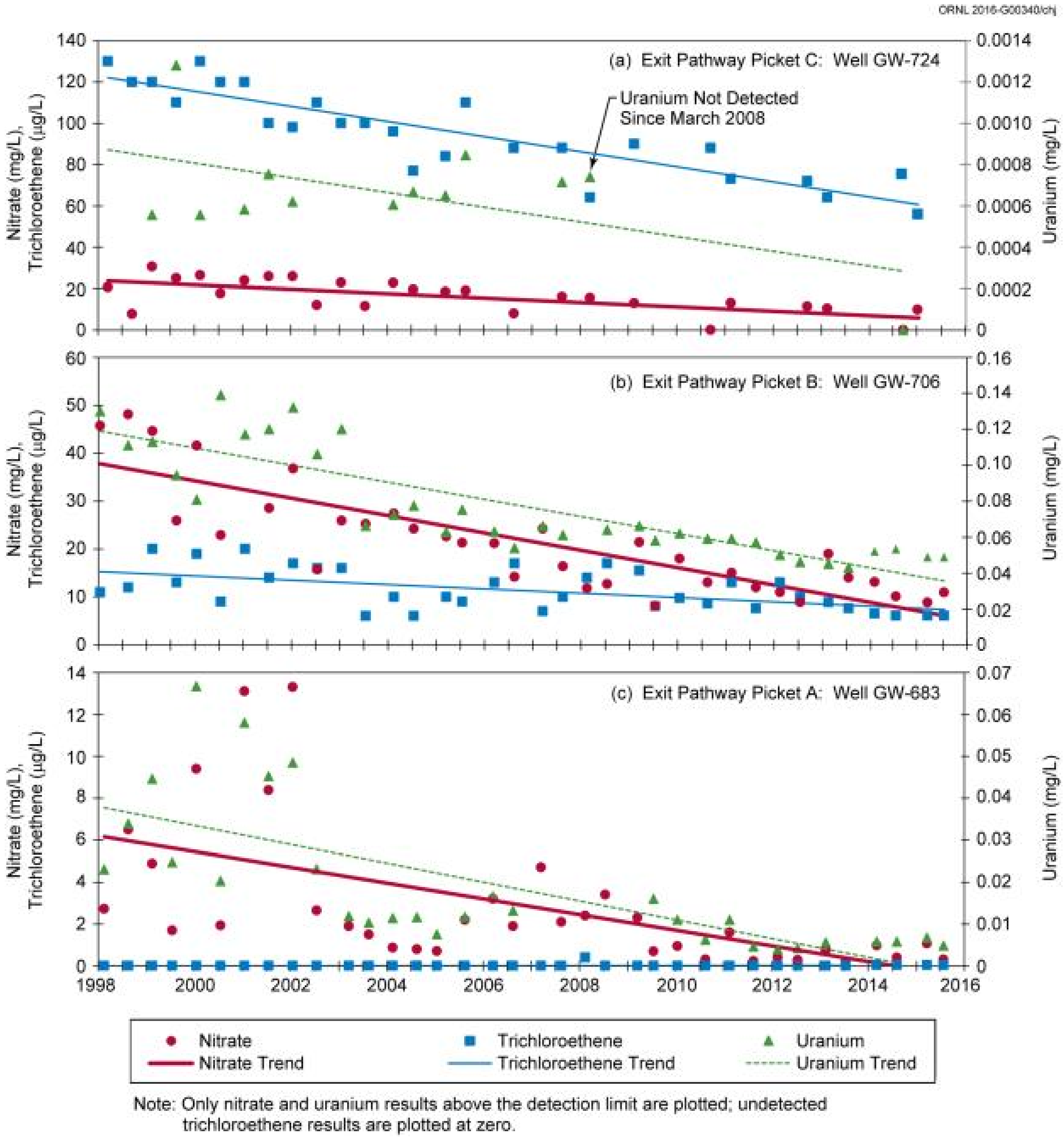

Fig. 4.42. CY 2015 concentrations of selected contaminants in exit pathway monitoring wells in the Bear Creek hydrogeologic regime.

4.6.4.3 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 (Fig. 4.35). 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. Table 4.22 summarizes the operational history of waste management units in the regime.

Table 4.22. Description of waste management units included in groundwater monitoring activities, Chestnut Ridge hydrogeologic regime, 2015

Site	Description
Chestnut Ridge Sediment Disposal Basin	Operated from 1973 to 1989. Received soil and sediment from New Hope Pond and mercury-contaminated soils from the Y-12 Complex. Site was closed under RCRA in 1989. Not a documented source of groundwater contamination.
Kerr Hollow Quarry	Operated from 1940s to 1988. Used for the disposal of reactive materials, compressed gas cylinders, and various debris. RCRA closure (waste removal) was conducted between 1990 and 1993. Certification of closure with some wastes remaining in place was approved by TDEC February 1995.
Chestnut Ridge Security Pits	Operated from 1973 to 1988. Series of trenches for disposal of classified materials, liquid wastes, thorium, uranium, heavy metals, and various debris. Closed under RCRA in 1989. Infiltration is the primary release mechanism to groundwater.
United Nuclear Corporation Site	Received about 29,000 drums of cement-fixed sludges and soils, demolition materials and low-level radioactive contaminated soils. CERCLA ROD issued in 1991.
Industrial Landfill II	Operated from 1983–1995. During operations this was the central sanitary landfill for ORR. Detection monitoring under postclosure plan has been ongoing since 1996.
Industrial Landfill IV	Opened for operations in 1989. Permitted to receive only nonhazardous industrial solid wastes. Detection monitoring under TDEC solid-waste-management regulations has been ongoing since 1988. Assessment monitoring began in 2008 because of consistent exceedance of the TDEC groundwater protection standard for 1,1-dichloroethene.
Industrial Landfill V	Initiated operations April 1994, replacing Industrial Landfill II. Currently under TDEC solid-waste-management detection monitoring.
Construction/Demolition Landfill VI	Operated from December 1993 to November 2003. The postclosure period ended, and the permit was terminated March 2007.
Construction/Demolition Landfill VII	Facility construction completed in December 1994. TDEC granted approval to operate January 1995. Permit-required detection monitoring per TDEC was temporarily suspended October 1997 pending closure of construction/demolition Landfill VI. Reopened and began waste disposal operations in April 2001.
Filled Coal Ash Pond	Site received Y-12 Steam Plant coal ash slurries from 1955 to 1968. A CERCLA ROD was issued in 1996. Remedial action complete. Monitoring under the ROD is ongoing.
East Chestnut Ridge Waste Pile	Operated from 1987 to 1989 to store contaminated soil and spoil material generated from environmental restoration activities at the Y-12 Complex. Closed under RCRA in 2005 and incorporated into RCRA postclosure permit issued by TDEC in 2006.

Acronyms

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
ORR = Department of Energy Oak Ridge Reservation
RCRA = Resource Conservation and Recovery Act
ROD = record of decision
TDEC = Tennessee Department of Environment and Conservation
Y-12 Complex = Y-12 National Security Complex

4.6.4.3.1 Plume Delineation

Through extensive monitoring of the wells on Chestnut Ridge, the horizontal extent of the VOC plume at the Chestnut Ridge Security Pits seems to be reasonably well defined in the water table and shallow bedrock zones. With two possible exceptions, historical monitoring indicates that the VOC plume from the Chestnut Ridge Security Pits has not migrated very far in any direction [305 m (<1,000 ft)]. Groundwater quality data obtained during CY 2015 indicate that the western lateral extent of the plume of VOCs at the site has not changed significantly from previous years. However, the continued observation of VOC contaminants over the past several years at a well about 458 m (1,500 ft) southeast and downgradient of the Chestnut Ridge Security Pits (well GW-798; Fig. 4.39) shows that some migration of the eastern plume has occurred. Additionally, 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 groundwater contaminants have migrated much further than the monitoring well network indicates.

The plumes depicted in this section reflect the average concentrations and radioactivity in groundwater between CYs 2008 and 2012. The circular icons presented on the plume maps (Figs. 4.37, 4.39-4.41) represent CY 2015 monitoring results. (See Section 4.6.4.1.1 for more details.)

4.6.4.3.2 Nitrate

Nitrate concentrations were below the drinking water standard at all monitoring stations in the Chestnut Ridge hydrogeologic regime.

4.6.4.3.3 Trace Metals

Elevated concentrations of arsenic were observed in two surface water monitoring locations downstream from the Filled Coal Ash Pond, which is monitored under a CERCLA ROD (DOE 2016). Under the ROD, migration of contaminated effluent from the Filled Coal Ash Pond is being reduced by a constructed wetland area. During CY 2015, elevated arsenic levels were detected both upgradient [McCoy Branch kilometer (MCK) 2.05] and downgradient (MCK 2.0) of this wetland area (Fig. 4.35). Even though both MCK 2.05 and MCK 2.0 monitoring station concentrations were higher than the drinking water standard for arsenic (0.01 mg/L), the results were 91% and 95% less than the preremediation average concentrations, respectively (DOE 2016). A surface water monitoring location (MCK 1.4) about 1,021 m (3,900 ft) downstream from the Filled Coal Ash Pond was also sampled during CY 2015 with one observed detection of arsenic below the drinking water standard (Fig. 4.35).

4.6.4.3.4 Volatile Organic Compounds

In 2015, the highest summed VOC concentration observed in the Chestnut Ridge hydrogeologic regime was at Chestnut Ridge Security Pits well GW-322 (126 µg/L; Fig. 4.39). Monitoring VOCs in groundwater attributable to the Chestnut Ridge Security Pits has been in progress since 1987. A review of historical data indicates that concentrations of VOCs in groundwater at the site have generally decreased since 1988. However, stable to very shallow increasing trends in VOCs in groundwater samples from monitoring well GW-798 (Fig. 4.39) have been developing since CY 2000. The maximum summed VOC concentration observed at well GW-798 during CY 2015 was 12.3 µg/L. The VOCs detected in well GW-798 continue to be characteristic of the Chestnut Ridge Security Pits plume.

At Industrial Landfill IV, a number of VOCs have been observed since 1992. Monitoring well GW-305, located immediately to the southeast of the facility, has historically displayed concentrations of compounds below applicable drinking water standards, but the concentrations have exhibited shallow increasing trends. In CY 2015, samples continue to exceed the drinking water standard for 1,1-DCE (7 µg/L). This has led to quarterly monitoring to further evaluate the trend. The CY 2015 samples had concentrations of 5.8 – 9.8 µg/L.

In CY 2014 a VOC, carbon tetrachloride, was consistently detected at low concentrations in groundwater samples from well GW-144 at Kerr Hollow Quarry (Fig. 4.39). This well is sampled as part of a RCRA postclosure permit with TDEC managed by the DOE EM contractor, UCOR. Three consecutive samples (all below 4 µg/L) confirmed the presence of this compound. Additional sampling at this well and at a downgradient surface water location was implemented in CY 2015 to more closely monitor this VOC. The CY 2015 carbon tetrachloride concentration at GW-144 was 1.1 µg/L and the contaminant was undetected at the associated downgradient surface water location.

4.6.4.3.5 Radionuclides

In CY 2015, no gross alpha or gross beta activity above the drinking water standard of 15 pCi/L and 50 pCi/L, respectively, was observed in any groundwater samples collected in the Chestnut Ridge hydrogeologic regime.

4.6.4.3.6 Exit Pathway and Perimeter Monitoring

Contaminant and groundwater flow paths in the karst bedrock underlying the Chestnut Ridge regime have not been well characterized by conventional monitoring techniques. A number of tracer studies have been conducted that show groundwater from Chestnut Ridge discharging into Scarboro Creek 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 the Y-12 Complex that is a known or potential groundwater contaminant source. Water quality from a spring along Scarboro Creek is monitored quarterly by the TDEC DOE Oversight Office, 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.

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. Five springs and five surface water monitoring locations were sampled during CY 2015. No contaminants at any of these monitoring stations were detected at levels above primary drinking water standards.

4.6.5 Quality Assurance

All groundwater monitoring is performed under QCs to ensure that representative samples and analytical results are obtained. Because there are a number of organizations responsible for performing groundwater sampling and analysis activities to meet separate requirements, there may be some minor differences in sampling and analysis procedures and methods, but the final results are comparable and therefore useful for all projects and programs. This permits the integrated use of all groundwater quality data obtained at the Y-12 Complex.

A number of QA measures are performed to ensure accurate, consistent, and comparable groundwater results. These measures are described in sampling and analysis plans and include the following.

- Groundwater sampling is performed across the Y-12 Complex using a number of sampling methods and procedures. The predominant method of sampling monitoring wells is by using a low-flow minimum drawdown method. Using this method, a sample is obtained from a discrete depth interval within the monitoring interval (screened or open borehole) without introducing stagnant water from the well casing. Groundwater is pumped from the well at a flow rate low enough to minimize drawdown of the water level in the well; field readings are also taken to ensure that the sample is representative of the groundwater system and not the water column inside the well casing itself. All sampling methods follow industry/regulator–recognized protocols to ensure that consistent and repeatable samples are obtained.

- QC samples such as field blank, trip blank, duplicate, and equipment rinsate samples are collected.
- All groundwater samples are controlled under chain of custody from their collection in the field to the analytical laboratory that performs the analyses.
- Laboratory analyses are performed using standard methods and protocols within established holding times.

During 2015 all groundwater monitoring and related analytical activities were performed in accordance with the established protocols.

4.7 Quality Assurance Program

The Y-12 Complex Quality Assurance Program establishes a quality policy and requirements for the overall QA program for the Y-12 site. Management requirement Y60-101PD, *Quality Assurance Program Description*, details the methods used to carry out work processes safely and securely and in accordance with established procedures. It also describes mechanisms in place to seek continuous improvements by identifying and correcting findings and preventing 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 record keeping. QA programs are designed to minimize these sources of variability and to control all phases of the monitoring process.

Field sampling QA encompasses many practices that minimize error and evaluate sampling performance. Some key quality practices include the following:

- use of work control processes and standard operating procedures for sample collection and analysis;
- use of chain-of-custody and sample-identification procedures;
- instrument standardization, calibration, and verification;
- sample technician and laboratory analyst training;
- sample preservation, handling, and decontamination; and
- use of QC samples, such as field and trip blanks, duplicates, and equipment rinses.

Y-12 Environmental Sampling Services performs field sampling, sample preservation and handling, and chain-of-custody and takes field control (QC) samples in accordance with Y-12 Environmental Compliance's internal procedures. Environmental Sampling Services developed a standards and calibration program (SCP) that conforms to ISO/IEC 17025, *General Requirements for Competence of Testing and Calibration Laboratories* (ISO 2005), and provides a process for uniform standardization, calibration, and verification of measurement and test equipment (M&TE). SCP ensures measurements are made using appropriate, documented methods; traceable standards; appropriate M&TE 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 the Y-12 Complex environmental monitoring programs use internal QA/QC programs to ensure the 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, matrix and reagent blanks, and maintenance of control charts to indicate analytical deficiencies. These activities are supported by the use of standard materials or reference materials (e.g., materials of known composition that are used in the calibration of instruments, methods standardization, spike additions for recovery tests, and other practices). Certified standards traceable to NIST, DOE sources, or EPA are used (when available) for such work.

The Y-12 Analytical Chemistry Organization (ACO) Quality Assurance manual describes QA program elements that are based on the Y-12 Complex Quality Assurance Program; customer-specific requirements; certification program requirements; ISO/IEC 17025, *General Requirements for Competence of Testing and Calibration Laboratories*; federal, state, and local regulations; and waste acceptance criteria. As a government-owned, contractor-operated laboratory that performs work for DOE, the ACO laboratory operates in accordance with DOE O 414.1D, *Quality Assurance* (DOE 2011b).

Other internal practices used to ensure that laboratory results are representative of actual conditions include training and managing staff; maintaining adequacy of the laboratory environment; safety; controlling the storage, integrity, and identity of samples; record keeping; maintaining and calibrating instruments; and the using technically validated and properly documented methods.

The Y-12 ACO participated in both Mixed Analyte Performance Evaluation Program studies conducted in 2015 for water, soil, and air filter matrices for metals, organics, and radionuclides. The overall acceptability rating from both studies was greater than 97%.

Verification and validation of environmental data are performed as components of the data collection process, which includes planning, sampling, analysis, and 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 of checking whether (1) data have been accurately transcribed and recorded, (2) appropriate procedures have been followed, (3) electronic and hard-copy data show one-to-one correspondence, and (4) 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 an RI 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 the identification of 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.

4.8 Environmental Management and Waste Management Activities

4.8.1 Mercury Technology Development Activities for Y-12, East Fork Poplar Creek

Mercury remediation in the Oak Ridge area is a high priority for DOE. Releases of mercury during Y-12 operations during the 1950s and early 1960s resulted in contamination of soil and groundwater. Subsequent transport from these sources resulted in off-site contamination of the lower EFPC.

As EM continues its mercury studies, results are revealing that source reduction alone at Y-12 may not achieve mercury regulatory goals in downstream waters (UCOR 2014). Mercury concentration, methylation, and bioaccumulation processes in the creek are complex and are driven by the mass of mercury in the system in addition to physical, chemical, and ecological factors in the receiving stream.

In FY 2014, DOE contracted with UCOR and ORNL to develop a number of mercury remediation technology activities (DOE. 2014a). The UCOR-ORNL technology development studies in the next few years will be timely because they will support evaluations of alternatives by regulators, which are scheduled in the early 2020s. In the years leading to that time, EM will conduct studies in a phased, adaptive approach to reduce uncertainties; to better define and target potential actions or new technology use; and to increase efficiencies in characterization, targeted removal and treatment, and waste disposition.

In FY 2015, research and technology development activities focused on the major factors influencing the accumulation of mercury in fish (fish are the major route of both human and wildlife exposure) were under way. Three lines of investigation for East Fork Poplar Creek were developed to: (1) examine potential downstream sources, such as bank soil and sediment control, (2) investigate the water chemistry and flow characteristics of the creek and its influence on mercury, and (3) study the ecology and how differences in food chain processes may influence the uptake of mercury in fish.

Understanding movement of mercury in the East Fork Poplar Creek system was deemed essential to the development of new technologies and ultimately to the development of remedial options and strategies for the creek. Early studies have pointed to the importance of bank soils and sediments as a source of mercury to the creek, especially during high flow events. Research is under way to examine potential technologies that may limit mercury erosion. Stream management changes, such as controlling nutrients or algae growth or managing fish populations, are also under investigation.

In March 2015, Oak Ridge National Laboratory scientists issued a report that offers science-based approaches and ideas to research and technology development activities that may lead to new options for mercury remediation (ORNL 2015).

DOE is conducting preliminary evaluations to determine the feasibility of placing a field research station along lower EFPC. The station will serve as a near-stream research facility for mercury research.

UCOR is investigating waste management practices to gain a better understanding of mercury-contaminated debris disposal techniques, strategies to reduce the quantity of debris that requires treatment, and the extent of contamination in mercury-contaminated areas at the Y-12 site. The results of these studies will be used in planning future D&D and RA projects within Y-12 mercury contamination zones using the latest cleanup and treatment techniques.

4.8.2 Mercury Remediation Strategy Developed

In 2015, DOE Headquarters approved the Outfall 200 Mercury Treatment Facility (MTF) Conceptual Design Report as well as plans to proceed with MTF design. The goal of the MTF is to reduce the mercury concentration in water exiting the Y-12 Complex and in levels of fish in East Fork Poplar Creek.

Outfall 200 is the point at which the west end Y-12 storm drain system discharges to Upper East Fork Poplar Creek. Mercury from historical operations is present in the Outfall 200 storm water entering Poplar Creek.

Also in 2015, eight pre-design studies were completed to provide information to support design. The studies evaluated storm water chemistry, optimal treatment parameters, potential water diversion strategies, storm impacts on mercury levels, and MTF siting.

As a CERCLA project, a Focused Feasibility Study and Proposed Plan that describes the MTF and goal has been prepared and approved. A public comment period, including a public meeting, was initiated to obtain comments and questions. An amendment to the Phase I UEFPC Record of Decision is being prepared to document the final remedy.

The MTF is being designed to treat storm water up to 3,000 gallons per minute and includes a 2-million-gallon storage tank to collect storm water during peak flow conditions up to 40,000 gallons per minute and treat it after storm flow subsides. Captured storm water will be piped to a treatment facility located on an available site east of Outfall 200.

Mercury treatment will be accomplished using chemical precipitation, clarification, and media filtration. Treated water will be discharged back into UEFPC. The Outfall 200 MTF design incorporates flexibility and expandability of treatment processes, if required in the future.

4.8.3 Waste Management

CERCLA Waste Disposal

The Environmental Management Waste Management Facility (EMWMF), located in east Bear Creek Valley near the Y-12 Complex, received 10,554 truckloads of waste, accounting for 99,787 tons during FY 2015. This engineered landfill consists of six disposal cells that only accept low-level radioactive and hazardous waste meeting specific waste acceptance criteria. Waste types that qualify for disposal include soil, dried sludge and sediment, solidified wastes, stabilized waste, building debris, scrap equipment, and personal protective equipment.

EMWMF operations collected, analyzed, and dispositioned approximately 5.2 million gallons of leachate at the ORNL Liquid/Gaseous Waste Operations Facility in FY 2015. No contact water (water that comes in contact with waste but does not enter the leachate collection system) required treatment at ORNL in FY 2015. However, 10.9 million gallons of contact water were collected, analyzed, and released to the storm water retention basin after laboratory analyses verified it met all discharge standards. Operating practices at the landfill also effectively controlled site erosion and sediment.

Solid Waste Disposal

In FY 2015, approximately 38,410 cubic yards of industrial wastes and construction/demolition debris were disposed in the landfill, which was a 22.7 percent increase over FY 2014 volumes.

Operation of the Oak Ridge Reservation Landfills generated approximately 2 million gallons of leachate that was collected, monitored, and discharged into the Y-12 Complex sanitary sewer system.

Wastewater Treatment

NNSA at the Y-12 Complex treats wastewater generated from both production activities and environmental cleanup activities. Safe and compliant treatment of more than 116 million gal of wastewater was provided at various facilities during the year.

West End Treatment Facility (WETF) and the Central Pollution Control Facility at the Y-12 Complex processed more than 717,000 gal of wastewater, primarily in support of NNSA operational activities.

Big Springs Water Treatment System treated more than 99 million gal of mercury-contaminated groundwater. The East End Volatile Organic Compounds Treatment System treated 11 million gal of VOC-contaminated groundwater.

The Liquid Storage Facility and Groundwater Treatment Facility treated more than 2.3 million gal of leachate from burial grounds and well purge waters from remediation areas.

The Central Mercury Treatment System treated approximately 2.0 million gal of mercury-contaminated sump waters from the Alpha 4 building.

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5. Oak Ridge National Laboratory

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

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

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

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

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

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

ORNL is managed by UT-Battelle, LLC, a partnership between the University of Tennessee and Battelle Memorial Institute. Other DOE contractors conducting activities at ORNL in 2015 included Wastren Advantage; North Wind Solutions, LLC; URS | CH2M Oak Ridge LLC; and Isotek Systems LLC. During 2015 activities of these contractors were conducted to comply with contractual and regulatory environmental requirements.

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

5.1 Description of Site, Missions, and Operations

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

Fig. 5.1. Location of Oak Ridge National Laboratory (ORNL) within the Oak Ridge Reservation and its relationship to other local US Department of Energy facilities.

[ETTP: East Tennessee Technology Park; ORISE: Oak Ridge Institute for Science and Education; Y-12: Y-12 National Security Complex.]

In March 2007, Isotek assumed responsibility for the Building 3019 Complex at ORNL, where the national repository of ^{233}U has been kept since 1962. A letter from the deputy secretary of energy, dated November 24, 2010, directed the conduct of an “alternatives analysis” to determine whether there were more efficient methods available for ^{233}U disposition. In April 2011, the deputy secretary of energy endorsed the recommendations in the *Final Draft ^{233}U Alternatives Analysis Phase I Report* (DOE 2011). The Phase I recommendations included the following: (1) proceed with a direct disposition campaign involving the transfer of Zero Power Reactor (ZPR) plate canisters to the National Nuclear Security Administration (NNSA) for future reuse and disposal of Consolidated Edison Uranium Solidification Project (CEUSP) material canisters at the Nevada National Security Site (NNSS) and (2) conduct a Phase II alternatives analysis to determine the best approach for processing the remaining 50% of the inventory. In December 2011, Isotek initiated transfer of the ZPR plate canisters to the NNSA Critical Safety Program located at the Device Assembly Facility at NNSS. Isotek completed transfer of the ZPR plate canisters in June 2012. In 2013 and 2014, Isotek continued to plan and prepare for future disposition of the remaining ^{233}U inventory. Disposal of the CEUSP material canisters began in 2015.

UT-Battelle provides air and water quality monitoring support for the Building 3019 complex and results are included in the UT-Battelle air and water monitoring discussions in this chapter.

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

For most of 2015, the TWPC was managed by Wastren Advantage, Inc., for DOE. On December 11, 2015, North Wind Solutions, LLC (NWSol) became the prime contractor for TWPC, which is located on the western boundary of ORNL on about 26 acres of land adjacent to the Melton Valley Storage Tanks along

State Route 95. TWPC's mission is to receive TRU wastes for processing, treatment, repackaging, and shipment to designated facilities for final disposal. TWPC consists of the waste-processing facility, the personnel building, and numerous support buildings and storage areas. TWPC began processing supernatant liquid from the Melton Valley Storage Tanks in 2002, contact-handled (CH) debris waste in December 2005 and remotely handled (RH) debris waste in May 2008. Based on the definition of TRU waste, some waste being managed as TRU is later determined to be low-level radioactive waste (LLW) or mixed LLW. UT-Battelle provides water quality monitoring for operations at the TWPC, and results are included in water monitoring discussions in this chapter. Air monitoring data from TWPC is provided to UT-Battelle for inclusion in the ORR National Emission Standards for Hazardous Air Pollutants for Radionuclides (Rad-NESHAPs) annual report, and is incorporated into air monitoring discussions in this chapter.

UT-Battelle manages several facilities located off the main ORNL campus for DOE. The Hardin Valley Campus (HVC) is home to the National Transportation Research Center (NTRC) User Facility and the Manufacturing Demonstration Facility (MDF). HVC is located on a 6-acre site owned by Pellissippi Investors, LLC, and is leased to UT-Battelle and the University of Tennessee. More than 85 industry partners work at the HVC to shape America's mobility future; more than 58 cooperative research and development (R&D) agreements are in place.

NTRC is DOE's only user facility dedicated to transportation and serves as the gateway to UT-Battelle's comprehensive capabilities for transportation R&D. Research focuses on fuels and lubricants, engines, emissions, electric drive technologies, lightweight and power-train materials, vehicle systems integration, energy storage and fuel cell technologies, vehicle cyber security, and intelligent transportation systems. Transportation staff have been members of teams that have won 20 R&D 100 awards.

MDF focuses on advanced manufacturing research, including additive manufacturing and carbon fiber composites. The facility also hosts local high school students who are building and analyzing robots in conjunction with FIRST Robotics, a program to inspire students to pursue education and career opportunities in science, technology, engineering, and mathematics.

In 2015, HVC received more than 6,600 visitors. The replica Shelby Cobra whose body and chassis were 3D-printed at MDF was a highlight during a visit from President Obama and Vice President Biden in January (Fig. 5.2). Also in 2015, MDF researchers unveiled the world's largest 3D-printed house and a 3D-printed utility vehicle.

Fig. 5.2. Dr. Lonnie Love discussing the 3D-printed Shelby Cobra with President Obama and Vice President Biden during a visit to the Hardin Valley Campus in January 2015. *[Photo by Techmer.]*

The Carbon Fiber Technology Facility (CFTF), a 42,000 ft^2 innovative technology facility located in the Horizon Center Business Park, in Oak Ridge, Tennessee, offers a flexible, highly instrumented carbon fiber line for demonstrating the scalability of advanced carbon fiber technology and for producing market-development volumes of prototypical carbon fibers (Fig. 5.3). CFTF is the world's most capable open-access facility for the scale-up emerging carbon fiber technology. The cost of carbon fiber material remains relatively high, prohibiting widespread adoption of carbon fiber–containing composite materials in the automotive manufacturing industry, which requires lower commodity pricing. The lower-cost carbon fiber produced at ORNL meets the performance criteria prescribed by some automotive manufacturers for carbon fiber materials for use in high-volume vehicle applications.

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

UT-Battelle also manages several buildings and trailers located at the Y-12 National Security Complex (Y-12); the American Museum of Science and Energy; and in the city of Oak Ridge.

5.2 Environmental Management Systems

An important priority for DOE contractors performing management and operations activities at ORNL is the demonstration of environmental excellence through high-level policies that clearly state expectations for continual improvement, pollution prevention, and compliance with regulations and other requirements.

In accordance with DOE O 436.1, *Departmental Sustainability* (DOE 2011a), UT-Battelle, WAI/NWSol, UCOR, and Isotek have implemented Environmental Management Systems (EMSs), modeled after International Organization for Standardization (ISO) 14001:2004 (ISO 2004), to measure, manage, and control environmental impacts. An EMS is a continuing cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental goals. In September 2015 the revised ISO 14001:2015 standard was issued. The standard allows for a 3-year implementation period, but UT-Battelle plans to re-register to the new standard in 2016.

UT-Battelle's EMS was initially registered to the ISO 14001 standard by a third-party registrar in 2004 and was re-registered in July 2013 by National Sanitation Foundation, International Strategic Registrations, Ltd. (NSF-ISR). No nonconformities were identified during the most recent surveillance audit. Detailed information on the UT-Battelle EMS is provided in Sections 5.2.1 through 5.2.1.6. The Wastren Advantage, Inc./North Wind Solutions, LLC (WAI/NWSol) EMS for activities at TWPC was registered to the ISO 14001:2004 standard by the NSF-ISR in May 2008. NSF-ISR conducted a surveillance audit for the WAI/NWSol EMS program in April 2015; no nonconformities or issues were identified, and several significant practices were noted. Section 5.2.2 describes the WAI/NWsol EMS and associated implementation activities. In June 2009, DOE conducted an external validation audit and concluded "that Isotek has implemented an Environmental Management System (EMS) that is consistent with the requirements of DOE O 450.lA, *Environmental Protection Program*" (DOE 2008). Validation audits were again conducted by DOE in May 2012 and August 2015. Both audits concluded that Isotek's EMS for the U-233 Disposition Project conforms to the ISO 14001:2004 standard. Section 5.2.3 describes the Isotek EMS and associated implementation activities. (The UCOR EMS is discussed in Chapter 3.)

5.2.1 UT-Battelle Environmental Management System

The UT-Battelle EMS is a fully integrated set of environmental management services for UT-Battelle activities and facilities. Services include pollution prevention, waste management, effluent management, regulatory review, reporting, permitting, and other environmental management programs. Through the UT-Battelle Standards-Based Management System (SBMS), the EMS establishes environmental policy and translates environmental laws, applicable DOE orders, and other requirements into laboratory-wide subject area documents (procedures and guidelines). SBMS information is based on an evaluation of external requirements (i.e., DOE directives and federal, state, and local laws), corporate policies, and best management practices that have been determined applicable to UT-Battelle operations and processes. Through environmental protection officers, environmental compliance representatives, and waste services representatives (WSRs), the UT-Battelle EMS assists the line organizations in identifying and addressing environmental issues in accordance with SBMS requirements.

5.2.1.1 Integration with the Integrated Safety Management System

The UT-Battelle EMS and Integrated Safety Management System (ISMS) are integrated to provide a unified strategy for the management of resources, the control and attenuation of risks, and the establishment and achievement of the organization's environmental safety and health (ES&H) goals. Guided by the ISMS and EMS, UT-Battelle strives for continual improvement through "plan-do-check-act" cycles. Under the ISMS, the term "safety" also encompasses ES&H, including pollution prevention, waste minimization, and resource conservation. Therefore, the guiding principles and core functions in the ISMS apply both to the protection of the environment and to safety. Figure 5.4 depicts the relationship between the EMS and the ISMS.

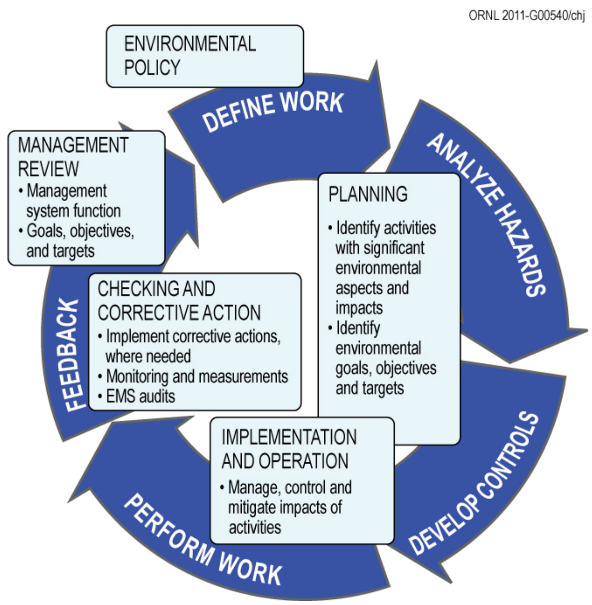

Fig. 5.4. The relationship between the UT-Battelle Environmental Management System and the Integrated Safety Management System.

The UT-Battelle EMS is consistent with the ISMS and includes the following elements:

- environmental policy;
- planning;
- legal and other requirements;
- objectives, targets, and programs;
- implementation and operation;
- resources, roles, responsibility, and authority;
- competence, training, and awareness;
- communication;
- documentation;
- control of documents;
- operational control;
- emergency preparedness and response;
- checking;
- monitoring and measurement;
- evaluation of compliance;
- nonconformity, corrective action, and preventative action;
- control of records;
- internal audit; and
- management review.

5.2.1.2 UT-Battelle Policy for Oak Ridge National Laboratory

The UT-Battelle environmental policy statements (Fig. 5.5) are part of the UT-Battelle Policy for ORNL, which is the highest-level statement of how UT-Battelle conducts business. By clearly stating expectations, the policy provides the framework for setting and reviewing environmental objectives and targets.

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Environmental Policy

- Provide and continually improve research, services, products, and management systems of the highest quality consistent with the needs, expectations, risk tolerance, and resources of our customers.
- Provide a safe and healthy workplace by developing and implementing work processes and equipment that abate hazards, operating in a manner that protects and restores the environment, and integrating sustainability (including pollution prevention) into planning and decision-making.
- Comply with applicable requirements for performing work and work-related activities on and off site, including requirements in the ORNL's Standards-Based Management System.
- Systematically integrate environmental, safety, health, quality, and physical and cyber security principles into management and work practices at all levels.
- Communicate appropriate environmental management system information to staff, subcontractors, customers, and other stakeholders.

Fig. 5.5. UT-Battelle environmental policy statements.

5.2.1.3 Planning

5.2.1.3.1 UT-Battelle Environmental Aspects

Environmental aspects are elements of an organization's activities, products, or services that can interact with the environment. Environmental aspects associated with UT-Battelle activities, products, and services have been identified at both the project and activity level. Activities that are relative to any of these aspects are carefully controlled to minimize or eliminate impacts to the environment. The following aspects have been identified as potentially having significant environmental impacts:

- hazardous waste generation;
- radioactive waste generation;
- mixed waste generation;
- energy use/intensity;
- greenhouse gas (GHG) emissions;
- permitted air emissions;
- regulated liquid discharges;
- storage, use, or transportation of chemicals; and
- storage, use, or transportation of radioactive materials.

5.2.1.3.2 UT-Battelle Legal and Other Requirements

Legal and other requirements that apply to the environmental aspects identified by UT-Battelle include federal, state, and local laws and regulations; environmental permits; applicable DOE orders; UT-Battelle contract clauses; waste acceptance criteria; and voluntary requirements such as ISO 14001:2004. 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.

5.2.1.3.3 UT-Battelle Objectives and Targets

To improve environmental performance, UT-Battelle has established and implemented objectives, targets, and performance indicators for appropriate functions and activities. In all cases, the objectives, targets, and performance indicators are consistent with the UT-Battelle Policy for ORNL and are supportive of the laboratory mission, and where practical, they are measurable. These objectives and targets are entered into a commitment tracking system and are tracked to completion.

5.2.1.3.4 UT-Battelle Programs

UT-Battelle has established an organizational structure to ensure that environmental stewardship practices are integrated into all facets of UT-Battelle's missions at ORNL. This includes programs led by experts in environmental protection and compliance, energy and resource conservation, pollution prevention, and waste management to ensure that laboratory activities are conducted in accordance with the environmental policy outlined in Fig. 5.5. Information on UT-Battelle's 2015 compliance status, activities, and accomplishments is presented in Section 5.3.

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

- waste management,
- National Environmental Policy Act (NEPA) compliance,

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

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

- pollution prevention staff who manage recycling programs, work with staff to reduce waste generation, and promote sustainable acquisition;

- radiological engineering staff who provide radiological characterization support to generators and WSRs, develop tools to help ensure compliance with facility safety and transportation, and provide packaging support;

- waste acceptance and disposition staff who review and approve waste characterization methods, accept waste from generator areas into Transportation and Waste Management Division storage areas, review waste disposal paperwork to ensure compliance with the disposal facility's waste acceptance criteria, and certify waste packages;

- WSRs who provide technical support to waste generators to properly manage waste by assisting in identifying, characterizing, packaging, and certifying wastes for disposal;

- the waste-handling team, which performs waste-packing operations and conducts inspections of waste items, areas, and containers;

- the waste acceptance and disposition team, which coordinates off-site disposition of UT-Battelle's newly generated waste;

- the transportation management team, which ensures that both the on-site and off-site packaging and transportation activities are performed in an efficient and compliant manner; and

- the hazardous material spill response team, which is the first line of response to hazardous materials spills at ORNL and controls and contains spills until the situation is stabilized.

5.2.1.4 UT-Battelle Sustainable Campus Initiative

The Sustainable Campus Initiative is an ORNL-wide effort that builds upon the laboratory's strength as a premier science and technology organization in integrating energy efficiency, cutting-edge technologies, and operational and business processes to achieve sustainability. The ultimate goal is to achieve benchmark sustainability in campus operation and in the research, development, and deployment of key technologies by 2025.

Table 5.1 summarizes FY 2015 performance and planned actions to achieve future sustainability goals. Detailed information can be found in *The Site Sustainability Plan for the Oak Ridge National Laboratory* (ORNL 2015) (http://sustainability-ornl.org/Documents/2015%20SSP%2011-24-15.pdf).

Table 5.1. Table of UT-Battelle Attainment of DOE Sustainability Goalsa

SSPP Goal #	DOE Goal	Performance Status through FY 2015	Planned Actions & Contribution
1.1	50% Scope 1 & 2 GHG reduction by FY 2025 from a FY 2008 baseline (2015 target: 19%).	**Scope 1** estimate is 65,388 $MTCO_2e$, a decrease of 27% from FY 2008. **Scope 2** estimate is 330,465 $MTCO_2e$, an increase of 33% from FY 2008 after purchased RECs. **Scope 1 & 2** combined estimate is 395,853 $MTCO_2e$, an increase of 17% from the baseline year of FY 2008.	**Scope 1** reductions are on target due to ECM efforts, ESPC implementation, the new steam plant system, and SF_6 process reductions. **Scope 2** reductions represent a substantial challenge due to growth in electricity demands for mission-critical facilities (HEMSFs). REC purchases and innovative technologies will be used to meet the goal by the target year.
1.2	25% Scope 3 GHG reduction by FY 2025 from a FY 2008 baseline (2015 target: 6%).	Scope 3 estimate is 44,440 $MTCO_2e$. Overall Scope 3 emissions have increased by 8%. Increased electricity consumption and a 33% increase in T&D losses limits the overall performance. A new electricity sub-station was commissioned on site in FY 2015.	Continuing focus on employee engagement areas such as responsible business travel (videoconferencing when possible), employee commutes, and telework programs will ensure progress toward Scope 3 reductions. T&D losses will grow along with purchased electricity. As with Scope 2, REC purchases will also produce credits to offset Scope 3 emissions by the target year.
2.1	25% energy intensity (Btu/GSF) reduction by FY 2025 from a FY 2015 baseline in goal subject buildings (2.5% reduction per year).	FY 2015 objective was to establish the energy intensity baseline. ORNL has calculated the new baseline at 265,326 Btu/GSF.	Ongoing process of energy audits will identify additional energy conservation projects to achieve the annual 2.5% reduction and the new FY 2025 goal of 25%.
2.2	EISA Section 432 energy and water evaluations.	Over 3.9% evaluated during this third year of the current four-year cycle.	Continue pace of 25% or more through current cycle (end of FY 2016). Leverage knowledge from previous cycles to conduct focused evaluations.
2.3	Meter all buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate.	The ORNL updated Metering Plan has been completed.	Continued implementation of metering plan will allow progress toward building level metering of all commodities.
2.4	At least 15% (by building count or GSF) of existing buildings greater than 5,000 GSF to be compliant with the revised Guiding Principles for HPSB by FY 2025, with progress to 100% thereafter.	ORNL has established an HPSB inventory of 25 buildings, exceeding the 15% goal.	Efforts will continue toward expanding the existing HPSB inventory.

Table 5.1 (continued)

SSPP Goal #	DOE Goal	Performance Status through FY 2015	Planned Actions & Contribution
2.5	Efforts to increase regional and local planning coordination and involvement.	Progress documented in Section 2.5 of the *Site Sustainability Plan.*	Continued participation in local and regional transportation and sustainability organizations.
2.6a	Net Zero Buildings: Percentage of the site's existing buildings (>5,000 GSF) intended to be energy, waste, or water net-zero buildings by FY 2025.	Progress documented in Section 2.6a of the *Site Sustainability Plan.*	See details in Section 2.6a of the *Site Sustainability Plan.*
2.6b	Net Zero Buildings: Percentage of new buildings (>5,000 GSF) entering the planning process designed to achieve energy net-zero beginning in FY 2020.	Progress documented in (Section 2.6b of the *Site Sustainability Plan*).	See details in Section 2.6b of the *Site Sustainability Plan.*
2.7	Data Center Efficiency. Establish a power usage effectiveness target in the range of 1.2 to 1.4 for new data centers and less than 1.5 for existing data centers.	In FY 2015 ORNL Data Centers experienced a portfolio average PUE of 1.28, exceeding the goal of 1.5.	Continue to optimize systems to meet or exceed goals. Engineering staff have identified several areas in which to pursue additional energy savings.
3.1	"Clean Energy" requires that the percentage of an agency's total electric and thermal energy accounted for by renewable and alternative energy shall be not less than: 10% in FY 2016–2017, working towards 25% by FY 2025.	The purchase of RECs for the Renewable Energy Target results in achieving a benchmark of 8% of the Clean Energy Target, as it readies to meet the targets in future years.	Purchase additional RECs, beyond the Renewable Energy Target, to meet and/or exceed the Clean Energy interim target of 10% in FY 2016.
3.2	"Renewable Electric Energy" requires that renewable electric energy account for not less than 10% of a total agency electric consumption in FY16–17, working towards 30% of total agency electric consumption by FY 2025.	ORNL has purchased RECs to supplement on-site renewable energy generation to achieve 11.2% of electrical energy to be from renewable resources, exceeding the interim 7.5% goal.	Purchase sufficient RECs to offset the on-site renewable energy generation and the TVA Southeastern Pilot Program RECs to meet and/or exceed the interim goal in FY 2016.
4.1	36% potable water intensity (Gal/GSF) reduction by FY 2025 from a FY 2007 baseline (2015 target: 16%).	Water use intensity measured 132 gal/GSF in FY 2015 (a reduction of 25% to date, exceeding the interim goal).	Continue to evaluate water conservation opportunities and to identify and repair leaks on an aging distribution system.
4.2	30% water consumption (gal) reduction of industrial, landscaping, and agricultural water by FY 2025 from a FY 2010 baseline (2015 target: 10%).	No ILA water use at ORNL.	No ILA water use at ORNL.

Table 5.1 (continued)

SSPP Goal #	DOE Goal	Performance Status through FY 2015	Planned Actions & Contribution
5.1	20% reduction in annual petroleum consumption by FY 2015 relative to a FY 2005 baseline; maintain 20% reduction thereafter. (2015 target: 20%).	In FY 2015 ORNL achieved a 57% reduction in cumulative petroleum consumption relative to the FY 2005 baseline, exceeding the DOE target.	Continue to use alternative fuel and continue to educate drivers about the importance of using alternative fuels in flex fuel vehicles to meet new Executive Order (EO) 13693.
5.2	10% increase in annual alternative fuel consumption by FY 2015 relative to a FY 2005 baseline; maintain 10% increase thereafter. (2015 target: 10%).	In FY 2015 ORNL achieved a 227% increase in cumulative alternative fuel consumption relative to the FY 2005 baseline, exceeding the DOE target of 160%.	Continue to use alternative fuel. Continue to ensure that biodiesel quality is maintained.
5.3	30% reduction in fleet-wide per-mile GHG emissions reduction by FY 2025 from a FY 2014 baseline. (2015 target: N/A; 2017 target: 4%).	Determine the 2014 GHG baseline for ORNL using final guidance and data to be provided by DOE (FEMP).	ORNL plans to support the GHG emission initiative through purchasing PHEVs.
5.4	75% of light duty vehicle acquisitions must consist of alternative fuel vehicles (AFV). (2015 target: 75%).	100% of the light duty vehicles purchased in FY 2015 were AFVs.	Continue to purchase AFVs from General Services Administration schedules as funds and approvals are provided.
5.5	50% of passenger vehicle acquisitions consist of zero emission or plug-in hybrid electric vehicles by FY 2025. (2015 target: N/A).	Not applicable for FY 2015. Note: ORNL has purchased 3 PHEVs and has EV charging infrastructure in place on campus and satellite locations (44 charging stations).	Prepare for new FY 2025 targets and other new EO and DOE directives
6.1	Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring BioPreferred and biobased provisions and clauses are included in 95% of applicable contracts.	100% of all applicable contracts in FY 2015 contained terms and conditions that invoke requirements for sustainable acquisitions.	As indicated in EO 13693, three FAR clauses will be added to the standard Commercial Items Terms and Conditions contracts beginning in January, 2016.
7.1	Divert at least 50% of nonhazardous solid waste, excluding construction and demolition debris.	A 49% diversion rate was achieved in FY 2015. While less than the target, this represents a significant improvement in the past year.	Continue mitigation measures and process improvements to close the gap for this goal in FY 2016 and beyond.
7.2	Divert at least 50% of construction and demolition materials and debris.	ORNL's diversion rate for construction and demolition debris for FY 2015 is 88%, exceeding the target.	Continue process improvements. Additional focus will be placed on segregation of waste.

Table 5.1 (continued)

SSPP Goal #	DOE Goal	Performance Status through FY 2015	Planned Actions & Contribution
8.1	Annual targets for performance contracting to be implemented in FY 2017 and annually thereafter as part of the planning of section 14 of EO 13693.	Progress documented in Section 8.1 of the *Site Sustainability Plan*.	Existing ESPC in place with JCI through FY 2031.
9.1	Purchases—95% of eligible acquisitions each year are EPEAT-registered products.	Exceeded the 95% goal in FY 2015.	Continue with guided procurement to assure compliance. Closely monitor nonstandard requests for electronic requisitions.
9.2	Power management—100% of eligible PCs, laptops, and monitors have power management enabled.	100% of eligible computers, monitors, and laptops are being actively power managed.	Continue to actively ensure all eligible computing equipment is power managed.
9.3	Automatic duplexing—100% of eligible computers and imaging equipment have automatic duplexing enabled.	Successful implementation of program to ensure all new print services include automatic duplexing set as default.	Update print management documents and strategy with respect to the DOE *Sustainable Print Management Guide* once the guide is finalized.
9.4	End of Life—100% of used electronics are reused or recycled using environmentally sound disposition options each year.	100% of dispositioned electronics equipment is reused or recycled using CFL and R2 certified reuse/recycle practices.	Continue to dispose of electronics equipment using CFL and R2 certified reuse/recycle practices.
10.1	Update policies to incentivize planning for and addressing the impacts of climate change.	See details in Section 10.1 of the *Site Sustainability Plan.*	CCR Team continues to review, update, and implement policies as needed.
10.2	Update emergency response procedures and protocols to account for projected climate change, including extreme weather events.	See details in Section 10.2 of the *Site Sustainability Plan.*	CCR Team working directly with subject matter experts to ensure that procedures and protocols are reviewed and updated as needed.
10.3	Ensure that workforce protocols and policies reflect projected human health and safety impacts of climate change.	See details in Section 10.3 of the *Site Sustainability Plan.*	CCR Team working directly with subject matter experts to ensure that procedures and protocols are reviewed and updated as needed.
10.4	Ensure that site/lab management demonstrates commitment to adaptation efforts through internal communications and policies.	See details in Section 10.4 of the of the *Site Sustainability Plan.*	ORNL management continues to be engaged and to communicate policy updates.
10.5	Ensure that site/lab climate adaptation and resilience policies and programs reflect best available current climate change science, updated as necessary.	See details in Section 10.5 of the *Site Sustainability Plan.*	Ongoing process for the CCR Team and subject matter experts

Table 5.1 (continued)

[a] *Source*: Adapted from the executive summary table in *Site Sustainability Plan with FY 2015 Performance Data*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 2015 (http://sustainability-ornl.org/Documents/2015%20SSP%2011-24-15.pdf).

Acronyms:

AFV	alternative fuel vehicle
Btu	British thermal unit
C&D	construction and demolition
CCR	Climate Change Resiliency (team)
CFL	Computers for Learning
CO_2e	carbon dioxide equivalent
DOE	US Department of Energy
ECM	energy conservation measure
EISA	Energy Independence and Security Act
EPEAT	Electronic Product Environmental Assessment Tool
ESPC	Energy Savings Performance Contract
EV	electric vehicle
FAR	federal acquisition regulation
FEMP	Federal Energy Management Program
FY	fiscal year
GAL	gallon
GHG	greenhouse gas
GP	guiding principle
GSA	General Services Administration
GSF	gross square feet
HEMSF	high-energy, mission-specific facility
HPSB	High Performance Sustainable Buildings
ILA	industrial, landscaping, and agricultural
JCI	Johnson Controls, Inc.
LEED	Leadership in Energy and Environmental Design
MWh	megawatt-hour
$MTCO_2e$	metric ton carbon dioxide equivalent
ORNL	Oak Ridge National Laboratory
PC	personal computer
PHEV	plug-in hybrid electric vehicle
PUE	power usage effectiveness
R2	responsible recycling
REC	renewable energy credit (also, renewable energy certificate)
SSPP	Strategic Sustainability Performance Plan (DOE)
T&D	transmission and distribution
TVA	Tennessee Valley Authority

5.2.1.4.1 *Pollution Prevention and Waste Reduction*

UT-Battelle implemented 35 new pollution prevention projects at ORNL during 2015, eliminating more than 5.5 million kg of waste. In total, these projects and ongoing reuse/recycle projects led to cost savings/avoidance of more than $3.2 million. Source reduction actions pursued in 2015 included moving toward paperless work processes; resource-efficient computing; and recycling efforts for paper, scrap metal, lead, ballasts, drums, electronics, and construction and demolition (C&D) debris. Fig 5.6 summarizes recycling results for 2015.

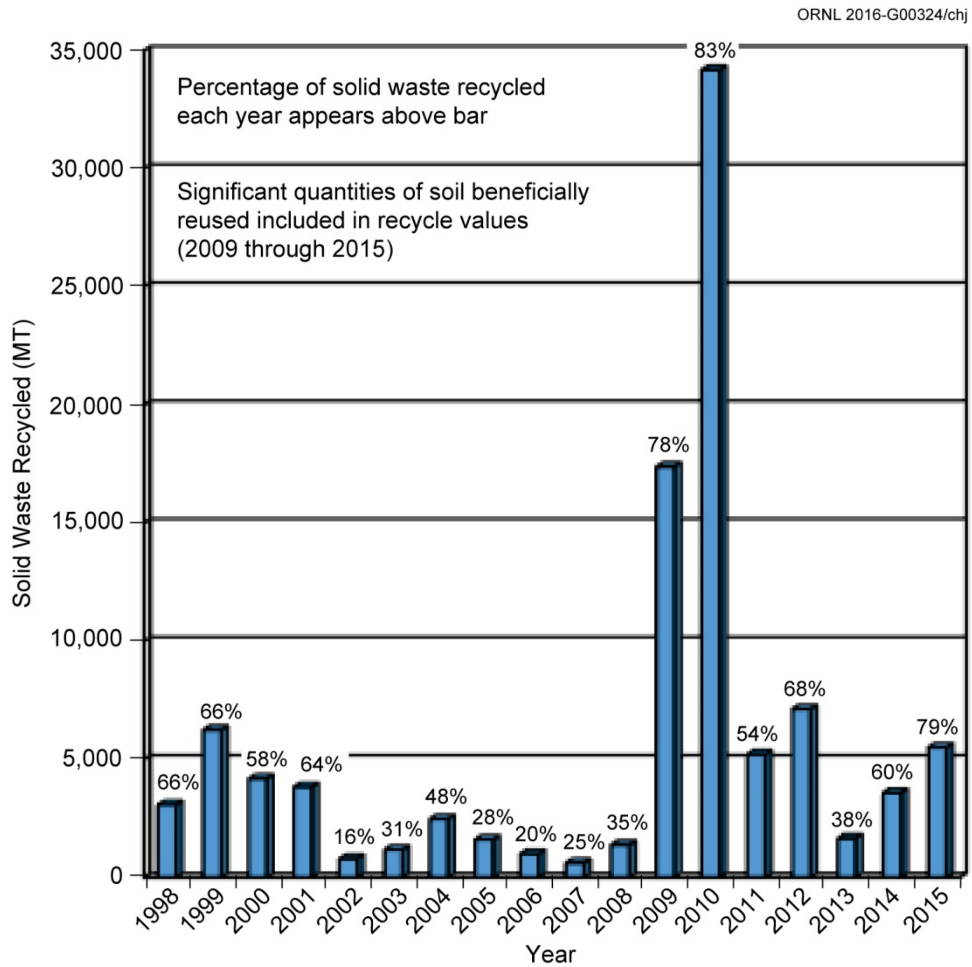


Fig. 5.6. Solid waste recycled at Oak Ridge National Laboratory as a result of recycling programs through 2015.

Oak Ridge National Laboratory Pollution Prevention/Sustainability Awards

- 2014 Clean Cities Coalition Davy Crockett Volunteer Leadership Award—awarded from DOE Clean Cities program in 2015 to recognize ORNL as a leader in alternative fuel use in the southeast and for alternative fuel use, sustainable transportation research, and public engagement among national labs.

- DOE 2015 DOE Earth Day Photo Contest—sustainability category winner for "Pull Horse Tilling—Sustainable Farming."

- 2015 Sustainable Transportation Award—ORNL's on-site electric vehicle charging project cited by Tennessee Department of Environment and Conservation (TDEC) in conjunction with Clean Air Month at the 2015 inaugural Sustainable Transportation Awards.

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

  - Top R&D technology product of the year in the Process/Prototype category awarded to UT-Battelle and Cincinnati Incorporated for the Big Area Additive Manufacturing System (a large-scale additive manufacturing system) (Fig. 5.7). The team also earned the *R&D Magazine's* 2015 Editor's Choice Award.

  - Award to researchers from ORNL and United Protective Technologies for development of a multifunctional superhydrophobic transparent glass coating.

  - Award received by a team of UT-Battelle researchers for development of a porous graphene desalination membrane.

Fig. 5.7. In 2015, UT-Battelle and Cincinnati Incorporated won an R&D 100 Award for the Big Area Additive Manufacturing System. *[Photo by Carlos Jones].*

5.2.1.4.2 Storm Water Management and the Energy Independence and Security Act of 2007

Section 438 of the Energy Independence and Security Act of 2007 (EISA 2007) stipulates the following: "The sponsor of any development or redevelopment project involving a Federal facility with a footprint that exceeds 5,000 square feet shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow."

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

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

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

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

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

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

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

In addition to GI/LID practices, the projects may remove impervious areas and reestablish pervious areas to allow infiltration or evapotranspiration to occur.

5.2.1.5 Emergency Preparedness and Response

The UT-Battelle Emergency Management Program supplies the resources and capabilities to provide emergency preparedness services and, in the event of an accident, emergency response services. Emergency preparedness personnel perform hazard surveys and hazard assessments to identify potential emergency situations. Procedures and plans have been developed to prepare for and respond to a wide variety of potential emergency situations. Training is provided to ensure appropriate response and performance during emergency events. Frequent exercises and drills are scheduled to ensure the effective performance of the procedures and plans. An environmental subject matter expert is a member of the emergency response team and participates in drills and exercises to ensure that environmental requirements are met and that environmental impacts from the event (and the response) are mitigated.

5.2.1.6 Checking

5.2.1.6.1 Monitoring and Measurement

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

5.2.1.6.2 Environmental Management System Assessments

UT-Battelle uses several methods to evaluate compliance with legal and other environmental requirements. Most of the compliance evaluation activities are implemented through the EMS or are a part of line-organization assessment activities. If a nonconformance were identified, the ORNL issues-management process requires that any regulatory or management system nonconformance be reviewed for cause and that corrective and/or preventive actions be developed. These actions are then implemented and tracked to completion.

Environmental assessments that cover both legal and other requirements are performed periodically. Additionally, management system owners are required to assess management system performance and 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, there are internal and external EMS assessments performed annually to ensure that the UT-Battelle EMS continues to conform to ISO requirements. An internal audit and an external surveillance audit conducted in 2015 verified that the EMS continued to conform to ISO 14001:2004. In addition to verifying conformance, these management system assessments also identify continual improvement opportunities.

5.2.2 Environmental Management System for the Transuranic Waste Processing Center

NSF-ISR registered the WAI/NWSol EMS for activities at TWPC to the ISO 14001:2004 Standard in May 2008 and is integrated with ISMS to provide a unified strategy for the management of resources, the control and reduction of risks, and the establishment and achievement of the organization’s ES&H goals. EMS and ISMS are incorporated into the *Integrated Safety Management System Description* (BJC 2009) and in a “plan-do-check-act” cycle is used for continual improvement in both. NSF-ISR conducted a recertification audit in April 2014 and a surveillance audit in April 2015. No nonconformances or issues were identified, and several significant practices were noted.

The NWSol EMS incorporates applicable environmental laws, DOE orders, and other requirements (i.e., DOE directives and federal, state, and local laws) through NWSol's regulatory management plan (NWSol 2015), which dictates how the various requirements are incorporated into subject area documents (procedures and guidelines). The EMS assists NWSol line organizations in identifying and addressing environmental issues.

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

NWSol has established and implemented objectives and measurable performance indicators for the targets associated with the identified significant impacts.

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

NWSol has a well-established recycling program at TWPC and continues to identify new material-recycling streams and to expand the types of materials included in the program. Currently, recycle streams at TWPC range from office materials such as paper, aluminum cans, plastic drinking bottles, Styrofoam cups, alkaline batteries, and toner cartridges to operations-oriented materials such as scrap metal, cardboard, construction debris, and batteries. NWSol has established a "single stream" recycling program that allows the mixing of multiple types of recyclables that increases the population of recyclable items and improves compliance. A construction debris recycling program began in September 2011 and has resulted in about 172 tons being diverted from the landfill to date.

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

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

5.2.3 Environmental Management System for Isotek

Isotek has developed and implemented an EMS for the U-233 Disposition Project that reflects the elements and framework found in the ISO14001:2004 standard and that satisfies the applicable requirements of DOE O 450.1A, *Environmental Protection Program* (DOE 2008). The scope of the Isotek EMS is to achieve and demonstrate environmental excellence by identifying, assessing, and controlling the impact of Isotek activities and facilities on the environment. The EMS is designed to ensure compliance with environmental laws, regulations, and other applicable requirements and to improve effectiveness and efficiency, reduce costs, and earn and retain regulator and community trust. The Isotek EMS and ISMS are fully integrated.

Project procedures provide a systematic approach to integrating environmental considerations into all aspects of Isotek's activities at ORNL. The Isotek EMS includes a procedure for identifying environmental aspects associated with the U-233 Disposition Project and for determining whether those aspects can have significant environmental impacts. Isotek has identified radiological air emissions as the only environmental aspect of its operations that has potentially significant environmental impacts and has developed an environmental management plan with measurable objectives and targets to address that aspect. Isotek reviews environmental aspects, potential impacts, objectives, targets, and environmental management plans at least annually and updates them as necessary.

The U-233 Disposition Project has a well-established recycling program that is implemented at all Isotek facilities and includes Buildings 3017 and 3019 at ORNL and an off-site administrative office in Oak Ridge. The materials currently recycled by Isotek include paper, cardboard, aluminum cans, plastic bottles, inkjet and toner cartridges, lamps, batteries, scrap metal, circuit boards, aerosol cans, and used oil.

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

5.3 Compliance Programs and Status

During 2015 UT-Battelle, UCOR, WAI/NWSol, and Isotek operations were conducted to comply with contractual and regulatory environmental requirements. A notice of violation (NOV) issued to UT-Battelle by TDEC was received on January 20, 2015, for failure to include two emergency generators in a timely manner in the ORNL site air permit. This was self-reported to TDEC on November 11, 2014 and the omission has since been corrected. The two generators are now included in a permit issued January 23, 2015.

Table 5.2 presents a summary of environmental audits conducted at ORNL in 2015.

The following discussions summarize the major environmental programs and activities carried out at ORNL during 2015 and provide an overview of the compliance status for the year.

Table 5.2. Summary of regulatory environmental audits, evaluations, inspections, and assessments conducted at Oak Ridge National Laboratory, 2015

Date	Reviewer	Subject	Issues
January 14	TDEC	Annual CAA Inspection for ORNL and CFTF	0
February 19	City of Oak Ridge	CFTF Wastewater Inspection	0
April 27 - 29	TDEC	Annual RCRA Inspection for ORNL (including TWPC)	1
April 29	1916-T2 Warehouse	1916-T2 Warehouse RCRA Inspection	0
August 3	City of Oak Ridge	CFTF Wastewater Inspection	0
October 21–22	TDEC	Annual CAA Inspection for ORNL and CFTF	0
October 28–29	City of Oak Ridge	CFTF Wastewater Inspection	0

Acronyms

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

5.3.1 Environmental Permits

Table 5.3 contains a list of environmental permits that were in effect in 2015 at ORNL.

Table 5.3. Oak Ridge National Laboratory environmental permits, 2015

Regulatory driver	Permit title/description	Permit number	Issue date	Expiration date	Owner	Operator	Responsible contractor
CAA	Title V Major Source Operating Permit, ORNL	562765	08-16-11	08-15-16	DOE	UT-B	UT-B
CAA	Construction Permit, CFTF facility (located near ETTP)[a]	965013P	03-27-12	11-01-14[b]	DOE	UT-B	UT-B
CAA	Construction Permit, CFTF emergency generator	967180P	03/07/14	03-06-15[b]	DOE	UT-B	UT-B
CAA	Construction Permit, Steam Plant boilers 7–9	969317F	01/07/15	01/06/16	DOE	UT-B	UT-B
CAA	Operating Permit, NTRC	0941-05[b]	10-23-12	Annually[b]	DOE	UT-B	UT-B
CAA	Operating Permit, WAI/NWSol	063331P	03-07-12	03-01-22	DOE	WAI/NWSol	WAI/NWSol
CAA	Operating Permit, WAI/NWSol emergency generator	068459P	04-14-14	10-01-23	DOE	WAI/NWSol	WAI/NWSol
CAA	Title V Major Source Operating Permit, ORNL	569768	09-18-15	09-17-20	DOE	UCOR	UCOR
CAA	Title V Major Source Operating Permit, Isotek	568276	10-06-14	10-05-19	DOE	Isotek	Isotek
CWA	ORNL NPDES Permit (ORNL sitewide wastewater discharge permit)	TN0002941	03-01-14	10-31-18	DOE	DOE	UT-B, UCOR, WAI/NWSol
CWA	Tennessee General NPDES Permit TNR10-0000, Storm Water Discharges from Construction Activities—Spallation Neutron Source	TNR139975	10-10-00	05-23-16	DOE	DOE	UT-B
CWA	Tennessee General NPDES Permit TNR10-0000, Storm Water Discharges from Construction Activities—7018 Renovations/Additions (2.81 acres)	TNR134552	08-05-14	05-23-16	DOE	DOE	UT-B
CWA	Industrial and Commercial User Waste Water Discharge Permit (CFTF)	1-12	10-15-12	03-31-15	UT-B	UT-B	UT-B
CWA	Tennessee General NPDES Permit TNR10-0000, Storm Water Discharges from Construction Activities—Pro2Serve National Security Engineering Center		10-06	NA	DOE	DOE	CROET
CWA	Tennessee Operating Permit, Holding Tank/Haul System for Domestic Wastewater	SOP-07014	06-01-12	04-30-17	UCOR	UCOR	UCOR
CWA	Tennessee Operating Permit (sewage)	SOP-02056	02-01-13	12-31-17	DOE	WAI/NWSol	WAI/NWSol
CWA	Tennessee General NPDES Permit TNR10-0000, Storm Water Discharges from Construction Activity—Site Expansion Project	TNR 133560	08-31-09	NA	DOE	WAI/NWSol	WAI/NWSol
CWA	ARAP for ORNL East Campus Pond Replacement	ARAP NR1403.060	05-06-14	06-30-15	DOE	UT-B	UT-B
RCRA	Hazardous Waste Transporter Permit	TN1890090003	01-12-15	01-31-16	DOE	DOE	UT-B, UCOR

Table 5.3 (continued)

Regulatory driver	Permit title/description	Permit number	Issue date	Expiration date	Owner	Operator	Responsible contractor
RCRA	Hazardous Waste Corrective Action Permit	TNHW-121	09-28-04	09-28-14[c]	DOE	DOE/all[d]	DOE/all
RCRA	Hazardous Waste Container Storage and Treatment Units	TNHW-134	09-26-08	09-26-18	DOE	DOE/UT-B	UT-B
RCRA	Hazardous Waste Container Storage and Treatment Units	TNHW-145	02-03-10	02-03-20	DOE	DOE/ UCOR/ WAI/NWSol	UCOR/ WAI/NWSol

[a]Permit issued by Knox County Department of Air Quality Management.
[b]Continued construction/operation under an expired permit is allowed under air pollution control regulations when timely renewal or construction permit applications are submitted.
[c] On September 15, 2015, the ORR Hazardous Waste Corrective Action Permit TNHW-121 was reissued as TNHW-164.
[d]DOE and Oak Ridge Reservation contractors are co-operators of hazardous waste permits.

Acronyms

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

5.3.2 National Environmental Policy Act/National Historic Preservation Act

NEPA provides a means to evaluate the potential environmental impact of proposed federal activities and to examine alternatives to those actions. UT-Battelle, WAI/NWSol, and Isotek maintain 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 establish NEPA as a key consideration in the formative stages of project planning. Table 5.4 summarizes NEPA activities conducted at ORNL during 2015.

Table 5.4. National Environmental Policy Act activities, 2015

Types of NEPA documentation	Number of instances
Oak Ridge National Laboratory	
Approved under general actions or generic CX determinations[a]	86
Project-specific CX determinations[b]	3
Wastren Advantage, Inc./North Wind Solutions	
Approved under general actions[a] or generic CX determinations	1

[a]Projects that were reviewed and documented through the site NEPA compliance coordinator.
[b]Projects that were reviewed and approved through the DOE Site Office and NEPA compliance officer.

Acronyms
CX = categorical exclusion
NEPA = National Environmental Policy Act

During 2015, UT-Battelle and WAI/NWSol continued to operate under site-level procedures that provide requirements for project reviews and NEPA compliance. The procedures call for a review of each proposed project, activity, or facility to determine the potential for impacts to the environment. To streamline the NEPA review and documentation process, the DOE Oak Ridge Office has approved generic categorical exclusion (CX) determinations that cover proposed bench- and pilot-scale research activities and generic CXs that cover proposed nonresearch activities (e.g., maintenance activities, facilities upgrades, personnel safety enhancements). A CX is one of a category of actions defined in 40 CFR 1508.4 that does not individually or cumulatively have a significant effect on the human environment and for which neither an environmental assessment nor an environmental impact statement is normally required.

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

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

5.3.3 Clean Air Act Compliance Status

The Clean Air Act (CAA), passed in 1970 and amended in 1977 and 1990, forms the basis for the national air pollution control effort. This legislation established comprehensive federal and state regulations to limit air emissions. It includes four major regulatory programs: the national ambient air quality standards, state implementation plans, new source performance standards, and NESHAPs. Airborne discharges from DOE Oak Ridge facilities, both radioactive and nonradioactive, are subject to regulation by EPA and the TDEC Division of Air Pollution Control. The sitewide UT-Battelle Title V Major Source Operating Permit, renewed in 2011, was modified one time in 2015 to keep current with the latest UT-Battelle operating status. Three additional modification requests submitted to TDEC in 2015 will likely be finalized in conjunction with the next Title V permit renewal by TDEC. The renewal application is due in early 2016. The Title V Major Source Operating Permit for the 3039 stack, operated by UCOR, was renewed in 2015. To demonstrate compliance with the Title V Major Source Operating Permits, more than 1,500 data points are collected and reported every year. In addition, nitrogen oxides (NO_X), a family of poisonous, highly reactive gases and defined collectively as a criteria pollutant by the EPA (EPA 2016), is monitored continuously at one location. Samples are collected continuously from 9 major radionuclide sources and periodically from 15 minor radionuclide sources; and there are numerous other demonstrations of compliance with generally applicable air quality protection requirements (e.g., asbestos, stratospheric ozone). NTRC and CFTF are two off-site CAA-regulated facilities maintained and operated by UT-Battelle. A minor-source operating permit issued by Knox County Air Quality Management for NTRC was cancelled in 2015 because the source had been reclassified as insignificant and no longer needed a permit. A separate permit to be issued by Knox County for an emergency generator located at NTRC was pending at the end of 2015. The CFTF operates under two construction permits issued by TDEC. A permit application to convert them to a true minor operating air permit was submitted in 2015.

In summary, there was one UT-Battelle CAA violation and no Isotek, UCOR, or WAI/NWSol CAA violations or exceedances in 2015. The one violation was for failure to permit two emergency generators in a timely manner. The two generators were inadvertently omitted from an application submitted previously. The permit for the two generators was issued by TDEC on January 23, 2015. An NOV issued by TDEC in 2014 was amended in early 2015 to include an additional building that was demolished without prior notification to TDEC.. Section 5.4 provides detailed information on 2015 activities conducted by UT-Battelle in support of the CAA.

5.3.4 Clean Water Act Compliance Status

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

In 2015, compliance with the ORNL NPDES permit was determined by about 2,300 laboratory analyses and field measurements. The NPDES permit limit compliance rate for all discharge points for 2015 was greater than 99%, with four measurements exceeding numeric NPDES permit limits. The four effluent limit exceedances occurred at the ORNL STP in May 2015, when issues with STP sludge-management equipment occurred. Efforts to maintain sludge management included decreases in flow and aeration, which led to unfavorable conditions for nitrification and ammonia control within the system. As a result, the STP ammonia discharge limits were exceeded four times during that month. Corrective actions including sludge-management system improvements were completed before the end of May 2015, after which there were no further NPDES compliance issues at the STP. A nonconformance with a narrative (non-numeric) condition of ORNL's NPDES permit occurred in January 2015, when electrical power was temporarily lost at the Building 3625 Microscopy Laboratory. The electrical outage prevented a sanitary sewer collection system lift station from functioning properly, which led to an overflow of sanitary sewage and cooling water to the ground surface near Building 3625. A portion of the released water ultimately flowed into White Oak Creek (WOC). Following the incident, utility systems were reconfigured to prevent future recurrence. Section 5.5 contains detailed information on the monitoring programs and activities carried out in 2015 by UT-Battelle in support of CWA.

5.3.5 Safe Drinking Water Act Compliance Status

ORNL's water distribution system is designated as a "nontransient, noncommunity" water system by the TDEC Division of Water Supply. TDEC's Water Supply rules, Chapter 0400-45-01, Public Water Systems (TDEC 2012), sets limits for biological contaminants and for chemical activities and chemical contaminants. TDEC requires sampling for the following constituents for compliance with state and federal regulations:

- residual chlorine,
- bacteria (total coliform),
- disinfectant by-product (trihalomethanes and haloacetic acids), and
- lead and copper (required once every 3 years).

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

In 2015, sampling results for ORNL's water system residual chlorine levels, lead and copper levels, bacterial constituents, and disinfectant by-products were all within acceptable limits. Sampling for lead and copper will not be required again until 2018.

5.3.6 Resource Conservation and Recovery Act Compliance Status

The Hazardous Waste Program under RCRA establishes a system for regulating hazardous wastes from the initial point of generation through final disposal. In Tennessee, TDEC has been delegated authority by EPA to implement the Hazardous Waste Program; EPA retains an oversight role. In 2015, 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 2015. 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, TNHW-145, TNHW-134, and TNHW-164, as shown in Table 5.5. In 2015, UT-Battelle and UCOR were permitted to transport hazardous wastes under an EPA ID number issued for ORNL activities. On September 15, 2015, the ORR Hazardous Waste Corrective Action Permit TNHW-121 was reissued as TNHW-164. TNHW-164 is a set of conditions pertaining to the current status of all solid waste management units (SWMUs) and areas of concern (AOCs) at ETTP, ORNL, and the Y-12

National Security Complex. The corrective action conditions require that the SWMUs and AOCs be investigated and, as necessary, remediated.

Table 5.5. Oak Ridge National Laboratory Resource Conservation and Recovery Act operating permits, 2015

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

[a]Treatment operating units within TWPC facilities.
[b] On September 15, 2015, the ORR Hazardous Waste Corrective Action Permit TNHW-121 was reissued as TNHW-164.

Acronyms
TWPC = Transuranic Waste Processing Center
WPB = Waste Processing Building

Reporting is required for hazardous waste activities on 42 active waste streams at ORNL, some of which are mixed wastes. The quantity of hazardous/mixed waste generated at ORNL in 2015 was 661,044 kg, with mixed wastewater accounting for 556,428 kg. Excluding the wastewater, 2015 hazardous waste generation decreased by about 2.5%. This reduction is attributed to a decrease in macroencapsulation of hazardous waste. ORNL generators treated 4,395 kg of hazardous/mixed waste by elementary neutralization, silver recovery, and deactivation. Ninety-four kg of hazardous/mixed radioactive waste was received from East Tennessee Technology Park and 228 kg waste was received from UT-Battelle generators at the Y-12 National Security Complex, all of which was stored at ORNL and subsequently shipped off site for treatment and disposal. The quantity of hazardous/mixed waste treated in RCRA-permitted treatment facilities at ORNL in 2015 was 1,406 kg. This included waste treated by macroencapsulation, size reduction, and stabilization/solidification. In addition, 556,428 kg of mixed waste was treated at an on-site wastewater treatment facility. The amount of hazardous/mixed waste shipped off site to commercial treatment, storage, and disposal facilities decreased about 4.5% to 108,151 kg in 2015.

In April 2015, TDEC conducted an annual RCRA inspection of ORNL generator areas; battery collection areas; RCRA-permitted treatment, storage, and disposal facilities; and RCRA records. During the inspection, all records and areas were found to be in compliance with RCRA regulations and the RCRA permits. One recommendation was made for making timely temporary repairs to the flooring in buildings where the flooring acts as part of the secondary containment system.

DOE and UT-Battelle operations at NTRC and CFTF were regulated as “conditionally exempt small-quantity generators” in 2015, meaning that less than 100 kg of hazardous waste per month was generated.

No hazardous/mixed wastes were generated, accumulated, or shipped by DOE or UT-Battelle at the DOE Office of Scientific and Technical Information, the 1916-T2 warehouse, or the 0800 Area in 2015. The 0800 Area is a location on ORR adjacent to ORNL that has been assigned EPA identification number TNR000019760.

5.3.7 Oak Ridge National Laboratory RCRA-CERCLA Coordination

The Federal Facility Agreement for the Oak Ridge Reservation (FFA) (DOE 2014a) is intended to coordinate the corrective action processes of RCRA required under the Hazardous and Solid Waste Amendments permit with CERCLA response actions. Annual updates for 2015 for ORNL’s SWMUs and AOCs were consolidated with updates for ETTP, the Y-12 Complex, and ORR and were reported to TDEC, DOE, and the EPA Region 4 in January 2016.

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

5.3.7.1 Resource Conservation and Recovery Act Underground Storage Tanks

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

ORNL has four USTs registered with TDEC under Facility ID 0-730089. A summary of the USTs follows.

- Two are in service (petroleum) and meet the current UST standards.
- One (formerly storing petroleum) has been placed into a “temporary closure” status in accordance with the regulations pending permanent closure in the future.

- One is a wastewater treatment tank that is exempt from regulation.

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

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

In 1989, ORR was placed on the EPA NPL. In 1992, the ORR FFA among EPA, TDEC, and DOE became effective and established the framework and schedule for developing, implementing, and monitoring remedial actions (RAs) on ORR. The on-site CERCLA Environmental Management Waste Management Facility (EMWMF) is operated by UCOR for DOE. Located in Bear Creek Valley, EMWMF is used for disposal of waste resulting from CERCLA cleanup actions on ORR, including ORNL. EMWMF is an engineered landfill that accepts low-level radioactive, hazardous, asbestos, and polychlorinated biphenyl (PCB) wastes and combinations of the aforementioned 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 are regulated under the Toxic Substance Control Act (TSCA). PCB waste generation, transportation, and storage at ORNL are regulated under EPA ID TN1890090003. In 2015, UT-Battelle operated 16 PCB waste storage areas. When longer-term storage was necessary, PCB/radioactive wastes were stored in RCRA-permitted storage buildings at ORNL. Two PCB waste storage areas were operated at UT-Battelle facilities at the Y-12 Complex. The continued use of authorized PCBs in electrical systems and/or equipment (e.g., transformers, capacitors, rectifiers) is regulated at ORNL. Most of the equipment at ORNL that required regulation under TSCA has been disposed of. However, some of the ORNL facilities at the Y-12 Complex continue to use (or store for future reuse) PCB equipment.

Because of the age of many of the ORNL facilities and the varied uses for PCBs in gaskets, grease, building construction, and equipment, DOE self-disclosed unauthorized use of PCBs to EPA in the late 1980s. As a result, DOE and ORNL contractors negotiated a compliance agreement with EPA (see Chapter 2) to address the compliance issues related to these unauthorized uses and to allow for continued use pending decontamination or disposal. As a result of that agreement, DOE continues to notify EPA when additional unauthorized uses of PCBs, such as PCBs in paint, adhesives, electrical wiring, or floor tile, are found at ORNL.

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

The Emergency Planning and Community Right-to-Know Act (EPCRA) and Title III of SARA require that facilities report inventories and releases of certain chemicals that exceed specific release thresholds. The reports are submitted to the local emergency planning committee and the state emergency response commission. Table 5.6 describes the main elements of EPCRA. UT-Battelle complied with these requirements in 2015 through the submittal of reports under EPCRA Sections 302, 303, 311, 312, and 313. These reports contain information on all DOE prime contractors and their subcontractors who reported activities at the ORNL site.

ORNL had no releases of extremely hazardous substances, as defined by EPCRA, in 2015. Releases of toxic chemicals that were greater than the Section 313 designated reportable threshold quantities are discussed in Section 5.3.10.2.

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

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

Acronyms
EPA = US Environmental Protection Agency
EPCRA = Emergency Planning and Community Right-to-Know Act

5.3.10.1 Material Safety Data Sheet/Chemical Inventory (Section 312)

Inventories, locations, and associated hazards of hazardous chemicals and/or extremely hazardous substances were submitted in an annual report to the E-Plan – Emergency Response Information System as required by the State of Tennessee. In 2015, there were 17 hazardous chemicals and/or extremely hazardous substances at ORNL met EPCRA reporting criteria.

Private-sector lessees were not included in the 2015 submittals. Under the terms of their leases, lessees must evaluate their own inventories of hazardous and extremely hazardous chemicals and must submit information as required by the regulations.

5.3.10.2 Toxic Chemical Release Reporting (EPCRA Section 313)

DOE submits annual toxic release inventory reports to EPA and TDEC on or before July 1 of each year. The reports cover the previous calendar year and address releases of certain toxic chemicals to air, water, and land and waste management, recycling, and pollution prevention activities. Threshold determinations and reports for each of the ORR facilities are made separately. Operations involving toxic release inventory 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 other waste management activities were calculated for each chemical that exceeded one or more of the thresholds.

For CY 2015, ORNL reported on the “otherwise use” of nitric acid and the “manufacture” of nitrate compounds in quantities greater than the designated reportable threshold quantities. Most of the nitric acid was used in wastewater treatment operations at the Process Waste Treatment Complex (PWTC). Nitrate compounds are coincidentally manufactured as by-products of neutralizing the nitric acid waste and as by-products of sewage treatment.

5.3.11 US Department of Agriculture/Tennessee Department of Agriculture

USDA, through Animal and Plant Health Inspection Services, issues permits for the import, transit, and controlled release of regulated animals, animal products, veterinary biologics, plants, plant products, pests, organisms, soil, and genetically engineered organisms. The Tennessee Department of Agriculture issues agreements and jointly regulates domestic soil. In 2015, UT-Battelle personnel had a combined 46 permits and agreements for the receipt, movement, or controlled release of regulated articles.

5.3.12 Wetlands

In May 2015, vegetation parameters were measured at the ORNL parking structure wetland approximately 4 years after mitigation that took place in 2011. The percentage of cover by species was measured for each plot. Information was also taken on any fauna present at the time of the survey. Five years of data, including the data collected during the year of mitigation, have shown excellent overall vegetation coverage, providing good quality habitat. Vegetation growing in the wetland in 2015 included both planted and volunteer plant species. There was a noted increase in black willow, sycamore, and green ash saplings. Climbing hempweed, an invasive, continues to infiltrate the west end of the wetland; however, the spread is being controlled by the UT-Battelle grounds crew. A good variety of fauna was noted in and around the wetland, including birds, frogs, and benthic macroinvertebrates.

Stream habitat assessments were conducted at both First Creek and WOC reaches using Habitat Assessment Data Sheets found in the Tennessee Mitigation Guidelines. Metrics evaluated at both sites included epifaunal substrate, embeddedness (e.g., the amount of silt between rocks), velocity/depth regime, sediment deposition, channel flow, frequency of riffles, bank stability, and vegetative cover (Fig. 5.8). Metrics evaluated were measured using rapid bioassessment protocols for use in wadeable streams and rivers (Barbour et al. 1999).

Fig. 5.8. First Creek Mitigation site in 2015. *[Photo by Neil Giffen]*

First Creek mitigation activities had already been completed before the first habitat assessment, which was conducted in 2011. The 2015 survey represented the fifth formal assessment of postmitigation conditions. Premitigation conditions for First Creek are discussed qualitatively based on information contained in previous reports (Ryon and Quarles 2008; Giffen, Ryon, and Jett 2011). The 2015 WOC habitat assessment was based on habitat conditions about 4 years after mitigation.

Riparian zone vegetation surveys were conducted by establishing 32.8 × 16.4 ft plots 32.8 ft apart (First Creek—east bank, WOC—north and south banks). Eleven plots were established at First Creek, and 13 plots were established at WOC. For each plot the following parameters were measured: trees (≥ 3 in. diam at breast height)—measured, shrub stems (< 3 in. diameter at breast height)—counted, percent groundcover, percent canopy cover, canopy height, and vegetation overhang (in centimeters) for each stream bank.

Fish and benthic community monitoring results were evaluated as an indicator of whether or not the stream sections were functioning as suitable habitat for instream organisms. Benthic macroinvertebrate community data were gathered at First Creek (July 9, 2015) and WOC (July 9, 2015) using an EPA-approved rapid qualitative assessment technique. At each site seven aquatic habitats were identified and sampled for aquatic macroinvertebrates, riffles, leaf packs, woody debris, rocks, root wads, aquatic vegetation, and instream sediment deposition. These habitats were located within 328 ft upstream and downstream of the sampling site established along each reach. Habitats missing from the site were not sampled. After all habitats were sampled, a tally of each insect family was completed to determine the number of families represented by Ephemeroptera, Plecoptera, and Trichoptera (EPT). Biological Monitoring and Abatement Plan (BMAP) fish survey data used for evaluation of First Creek were from fishes in close proximity to the subject reach. The fish community data used for evaluation of the WOC site were from data taken during routine BMAP surveys within the subject reach. The fish communities within the reaches were monitored using a multiple-pass removal estimate method (Ryon 2011). The sample sites were isolated by block nets, multiple passes were made using backpack or barge electrofishers, and all stunned fish were collected. Fish were identified by species, measured for length and weight, and returned to the site.

The results of habitat measurements conducted along the First Creek reach in 2015 showed that the creek continued to provide good overall habitat and that it remained in an unimpaired state. The relatively linear condition of the creek was evidence of past channelization with the development of the area. Relatively narrow riparian zones are a weakness of the site from the perspective of providing good quality habitat. However, riparian zones in this area are restricted by paved and landscaped areas because the creek runs through a developed area. Mitigation plantings on the east side of the creek have improved habitat quality in that area over original habitat conditions, which included large mowed turf grass areas and a high number of invasive plant species. The riparian zone on the west side is highly restricted because of the close proximity of landscaped and parking areas associated with a building complex. Cover is maintained to the maximum extent possible in that narrow zone. Invasive plants were not found to be a major concern, with only a slight increase from the previous year. Invasive plant management was conducted for winter creeper and Bradford pear in fall 2015.

Good plant survivorship was noted. The number of dead or dying plants was higher than in 2014 but similar to that recorded in 2013. In general, planted vegetation appears to be thriving, and regeneration is evident. Dense growths of shrubs previously existing on the site (e.g., silky dogwood, spicebush) provided significant cover along the creek banks, particularly along northern portions of the study area. Both percent canopy cover and ground cover increased. Plant species diversity showed a significant increase from the 2014 survey. Overall conditions at the site related to vegetation growth and success remain very good.

A moderately diverse benthic macroinvertebrate population was recorded at the First Creek site in 2015, with a slight increase since 2014. It included some less-tolerant taxa typically found in clear streams. The number of fish species increased slightly compared to 2014 for both downstream and upstream sampling locations for the October–December sampling period. For the March–May sampling period, number of fish species decreased slightly for the downstream sampling location and remained the same for the upstream sampling location in comparison with the number of species found in 2014. The frequency of riffles in the creek increased slightly since 2014.

An increase in plant species diversity was observed at the WOC reach, and plant survivorship remains good. However, of the mitigation plantings, a total of 52 dead or dying plants were noted along the stretch. A number of plants have volunteered into many of the areas to fill gaps that may have been left by the dead plants, but an area on the northwest end of the site has been identified as being in need of supplemental planting; plans will be made to address that area The percentage of groundcover slightly decreased and percent canopy cover increased since 2014. The percentage of invasive species increased fairly significantly from that recorded in 2014. However, the percentage for invasive winter creeper decreased from that recorded in 2014. This is believed to be due to concentrated efforts to control this species. The area will be evaluated for overall treatment of invasive plant species.

5.3.13 Radiological Clearance of Property at Oak Ridge National Laboratory

5.3.13.1 General Property Clearance Processes

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

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

- documents, mail, diskettes, compact disks, and other office media;
- nonradioactive items or materials received that are immediately (within the same shift) determined to have been delivered in error or damaged;
- personal items or materials;
- paper, plastic products, aluminum beverage cans, toner cartridges, and other items released for recycling;
- office trash;
- housekeeping materials and associated waste;
- breakroom, cafeteria, and medical wastes;
- compressed gas cylinders and fire extinguishers;
- medical and bioassay samples; and
- other items with an approved release plan.

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

When the process knowledge approach is used, the item's custodian is required to sign a statement that specifies the history of the material and confirms that no radioactive material has passed through or contacted the item. This process knowledge certification is more stringent than what is allowed by DOE Order 458.1 (DOE 2011b) in that ORNL requires an individual to take personal responsibility and accountability for knowing the complete history of an item before it can be cleared using process knowledge alone. DOE 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 100% 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 clearance of bulk items with low contamination potential. For such projects, survey and release plans are developed based on guidance from the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (NRC 2000) or the *Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual* (MARSAME) (NRC 2009). MARSSIM and MARSAME allow for statistically based survey protocols that typically require survey measurements for a representative portion of the items being released. The survey protocols are documented in separate survey and release plans, and the measurements from such surveys are documented in radiological release survey reports.

UT-Battelle continues to use the preapproved authorized limits for surface contamination established in Table IV-1 of DOE Order 5400.5 (cancelled in 2011) and the November 17, 1995, Pelletier memorandum (Pelletier 1995) for TRU alpha contamination. UT-Battelle also continues to follow the requirements of the scrap metal suspension. No scrap metal directly released from radiological areas is being recycled. In 2015, UT-Battelle cleared more than 15,000 items through the excess items and property sales processes. A summary of items requested for release through these processes (including donations, transfers, landfill, reutilization, and sales) is shown in Table 5.7.

Table 5.7. Excess items requested for release and/or recycling, calendar year 2015

	Process knowledge	Radiologically surveyed
Release request totals for calendar year 2015		
Computers-for-Learning	44	0
DOE donations	0	0
Other donations	912	196
LEDP (donations to colleges/universities)	28	6
DOE transfers	503	156
Other federal agency transfers	434	38
Landfill	0	0
Reuse at ORNL	510	66
Sales	11,005	2,116
Totals	13,436	2,578
Recycling request totals for calendar year 2015		
Cardboard (tons)	125.15	
Scrap metal (nonradiological areas) (tons)	794.33	
Used tires (each)	611	
Used batteries (pounds)	29,031	

Acronyms
DOE = US Department of Energy
LEDP = Laboratory Equipment Donation Program
ORNL = Oak Ridge National Laboratory
PCB = polychlorinated biphenyl

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

The Spallation Neutron Source (SNS) and High Flux Isotope Reactor (HFIR) facilities provide unique neutron scattering experiment capabilities that allow researchers to explore the properties of various materials by exposing samples to well-characterized neutron beams. Because materials exposed to neutrons can become radioactive, a process has been developed to evaluate and clear samples for release to off-site facilities. DOE regulations and orders governing radiological release of material do not specifically cover items that may have radioactivity distributed throughout the volume of the material. To address sample clearance, activity-based limits were established using the authorized limits process defined in DOE O 458.1 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., US Nuclear Regulatory Commission licensing regulations). Implementation of the clearance limits involves use of unique instrument screening and sample activity prediction methods to provide an efficient and defensible process to release neutron scattering experiment samples to researchers without further DOE control.

The approved revised process for notification was continued in 2015. In 2015 ORNL cleared 101 samples from neutron scattering experiments using the SNS and HFIR sample authorized limits process.

5.4 Air Quality Program

5.4.1 Construction and Operating Permits

Permits issued by the State of Tennessee convey the clean air requirements that are applicable to ORNL. New projects are governed by construction permits until the projects are converted to operating status. The sitewide Title V Major Source Operating Permits include requirements that are generally applicable to large operations such as national laboratories (e.g., asbestos and stratospheric ozone) as well as specific requirements directly applicable to individual air emission sources. Source-specific requirements include Rad-NESHAPs (see Section 5.4.3), requirements applicable to sources of ambient air criteria pollutants, and requirements applicable to sources of other hazardous air pollutants (HAPs) (nonradiological). In September 2011 the State of Tennessee issued Title V Major Source Operating Permit 562765 to DOE and UT-Battelle operations at ORNL. This permit was modified in 2013 and 2014 to reflect current operations. In January 2015, TDEC issued a construction permit for 3 new duel fuel fired boilers. DOE and UT-Battelle also maintained a valid minor source operating permit with the Knox County Air Quality Management Division for NTRC facilities located in Knox County.

In 2012 UT-Battelle applied for and received construction permit number 965103P for the construction of CFTF, located off-site at the Horizon Center Business Park in Oak Ridge, Tennessee. The initial start-up of CFTF occurred in March 2013. In accordance with provisions of the construction permit an emissions test was performed in July 2013 and confirmed that the hydrogen cyanide (HCN) mass emission rate was 0.0024 lb/h, far less than the maximum hourly emission rate of 0.05 lb/h established in the permit. The test results were provided to TDEC, and DOE–UT-Battelle applied for a Title V Major Source Operating Permit for CFTF in 2014. However, based on conversations with TDEC Division of Air Pollution Control, UT-Battelle has determined that potential HCN emissions will be below the major source threshold for Title V facilities, and UT-Battelle applied for True Minor Source Operating Permit for CFTF in April 2015. As a True Minor Facility, potential emissions of HCN are determined to less than 2 tons per year as opposed to Major Source Threshold of 10 tons per year. Potential emissions do not take into account the thermal oxidizer control efficiency rated at 99%. A construction permit was also obtained in 2013 for the CFTF emergency generator. The True Minor Source Operating Permit for the facility and its emergency generator is anticipated to be issued in 2016.

DOE WAI /NWSol has two Title V Major Source Operating Permits for one emission source and two emergency generators at TWPC. DOE Isotek has a Title V Major Source Operating Permit for the Radiochemical Development Facility (Building 3019 complex). During 2015, no permit limits were exceeded. UCOR also has a Title V Major Source Operating Permit for the 3039 stack and the 3608 air stripper. No permit limits were exceeded for these sources in 2015.

5.4.2 National Emission Standards for Hazardous Air Pollutants—Asbestos

Numerous facilities, structures, facility components, and various pieces of equipment at ORNL contain asbestos-containing material (ACM). UT-Battelle's Asbestos Management Program manages the compliance of work activities involving the removal and disposal of ACM, which include notifications to TDEC for all demolition activities and required renovation activities, approval of asbestos work authorization requests, current use of engineering controls and work practices, inspections, air monitoring, and waste tracking of asbestos-contaminated waste material. During 2015, there were no deviations or releases of reportable quantities of ACM.

5.4.3 Oak Ridge National Laboratory Radiological Airborne Effluent Monitoring

Radioactive airborne discharges at ORNL consist primarily of ventilation air from radioactively contaminated or potentially contaminated areas, vents from tanks and processes, and ventilation for hot cell operations and reactor facilities. (See Appendix E, Table E.1, for a list of radionuclides and associated radioactive half-lives.) 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, adsorbable gases (e.g., iodine), tritium, and nonadsorbable gases (e.g., noble gases).

The major radiological emission point sources for ORNL consist of the following seven stacks. Six are located in Bethel and Melton Valleys and one, the SNS Central Exhaust Facility stack, is located on Chestnut Ridge (Fig. 5.9).

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

In 2015 there were 14 minor point/group sources, and emission calculations/estimates were made for each of them.

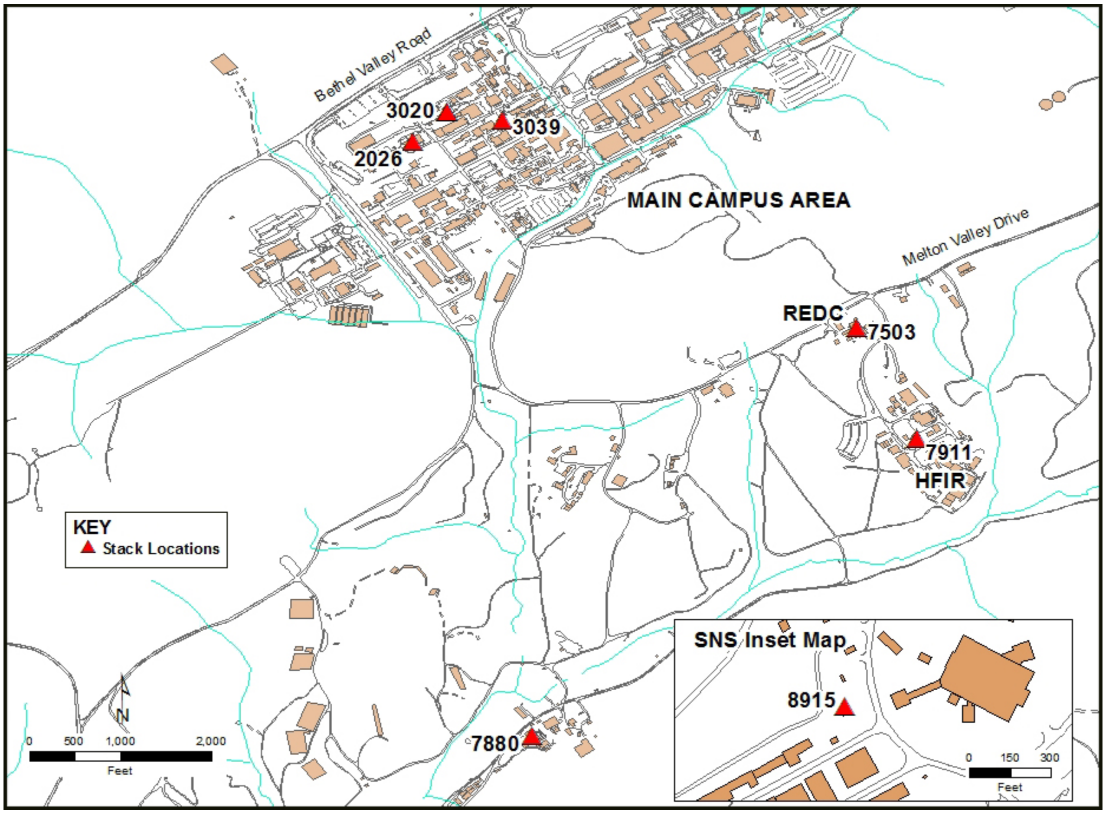


Fig. 5.9. Locations of major radiological emission points at Oak Ridge National Laboratory. *(HFIR = High Flux Isotope Reactor, REDC = Radiochemical Engineering Development Center, and SNS = Spallation Neutron Source.)*

5.4.3.1 Sample Collection and Analytical Procedure

Four of the major point sources (stacks 2026, 3020, 3039, and 7503) are equipped with in-stack source-sampling systems that comply with criteria in the American National Standards Institute (ANSI) standard ANSI N 13.1-1969R (ANSI 1969). The sampling systems generally consist of a multipoint in-stack sampling probe, a sample transport line, a particulate filter, activated charcoal cartridges, a silica gel cartridge (if required), flow-measurement and totalizing instruments, a sampling pump, and a return line to the stack. The 7911 (Melton Valley complex) and 7880 (TWPC) stacks are equipped with in-stack source-sampling systems that comply with criteria in the ANSI–Health Physics Society standard ANSI/HPS N13.1-1999 (ANSI 1999).

The 7911 sampling system has the same components as the ANSI 1969 sampling systems but uses a stainless-steel-shrouded probe instead of a multipoint in-stack sampling probe. The sampling system also consists of a high-purity germanium detector with an analog-to-digital converter) and ORTEC GammaVision software, which allows for continuous isotopic identification and quantification of radioactive noble gases (e.g., ^{41}Ar) in the effluent stream. The 7880 sampling system consists of a stainless-steel-shrouded probe, an in-line filter-cartridge holder placed at the probe to minimize line losses, a particulate filter, a sample transport line, a rotary vane vacuum pump, and a return line to the stack. The sample probes from both the ANSI 1969 and ANSI 1999 stack sampling systems are removed, inspected, and cleaned annually. The 8915 (SNS Central Exhaust Facility) stack is equipped with an in-stack radiation detector that complies with criteria in ANSI/HPS N13.1-1999. The detector monitors radioactive gases flowing through the exhaust stack and provides a continual readout of detected activity using a scintillator probe. The detector is calibrated to correlate with isotopic emissions.

Velocity profiles are performed quarterly at major and some minor sources; the criteria in EPA Method 2 (EPA 2010) are followed. The profiles provide accurate stack flow data for subsequent emission-rate calculations. An annual leak-check program is carried out to verify the integrity of the sample transport system. For the 7880 stack, an annual comparison between the effluent flow rate totalizer and EPA Method 2 is performed. The stack effluent-flow-rate monitoring system response is checked quarterly with the manufacturer's instrument test procedures. The stack sampler rotameter is calibrated at least quarterly in comparison with a secondary (transfer) standard. Only a certified secondary standard is used for all rotameter tests.

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

The charcoal cartridges, particulate filters, and silica-gel traps are collected weekly to biweekly. The use of charcoal cartridges is a standard method for capturing and quantifying radioactive iodine in airborne emissions. Gamma spectrometric analysis of the charcoal samples quantifies the adsorbable gases. Analyses are performed weekly to biweekly. Particulate filters are held for 8 days before a weekly gross alpha and gross beta analysis to minimize the contribution from short-lived isotopes such as ^{220}Rn and its daughter products. At stack 7911, a weekly gamma scan is conducted to better detect short-lived gamma isotopes. The filters are then composited quarterly or semiannually and are analyzed for alpha-, beta-, and gamma-emitting isotopes. At stack 7880, the filters are composited monthly and analyzed for alpha-, beta-, and gamma-emitting isotopes. The sampling system on stack 7880 requires no other type of radionuclide collection media. Compositing provides a better opportunity for quantification of the low-concentration isotopes. Silica-gel traps are used to capture water vapor that may contain tritium. Analysis is performed weekly to biweekly. At the end of the year, the sample probes for all of the stacks are rinsed, except for the 8915 and 7880 probes, and the rinsate is collected and submitted for isotopic analysis identical to that performed on the particulate filters. A probe-cleaning program has been determined unnecessary for 8915 because the sample probe is a scintillator probe used to detect radiation and not to extract a sample of stack exhaust emissions. It is not anticipated that contaminant deposits would collect on the scintillator probe. A probe-cleaning program for 7880 has established that rinse analysis historically showed no detectable contamination. Therefore, the frequency of probe rinse collection and analysis is no more often than every 3 years unless there is an increase in particulate emissions, an increase in detectable radionuclides in the sample media, or process modifications.

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

5.4.3.2 Results

Annual radioactive airborne emissions for ORNL in 2015 are presented in Table 5.8. All data presented were determined to be statistically different from zero at the 95% confidence level. Any number not statistically different from zero was not included in the emission calculation. Because measuring a radionuclide requires counting random radioactive emissions from a sample, the same result may not be obtained if the sample is analyzed repeatedly. This deviation is referred to as the "counting uncertainty." Statistical significance at the 95% confidence level means that there is a 5% chance that the results could be erroneous.

Historical trends for tritium (^{3}H) and ^{131}I are presented in Figs. 5.10 and 5.11. For 2015, tritium emissions totaled about 450.2 Ci (Fig. 5.10), a decrease from 2014 but in line with 2013 emissions; ^{131}I emissions totaled 0.09 Ci (Fig. 5.11), a slight decrease but in line with emissions from the past 3 years. For 2015, the isotopes that contributed 10% or more to the off-site dose at ORNL were ^{234}U, ^{11}C, and ^{238}Pu, with dose contributions of approximately 26%, 25%, and 12%, respectively. Emissions of ^{234}U and ^{238}Pu are associated with a number of sources at ORNL, including 4000 and the Melton Valley area laboratory hoods. Carbon-11 emissions result from SNS operations and research activities. For 2015, ^{234}U emissions totaled 0.029 Ci; ^{11}C emissions totaled 21,900 Ci, almost double that of 2014; and ^{238}Pu emissions totaled 9.08E-04 Ci. Emissions of ^{138}Cs totaled 255 Ci, which was double that of 2014 and ^{41}Ar emissions remained in the same range as 2014, totaling 317 Ci (Fig. 5.12).

The calculated radiation dose to the maximally exposed individual (MEI) from all radiological airborne release points at ORR during 2015 was 0.4 mrem. The dose contribution to the MEI from all ORNL radiological airborne release points was 98.4% of the ORR dose. This dose is well below the NESHAPs standard of 10 mrem and is less than 0.1% of the roughly 300 mrem that the average individual receives from natural sources of radiation. (See Section 7.1.2 for an explanation of how the airborne radionuclide dose was determined.)

Table 5.8. Radiological airborne emissions from all sources at ORNL, 2015 (Ci)[a]

Isotope	Inhalation form	Chemical form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor source	ORNL total
^{225}Ac	M	particulate								1.35E-04	1.35E-04
^{226}Ac	M	particulate								8.50E-06	8.50E-06
^{227}Ac	M	particulate								2.89E-07	2.89E-07
^{228}Ac	M	particulate								2.34E-05	2.34E-05
^{110m}Ag	M	particulate								5.68E-05	5.68E-05
^{110m}Ag	S	particulate					2.09E-06				2.09E-06
^{111}Ag	M	particulate								1.05E-03	1.05E-03
^{241}Am	M	particulate	5.02E-08	1.78E-07				4.12E-08		9.71E-06	9.98E-06
^{241}Am	F	particulate			3.22E-07	2.50E-08	1.25E-06			1.95E-07	1.79E-06
^{243}Am	M	particulate								6.92E-09	6.92E-09
^{41}Ar	B	unspecified						2.31E+02	8.59E+01		3.17E+02
^{131}Ba	M	particulate								1.23E-04	1.23E-04
^{137m}Ba	B	unspecified								1.16E-12	1.16E-12
^{139}Ba	M	particulate						3.20E-01			3.20E-01
^{140}Ba	M	particulate						3.71E-04		3.43E-04	7.14E-04
^{140}Ba	S	particulate					2.82E-05				2.82E-05
^{7}Be	M	particulate	1.96E-07	9.30E-08				3.65E-07		3.08E-06	3.74E-06
^{7}Be	S	particulate			4.71E-06		1.93E-05			5.22E-07	2.45E-05
^{211}Bi	B	unspecified								1.21E-08	1.21E-08
^{212}Bi	M	particulate								2.00E-07	2.00E-07
^{214}Bi	M	particulate								1.23E-13	1.23E-13
^{249}Bk	M	particulate								7.00E-11	7.00E-11
^{11}C	G	dioxide							2.19E+04		2.19E+04
^{14}C	M	particulate								1.03E-12	1.03E-12
^{45}Ca	M	particulate								1.40E-09	1.40E-09
^{47}Ca	M	particulate								1.57E-10	1.57E-10

Table 5.8 (continued)

Isotope	Inhalation form	Chemical form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor source	ORNL total
^{115}Cd	M	particulate									
^{139}Ce	M	particulate								3.76E-06	3.76E-06
^{141}Ce	M	particulate						8.04E-07		2.06E-04	2.07E-04
^{144}Ce	M	particulate								4.86E-05	4.86E-05
^{252}Cf	M	particulate						1.52E-09		1.73E-08	1.88E-08
^{36}Cl	M	particulate								5.50E-15	5.50E-15
^{242}Cm	M	particulate								8.00E-14	8.00E-14
^{243}Cm	M	particulate	6.95E-08					4.22E-10		2.85E-12	6.99E-08
^{243}Cm	F	particulate				1.25E-08	7.29E-07			1.19E-07	8.61E-07
^{244}Cm	M	particulate	6.95E-08					4.22E-10		3.76E-06	3.83E-06
^{244}Cm	F	particulate				1.25E-08	7.29E-07			1.19E-07	8.61E-07
^{245}Cm	M	particulate								2.97E-10	2.97E-10
^{246}Cm	M	particulate								5.95E-15	5.95E-15
^{247}Cm	M	particulate								6.84E-14	6.84E-14
^{248}Cm	M	particulate								1.11E-13	1.11E-13
^{57}Co	M	particulate								1.26E-13	1.26E-13
^{58}Co	M	particulate								1.77E-12	1.77E-12
^{60}Co	M	particulate								2.65E-05	2.65E-05
^{60}Co	S	particulate					2.71E-06				2.71E-06
^{51}Cr	M	particulate								2.03E-04	2.03E-04
^{132}Cs	F	particulate								7.64E-05	7.64E-05
^{134}Cs	F	particulate								1.81E-06	1.81E-06
^{134}Cs	S	particulate					1.95E-06				1.95E-06
^{136}Cs	F	particulate								2.26E-04	2.26E-04
^{137}Cs	F	particulate	9.97E-06	1.45E-06				5.35E-06		4.84E-04	5.01E-04
^{137}Cs	S	particulate			3.43E-05	3.36E-08	2.18E-06			4.90E-04	5.27E-04
^{138}Cs	F	particulate						2.55E+02			2.55E+02

Table 5.8 (continued)

Isotope	Inhalation form	Chemical form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor source	ORNL total
^{64}Cu	M	particulate								8.17E-07	8.17E-07
^{66}Cu	B	unspecified								1.93E-13	1.93E-13
^{67}Cu	M	particulate								3.72E-09	3.72E-09
^{152}Eu	M	particulate								2.57E-04	2.57E-04
^{154}Eu	M	particulate								4.86E-05	4.86E-05
^{155}Eu	M	particulate								5.09E-06	5.09E-06
^{55}Fe	M	particulate								3.86E-06	3.86E-06
^{59}Fe	M	particulate								9.41E-07	9.41E-07
^{72}Ga	M	particulate								2.08E-12	2.08E-12
^{153}Gd	M	particulate								2.96E-10	2.96E-10
^{71}Ge	M	particulate								2.46E-09	2.46E-09
^{3}H	V	vapor	3.50E-02		3.85E+00	8.25E-01		1.10E+02	3.35E+02	5.16E-01	4.50E+02
^{175}Hf	M	particulate								1.42E-08	1.42E-08
^{178m}Hf	M	particulate								4.01E-11	4.01E-11
^{181}Hf	M	particulate								3.21E-07	3.21E-07
^{203}Hg	M	inorganic								6.12E-14	6.12E-14
^{166m}Ho	M	particulate								1.20E-04	1.20E-04
^{124}I	V	vapor								3.59E-16	3.59E-16
^{125}I	F	particulate								3.28E-05	3.28E-05
^{125}I	V	vapor								5.62E-10	5.62E-10
^{126}I	V	vapor								4.11E-10	4.11E-10
^{129}I	F	particulate								1.83E-05	1.83E-05
^{129}I	V	vapor					5.48E-06			8.94E-13	5.48E-06
^{130}I	V	vapor								2.28E-32	2.28E-32
^{131}I	F	particulate						9.15E-02		1.90E-04	9.17E-02
^{131}I	V	vapor			3.54E-06		1.71E-05			4.28E-07	2.11E-05
^{132}I	F	particulate						5.34E-01			5.34E-01

Table 5.8 (continued)

Isotope	Inhalation form	Chemical form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor source	ORNL total
^{133}I	V	vapor			6.01E-05					1.73E-35	6.01E-05
^{133}I	F	particulate						3.82E-01			3.82E-01
^{134}I	F	particulate						6.00E-01			6.00E-01
^{135}I	F	particulate						1.03E+00			1.03E+00
^{114m}In	M	particulate								4.50E-13	4.50E-13
^{192}Ir	M	particulate								1.27E-11	1.27E-11
^{40}K	M	particulate								7.99E-05	7.99E-05
^{79}Kr	B	unspecified								1.60E-29	1.60E-29
^{81}Kr	B	unspecified								3.49E-15	3.49E-15
^{85}Kr	B	unspecified						6.40E+02		3.52E-07	6.40E+02
^{85m}Kr	B	unspecified						3.27E+00			3.27E+00
^{87}Kr	B	unspecified						2.41E+01			2.41E+01
^{88}Kr	B	unspecified						3.67E+01	1.63E+02		2.00E+02
^{89}Kr	B	unspecified						2.47E+01			2.47E+01
^{140}La	M	particulate						5.50E-02		4.46E-05	5.50E-02
^{140}La	S	particulate					1.26E-05				1.26E-05
^{172}Lu	M	particulate								3.61E-12	3.61E-12
^{177}Lu	M	particulate								9.28E-11	9.28E-11
^{177m}Lu	M	particulate								2.20E-12	2.20E-12
^{27}Mg	B	unspecified								1.09E-33	1.09E-33
^{54}Mn	M	particulate								1.94E-07	1.94E-07
^{54}Mn	S	particulate					2.22E-06				2.22E-06
^{56}Mn	M	particulate								2.00E-18	2.00E-18
^{93}Mo	M	particulate								3.88E-10	3.88E-10
^{99}Mo	M	particulate								9.36E-04	9.36E-04
^{13}N	B	unspecified							4.70E+02		4.70E+02
^{22}Na	M	particulate								7.54E-11	7.54E-11

Table 5.8 (continued)

Isotope	Inhalation form	Chemical form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor source	ORNL total
^{24}Na	M	particulate								1.21E-07	1.21E-07
^{91}Nb	B	unspecified								5.30E-11	5.30E-11
^{91m}Nb	B	unspecified								1.20E-11	1.20E-11
^{93m}Nb	M	particulate								2.49E-10	2.49E-10
^{94}Nb	M	particulate								1.46E-12	1.46E-12
^{95}Nb	M	particulate								1.08E-04	1.08E-04
^{95m}Nb	M	particulate								1.50E-15	1.50E-15
^{96}Nb	M	particulate								8.55E-12	8.55E-12
^{147}Nd	M	particulate								2.73E-05	2.73E-05
^{59}Ni	M	particulate								5.36E-11	5.36E-11
^{63}Ni	M	particulate								1.77E-03	1.77E-03
^{65}Ni	M	particulate								3.33E-21	3.33E-21
^{66}Ni	M	particulate								1.92E-13	1.92E-13
^{237}Np	M	particulate								8.80E-04	8.80E-04
^{239}Np	M	particulate								2.02E-09	2.02E-09
^{191}Os	M	particulate								1.86E-12	1.86E-12
^{32}P	M	particulate								2.66E-09	2.66E-09
^{33}P	M	particulate								9.77E-17	9.77E-17
^{228}Pa	M	particulate								4.40E-05	4.40E-05
^{229}Pa	B	unspecified								1.20E-04	1.20E-04
^{230}Pa	M	particulate								1.17E-04	1.17E-04
^{231}Pa	M	particulate								3.54E-10	3.54E-10
^{232}Pa	M	particulate								2.49E-04	2.49E-04
^{233}Pa	M	particulate								2.90E-04	2.90E-04
^{210}Pb	M	particulate								2.53E-11	2.53E-11
^{211}Pb	M	particulate								4.26E-08	4.26E-08
^{212}Pb	M	particulate	3.67E-01	4.41E-01				1.84E-02		1.08E-05	8.26E-01

Table 5.8 (continued)

Isotope	Inhalation form	Chemical form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor source	ORNL total
^{212}Pb	S	particulate			7.27E-01	1.17E-01				1.87E-02	8.63E-01
^{214}Pb	M	particulate								2.50E-13	2.50E-13
^{147}Pm	M	particulate								1.50E-12	1.50E-12
^{148m}Pm	M	particulate								9.41E-07	9.41E-07
^{144}Pr	M	particulate								3.79E-12	3.79E-12
^{144m}Pr	B	unspecified								4.54E-14	4.54E-14
^{238}Pu	M	particulate	6.66E-09	2.17E-08						9.05E-04	9.05E-04
^{238}Pu	F	particulate					1.87E-06			5.07E-07	2.38E-06
^{239}Pu	M	particulate	2.03E-08	3.47E-07				1.58E-08		1.44E-07	5.27E-07
^{239}Pu	F	particulate			4.85E-07	7.60E-09	8.17E-07			3.21E-07	1.63E-06
^{240}Pu	M	particulate	2.03E-08					1.58E-08		3.65E-08	7.25E-08
^{240}Pu	F	particulate			4.85E-07	7.60E-09	8.17E-07			3.21E-07	1.63E-06
^{241}Pu	M	particulate								1.72E-11	1.72E-11
^{242}Pu	M	particulate								4.54E-09	4.54E-09
^{223}Ra	M	particulate								1.63E-05	1.63E-05
^{224}Ra	M	particulate								4.14E-04	4.14E-04
^{225}Ra	M	particulate								2.88E-05	2.88E-05
^{226}Ra	M	particulate								4.51E-08	4.51E-08
^{228}Ra	M	particulate								2.34E-05	2.34E-05
^{186}Re	M	particulate								3.58E-10	3.58E-10
^{188}Re	M	particulate								6.91E-04	6.91E-04
^{189}Re	M	particulate								3.04E-11	3.04E-11
^{103m}Rh	M	particulate								1.27E-14	1.27E-14
^{106}Rh	B	unspecified								1.29E-12	1.29E-12
^{219}Rn	B	unspecified								2.49E-08	2.49E-08
^{220}Rn	B	unspecified								2.00E-07	2.00E-07
^{103}Ru	M	particulate								3.43E-04	3.43E-04

Table 5.8 (continued)

Isotope	Inhalation form	Chemical form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor source	ORNL total
^{103}Ru	S	particulate					2.73E-06				2.73E-06
^{106}Ru	M	particulate								4.33E-05	4.33E-05
^{35}S	M	particulate								5.00E-08	5.00E-08
^{120m}Sb	M	particulate								3.77E-05	3.77E-05
^{122}Sb	M	particulate								1.71E-10	1.71E-10
^{124}Sb	M	particulate								7.67E-05	7.67E-05
^{125}Sb	M	particulate								3.71E-06	3.71E-06
^{126}Sb	M	particulate								9.32E-05	9.32E-05
^{127}Sb	M	particulate								8.91E-05	8.91E-05
^{44}Sc	M	particulate								1.96E-22	1.96E-22
^{46}Sc	M	particulate								1.36E-08	1.36E-08
^{47}Sc	M	particulate								2.78E-08	2.78E-08
^{48}Sc	M	particulate								2.17E-08	2.17E-08
^{75}Se	F	particulate								1.02E-10	1.02E-10
^{75}Se	S	particulate			5.42E-02		1.53E-06				5.42E-02
^{31}Si	M	particulate								1.15E-23	1.15E-23
^{145}Sm	M	particulate								2.91E-10	2.91E-10
^{151}Sm	M	particulate								1.99E-15	1.99E-15
^{113}Sn	M	particulate								9.02E-10	9.02E-10
^{117m}Sn	M	particulate								5.25E-05	5.25E-05
^{119m}Sn	M	particulate								2.12E-10	2.12E-10
^{121}Sn	M	particulate								3.39E-10	3.39E-10
^{121m}Sn	M	particulate								4.24E-12	4.24E-12
^{123}Sn	M	particulate								1.74E-15	1.74E-15
^{125}Sn	M	particulate								1.20E-04	1.20E-04
^{85}Sr	M	particulate								2.00E-10	2.00E-10
^{89}Sr	M	particulate	6.30E-08	5.15E-07				7.35E-06		3.14E-04	3.22E-04

Table 5.8 (continued)

Isotope	Inhalation form	Chemical form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor source	ORNL total
^{89}Sr	S	particulate			5.85E-06	3.44E-08				1.09E-04	1.15E-04
^{90}Sr	M	particulate	6.30E-08	5.15E-07				7.35E-06		4.16E-04	4.24E-04
^{90}Sr	S	particulate			5.85E-06	3.44E-08	8.87E-06			1.09E-04	1.24E-04
^{182}Ta	M	particulate								2.49E-08	2.49E-08
^{183}Ta	M	particulate								2.97E-06	2.97E-06
^{184}Ta	M	particulate								4.08E-14	4.08E-14
^{160}Tb	M	particulate								5.40E-10	5.40E-10
^{99}Tc	M	particulate								8.17E-07	8.17E-07
^{99}Tc	S	particulate					9.75E-06			6.37E-05	7.35E-05
^{123m}Te	M	particulate								3.42E-06	3.42E-06
^{125m}Te	M	particulate								1.09E-12	1.09E-12
^{127}Te	M	particulate								2.89E-15	2.89E-15
^{127m}Te	M	particulate								2.95E-15	2.95E-15
^{129m}Te	M	particulate								4.60E-05	4.60E-05
^{132}Te	M	particulate								9.89E-05	9.89E-05
^{227}Th	S	particulate								4.20E-04	4.20E-04
^{228}Th	S	particulate	6.54E-09	5.41E-09	6.61E-09	1.30E-09		1.23E-08		2.64E-05	2.64E-05
^{229}Th	S	particulate								2.29E-08	2.29E-08
^{230}Th	S	particulate	8.83E-10	2.79E-09				6.61E-09		7.13E-08	8.16E-08
^{230}Th	F	particulate			1.09E-08	5.92E-10				3.37E-09	1.49E-08
^{231}Th	S	particulate								4.82E-04	4.82E-04
^{232}Th	S	particulate	3.81E-10	2.45E-09				5.43E-09		1.01E-03	1.01E-03
^{232}Th	F	particulate			7.47E-09	4.91E-10				1.47E-09	9.43E-09
^{234}Th	S	particulate								1.08E-11	1.08E-11
^{45}Ti	M	particulate								1.08E-24	1.08E-24
^{208}Tl	B	unspecified								3.20E-06	3.20E-06
^{232}U	M	particulate								2.00E-07	2.00E-07

Table 5.8 (continued)

Isotope	Inhalation form	Chemical form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor source	ORNL total
^{233}U	M	particulate	2.59E-08					1.02E-07		1.30E-04	1.30E-04
^{233}U	S	particulate			2.85E-07	2.98E-08	9.19E-07			1.32E-05	1.44E-05
^{234}U	M	particulate	2.59E-08	3.60E-07				1.02E-07		2.93E-02	2.93E-02
^{234}U	S	particulate			2.85E-07	2.98E-08	9.19E-07			1.32E-05	1.44E-05
^{235}U	M	particulate	5.42E-09	1.70E-07				4.83E-08		7.35E-03	7.35E-03
^{235}U	S	particulate			2.63E-07	1.76E-08	1.50E-06			1.96E-06	3.74E-06
^{236}U	M	particulate								1.29E-04	1.29E-04
^{236}U	S	particulate								3.24E-06	3.24E-06
^{238}U	M	particulate	3.71E-09	1.30E-07				4.46E-08		8.90E-03	8.90E-03
^{238}U	S	particulate			1.82E-07	1.06E-08	1.26E-06			1.18E-06	2.63E-06
^{49}V	M	particulate								9.82E-10	9.82E-10
^{181}W	M	particulate								1.27E-11	1.27E-11
^{185}W	M	particulate								5.02E-09	5.02E-09
^{187}W	M	particulate								8.22E-03	8.22E-03
^{188}W	M	particulate								6.08E-04	6.08E-04
^{127}Xe	B	unspecified							1.57E+02	4.37E-11	1.57E+02
^{129m}Xe	B	unspecified								9.23E-11	9.23E-11
^{131m}Xe	B	unspecified						1.20E+02		6.02E-08	1.20E+02
^{133}Xe	B	unspecified						5.13E+00		5.66E-09	5.13E+00
^{133m}Xe	B	unspecified						2.05E+01		3.45E-16	2.05E+01
^{135}Xe	B	unspecified	7.15E-06					1.14E+01			1.14E+01
^{135m}Xe	B	unspecified						8.87E+00			8.87E+00
^{137}Xe	B	unspecified						3.84E+01			3.84E+01
^{138}Xe	B	unspecified						5.14E+01			5.14E+01
^{88}Y	M	particulate								3.06E-07	3.06E-07
^{88}Y	F	particulate					2.69E-06				2.69E-06
^{90}Y	M	particulate								5.17E-11	5.17E-11

Table 5.8 (continued)

Isotope	Inhalation form	Chemical form	Stack								
			X-2026	X-3020	X-3039	X-7503	X-7880	X-7911	X-8915	Total minor source	ORNL total
^{91}Y	M	particulate								1.16E-13	1.16E-13
^{65}Zn	M	particulate								1.34E-05	1.34E-05
^{65}Zn	F	particulate					5.72E-06				5.72E-06
^{69}Zr	M	particulate								1.45E-09	1.45E-09
^{69m}Zr	M	particulate								4.52E-08	4.52E-08
^{93}Zr	M	particulate								2.19E-13	2.19E-13
^{95}Zr	M	particulate								1.48E-06	1.48E-06
^{95}Zr	S	particulate					4.56E-06				4.56E-06
Totals			**4.02E-01**	**4.41E-01**	**4.63E+00**	**9.42E-01**	**1.40E-04**	**1.58E+03**	**2.31E+04**	**6.05E-01**	**2.47E+04**

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

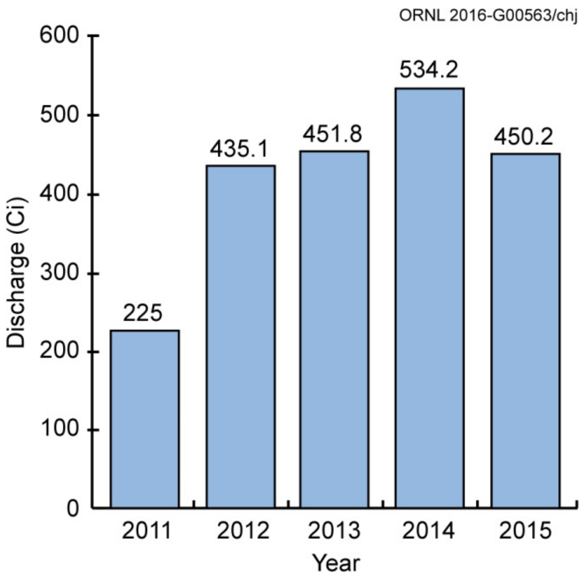


Fig. 5.10. Total curies of tritium discharged from Oak Ridge National Laboratory to the atmosphere, 2011–2015.

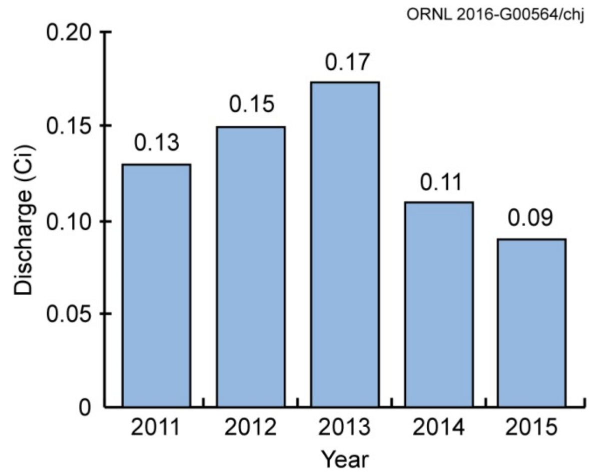


Fig. 5.11. Total curies of 131I discharged from Oak Ridge National Laboratory to the atmosphere, 2011–2015.

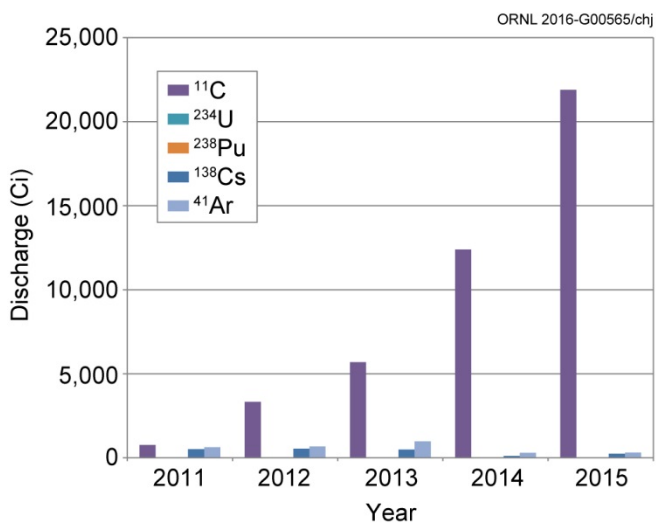


Fig. 5.12. Total discharges of ^{41}Ar, ^{11}C, ^{138}Cs, ^{238}Pu, and ^{234}U from Oak Ridge National Laboratory to the atmosphere, 2011–2015.

5.4.4 Stratospheric Ozone Protection

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

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

5.4.5 Ambient Air

The ORNL ambient air monitoring network consists of three stations located in areas most likely to show the impacts of airborne emissions from ORNL (Fig. 5.13). During 2015 sampling was conducted at each station to quantify levels of tritium; uranium; and gross alpha-, beta-, and gamma-emitting radionuclides (Table 5.9).

The sampling system consists of a low-volume air sampler for particulate collection in a 47 mm glass-fiber filter. The filters are collected biweekly, composited annually, then submitted to an analytical laboratory for analysis. A silica-gel column is used for collection of tritium as tritiated water. Samples are typically collected biweekly or weekly, depending on ambient humidity levels, and composited quarterly for tritium analysis.

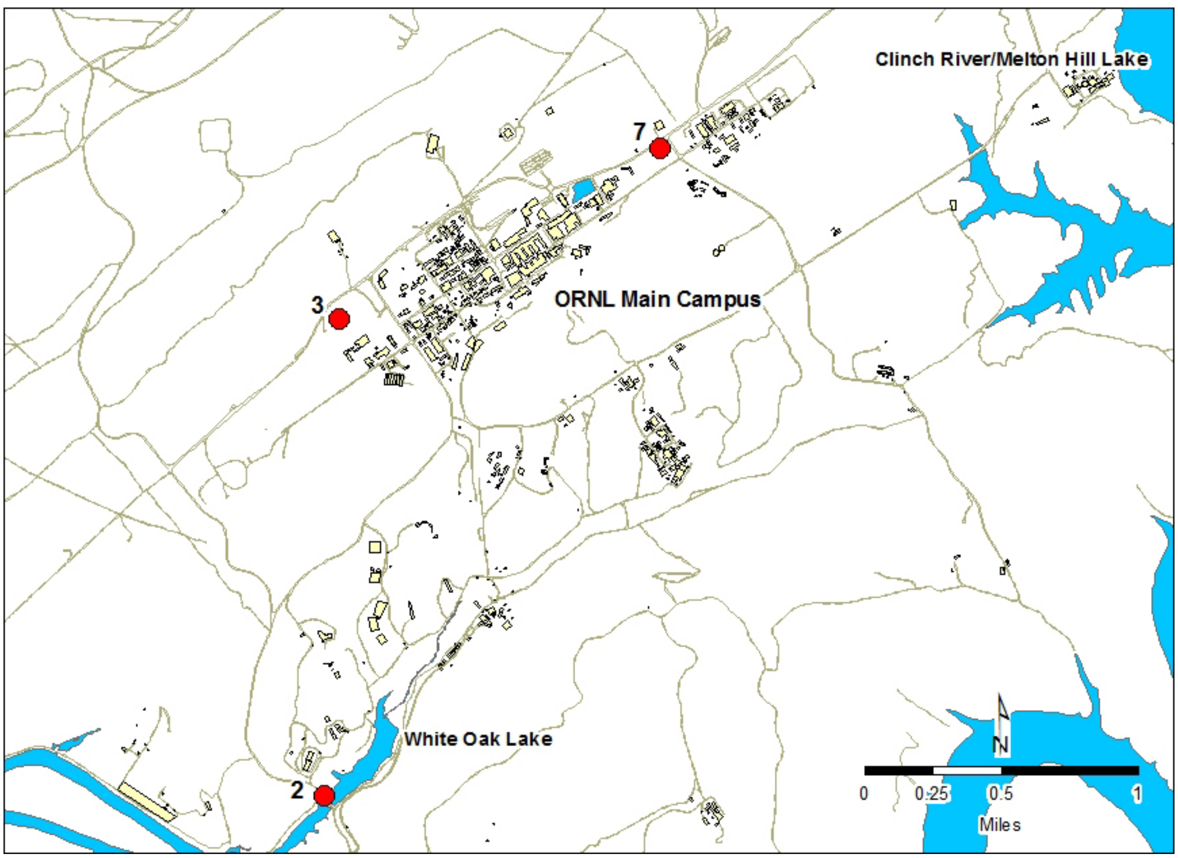


Fig. 5.13. Locations of ambient air monitoring stations at Oak Ridge National Laboratory.

Table 5.9. Radionuclide concentrations (pCi/mL)a measured at Oak Ridge National Laboratory perimeter air monitoring stations, 2015

Parameter	Number detected/ sampled	Concentration		
		Average	Minimum	Maximum
		Station 2		
Alpha	1/1	9.18E-09	*b*	*b*
^{7}Be	1/1	1.73E-08	*b*	*b*
Beta	1/1	1.83E-08	*b*	*b*
^{40}K	0/1	-1.24E-09	*b*	*b*
^{234}U	1/1	4.26E-12	*b*	*b*
^{235}U	0/1	1.11E-13	*b*	*b*
^{238}U	1/1	3.91E-12	*b*	*b*
Total U	1/1	8.29E-12	*b*	*b*
		Station 3		
Alpha	1/1	7.79E-09	*b*	*b*
^{7}Be	1/1	1.93E-08	*b*	*b*
Beta	1/1	1.61E-08	*b*	*b*
^{40}K	0/1	-2.03E-09	*b*	*b*
^{234}U	1/1	6.03E-12	*b*	*b*
^{235}U	0/1	4.21E-14	*b*	*b*
^{238}U	1/1	4.38E-12	*b*	*b*
Total U	1/1	1.04E-11	*b*	*b*
		Station 7		
Alpha	1/1	1.02E-08	*b*	*b*
^{7}Be	1/1	1.97E-08	*b*	*b*
Beta	1/1	1.77E-08	*b*	*b*
^{40}K	0/1	-1.34E-09	*b*	*b*
^{234}U	1/1	5.21E-12	*b*	*b*
^{235}U	1/1	1.37E-12	*b*	*b*
^{238}U	1/1	5.99E-12	*b*	*b*
Total U	1/1	1.26E-12	*b*	*b*

[a] 1 pCi = 3.7×10^{-2} Bq.
[b] Not applicable.

5.4.5.1 Results

The ORNL perimeter air monitoring stations are designed to provide data for collectively assessing the specific impact of ORNL operations on local air quality. Sampling data from these stations (Table 5.9) are compared with derived concentration standards (DCSs) for air established by DOE as guidelines for controlling exposure to members of the public. During 2015, average radionuclide concentrations measured for the ORNL network were less than 1% of the applicable DCSs in all cases.

5.5 Oak Ridge National Laboratory Water Quality Program

NPDES permit TN 0002941, issued to DOE for the ORNL site, was renewed by the State of Tennessee in 2014 and includes requirements for discharging wastewaters from the two ORNL on-site wastewater treatment facilities and for the development and implementation of a water quality protection plan (WQPP). The permit calls for a WQPP to "establish better linkages between water quality monitoring and detecting and abating water quality and ecological impact." Rather than prescribing rigid monitoring schedules, the ORNL WQPP is flexible, allows an annual assessment of all outfalls, and focuses on significant findings. The WQPP goals are to meet the requirements of the NPDES permit, improve the quality of aquatic resources on the ORNL site, prevent further impacts to aquatic resources from current activities, identify the stressors that contribute to impairment of aquatic resources, use available resources efficiently, and communicate outcomes with decision makers and stakeholders.

The ORNL WQPP was developed by UT-Battelle and was approved by TDEC in 2008, and the WQPP monitoring was initiated in 2009. The WQPP incorporated several control plans that were required under the previous NPDES permit, including a BMAP, a chlorine control strategy, a storm water pollution prevention plan, a non-storm-water best management practices plan, and an NPDES radiological monitoring plan. The WQPP has been reviewed and revised annually and submitted to TDEC for review and comment.

To prioritize the stressors and/or contaminant sources that may be of greatest concern to water quality and to define conceptual models that would guide any special investigations, the WQPP strategy was defined using EPA's *Stressor Identification Guidance Document* (EPA 2000). Figure 5.14 summarizes this process. The process involves three major steps for identifying the cause of any impairment:

1. list candidate causes of impairment (based on historical data and a working conceptual model),
2. analyze the evidence (using both case study and outside data), and
3. characterize the causes.

The first two steps of the stressor identification process were initiated in 2009, focusing first on mercury impairment (Fig. 5.15) and then on PCBs because mercury and PCB concentrations in fish from WOC are at or near human health risk thresholds [e.g., EPA ambient water quality criteria (AWQCs) and TDEC fish advisory limits]. Some of the major sources of mercury to biota in the WOC watershed are known, providing a good basis from which to define an appropriate conceptual model for mercury contamination in WOC. A list of potential causes of PCB contamination was also developed.

After potential causes were listed and the available evidence on mercury and PCB contamination in the WOC watershed was analyzed, it was clear that additional investigation was needed to characterize the causes. Special investigations were designed to identify specific source areas and to revise the conceptual model of the major causes of contamination in the WOC watershed.

At the end of each year, monitoring and investigation data collected under the ORNL WQPP are analyzed, interpreted, reported, and compared with past results in the WQPP annual report. This information provides a solid, overall assessment of the status of ORNL's receiving-stream watersheds and the impact of ongoing efforts to protect and restore those watersheds and will guide efforts to improve the water quality in the watershed.

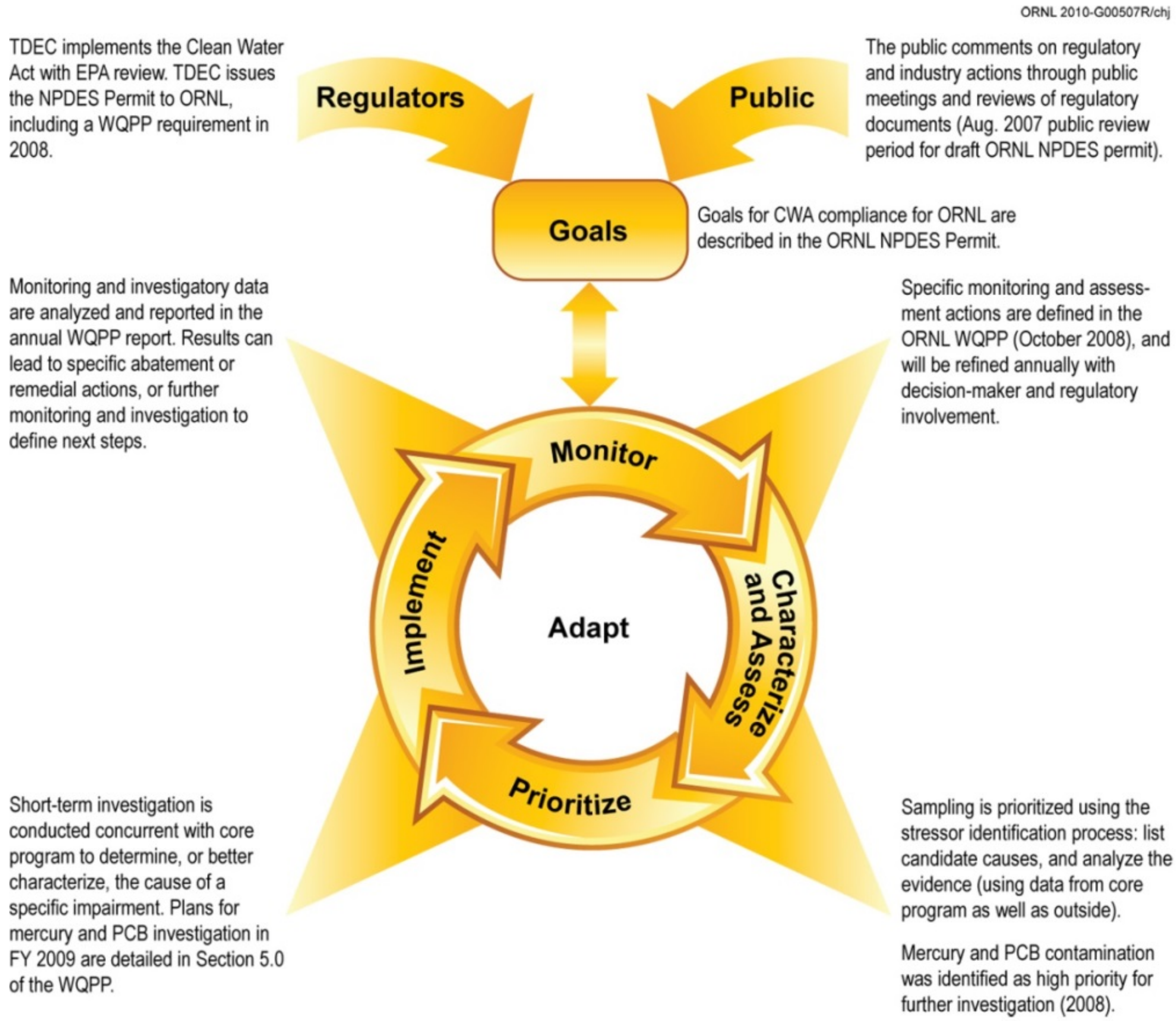


Fig. 5.14. Diagram of the adaptive management framework with step-wise planning specific to the Oak Ridge National Laboratory Water Quality Protection Plan (WQPP). *[Adapted from the US Environmental Protection Agency (EPA) stressor guidance document (EPA 2000). Acronyms: CWA = Clean Water Act, NPDES = National Pollutant Discharge Elimination System, ORNL = Oak Ridge National Laboratory, PCB = polychlorinated biphenyl, TDEC = Tennessee Department of Environment and Conservation.]*

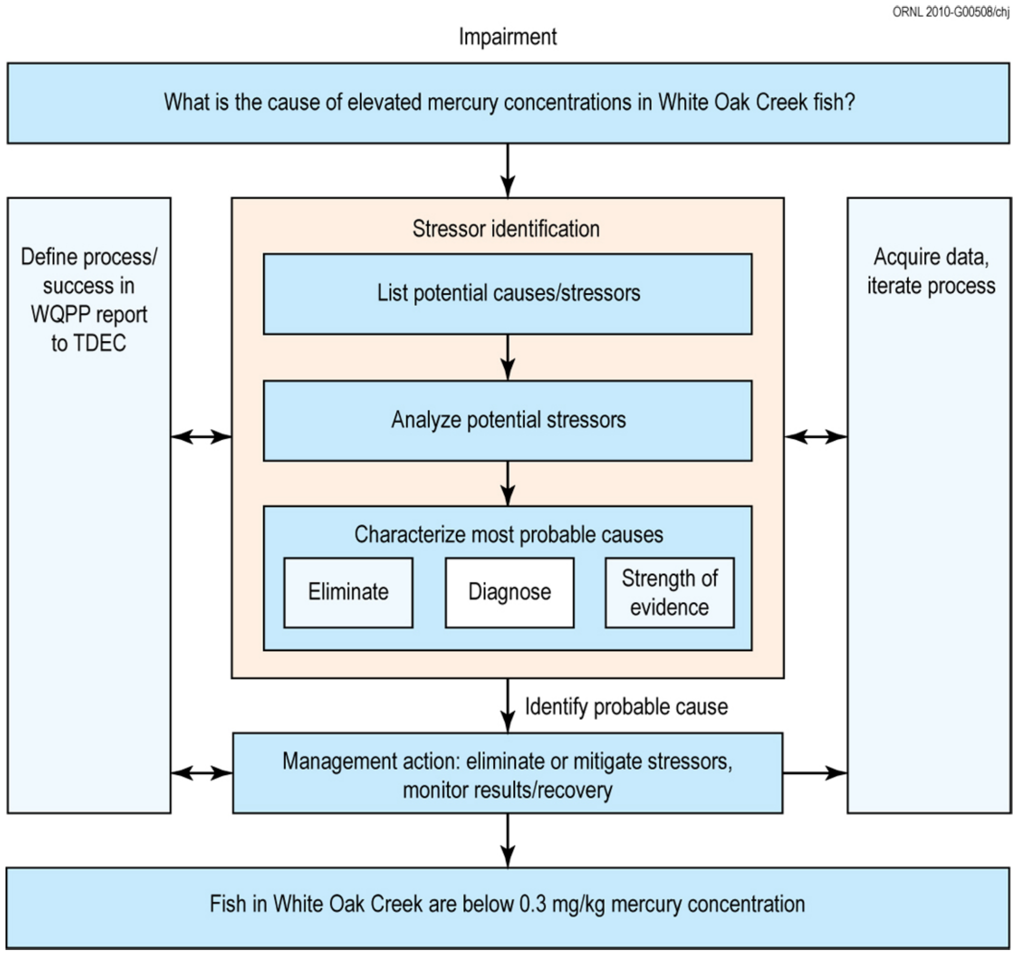


Fig. 5.15. Application of stressor identification guidance to address mercury impairment in the White Oak Creek watershed. *[Modified from Figure 1-1 in the US Environmental Protection Agency stressor guidance document (EPA 2000). TDEC = Tennessee Department of Environment and Conservation, WQPP = water quality protection plan.]*

5.5.1 Treatment Facility Discharges

Two on-site wastewater treatment systems were operated at ORNL in 2015 to provide appropriate treatment of the various R&D, operational, and domestic wastewaters generated by site staff and activities. Both were permitted to discharge treated wastewater and were monitored under NPDES Permit TN0002941, issued to DOE for the ORNL site by TDEC. These are the ORNL STP (outfall X01) and the ORNL PWTC (outfall X12). The ORNL NPDES permit requirements include monitoring the two ORNL wastewater treatment facility effluents for conventional, water-quality-based, and radiological constituents and for effluent toxicity, with numeric parameter-specific compliance limits established by TDEC as determined to be necessary. The ORNL NPDES permit was last renewed by TDEC in March 2014. The results of field measurements and laboratory analyses to assess compliance for the parameters required by the NPDES permit and rates of compliance with numeric limits established in the permit are provided in Table 5.10. ORNL wastewater treatment facilities achieved 99% compliance with permit limits and conditions in 2015. On infrequent occasions, the plant has gone into partial-treatment mode (disinfection) when the influent-handling capacity was exceeded due to heavy rain storms. A project to upgrade the ORNL STP is in design, including increased influent-handling capacity. The project is planned to be completed in 2016.

Table 5.10. National Pollutant Discharge Elimination System compliance at Oak Ridge National Laboratory, January through December 2015

Effluent parameters	Permit limits					Permit compliance		
	Monthly average (lb/day)	Daily max. (lb/day)	Monthly average (mg/L)	Daily max. (mg/L)	Daily min. (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
X01 (ORNL Sewage Treatment Plant)								
LC_{50} for *Ceriodaphnia* (%)					100	0	1	100
LC_{50} for fathead minnows (%)					100	0	1	100
Ammonia, as N (summer)	6.26	9.39	2.5	3.75		4[b]	26	84.62
Ammonia, as N (winter)	13.14	19.78	5.25	7.9		0	26	100
Carbonaceous biological oxygen demand	19.2	28.8	10	15		0	52	100
Dissolved oxygen					6	0	52	100
Escherichia coliform (col/100 mL)			941	126		0	52	100
Oil and grease				15		0	1	100
pH (standard units)				9	6	0	52	100
Total suspended solids	57.5	86.3	30	45		0	52	100
X12 (Process Waste Treatment Complex)								
LC_{50} for *Ceriodaphnia* (%)					100	0	1	100
LC_{50} for fathead minnows (%)					100	0	1	100
Arsenic, total				0.014		0	4	100
Chromium, total				0.44		0	4	100
Copper, total				0.11		0	4	100
Cyanide, total				0.046		0	2	100
Lead, total				0.69		0	4	100
Oil and grease				15		0	12	100
pH (standard units)				9.0	6.0	0	52	100
Temperature (°C)				30.5		0	52	100
Instream chlorine monitoring points								
Total residual oxidant			0.011	0.019		0	792	100

[a] Percentage compliance = 100 – [(number of noncompliances/number of samples) × 100].
[b] There were three measured effluent ammonia-limit exceedances, which resulted in a fourth, calculated exceedance of a monthly average limit in May 2015 at the STP Outfall X01. There were sludge management issues due to equipment reaching the end of its design life; these issues were resolved by the end of May 2015.

Abbreviated terms

LC_{50} = lethal concentration; the concentration (as a percentage of full-strength wastewater) that kills 50% of the test species in 48 h.
IC_{25} = inhibition concentration; the concentration (as a percentage of full-strength wastewater) that causes 25% reduction in survival, reproduction, or growth of the test organisms.
NPDES = National Pollutant Discharge Elimination System
ORNL = Oak Ridge National Laboratory

Toxicity testing provides an assessment of any harmful effects that could occur from the total combined constituents in discharges from ORNL wastewater treatment facilities. Effluents from the STP have been required to be tested for toxicity to aquatic species under the NPDES permit every year since 1986, and effluents from PWTC have been tested since it went into operation in 1990. Test species have been *Ceriodaphnia dubia* (*C. dubia*), an aquatic invertebrate, and fathead minnow (*Pimephales promelas*) larvae. They have been tested using EPA chronic and acute test protocols at frequencies ranging from one to four times per year. Test results have been excellent. PWTC effluent has always been shown to be nontoxic. The STP has shown isolated indications of effluent toxicity, none recent, but confirmatory tests conducted as required by the permit have shown that either the result of the routine test was an anomaly or that the condition of toxicity that existed at the time of the routine test was temporary and of short duration.

Toxicity test requirements under the current NPDES permit include testing the ORNL STP and PWTC once per year each, using two test species. In 2015, toxicity test results for the ORNL wastewater treatment facilities were once again favorable, with no indication of toxicity in any of the tests that were conducted (Table 5.10).

5.5.2 Residual Bromine and Chlorine Monitoring

Chlorine is added to drinking water as a disinfectant prior to consumption. Chlorine and bromine are added to cooling system water to prevent bacterial growth in the system. When waters are discharged to streams, residual chlorine and bromine can be toxic to fish and other aquatic life. The ORNL NPDES permit controls the discharge of chlorinated and brominated waters, reported as “total residual oxidant” (TRO), by limiting the TRO mass loading from outfalls and the instream TRO concentration. Outfalls with low potential to discharge chlorinated water are generally monitored semiannually; outfalls with known sources that are dechlorinated are monitored more frequently to ensure operational integrity of the dechlorinator. Instream locations are monitored bimonthly.

NPDES permit outfalls are monitored for TRO to ensure effective operation of cooling towers and dechlorination systems and maintenance of waterlines. When the permit action level of 1.2 g/day is exceeded at an outfall, the staff investigate and implement treatment and reduction measures. TRO is also monitored at instream points twice per month to verify that releases are not creating adverse conditions for fish and other aquatic life.

Twenty-two individual outfalls are checked for TRO either semiannually, quarterly, monthly, or bimonthly. Flow was detected 273 times in the outfalls. Table 5.11 lists instances in 2015 where TRO levels at outfalls were found to be in excess of the permit action level. One outfall tested, Outfall 267, was found once to be in excess of the permit action level of 1.2 g/day. A valve for supplied water was inadvertently diverted around a carbon prefilter in Building 3147 that is designed to remove residual chlorine and other contaminants from the incoming potable supply water. The residual chlorine in Outfall 267 was below detection after the valve was reopened.

Table 5.11. Outfalls exceeding total residual oxidant NPDES permit action level in 2015a

Sample date	Outfall	TRO concentration (mg/L)	Flow (gpm)	Load (g/day)	Receiving stream	Downstream integration point	Instream TRO point
2/5/2015	267	0.75	12	49.05	Fifth Creek	FFK 0.2	X19

[a] The National Pollutant Discharge Elimination System (NPDES) action level is 1.2 g/day.

Acronyms
FFK = Fifth Creek kilometer
TRO = total residual oxidant

5.5.3 Radiological Monitoring

At ORNL, monitoring of liquid effluents and selected instream locations for radioactivity is conducted under the WQPP. Table 5.12 details the analyses performed on samples collected in 2015 at two treatment facility outfalls, three instream monitoring locations, and 20 category outfalls (outfalls that are categorized into groups with similar effluent characteristics for the purposes of setting monitoring and reporting requirements in the site NPDES permit). Dry-weather discharges from category outfalls are primarily cooling water, groundwater, and condensate. Low levels of radioactivity can be discharged from category outfalls in areas where groundwater contamination exists and where contaminated groundwater enters category outfall collection systems from building and facility sumps, building footer drains, and direct infiltration. In 2015, dry-weather grab samples were collected at 15 of the 20 category outfalls targeted for sampling. Five category outfalls (205, 241, 265, 284, and 368) were not sampled because there was no discharge present during sampling attempts.

The ORNL STP outfall (outfall X01) and PWTC outfall (outfall X12) were monitored for radioactivity in 2015. Instream monitoring was also performed at X13 on Melton Branch, X14 on WOC, and X15 at White Oak Dam (WOD) (Fig. 5.16). At each treatment facility and instream monitoring location, monthly flow-proportional composite samples were collected using dedicated automatic water samplers.

DOE DCSs are radionuclide-specific concentration limits used to evaluate discharges of radioactivity from DOE facilities. DCSs were developed for evaluating effluent discharges and are not intended to be applied to instream values, but such comparisons can provide a useful frame of reference. Four percent of the DCS is roughly equivalent to the 4 mrem dose limit on which the EPA radionuclide drinking water standards are based and is a convenient comparison point. Although these comparisons are made, neither ORNL effluents nor ambient surface waters are direct sources of drinking water. The annual average concentration of at least one radionuclide exceeded 4% of the relevant DCS concentration in dry-weather discharges from NPDES outfalls 080, 085, 204, 207, 302, 304, X01, and X12 and at instream sampling locations on Melton Branch and at WOD (Fig. 5.17).

In 2015, average total radioactive strontium (^{89,90}Sr) concentrations at Outfalls 085, 207, and 304 exceeded the DCS for ^{90}Sr (it is reasonable to assume that ^{89,90}Sr activity is comparable to ^{90}Sr activity due to the relatively short half-life of ^{89}Sr—50.55 days). The concentrations of ^{89,90}Sr were 300%, 150%, and 820% of the DCS at outfalls 085, 207, and 304 respectively. Consequently, concentrations of radioactivity in discharges from each of these three outfalls were also greater than DCS levels on a sum-of-fractions basis (i.e., on the basis of the summation of DCS percentages of multiple radiological parameters); the sum-of-fractions were 330%, 160% and 830% respectively.

Table 5.12. Radiological monitoring conducted under the Oak Ridge National Laboratory Water Quality Protection Plan, 2015

Location	Frequency	Gross alpha/beta	Gamma scan	^{3}H	^{14}C	$^{89/90}$Sr	^{99}Tc	Isotopic uranium	Isotopic plutonium	^{241}Am	$^{243/244}$Cm
Outfall 001	Annual	X									
Outfall 080	Monthly	X	X	X		X				X[a]	X
Outfall 081	Annual	X									
Outfall 085	Quarterly	X	X	X		X		X[a]	X[a]	X[a]	X[a]
Outfall 203	Annual	X	X			X					
Outfall 204	Semiannual	X	X			X					
Outfall 205[b]	Annual										
Outfall 207	Quarterly	X	X[a]			X[a]		X[a]	X[a]	X[a]	X[a]
Outfall 211	Annual	X									
Outfall 234	Annual	X									
Outfall 241[b]	Quarterly										
Outfall 265[b]	Annual										
Outfall 281	Quarterly	X		X							
Outfall 282	Quarterly	X									
Outfall 284[b]	Annual										
Outfall 302	Monthly	X	X	X		X	X[a]	X[a]	X[a]	X[a]	X[a]
Outfall 304	Monthly	X	X	X		X	X[a]	X[a]	X[a]	X[a]	X[a]
Outfall 365	Semiannual	X									
Outfall 368[b]	Annual										
Outfall 383	Annual	X		X							
STP (X01)	Monthly	X	X	X	X	X					
PWTC (X12)	Monthly	X	X	X		X	X[a]	X	X[a]	X[a]	X[a]
Melton Branch (X13)	Monthly	X	X	X		X					
WOC (X14)	Monthly	X	X	X		X					
WOD (X15)	Monthly	X	X	X		X					

[a]The Water Quality Protection Plan does not require this parameter for this location, and therefore it may have been monitored on a frequency less than indicated in the table. Additional analyses are sometimes performed on samples, the most common reason being that gross alpha and gross beta activities exceeded a screening criteria (as described in the May 2012 update to the Water Quality Protection Plan).

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

Acronyms

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

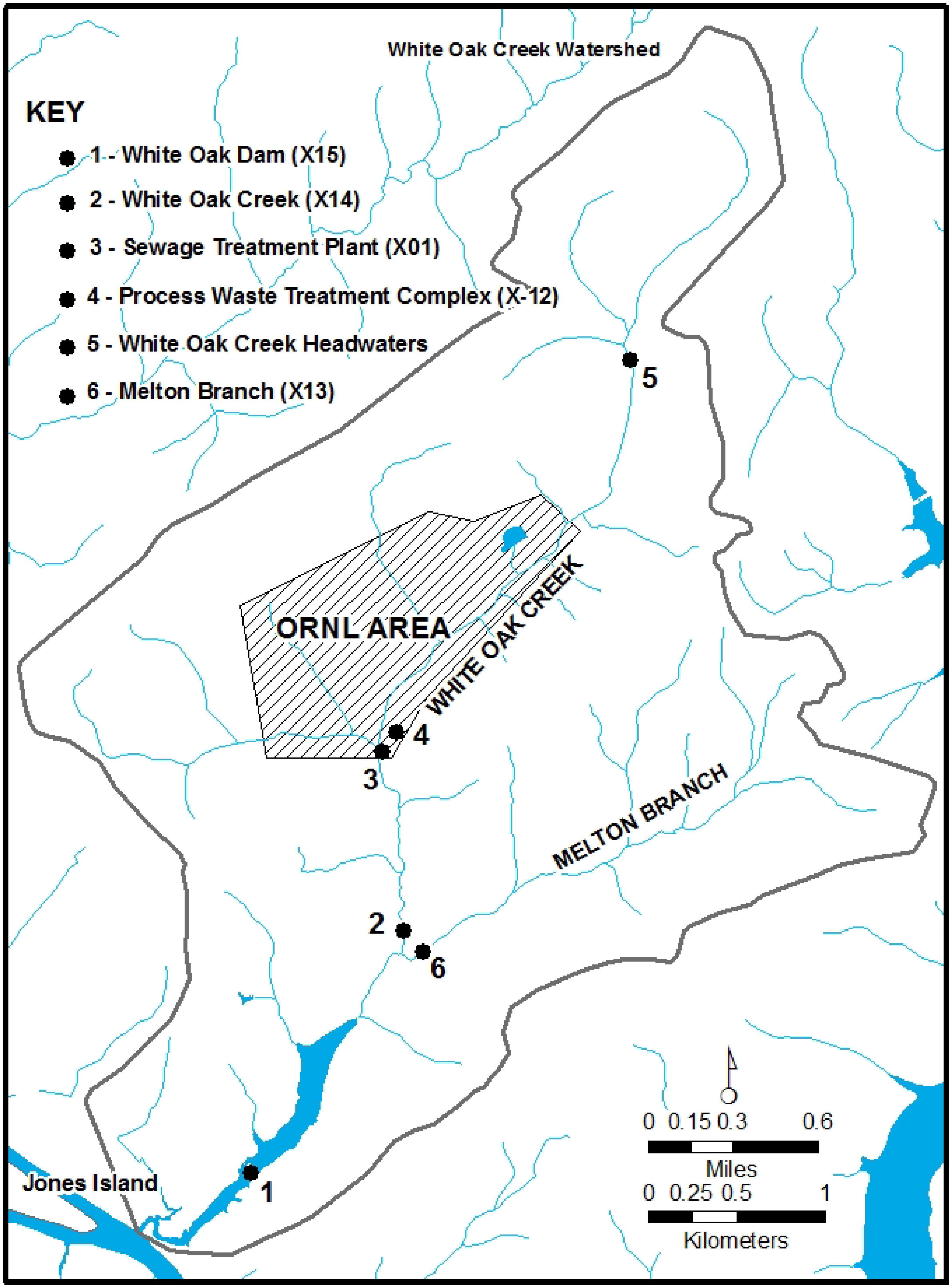


Fig. 5.16. Selected surface water, National Pollutant Discharge Elimination System, and reference sampling locations at Oak Ridge National Laboratory.

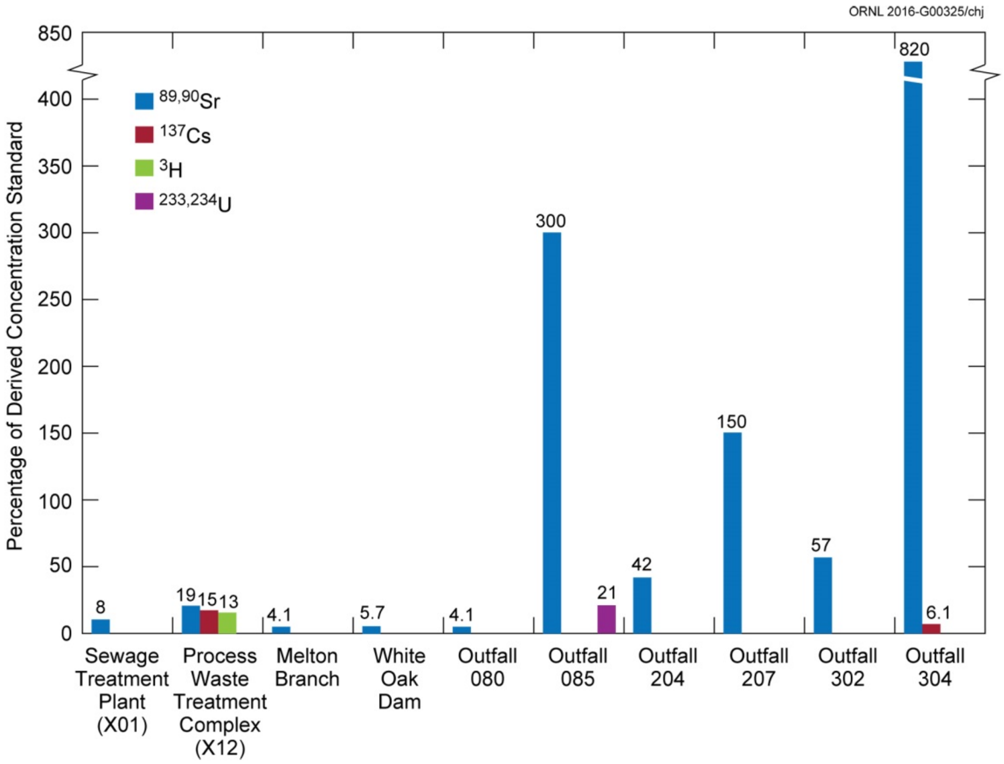


Fig. 5.17. Outfalls and instream locations at Oak Ridge National Laboratory with average radionuclide concentrations greater than 4% of the relevant derived concentration standards in 2015.

The increases in radioactivity concentrations at outfall 085 in 2015 are believed to be the result of existing underground contamination being mobilized by a water leak in Building 7830A. In the early morning hours of February 23, 2015, a pipe that is part of the fire suppression system in that building froze and ruptured. Workers discovered the leak later that morning and quickly isolated it. The facility was dewatered, and no surface contamination was found in areas where water exited a door of the facility. Outfall 085 is the outlet of the foundation drain for that facility, and it is sampled for radioactivity under the WQPP on a quarterly basis. The first sample collected following the water leak was on April 23, 2015; elevated concentrations of radioactivity, primarily from ^{89,90}Sr and ^{233,234}U, were detected. The highest concentrations measured after the water leak were from that first set of samples, and they were 6,600 pCi/L ^{89,90}Sr and 380 pCi/L ^{233,234}U. Other than the leak from the fire suppression system, the follow-up investigation discovered no changes or occurrences at the facility that would cause increases of radioactivity in the foundation drain. Concentrations have been steadily declining since April 2015, but they have not yet returned to levels that existed prior to the leak.

As reported in the 2014 *Oak Ridge Reservation Annual Site Environmental Report for 2014* (DOE 2015), levels of radioactivity started increasing at outfalls 207 and 304 in 2014 as a result of a failed pump in a groundwater suppression sump at the DOE Office of Environmental Management (EM) WOC-9 (WC-9) Low Level Liquid Waste Tank Farm, a CERCLA soil and groundwater contamination area. The stormwater collection networks for both outfalls extend to areas near WC-9, and it is believed that when it is operational, the sump pump suppresses groundwater levels, preventing or minimizing leakage of contaminated groundwater into the storm drains from the area around WC-9. The sump pump was repaired, but it is believed that levels of radioactivity continue to be elevated at Outfall 207 as a result of these 2014 events.

There were additional increases in radioactivity levels in discharges from outfall 304 in 2015. In June 2015, levels of radioactivity, primarily ^{89,90}Sr, began increasing at outfall 304. Concentrations exceeded those observed in 2014, with ^{89,90}Sr eventually peaking at 29,000 pCi/L in August and September. A dye tracer test conducted during the subsequent investigation led to the discovery that there was a leak in an underground pipe that leads from Pump Station #2 to a downstream diversion box in the PWTC and that there was a groundwater connection between the location of the leak and a nearby catch basin in the outfall 304 storm drain network. Following that discovery, the leaky section of pipe was bypassed and was taken out of service. Since the bypass was implemented, levels of radioactivity in the outfall effluent have trended downward but continue to be above DCS levels. No additional infrastructure issues affecting outfall 304 have been discovered, and it is believed that concentrations of radioactivity in outfall 304 effluent will slowly decline as concentrations of radioactivity in the groundwater surrounding the outfall pipe decline from normal hydrologic processes.

The total annual discharges (or amounts) of radioactivity measured in stream water at WOD, the final monitoring point on WOC before the stream flow leaves ORNL, were calculated from concentration and flow. Results of those calculations for each of the past 5 years are shown in Figs. 5.18 through 5.22. Because discharges of radioactivity are somewhat correlated to stream flow, annual flow volumes measured at the WOD monitoring station are given in Fig. 5.23. Discharges of radioactivity at WOD in 2015 were similar to those made in recent years, particularly when taking into account differences in annual flow volume and continue to be generally lower than in the years preceding completion of the waste area caps in Melton Valley (substantially complete by 2006).

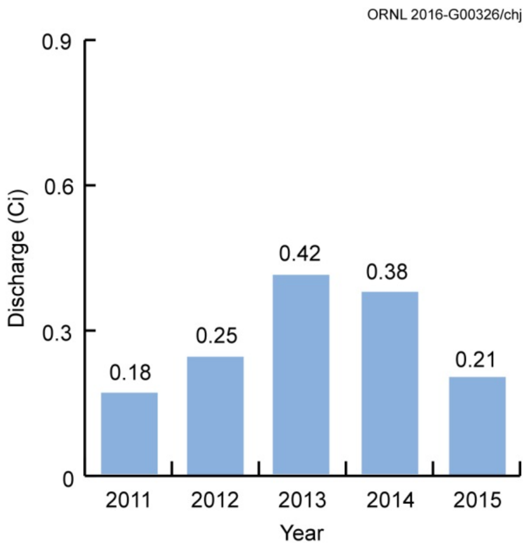


Fig. 5.18. Cesium-137 discharges at White Oak Dam, 2011–2015.

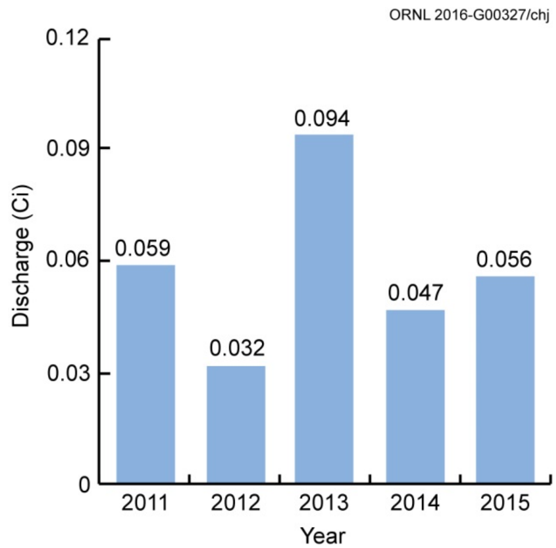


Fig. 5.19. Gross alpha discharges at White Oak Dam, 2011–2015.

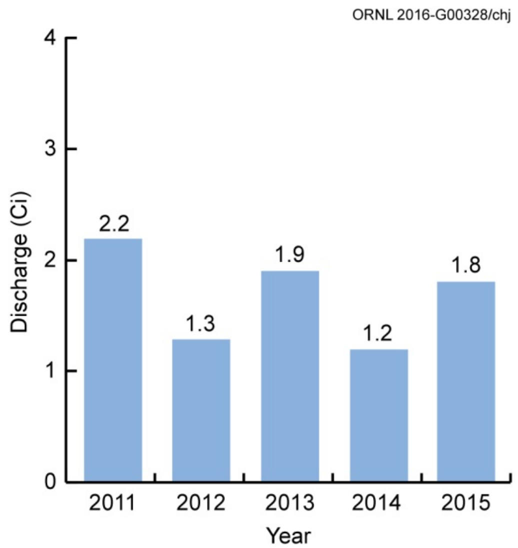


Fig. 5.20. Gross beta discharges at White Oak Dam, 2011–2015.

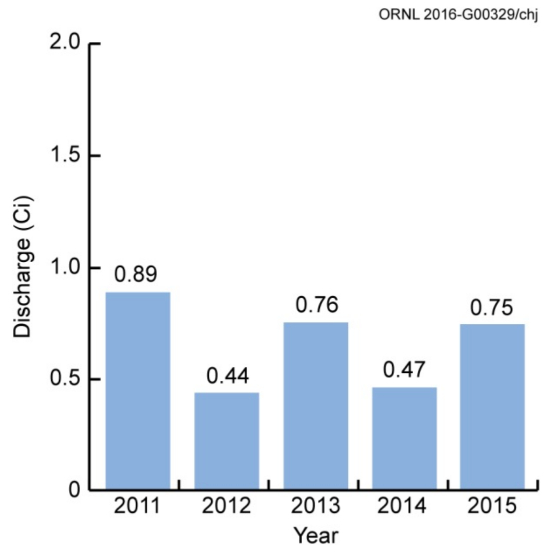


Fig. 5.21. Total radioactive strontium discharges at White Oak Dam, 2011–2015.

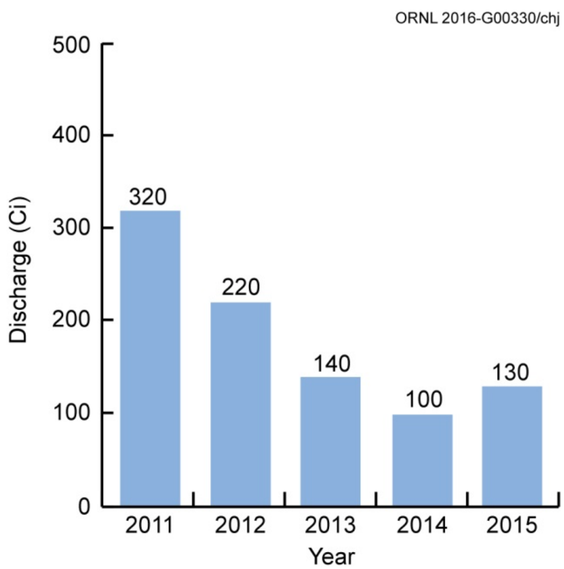


Fig. 5.22. Tritium discharges at White Oak Dam, 2011–2015.

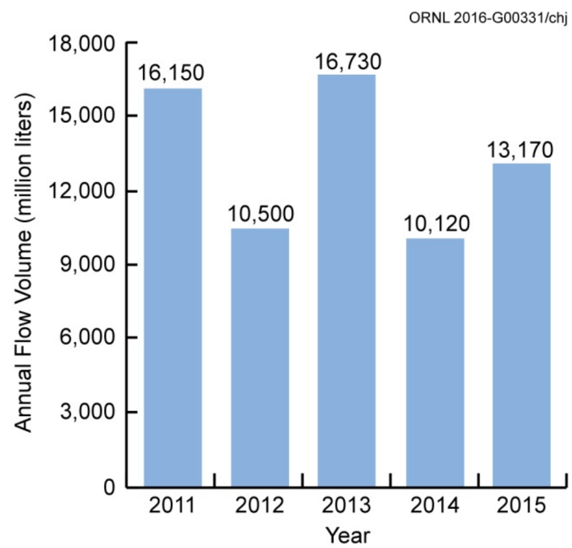


Fig. 5.23. Annual flow volume at White Oak Dam, 2011–2015.

Radiological monitoring at category outfalls in 2015 also included monitoring of 10 storm water outfalls during storm runoff conditions. Storm water samples were analyzed for gross alpha, gross beta, Sr-89/90, and tritium activities. A gamma scan analysis was also performed. The monitoring plan calls for additional analyses to be added when sufficient gross alpha and/or gross beta activity is present in a sample to indicate that levels of radioactivity may exceed DCS levels, but in 2015 no additional analyses were required.

Concentrations of radioactivity in storm water discharges were compared with DCSs if a DCS existed for that parameter (there are no DCSs for gross alpha or gross beta activities) and if the concentration was greater than or equal to the minimum detectable activity for the measurement. The $^{89/90}$Sr concentration at outfall 004 was 17% of the DCS.

5.5.4 Mercury in the White Oak Creek Watershed

Legacy mercury environmental contamination exists at ORNL, largely as a result of spills and releases that occurred in the 1950s during pilot-scale isotope separation work in Buildings 3503, 3592, 4501, and 4505. As a result, mercury is present in soils and groundwater in and around the four facilities. Buildings 3592 and 3503 were taken down and removed under the CERCLA remedial process in 2011 and 2012, respectively. Mercury is also present in Fifth Creek and WOC surface streams that receive surface runoff and groundwater flow from the area of these buildings.

In the past, process wastewater drains and building sumps from Buildings 4501 and 4505, the facilities where most of the ORNL mercury work was conducted, were routed via underground collection-system piping to the ORNL PWTC for treatment to remove constituents, including mercury, before discharge to WOC. Since 2007, three additional groundwater sumps have been redirected to receive treatment for mercury removal, and a mercury pretreatment system was installed on one of the sumps, in Building 4501. These recent actions have significantly diminished the release of legacy mercury contamination from the ORNL site to the WOC watershed (Fig. 5.24).

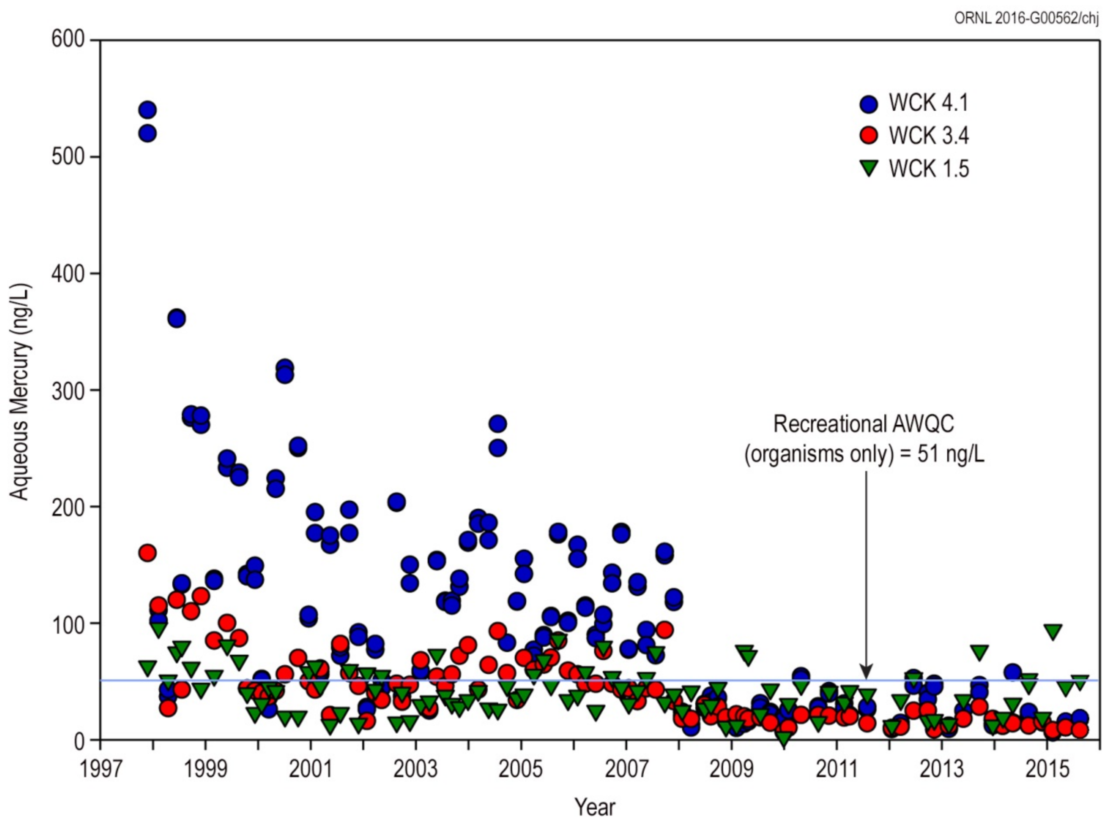


Fig. 5.24. Total aqueous mercury concentrations at sites in White Oak Creek downstream from Oak Ridge National Laboratory, 1998–2015. *(AWQC = ambient water quality criterion; WCK = White Oak Creek kilometer.)*

For the WQPP mercury-investigation component, effluent sampling at various outfalls and instream reaches is being conducted to help prioritize future abatement actions and to delineate mercury sources.

In 2015, monitoring conducted under WQPP included dry-weather sampling at a number of instream points in the WOC watershed upstream, within, and downstream from ORNL and ORNL NPDES outfalls where previous monitoring or site history has shown the potential for effluent mercury. Flow measurements were made for instream and outfall sampling locations. Values for concentration and flux (the amount of a substance detected per unit time in flowing water) were measured and calculated. Selected results of the 2015 monitoring are shown in Fig. 5.25. Semiannual monitoring at Melton Branch kilometer (MEK) 0.6 was discontinued in 2015 due to the consistently low mercury levels found there from 2009 to 2014. Complete mercury monitoring results are available in the Oak Ridge Environmental Information System (OREIS). Access to OREIS can be requested via email (oreis@ettp.doe.gov) or by telephone (865-574-3257).

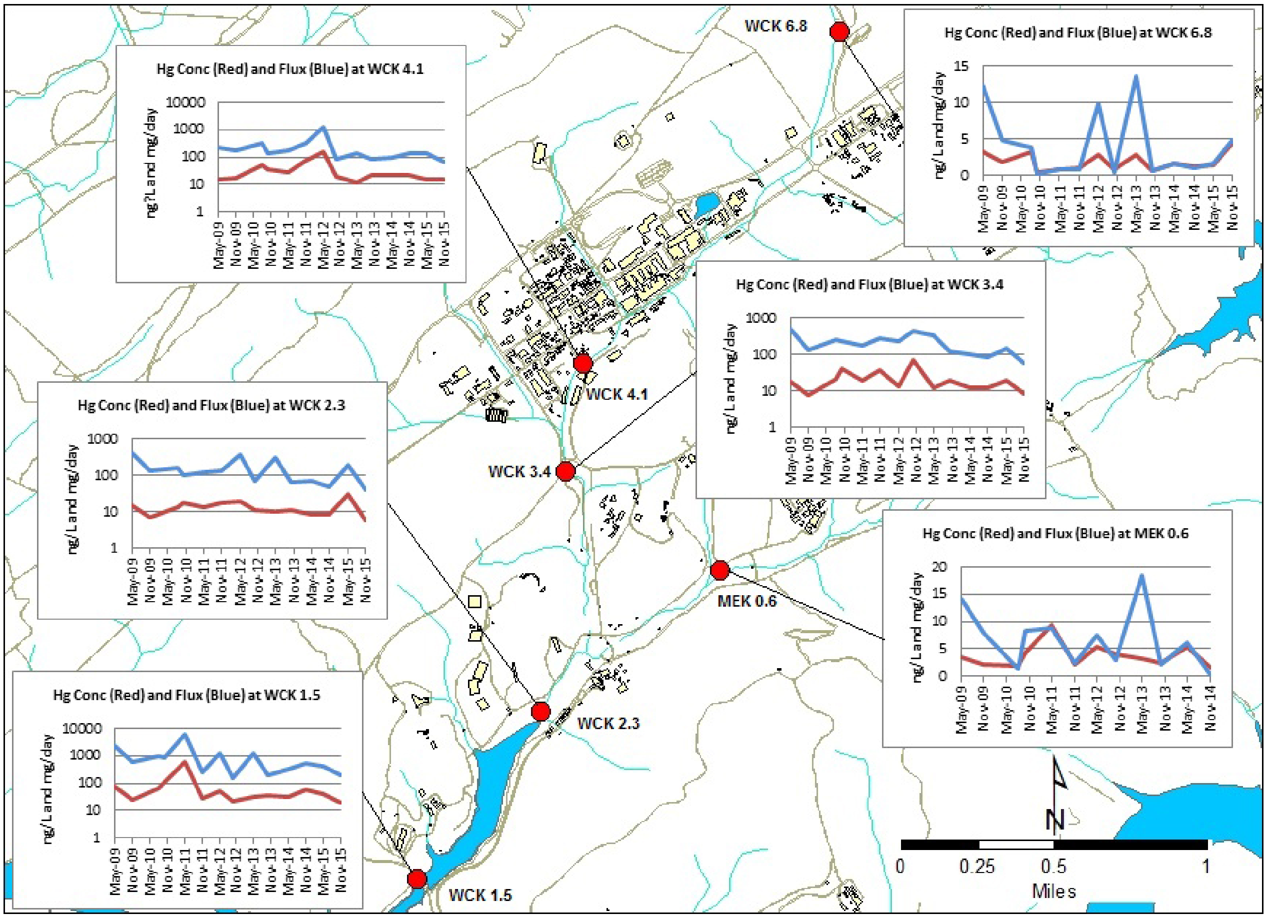


Fig. 5.25. Total mercury concentration and flux at selected Oak Ridge National Laboratory instream locations, 2009 through 2015.

Monitoring results for 2015 indicated that Tennessee mercury water-quality criteria (WQCs) were met at all instream locations monitored in the WOC watershed.

In 2015, targeted WQPP mercury monitoring included repeating a study that was first done in 2011, where selected reaches of two ORNL streams, Fifth Creek and WOC, were monitored for mercury at various locations and time intervals. The purpose of the study was to assess whether mercury concentrations in a reach of stream increase or decrease from the upper end to the lower end, and if so, whether there are discernable spatial or temporal patterns to the changes. Both stream reaches studied showed consistent increases in mercury flux and concentration, moving from the upper to the lower end, as would be expected given that individual ORNL storm water outfalls along the reaches were shown to introduce mercury into their respective stream reaches. One main finding from the study was that mercury concentrations and fluxes were significantly lower in several of the locations monitored than at those same spots in 2011; this was mainly true in the WOC locations. The data also showed apparent mercury flux increases occurring in the lower (downstream) end of both stream reaches that were not completely explained by the flux data from the individual outfalls. A follow-up study is being planned for the future to investigate these two stream sub-reaches more closely.

In 2015 the WQPP Mercury Subteam began drafting an internal ORNL mercury “white paper,” a narrative information summary of mercury on the ORNL site, past and present. The white paper will include summaries of the work done under the WQPP and will remain an open/living document for future augmentation.

In 2015, improvements were made at the ORNL PWTC, the wastewater treatment facility where mercury-bearing legacy wastewater is treated before being released to WOC. The PWTC treatment units include granular activated carbon filter columns, and in 2014 the filter media in one of the columns was replaced with sulfur-impregnated carbon that is optimized for mercury removal. PWTC effluent-monitoring data collected in 2015 continue to show noticeable improvement in the plant’s mercury-removal efficiency. An ongoing WQPP mercury-characterization monitoring protocol, which has been maintained at various instream- and outfall-monitoring locations in the WOC watershed since 2009, continued in 2015.

5.5.5 Storm Water Surveillances and Construction Activities

Substantive requirements of the appropriate water pollution control permits are followed for construction areas at ORNL that are part of CERCLA remediation, but official permit coverage is not required. Figure 5.26 depicts the location of construction sites that were active in 2015. Only two sites were inspected to evaluate overall effectiveness of the best management practices in use. They were considered significant and thus subject to inspection because they occupy an area of nearly 1 acre or more than 1 acre and/or because of the requirements of a Tennessee construction general permit. In general, while some short-term impacts to receiving streams were noted, no long-term adverse impacts were observed.

Land use within drainage areas is typical of office/industrial settings with surface features including laboratories, support facilities, paved areas, and grassy lawns. Outdoor material storage is most prevalent in the 7000 area on the east end of the main ORNL facility (where most of the craft and maintenance shops are located), with other smaller outdoor storage areas located throughout the facility in and around loading docks and material delivery areas at laboratory and office buildings. The types of materials stored outside include metal items (sheeting, pipes, and parts); equipment awaiting use, disposal, or repair; construction material; and deicer product.

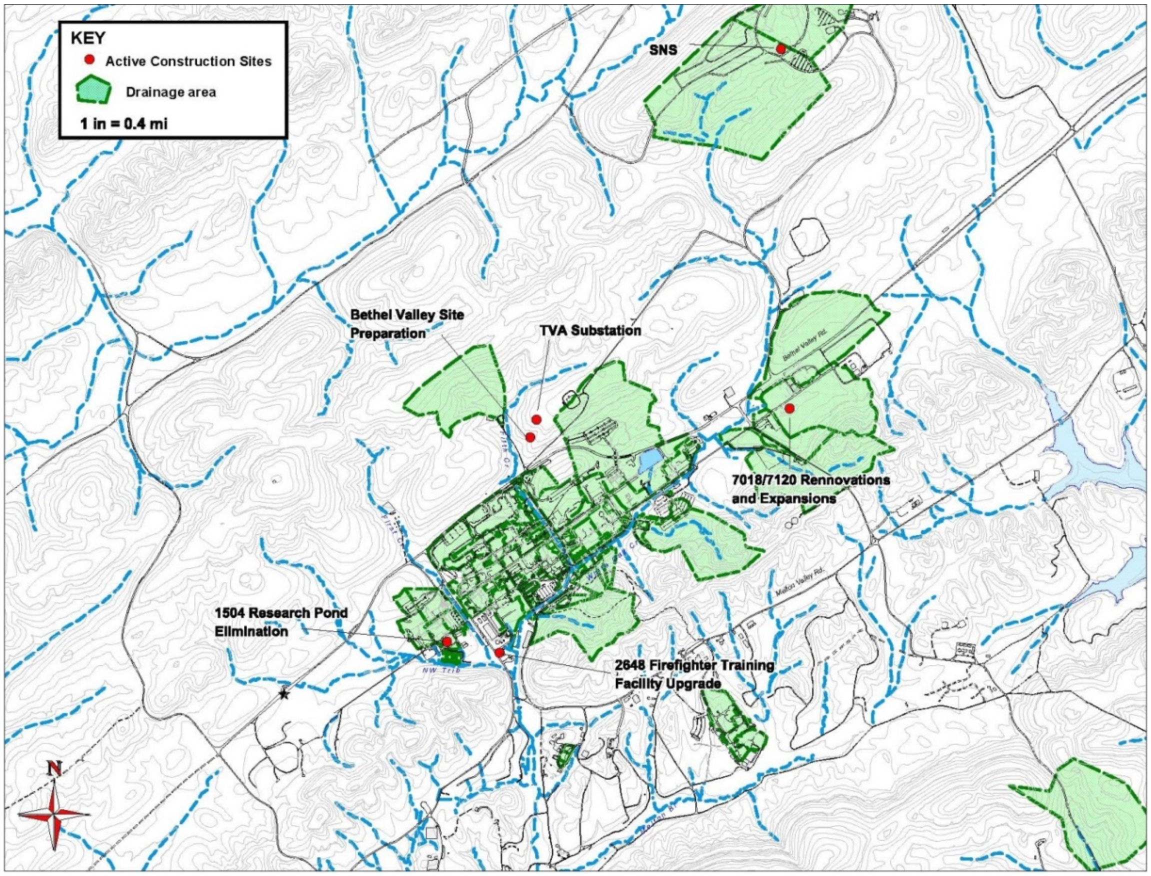


Fig. 5.26. Active construction sites and Oak Ridge National Laboratory Water Quality Protection Plan monitoring locations, 2015.
(SNS = Spallation Neutron Source, TVA = Tennessee Valley Authority)

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

5.5.6 Biological Monitoring

5.5.6.1 Bioaccumulation Studies

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

5.5.6.1.1 Mercury in Water

In continuation of a monitoring effort initiated in 1997, bimonthly water samples were collected from WOC at four sites in 2015. Stream conditions were selected to be representative of seasonal base-flow conditions (dry weather, clear flow) based on historical results that indicate higher mercury concentrations under those conditions.

The concentration of mercury in WOC upstream from ORNL was less than 2 ng/L in 2015. Long-term trends in waterborne mercury in the WOC system downstream of ORNL are shown in Fig. 5.24. Waterborne mercury downstream of ORNL declined abruptly in 2008 and remained low through 2015 as a result of rerouting highly contaminated sump water in Building 4501 to PWTC in December 2007. The mean total mercury concentration at WCK 4.1 was 13.7 ± 4.8 ng/L in 2015 compared with 108 ± 33 ng/L in 2007. The decrease was also apparent but less pronounced at WCK 3.4, with mercury averaging 10.6 ± 3.4 ng/L in 2015 versus 49 ± 23 ng/L in 2007. Mercury concentrations at these two sites were significantly lower than levels in 2007. A pretreatment system for the sump water, which started operation on October 22, 2009, removes almost all of the mercury before sending the water to PWTC. This system reduces the mercury concentration in the PWTC influent and effluent. Average aqueous mercury concentration at WOD was 52.4 ± 31.1 ng/L in 2015, higher than concentrations reported in recent years, possibly due to elevated particulates from a beaver dam.

5.5.6.1.2 Bioaccumulation in Fish

In WOC, mercury and PCB concentrations in fish have been at or near human health risk thresholds [e.g., EPA recommended fish-based AWQC (0.3 µg/g for mercury), TDEC fish advisory limits for PCBs]. Actions taken in 2007 to treat a mercury-contaminated sump resulted in significant decreases in mercury concentrations in fish throughout WOC. The decreases were most apparent at upstream locations closest to the sump water reroute (Fig. 5.27). Mean fillet concentrations decreased from 0.24 µg/g in 2014 to 0.16 µg/g in 2015 at WCK 3.9 and from 0.29 µg/g in 2014 to 0.21 µg/g in 2015 at WCK 2.9 (Fig. 5.27). These concentrations are below the AWQC for mercury in fish. Mercury concentrations in largemouth bass collected from WCK 1.5 (White Oak Lake) have been decreasing in recent years but remained above the guideline in 2015 (0.36 µg/g). Mercury concentrations in bluegill collected from WCK 1.5 showed the same decreasing trend as largemouth bass and remained below the recommended guideline. Mean PCB concentrations in redbreast sunfish at WCK 3.9 and WCK 2.9 (0.27 and 0.43µg/g, respectively) were comparable to values recorded in recent years. Mean PCB concentrations in largemouth bass from WCK 1.5 were near typical concentrations and resulted in a TDEC fish advisory limit of ~1 µg/g in 2015 (Fig. 5.28).

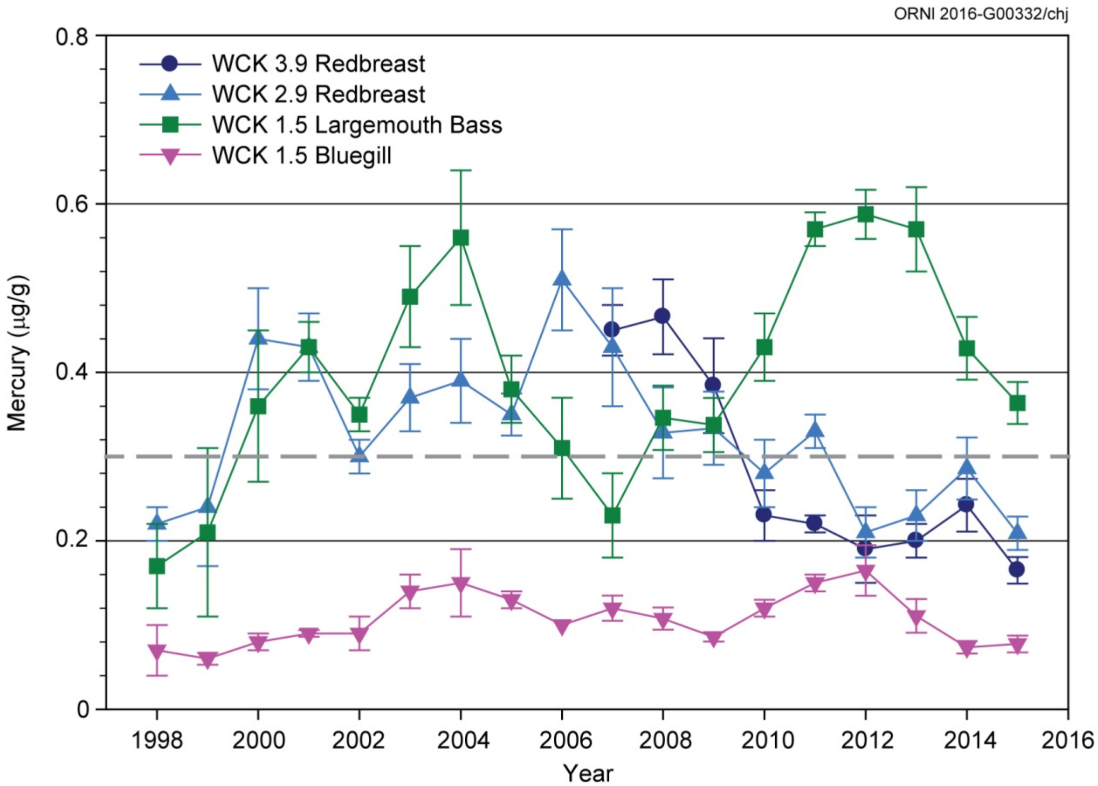


Fig. 5.27. Mean concentrations of mercury (± standard error, N = 6) in muscle tissue of sunfish and bass from White Oak Creek [White Oak Creek kilometers (WCKs) 3.9 and 2.9] and White Oak Lake (WCK 1.5), 1998–2015. *[Dashed grey line indicates the US Environmental Protection Agency ambient water quality criterion for mercury (0.3 µg/g in fish tissue).]*

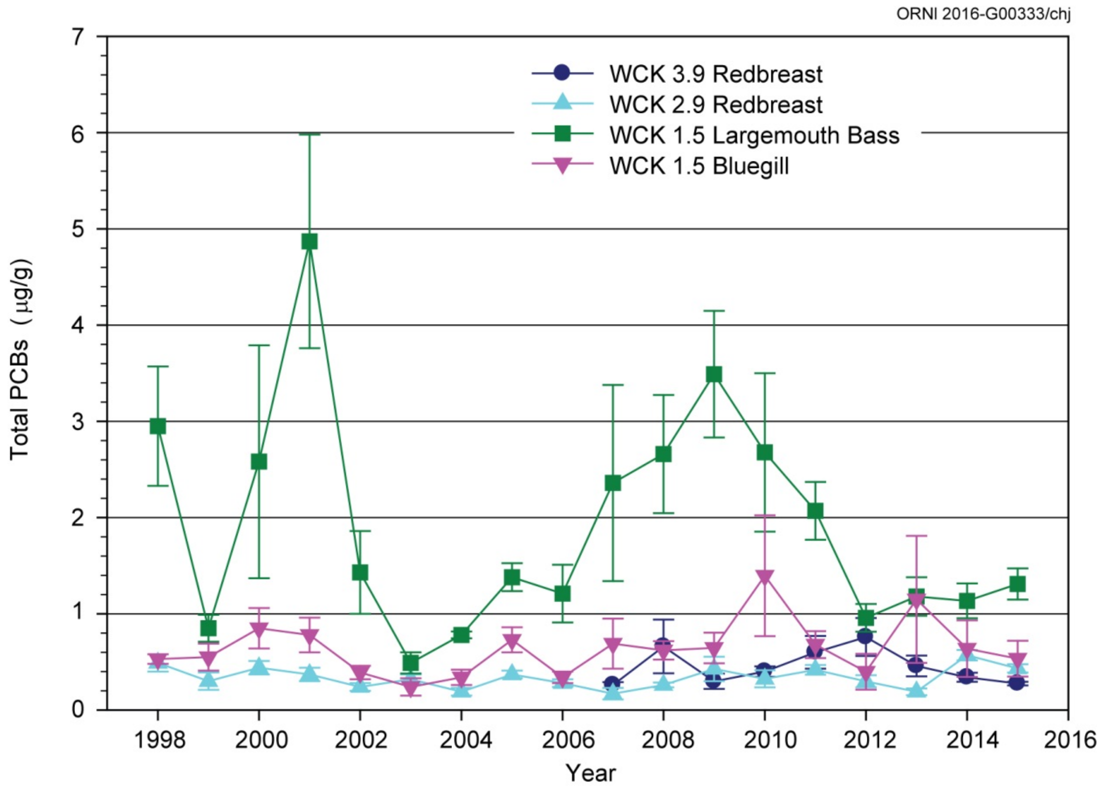


Fig. 5.28. Mean total polychlorinated biphenyl (PCB) concentrations (± standard error, N = 6) in fish fillets collected from the White Oak Creek watershed, 1998–2015.
(WCK = White Oak Creek kilometer.)

5.5.6.2 Benthic Macroinvertebrate Communities

Monitoring of benthic macroinvertebrate communities in WOC, First Creek, and Fifth Creek continued in 2015. Additionally, monitoring of the macroinvertebrate community in lower Melton Branch (MEK 0.6) continued under the EM Water Resources Restoration Program (WRRP). Benthic macroinvertebrate samples are collected once annually following two sets of protocols: protocols developed by ORNL staff and used since 1986 and TDEC protocols. The protocols developed by ORNL staff provide a continuous long-term record (29 years) of spatial and temporal trends in the invertebrate community from which the effectiveness of pollution abatement and remedial actions taken at ORNL can be evaluated and verified. The ORNL protocols also provide quantitative results that can be used to statistically evaluate changes in trends relative to historical conditions. TDEC protocols, on the other hand, provide a qualitative estimate of the condition of a macroinvertebrate community relative to a state-defined reference condition. The results from both protocols are used to help assess ORNL compliance with current NPDES permit requirements. This report provides a summary of available results from both sets of protocols through 2015.

Compared with the TDEC-derived reference condition, the only site monitored in the WOC watershed that has consistently been rated as unimpaired is White Oak Creek kilometer (WCK) 6.8, which until construction of SNS had served as the reference site for WOC (Fig. 5.29). The invertebrate community at all other sites except MEK 0.6 was rated as slightly impaired in 2015, while MEK 0.6 was rated as unimpaired.

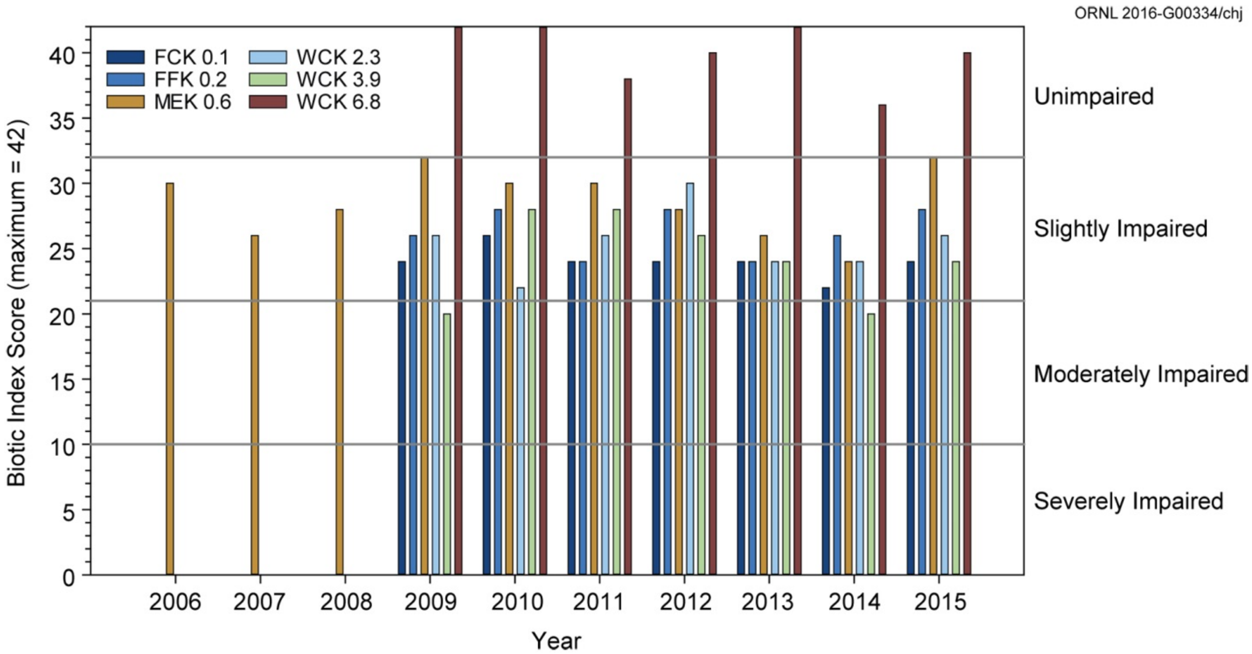


Fig. 5.29. Temporal trends in Tennessee Department of Environment and Conservation Biotic Index Scores for White Oak Creek watershed, August 2006–August 2015. *Horizontal lines show the lower thresholds for biotic condition ratings for index scores; respective narrative ratings for each threshold are shown at right of graph. (FCK = First Creek kilometer, FFK = Fifth Creek kilometer, MEK = Melton Branch kilometer, and WCK = White Oak Creek kilometer.)*

At the time of publication, 2015 sample results for benthic macroinvertebrate communities in First Creek, Fifth Creek, and WOC downstream of effluent discharges were not available. These results will be reported in the 2016 annual report. The 2014 results indicated significant recovery in these communities since 1987, but community characteristics indicated that ecological impairment remains (Figs. 5.30–5.32). Relative to respective upstream reference sites, total taxonomic richness (i.e., the mean number of different species per sample) and richness of the pollution-intolerant taxa (i.e., the mean number of different mayfly, stonefly, and caddisfly species per sample or Ephemeroptera, Plecoptera, and Trichoptera [EPT] taxa richness) continued to be lower at these downstream sites. After modest increases in the mid-1990s, total taxa richness appeared to have generally decreased at First Creek kilometer (FCK) 0.1, and in 2014 the total number of taxa was the lowest it had been since 1989. Similarly, the number of pollution intolerant EPT taxa decreased in 3 consecutive years, and in 2014 EPT taxa richness was the lowest it had been since the early 1990s. These results suggest a change may have occurred in conditions in lower First Creek. If change has occurred, it is not known whether it is related to a change in chemical conditions (e.g., change in water quality or the possible presence of a toxicant), physical conditions (e.g., unstable substrate, increased frequency of high discharge events), or natural variation. Trends in metrics at Fifth Creek kilometer (FFK) 0.2 since the mid-1990s suggest that a change in conditions at that site occurred between 2007 and 2008. More recent results, however, suggest that improvements have occurred, and the condition of the invertebrate community is now comparable to what it was from the late 1990s through the early 2000s. Metric values for WCK 2.3 and WCK 3.9 continued to remain within the ranges of values found since the early 2000s, although they also continued to be notably lower than those for the reference sites, suggesting that no additional major changes had occurred at those sites for roughly 12 years.

Macroinvertebrate community metrics for lower Melton Branch (MEK 0.6, Fig. 5.33) suggested that in 2014 taxa richness metrics continued to be similar to reference conditions. However, like the results from the TDEC protocols, other invertebrate community metrics potentially sensitive to more specific types of pollutants, such as the percent density of pollution-intolerant and pollution-tolerant species (not shown), continued to fluctuate annually between comparable values and values below those of the reference sites. Thus, while the condition of the invertebrate community at MEK 0.6 was generally at or near reference conditions, annual changes in some characteristics of the community suggested that annual fluctuations in environmental conditions at the site appear to have some minor negative influence on the condition of the community.

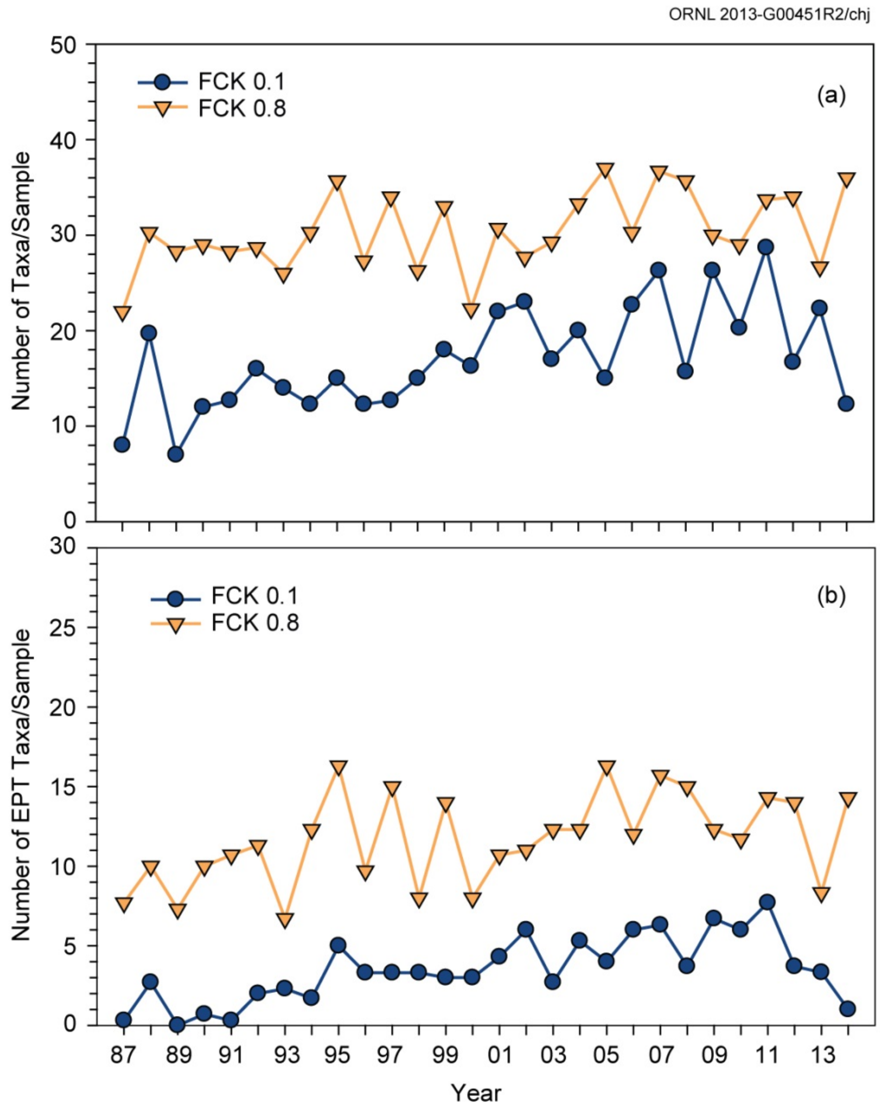


Fig. 5.30. Benthic macroinvertebrate communities in First Creek: (a) total taxonomic richness (mean number of all taxa/sample) and (b) taxonomic richness of the pollution-intolerant taxa, Ephemeroptera, Plecoptera, and Trichoptera [(EPT); mean number of EPT taxa/sample], April sampling periods, 1987−2014. Results for 2015 were not available at the time of publication. *(FCK = First Creek kilometer; FCK 0.8 = reference site.)*

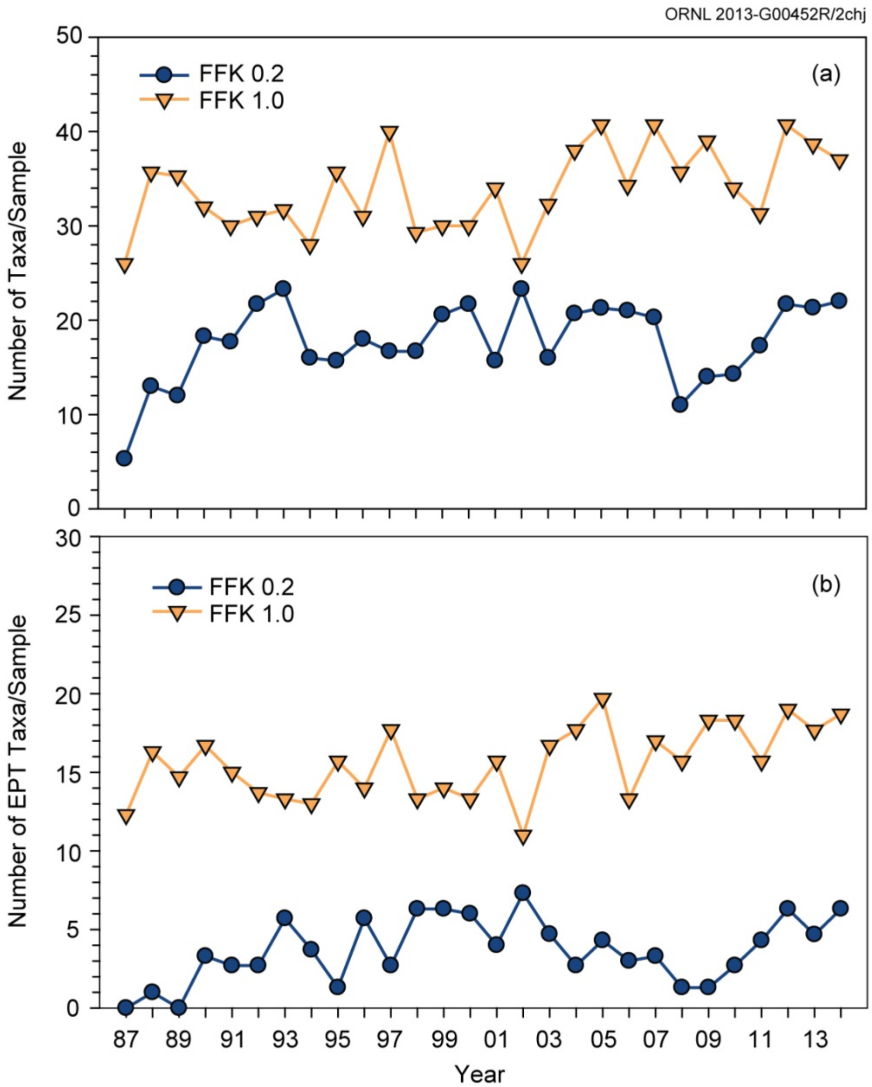


Fig. 5.31. Benthic macroinvertebrate communities in Fifth Creek: (a) total taxonomic richness (mean number of all taxa/sample) and (b) taxonomic richness of the pollution-intolerant taxa, Ephemeroptera, Plecoptera, and Trichoptera [(EPT); mean number of EPT taxa/sample], April sampling periods, 1987−2014. Results for 2015 were not available at the time of publication. *(FFK = Fifth Creek kilometer; FFK 1. 0 = reference site.)*

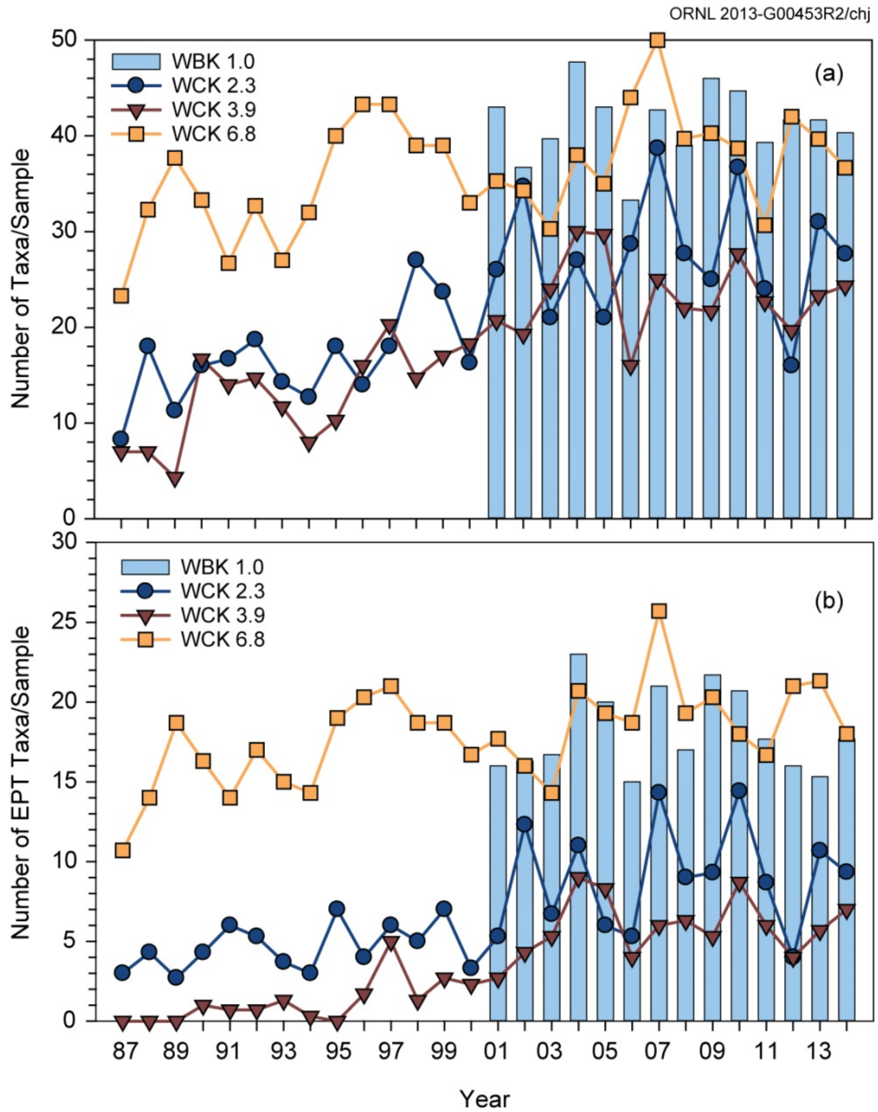


Fig. 5.32. Benthic macroinvertebrate communities in White Oak Creek: (a) total taxonomic richness (mean number of all taxa/ sample) and (b) taxonomic richness of the pollution-intolerant taxa, Ephemeroptera, Plecoptera, and Trichoptera [(EPT); mean number of EPT taxa/sample], April sampling periods, 1987−2014. Results for 2015 were not available at the time of publication. *(WCK = White Oak Creek kilometer and WBK = Walker Branch kilometer; WBK 1.0 = reference site.)*

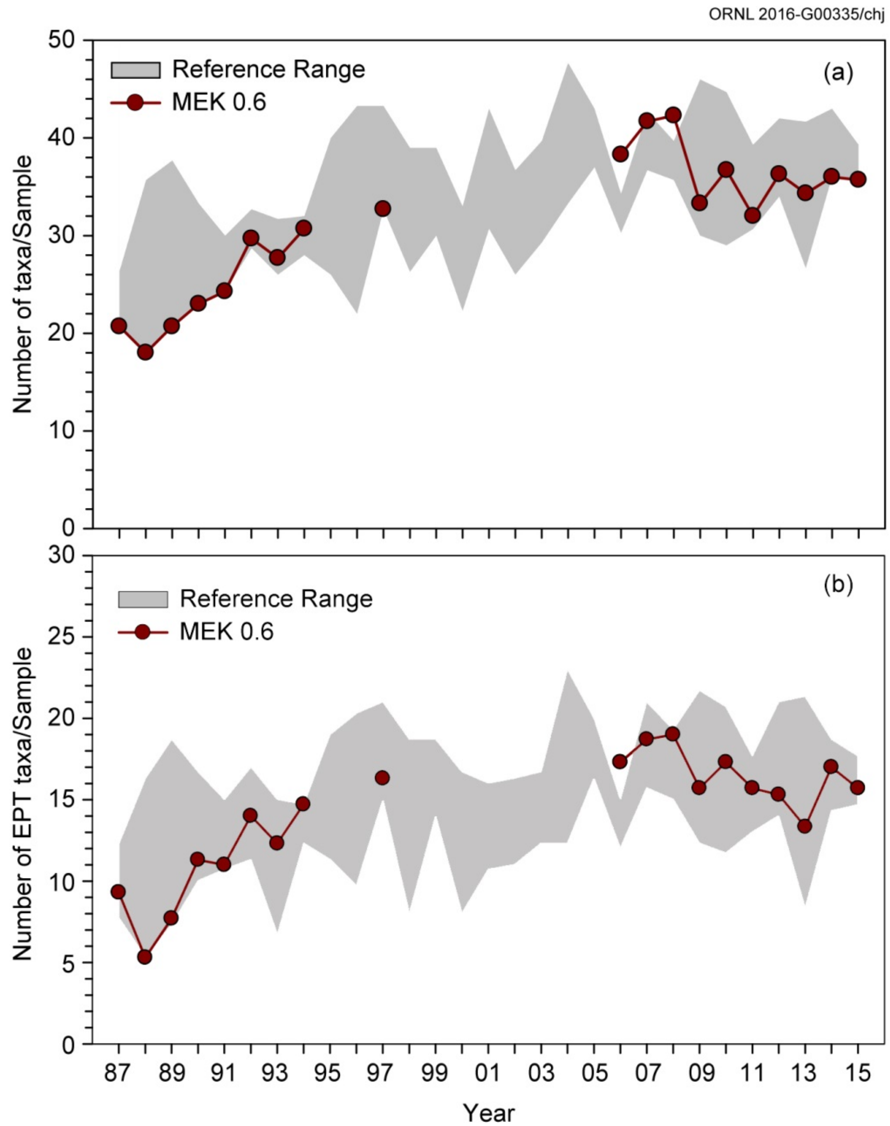


Fig. 5.33. Benthic macroinvertebrate communities in lower Melton Branch: (a) total taxonomic richness (mean number of all taxa/sample) and (b) taxonomic richness of the pollution-intolerant taxa, Ephemeroptera, Plecoptera, and Trichoptera [(EPT); mean number of EPT taxa/sample], April sampling periods, 1987−2015.
[MEK = Melton Branch kilometer; reference range = minimum and maximum values for Oak Ridge National Laboratory Biological Monitoring and Abatement Program reference sites on upper Melton Branch (1987–1997), First Creek and Fifth Creek (1987–2014), Walker Branch (2001–2014), and White Oak Creek (1987–2000, 2007–2014), and other Oak Ridge Reservation reference sites]

5.5.6.3 Fish Communities

Monitoring fish communities in WOC and major tributaries continued in 2015. Fish community surveys were conducted at 11 sites in the WOC watershed, including five sites in the main channel, two sites in First Creek, two sites in Fifth Creek, and two sites in Melton Branch. Streams located near or within the city of Oak Ridge (Mill Branch and Brushy Fork) were also sampled as reference sites for comparison.

In the WOC watershed, the fish community continued to be slightly degraded in 2015 compared with communities in reference streams. Sites closest to outfalls within the ORNL campus have lower species richness (number of species) (Fig. 5.34), fewer pollution-sensitive species, more pollution-tolerant species, and elevated density (number of fish per square meter) of pollution-tolerant species compared with similar-sized reference streams. Seasonal fluctuations in diversity and density are expected and explain some of the variability seen at these sites as well as recent fish introduction work. Overall, the fish communities in tributary sites adjacent to and downstream of ORNL outfalls also remained negatively affected by ORNL effluent in 2015 relative to reference streams or upstream sites.

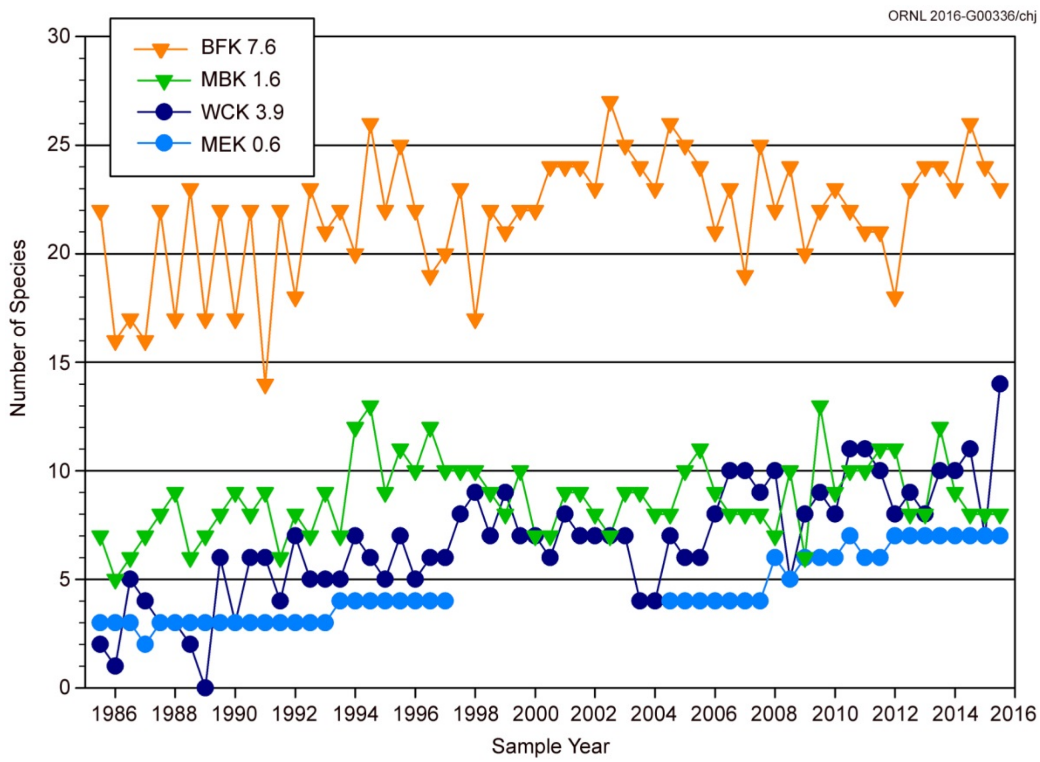


Fig. 5.34. Fish species richness (number of species) in upper White Oak Creek and lower Melton Branch compared with two reference streams (Brushy Fork and Mill Branch) 1985–2015. *(BFK = Brushy Fork kilometer; MBK = Mill Branch kilometer; MEK = Melton Branch kilometer; and WCK = White Oak Creek kilometer.)*

A project to introduce fish species that were not found in the WOC watershed but that exist in similar systems on the ORR and that may have historically existed in WOC was initiated in 2008 with the stocking of six such native species. Reproduction has been noted for five of the species, and several species have expanded their ranges downstream from initial introduction sites to establish new reproducing populations. In general, introduced species have had more difficulty establishing populations at upstream sites in both WOC and Melton Branch, and as a result, introductions to supplement the small populations of these fish species will continue at sites within the watershed. The introductions have enhanced species richness at almost all sample locations within the watershed and illustrate the capacity of this watershed to support increased diversity, which seems to be limited by impassible barriers such as dams, weirs, and culverts, and by limited access to source populations.

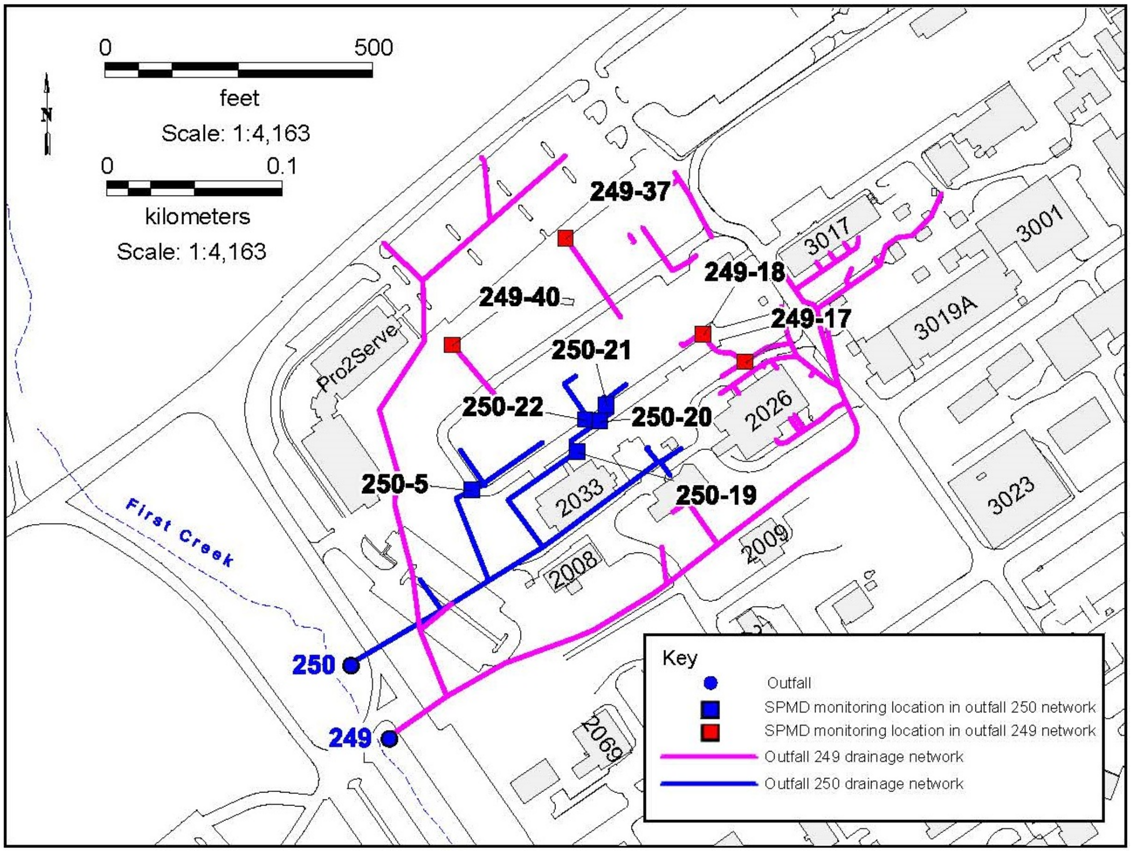
5.5.7 Polychlorinated Biphenyls in the White Oak Creek Watershed

The objective of this task was to identify the stream reaches, outfalls, or sediment areas that are contributing to elevated PCB exposure in the WOC watershed. Results for largemouth bass collected from White Oak Lake show that tissue PCB concentrations continue to be higher than those recommended by TDEC and EPA for frequent consumption (Fig. 5.28), but the mobility of the fish precludes the possibility of source identification. Because PCBs are hydrophobic, they tend not to be dissolved in water, and therefore aqueous PCB concentrations are often below the detection limits of conventional methods, even at contaminated sites. Therefore, the source identification task involved the use of semipermeable membrane devices (SPMDs) to assess the chronic low-level sources of PCBs at critical sites on the reservation. SPMDs are thin plastic sleeves filled with oil in which PCBs are soluble. Because SPMDs are in contact with water at a given site for 4 weeks and have a high affinity for PCBs, a time-integrated semiquantitative index of the mean PCB concentration in the water column during the deployment period is obtained. SPMDs also have advantages over “snapshot” water concentration analyses. The long deployment period enables distinction between the relative PCB inputs at sites whose aqueous PCB concentrations are below detection limits in water.

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

In 2015, ORNL’s PCB monitoring efforts continued focusing on the First Creek watershed, which was identified previously as a source of PCBs. SPMDs were deployed in pipe networks for outfalls 249 and 250, which contribute to First Creek (Fig. 5.35). The results are summarized in Table 5.13.

The results from the 2015 assessment confirm that the upper parts of the outfall 249 and 250 pipe networks continue to be of primary interest for investigation of legacy PCB sources in the First Creek watershed. The results from sample location 250-19 (Table 5.13) indicate that PCBs remain available in that area despite recent actions to remove PCB-contaminated building materials from the upper part of the 250 watershed. Results for outfalls 249 and 250 were within the ranges of past monitoring, giving no indication that the nature of PCB movement is significantly changing in those networks.



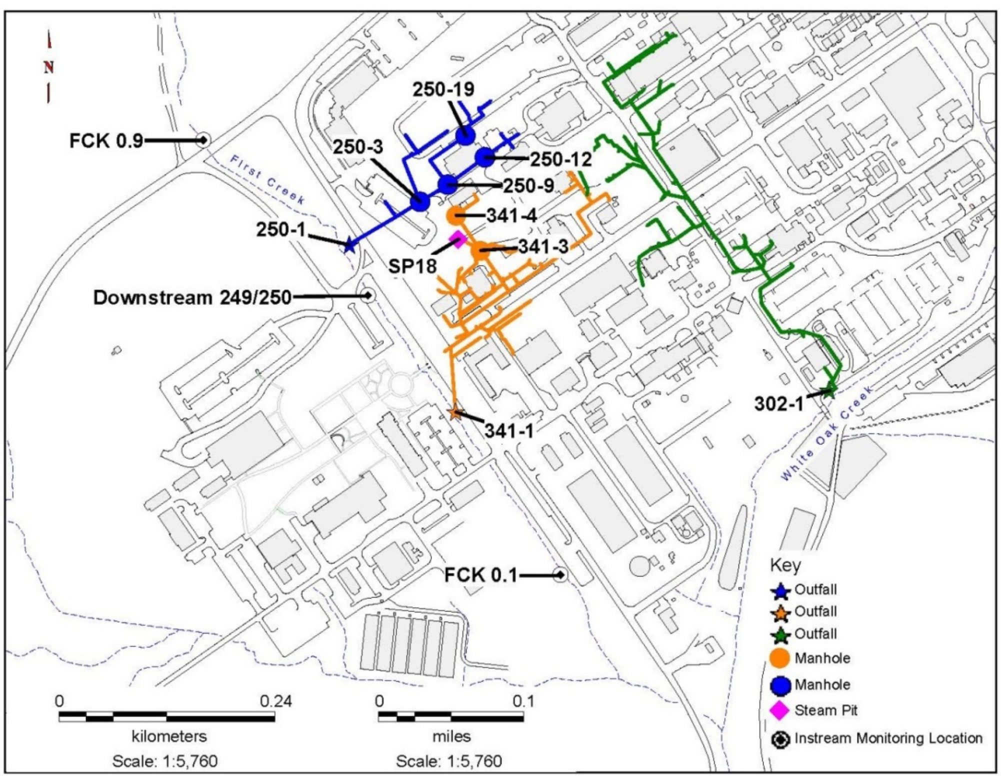


Fig. 5.35. Locations of monitoring points for First Creek source investigation.
(FCK = First Creek kilometer.)

Table 5.13. First Creek PCB source assessment, May 2015
[Total PCBs (parts per billion)]

Sample location	Location type	SPMD
249-17	Outlet	396
249-18	Outlet	2500
249-37	Outlet	871
249-40	Outlet	354
250-5	Inlet	314
250-19	Inlet/Outlet	22530
250-20	Inlet	4560
250-21	Inlet	855
250-22	Inlet	6320

Acronyms
PCB = polychlorinated biphenyl
SPMD semipermeable membrane device

5.5.8 Oil Pollution Prevention

CWA Section 311 regulates the discharge of oils or petroleum products to waters of the United States and requires the development and implementation of spill prevention, control, and countermeasures (SPCC) plans to minimize the potential for oil discharges. These requirements are provided in 40 CFR 112, *Oil Pollution Prevention*. Each ORR facility implements a site-specific SPCC plan. NTRC, which is located off ORR, also has an SPCC plan covering the oil inventory at its location. CFTF is also located off ORR; however, that facility was evaluated, and a determination was made that it did not require an SPCC plan. There were no regulatory or permitting actions related to oil pollution prevention at ORNL or NTRC in 2015. An oil-handler training program exists to comply with training requirements in 40 CFR 112.

5.5.9 Surface Water Surveillance Monitoring

The ORNL surface water monitoring program is conducted in conjunction with the ORR surface water monitoring activities discussed in Section 6.4 to enable assessing the impacts of ongoing DOE operations on the quality of local surface water. The sampling locations (Fig. 5.36) 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 5.14. Radiological monitoring at the discharge point downstream of ORNL (White Oak Lake at WOD) is conducted monthly under the ORNL WQPP (Section 5.5.3) and, therefore, is not duplicated by this program. Radiological monitoring at a point upstream of ORNL is conducted monthly under the ORNL WQPP (Section 5.5.3) and, therefore, is not duplicated by this program. Total radioactive strontium is monitored quarterly by this surveillance program.

Samples are collected and analyzed for general water quality parameters and are screened for radioactivity at all locations (either under this program or under WQPP). Samples are further analyzed for specific radionuclides when general screening levels are exceeded. Samples from White Oak Lake at WOD are also checked for volatile organic compounds (VOCs), PCBs, and mercury. WCK 6.8 and WCK 1.0 are classified by the State of Tennessee for freshwater fish and aquatic life. Tennessee WQCs associated with these classifications are used as references where applicable. The Tennessee WQCs do not include criteria for radionuclides. Four percent of the DOE DCS is used for radionuclide comparison because that value is roughly equivalent to the 4 mrem dose limit from ingestion of drinking water on which the EPA radionuclide drinking water standards are based.

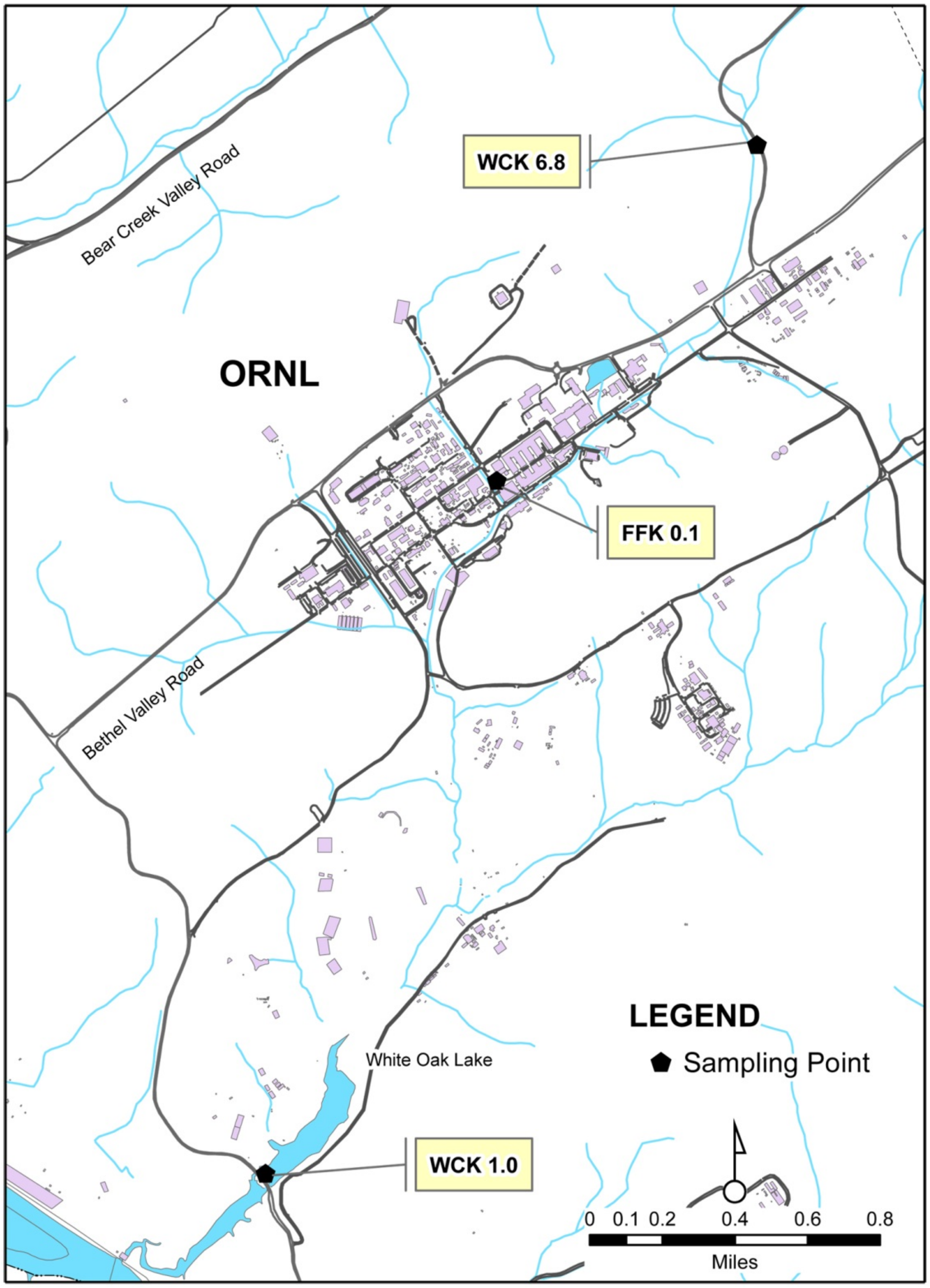


Fig. 5.36. Oak Ridge National Laboratory surface water sampling locations.
(FFK = Fifth Creek kilometer; WCK = White Oak Creek kilometer.)

Table 5.14. Oak Ridge National Laboratory surface water sampling locations, frequencies, and parameters, 2015

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

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

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

The results from the ORR upstream reference site (CRK 66) may be compared with results from the ORNL surface water monitoring program as applicable to evaluate potential impacts to area surface water as a result of DOE activities at ORNL (Section 6.4.1). Overall radionuclide results from 2015 surveillance monitoring efforts are consistent with historical data.

There were no radionuclides reported above 4% of DCS at either the upstream White Oak Creek (WCK 6.8) or the Fifth Creek (FFK 0.1) location. Radionuclide results from samples collected at WOD (immediately before WOC empties into the Clinch River) are discussed in Section 5.5.3.

Neither mercury nor PCBs were detected during 2015 in WOC at WOD.

5.5.10 Carbon Fiber Technology Facility Waste Water Monitoring

Facility and process waste water from activities at CFTF are discharged to the City of Oak Ridge sanitary sewer system under conditions established in City of Oak Ridge Industrial Waste Water Discharge Permit 1-12. Permit limits, parameters, and 2015 compliance status for this permit are summarized in Table 5.15.

Table 5.15. Industrial and Commercial User Waste Water Discharge Permit compliance at the Oak Ridge National Laboratory Carbon Fiber Technology Facility, 2015

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

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

5.6 Groundwater Monitoring Program

Groundwater monitoring at ORNL was conducted under two sampling programs in 2015: DOE EM monitoring and DOE Office of Science (OS) surveillance monitoring. The DOE EM groundwater monitoring program was conducted by UCOR in 2015. The OS groundwater monitoring surveillance program was conducted by UT-Battelle.

5.6.1 DOE Office of Environmental Management Groundwater Monitoring

Monitoring was performed as part of an ongoing comprehensive CERCLA cleanup effort in Bethel and Melton Valleys, the two administrative watersheds at the ORNL site. Groundwater monitoring for baseline and trend evaluation in addition to measuring effectiveness of completed CERCLA RAs is conducted as part of the WRRP. WRRP is managed by UCOR for the DOE EM program. The results of CERCLA monitoring for ORR for FY 2015, including monitoring at ORNL, are evaluated and reported in the 2016 remediation effectiveness report (DOE 2016) as required by the ORR FFA. The monitoring results and remedial effectiveness evaluations for Bethel and Melton Valley are reported in Sections 2 and 3, respectively, in that report.

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

In FY 2010 DOE initiated activities on a groundwater treatability study at the Bethel Valley 7000 Services Area VOC plume. This plume contains trichloroethylene (TCE) and its transformation products cis-1,2-DCE and vinyl chloride, all at concentrations greater than EPA primary drinking water standards.

The treatability study is a laboratory and field demonstration to determine whether microbes inherent to the existing subsurface microbial population can fully degrade the VOCs to nontoxic end products.

During FY 2015 postremediation monitoring continued at Solid Waste Storage Area (SWSA) 3 following completion of hydrologic isolation of the area by construction of a multilayer cap and upgradient stormflow/shallow groundwater diversion drain. RAs and monitoring were specified in a CERCLA RA work plan that was developed by DOE and approved by EPA and TDEC before the project was started.

During FY 2015 EM continued to collect and analyze samples from the off-site groundwater monitoring well array west of the Clinch River adjacent to Melton Valley. In addition, exit pathway groundwater monitoring in Melton Valley is conducted as part of the EM program, including sampling at six multiport monitoring wells in western Melton Valley (wells 4537, 4538, 4539, 4540, 4541, 4542).

During FY 2014 the EM Groundwater Program staff conducted planning for an ORR off-site groundwater quality assessment and started development of an ORR regional groundwater flow model. The off-site groundwater assessment project is aimed at documenting water quality in selected residential water supply wells and at springs to the west and southwest of the ORR. General water chemistry, metals, organic compounds, and radionuclides are included in the suite of analytes to be assessed. During FY 2015 two sampling events were completed in accordance with an approved work plan. A confirmatory sampling event and preparation and issuance of a report of results are planned for 2016 for the groundwater flow model task. Efforts were initiated to develop an ORR-wide regional flow model. The geologic framework for the regional-scale flow model was completed in 2015. Testing activities on a test case model were also completed in 2015. Construction of the regional-scale flow model is continuing in 2016. The model will serve as an underlying framework to support future cleanup decisions and actions.

5.6.1.1 Summary of DOE Office of Environmental Management Groundwater Monitoring

5.6.1.1.1 Bethel Valley

During FY 2011 construction was completed for RAs at two former waste storage sites, SWSA 1 and SWSA 3, which 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 waste disposed of at SWSA 3 was solid, some were containerized liquid wastes. Some wastes were encapsulated in concrete after placement in burial trenches, but most of the waste was soil-covered. The Bethel Valley Record of Decision (ROD) (DOE 2002) selected hydrologic isolation using multilayer caps and groundwater diversion trenches as the RA for the waste burial grounds and construction of soil covers over the former contractor's landfill and contaminated soil areas near SWSA 3. The baseline monitoring conducted during FY 2010 included measurement of groundwater levels to obtain baseline data to allow evaluation of postremediation groundwater-level suppression. Sampling and analysis of groundwater quality and contaminants were also conducted. Postremediation monitoring was specified for SWSA 3 in the *Phased Construction Completion Report for the Bethel Valley Burial Grounds at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE 2012). Required monitoring includes quarterly groundwater-level monitoring in 42 wells with continuous water-level monitoring in 8 wells to confirm cap performance. Groundwater samples are collected semiannually at 13 wells for laboratory analyses to evaluate groundwater contaminant concentration trends.

During FY 2015 monitoring results showed that the cap was effective although target groundwater elevations were exceeded at three of eight wells. Comparison of preremediation to postremediation groundwater contaminant concentrations showed that evaluated contaminant levels increased at one location, decreased at seven locations, were stable at six locations, and exhibited no trend at one location.

During FY 2015, as part of the DOE EM program, three groundwater monitoring wells in Bethel Valley to the west of Tennessee Highway 95 were monitored to detect and track contamination from the SWSA 3 area. Data from those three wells supplement data being collected from a multiport well (4579) near SWSA 3 for exit pathway groundwater monitoring in western Bethel Valley. Groundwater monitoring near SWSA 3, along with the exit pathway, and groundwater and surface water monitoring at the northwest tributary of WOC and in the headwaters of Raccoon Creek allow integration of data concerning SWSA 3 contaminant releases. The data are presented in the 2016 remediation effectiveness report (DOE 2016).

Groundwater monitoring continued at the ORNL 7000 Area during FY 2015 to evaluate treatability of the VOC plume at that site. Site characterization testing of the endemic microbial community showed that microbes were present that are capable of fully degrading TCE and its degradation products if sufficient electron donor compounds were 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. Monitoring of the stimulation of the endemic microbial community along with concentrations of chlorinated VOCs continued through FY 2015. Results of the monitoring show that the microbial community responded well to the addition of the carbon electron donor, and the VOC concentrations in the treated area have decreased significantly.

The other principal element of the Bethel Valley ROD (DOE 2002) remedy that requires groundwater monitoring is the containment pumping to control and treat discharges from the ORNL Central Campus core hole 8 plume. The original action for the plume was a CERCLA removal action that was implemented in 1995. The remedy had performed well until the latter portion of FY 2008 when conditions changed and ^{90}Sr and $^{233/234}$U concentrations in monitoring wells and the groundwater collection system began increasing. Leaking utility waterlines near the source area are suspected to have increased the mass of contaminants feeding the plume. Increased infiltration of plume water into storm drains has allowed increased contaminant flux to First Creek, a tributary of WOC. During FY 2009 the remedy did not meet its performance goal, which is a reduction of ^{90}Sr in WOC. In March 2012 DOE completed refurbishment and enhancement of the groundwater collection system to increase the plume containment effectiveness. Since FY 2013 the remedy has met its performance goal of reducing ^{90}Sr levels in WOC as measured at the 7500 bridge.

5.6.1.1.2 Melton Valley

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

Groundwater-level monitoring shows that the hydrologic isolation component of the Melton Valley remedy is effectively minimizing the amount of percolation water contacting buried waste and is reducing contaminated leachate formation. The total amount of rainfall during FY 2015 was slightly more than the long-term annual average for ORR. In a few areas groundwater levels within capped areas continue to respond to groundwater fluctuations imposed from areas outside the caps, but contact of groundwater with buried waste is minimal. Overall the hydrologic isolation systems are performing as designed.

Groundwater quality monitoring in the interior of Melton Valley shows that in general groundwater contaminant concentrations are declining or are stable following RAs. Groundwater quality monitoring substantively equivalent to the former RCRA monitoring continues at SWSA 6. Several VOC substances continue to be detected in wells along the eastern edge of the site.

During the past 10 years of groundwater monitoring in the Melton Valley exit pathway, several site-related contaminants have been detected in groundwater near the Clinch River. Low concentrations of ^{90}Sr, tritium, uranium, and VOCs have been detected intermittently in a number of the multizone sampling locations. Groundwater in the exit pathway wells has high alkalinity and sodium and exhibits elevated pH. During FY 2015 an off-site groundwater monitoring well array west of the Clinch River and adjacent to Melton Valley was monitored as part of the EM program. Monitoring included groundwater-level monitoring to evaluate potential flowpaths near the river and sampling and analysis for a wide array of metals, anions, radionuclides, and VOCs. Groundwater-level monitoring showed that natural head gradient conditions cause groundwater seepage to converge toward the Clinch River from both the DOE (eastern) and off-site (western) sides of the river. The maximum concentrations of ^{90}Sr, ^{3}H, and ^{99}Tc for the on-site exit pathway groundwater monitoring network during FY 2015 were estimated by the analytical laboratory (as indicated by the "J" flag on the reported results) indicating the presence of concentrations below quantitation limits. These estimated values were very low in comparison with the maximum contaminant levels (MCLs) specified in EPA regulations:

- Sr-90: 2.45 pCi/L (8 pCi/L MCL-derived concentration),
- H-3: 169 J pCi/L (20,000 pCi/L MCL-derived concentration), and
- Tc-99: 5.3 J pCi/L (900 pCi/L MCL-derived concentration).

Monitoring results are summarized in the 2016 remediation effectiveness report (DOE 2016).

5.6.1.1.3 Off-Site Groundwater Monitoring

In 2015, EM conducted groundwater monitoring in off-site wells adjacent to Melton Valley to determine whether contaminants were migrating off the ORR. Through its extensive groundwater monitoring efforts, EM has detected certain signature man-made contaminants near former Melton Valley waste disposal areas on DOE property. These contaminants include tritium; ^{90}Sr; ^{99}Tc; and chlorinated organic compounds, including TCE (an industrial solvent) and its degradation products. During FY 2015 DOE detected ^{90}Sr at very low concentrations in seven samples collected from six off-site monitoring wells (max of 0.74 pCi/L compared to the 8 pCi/L EPA MCL-derived concentration). Technetium-99 was detected in two of the Melton Valley off-site monitoring wells at estimated levels (maximum of 4.93 pCi/L compared to the 900 pCi/L MCL-derived concentration). Tritium was detected in six samples collected from five of the off-site monitoring wells (max of 220 pCi/L compared to the 20,000 pCi/L MCL).

5.6.2 DOE Office of Science Groundwater Monitoring

DOE O 458.1 (DOE 2011b) 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 DOE OS groundwater surveillance monitoring program are reported in the following sections.

Exit pathway and active-sites groundwater surveillance monitoring points sampled during 2015 included seep/spring and surface-water monitoring locations in addition to groundwater surveillance monitoring wells. Seep/spring and surface-water monitoring points located in appropriate groundwater discharge areas were used in the absence of monitoring wells.

Groundwater monitoring performed under the exit pathway groundwater surveillance and active-sites monitoring programs are not regulated by federal or state rules. Consequently, no permit or standards exist for evaluating sampling results. To provide a basis for evaluating analytical results and to assess groundwater quality at locations monitored by UT-Battelle, current federal drinking water standards and/or Tennessee WQCs for radiological and nonradiological contaminants were used as reference standards. If no federal or state standard had been established for a particular radionuclide, 4% of the DCSs for radionuclides found in DOE O 458.1 was used to evaluate sampling results. Although drinking water standards and DOE DCSs were used for comparative purposes, it is important to note that no members of the public consume groundwater from ORNL wells, nor do any groundwater wells furnish drinking water to personnel at ORNL.

5.6.2.1 Exit Pathway Monitoring

During 2015, exit pathway groundwater surveillance monitoring was performed in accordance with the *UT-Battelle Sampling and Analysis Plan for Surveillance Monitoring of Exit Pathway Groundwater at Oak Ridge National Laboratory* (Bonine 2012). Groundwater exit pathways at ORNL include areas from watersheds or sub-watersheds where groundwater discharges to the Clinch River–Melton Hill Reservoir to the west, south, and east of the ORNL main campus. The exit pathway monitoring points were chosen based on hydrologic features, screened interval depths (for wells), and locations relative to discharge areas proximate to DOE facilities operated by or under the control of UT-Battelle. The groundwater exit pathways at ORNL include four discharge zones identified by a data quality objectives process. One of the original exit pathway zones, the East End Discharge Area, was subsequently divided into two zones—the Southern Discharge Area Exit Pathway and the East End Discharge Area Exit Pathway.

The five zones are as follows:

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

Figure 5.37 shows the locations of the exit pathway monitoring points sampled in 2015.

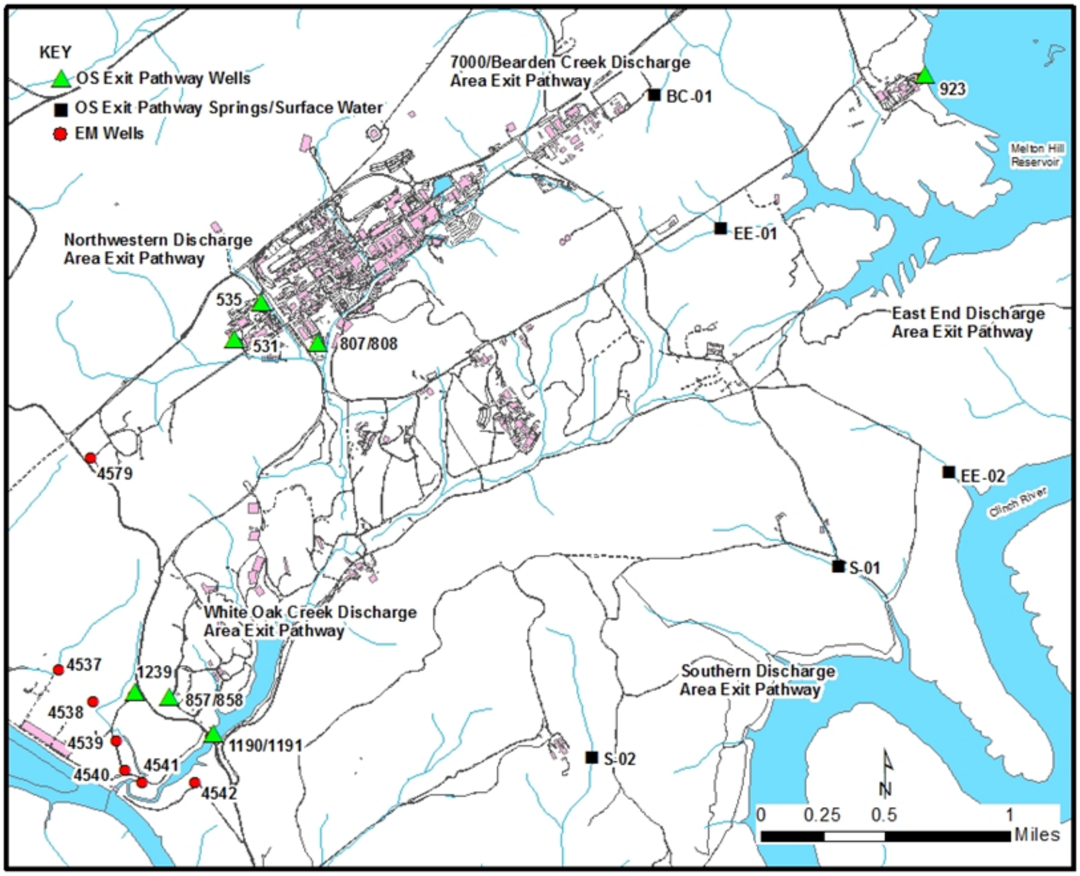


Fig. 5.37. UT-Battelle exit pathway groundwater monitoring locations at Oak Ridge National Laboratory, 2015. *[EM = Environmental Management and OS = Office of Science (both Department of Energy).]*

The efficacy of the exit pathway monitoring program was reviewed in late 2011. As a result, the groundwater monitoring program was modified through an optimization approach that included frequency analysis of parameters and their concentrations based on an exhaustive review of historical groundwater sampling data. The modification resulted in a 10-year staggered groundwater monitoring schedule and analytical suite selection. This approach was initiated in 2012. The groundwater monitoring program implemented in 2015 is outlined in Table 5.16.

Unfiltered samples were collected from the exit pathway groundwater surveillance monitoring points in 2015. The organic suite was composed of VOCs and semivolatile organic compounds (SVOCs); the metallic suite included heavy and non-heavy metals; and the radionuclide suite was composed of gross alpha/gross beta activity, gamma emitters, total radioactive strontium, and tritium. Under the monitoring strategy outlined in the *Sampling Analysis Plan* (Bonine 2012), samples were collected semiannually during the wet (April) and dry (August) seasons.

Table 5.16. Scheduled 2015 exit pathway groundwater monitoring

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

5.6.2.1.1 Exit Pathway Monitoring Results

Statistical trend analyses were performed on 2015 exit pathway monitoring data sets containing data exceeding reference standards. The bases used for the trend analyses were the historical data collected from the late 1980s through 2015. Trend analyses were not performed on data sets where minimum detection limits exceeded reference standards [i.e., the SVOCs atrazine, benzo(a)pyrene, hexachlorobenzene, and pentachlorophenol] and were not performed on parameters for which there are no reference standards or where data densities were insufficient. Parameters that exhibited statistically significant (80% to 99% confidence levels) upward or downward trends are reported. Trend analysis results are summarized in Table 5.17.

Samples were not collected at S-01 during the wet and dry season in 2015. Additionally, no sample was collected from EE-02 during the dry season. Samples were not collected due to a lack of water flow at the locations. Samples were collected at all other monitoring points during both the wet and dry seasons. Monitoring results are available in OREIS. Access to this system can be requested via email (oreis@ettp.doe.gov) or by telephone (865-574-3257).

Table 5.18 provides a summary of radiological parameters detected in samples collected from exit pathway monitoring points during 2015. Metals are ubiquitous in groundwater exit pathways and so are not summarized here.

Table 5.17. 2015 exit pathway groundwater monitoring—results of trend analyses for parameters exceeding reference standards

Discharge area	Monitoring point	Parameter	Statistically significant trend
White Oak Creek	1190	Iron	Downward
		Manganese	Downward
		Tritium	Downward
	1191	Iron	Downward
		Manganese	Upward
		Gross beta	Downward
		Total radioactive strontium	None detected
		Tritium	Downward
	807	Iron	None detected
		Manganese	None detected
Southern	S-02	Aluminum	None detected
		Iron	None detected
7000-Bearden Creek	BC-01	Aluminum	None detected

Table 5.18. 2015 exit pathway groundwater monitoring results—detected radiological parameters

Discharge Area	Monitoring Station	Radionuclide	Wet season (pCi/L)	Dry season (pCi/L)
White Oak Creek	857	Beta activity	3.2	*a*
		Bismuth-214	67	120
		Lead-214	77	*a*
	858	Beta activity	5.1	6.4
		Bismuth-214	*a*	19
		Lead-214	*a*	17
		Potassium-40	*a*	35
	1190	Alpha activity	1.7	6
		Beta activity	6.1	3.7
		Bismuth-214	71	24
		Lead-212	7.6	*a*
		Lead-214	74	23
		Tritium	23,000	23,000
	1191	Alpha activity	3	*a*
		Beta activity	430	330
		Bismuth-214	110	*a*
		Lead-214	130	22
		Strontium-89/90	190	150
		Tritium	32,000	15,000
	1239	Beta activity	2.6	*a*
		Potassium-40	*a*	51

Table 5.18 (continued)

Discharge Area	Monitoring Station	Radionuclide	Wet Season (pCi/L)	Dry Season (pCi/L)
Northwest	531	Beta activity	*a*	1.6
		Bismuth-214	13	*a*
		Lead-214	14	*a*
	535	Beta activity	2.1	6.8
		Bismuth-214	34	*a*
		Lead-214	31	*a*
		Tritium	230	*a*
	807	Alpha activity	2.2	*a*
		Beta activity	2.4	*a*
		Bismuth-214	150	19
		Lead-214	170	18
		Tritium	390	500
	808	Alpha activity	3	*a*
		Beta activity	9.6	2.2
		Bismuth-214	[a]	7
		Thallium-208	3	*a*
East End	923	Beta activity	2.6	7.5
		Bismuth-214	*a*	15
		Lead-214	*a*	19
	EE-01	Bismuth-214	11	*a*
		Lead-214	23	*a*
	EE-02	Bismuth-214	170	*b*
		Lead-214	180	*b*
Southern	S-01	*b*	*b*	*b*
	S-02	Bismuth-214	31	16
		Lead-214	38	20
7000-Bearden Creek	BC-01	Beta activity	2.1	*a*
		Bismuth-214	36	15
		Lead-214	33	16

[a] Parameter was not detected in sample aliquot.
[b] No sample was collected because the spring was dry.

Summary

A summary of 2015 analytical results associated with the OS exit pathway groundwater surveillance program monitoring efforts ORNL is presented below:

- Nine radiological contaminants were detected in exit pathway groundwater samples collected in 2015. Tritium, total radioactive strontium, and gross beta activity were the only radiological contaminants exceeding reference standards at any of the discharge areas and, as in past years, those three contaminants were observed at the WOC discharge area in 2015 (in wells 1190 and 1191). Statistical trend analyses show that the concentration trends for those parameters continue downward. No other radiological contaminants exceed reference standards at other discharge areas.

- Twenty-seven metallic contaminants were detected in exit pathway groundwater samples collected in 2015; however only four metals (iron, manganese, lead, and aluminum) were detected at concentrations exceeding reference standards. These metals are commonly found in groundwater at ORNL

- No organics (VOCs or SVOCs) were detected in exit pathway groundwater at ORNL during 2015.

Radiological and metal contaminant concentrations observed in groundwater exit pathway discharge areas were generally consistent with observations reported in past ORR annual site environmental reports. Based on the results of the 2015 monitoring effort, there is no indication that current OS operations are having a significant adverse effect on groundwater at ORNL.

5.6.2.2 Active Sites Monitoring

5.6.2.2.1 Active Sites Monitoring—High Flux Isotope Reactor

Outfall pipelines intercepting groundwater from the HFIR area are routinely monitored. The sampling is required under the ORNL NPDES permit. (See Section 5.5 for a discussion of results.)

5.6.2.2.2 Active Sites Monitoring—Spallation Neutron Source

Active sites groundwater surveillance monitoring was performed in 2015 at the SNS site under the SNS operational monitoring plan (OMP) (Bonine et al. 2007) due to the potential for adverse impact on groundwater resources at ORNL if a release were to occur. Operational monitoring was initiated following a 2-year (2004–2006) baseline monitoring program and will continue throughout the duration of SNS operations.

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

The SNS site is a hydrologic recharge area underlain by geologic formations that form karst geologic features. Groundwater flow directions at the site are based on the generally observed tendency for groundwater to flow parallel to geologic strike (parallel to the orientation of the rock beds) and via karst conduits that break out at the surface in springs and seeps located downgradient of the SNS site. A sizable fraction of infiltrating precipitation (groundwater recharge) flows to springs and seeps via the karst conduits.

SNS operations have the potential for introducing radioactivity (via neutron activation) in the shielding berm surrounding the SNS linac, accumulator ring, and/or beam transport lines. A principal concern is the potential for water infiltrating the berm soils to transport radionuclide contamination generated by neutron activation to saturated groundwater zones. The ability to accurately model the fate and transport of neutron activation products generated by beam interactions with the engineered soil berm is complicated by multiple uncertainties resulting from a variety of factors, including hydraulic conductivity differences in earth materials found at depth, the distribution of water-bearing zones, the fate and transport characteristics of neutron activation products produced, diffusion and advection, and the presence of karst geomorphic features found on the SNS site. These uncertainties led to the initiation of the groundwater surveillance monitoring program at the SNS site. Objectives of the groundwater monitoring program outlined by the OMP include (1) maintaining compliance with applicable DOE contract requirements and environmental quality standards and (2) providing uninterrupted monitoring of the SNS site.

Seven seeps/springs and surface water sampling points (seeps/springs S-1, S-2, S-3, S-4, S-5, and SP-1 and surface-water point SW-1) were routinely monitored as analogues to, and in lieu of, groundwater monitoring wells. Locations were chosen based on hydrogeological factors and proximity to the beam line. Figure 5.38 shows the locations of the specific monitoring points sampled during 2015.

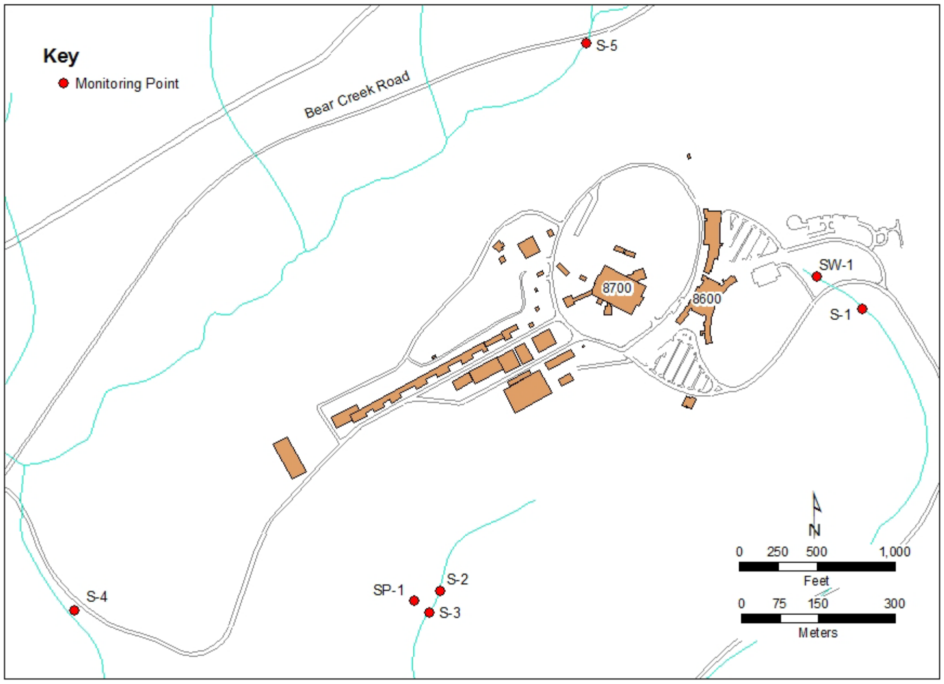


Fig. 5.38. Groundwater monitoring locations at the Spallation Neutron Source, 2015.

In November 2011 the SNS historical tritium data were evaluated to determine whether sampling could be optimized. The influence of flow condition on the proportion of tritium detects and nondetects in water samples collected at SNS from April 2004 through September 2011 was examined. In addition, the effect of seasonality on the proportion of detects and nondetects was examined for the same data set. The results of the analysis indicated that the proportion of detects to nondetects is not related to flow conditions or seasonality. This implies that samples could be collected during any flow condition and season with the expectation that there would be no statistical difference in the proportion of tritium detects to nondetects. The results of this statistical analysis of the April 2004–September 2011 data set were the basis for the modified OMP monitoring scheme implemented in 2015.

Taking a conservative approach, quarterly sampling at each monitoring point continued in 2015, allowing the opportunity for wet and dry season monitoring. All sampling performed in 2015 was performed in conjunction with rainfall events, with samples being collected during rising or falling (recession) limb flow conditions (see Fig. 5.39). Table 5.19 shows the sampling and parameter analysis schedule followed in 2015.

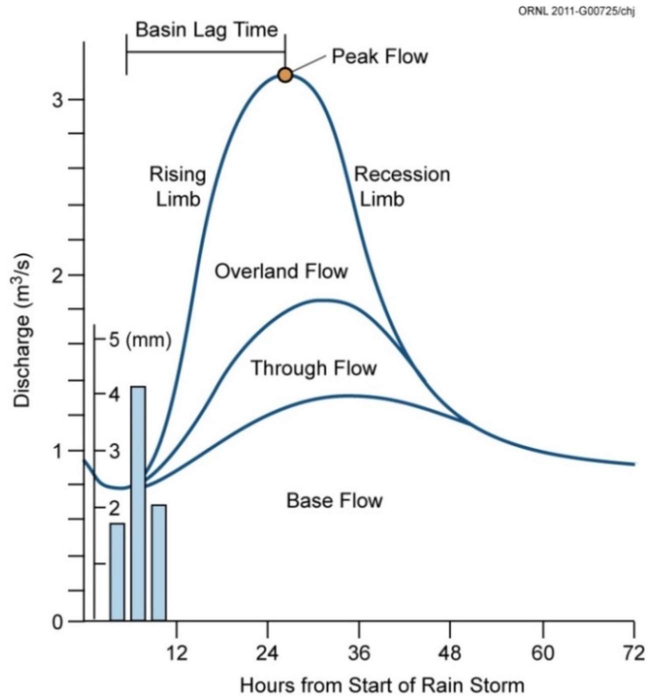


Fig. 5.39. Simple hydrograph of spring discharge vs. time after initiation of rainfall.

Table 5.19. 2015 Spallation Neutron Source monitoring program schedule

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

[a] The expanded suite includes gross alpha and gross beta activity, carbon-14, hydrogen-3, and gamma emitters.

Spallation Neutron Source Site Results

In 2015 sampling at the SNS site occurred during March (quarter 1), June (quarter 2), September (quarter 3), and November (quarter 4). Low concentrations of several radionuclides were detected numerous times during 2015. Table 5.20 provides a summary of the locations for radionuclide detections observed during 2015. The reference standard for tritium was not exceeded at any SNS monitoring location in 2015.

Table 5.20. Analytical results for parameters detected in samples collected at the Spallation Neutron Source during 2015 (pCi/L)

Location	Quarter	Parameter	Result	Reference standard
S-1	1	Tritium	376	20,000
S-4	1	Bi-214	20.3	10,595
S-4	1	Pb-214	11.7	8,000
S-5	1	Beta	4.8	50
S-5	1	Bi-214	23.6	10,595
S-5	1	Pb-214	21.3	8,000
S-2	1	Tritium	378	20,000
S-5	1	Tritium	956	20,000
S-1	2	Tritium	301	20,000
S-2	2	Tritium	345	20,000
SW-1	2	Tritium	1,770	20,000
S-2	3	Tritium	241	20,000
S-1	3	Beta	3.67	50
S-1	3	Bi-214	31.4	10,595
S-1	3	Pb-214	25.6	8,000
SW-1	3	Bi-214	71.6	10,595
SW-1	3	Pb-214	90.9	8,000
SW-1	3	Tritium	1,210	20,000
S-2	4	Tritium	1,700	20,000
S-3	4	Tritium	269	20,000
S-4	4	Tritium	1,620	20,000
S-2	4	Beta	4.59	50
S-2	4	Bi-214	5.42	10,595
SP-1	4	Tritium	511	20,000
SW-1	4	Tritium	694	20,000

Reference standards for ^{14}Bi and ^{214}Pb are 4% of the DOE O 458.1 derived concentration standards. Reference standards for the remainder of the parameters are the National Primary Drinking Water Standards (40 CFR Part 141).
No radionuclides exceeded a reference standard during 2015.

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*. The methods used for successful implementation of the QMS rely on the integration and implementation of quality elements/criterion flowed-down through multiple management systems and daily operating processes. These management systems and processes are described in the Standards-Based Management System (SBMS), where basic requirements are communicated to staff. Additional or specific customer requirements are addressed at the project or work activity level. The QMS provides a graded approach to implementation based upon risk. The application of QA and quality assurance (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 necessary for staff to safely and effectively perform work. SBMS translates laws, orders, directives, policies, and best-management practices into laboratorywide subject areas and procedures.

5.7.1 Work/Project Planning and Control

UT-Battelle's work/project planning and control directives establish the processes and requirements for executing work activities at ORNL. All environmental sampling tasks are performed following the four steps required in the work control subject areas:

- define scope of work;
- perform work planning—analyze hazards and define controls;
- execute work; and
- provide feedback.

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

Environmental sampling standard operating procedures developed for UT-Battelle environmental sampling programs provide detailed instructions on maintaining chain of custody, sample identification, sample collection and handling, sample preservation, equipment decontamination, and collection of quality control samples such as field and trip blanks, duplicates, and equipment rinses.

5.7.2 Personnel Training and Qualifications

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

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

5.7.3 Equipment and Instrumentation

5.7.3.1 Calibration

The UT-Battelle Quality Management System includes subject area directives that require all UT-Battelle staff to use equipment of known accuracy based on appropriate calibration requirements that are traceable to an authority standard. The UT-Battelle Facilities and Operations Instrumentation and Control Services team tracks all equipment used in the environmental monitoring programs conducted by UT-Battelle for the ORNL site and ORR through a maintenance recall program to ensure that equipment is functioning properly and within defined tolerance ranges. The determination of calibration schedules and frequencies is based on a graded approach at the activity planning level. EPSD environmental monitoring programs follow rigorous calibration schedules to eliminate gross drift and the need for data adjustments. Instrument tolerances, functions, ranges, and calibration frequencies are established based on manufacturer specifications, program requirements, actual operating environment and conditions, and budget considerations.

In addition, a continuous monitor used for CAA compliance monitoring at ORNL boiler 6 is subject to rigorous QA protocols as specified by EPA methods. A relative accuracy test audit (RATA) is performed annually to certify the Predictive Emissions Monitoring System (PEMS) for nitrogen oxides and oxygen. The purpose of RATA is to provide a rigorous QA assessment in accordance with EPA 40 CFR, Performance Specification 16. Three out of four quarters a RATA is performed on PEMS using a second, calibrated system to verify the accuracy of PEMS. The results of these QA tests are provided to TDEC quarterly, semiannually, or annually as applicable.

5.7.3.2 Standardization

The UT-Battelle IDMS provides the necessary functionality and controls to ensure that controlled documents are managed, distributed, revised, and maintained in accordance with ORNL document control requirements. EPSD sampling procedures are maintained in IDMS and include requirements and instructions for the proper standardization and use of monitoring equipment. Requirements include the use of traceable standards and measurements; performance of routine, before-use equipment standardizations; and actions to follow when standardization steps do not produce required values. Standard operating procedures for sampling also include instructions for designating nonconforming instruments as “out-of-service” and initiating requests for maintenance.

5.7.3.3 Visual Inspection, Housekeeping, and Grounds Maintenance

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

5.7.4 Assessment

Independent audits, surveillance, and internal management assessments are performed to verify that requirements have been accurately specified and activities that have been performed conform to expectations and requirements. External assessments are scheduled based on requests from auditing agencies. Table 5.2 presents a list of environmental audits and assessments performed at ORNL in 2015 and information on the number of findings identified, if any. EPSD also conducts internal management assessments of UT-Battelle environmental monitoring procedural compliance, safety performance, and work planning and control. Surveillance results, recommendations, and completion of corrective actions, if required, are also documented and tracked in the UT-Battelle Assessment and Commitment Tracking System.

WAI/NWSol and Isotek perform independent audits, surveillances, and internal management assessments to verify that requirements have been accurately specified and that activities that have been performed conform to expectations and requirements. WAI/NWSol corrective actions, if required, are documented and tracked in an Issues Management Database or Deficiency Reporting Database, and Isotek corrective actions are tracked in its Assessment and Commitment Tracking System.

5.7.5 Analytical Quality Assurance

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

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

5.7.6 Data Management and Reporting

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

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

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

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

5.7.7 Records Management

The UT-Battelle Records Management System provides the requirements for managing all UT-Battelle records. Requirements include creating and identifying record material; scheduling, protecting, and record storage in office areas and the UT-Battelle Inactive Records Center; and destroying records.

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

5.8 Environmental Management and Waste Management Activities at Oak Ridge National Laboratory

ORNL is becoming one of the world’s most modern campuses for scientific discovery in materials and chemical sciences, nuclear science, energy research, and supercomputing. However, in the midst of all this modern infrastructure are large contaminated areas—the legacy of past operations and waste disposal practices. The DOE EM program has divided ORNL into two major cleanup areas: Bethel Valley and Melton Valley. The Bethel Valley area includes reactors and the principal research facilities, and Melton Valley includes reactors and waste management areas. The following sections summarize some of the 2015 EM activities undertaken at ORNL. More detailed information is available in the 2015 cleanup progress report (UCOR 2015).

5.8.1 Uranium-233 and Consolidated Edison Uranium Solidification Project Material Disposition Activities

In 2015, DOE remained focused on disposing of a significant inventory of uranium-233 (U-233) stored in Building 3019 at ORNL. The U-233 Project objective is to address safeguards and security requirements, eliminate safety and nuclear criticality concerns, and safely dispose of the material. In 2015, DOE also successfully resolved concerns associated with the disposition of the CEUSP material. CEUSP originated from a 1960s R&D test of thorium and uranium fuel at Consolidated Edison’s Indian Point 1 Nuclear Plant. Direct disposition efforts resumed during 2015, and preparations continued for a processing campaign for material that cannot be disposed of directly.

5.8.2 Waste Disposal at Molten Salt Reactor Experiment Facility

Work continued during FY 2015 to characterize and dispose of waste items from the Molten Salt Reactor Experiment facility, a graphite-moderated, liquid-fueled test reactor that operated at ORNL from June 1965 until December 1969 (Fig 5.40). In 2015, 14 waste items were characterized, and 16 waste items were disposed of, which exceeds the scheduled plan.

Since the reactor’s shutdown, EM has performed several studies and removal actions to stabilize the facility, including removal of uranium deposits and defueling of the reactor salts. Routine surveillance and maintenance activities continue to manage the remaining hazards associated with the facility, including periodic removal of reactive gas generated by the defueled salts.

Fig. 5.40. The Molten Salt Reactor Experiment facility.

5.8.3 Waste Management at Oak Ridge National Laboratory

5.8.3.1 Oak Ridge National Laboratory Wastewater Treatment

At ORNL, DOE EM operates PWTC and the Liquid Low-Level Waste Treatment Facility. In 2015 358 million L of wastewater was treated and released at PWTC. In addition, the liquid LLW evaporator at ORNL treated 557,466 L of waste. The waste treatment activities of these facilities support both DOE EM and DOE OS mission activities, ensuring that wastewaters from activities associated with projects of both offices are managed in a safe and compliant manner.

5.8.3.2 Oak Ridge National Laboratory Newly Generated Waste Management

ORNL is the largest, most diverse DOE OS laboratory in the DOE complex. Although much effort is expended to prevent pollution and eliminate waste generation, some waste streams are generated as a by-product of performing research and operational activities and must be managed to ensure that the environment is protected from associated hazards. UT-Battelle, as the prime contractor for the management of ORNL, is responsible for management of most of the wastes generated from R&D activities and wastes generated from operation of the R&D facilities. TRU wastes and waste streams that can be treated by on-site liquid and/or gaseous waste treatment facilities operated by EM are treated via these systems. Other R&D waste streams are generally packaged by UT-Battelle in appropriate shipping containers for off-site transport to commercial waste-processing facilities. In CY 2015, ORNL performed 73 waste shipments to off-site hazardous/radiological/mixed waste treatment and/or disposal vendors with no shipment rejections or violations.

5.8.3.3 Transuranic Waste Processing Center

TRU waste-processing activities carried out for DOE in 2015 by NWSol addressed CH solids/debris and RH solids/debris, which involved processing, treating, and repackaging of waste. Off-site transportation and disposal of LLW at NNSS or other approved off-site facilities was also performed in 2015. TRU waste disposal at the Waste Isolation Pilot Plant will resume once the facility is reopened to receive TRU waste.

During CY 2015, 26.0 m^3 of CH waste and 53.4 m^3 of RH waste were processed and 33.8 m^3 of mixed LLW (TRU waste that dropped out as low level) was shipped off the site.

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6. Oak Ridge Reservation Environmental Monitoring Program

In addition to environmental monitoring conducted at the three major Oak Ridge Department of Energy (DOE) installations, reservation wide environmental monitoring is performed to measure radiological and nonradiological parameters directly in environmental media adjacent to the facilities. Data from the Oak Ridge Reservation–wide environmental monitoring program are analyzed to assess the environmental impact of DOE operations on the entire reservation and the surrounding area. Dose assessment information based on data from this program is presented in Chapter 7.

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

6.1 Meteorological Monitoring

Nine meteorological towers provide data on meteorological conditions and on the transport and diffusion qualities of the atmosphere on the Oak Ridge Reservation (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 potential accidental releases from a facility. Data from the towers are also used to support various research and engineering projects.

6.1.1 Description

The nine meteorological towers on ORR are described in Table 6.1 and depicted in Fig. 6.1. In this document, the individual ORR-managed towers are designated by “MT” followed by a numeral. Other commonly used names for the sites are also provided in Table 6.1. Meteorological data are collected at different levels above the ground (2, 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 the 10 or 15 m level at most towers, but the lowest wind measurement height is 25 m for MT11. Additionally, data are collected at selected towers at the 30, 33, 35, and 60 m levels. At each measurement level except 2 m, temperature, wind speed, and wind direction are measured. Atmospheric stability (a measure of vertical mixing properties of the atmosphere) is measured at most towers; however, measurements involving vertical temperature profiles (SRDT Method) limit accurate determination of nighttime stability to the towers that are 60 m in height. Barometric pressure is measured at one or more of the towers at each ORR plant (MT1, MT2, MT4, MT6, MT7, and MT9). Precipitation is measured at MT6 and MT9 at the Y-12 National Security Complex (the Y-12 Complex), at MT1 and MT7 at the East Tennessee Technology Complex (ETTP), and at MT2 and MT4 at Oak Ridge National Laboratory (ORNL). Solar radiation is measured at MT6 and MT9 at the Y-12 Complex, at MT1 and MT7 at ETTP, and at MT2 at ORNL. Data are collected at 1 s intervals and are averaged for 1, 15, and 60 min intervals. Calibrations of the instruments were managed by UT-Battelle and were performed every 6 months by an independent auditor.

In addition to the meteorological towers, sonic detection and ranging (SODAR) devices have been installed at the east end of the Y-12 Complex and adjacent to Tower MT2 at ORNL. These devices use acoustic waves to estimate wind direction, wind speed, and turbulence at altitudes higher than the reach of meteorological towers (60–500 m above ground level). Although SODAR measurements are somewhat less accurate than measurements made on the meteorological towers, SODAR devices provide useful information regarding stability, upper air winds, and mixing depth. Mixing depth represents the thickness of the air layer adjacent to the ground over which an emitted or entrained inert nonbuoyant tracer would be mixed by turbulence within 1 h or less.

Table 6.1. Oak Ridge Reservation meteorological towers

Tower	Alternate tower names	Location (lat., long.)	Altitude (m MSL)	Measurement heights (m)
		ETTP		
MT1	K, 1208	35.93317N, -84.38833W	263	10, 60
MT7	L, 1209	35.92522N, -84.39414W	233	10, 30
		ORNL		
MT2	D*, 1047	35.92559N, -84.32379W	261	2, 15, 35, 60
MT3	B, 6555	35.93273N, -84.30254W	256	15, 30
MT4	A, 7571	35.92185N, -84.30470W	266	10/15, 30
MT10	M, 208A	35.90947N, -84.38796W	244	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	35.98190 N,-84.25504W	352	25

Acronyms
ETTP = East Tennessee Technology Park
MSL = mean sea level
ORNL = Oak Ridge National Laboratory
PSS = plant shift superintendent
Y-12 Complex = Y-12 National Security Complex
*Tower "C" before May 2014 with measurement heights of 10, 30, and 100 m.

Data are collected in real time for 1 min, 15 min, and hourly average intervals for emergency-response purposes, including dispersion modeling at the ORNL and Y-12 Complex Emergency Operations Centers.

Annual dose estimates are calculated from the archived hourly data. Data quality is checked continuously against predetermined data constraints, and out-of-range parameters are marked as invalid and are excluded from compliance modeling.

Mixing depth represents the thickness of the air layer adjacent to the ground over which an emitted or entrained inert nonbuoyant tracer would be mixed by turbulence within 1 h or less.

Appropriate substitution data are identified when possible. Quality assurance records of missing and erroneous data are routinely kept for the nine towers.

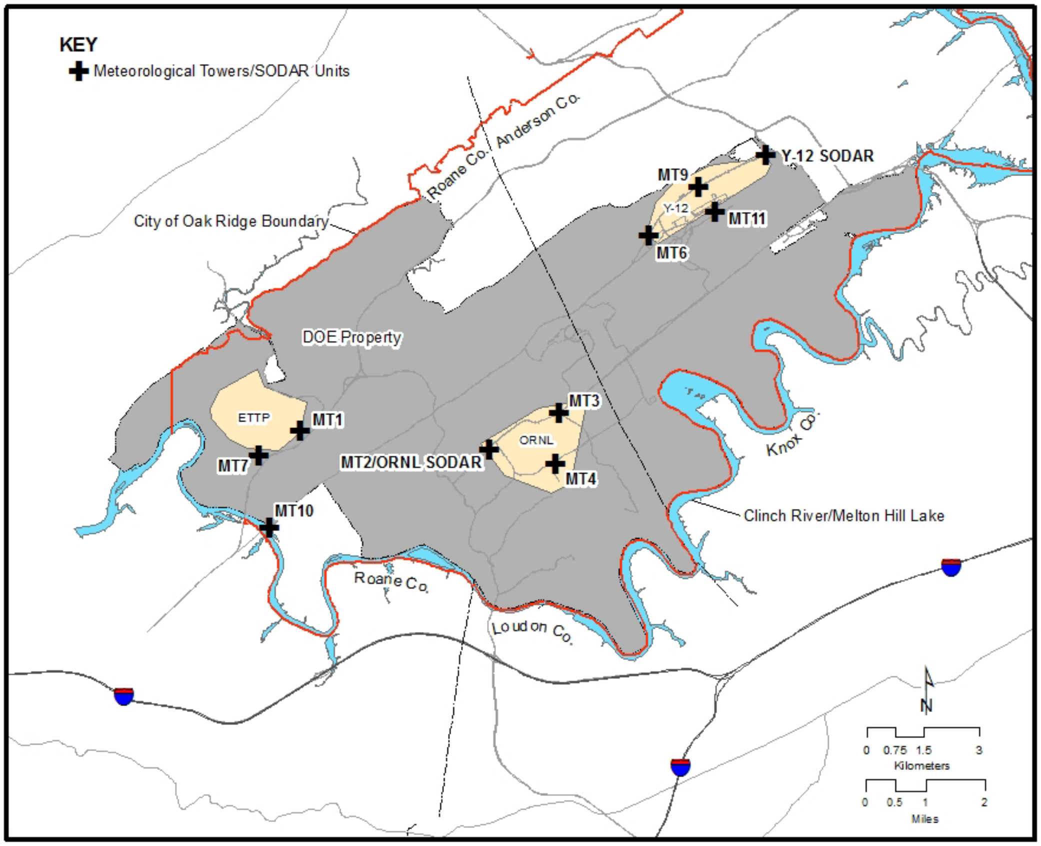

Fig. 6.1. The Oak Ridge Reservation meteorological monitoring network, including sonic detection and ranging (SODAR) devices.

6.1.2 Results

Prevailing winds are generally up-valley from the southwest and west-southwest or down-valley from the northeast and east-northeast, a pattern that typically results from channeling effects produced by the 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 in a less-constrained open valley bottom.

On the ORR, low-speed winds dominate near the valley surfaces, largely because of the decelerating influence of nearby ridges and mountains. Wind acceleration sometimes is observed at ridge-top level, particularly when flow is not parallel to the ridges (see Appendix B).

The atmosphere over ORR is often dominated 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 emitted from the facilities. However, high roughness values (caused by terrain and obstructions such as trees and buildings) partially mitigate these factors through increased turbulence processes (atmospheric mixing). These features are captured in data input to dispersion models and are reflected in modeling studies conducted for each facility.

Precipitation data from tower MT2 are used in stream-flow 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 thunderstorms. The total precipitation in Oak Ridge (townsite) during 2015 (1449 mm or 57.08 in.) was more than 10% above the long-term average of 1337.5 mm (52.64 in.) The average annual wind data recovery rates (a measure of acceptable data) across locations used for modeling during 2015 were greater than 97% for wind sensors at the ORNL sites (towers MT2, MT3, MT4, and MT10) with the exception of the 10/15 m Tower MT4 wind sensor (41%) due to the destruction of the instrument during an ice storm in February 2015 and associated damage to the tower boom. (Considerable time was required to procure replacement parts and to repair the equipment.). All other tower MT2, MT3, and MT4 instrument recoveries were well above 90% for both quarterly and annual values.

Annual data recovery from ETTP meteorological towers during 2015 ranged from 94.5% to 100% (towers MT1 and MT7). The Y-12 towers (MT6, MT9, and MT11) had recovery rates ranging from 95% to 100% during 2015.

6.2 External Gamma Radiation Monitoring

6.2.1 Data Collection and Analysis

External gamma exposure rates are continuously recorded by dual-range Geiger-Müller (GM) tube detectors at six ORR ambient air stations (Fig. 6.2) including station 52, the reference location at Fort Loudoun Dam. Table 6.2 summarizes the data for each station.

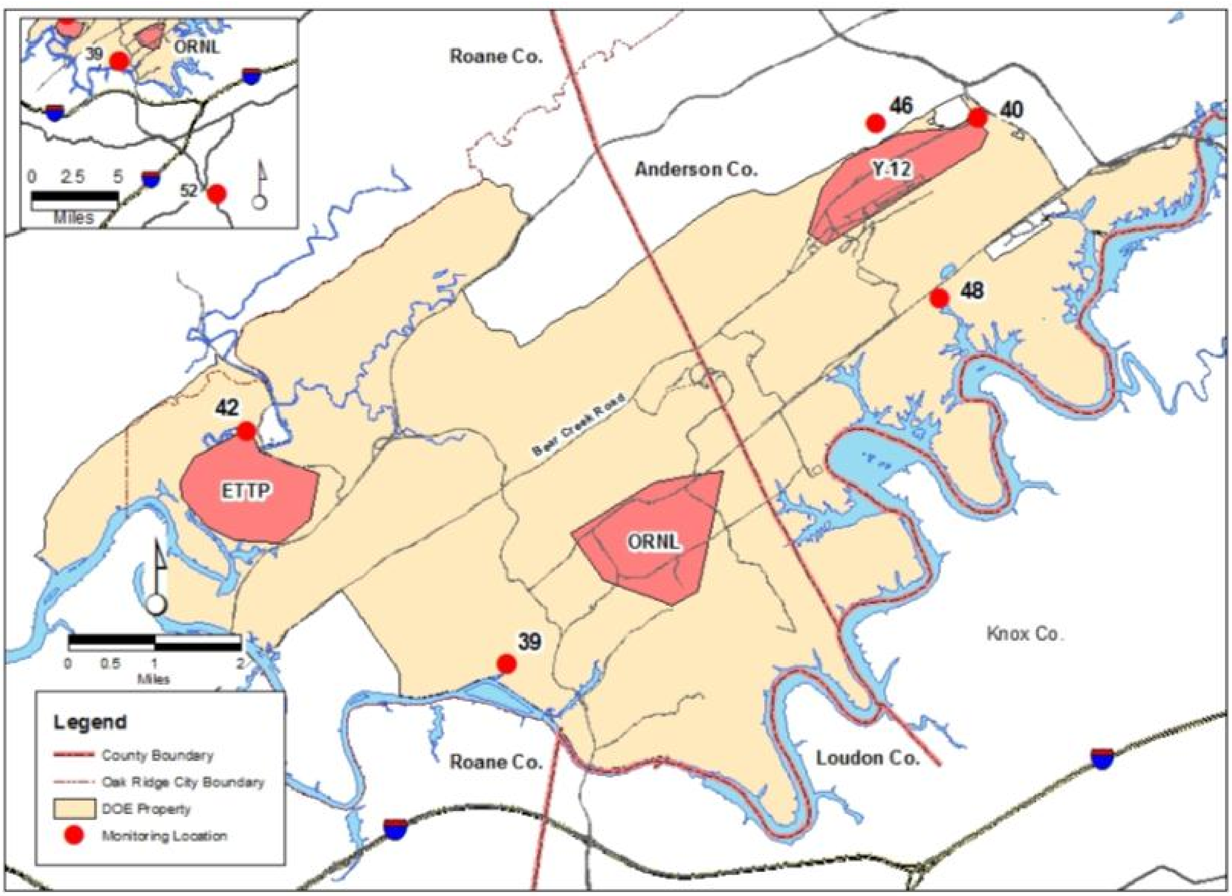

Fig. 6.2. External gamma radiation monitoring locations on the Oak Ridge Reservation.

Table 6.2. External gamma (exposure rate) averages for the Oak Ridge Reservation, 2015

Monitoring location	Number of data points (daily)	Measurement (μR/h)[a]		
		Min	Max	Mean
39	365	10.4	13.0	11.7
40	365	9.3	12.3	10.4
42	359	8.9	11.5	9.6
46	365	9.8	13.1	11.0
48	365	9.0	26.7	9.9
52	365	8.8	10.6	9.5

[a]To convert microroentgens per hour (μR/h) to milliroentgens per year, multiply by 8.760

6.2.2 Results

The mean exposure rate for the reservation network in 2015 was 10.5 μR/h, and the mean at the reference location was 9.5 μR/h. Exposure rates from background sources in Tennessee range from 2.9 to 11 μR/h.

6.3 Ambient Air Monitoring

In addition to exhaust stack monitoring conducted at the DOE Oak Ridge 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 (Fig. 6.3). 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 allow determination of contaminant levels at monitoring locations in the event of an emergency.

Fig. 6.3. Oak Ridge Reservation ambient air station.

Ambient air monitoring conducted by individual site programs is discussed in chapters 3, 4, and 5. The ORR ambient air monitoring program complements these individual site programs and permits the impacts of ORR operations to be assessed on an integrated basis. This program is discussed in detail in the following sections.

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 ORR perimeter air monitoring network includes stations 1, 35, 37, 38, 39, 40, 42, 46, and 48 (Fig. 6.4). Reference samples are collected from Station 52 (Fort Loudoun Dam). Sampling was conducted at each ORR station during 2015 to quantify levels of alpha-, beta-, and gamma-emitting radionuclides.

Atmospheric dispersion modeling was used to select appropriate sampling locations. The locations selected are those likely to be affected most by releases from the Oak Ridge facilities. Therefore, in the event of a release, no residence or business in the vicinity of ORR should receive a radiation dose greater than doses calculated at the sampled locations.

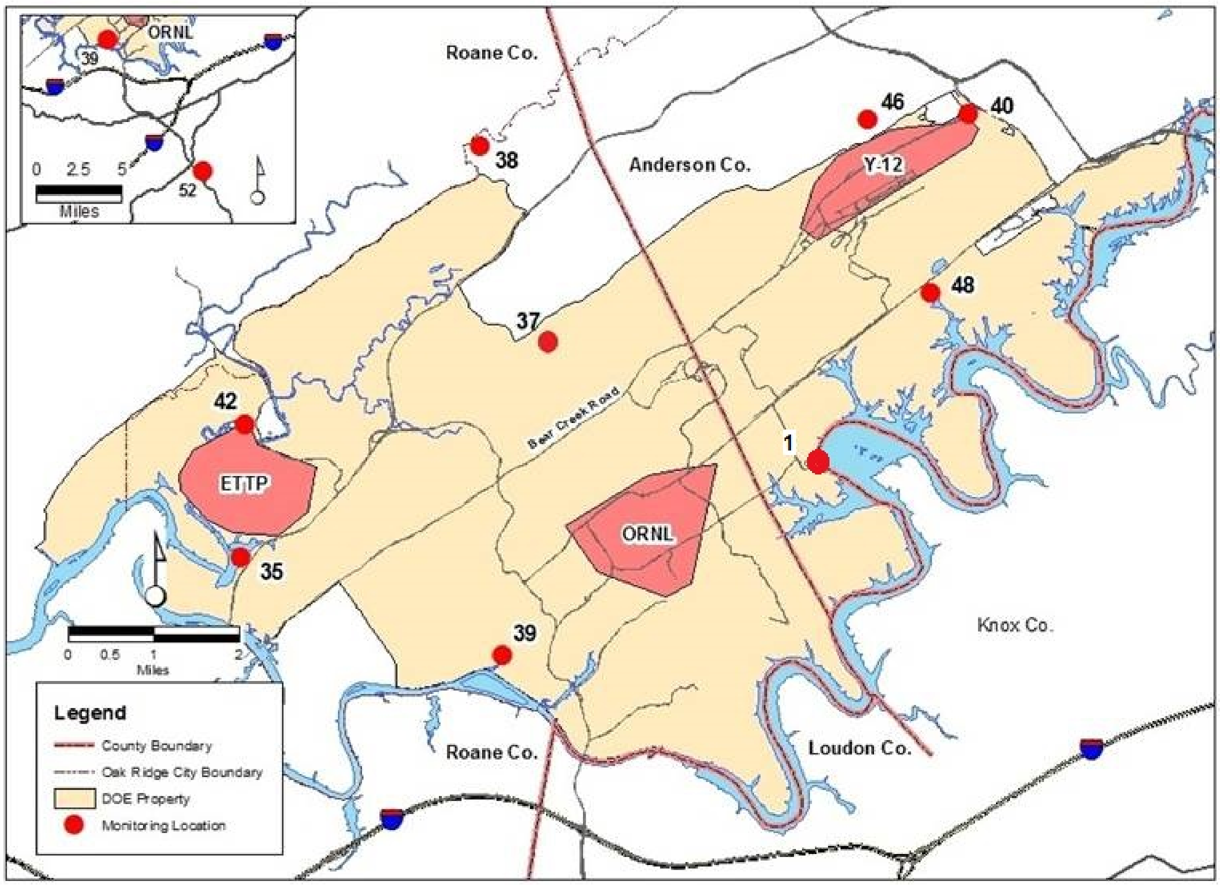

Fig. 6.4. Locations of Oak Ridge Reservation perimeter air monitoring stations.

The sampling system consists of two separate instruments. Particulates are captured by high-volume air samplers equipped with glass-fiber filters. The filters are collected weekly, composited quarterly, and then submitted to an analytical laboratory to quantify gross alpha and beta activity and to determine the concentrations of specific isotopes of interest on ORR. The second system 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 tritium analysis.

6.3.1 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 6.3) is compared with derived concentration standards (DCSs) for air established by DOE as guidelines for controlling exposure to members of the public. All radionuclide concentrations measured at the ORR ambient air stations during 2015 were less than 1% of applicable DCSs, indicating that activities on the reservation are not adversely affecting local air quality.

Table 6.3. Average concentrations of radionuclides at Oak Ridge Reservation perimeter air monitoring stations, 2015

Parameter	N detected/ N total	Concentration (pCi/mL)		
		Average	Minimum	Maximum
		Station 1		
Be-7	4/4	4.78E-08	3.91E-08	5.51E-08
K-40	1/4	5.88E-10	-4.87E-10	3.05E-09
Tc-99	3/4	3.09E-10	2.03E-11	4.59E-10
Tritium	0/4	1.92E-06	2.30E-07	4.80E-06
U-234	4/4	4.18E-12	2.51E-12	5.29E-12
U-235	2/4	3.26E-13	1.03E-13	8.07E-13
U-238	4/4	2.68E-12	2.46E-12	2.95E-12
		Station 35		
Be-7	4/4	4.51E-08	3.63E-08	5.56E-08
K-40	0/4	-1.91E-10	-5.27E-10	6.65E-11
Tc-99	4/4	4.65E-10	3.01E-10	6.15E-10
Tritium	0/4	3.67E-06	1.57E-07	7.69E-06
U-234	4/4	2.73E-12	2.32E-12	3.37E-12
U-235	2/4	3.25E-13	1.35E-13	5.26E-13
U-238	4/4	2.25E-12	1.53E-12	2.80E-12
		Station 37		
Be-7	4/4	4.43E-08	2.39E-08	5.86E-08
K-40	1/4	5.33E-10	-1.75E-10	1.04E-09
Tc-99	3/4	2.71E-10	1.60E-10	4.55E-10
Tritium	0/4	6.30E-07	-4.25E-07	1.68E-06
U-234	4/4	2.66E-12	2.12E-12	2.94E-12
U-235	1/4	1.34E-13	9.54E-15	2.92E-13
U-238	4/4	2.07E-12	1.92E-12	2.33E-12
		Station 38		
Be-7	4/4	4.92E-08	3.77E-08	6.10E-08
K-40	0/4	-5.65E-11	-2.61E-10	7.18E-11
Tc-99	2/4	2.59E-10	1.34E-10	3.86E-10

Table 6.3 (continued)

Parameter	N detected/ N total	Concentration (pCi/mL)		
		Average	Minimum	Maximum
Tritium	0/4	3.66E-06	-6.26E-07	1.10E-05
U-234	4/4	2.47E-12	1.64E-12	3.31E-12
U-235	2/4	1.21E-13	-1.14E-13	2.77E-13
U-238	4/4	2.16E-12	1.70E-12	2.86E-12
		Station 39		
Be-7	4/4	4.46E-08	3.54E-08	4.81E-08
K-40	0/4	-3.49E-11	-4.34E-10	3.96E-10
Tc-99	3/4	2.41E-10	7.42E-12	4.14E-10
Tritium	1/4	6.43E-06	4.22E-07	1.82E-05
U-234	4/4	2.55E-12	1.91E-12	3.84E-12
U-235	1/4	1.71E-13	1.25E-13	2.90E-13
U-238	4/4	1.77E-12	1.43E-12	2.21E-12
		Station 40		
Be-7	4/4	4.57E-08	3.31E-08	6.28E-08
K-40	0/4	-6.09E-11	-3.71E-10	1.88E-10
Tc-99	2/4	2.39E-10	7.57E-11	4.00E-10
Tritium	0/4	4.62E-06	5.62E-07	1.27E-05
U-234	4/4	1.09E-11	8.12E-12	1.37E-11
U-235	2/4	4.81E-13	2.23E-13	6.51E-13
U-238	4/4	6.34E-12	2.56E-12	1.45E-11
		Station 42		
Be-7	4/4	4.75E-08	3.73E-08	5.50E-08
K-40	0/4	-3.64E-10	-9.36E-10	8.70E-11
Tc-99	2/4	3.12E-10	-1.73E-12	7.23E-10
Tritium	0/4	4.94E-06	1.23E-07	1.52E-05
U-234	4/4	3.08E-12	2.29E-12	4.48E-12
U-235	0/4	1.40E-13	1.25E-14	3.94E-13
U-238	4/4	1.97E-12	1.66E-12	2.30E-12
		Station 46		
Be-7	4/4	4.46E-08	3.69E-08	4.89E-08
K-40	1/4	1.40E-10	-2.76E-10	1.01E-09
Tc-99	3/4	3.38E-10	5.77E-11	5.29E-10
Tritium	0/4	4.87E-06	6.26E-07	1.30E-05
U-234	4/4	4.53E-12	4.06E-12	4.99E-12
U-235	2/4	2.32E-13	1.50E-13	3.49E-13
U-238	4/4	2.80E-12	1.91E-12	4.05E-12

Table 6.3 (continued)

Parameter	N detected/ N total	Concentration (pCi/mL)		
		Average	Minimum	Maximum
		Station 48		
Be-7	4/4	4.60E-08	3.67E-08	5.34E-08
K-40	0/4	-3.53E-10	-6.35E-10	2.54E-10
Tc-99	3/4	2.66E-10	2.18E-11	4.55E-10
Tritium	0/4	3.13E-06	-1.43E-06	8.86E-06
U-234	4/4	4.20E-12	3.02E-12	5.37E-12
U-235	2/4	2.15E-13	5.30E-14	4.56E-13
U-238	4/4	3.39E-12	1.80E-12	4.17E-12
		Station 52		
Be-7	4/4	5.18E-08	4.24E-08	5.65E-08
K-40	1/4	1.85E-10	-2.98E-10	1.30E-09
Tc-99	3/4	2.56E-10	-3.56E-11	4.89E-10
Tritium	1/4	3.98E-06	4.60E-07	1.40E-05
U-234	4/4	3.08E-12	2.59E-12	3.62E-12
U-235	1/4	2.84E-13	2.09E-14	4.93E-13
U-238	4/4	3.08E-12	2.46E-12	3.72E-12

6.4 Surface Water Monitoring

6.4.1 Oak Ridge Reservation Surface Water Monitoring

The ORR surface water monitoring program consists of sample collection and analysis from five locations on the Clinch River, including public water intakes (Fig. 6.5). This 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.

Grab samples are collected quarterly at all five 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 specific locations and associated sampling frequencies and parameters.

The sampling locations are classified by the State of Tennessee for recreation and domestic use. Tennessee Water Quality Criteria (WQCs) associated with these classifications are used as references where applicable (TDEC 2008). The Tennessee WQCs do not include criteria for radionuclides. Four percent of the DOE DCS is used for radionuclide comparison because this value is roughly equivalent to the 4 mrem dose limit from ingestion of drinking water on which the US Environmental Protection Agency (EPA) radionuclide drinking water standards are based.

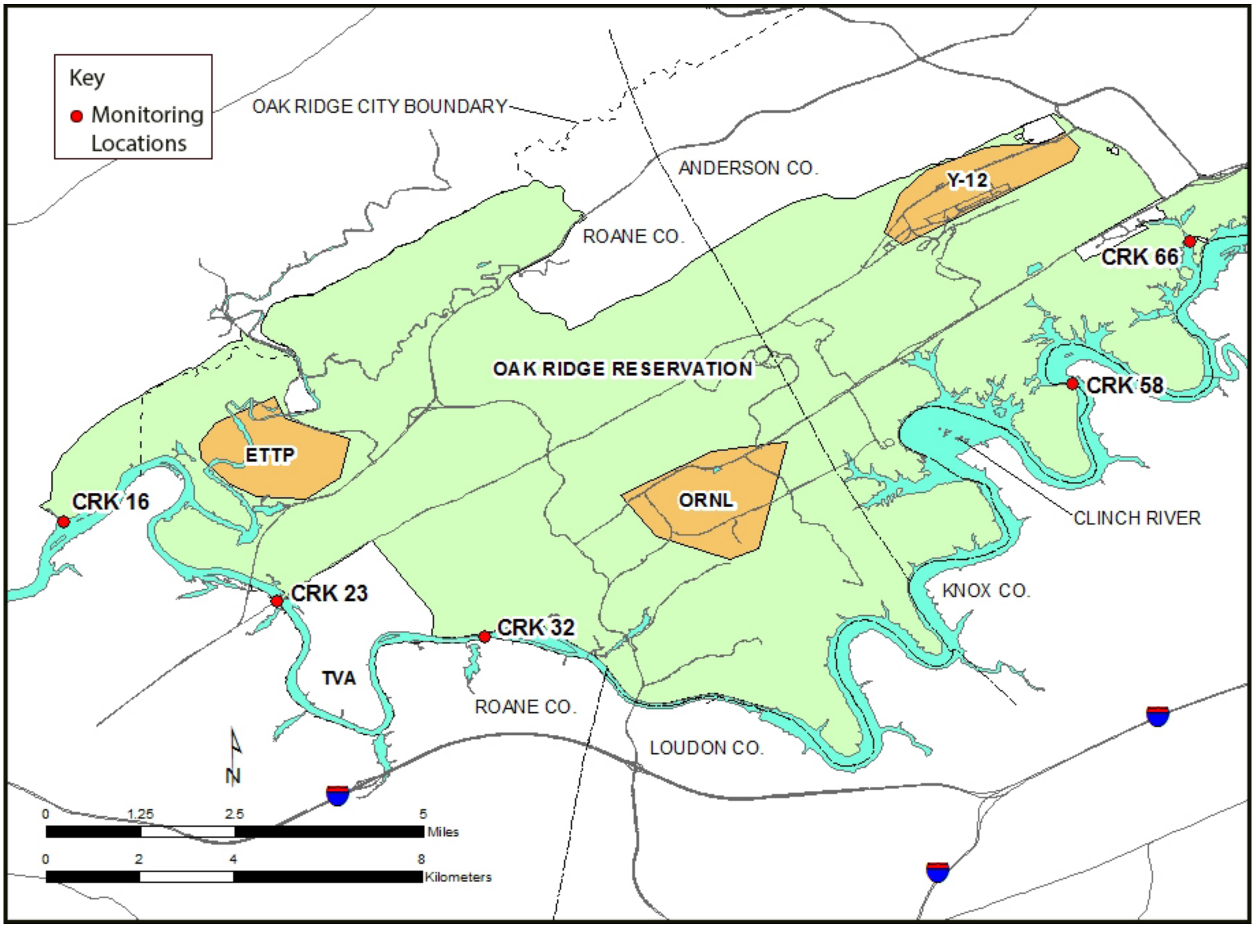

Fig. 6.5. Oak Ridge Reservation surface water surveillance sampling locations.

Table 6.4. Oak Ridge Reservation surface water sampling locations, frequencies, and parameters, 2015

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 23	Former water supply intake for ETTP	Quarterly	Mercury, gross alpha, gross beta, gamma scan, ^{3}H, field measurements[b]
CRK 32	Clinch River downstream from ORNL	Quarterly	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, Watts Bar Reservoir).
[b]Field measurements consist of dissolved oxygen, pH, and temperature.

Acronyms

CRK = Clinch River kilometer
DOE = US Department of Energy
ETTP = East Tennessee Technology Park
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation

6.4.2 Results

A comparison of radionuclide concentrations from 2015 sampling results for surface water collected upstream of DOE inputs with surface water collected downstream of DOE inputs shows no statistically significant differences. No radionuclides were detected above 4% of the respective DCSs or the 4 mrem dose limit, which is the maximum contaminant level (MCL) for beta and photon emitters in community drinking water systems. There were no mercury detections above MCLs at the three sampling locations where mercury samples are collected.

6.5 Groundwater Monitoring

Work continued in 2015 to implement key recommendations from the *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation* (DOE 2013), which was approved in 2014.

Two off-site groundwater sampling events were completed in 2015 in accordance with an approved work plan. Samples were collected at 34 wells and 15 springs located west and north of the Clinch River at the western boundary of the ORR. The project is a cooperative effort by DOE, EPA, and the Tennessee Department of Environment and Conservation (TDEC). A report on the study is planned for November 2016.

A technical advisory group composed of DOE, EPA, and TDEC members as well as industry experts met several times in 2014 and 2015 to review progress and make recommendations for development of a regional groundwater flow model.

The geologic framework for the model was completed in 2015. Testing activities on a test case model were also completed, and construction of the regional-scale groundwater flow model is under way. The regional flow model will serve as an underlying framework to support future cleanup decisions and actions.

6.6 Food

Vegetation samples were collected from areas that could be affected by activities on the reservation and from off-site reference locations. The samples were analyzed to evaluate potential radiation doses to consumers of local food crops and to monitor trends in environmental contamination and possible long-term accumulation of radionuclides.

6.6.1 Vegetables

Tomatoes, lettuce, and turnips were purchased from farms near ORR, and from reference locations outside the potential DOE impact area. The locations were chosen based on availability and on the likelihood of effects from routine releases from the Oak Ridge facilities.

6.6.1.1 Results

Samples were analyzed for gross alpha, gross beta, gamma emitters, and uranium isotopes. No gamma-emitting radionuclides were detected above the minimum detectable activity (MDA), with the exception of the naturally occurring radionuclides ^{7}Be and ^{40}K (Table 6.5).

Table 6.5. Concentrations of radionuclides detected in vegetables, 2015 (pCi/kg)[a]

Location	Gross alpha	Gross beta	^{7}Be	^{40}K	^{234}U	^{235}U	^{238}U
			Lettuce				
East of Y-12, Claxton vicinity	0.0000809	0.00411	*b*	0.00527	0.00000937	*b*	0.00000758
West of ETTP	*b*	0.00374	*b*	0.00521	0.00000153	*b*	0.00000245
North of Y-12	0.0000861	0.00442	0.000725	0.00541	0.00000748	*b*	0.00000369
South of ORNL	0.0000231	0.00372	0.000612	0.00385	0.0000055	*b*	0.00000411
Southwest of ORNL, Lenoir City	0.0000818	0.00436	0.000625	0.00452	*b*	0.00000146	*b*
Reference location,	*b*	0.00471	*b*	0.00631	0.00000184	*b*	*b*
			Tomato				
East of Y-12, Claxton vicinity	0.0000241	0.000572	*b*	0.00104	*b*	*b*	*b*
West of ETTP	0.0000193	0.00333	*b*	0.00182	*b*	*b*	0.0000023
North of Y-12	0.0000174	0.000897	*b*	0.000973	0.00000404	0.00000146	*b*

Table 6.5 (continued)

Location	Gross alpha	Gross beta	^{7}Be	^{40}K	^{234}U	^{235}U	^{238}U
South of ORNL	0.0000267	0.000935	*b*	0.00152	0.00000266	0.0000013	*b*
Southwest of ORNL, Lenoir City	0.0000276	0.000908	*b*	0.00154	*b*	*b*	*b*
Reference location,	0.0000194	0.00046	*b*	0.00103	0.00000307	0.0000016	*b*
			Turnips				
East of Y-12, Claxton vicinity	0.0000341	0.0028	*b*	0.00341	*b*	*b*	*b*
West of ETTP	*b*	0.00216	*b*	0.00205	*b*	*b*	0.00000175
North of Y-12	*b*	0.00297	*b*	0.00443	0.00000374	*b*	*b*
South of ORNL	*b*	0.00207	*b*	0.0018	0.00000636	*b*	*b*
Southwest of ORNL, Lenoir City	*b*	0.00224	*b*	0.00141	0.00000189	*b*	0.00000294
Reference location,	0.0000302	0.00353	*b*	0.0036	0.00000176	*b*	*b*

[a]Detected radionuclides are those at or above minimum detectable activity. 1 pCi = 3.7×10^{-2} Bq.
[b]Value was not above minimum detectable activity.

Acronyms
ETTP = East Tennessee Technology Park
ORNL = Oak Ridge National Laboratory
Y-12 = Y-12 National Security Complex

6.6.2 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.

The 2015 milk-sampling program consisted of grab samples collected every other month from a dairy in Claxton that could be impacted by activities on the ORR and from one reference location in Maryville (Fig. 6.6). Milk samples are analyzed for gamma emitters and for total radioactive strontium (^{89}Sr + ^{90}Sr).

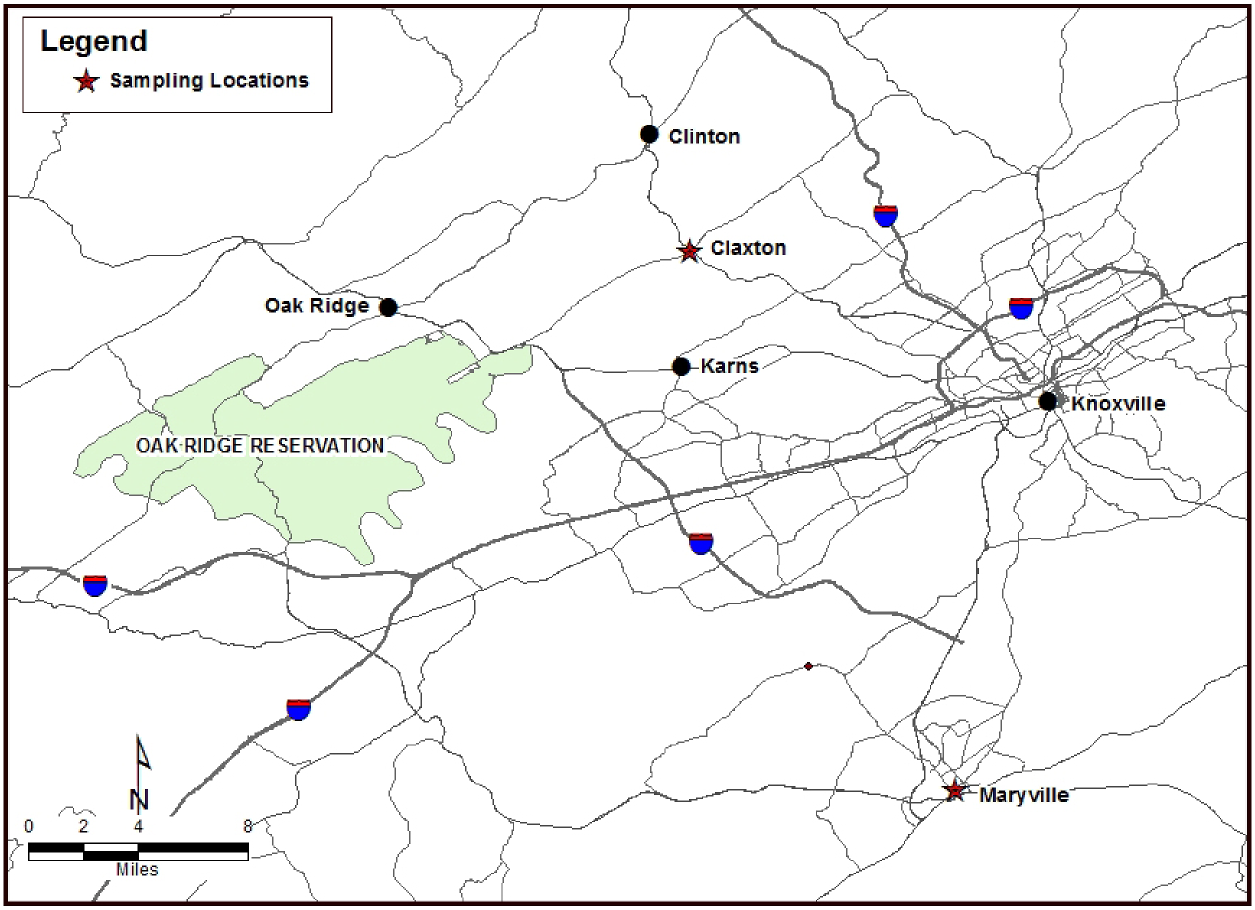

Fig. 6.6. Milk-sampling locations in the vicinity of the Oak Ridge Reservation.

6.6.2.1 Results

Concentrations of radionuclides detected above MDA in milk are presented in Table 6.6.

At the Maryville reference location, the tritium concentration from the August 2015 sampling event was higher than would be expected based on historical results. It is suspected that bias was introduced from equipment and matrix issues. The analytical lab initially reported equipment failure, and a request was made for sample reanalysis when new equipment was procured. However, reanalysis could not be accomplished due to sample breakdown (the fat solids in milk make this matrix complicated), and equipment/matrix bias could not be confirmed.

A comparison of results for milk collected from the Claxton dairy with those for milk collected from the reference dairy indicate that ORR activities are not significantly impacting radionuclide concentrations in milk.

Table 6.6. Concentrations of radionuclides detected in raw milk, 2015

Analysis	Number detected/ total number	Detected concentration (pCi/L)[a]			Standard error of mean
		Maximum	Minimum	Average	
		Claxton			
^{40}K	6/6	1200[b]	1000[b]	1100[b]	32
		Reference location			
^{40}K	6/6	1400[b]	1200[b]	1300[b]	17
Tritium	2/6	1400[b]	U-82	~560[b]	200

[a]Detected radionuclides are those above minimum detectable activity. 1 pCi = 3.7 × 1012 Bq.
[b]Individual and average concentrations significantly greater than zero at the 95% confidence level.

6.7 Fish

Members of the public could be exposed to contaminants originating from DOE ORR activities through consumption of 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 (Fig. 6.7):

- Clinch River upstream from all DOE ORR inputs (CRK 70),
- Clinch River downstream from ORNL (CRK 32), and
- Clinch River downstream from all DOE ORR inputs (CRK 16).

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 2015, a composite sample of each of these species at each location was analyzed for selected metals, PCBs, tritium, gross alpha, gross beta, gamma-emitting radionuclides, and total radioactive strontium. To accurately estimate exposure levels to consumers, only edible portions of the fish were submitted for analysis.

TDEC issues advisories on consumption of certain fish species caught in specified Tennessee waters. These advisories apply to fish that could contain potentially hazardous contaminants. TDEC has issued a "do not consume" advisory for catfish in the Melton Hill Reservoir in its entirety, not just in areas that could be impacted by ORR activities, because of PCB contamination. Similarly, a precautionary advisory for catfish in the Clinch River arm of Watts Bar Reservoir has been issued because of PCB contamination (TDEC 2008).

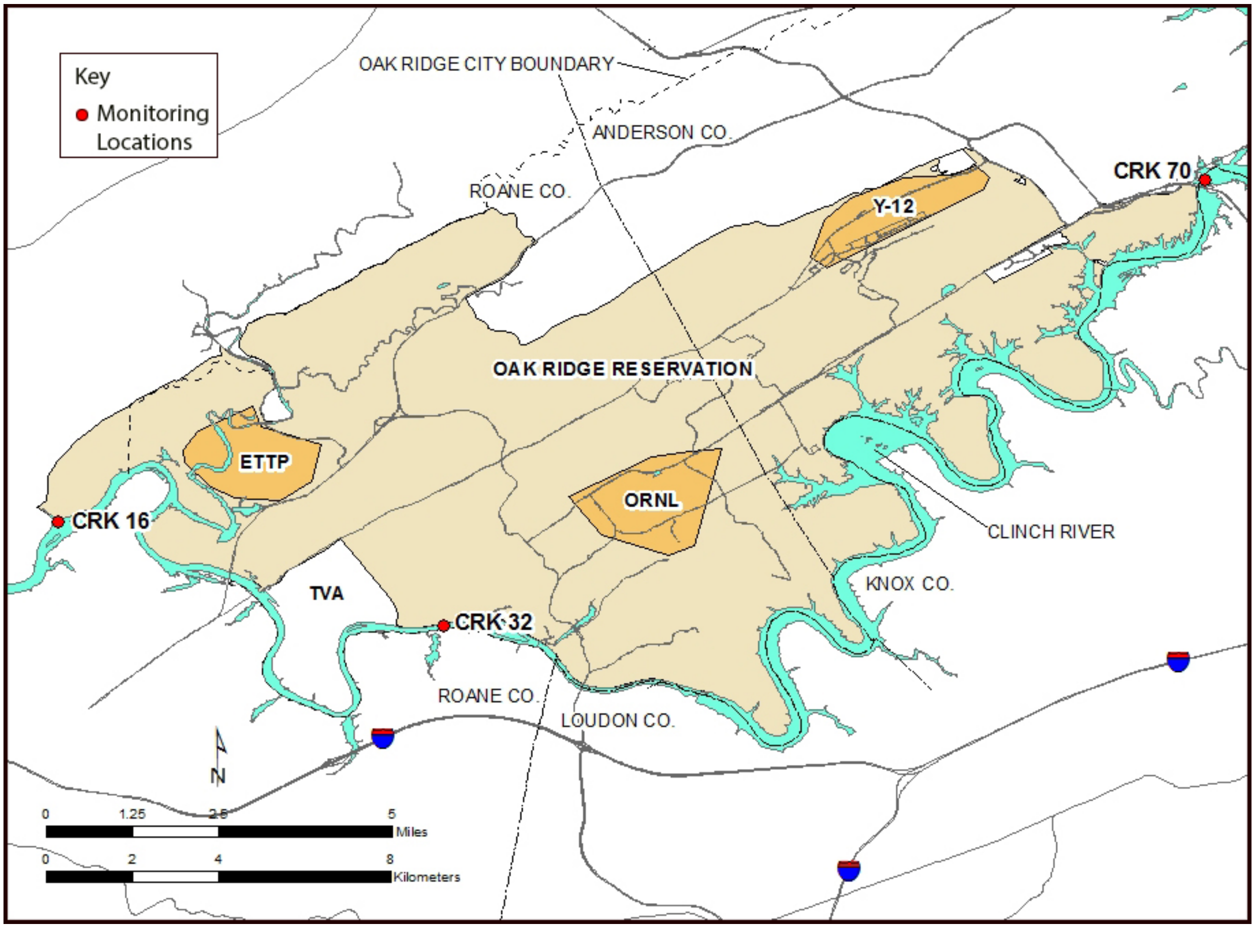

Fig. 6.7. Fish-sampling locations for the Oak Ridge Reservation Surveillance Program.

6.7.1 Results

PCBs, specifically Aroclor-1260, and mercury were detected in both sunfish and catfish at all three locations in 2015. These results are consistent with the TDEC advisories. Detected PCBs, mercury, and radionuclide concentrations are shown in Table 6.7.

Radiological analyses for fish tissues sampled in 2015 showed few statistical differences (at the 95% confidence level) between the upstream and downstream locations, indicating that DOE activities on the ORR are not significant contributors to the public radiological dose from fish consumption.

Table 6.7. Tissue concentrations in catfish and sunfish for mercury, detected PCBs, and detected radionuclides, 2015[a]

Parameter	Catfish[b]	Sunfish[b]
Clinch River downstream from all DOE ORR inputs (CRK 16)		
Metals (mg/kg)		
Hg	0.073	0.082
Pesticides and PCBs (µg/kg)		
PCB-1260	190	90
Radionuclides (pCi/g)[b]		
Beta activity	2.1[c]	1.9[c]
^{40}K	2.7[c]	3.3[c]
Clinch River downstream from ORNL (CRK 32)		
Metals (mg/kg)		
Hg	0.061	0.032
Pesticides and PCBs (µg/kg)		
PCB-1260	100	21
Radionuclides (pCi/g)[b]		
Alpha activity	0.055[c]	0.037[c]
Beta activity	1.9[c]	1.9[c]
^{40}K	3.2[c]	2.6[c]
Clinch River (Solway Bridge) upstream from all DOE ORR inputs (CRK 70)		
Metals (mg/kg)		
Hg	0.089	0.035
Pesticides and PCBs (µg/kg)		
PCB-1260	130	J18[d]
Radionuclides (pCi/g)[b]		
Alpha activity	0.2[c]	0.042[c]
Beta activity	3.1[c]	1.6[c]
^{40}K	2.5[c]	2.8[c]

[a]Only parameters that were detected for at least one species are listed in the table.
[b]Radiological results are reported after background activity has been subtracted. Negative values are reported when background activity exceeds sample activity.
[c]Radionuclide concentrations were significantly greater than zero. Detected radionuclides are at or above the minimum detectable activity.
[d]"J" indicates that the result is an estimated value.

Acronyms
CRK = Clinch River kilometer
DOE = US Department of Energy
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
PCB = polychlorinated biphenyl

6.8 White-Tailed Deer

Three weekend quota deer hunts were held on ORR during the final quarter of CY 2015. The hunts took place October 31–November 1, November 14–15, and December 12–13. Each hunt was limited to 450 shotgun/muzzleloader permittees and 600 archery permittees. ORNL staff, Tennessee Wildlife Resources Agency (TWRA) personnel, and student members of the Wildlife Society (University of Tennessee chapter) performed most of the necessary operations at the checking station.

A total of 27,419 acres was available to deer hunters on the Oak Ridge Wildlife Management Area (ORWMA) in 2015 (15,195 acres for gun hunting and 12,224 acres for archery hunting). The ORWMA includes some properties not owned by DOE, including Haw Ridge Park (city of Oak Ridge), the Clinch River Small Modular Reactor Site (the Tennessee Valley Authority), and the University of Tennessee (UT) Arboretum. The total harvest in 2015 was 244 deer, of which 147 (~60.2%) were bucks, and 97 (~39.8%) were does. The heaviest buck weighed 172 lb and had thirteen antler points. The greatest number of antler points found on one buck was 14. The heaviest doe weighed 108 lb.

A total of 12,481 deer have been harvested since 1985, of which 216 (~1.7%) 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 ~86.1 lb. The oldest deer harvested was a doe estimated to be 12 years old (1989), and the average age of all harvested deer is ~2 years. See the ORR hunt information website (http://web.ornl.gov/sci/rmal/hunts/) for more information.

6.8.1 Results

The wildlife administrative release limits associated with deer, turkey, and geese harvested on ORR are conservative and were established based on the “as low as reasonably achievable “ALARA” principle to ensure that doses to consumers are managed at levels well below regulatory dose thresholds. The ALARA 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 this consumption pathway. In addition, a conservative administrative limit of 1.5 times background for gross beta activity has been established, a threshold that is near the detection limit for field measurements of 90Sr in deer leg bone.

Only one of the 244 (~0.4%) deer harvested on ORR during the 2015 hunts was retained for exceeding the administrative release limits [1.5 times the background for beta activity in bone (~20 pCi/g of $^{89/90}$Sr) or 5 pCi/g of ^{137}Cs in edible tissue].

6.9 Fowl

6.9.1 Waterfowl Surveys—Canada Geese

Statewide, Canada goose hunting was allowed September 1–15, 2015, October 10–27, 2015, November 28–29, 2015, and December 5, 2015–January 31, 2016. On the Three Bends region of ORR, Canada goose hunting was allowed until noon on five of the September dates and four of the October dates. The consumption of Canada geese is a potential pathway for exposing members of the public to radionuclides released from ORR operations. To determine concentrations of gamma-emitting radionuclides accumulated by waterfowl that feed and live on ORR, Canada geese are rounded up each summer for noninvasive gross radiological surveys.

6.9.1.1 Results

During the 2015 roundup, 28 geese (20 adults, 8 goslings) were captured and 27 of those were subjected to live whole-body gamma scans. The geese were collected from Clark Center Park (*n* = 14) and Oak Ridge Associated Universities (*n* = 14). Gamma scan results of the 27 geese showed that all were at least an order of magnitude (0.06–0.29 pCi/g) below the administrative release limit of 5 pCi/g.

The 5 pCi/g administrative release limit for ^{137}Cs discussed for deer is also applied to geese. This limit assumes that one person consumes all of the meat from a maximum-weight goose. The administrative limits were established to keep doses ALARA and to provide consistent standards for releasing harvested wildlife.

6.9.2 Turkey Monitoring

Two wild turkey hunts, managed by DOE and TWRA, were held on the reservation (April 11–12 and April 18–19, 2015). Each hunt was limited to 225 hunters, preselected in a quota drawing. Approximately 23,000 acres was available to turkey hunters in 2015, of which 255 acres was available to archery-only hunters. Forty-five male turkeys were harvested on these two hunts, of which 3 (~ 6.7%) were juveniles and 42 (~ 93.3%) were adults. The average weight of all turkeys harvested during spring 2015 hunts was ~19.5 lb, and the largest turkey weighed 25.0 lb. The average beard length was ~9.7 in., and the longest beard was 11.5 in. The average spur length was ~0.8 in., and the longest spur was 1.5 in.

In addition, a juvenile female turkey weighing 8.0 lb was legally harvested on December 12, 2015, with a bow during the deer hunts. The largest turkey harvested to date on ORR weighed 25.7 lb (harvested in 2009).

6.9.2.1 Results

None of the 46 turkeys harvested in 2015 exceeded the administrative release limits established for radiological contamination. Since 1997, 812 turkeys have been harvested on spring turkey hunts. Six additional turkeys have been harvested (since 2012) by archery hunters during fall deer hunts. Of all turkeys harvested, only three (< 0.4%) have been retained because of potential radiological contamination; one in 1997, one in 2001, and one in 2005. For additional information, see http://web.ornl.gov/sci/rmal/hunts/.

The 5 pCi/g administrative release limit for ^{137}Cs that is applied to deer and geese is also applied to turkey. This limit assumes that one person consumes all of the meat from a maximum-weight turkey. The administrative limits were established to keep doses ALARA and to provide consistent standards for releasing harvested wildlife.

6.10 Quality Assurance

The activities associated with administration, sampling, data management, and reporting for the ORR environmental surveillance programs are performed by UT-Battelle. Project scope is established by a task team whose members represent DOE; UT-Battelle; Consolidated Nuclear Security, LLC; and URS | CH2M Oak Ridge LLC. UT-Battelle integrates quality assurance, environmental, and safety considerations into every aspect of ORR environmental monitoring. (See Section 5.7 for a detailed discussion of UT-Battelle quality assurance program elements for environmental monitoring and surveillance activities.)

6.11 References

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7. Dose

Activities on Oak Ridge Reservation (ORR) have the potential to release small quantities of radionuclides and hazardous chemicals to the environment. These releases could expose members of the public to low concentrations of radionuclides or chemicals. Monitoring of materials released from the reservation 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 the law.

In 2015, a hypothetical maximally exposed individual could have received an effective dose (ED) of about 0.4 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 for protection of the public.

A worst-case analysis of exposures to waterborne radionuclides for all pathways combined gives a maximum possible individual ED of about 1 mrem. This dose is based on a person eating 27 kg/year (60 lb/year) of the most contaminated fish accessible, drinking 680 L/year (180 gal/year) of the most contaminated drinking water, and using the shoreline near the most contaminated stretch of water for 60 h/year.

In addition, if a hypothetical person consumed one deer, one turkey, and two geese (containing the maximum ^{137}Cs concentration and maximum weights), that person could have received an ED of about 1 mrem. This calculation is conducted to provide an estimated upper-bound ED from consuming wildlife harvested from ORR.

Therefore, the annual dose to a maximally exposed individual from all these potential exposure pathways combined was estimated to be about 3 mrem. There are no known significant doses from discharges of radioactive constituents from ORR other than those reported. US Department of Energy (DOE) Order 458.1, *Radiation Protection of the Public and the Environment* (DOE 2011), limits the ED that an individual may receive from all exposure pathways from all radionuclides released from ORR during 1 year to no more than 100 mrem. The 2015 maximum ED was about 3% of the limit given in DOE O 458.1.

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 an adverse impact on plants or animal populations.

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

7.1 Radiation Dose

Small quantities of radionuclides were released to the environment from operations at Oak Ridge Reservation (ORR) facilities during 2015. Those releases were described, characterized, and quantified in previous chapters of this report. This chapter presents estimates of potential radiation doses to the public from the releases. The dose estimates were obtained using monitored and estimated release data, environmental monitoring and surveillance data, estimated exposure conditions that tend to maximize the calculated doses, and environmental transport and dosimetry codes that also tend to overestimate the calculated doses. Thus, the presented doses 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 as long as the radionuclides remain inside a person. Also, external exposures may result in uniform irradiation of the entire body, including all organs, while internal exposures usually result in nonuniform irradiation of the body and organs. When taken into the body, most radionuclides deposit preferentially in specific organs or tissues and thus do not irradiate the body uniformly.

A number of the specialized terms and units used to characterize exposures to ionizing radiation are defined in Appendix E. “Effective dose” (ED) is a risk-based equivalent dose 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).

One rem of ED, regardless of radiation type or method of delivery, has the same total radiological (in this case, also 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

7.1.2.1 Airborne Radionuclides

The radiological consequences of radionuclides released to the atmosphere from ORR operations during 2015 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 ORR center. The calculations were performed for each major facility and for the entire ORR. The dose calculations were made using the Clean Air Act Assessment Package—1988 (CAP-88 PC) Version 4 (EPA 2015), a software program developed under sponsorship of the US Environmental Protection Agency (EPA) to demonstrate compliance with 40 CFR 61, Subpart H, which governs the emissions of radionuclides other than radon from US Department of Energy (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 (vegetables, meat, and milk) and subsequent intakes by humans.

CAP-88 PC Version 4 was used for the first time in 2015 to estimate doses from airborne emissions. Version 4 differs significantly from Version 3 in three areas:

- incorporation of age-dependent radionuclide dose and risk factors for ingestion and inhalation,
- increase in the number of radionuclides included in the database, and
- a change in the file management system used by the program (EPA 2015).

In this assessment, adult dose coefficients were used to estimate doses. These 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 35 emission points on ORR were modeled during 2015. The total includes 3 (two combined) points at the Y-12 National Security Complex (Y-12), 27 points at Oak Ridge National Laboratory (ORNL), and 5 points at the East Tennessee Technology Park (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 2015 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 2015, rainfall, as averaged over the five rain gauges located on ORR, was 152.6 cm (60.1 in.). The average air temperature was 15.1°C (59.2°F) at the 10 to 15 m levels, and the average mixing-layer height for ETTP and ORNL was 811.9 m (2,664 ft) and for Y-12 was 796.5 m (2,613 ft). The mixing height is the depth of the atmosphere adjacent to the surface within which air is mixed.

Table 7.1. Emission point parameters and receptor locations used in the dose calculations

Source	Stack height (m)	Stack diameter (m)	Effective exit gas velocity (m/s)[a]	Distance (m) and direction to the maximally exposed individual			
				Plant maximum		Oak Ridge Reservation maximum	
Oak Ridge National Laboratory							
X-2000 Lab Hoods	15	0.5	0	5,482	E	5482	E
X-3000 Lab Hoods	15	0.5	0	4,949	E	4,949	E
X-4000 Lab Hoods	15	0.5	0	4,729	E	4,729	E
X-6000 Lab Hoods	15	0.5	0	4,208	E	4,208	E
X-7000 Lab Hoods	15	0.5	0	4,176	E	4,176	E
X-2026	22.9	1.05	7.09	5,295	E	5,295	E
X-2099	3.66	0.18	19.03	5,283	E	5,283	E
X-3018	61	4.11	0.17	5,115	E	5,115	E
X-3020	61	1.22	16.10	5,155	E	5,155	E
X-3039	76.2	2.44	5.96	5,002	E	5,002	E
X-3544	9.53	0.279	21.98	5,043	ENE	5,043	ENE
X-3608 Air Stripper	10.97	2.44	0.57	4,883	ENE	4,883	ENE
X-3608 Filter Press	8.99	0.36	9.27	4,883	ENE	4,883	ENE
X-5505M	11	0.305	2.53	4,369	E	4,369	E
X-5505NS	11	0.96	0	4,342	E	4,342	E
X-7503	30.5	0.91	12.55	4,183	ENE	4,183	ENE
X-7830 Group	4.6	0.248	7.58	5,524	ENE	5,524	ENE
X-7856-CIP	18.29	0.483	11.58	5,478	ENE	5,478	ENE
X-7877	13.9	0.406	13.56	5,553	ENE	5,553	ENE
X-7880	27.7	1.52	14.92	5,588	ENE	5,588	ENE
X-7911	76.2	1.52	14.12	4,218	ENE	4,218	ENE
X-7935 Building Stack	18.29	0.6096	0	4,230	ENE	4,230	ENE
X-7935 Glove Box	9.14	0.25	0	4,230	ENE	4,230	ENE

Table 7.1 (continued)

Source ID	Stack height (m)	Stack diameter (m)	Effective exit gas velocity (m/s) [a]	Distance (m) and direction to the maximally exposed individual			
				Plant maximum		Oak Ridge Reservation maximum	
Oak Ridge National Laboratory (continued)							
X-7966	6.096	0.292	9.62	4,162	ENE	4,162	ENE
X-8915	24.38	1.219	6.6	4,242	ESE	4,242	ESE
X-Decon Areas	15	0.5	0	4,703	E	4,703	E
X-STP	7.6	0.203	7.39	5,240	ENE	5,240	ENE
East Tennessee Technology Park							
K-1200 South Bay	28	0.81	13.7	753	NW	11,315	E
K-1407-AL CWTS	2.74	0.15	0	455	WSW	11,339	E
K-2500-H-B	8.23	0.61	12.9	553	SE	12,181	E
K-2500-H-C	8.23	0.61	12.9	547	SE	12,173	E
L-2500-H-D	8.23	0.61	12.9	524	SE	12,149	E
Y-12 National Security Complex							
Y-Monitored	20	0.5	0	2,272	NE	5,800	S
Y-Unmonitored Processes	20	0.5	0	2,272	NE	5,800	S
Y-Unmonitored Lab Hoods	20	0.5	0	2,272	NE	5,800	S

[a] Exit gas temperatures are "ambient air" unless noted otherwise.

Acronyms
CIP = Capacity Increase Project
CWTS = Chromium Water Treatment System
STP = Sewage Treatment Plant

For occupants of residences, the dose calculations assume that the occupant remained at home during the entire year and obtained food according to the rural pattern. This pattern specifies that 70% of the vegetables and produce, 44.2% of the meat, and 39.9% of the milk consumed are produced in the local area (e.g., a home garden). The remaining portion of each food category is assumed to be produced within 80 km (50 miles) of ORR. The same assumptions are used for occupants of businesses, but the resulting doses are 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 7.2. Meteorological towers and heights used to model atmospheric dispersion from source emissions

Tower	Height (m)	Source
		Y-12 National Security Complex
MT6 (West Y-12)	30	All Y-12 sources
	60	X-8915 Spallation Neutron Source (ORNL)
		East Tennessee Technology Park
MT7 (K1209)	10	K-1407-AL CWTS, K-2500-H- A, B, C, and D
	30	K-1200 South Bay
		Oak Ridge National Laboratory
MT4 (Tow A)	30	X-7503, X-7856-CIP, X-7877, X-7830,X-7880, X-7911, X-7935, X 7966,and X-7000 Lab Hoods
MT3 (Tow B)	15	X-6000 Lab Hoods, X-5505
MT2 (Tow D)	15	X-2099, X-3026 D, X-3544, X-3608 FP, X-3608 AS, STP, X-Decon Hoods, X-2000, X-3000, and X-4000 Lab Hoods
	30	X-2026
	60	X-3018, X-3020, and X-3039

Acronyms

CIP = Capacity Increase Project
CWTS = Chromium Water Treatment System
ORNL = Oak Ridge National Laboratory
STP = Sewage Treatment Plant

7.1.2.1.1 Results

Calculated EDs from radionuclides emitted to the atmosphere from the ORR are listed in Table 7.3 (maximum individual) and Table 7.4 (collective). The hypothetical maximally exposed individual for ORR was located about 5,800 m south of the main Y-12 release point, about 4,218 m east-northeast of the 7911 stack at ORNL, and about 11,339 m east of the K-1407-AL Chromium Water Treatment System (CWTS) at ETTP. This individual could have received an ED of about 0.4 mrem, which is well below the National Emission Standards for Hazardous Air Pollutants for Radionuclides standard of 10 mrem and is about 0.1% of the roughly 300 mrem that the average individual receives from natural sources of radiation. Based on the 2010 population census data, the calculated collective ED to the entire population within 80 km (50 miles) of ORR (about 1,172,530 persons) was about 10.8 person-rem, which is about 0.003% of the 351,759 person-rem that this population received from natural sources of radiation (based on an individual dose of about 300 mrem/year). As mentioned, CAP-88 PC Version 4 was used in 2015 to calculate both individual and collective doses. Due to improved time-in-flight calculations (implementation of full chain decay of isotopes in flight for each sector), collective doses associated with short-lived radionuclides are lower than would have been calculated using CAP-88 PC Version 3 (EPA 2015).

Table 7.3. Calculated radiation doses to maximally exposed off-site individuals from airborne releases, 2015

Plant	Effective dose, mrem (mSv)	
	At plant maximum	At Oak Ridge Reservation maximum
Oak Ridge National Laboratory	0.4 (0.004)[a]	0.4 (0.004)
East Tennessee Technology Park	0.0004 (0.000004)[b]	1E-5 (1E-7)
Y-12 National Security Complex	0.1 (0.0011)[c]	0.007 (0.00007)
Entire Oak Ridge Reservation	*d*	0.4 (0.004)[e]

[a]The maximally exposed individual was located 5,002 m E of X-3039 and 4,218 m ENE of X-7911.
[b]The maximally exposed individual was located 460 m WSW of K-1407-AL Chromium Water Treatment System.
[c]The maximally exposed individual was located 2,270 m NE of the Y-12 National Security Complex release point.
[d]Not applicable.
[e]The maximally exposed individual for the entire Oak Ridge Reservation is also the Oak Ridge National Laboratory maximally exposed individual.

wsw

Table 7.4. Calculated collective effective doses from airborne releases, 2015

Plant	Collective effective dose[a]	
	Person-rem	Person-Sv
Oak Ridge National Laboratory	9.4	0.094
East Tennessee Technology Park	0.0007	7E-6
Y-12 National Security Complex	1.4	0.014
Entire Oak Ridge Reservation	10.8	0.108

[a]Collective effective dose to the 1,172,530 persons residing within 80 km (50 miles) of the Oak Ridge Reservation (based on 2010 census data).

The maximally exposed individual for the Y-12 Complex was located at a residence about 2,272 m (1.4 miles) northeast of the main Y-12 release point. This individual could have received an ED of about 0.1 mrem from Y-12 airborne emissions. Inhalation and ingestion of uranium radioisotopes (i.e., 233U, 234U, 235U, 236U, and 238U) accounted for about 94% and technicium-99 (99Tc) accounted for about 0.6% of the dose (Fig. 7.1). 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 1.4 person-rem, which is about 13% of the collective ED for ORR.

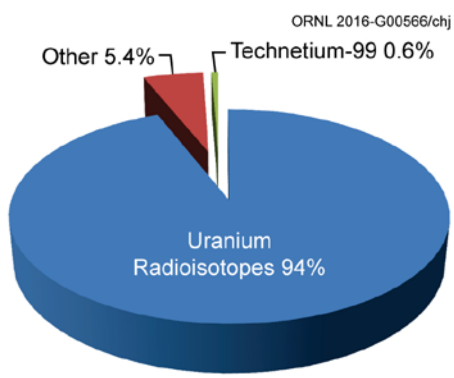

Fig. 7.1. Nuclides contributing to the effective dose at the Y-12 National Security Complex.

The maximally exposed individual for ORNL was located at a residence about 5,002 m (3.1 miles) east of the 3039 stack and 4,218 m (2.6 miles) east-northeast of the 7911 stack. This individual could have received an ED of about 0.4 mrem from ORNL airborne emissions. Radionuclides contributing 5% or more to the dose include ^{234}U (26%), ^{11}C (25%), ^{238}Pu (12%), ^{237}Np (6%), and ^{212}Pb (5%) (Fig. 7.2). The total contribution from uranium radioisotopes (i.e., ^{233}U, ^{234}U, ^{235}U, ^{236}U, and ^{238}U) accounted for about 29% of the dose, and ^{234}U contributed about 26% of the dose. 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 9.4 person-rem or about 87% of the collective ED for ORR.

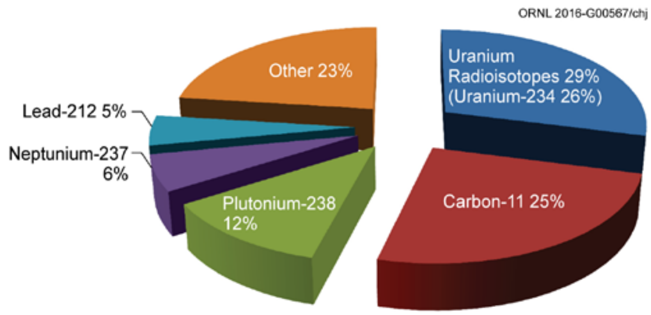

Fig. 7.2. Nuclides contributing to effective dose at Oak Ridge National Laboratory.

The maximally exposed individual for ETTP was located at a business about 455 m (0.3 miles) west southwest of the K-1407-AL Chromium Water Treatment System. The ED received by this individual from airborne emissions was calculated to be about 0.0004 mrem. About 88% of the dose is from uranium radioisotopes (^{234}U, ^{235}U, ^{236}U, and ^{238}U) and 8% of the dose is from ^{99}Tc (Fig. 7.3). The contribution of ETTP emissions to the collective ED to the population residing within 80 km (50 miles) of ORR was calculated to be about 0.0007 person-rem, or about 0.006% of the collective ED for the reservation.

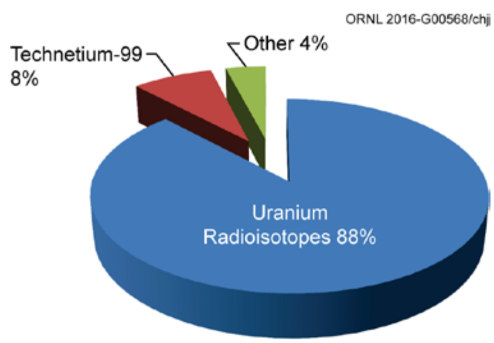

Fig. 7.3. Nuclides contributing to effective dose at East Tennessee Technology Park.

The reasonableness of the estimated doses can be inferred by comparing EDs calculated at the ORR perimeter area monitoring (PAM) stations from measured air concentrations of radionuclides, excluding naturally occurring ^{7}Be and ^{40}K, with air concentrations calculated using CAP-88 PC Version 3 and emissions data (Table 7.5). Based on measured air concentrations, hypothetical individuals assumed to reside at PAM stations 35–48 could have received EDs between 0.008 and 0.04 mrem/year. Based on emissions data using CAP-88 PC Version 4, the above individuals could have received EDs between 0.03 and 0.5 mrem/year. As shown in Table 7.5, EDs calculated using CAP-88 PC Version 4 and emissions data tend to be greater than or equivalent to EDs calculated using measured air concentrations.

Table 7.5. Hypothetical effective doses from living near the Oak Ridge Reservation, Oak Ridge National Laboratory, and the East Tennessee Technology Park ambient air monitoring stations, 2015

Station	Calculated effective doses			
	Using air monitor data		Using CAP-88[a] and emission data	
	mrem/year	mSv/year	mrem/year	mSv/year
1	0.01	0.0001	0.5	0.005
35	0.02	0.0002	0.07	0.0007
37	0.009	0.00009	0.2	0.002
38	0.008	0.00008	0.03	0.0003
39	0.04	0.0004	0.4	0.004
40	0.009	0.00009	0.3	0.003
42	0.01	0.0001	0.04	0.0004
46	0.01	0.0001	0.3	0.003
48	0.009	0.00009	0.5	0.005
52	0.03	0.0003	0.01	0.0001
K2	0.03	0.0003	0.06	0.0006
K6	0.03	0.0003	0.03	0.0003
K11	0.03	0.0003	0.04	0.0004
K12	0.02	0.0002	0.04	0.0004

[a]CAP-88 PC Version 4 software, developed under US Environmental Protection Agency sponsorship to demonstrate compliance with 40 CFR 61, Subpart H.

Station 52, located remotely from the ORR, gives an indication of potential EDs from background sources. Based on measured air concentrations, the ED was estimated to be 0.03 mrem/year (the isotopes 7Be and 40K also were not included in the background air monitoring station calculation), whereas the estimated ED based on calculated air concentrations using CAP-88 PC Version 4 was estimated to be 0.01 mrem/year, the only case where the dose calculated with measured concentration was greater than the dose calculated using emission data. The measured air concentrations of 7Be were similar at the PAM stations and at the background air monitoring station.

Of particular interest is a comparison of EDs calculated using measured air concentrations of radionuclides at PAM stations located near the maximally exposed individuals for each plant and EDs calculated for those individuals using source emissions data. K11 station is located near the on-site maximally exposed individual for ETTP. The ED calculated with measured air concentrations was 0.03 mrem/year, which is comparable to the ED of 0.04 mrem/year estimated using source emissions data. PAM station 46 is located near the off-site maximally exposed individual for the Y-12 Complex. The ED calculated with measured air concentrations was 0.01 mrem/year, which is considerably less than the ED of 0.3 mrem/year estimated using source emissions data. This year PAM Station 1 was located near the ORR/ORNL off-site maximally exposed individual location; the ED calculated with measured air concentrations was 0.01 mrem/year, which was considerably less than the 0.5 mrem/year calculated using source emissions data.

7.1.2.2 Waterborne Radionuclides

Radionuclides discharged to surface waters from ORR enter the Tennessee River system by way of the Clinch River (see Section 1.3.4 for the surface water setting of ORR). Discharges from Y-12 enter the Clinch River via Bear Creek and East Fork Poplar Creek (EFPC), both of which enter Poplar Creek before it enters the Clinch River, and by discharges from Rogers Quarry into McCoy Branch and then into Melton Hill Lake. Discharges from ORNL enter the Clinch River via White Oak Creek (WOC) and enter Melton Hill Lake via some 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 drink water; eat fish; and swim, boat, and use the shoreline at various locations along the Clinch and Tennessee Rivers.

For assessment purposes, surface waters potentially affected by ORR are divided into seven segments:

1. Melton Hill Lake above all possible ORR inputs,
2. Melton Hill Lake,
3. Upper Clinch River (from Melton Hill Dam to confluence with Poplar Creek),
4. Lower Clinch River (from confluence with Poplar Creek to confluence with the Tennessee River),
5. Upper Watts Bar Lake (from near the confluence of the Clinch and Tennessee Rivers to below Kingston),
6. the lower system (the remainder of Watts Bar Lake and Chickamauga Lake to Chattanooga), and
7. Poplar Creek (including the confluence of EFPC).

Two methods are used to estimate potential radiation doses to the public. The first method uses radionuclide concentrations in the medium of interest (i.e., in water and fish) determined by laboratory analyses of water and fish samples (see Sections 6.4, 6.5, and 6.7). The second method calculates possible radionuclide concentrations in water and fish from measured radionuclide discharges and known or estimated stream flows. In both methods, reported concentrations of radionuclides were used if the reported value was statistically significant. 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 (1) that most radionuclides discharged from ORR will be quantified and (2) 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). However, utilizing the two methods to estimate potential doses takes into account both field measurements and discharge measurements.

7.1.2.2.1 Drinking Water Consumption

Surface Water

Several water treatment plants that draw water from the Clinch and Tennessee River systems could be affected by discharges from ORR. No in-plant radionuclide concentration data are available for these plants; all of the dose estimates given below likely are high because they are based on radionuclide concentrations in water before it enters a processing plant. Based on a nationwide food consumption survey (EPA 2011) and weighted based on the combined population of Anderson, Knox, Loudon, and Roane counties, the drinking water consumption rate for the maximally exposed individual is 680 L/year (180 gal/year), and the drinking water consumption rate for the average person is 330 L/year (87 gal/year). The average drinking water consumption rate is used to estimate the collective ED. At all locations in 2015, estimated maximum EDs to a person drinking water were calculated using both measured radionuclide concentrations in and measured radionuclide discharges to off-site surface water, excluding naturally occurring radionuclides such as 40K.

- **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], a maximally exposed individual drinking water at this location could have received an ED of about 0.001 mrem. The collective ED to the 46,676 persons who drink water from the City of Oak Ridge water plant would also be 0.03 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. A maximally exposed individual could have received an ED of about 0.001 mrem; the collective dose to the 62,812 persons who drink water from this plant could have been 0.04 person-rem.

- **Upper Clinch River.** The ETTP (Gallaher) water plant that drew water from the Clinch River near CRK 23 was deactivated; therefore doses from drinking water are no longer calculated. ETTP and the Rarity Ridge community receive drinking water from the City of Oak Ridge water plant, which is located near CRK 66.

- **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 very far from its confluence with the Clinch River. A maximally exposed individual could have received an ED of about 0.02 mrem. The collective dose to the 25,871 persons who drink water from these plants could have been about 0.2 person-rem.

- **Lower system.** Several water treatment plants are located on tributaries of Watts Bar Lake and Chickamauga Lake. Persons drinking water from these plants could not have received EDs greater than the 0.01 mrem calculated for drinking water from the Kingston or Rockwood municipal water plants. The collective dose to the 311,622 persons who drink water within the lower system could have been about 1.5 person-rem.

- **Poplar Creek/Lower EFPC.** No drinking water intakes are located on Poplar Creek or lower EFPC.

Groundwater

In 2004, six groundwater monitoring wells were installed in the western end of Melton Valley as sentinel wells to detect site-related contaminants that might seep toward the Clinch River. In fiscal year (FY) 2010, off-site monitoring was initiated west of the Clinch River across from the Melton Valley waste management areas. This action was taken in response to detection of site-related contaminants in some of the on-site sentinel well monitoring zones in FY 2007 through FY 2009. As a precaution, DOE funded installation of potable water lines to the residential area near Jones Road on the west side of the Clinch River to provide utility water to residents in the area. Sampling of the off-site wells occurred semiannually from FY 2010 through FY 2014. During FY 2014, EPA drinking water maximum contaminant levels (MCLs) for alpha activity (15 pCi/L) were exceeded in two off-site wells (both of which produce highly saline groundwater samples; samples containing high levels of dissolved solids are known to cause high bias in the analytical result). The MCL for total radium alpha activity (5 pCi/L) was exceeded in one deep off-site well. Beta activity exceeded the 50 pCi/L screening level during FY 2014 in one deep off-site well. Similar to alpha activity, high dissolved solids content in the saline zone contributed to elevated beta analysis in the analyses. Strontium-90 was not detected in any of the off-site monitoring wells in FY 2014. Although ^{99}Tc was detected in one off-site well early in the monitoring program, it was not detected in any of the on-site sentinel wells or in the off-site monitoring wells during FY 2012 through FY 2014. Currently no water is consumed from these groundwater wells. A revised sampling was agreed upon in FY 2013 by DOE, EPA, and the Tennessee Department of Environment and Conservation (TDEC) (DOE 2015).

Two off-site groundwater sampling events were completed in 2015 to implement key recommendations from the Oak Ridge Reservation groundwater strategy report that was approved in 2014 (DOE 2014a). Samples were collected at 34 wells and 15 springs located west and north of the Clinch River at the western boundary of the ORR. Ongoing evaluation of results includes comparison to screening levels for protection of human health and the environment and review of data for indicators of potential contaminant sources and pathways (e.g., potential ORR contaminants, potential migration beyond the Clinch River, potential naturally occurring substances.). The project is a cooperative DOE, EPA, and TDEC effort. A report on the study is planned for November 2016.

7.1.2.2.2 Fish Consumption

Fishing is quite common on the Clinch and Tennessee River systems. Based on a nationwide food consumption survey (EPA 2011) and weighted based on the combined population of Anderson, Knox, Loudon, and Roane counties, it was assumed that avid fish consumers would have eaten 27 kg (60 lb) of fish during 2015. For the average person used for collective dose calculations, it was assumed that 11 kg (24 lb) of fish was consumed in 2015. The estimated maximum ED will be based on either the first method, measured radionuclide concentrations in fish, or by the second method, which calculates possible radionuclide concentrations in fish from measured radionuclide discharges and known or estimated stream flows. The EDs estimated by both methods, in each of the surface water segments, are provided in Appendix E. The number of individuals who could have eaten fish is based on lake creel surveys conducted annually by the Tennessee Wildlife Resources Agency (TWRA 2015). The 2012 Melton Hill and Chickamauga creel surveys and 2013 Watts Bar creel survey data (creel survey data for Melton Hill and Chickamauga were not collected in 2013) are used to estimate the numbers of individuals who harvested fish from these water bodies.

- **Upper Melton Hill Lake above All Possible ORR Inputs.** For reference purposes, a hypothetical avid fish consumer who ate fish caught at CRK 66, which is above all possible ORR inputs, could have received an ED of about 5×10^{-5} mrem. This dose was estimated from a composite fish sample collected near CRK 70, and major contributor to dose was ^{3}H. The collective ED to the 25 persons who could have eaten such fish was about 6×10^{-7} person-rem.

- **Melton Hill Lake.** An avid fish consumer who ate fish from Melton Hill Lake could have received an ED of about 5×10^{-5} mrem. The collective ED to the 222 persons who could have eaten such fish could be about 5×10^{-6} person-rem.

- **Upper Clinch River.** An avid fish consumer who ate fish from the upper Clinch River could have received an ED of about 0.03 mrem. The collective ED to the 127 persons who could have eaten such fish could have been about 0.001 person-rem.

- **Lower Clinch River.** An avid fish consumer who ate fish from the lower Clinch River (CRK 16) could have received an ED of about 0.03 mrem. The collective ED to the 297 persons who could have eaten such fish could have been about 0.003 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 0.006 mrem. The collective ED to the 849 persons who could have eaten such fish could be about 0.002 person-rem.

- **Lower System.** An avid fish consumer who ate fish from the lower system could have received an ED of about 0.005 mrem. The collective ED to the about 9,997 persons who could have eaten such fish could have been about 0.02 person-rem.

- **Poplar Creek/Lower East Fork Poplar Creek.** An avid fish consumer who ate fish from lower EFPC above its confluence with Poplar Creek could have received an ED of about 0.8 mrem. Assuming that 100 people could have eaten fish from lower EFPC and 100 from Poplar Creek, the collective ED could have been about 0.04 person-rem.

7.1.2.2.3 Other Uses

Other uses of ORR area waterways include swimming or wading, boating, and use of the shoreline. 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. Measured and calculated concentrations of radionuclides in water and equations used in the LADTAP XL code (Hamby 1991) were used to estimate potential EDs from these activities. At all locations in 2015, the estimated maximally exposed individual EDs were based on measured off-site surface water radionuclide concentrations and excluded naturally occurring radionuclides such as ^{7}Be and ^{40}K.

The number of individuals who could have been other users is different for each section of water because the data sources differ. For Watts Bar parts (upper Clinch River through lower Watts Bar), the assumption for other users is five times the number of people who harvest fish. For Chickamauga and Melton Hill, the number for other users is based on surveys conducted by TVA.

- **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 2×10^{-6} mrem. The collective ED to the 10,412 other users could have been 7×10^{-7} person-rem.

- **Melton Hill Lake.** An individual other user of Melton Hill Lake could have received an ED of about 2×10^{-6} mrem. The collective ED to the 24,294 other users could have been about 6×10^{-6} person-rem.

- **Upper Clinch River.** An individual other user of the upper Clinch River could have received an ED of about 0.002 mrem. The collective ED to the 3,232 other users could have been about 0.002 person-rem.

- **Lower Clinch River.** An individual other user of the lower Clinch River could have received an ED of about 0.002 mrem. The collective ED to the 7,559 other users could have been about 0.004 person-rem.

- **Upper Watts Bar Lake.** An individual other user of upper Watts Bar Lake could have received an ED of about 6×10^{-4} mrem. The collective ED to the 21,609 other users could have been about 0.004 person-rem.

- **Lower system.** An individual other user of the lower system could have received an ED of about 5×10^{-4} mrem. The collective ED to the 325,259 other users could have been about .03 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 0.005 mrem. The collective ED to the 200 other users of Poplar Creek and Lower EFPC could have been about 2×10^{-4} person-rem.

7.1.2.2.4 Summary

Table 7.6 is a summary of potential EDs from identified waterborne radionuclides around ORR. Adding worst-case EDs for all pathways in a water-body segment gives a maximum individual ED of about 0.8 mrem to a person obtaining his or her full annual complement of fish from and participating in other water uses on Lower EFPC. The maximum collective ED to the 80 km (50 mile) population could be as high as 2 person-rem. These are small percentages of individual and collective doses attributable to natural background radiation, about 0.3% of the average individual background dose of roughly 300 mrem/year and 6×10^{-4} % of the 351,759 person-rem that this population received from natural sources of radiation.

Table 7.6. Summary of annual maximum individual (mrem) and collective (person-rem) effective doses (EDs) from waterborne radionuclides, 2015[a,b]

	Drinking water	Eating fish	Other uses	Total[c]
Upstream of all Oak Ridge Reservation discharge locations (CRK 66, City of Oak Ridge Water Plant)				
Individual ED	1×10^{-3}	5×10^{-5}	2×10^{-6}	0.001
Collective ED	0.03	6×10^{-7}	7×10^{-7}	0.03
Melton Hill Lake (CRK 58, Knox County Water Plant)				
Individual ED	0.001	5×10^{-5}	2×10^{-6}	0.001
Collective ED	0.04	5×10^{-6}	6×10^{-6}	0.04
Upper Clinch River (CRK 23,32)				
Individual ED	NA[d]	0.03	0.002	0.03
Collective ED	NA[d]	0.001	0.002	0.003
Lower Clinch River (CRK 16)				
Individual ED	NA[d]	0.03	0.002	0.03
Collective ED	NA[d]	0.003	0.004	0.007
Upper Watts Bar Lake, Kingston Municipal Water Plant				
Individual ED	0.02	0.006	6×10^{-4}	0.02
Collective ED	0.2	0.002	0.004	0.2
Lower system (Lower Watts Bar Lake and Chickamauga Lake)				
Individual ED	0.01	0.005	5×10^{-4}	0.02
Collective ED	1.5	0.02	0.03	2

Table 7.6. Summary of annual maximum individual (mrem) and collective (person-rem) effective doses (EDs) from waterborne radionuclides, 2015[a,b](Continued)

	Drinking water	Eating fish	Other uses	Total[c]
	Lower East Fork Poplar Creek and Poplar Creek			
Individual ED	NA[d]	0.8	0.005	0.8
Collective ED	NA[d]	0.04	0.0002	0.04

[a]1 mrem = 0.01 mSv.
[b]Doses based on measured radionuclide concentrations in water or estimated from measured discharges and known or estimated stream flows.
[c]Total doses and apparent sums over individual pathway doses may differ because of rounding.
[d]Not at or near drinking water supply locations.

Acronyms
CRK = Clinch River kilometer.

7.1.2.2.5 Irrigation

Although there are no known locations that 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 one or more members of the public. To make this determination, the method described by the Nuclear Regulatory Commission (NRC 1977) was used. Based on measured and calculated concentrations of radionuclides at CRK 16, which is a location on the lower Clinch River and downstream of the ORR, the maximum potential dose (excluding ^{7}Be and ^{40}K, naturally occurring radionuclides) to an individual due to irrigation ranged from 0 to 0.03 mrem in 2015. The individual was assumed to consume 24 kg of leafy vegetables, 90 kg of produce, 321 L of milk and 671 kg of meat (beef) during the year.

7.1.2.3 Radionuclides in Other Environmental Media

The CAP-88 PC computer codes are used to calculate radiation doses from ingestion of meat, milk, and vegetables that contain radionuclides released to the atmosphere. These doses are included in the dose calculations for airborne radionuclides. However, some environmental media, including milk and vegetables, are sampled as part of the surveillance program. The following dose estimates are based on environmental sampling results and may include contributions from radionuclides occurring in the natural environment, released from ORR, or both.

7.1.2.3.1 Milk

During 2015, milk samples were collected from a nearby dairy (in Claxton, Tennessee), and milk samples were composited from several reference locations. Based on a nationwide food consumption survey (EPA 2011), a hypothetical person (weighted based on the combined population of Anderson, Knox, Loudon, and Roane counties) who drank milk was assumed to have consumed a maximum of about 321 L (85 gal) of milk annually. Statistically significant concentrations of ^{40}K, ^{3}H, and ^{90}Sr were detected in all samples from both the nearby dairy and the composite of several reference locations. Annual EDs attributable to ^{40}K at both "locations" were estimated to be about 11 mrem and 15 mrem, respectively. Excluding ^{40}K, a naturally occurring radionuclide, the doses associated with tritium and strontium were estimated to be 0.05 mrem for the Claxton dairy and 0.04 mrem for the composite of several reference locations.

7.1.2.3.2 Food Crops

The food-crop sampling program is described in Chapter 6. Samples of tomatoes, lettuce, and turnips were obtained from six gardens, five local and one distant. These vegetables represent fruit-bearing, leafy, and root vegetables. All radionuclides detected in the food crops are found in the natural environment and in commercial fertilizers, and all but ^{7}Be and ^{40}K also are emitted from ORR. Dose estimates are based on hypothetical consumption rates of vegetables that contain statistically significant amounts of detected radionuclides that could have come from ORR. Based on a nationwide food consumption survey (EPA 2011), a hypothetical home gardener (weighted based on the combined population of Anderson, Knox, Loudon, and Roane counties) was assumed to have eaten a maximum of about 72 kg (158 lb) of homegrown tomatoes, 24 kg (53 lb) of homegrown lettuce, and 90 kg (198 lb) of homegrown turnips. The hypothetical gardener could have received a 50-year committed ED of between 0.08 and 0.2 mrem, depending on garden location. Of this total, between 0 and 0.08 mrem could have come from eating tomatoes, between 0.007 and 0.08 mrem from eating lettuce, and between 0 and 0.1 mrem from eating turnips. The highest dose to a gardener could have been about 0.2 mrem from consuming all three types of homegrown vegetables. A person eating food from the distant (background) garden could have received a committed ED of 0.3 mrem from consumption of all three vegetables.

An example of a naturally occurring and fertilizer-introduced radionuclide is ^{40}K, which is specifically identified in the samples and accounts for most of the beta activity found in them. The presence of ^{40}K in the samples adds, on average, about 14 mrem to the hypothetical home gardener's ED. In 2015, the gardeners were asked about water sources and fertilizers used, and it was reported that they did not use fertilizers and did not irrigate. It is believed ^{40}K and most of the excess unidentified alpha activities are due to naturally occurring radionuclides, not radionuclides discharged from ORR.

7.1.2.3.3 White-Tailed Deer

TWRA conducted three 2-day deer hunts during 2015 on the Oak Ridge Wildlife Management Area, which is part of ORR (see Chapter 6). During the hunts, 244 deer were harvested and were brought to the TWRA checking station. At the station, a bone sample and a muscle tissue sample were taken from each deer. The samples were field-counted for radioactivity to ensure that the deer met wildlife release criteria (less than net counts not greater than 1 ½ times background (~20 pCi/g) of beta activity in bone or 5 pCi/g of 137Cs in edible tissue). One deer exceeded the limit for beta-particle activity in bone and was retained. The remaining 243 deer were released to the hunters.

The average 137Cs concentration in muscle tissue of the 243 released deer, as determined by field counting, was 0.47 pCi/g; the maximum 137Cs concentration in released deer was 0.89 pCi/g. Most of the 137Cs concentrations were less than minimum detectable levels. The average weight of released deer was approximately 41 kg (90 lb); the maximum weight was 78 kg (172 lb). The EDs attributed to field-measured 137Cs concentrations and actual field weights of the released deer ranged from about 0 to 1 mrem, with an average of about 0.5 mrem.

Potential doses attributed to deer that might have moved off ORR and been harvested elsewhere were also evaluated. In this scenario, an individual who consumed one hypothetical average-weight 41 kg (90 lb) deer (assuming 55% field weight is edible meat) containing the 2015 average field-measured concentration of 137Cs (0.47 pCi/g) could have received an ED of about 0.5 mrem. The maximum field-measured 137Cs concentration was 0.89 pCi/g, and the maximum deer weight was 78 kg (172 lb). A hunter who consumed a hypothetical deer of maximum weight and 137Cs content could have received an ED of about 1 mrem.

Muscle tissue samples collected in 2015 from 13 deer (12 released and 1 retained) were subjected to laboratory analyses. Requested radioisotopic analyses included ^{137}Cs, ^{90}Sr, and ^{40}K radionuclides. Comparison of the released-deer field results to analytical ^{137}Cs concentrations found that the field concentrations were either equal to or greater than the analytical results and that all were less than the administrative limit of 5 pCi/g. Using analytically measured ^{137}Cs and ^{90}Sr (excluding ^{40}K, a naturally occurring radionuclide) and actual deer weights, the estimated doses for the 12 released deer ranged from 0 to 0.7 mrem**.** The estimated dose for a human consuming the retained deer would have been 0.8 mrem.

The maximum ED to an individual consuming venison from two or three deer was also evaluated. Twenty-four hunters each harvested two deer from ORR. Based on ^{137}Cs concentrations determined by field counting and actual field weight, the ED range to a hunter who consumed two or more harvested deer was estimated to be between 0.5 and 1.4 mrem**.**

The collective ED from eating all the harvested venison from ORR with a 2015 average field-derived ^{137}Cs concentration of 0.47 pCi/g and an average weight of 41 kg (90 lb) is estimated to be about 0.1 person-rem.

7.1.2.3.4 Canada Geese

During the 2015 goose roundup, 27 geese were weighed and subjected to 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 0.18 pCi/g, with a maximum ^{137}Cs concentration in the released geese of 0.29 pCi/g. All of the ^{137}Cs concentrations were below minimum detectable activity levels. The average weight of the geese screened during the roundup was about 4 kg (8.8 lb), and the maximum weight was about 5.1 kg (11.2 lb).

The EDs attributed to field-measured ^{137}Cs concentrations and actual field weights of the geese ranged from 0.007 to 0.02 mrem. However, for bounding purposes, if a person consumed a released goose with an average weight of 4 kg (8.8 lb) and an average ^{137}Cs concentration of 0.18 pCi/g, the estimated ED would be approximately 0.02 mrem. It is assumed that about half the weight of a Canada goose is edible. The maximum estimated ED to an individual who consumed a hypothetical released goose with the maximum ^{137}Cs concentration of 0.29 pCi/g and maximum weight of 5.1 kg (11.2 lb) is about 0.04 mrem.

It is possible that a person could eat more than one goose that spent time on ORR. The average seasonal goose bag per active hunter from Tennessee in the Mississippi Flyway has ranged from 1.9 to 3.0 geese per hunting season between 1999 and 2010 (TWRA 2010). If one person consumed two hypothetical geese of maximum weight with the highest measured concentration of ^{137}Cs, that person could have received an ED of about 0.08 mrem.

Between 2000 and 2009, 22 geese tissue samples were analyzed. An evaluation of potential doses was made based on laboratory-determined concentrations of the following radionuclides: ^{40}K, ^{137}Cs, ^{90}Sr, thorium (^{228}Th, ^{230}Th, ^{232}Th), uranium ($^{233/234}$U, ^{235}U, ^{238}U), and transuranic elements (^{241}Am, $^{243/244}$Cm, ^{238}Pu, $^{239/240}$Pu). The total dose, less the contribution of ^{40}K, ranged from 0.01 to 0.5 mrem, with an average of 0.2 mrem (EP&WSD 2010).

7.1.2.3.5 Eastern Wild Turkey

Participating hunters are allowed to harvest one turkey from the reservation in a given season unless a harvested turkey is retained, in which case, the hunter is allowed to hunt for another turkey. Two wild turkey hunts took place on the reservation in 2015: April 11–12 and April 18–19. In addition, a hunter requested screening of a turkey legally harvested by an archery deer hunter during the 2015 fall deer hunt season on December. Forty-six birds were harvested (including the turkey harvested in December), and none were retained. The average 137Cs concentration measured in the released turkeys was 0.1 pCi/g, and the maximum 137Cs concentration was 0.16 pCi/g. All of the 137Cs concentrations were below minimum detectable activity levels. The average weight of the turkeys released was about 8.9 kg (19.5 lb). The maximum turkey weight was about 11.3 kg (25 lb).

The EDs attributed to the field-measured 137Cs concentrations and the actual field weights of the released turkeys ranged from about 0.02 to 0.03 mrem with an average dose of 0.02 mrem. Potential doses were also evaluated for turkeys that might have moved off ORR and were then harvested elsewhere. In this scenario, if a person consumed a wild turkey with an average weight of 8.9 kg (19.5 lb) and an average 137Cs concentration of 0.1 pCi/g, the estimated ED would be about 0.02 mrem. The maximum estimated ED to an individual who consumed a hypothetical released turkey with the maximum 137Cs concentration of 0.16 pCi/g and the maximum weight of 11.3 kg (25 lb) was about 0.05 mrem. It is assumed that approximately half the weight of a wild turkey is edible. No tissue samples were analyzed in 2015.

The collective ED from consuming all the harvested wild turkey meat (46 birds) with an average field-derived 137Cs concentration of 0.1 pCi/g and average weight of 8.9 kg (19.5 lb) is estimated to be about 0.001 person-rem.

Earlier evaluations of doses based on laboratory-determined concentrations of radionuclides included 40K, 137Cs, 90Sr, 230Th, 3H, 234U, 235U, 238U, and transuranic elements (241Am, 244Cm, 237Np, 239Pu). The total dose, less the contribution of 40K, ranged from 0.06 to 0.2 mrem (EP&WSD 2010).

7.1.2.3.6 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). External exposure rates due to natural external background sources in the state of Tennessee average about 6.4 μR/h and range from 2.9 to 11 μR/h (Myrick 1981). These exposure rates correspond to ED rates between 18 and 69 mrem/year, with an average of 40 mrem/year.

External radiation exposure rates are measured at numerous locations on and off ORR. In 2014, high-pressure ion chamber detectors, which had been used since the early 1990s to measure external radiation exposure rates, were replaced with Geiger-Müller (GM)–based detectors. In 2015, exposure rates measured by the new GM-type detectors averaged about 10.5 μR/h and ranged from 9.6 to 11.7 μR/h. These exposure rates correspond to an annual average ED of about 65 mrem and a range of 59 to 72 mrem. At the remote PAM station, the exposure rate measured with the new GM instrument averaged about 9.5 μR/h (annual ED of 58 mrem). The annual dose based on measured exposure rates at or near the ORR boundaries were somewhat greater than the exposure rate measured at the remote location but were within the state external exposure rates range due to natural external background sources.

7.1.3 Current-Year Summary

A summary of the maximum EDs to individuals by pathway of exposure is given in Table 7.7. In the unlikely event that any person was irradiated by all of those sources and pathways for the duration of 2015, that person could have received a total ED of about 3 mrem. Of that total, 0.4 mrem would have come from airborne emissions and approximately 1 mrem from waterborne emissions (0.02 mrem from drinking water, 0.8 mrem from consuming fish and 0.005 mrem from other water uses along Lower East Fork Popular Creek, and 0.03 mrem from irrigation at CRK16), no appreciable dose above background from external radiation, and about 1 mrem from consumption of wildlife. There are no known significant doses from discharges of radioactive constituents from ORR other than those reported.

Table 7.7. Summary of maximum estimated effective doses to an adult by exposure pathway

Pathway	Dose to maximally exposed individual		Percentage of DOE mrem/year limit (%)	Estimated population dose		Population within 80 km	Estimated background radiation population dose (person-rem)[a]
	mrem	mSv		person-rem	person-Sv		
				Airborne effluents			
All pathways	0.4	0.004	0.4	10.8	0.108	1,172,530[b]	
				Liquid effluents			
Drinking water	0.02	0.0002	0.02	1.8	0.018	446,981[c]	
Eating fish	0.8	0.008	0.8	0.06	0.0006	11,717[d]	
Other activities	0.005	0.00005	0.005	0.04	0.0004	468,234[d]	
Irrigation	0.03	0.003	0.03				
				Other Pathways			
Eating deer	1[e]	0.01	1	0.1	0.001	244	
Eating geese	0.08[f]	0.0008	0.08	*g*	*g*		
Eating turkey	0.05[h]	0.0005	0.05	0.001	0.00001	46	
Direct radiation	NA[i]	NA					
All pathways	**3**	**0.003**	**3**	**13**	**0.13**	**1,172,530**	**363,484**

[a]Estimated background population dose is based on the roughly 300 mrem/year individual dose and the population within 80 km (50 miles) of the Oak Ridge Reservation.
[b]Population based on 2010 census data.
[c]Population estimates based on community and non-community drinking water supply data from the Tennessee Department of Environment and Conservation, Division of Water.
[d]Population estimates based on population within 80 km (50 miles) and fraction of fish harvested from Melton Hill, Watts Bar, and Chickamauga reservoirs. Melton Hill and Chickamauga recreational use information was obtained from the Tennessee Valley Authority (Stephens et al. 2006 and Stephens et al. 2007).
[e]From consuming one hypothetical worst-case deer, a combination of the heaviest deer harvested and the highest measured concentrations of ^{137}Cs in released deer on ORR; population dose based on number of hunters that harvested deer.
[f]From consuming two hypothetical worst-case geese, each a combination of the heaviest goose harvested and the highest measured concentrations of ^{137}Cs in released geese.
[g]Population doses were not estimated for the consumption of geese since no geese were brought to the checking station during the goose hunt.
[h]From consuming one hypothetical worst-case turkey, a combination of the heaviest turkey harvested and the highest measured concentrations of ^{137}Cs in released turkey. The population dose is based on the number of hunters who harvested turkey.
[i]Direct radiation dose estimates were conducted, although exposure rates near the Clinch River were near background levels. In addition, direct radiation monitoring is no longer conducted for locations that were formerly the UF_6 cylinder storage yards and the K-770 Scrap Yard. Direct dose measurements have been taken and have confirmed that there is no longer a source of potential dose to the public above the background levels. Current exposure rates at PAM stations are at or near background levels.

The dose of 3 mrem is about 1% of the annual dose (roughly 300 mrem) from background radiation. The ED of 3 mrem includes the person who received the highest EDs from eating wildlife harvested on ORR. If the maximally exposed individual did not consume wildlife harvested from ORR, the estimated dose would be about 2 mrem. DOE O 458.1 limits the ED that an individual may receive from all exposure pathways from all radionuclides released from ORR during 1 year to no more than 100 mrem. The 2015 maximum ED should not have exceeded about 3 mrem, or about 3% of the limit given in DOE O 458.1. (For further information, see Appendix E, which summarize dose levels associated with a wide range of activities.)

The total collective ED to the population living within an 80-km (50-mile) radius of ORR was estimated to be about 12.8 person-rem. This dose is about 0.004% of the 363,484 person-rem that this population received from natural sources during 2015.

7.1.4 Five-Year Trends

EDs associated with selected exposure pathways for the years 2011 to 2015 are given in Table 7.8. In 2015, the air pathway dose decreased slightly due in part to using CAP-88 PC Version 4, which updated the time-in-flight calculation that can influence doses from short-lived radionuclides. The dose from fish consumption is comparable to the dose estimated in 2011. The increase in the 2014 fish consumption was due to a composite fish sample collected at CRK16, in which ^{90}Sr was a primary dose contributor. In 2013, an increase in the dose from fish consumption was observed; this increase in dose was primarily due to a composite fish sample collected near CRK 32, in which ^{137}Cs was the primary dose contributor. Recent measurements along the Clinch River indicate doses near background levels. There was a decrease in drinking water dose in 2014, but the doses in 2015 are comparable to earlier estimated doses. Doses from consumption of wildlife have been similar for the last 5 years with a slight decrease in dose from consumption of venison in 2015.

Table 7.8. Trends in effective dose (mrem)[a]

Pathway	2011	2012	2013	2014	2015
Air pathway (all routes)	0.3	0.3	0.4	0.6	0.4
Surface water pathway					
Fish consumption (Clinch River)	0.3	0.08	1.5	1.2	0.03
Drinking water (Kingston)	0.02	0.02	0.01	0.003	0.02
Clinch River	NA[b]	NA[b]	NA[b]	NA[b]	NA[b]
Deer	2	2	2	2	1
Geese	0.1	0.1	0.1	0.1	0.08
Turkey	0.1	0.06	0.08	0.04	0.05

[a] 1 mrem = 0.01 mSv.
[b] Direct radiation dose estimates were conducted, although exposure rates near the Clinch River were near background levels.

7.1.5 Potential Contributions from Non-DOE Sources

DOE O 458.1 requires that if the DOE-related annual dose is greater than 25 mrem, the dose to members of the public must include major non-DOE sources of exposure as well as doses from DOE-related sources. In 2015, the DOE-related source doses were considerably below the 25 mrem criterion. However, DOE requested information from non-DOE facilities pertaining to potential radiation doses to members of the public. There are several non-DOE facilities on or near ORR that could contribute radiation doses to the public. Ten facilities responded to the DOE request. Two facilities used the COMPLY, a computerized screening tool for evaluating radiation exposure from atmospheric releases of radionuclides (EPA 2016). One facility reported annual doses from airborne emissions of 0.27 mrem; the other facility reported < 10 mrem (COMPLY, level 1). Another facility, using CAP-88 PC Version 4 for evaluating radiation exposure from atmospheric releases of radionuclides, reported an annual dose from airborne emissions of 0.2 mrem. Most of the non-DOE facilities reported no water emissions and only one facility reported that sewer discharges were less than the sum of ratios. Doses from direct radiation ranged from none to an annual dose of 28 mrem, based on area monitors located within one of the facilities and fence-line TLDs used by another facility. The estimated an annual dose to members of the public associated with the fence-line TLDs was 28 mrem. Therefore, annual doses from air and water emissions and external radiation from both non-DOE and DOE sources should be less than the DOE O 458.1 annual public dose limit of 100 mrem.

7.1.6 Doses to Aquatic and Terrestrial Biota

7.1.6.1 Aquatic Biota

DOE O 458.1 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, the aquatic organism assessment was conducted using the RESRAD-Biota code (1.8), a companion tool for implementing the DOE technical standard, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002). 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. The 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, it is generally assumed that protecting the more-sensitive organisms will adequately protect other less-sensitive organisms. Depending on the radionuclide, either aquatic organisms (e.g., crustaceans) or riparian organisms (e.g., raccoons) may be considered to be the more sensitive and are typically the limiting organisms for the general screening phase of the graded approach for aquatic organisms.

At ORNL, doses to aquatic organisms are based on surface water concentrations and sediment concentrations [Melton Branch, WOC, and White Oak Dam (WOD)] at the following seven different instream sampling locations.

- Melton Branch [Melton Branch (X13)]
- WOC [WOC headwaters, WOC (X14), and WOD (X15)]
- First Creek
- Fifth Creek
- Northwest Tributary

All locations, except Melton Branch (X13), WOC (X14) and WOD (X15), passed the general screening phase (comparison of maximum radionuclide water concentrations to default BCGs). Melton Branch (X13), WOC (X14), and WOD (X15) passed when average radionuclide water concentrations were compared to default BCGs. This resulted in absorbed dose rates to aquatic organisms below the DOE aquatic dose limit of 1 rad/day at all seven sampling locations.

At Y-12, doses to aquatic organisms were estimated from surface water concentrations and sediment concentrations (at Station 9422-1 and S24) at the following five different instream sampling locations.

- Surface Water Hydrological Information Support System Station 9422-1 (also known as station 17)
- Bear Creek at kilometer 9.2 (BCK 9.2)

- Discharge Point S24, Bear Creek at BCK 9.4
- Discharge Point S17 (unnamed tributary to the Clinch River)
- Discharge Point S19 (Rogers Quarry)

All locations passed the general screening phase (maximum water concentrations and default parameters for BCGs). This resulted in absorbed dose rates to aquatic organisms below the DOE aquatic dose limit of 1 rad/day at all four Y-12 locations.

At ETTP, doses to aquatic organisms were estimated from surface water concentrations at the following 12 different 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)
- Clinch River (CRK 16 and CRK 23)

All of these locations passed the initial general screening (using maximum concentrations and default parameters for BCGs). This resulted in absorbed dose rates to aquatic organisms that were below the DOE aquatic dose limit of 1 rad/day at all 12 sampling locations.

7.1.6.2 Terrestrial Biota

To evaluate impacts on biota, in accordance with requirements in DOE O 458.1, a terrestrial organism assessment was conducted. An absorbed dose rate of 0.1 rad/day is recommended as the limit for terrestrial animal exposure to radioactive material in soils. As for aquatic and riparian biota, certain terrestrial organisms are more sensitive to ionizing radiation than others, and it is generally assumed that protecting the more sensitive organisms will adequately protect other, less-sensitive organisms. Initial soil sampling for terrestrial dose assessment was initiated in 2007 and was reassessed in 2014. This biota sampling strategy was developed by taking into account guidance provided in *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002) and existing radiological information on the concentrations and distribution of radiological contaminants on ORR. As in 2007, the 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. Soil sampling locations are identified as follows.

- WOC floodplain and upland location
- Bear Creek Valley floodplain
- Mitchell Branch floodplain
- Two background locations: Gum Hollow and near Bearden Creek

The soil samples were collected in similar locations as in 2007. With the exception of samples collected on the WOC floodplain (collected on the WOC floodplain upstream from WOD), samples taken at all other soil sampling locations passed either the initial-level screening (comparison of maximum radionuclide soil concentrations to default BCGs) or second-level screening, for which BCG default parameters and average soil concentrations were used. Cesium-137 is the primary dose contributor in the soil samples collected on the WOC floodplain.

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. Based on the current measured concentrations in soil and tissue concentrations collected, the absorbed doses to the terrestrial organisms collected along the confluence of Melton Branch and WOC and in the floodplain upstream of White Oak Lake were less than 0.1 rad/day.

The next evaluation of exposure to terrestrial organisms would be within the next 5 years or if an abnormal event occurs that could have adverse effects on terrestrial organisms.

7.2 Chemical Dose

7.2.1 Drinking Water Consumption

Surface Water

To evaluate the drinking water pathway, hazard quotients (HQs) were estimated downstream of ORNL and downstream of ORR discharge points (Table 7.9). The HQ is a ratio that compares the estimated exposure dose or intake to the reference dose. Based on a nationwide food consumption survey (EPA 2011) and weighted based on the combined population of Anderson, Knox, Loudon, and Roane counties, it was assumed that the drinking water consumption rate for the maximally exposed individual is 680 L/year (180 gal/year). 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 23 and CRK 16. The water intake for ETTP used to be located near CRK 23 which was deactivated in 2014 and CRK 16 is located downstream of all DOE discharge points. As shown in Table 7.9, HQs were less than 1 for detected chemical analytes for which there are reference doses or MCLs.

Acceptable risk levels for carcinogens typically range in magnitude from 10^{-4} to 10^{-6}. A risk value slightly greater than or equal to 10^{-5} was calculated for the intake of vinyl chloride in water collected at both locations.

Table 7.9. Chemical hazard quotients and estimated risks for drinking water, 2015

Chemical	Hazard quotient	
	CRK 23[a]	CRK 16[b]
Metals		
Antimony	0.01	0.01
Arsenic	0.06	0.07
Cadmium	0.009	0.01
Chromium	0.005	0.005
Copper	0.002	0.002
Lead	0.02	

Table 7.9 (continued)

Chemical	Hazard quotient	
	CRK 23[a]	CRK 16[b]
Mercury	0.0002	0.0003
Nickel	0.003	0.003
Selenium	0.01	0.006
Silver	0.0002	0.0002
Thallium	0.02	0.02
Uranium	0.003	0.002
Zinc	0.0006	0.0007
Organics		
cis 1,2,Dichlorethene	0.01	0.01
1,1,1 Tricholoroethane	1×10^{-5}	1×10^{-5}
Trichloroethene	0.05	0.05
Vinyl Chloride	0.009	0.009
Risk for carcinogens		
Arsenic	1×10^{-5}	1×10^{-5}
Trichloroethene	6×10^{-7}	6×10^{-7}
Vinyl Chloride	2×10^{-5}	2×10^{-5}

[a]Clinch River near the water deactivated intake for East Tennessee Technology Park.
[b]Clinch River downstream of all US Department of Energy inputs.

Acronyms
CRK = Clinch River kilometer.

Groundwater

As mentioned in Section 7.1.2.2.1, a series of off-site monitoring wells were installed across the Clinch River from ORNL west of the Melton Valley waste management areas in 2010. Sampling of the off-site wells occurred semiannually during FY 2012 and FY 2013, and results were compared to EPA MCLs (DOE 2015). A trend evaluation of monitoring data from two off-site monitoring wells (2012 through 2013) indicates that fluoride and barium concentrations were increasing, antimony levels were decreasing, and arsenic concentrations were stable (DOE 2015). Reviews of shallow groundwater monitoring data near the Melton Valley waste disposal areas do not show fluoride plumes emanating from the buried waste. Fluoride has natural and potential human-made sources in Melton Valley. Barium is a common constituent of geologic brines (DOE 2014). Volatile organic compounds have not been detected in off-site wells since September 2010 (DOE 2015). Currently, no water is consumed from these off-site groundwater wells.

7.2.2 Fish Consumption

Chemicals in water can be accumulated by 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 the ORR discharge points. Based on a nationwide food consumption survey (EPA 2011) and weighted based on the combined population of Anderson, Knox, Loudon, and Roane counties, it was assumed that avid fish consumers would have eaten 27 kg (60 lb) of fish during 2015. This fish consumption rate of 74 g/day (27 kg/year) is assumed for both the noncarcinogenic and carcinogenic pollutants. This is the same fish consumption rate used in the estimation of the radiological dose from consumption of fish.

As shown in Table 7.10, for consumption of sunfish and catfish, HQ values of less than 1 were calculated for all detected analytes except for Aroclor-1260, which are polychlorinated biphenyls (PCBs), also referred to as PCB-1260. An HQ at or less than 1 was estimated for sunfish at all three locations (CRK 16, CRK 32, and CRK 70). An HQ greater than 1 for Aroclor-1260 was estimated in catfish at all three locations (CRKs 16, 32, and 70).

For carcinogens, risk values at or greater than 10^{-5} were calculated for the intake of Aroclor-1260 and arsenic in sunfish and catfish collected at all three locations. TDEC has issued a fish advisory that states that catfish should not be consumed from Melton Hill Reservoir (in its entirety) because of PCB contamination and has issued a precautionary fish consumption advisory for catfish in the Clinch River arm of Watts Bar Reservoir (TWRA 2012). The risk values estimated in 2015 for Aroclor-1260 for sunfish and catfish at CRK 70 and 32 were similar to risk values estimated in 2014. The Aroclor-1260 risk values for sunfish and catfish at CRK 16 estimated in 2015 were slightly elevated compared to the estimated risks in 2014.

Table 7.10. Chemical hazard quotients and estimated risks for carcinogens in fish, 2015[a]

Carcinogen	Sunfish			Catfish		
	CRK 70[b]	CRK 32[c]	CRK 16[d]	CRK 70[b]	CRK 32[c]	CRK 16[d]
Hazard quotients for metals						
Arsenic	0.7	0.9	0.6	0.4	0.5	0.8
Barium	0.001	0.002	0.003	0.0003	0.0002	0.0002
Chromium	0.02	0.04	0.04	0.02	0.03	0.02
Copper	0.009	0.009	0.01	0.009	0.01	0.009
Manganese	0.008	0.02	0.04	0.002	0.003	0.002
Mercury	0.1	0.1	0.3	0.3	0.2	0.3
Nickel	0.002		0.004	0.003	0.02	0.004
Selenium	0.2	0.2	0.2	0.1	0.1	0.2
Strontium	0.003	0.006	0.008	0.0003	0.0003	0.0002
Thallium	0.06	0.2	0.1	0.06	0.1	0.05
Uranium			0.0005			0.0004
Vanadium						
Zinc	0.04	0.05	0.05	0.03	0.03	0.03
Hazard quotients for pesticides and Aroclors						
Aroclor-1260	0.9	1	5	7	5	9.6
Risks for carcinogens						
Arsenic	1E-4	2E-4	1E-4	9E-5	1E-4	2E-4
Aroclor-1260	2E-5	2E-5	8E-5	1E-4	9E-5	2E-4
PCBs (mixed)[e]	2E-5	2E-5	8E-5	1E-4	9E-5	2E-4

[a]A blank space for a particular location indicates that the parameter was undetected.
[b]Melton Hill Reservoir, 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 polychlorinated biphenyls (PCBs) consist of the summation of Aroclors detected or estimated.

Acronyms
CRK = Clinch River kilometer

7.3 References

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Appendix A. Glossary

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.

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.

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 that 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. The US Environmental Protection Agency (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.

CERCLA-reportable release—A release to the environment that exceeds reportable quantities as defined by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

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. Cosmic radiation is one source contributing to natural background radiation.

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 guide (DCG)—The concentration of a radionuclide in air or water that, under conditions of continuous exposure for 1 year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in either an effective dose equivalent of 0.1 rem (1 mSv) or a dose equivalent of 5 rem (50 mSv) to any tissue, including skin and lens of the eye. The guides for radionuclides in air and water are given in DOE O 5400.5.

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 of its sites (remediation) 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.

Leadership in Energy and Environmental Design (LEED)—A suite of rating systems for the design, construction, operation, and maintenance of green buildings, homes, and neighborhoods. LEED is intended to help building owners and operators find and implement ways to be environmentally responsible and resource-efficient.

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.

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 6, 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.

remedial investigation/feasibility study (RI/FS)—An in-depth study designed to gather data needed to determine the nature and extent of contamination at a Superfund site; establish site cleanup criteria; identify preliminary alternatives for remedial action; and support technical and cost analyses of alternatives. The remedial investigation is usually done with the feasibility study. Together they are usually referred to as the “RI/FS.”

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—Surface streams that appear after precipitation.

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 government's program to clean up the nation's uncontrolled hazardous waste, is now commonly 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. Terrestrial radiation contributes to natural background radiation.

total activity—The total number of atoms of a radioactive substance that decay per unit of time.

total dissolved solids—Dissolved solids and total dissolved solids are terms generally associated with freshwater systems; they 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.

wetlands—Lowland areas, such as a marshes or swamps, sufficiently inundated or saturated by surface water or groundwater to support aquatic vegetation or plants adapted for life in saturated soils.

wind rose—A diagram in which statistical information concerning direction and speed of the wind at a location is summarized.

Appendix B. Climate Overview of the Oak Ridge Area

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 to the level of evaporation and transpiration that is normally experienced throughout the year. The “subtropical” designation indicates that the region experiences a wide range of seasonal temperatures. Such areas are typified by significant differences in temperature between summer and winter.

Oak Ridge winters are characterized by synoptic weather systems that produce significant precipitation events 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 occur. Winter cloud cover tends to be enhanced by the regional terrain (due to cold air wedging and moisture trapping).

Severe thunderstorms are most frequent during spring, very infrequent during winter, but can occur at any time of the year. The Cumberland Mountains and Cumberland Plateau often inhibit the intensity of severe systems that traverse the region, particularly those moving from west to east, due to 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 tornados). 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 adequate precipitation usually occurs during the fall, the months of August through October often represent the driest period of the year. The occurrence of precipitation during the fall tends to be less cyclical than for other seasons but is occasionally enhanced by decaying tropical cyclones moving north from the Gulf of Mexico. During November, winter-type cyclones again begin to dominate the weather and may continue in dominance until April or May.

Decadal-scale climate change has recently affected the East Tennessee region. Most of these changes appear to be related to the hemispheric effects caused by the frequency and phase of the El Niño–Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), and the Atlantic Multidecadal Oscillation (AMO). The ENSO and PDO patterns, with cycles of 3 to 7 years and about 40 years, respectively, affect Pacific Ocean sea surface temperatures. The AMO, with a cycle of 30 to 70 years, affects Atlantic sea surface temperature. All of these patterns collectively modulate long-term regional temperature and precipitation trends in eastern Tennessee. The AMO shifted from a cold to a warm sea surface temperature phase (mid-1990s) and could continue in its present state for another decade or so. The PDO entered an either cool or transitional sea surface temperature state around 2000. Also, the ENSO pattern had frequently brought about warmer Eastern Pacific sea surface temperatures during the 1990s, but this phenomenon had subsided somewhat in the 2000s. A very strong El Niño occurred in 2015, leading to above-normal temperatures, both locally and in much of the globe during 2015. Additionally, some evidence exists that human-induced climate change may be producing some effects (via an assembly of first-order influences such as well-mixed greenhouse gases, land cover change, carbon soot, aerosols, and other effects). Solar influences on the jet stream, via changes to the stratospheric temperature gradient with respect to the 11-year solar cycle, also play a role in inter-annual climate variability (Ineson et al. 2011). Largely due to the effects of the AMO and ENSO, the Oak Ridge climate warmed about 1.1°C from the 1980s to the 1990s but has stabilized just above the 1990s values during the

2000s (a further warming of 0.2°C was observed). The recent warming appears to have lengthened the growing season [i.e., the period with temperatures above 0°C (32°F)] by about 2 to 3 weeks over the last 30 years. This warming has primarily affected minimum temperature over the last 30 years, the effect being 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 can vary significantly, as noted by the recent contrast of greater than 1°C between 2014 (14.8°C average) and 2015 (16.0°C average), largely the result of the recent strong El Niño.

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, and down sloping. Pressure-driven channeling and vertically coupled flow affect winds on scales comparable to those 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 on the Oak Ridge Reservation (ORR) (Birdwell 2011). Along-valley and mountain-valley circulations are thermally driven and occur within a large range of spatial scales. Thermally driven flows are more prevalent under conditions of clear skies and low humidity, favoring summer and fall months.

Forced channeling is defined as the direct deflection of wind by terrain. This form of channeling necessitates some degree of vertical motion transfer, implying that the mechanism is less pronounced during strong temperature-inversion conditions. Although forced channeling may result from interactions between large valleys and mountain ranges (such as the Great Valley and the surrounding mountains), the mechanism is especially important in narrow, small valleys such as those on the ORR (Kossman and Sturman 2002).

Forced channeling within the Central Great Valley represents the dominant large-scale wind mechanism, influencing 50% to 60% of all winds observed in the area. For up-valley flow cases, these winds are frequently associated with large wind shifts when they initiate or terminate (45°–90°). At small scales, ridge-and-valley terrain usually produces forced-channeled local flow (> 90% of cases). Most forced-channeled winds prefer weak to moderate synoptic pressure gradients of less than 0.010 mb/km (Birdwell 2011).

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. The phenomenon sometimes results in a split-flow pattern (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). The convex shape of the Great Valley with respect to a northwest wind flow may lead to a divergent wind flow pattern in the Knoxville area. This results in downward air motion. Additionally, horizontal flow is reduced by the windward mountain range (Cumberland Mountains), which increases buoyancy and Coriolis effects (also known as Froude and Rossby ratios). Consequently, the leeward mountain range (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 cold air advection, winds tend to override the terrain, flowing roughly in the same direction as the winds aloft. This phenomenon is a consequence of the horizontal transport and momentum aloft being transferred to the surface. However, Coriolis effects may turn the winds by up to 40° to the left (Birdwell 1996).

In the Central Valley, vertically coupled winds dominate about 25% to 35% of the time; however, most such winds are turned toward an up-valley or down-valley direction when small-scale ridge-and-valley terrain is present. Wintertime vertically coupled flow is typically dominated by strong large-scale pressure forces, whereas the summertime cases tend to be more associated with deep mixing depths (> 500 m). Most vertically coupled flows are associated with major wind shifts (90°–135°) when such flow patterns begin or terminate (Birdwell 2011).

Pressure-driven channeling, in essence, is the redirection of synoptically induced wind flow through a valley channel. The direction of wind flow through the valley is determined by the pressure gradient superimposed on a 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 such a process shift from up-valley to down-valley flow or conversely as large-scale pressure systems induce flow shifts across the axis of the Great Valley. Since 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 each other (Monti et al. 2002).

Within the Central Great Valley, especially ORR, winds dominated by down-valley pressure-driven channeling range in frequency from 2% to 10%, 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% 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 the ORR when compared to other parts of the Great Valley (Birdwell 2011). Most pressure-driven channeled winds occurred in association with moderate synoptic pressure gradients (0.006–0.016 mb/km).

Thermally driven winds are common in areas of significant complex terrain. These winds occur as a result of pressure and temperature differences caused by varied surface-air energy exchange at similar altitudes along a valley's axis, sidewalls, and/or slopes. Thermal flows operate most effectively 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 wind frequency varies from 2% to 20% with respect to season in the Central Great Valley. Frequencies are highest during summer and fall when intense surface heating and/or low humidity help drive flow patterns (Birdwell 2011).

Annual wind roses have been compiled for 2015 for each of the nine DOE-managed ORR meteorological towers (towers MT1, MT2, MT3, MT4, MT6, MT7, MT9, MT10, and MT11). These, along with other annual wind rose data may be viewed online at http://web.ornl.gov/adm/fo/lp/orrm/page7.htm. The wind roses represent large-scale trends and should be used with caution for estimates involving short-term variations.

A wind rose depicts the typical distribution of wind speed and direction for a given location. The winds are represented in terms of the direction from which they originate. The rays emanating from the center correspond to points of the compass. The length of each ray is related to the frequency at which winds blow from the given direction. The concentric circles represent increasing frequencies from the center outward, given in percentages. Precipitation wind roses display similar information except that wind speed frequencies are replaced with data associated with the rate of hourly precipitation. Likewise, wind direction stability and wind direction mixing height roses replace wind speeds with data on stability class and mixing height, respectively. Wind direction peak gust roses reflect the frequency of peak 1-sd wind gusts for various wind directions. All of these roses can be found at http://web.ornl.gov/adm/fo/lp/orrm/page7.htm.

B.3 Temperature and Precipitation

Temperature and precipitation normal (1981–2010) and extremes (1948–2015) and their durations for the city of Oak Ridge are summarized in Table B.1. Decadal temperature and precipitation averages for the four decades of the 1970s to 2000s, as well as the partial decade of the 2010s, are provided in Table B.2. Hourly freeze data (1985–March 2016) are given in Table B.3. Overall, 2015 was 1.1°C above normal with regard to temperatures compared to the 1981-2010 base period and precipitation was over 10% above normal compared to the 1981-2010 mean.

B.3.1 Recent Climate Change with Respect to Temperature and Precipitation

Table B.2 presents a decadal analysis of temperature patterns for the decades of the 1970s to the 2010s (to 2015). In general, temperatures in Oak Ridge rose until the 1990s but have risen much more slowly since the 1990s. Based on these average decadal temperatures, temperatures have risen 1.4°C between the decades of the 1970s and the 2000s from 13.8°F to 15.2°C (56.8°F to 59.3°F). More detailed analysis reveals that these temperature increases have been neither linear nor equal throughout the months or seasons.

For the 1970s to the 2000s, January and February average temperatures have seen increases of 2.1°C and 1.9°C, respectively. This significant increase is probably dominated by the effects of the AMO, though this climate response may include both natural and anthropogenic effects. The Arctic has seen the largest increase in temperatures of anywhere in the Northern Hemisphere over the last 30 years, though this also could be associated with a variety of effects.

During the 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 from the 1970s and 1980s to the 2000s. However, this trend has noticeably stalled or reversed during the 2010s thus far. Spring temperatures (March–April) have risen by about 1.4°C. Summer and fall temperatures have exhibited lesser temperature rises of 1.1°C and 0.9°C (2.5°F), respectively. September and December temperatures changed little (0.0°C and +0.1°C, respectively). Fall temperatures have also leveled off or fallen slightly in 2010s vs. the 2000s. Most of the warming that has occurred overall has been driven by significant increases in minimum daily temperatures, a change likely resulting from the redistribution of heat in the boundary layer resulting from the increased presence of greenhouse gases and aerosols near the surface. More greenhouse gases and aerosols act to weaken the strength of nighttime surface temperature inversions. Overall, annual minimum temperatures seem to have increased more dramatically (2.1°C to the 2010s) than maximum temperatures (0.7°C to the 2010s). For the most recent full decade (2000s), August average temperatures were slightly warmer than those of July

Table B.1. Climate normal (1981–2010) and extremes (1948–2015) for City of Oak Ridge, Tennessee (townsite), with 2015 comparisons

Monthly variables	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Temperature, °C (°F)													
30-Year Average Max	8.3 (46.9)	11.2 (52.1)	16.4 (61.6)	21.6 (70.8)	25.9 (78.6)	29.8 (85.7)	31.4 (88.5)	31.2 (88.1)	27.7 (81.9)	22.0 (71.6)	15.7 (60.2)	9.4 (49.0)	20.9 (69.6)
2015 Average Max	8.2 (46.7)	5.9 (42.7)	17.3 (63.1)	22.7 (72.9)	28.5 (83.3)	32.0 (89.6)	31.5 (88.7)	30.3 (86.5)	28.4 (83.2)	22.1 (71.7)	16.8 (62.3)	16.3 (61.4)	21.7 (71.0)
66-Year Record Max	25 (77)	26 (79)	30 (86)	33 (92)	35 (95)	41 (105)	41 (105)	39 (103)	39 (102)	32 (90)	28 (83)	26 (78)	41 (105)
30-Year Average Min	-2.2 (28.0)	-0.6 (30.9)	3.1 (37.5)	7.4 (45.4)	12.6 (54.7)	17.3 (63.1)	19.7 (67.5)	18.9 (66.1)	15.2 (59.3)	8.4 (47.2)	3.1 (37.6)	-0.9 (30.4)	8.5 (47.3)
2015 Average Min	-2.1 (28.2)	-4.7 (23.5)	5.1 (41.1)	9.9 (49.9)	15.1 (59.2)	19.7 (67.5)	21.2 (70.2)	19.1 (66.3)	16.8 (62.3)	10.5 (50.9)	7.0 (44.6)	6.8 (44.2)	10.4 (50.7)
66-Year Record Min	-27 (-17)	-25 (-13)	-17 (1)	-7 (20)	-1 (30)	4 (39)	9 (49)	10 (50)	1 (33)	-6 (21)	-16 (3)	-22 (-7)	-27 (-17)
30-Year Average	3.1 (37.5)	5.3 (41.5)	9.8 (49.6)	14.6 (58.3)	19.3 (66.7)	23.6 (74.5)	25.6 (78.1)	25.2 (77.4)	21.5 (70.7)	15.2 (59.4)	9.4 (48.9)	4.3 (39.7)	14.7 (58.5)
2015 Average	3.1 (37.5)	0.6 (33.1)	11.2 (52.1)	16.3 (61.4)	21.8 (72.1)	25.9 (78.6)	26.2 (79.2)	24.7 (76.4)	22.7 (72.8)	16.3 (61.3)	11.9 (53.5)	11.6 (52.8)	16.0 (60.8)
2015 Departure from Average	0.0 (0.0)	-4.7 (-8.4)	1.4 (2.5)	1.7 (3.1)	2.5 (4.5)	2.3 (4.1)	0.6 (1.1)	-0.6 (-1.0)	1.2 (2.1)	1.1 (1.9)	2.6 (4.6)	7.3 (13.1)	1.3 (2.3)
30-year average heating degree days, °C (°F)[a]													
	471 (847)	365 (657)	264 (476)	126(226)	35(63)	2 (3)	0	0	13 (24)	111 (199)	266 (479)	432 (778)	2084 (3752)
30-year average cooling degree days, °C (°F)[a]													
	0	0	2 (4)	16 (29)	68 (122)	164 (296)	228 (410)	217 (390)	108 (194)	18 (32)	1 (2)	0	822 (1479)
Precipitation, mm (in.)													
30-Year Average	120.9 (4.76)	124.2 (4.89)	120.9 (4.76)	112.6 (4.43)	116.6 (4.59)	98.3 (3.87)	134.4 (5.29)	82.1 (3.23)	98.1 (3.86)	76.0 (2.99)	122.2 (4.81)	131.1 (5.16)	1337.5 (52.64)
2015 Totals	92.2 (3.63)	105.4 (4.15)	119.9 (4.72)	172.0 (6.77)	26.2 (1.03)	90.7 (3.57)	200.0 (7.87)	151.7 (5.97)	56.7 (2.23)	81.1 (3.19)	135.2 (5.32)	217.7 (8.57)	1448.8 (57.02)
2015 Departure from Average	-28.7 (-1.13)	-18.8 (-0.74)	-1.0 (-0.04)	59.5 (2.34)	-90.5 (-3.56)	-7.6 (-0.30)	65.6 (2.58)	69.6 (2.74)	-41.4 (-1.63)	5.1 (0.20)	13.0 (0.51)	86.6 (3.41)	111.3 (4.38)
68-Year Max Monthly	337.2 (13.27)	324.7 (12.78)	311.0 (12.24)	356.5 (14.03)	271.9 (10.70)	283.0 (11.14)	489.6 (19.27)	265.8 (10.46)	257.4 (10.14)	176.6 (6.95)	310.5 (12.22)	321.2 (12.64)	1939.4 (76.33)
68-Year Max 24-hr	108.0 (4.25)	131.6 (5.18)	120.4 (4.74)	158.5 (6.24)	112.0 (4.41)	94.0 (3.70)	124.8 (4.91)	190.1 (7.48)	160.1 (6.30)	67.6 (2.66)	130.1 (5.12)	130.1 (5.12)	190.1 (7.48)
68-Year Min Monthly	23.6 (0.93)	21.3 (0.84)	54.1 (2.13)	46.2 (1.82)	20.3 (0.80)	13.5 (0.53)	31.3 (1.23)	13.7 (0.54)	Trace	Trace	34.8 (1.37)	17.0 (0.67)	911.4 (35.87)
Snowfall, cm (in.)													
30-Year Average	7.4 (2.9)	6.6 (2.6)	2.5 (1.0)	7.6 (0.3)	0	0	0	0	0	0	Trace	4.1 (1.6)	21.3 (8.4)
2015 Totals	0.8 (0.3)	25.4 (10.0)	0.7 (0.3)	0	0	0	0	0	0	0	Trace	0	26.9 (10.6)
68-Year Max Monthly	24.4 (9.6)	43.7 (17.2)	53.4 (21.0)	15.0 (5.9)	Trace	0	0	0	0	Trace	16.5 (6.5)	53.4 (21.0)	105.2 (41.4)
68-Year Max 24-hr	21.1 (8.3)	28.7 (11.3)	30.5 (12.0)	13.7 (5.4)	Trace	0	0	0	0	Trace	16.5 (6.5)	30.5 (12.0)	30.5 (12.0)
Days w/temp													
30-Year Max ≥ 32°C	0	0	0	0.2	0.8	8.0	14.5	13.1	3.9	0	0	0	40.5
2015 Max ≥ 32°C	0	0	0	0	1	17	19	8	6	0	0	0	51
30-Year Min ≤ 0°C	21.6	16.6	10.7	2.7	0	0	0	0	0	1.7	10.4	18.8	82.5
2015 Min ≤ 0°C	23	24	6	0	0	0	0	0	0	0	3	7	63
30-Year Max ≤ °C	2.8	0.9	0.1	0	0	0	0	0	0	0	0	1.6	5.4
2015 Max ≤ 0°C	2	6	0	0	0	0	0	0	0	0	0	0	8
Days w/precipitation													
30-Year Avg ≥ 0.01 in.	11.5	11.0	11.7	10.4	11.7	11.1	12.4	9.6	8.4	8.4	9.6	12.0	127.8
2015 Days ≥ 0.01 in.	12	12	17	12	9	13	15	10	8	11	10	13	142
30-Year Avg ≥ 1.00 in.	1.3	1.4	1.2	1.2	1.3	1.0	1.4	0.8	1.3	1.0	1.5	1.6	15.0
2015 Days ≥ 1.00 in.	2	2	0	1	0	0	3	2	0	1	3	2	16

Table B.2. Decadal climate change (1970–2015) for City of Oak Ridge, Tennessee, with 2015 comparisons

Monthly variables	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Temperature, °C (°F)													
1970–1979 Avg Max	6.6 (43.8)	9.7 (49.5)	15.6 (60.1)	21.4 (70.6)	24.8 (76.7)	28.5 (83.3)	30.0 (85.9)	29.7 (85.5)	26.8 (80.2)	20.8 (69.4)	14.5 (58.2)	10.0 (49.9)	19.9 (67.8)
1980–1989 Avg Max	6.9 (44.4)	10.2 (50.3)	15.9 (60.7)	21.0 (69.8)	25.6 (78.1)	29.8 (85.7)	31.6 (88.8)	30.7 (87.3)	27.1 (80.8)	21.3 (70.3)	15.6 (60.2)	8.6 (47.5)	20.3 (68.6)
1990–1999 Avg Max	9.4 (48.8)	12.3 (54.1)	16.2 (61.2)	21.9 (71.3)	26.2 (79.1)	29.7 (85.5)	32.1 (89.8)	31.4 (88.6)	28.4 (83.2)	22.6 (72.8)	15.2 (59.4)	10.4 (50.8)	21.3 (70.4)
2000–2009 Avg Max	8.8 (47.9)	11.2 (52.1)	17.0 (62.7)	21.4 (70.6)	25.8 (78.4)	29.8 (85.6)	30.8 (87.5)	31.4 (88.5)	27.6 (81.8)	21.8 (71.2)	15.9 (60.6)	9.8 (49.6)	21.0 (69.7)
2010–2015 Avg Max	7.8 (46.1)	9.9 (49.9)	16.4 (61.6)	23.1 (73.6)	27.1 (80.8)	31.0 (87.8)	31.6 (88.8)	31.2 (88.1)	27.9 (82.2)	21.7 (71.0)	15.2 (59.3)	11.1 (52.0)	21.1 (69.9)
1980s vs. 2010s	0.9 (1.7)	-0.2 (-0.4)	0.5 (0.9)	2.1 (3.8)	1.5 (2.7)	1.2 (2.1)	0.0 (0.0)	0.4 (0.8)	0.8 (1.4)	0.4 (0.7)	-0.5 (-0.9)	2.5 (4.5)	0.7 (1.3)
2000s vs. 2010s	-1.0 (-1.8)	-1.2 (-2.2)	-0.6 (-1.1)	1.7 (3.0)	1.3 (2.4)	1.2 (2.2)	0.7 (1.3)	-0.2 (-0.4)	0.2 (0.4)	-0.1 (-0.2)	-0.7 (-1.3)	1.3 (2.4)	0.1 (0.2)
2015 Avg Max	8.2 (46.7)	5.9 (42.7)	17.3 (63.1)	22.7 (72.9)	28.5 (83.3)	32.0 (89.6)	29.2 (88.7)	30.3 (86.5)	28.4 (83.2)	22.1 (71.7)	16.8 (62.3)	16.3 (61.4)	20.3 (69.0)
1970–1979 Avg Min	-3.4 (25.8)	-2.4 (27.6)	3.0 (37.4)	6.7 (44.1)	11.6 (52.8)	15.7 (60.2)	18.3 (64.9)	18.1 (64.6)	15.5 (59.9)	7.5 (45.5)	2.6 (36.8)	-0.8 (30.5)	7.7 (45.8)
1980–1989 Avg Min	-4.1 (24.7)	-2.1 (28.3)	1.7 (35.0)	6.0 (42.9)	11.4 (52.4)	16.2 (61.2)	19.0 (66.2)	18.4 (65.1)	14.4 (57.9)	7.5 (45.4)	3.1 (37.5)	-2.3 (27.8)	7.4 (45.3)
1990–1999 Avg Min	-0.9 (30.3)	0.0 (32.0)	2.9 (37.1)	7.2 (45.0)	12.5 (54.5)	17.2 (63.0)	20.0 (67.9)	18.9 (66.1)	15.1 (59.2)	8.2 (46.8)	2.2 (36.0)	0.1 (32.2)	8.6 (47.6)
2000–2009 Avg Min	-1.4 (29.5)	0.0 (32.0)	4.4 (39.9)	8.6 (47.5)	13.6 (56.4)	18.0 (64.3)	20.0 (67.9)	20.0 (68.0)	16.1 (61.0)	9.5 (49.0)	3.9 (39.0)	-0.4 (31.4)	9.4 (48.9)
2010–2015 Avg Min	-2.2 (28.1)	-0.7 (30.8)	4.6 (40.2)	9.3 (48.7)	14.5 (58.1)	19.2 (66.6)	20.8 (69.5)	19.8 (67.6)	16.2 (61.2)	9.2 (48.6)	3.1 (37.6)	1.7 (35.1)	9.5 49.1)
1980s vs. 2010s	1.9 (3.4)	1.4 (2.5)	2.9 (5.2)	3.2 (5.8)	3.2 (5.7)	3.0 (5.4)	1.8 (3.3)	1.4 (2.5)	1.8 (3.3)	1.8 (3.2)	0.1 (0.1)	4.1 (7.3)	2.1 (3.8)
2000s vs. 2010s	-0.8 (-1.4)	-0.7 (-1.2)	0.2 (0.3)	0.7 (1.2)	0.9 (1.7)	1.3 (2.3)	0.9 (1.6)	-0.2 (-0.4)	0.1 (0.2)	-0.2 (-0.4)	-0.8 (-1.4)	2.1 (3.7)	0.1 (0.2)
2015 Avg Min	1.1 (28.2)	-4.7 (23.5)	5.1 (41.1)	9.9 (49.9)	15.1 (59.2)	19.7 (67.5)	21.2 (70.2)	19.1 (66.3)	16.8 (62.3)	10.5 (50.9)	7.0 (44.6)	6.8 (44.2)	9.4 (48.1)
1970–1979 Avg	1.6 (34.9)	3.7 (38.6)	9.3 (48.8)	14.1 (57.4)	18.1 (64.7)	22.1 (71.8)	24.1 (75.4)	23.9 (75.0)	21.1 (70.0)	14.2 (57.5)	8.6 (47.5)	4.6 (40.3)	13.8 (56.8)
1980–1989 Avg	1.4 (34.6)	4.1 (39.3)	8.8 (47.9)	13.5 (56.4)	18.5 (65.3)	23.0 (73.4)	25.3 (77.5)	24.6 (76.2)	20.8 (69.4)	14.4 (57.9)	9.4 (48.8)	3.1 (37.7)	13.9 (57.0)
1990–1999 Avg	4.2 (39.6)	6.2 (43.1)	9.6 (49.2)	14.5 (58.2)	19.4 (66.8)	23.5 (74.3)	26.0 (78.9)	25.2 (77.4)	21.9 (71.4)	15.5 (59.8)	8.8 (47.8)	5.3 (41.5)	15.0 (59.0)
2000–2009 Avg	3.7 (38.7)	5.6 (42.1)	10.7 (51.3)	15.3 (59.6)	19.7 (67.5)	23.9 (75.1)	25.4 (77.7)	25.7 (78.3)	21.9 (71.4)	15.6 (60.1)	9.9 (49.8)	4.7 (40.5)	15.2 (59.3)
2010–2015 Avg	2.8 (37.1)	4.7 (40.4)	10.7 (51.2)	16.2 (61.2)	20.8 (69.5)	25.1 (77.2)	26.2 (79.2)	25.5 (77.9)	22.1 (71.7)	15.4 (59.8)	9.1 (48.4)	6.4 (43.6)	15.4 (59.8)
1980s vs. 2010s	1.4 (2.5)	0.6 (1.1)	1.8 (3.3)	2.7 (4.8)	2.3 (4.2)	2.1 (3.8)	0.9 (1.7)	0.9 (1.7)	1.3 (2.3)	1.1 (1.9)	-0.2 (-0.4)	3.3 (5.9)	1.5 (2.7)
2000s vs. 2010s	-0.9 (-1.6)	-0.9 (-1.7)	-0.1 (-0.1)	0.9 (1.6)	1.1 (2.0)	1.2 (2.1)	0.8 (1.5)	-0.2 (-0.4)	0.2 (0.3)	-0.2 (-0.3)	-0.8 (-1.4)	1.7 (3.1)	0.2 (0.4)
2015 Avg	3.1 (37.5)	0.6 (33.1)	11.2 (52.1)	16.3 (61.4)	21.8 (71.2)	25.9 (78.6)	26.4 (79.5)	24.7 (76.4)	22.7 (72.8)	16.3 (61.3)	12.0 (53.6)	11.6 (52.8)	14.7 (58.5)
Precipitation, mm (in.)													
1970–1979 Avg	143.4 (5.65)	94.6 (3.72)	169.4 (6.67)	118.3 (4.66)	149.8 (5.89)	120.5 (4.74)	130.4 (5.13)	109.8 (4.32)	107.2 (4.22)	99.8 (3.93)	129.6 (5.10)	145.3 (5.72)	1516.4 (59.68)
1980–1989 Avg	100.4 (3.95)	109.1 (4.29)	112.6 (4.43)	88.8 (3.49)	110.6 (4.35)	84.1 (3.31)	120.4 (4.74)	82.6 (3.25)	108.9 (4.29)	79.8 (3.14)	128.0 (5.04)	107.6 (4.23)	1236.2 (48.66)
1990–1999 Avg	141.4 (5.57)	136.5 (5.37)	149.0 (5.86)	126.3 (4.97)	113.4 (4.47)	110.0 (4.33)	134.8 (5.31)	83.6 (3.29)	71.9 (2.83)	67.3 (2.65)	109.8 (4.32)	161.0 (6.34)	1429.4 (56.26)
2000–2009 Avg	116.9 (4.60)	121.8 (4.80)	115.6 (4.55)	125.0 (4.92)	117.8 (4.64)	95.2 (3.75)	138.9 (5.47)	78.4 (3.09)	108.8 (4.28)	74.0 (2.91)	121.4 (4.78)	124.4 (4.90)	1333.4 (52.48)
2010–2015 Avg	149.9 (5.90)	104.2 (4.10)	127.0 (5.00)	138.7 (5.46)	84.4 (3.32)	122.2 (4.81)	171.5 (6.75)	86.1 (3.39)	129.3 (5.09)	85.9 (3.38)	133.6 (5.26)	152.7 (6.01)	1477.0 (58.13)
1980s vs. 2010s	49.5 (1.95)	-4.8 (-0.19)	14.5 (0.57)	50.1 (1.97)	-26.2 (-1.03)	38.1 (1.50)	51.1 (2.01)	3.6 (0.14)	20.3 (0.80)	6.1 (0.24)	5.6 (0.22)	45.2 (1.78)	238.1 (9.37)
2000s vs. 2010s	33.0 (1.30)	-17.8 (-0.70)	11.4 (0.45)	13.7 (0.54)	-33.5 (-1.32)	26.9 (1.06)	32.5 (1.28)	7.6 (0.30)	20.6 (0.81)	11.9 (0.47)	12.2 (0.48)	28.2 (1.11)	145.6 (5.73)
2015 Totals	92.2 (3.63)	105.4 (4.15)	119.9 (4.72)	172.0 (6.77)	26.2 (1.03)	90.7 (3.57)	200.0 (7.87)	151.7 (5.97)	56.7 (2.23)	81.1 (3.19)	135.2 (5.32)	217.7 (8.57)	1448.8 (57.02)
Snowfall, cm (in.)													
1970–1979 Avg	11.1 (4.4)	12.5 (4.9)	4.2 (1.7)	0.2 (0.1)	0	0	0	0	0	0	0.5 (0.2)	4.4 (1.8)	35.1 (13.8)
1980–1989 Avg	11.4 (4.5)	8.8 (3.5)	2.2 (0.9)	2.2 (0.9)	0	0	0	0	0	0	0	7.5 (3.0)	32.8 (12.9)
1990–1999 Avg	6.9 (2.7)	7.8 (3.1)	8.1 (3.2)	Trace	0	0	0	0	0	0	0.3 (0.1)	3.1 (1.2)	10.9 (4.3)
2000–2009 Avg	2.1 (0.8)	4.5 (1.8)	Trace	Trace	0	0	0	0	0	0	Trace	1.7 (0.7)	8.3 (3.3)
2010–2015 Avg	5.3 (2.1)	9.9 (3.9)	0.8 (0.3)	0.0 (0.0)	0	0	0	0	0	0	0.3 (0.1)	2.3 (0.9)	14.7 (5.8)
1980s vs. 2010s	-1.3 (-2.4)	0.2 (0.4)	-0.3 (-0.6)	-0.5 (-0.9)	0	0	0	0	0	0	0.1 (0.1)	-1.2 (-2.1)	-2.4 (-4.3)
2000s vs. 2010s	0.7 (1.3)	1.2 (2.1)	0.2 (0.3)	0.0 (0.0)	0	0	0	0	0	0	0.1 (0.2)	0.1 (0.2)	1.8 (3.2)
2015 Totals	7.6 (0.3)	25.4 (10.0)	0.8 (0.3)	0	0	0	0	0	0	0	0	0	26.9 (10.6)

Table B.3. Hourly subfreezing temperature data for Oak Ridge, Tennessee, January 1985–March 2016[a]

(Hours at or below 0, −5, −10, and −15°C[a])

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	1399	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	1190	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	1029	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	1123	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
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[b]	295	58	6	0	183	12	0	0	25	0	0																	
Avg.	248	78	17	3	153	34	6	1	63	7	1	10	0	0	0	7	0	68	4	0	200	43	6	1	740	165	29	5

[a]Source: 1985–2016 National Oceanic and Atmospheric Administration, Atmospheric Turbulence and Diffusion Division, KOQT Station, Automated Surface Observing System.
[b]2016 values through March 31, 2015.

Decadal precipitation averages suggest some important changes in precipitation patterns in Oak Ridge over the period of the 1980s to 2010s. Although overall precipitation has remained within a window of about 48 to 60 in. annually, there have been some recent decadal shifts in the patterns of rainfall on a monthly or seasonal scale. In particular, precipitation has tended to increase during winter with the exception of February, when it has decreased. During the remaining months of the year, precipitation has generally increased with the exception of May, when it has significantly decreased. Overall, annual precipitation during the 2010s is above the 30 year average [around 148 cm (58 in.)]. The year 2007 was the driest year on record in Oak Ridge (91.1 cm or 35.87 in.), which represented the core of a 4 year period of below-average precipitation (2005–2008). The most recent calendar year of 2015 yielded precipitation totals over 10% above the 30 year mean, with a total of 57.02 in. (1,448.8 mm). The statistics presented here encompass the period from 1948 to 2015.

The previously discussed increase in winter temperatures by the 2000s has affected monthly and annual snowfall amounts until recently. 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 full decade (2000s), snowfall has averaged only 6.6 cm (2.6 in). This decrease seems to have occurred largely since the mid-1990s. The slight cooling of winter temperatures in the 2010s thus far has reversed the decrease in snowfall somewhat, with annual averages of 5.8 in. (14.7 cm). Concurrently with the overall decrease in snowfall, the annual number of hours of subfreezing weather has generally declined since the 1980s (Table B.3). However, the number of subfreezing hours during 2010 (1123) 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 h.

Select wind roses for the ORR towers that show wind direction for hours with precipitation and other relevant meteorological parameters have been compiled for 2014 and may be reviewed at http://web.ornl.gov/adm/fo/lp/orrm/page7.htm.

Hourly values of subfreezing temperatures in Oak Ridge are presented in Table B.3 for January 1985 through March 2016. During the middle-to-late 1980s, a typical year experienced about 900–1,000 h of subfreezing temperatures. In recent years, the value has fallen to about 600–700 h, though higher values have occurred recently (2010 at 1,123 h). Other statistics on winter precipitation may be found at http://web.ornl.gov/adm/fo/lp/orrm/page5.htm.

B.4 Moisture

ORR's humid environment results in frequent saturation of the surface layer, especially at night. Average annual humidity at Oak Ridge National Laboratory (ORNL) is 73.5% (1998–2013). In terms of absolute humidity (grams per cubic meter), the average annual humidity for ORR is 10.24 g/m^3. This value varies greatly throughout the annual cycle, ranging from a monthly minimum of about 4.9 g/m^3 during winter to a maximum of about 17.2 g/m^3. These data are summarized for absolute and relative humidity and dew point at http://web.ornl.gov/adm/fo/lp/orrm/page5.htm.

B.5 Severe Weather

On average, thunderstorms and associated lightning occur in the Oak Ridge area at a rate of 49 days/year, with a monthly maximum between 10 and 11 occurring in July. About 42 of these thunderstorm days occur during a 7 month period from April through October, with the remainder spread evenly throughout the late fall and winter. Monthly and annual average numbers of thunderstorm days for ORNL and Knoxville McGhee-Tyson Airport, respectively, during 2001–2015 can be viewed at http://web.ornl.gov/adm/fo/lp/orrm/page5.htm. The highest number of thunderstorm days at ORNL was observed during 2012 (65); the lowest was observed during 2007 (34).

Hailstorms are infrequent on ORR but typically occur in association with severe thunderstorms. The phenomenon usually occurs as a result of high-altitude thunderstorm updrafts, which propel water droplets above the freezing level. Some hail events have been known to occur in association with non-thunder rain showers in association with low freezing levels (particularly during winter or spring). Most hailstorm occurrences (77%) do not result in hailstones larger than 2 cm. During the period from 1961through 1990, about six hail events (having hailstones larger than about 2 cm) were documented to have occurred at locations within 40 km (25 miles) of ORNL. Virtually 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.

Although greater tornado frequencies occur in Middle and West Tennessee, East Tennessee experiences infrequent tornado outbreaks (once every 3 to 6 years on average). Tornado indices from the National Weather Service in Morristown show that since 1950, three tornadoes have been documented within 10 km (6 miles) of ORNL, represented by two F0 (Fujita Scale) tornadoes and one F3 tornado. A moderately strong 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 has been the only documented tornado to occur within the ORR.

Nine additional tornadoes have been documented since 1950 at distances within 20 km (12 miles) of ORNL, ranging in intensity from F0/EF0 (Enhanced Fujita Scale) to F2/EF2 in intensity. The most recent of these were three EF0–EF1 tornadoes that occurred during the April 27, 2011, tornado outbreak and an EF0 tornado near Kingston, Tennessee, on June 10, 2014. The storm system that produced the latter tornado brought a squall line through ORNL that produced high winds and some minor damage. The remaining group of tornadoes that were within 20 km 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 e occurred in the Rocky Top and Norris areas. Tornado statistics relevant to ORR are provided for Anderson, Knox, Loudon, and Roane Counties at: http://web.ornl.gov/adm /fo/lp/orrm/page5.htm.

The annual probability that a tornado will strike any location in a grid square may 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 such a calculation is seen to be greatly affected by the assumption of the size of the path area of a tornado. In total, about 22 tornadoes have been documented within 35 km (22 miles) of ORNL since 1950. This represents a surface area of 3,848 km^2 (1,485 $miles^2$) and yields a probability of about 0.006 tornadoes per square kilometer per 50-year period.

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 air flow. Although ridge-and-valley terrain creates identifiable patterns of association during 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. Deep stable layers of air tend to reduce the vertical space available for oscillating vertical air motions caused by local mountain ranges (Smith et al. 2002). This effect on mountain wave formation may be important with regard to the impact that the nearby Cumberland Mountains may have on local air flow.

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 due to direct insolation on the cloud tops. Warming may also occur within the clouds as latent energy, which is released due to the condensation of moisture. Surface air underlying the clouds may remain relatively cool as 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 cooling of fog decks has also been observed to help modify stability in the surface layer (Whiteman et al. 2001).

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 is in turn influenced by the synoptic-scale "weather"-related pressure gradient. Ridge-and-valley terrain may have significant ability to block such winds and their associated mechanical energy (Carlson and Stull 1986). Consequently, radiational cooling at the surface is enhanced since there is less wind energy available to remove chilled air.

Stable boundary layers also exhibit intermittent turbulence, which has been associated with a number of the above factors. The process results from "give-and-take" between the effects of friction and radiational cooling. As a stable surface layer intensifies via a radiation 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 results in an increase in 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 winds 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 (7ºF) may result from these processes. Since these intermittent processes are driven primarily by large-scale horizontal wind flow and radiational cooling of the surface, ridge-and-valley terrain significantly affect these oscillations.

Wind roses for stability and mixing depth have been compiled for all of the ORR tower sites for 2015. These may be viewed at: http://web.ornl.gov/adm/fo/lp/orrm/page7.htm. The wind roses in general reveal that both unstable conditions and/or deep mixing depths are associated with less channeling of winds and that stable conditions and/or shallow mixing depths tend to promote channeled flow. Associated mixing height tables can be accessed at http://web.ornl.gov/adm/fo/lp/orrm/page5.htm.

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Appendix C. Reference Standards and Data for Water

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		170
^{214}Bi		260,000
^{109}Cd		16,000
^{143}Ce		26,000
^{60}Co		7,200
^{51}Cr		790,000
^{137}Cs		3,000
^{155}Eu		87,000
Gross alpha[d]	15	
Gross beta (mrem/year)	4	
^{3}H		1,900,000
^{131}I		1,300
^{40}K		4,800
^{237}Np		320
^{234m}Pa		71,000
^{238}Pu		150
$^{239/240}Pu$		140
^{226}Ra		87
^{228}Ra		25
^{106}Ru		4,100
^{90}Sr		1,100
^{99}Tc		44,000
^{228}Th		340
^{230}Th		160
^{232}Th		140
^{234}Th		8,400
^{234}U		680
^{235}U		720
^{236}U		720
^{238}U		750

[a]Only the radionuclides included in the Oak Ridge Reservation monitoring programs are listed. Unless labeled otherwise, units are pCi/L.
[b]40 CFR 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-1196-2011, April 2011*."
[d]Excludes radon and uranium.
[e]These values are not maximum contaminant levels but are concentrations that result in the effective dose equivalent of the maximum contaminant level for gross beta emissions, which is 4 mrem/year.
[f]Applies to combined ^{226}Ra and ^{228}Ra.
[g]Minimum of uranium isotopes.

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				6,9
Acrylonitrile (c)				0.51, 2.5
Alachlor	2 (E1, T)			
Aldrin (c)		3.0	–	0.00049, 0.00050
Aldicarb	3 (E1)			
Aldicarb sulfoxide	4 (E1)			
Aldicarb sulfone	2 (E1)			
Aluminum	200 (E2)			
Anthracene				8300, 40,000
Antimony	6 (E1, T)			5.6, 640
Arsenic (c)	10 (E1, T)			10.0, 10.0
Arsenic(III)[c]		340[c]	150[c]	
Asbestos	7 million fibers/L (MFL) (E1)			
Atrazine	3 (E1, T)			
Barium	2000 (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 (c)	0.2 (E1, T)			0.038, 0.18
Benzo(b)fluoranthene (c)				0.038, 0.18
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)	0.2 (E1, T)	0.95	–	0.98, 1.8
Bis(2-chloroethyl)ether (c)				0.30, 5.3
Bis(2-chloro-isopropyl)ether				1400, 65,000
Bis(2-ethylhexyl)phthalate (c)				12, 22
Bis (Chloromethyl)ether (c)				12,22
Bromate	10 (E1)			
Bromoform (c)				43, 1400
Butylbenzyl phthalate				1500, 1900
Cadmium	5 (E1, T)	2.0[d]	0.25[d]	
Carbofuran	40 (E1, T)			
Carbon tetrachloride (c)	5 (E1, T)			2.3, 16
Chlordane (c)	2 (E1, T)	2.4	0.0043	0.0080, 0.0081
Chloride	250,000 (E2)			
Chlorine (TRC)	4000 (E1)	19	11	
Chlorite	1000 (E1)			
Chlorobenzene				130, 1600
Chlorodibromomethane (c)				4.0, 130
Chloroform (c)				57, 4700
Chloromines (as Cl2)	4000 (E1)			
Chlorine dioxide (as Cl2)	800 (E1)			

Table C.2 (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	
2-Chloronaphthalene				1000, 1600
2-Chlorophenol				81, 150
Chromium (total)	100 (E1, T)			
Chromium(III)		570[d]	74[d]	
Chromium(VI) [c]		16[c]	11[c]	
Chrysene (c)				0.038, 0.18
Coliforms	no more than 5% of samples per month can be positive for total coliforms (E1)	2880/100 mL, *E. coli* (single sample)	630/100 mL, *E. coli* (geometric mean)	126/100 mL, geometric mean, *E. coli* 487, maximum lakes/reservoirs, *E. coli* 941, maximum, other water bodies, *E. coli*
Color	15 color units (E2)			
Copper	1000 (E2) 1300 (E1 "Action Level")	13[d]	9.0[d]	
Cyanide (as free cyanide)	200 (E1, T)	22	5.2	140, 140
2,4-D (Dichlorophennoxyacetic acid)	70 (E1, T)			
4,4'-DDT (c)		1.1	0.001	0.0022, 0.0022
4,4'-DDE (c)				0.0022, 0.0022
4,4'-DDD (c)				0.0031, 0.0031
Dalapon	200 (E1, T)			
Demeton			0.1	
Diazinon		0.1	0.1	
Dibenz(a,h)anthracene (c)				0.038, 0.18
1,2-dibromo-3-chloropropane (DBCP)	0.2 (E1, T)			
1,2-Dichlorobenzene (*ortho-*)	600 (E1, T)			420, 1300
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, 7100
Cis-1,2-Dichloroethylene	70 (E1, T)			
trans 1,2-Dichloroethylene	100 (E1, T)			140, 10,000
Dichloromethane	5 (E1, T)			
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
Diethyl phthalate				17,000, 44,000
Di (2-ethylhexyl) adipate	400 (E1, T)			
Di (2-ethylhexyl) phthalate	6 (E1, T)			
Dinoseb	7 (E1, T)			
Dimethyl phthalate				270,000, 1,100,000

Table C.2 (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	
Dimethylphenols				380, 850
Di-n-butyl phthalate				2000, 4500
2,4-Dinitrophenol				69, 5300
2,4-Dinitrotoluene (c)				1.1, 34
Dioxin (2,3,7,8-TCDD) (c)	3 E-5 (E1, T)			0.000001, 0.000001
Diquat	20 (E1, T)			
1,2-Diphenylhydrazine (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, 2100
Ethylene dibromide	0.05 (E1, T)			
Fluoranthene				130, 140
Fluorene				1100, 5300
Fluoride	2000 (E2) 4000 (E1,T)			
Foaming agents	500 (E2)			
Glyphosate	700 (E1, T)			
Guthion			0.01	
Haloacetic acids (five)	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
Hexachlorocyclopentadiene	50 (E1, T)			40, 1100
Hexachloroethane (c)				14, 33
Ideno(1,2,3-cd)pyrene (c)				0.038, 0.18
Iron	300 (E2)			
Isophorone (c)				350, 9600
Lead	15 (E1 “Action Level”)	65[d]	2.5[d]	
Lindane	0.2 (T)			
Malathion			0.1	
Manganese	50 (E2)			
Mercury (inorganic)[c]	2 (E1)	1.4[c]	0.77[c]	0.05, 0.051
Methoxychlor	40 (E1, T)		0.03	
Methyl bromide				47, 1500
2-Methyl-4,6-dinitrophenol				13, 280
Methylene chloride (Dichloromethane) (c)				46, 5900
Mirex (b)			0.001	
Monocholorobenzene	100 (E1, T)			
Nickel	100 (T)	470[d]	52[d]	610, 4600

Table C.2 (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	
Nitrate as N	10,000 (E1,T)			
Nitrite as N	1000 (E1, T)			
Nitrobenzene				17, 690
Nitrosamines				0.0008, 1.24
Nitrolsodibutylamine (c)				0.063, 2.2
Nitrosodiethylamine (c)				0.008, 12.4
Nitrosopyrrolidine (c)				0.16, 340
N-Nitrosodimethylamine (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 number (E2)			
Oxamyl (Vydate)	200 (E1, T)			
Parathion		0.065	0.013	
Pentachlorobenzene (b)				1.4, 1.5
Pentachlorophenol (c)	1 (E1, T)	19[e]	15[e]	2.7, 30
pH	6.5 to 8.5 units (E2) 6.0 to 9.0 units (T)		6.0 to 9.0 units, wade-able streams 6.5 to 9.0 units, larger rivers, lakes, etc	6.0 to 9.0 units
Phenol				10,000, 860,000
Picloram	500 (E1,T)			
PCBs, total (c)	0.5 (E1, T)	–	0.014	0.00064, 0.00064
Pyrene				830, 4000
Selenium	50 (E1, T)	20	5	170,4200
Silver	100 (E2)	3.2[d]	–	
Simazine	4 (E1, T)			
Styrene	100 (E1, T)			
Sulfate	250,000 (E2)			
1,1,2,2-Tetrachloroethane (c)				1.7, 40
1,2,4,5-Tetrachlorobenzene (b)				0.97, 1.1
Tetrachloroethylene (c)	5 (E1, T)			6.9, 33
Thallium	2 (E1, T)			0.24, 0.47
Toluene	1000 (E1, T)			1300, 15,000
Total dissolved solids	500,000 (E2)			
Total Nitrate and Nitrite	10,000 as N (E1,T)			
Total trihalomethanes	80 (E1)			
Toxaphene (b)(c)	3 (E1, T)	0.73	0.0002	0.0028, 0.0028
2,4,5-TP (Silvex)	50 (E1, T)			1800,3600
Tributyltin (TBT)		0.46	0.072	
1,2,4-Trichlorobenzene	70 (E1, T)			35, 70
1,1,1-Trichloroethane	200 (E1, T)			

Table C.2 (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 (c)	5 (E1, T)			25, 300
2,4,6-Trichlorophenol (c)				14, 24
Vinyl chloride (c)	2 (E1, T)			0.25, 24
Xylenes (total)	10,000 (E1, T)			
Zinc	5000 (E2)	120[d]	120[d]	7400,26,000

[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 the Clinch is the only stream on ORR that is 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 with "(c)" under "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]Criteria are expressed as dissolved.
[d]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.
[e]Criteria are expressed as a function of pH; values shown correspond to a pH of 7.8.

Abbreviations

TDEC = Tennessee Department of Environment and Conservation
EPA = US Environmental Protection Agency

Appendix D: National Pollutant Discharge Elimination System Noncompliance Summaries for 2015

Appendix D. National Pollutant Discharge Elimination System Noncompliance Summaries for 2015

D.1 Y-12 National Security Complex

The Y-12 complex was in full compliance with the National Pollutant Discharge Elimination System (NPDES) permit in 2015. About 3,400 data points were obtained from sampling required by the NPDES permit. Compliance with permit discharge limits for 2015 was almost 100%.

D.2 East Tennessee Technology Park

The East Tennessee Technology Park was in full compliance with the NPDES permit in 2015 based on 32 laboratory analyses and 27 field measurements and flow estimates. There were no instances of NPDES permit non-conformances. The current ETTP NPDES permit became effective on April 1, 2015. It will be in effect until March 31, 2020.

D.3 Oak Ridge National Laboratory

The summer daily-maximum limit for ammonia at the Sewage Treatment Plant (STP), NPDES Outfall X01, was exceeded four times in May 2015, resulting also in a calculated exceedance of the monthly-average limit. The exceedances were attributed to malfunctioning sludge drying equipment, which caused a gradual increase in the mixed liquor suspended solids (MLSS) concentration in the treatment process. This resulted in an unfavorable environment for nitrification and ammonia removal at the facility.

The ORNL STP has also experienced several instances in past years where the rate of influent after heavy rain storms overwhelms the existing pump system and results in only partial treatment (disinfection) before discharge to White Oak Creek. A project is in progress to upgrade the ORNL STP, and this project is estimated to begin in 2016.

In 2015, compliance with the ORNL NPDES permit was determined by about 2,300 laboratory analyses and field measurements. The NPDES permit limit compliance rate for all discharge points for 2015 was greater than 99%, with four measurements exceeding numeric NPDES permit limits. The four effluent limit exceedances occurred at the ORNL STP in May 2015, when issues with STP sludge-management equipment occurred. Efforts to maintain sludge management included flow and aeration decreases, which led to unfavorable conditions for nitrification and ammonia control within the system. As a result, the STP ammonia discharge limits were exceeded four times during that month. Corrective actions including sludge-management system improvements were completed before the end of May 2015, after which there were no further NPDES compliance issues at the STP.

Appendix E. Radiation

Appendix E. Radiation

This appendix presents basic information about radiation. The information is intended to be a basis for understanding the potential doses associated with releases of radionuclides from the Oak Ridge Reservation (ORR), and is not a comprehensive discussion of radiation and its effects on the environment and biological systems.

Radiation comes from natural and human-made 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; types, sources, and pathways of radiation; 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. With the exception of 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 (Fig. E.1).

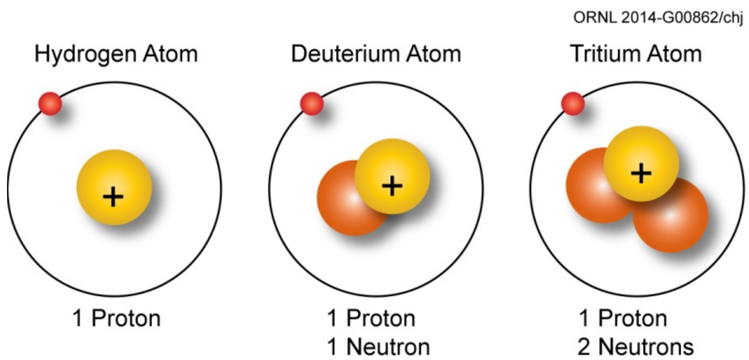

Fig. E.1. The hydrogen atom and its isotopes.

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-238 has 92 protons and 146 neutrons
- uranium-235 has 92 protons and 143 neutrons
- uranium-234 has 92 protons and 142 neutrons

Some isotopes are stable, or nonradioactive; some are radioactive. Radioactive isotopes are called "radionuclides" or "radioisotopes." In an attempt to become stable, radionuclides emit rays or particles. This emission of rays and particles 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).

Table E.1. Selected radionuclide half-lives

Radionuclide	Symbol	Half-life (years unless otherwise noted)	Radionuclide	Symbol	Half-life (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, or radiant energy, 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 radiation in the form of electromagnetic waves. Examples include gamma rays, ultraviolet light, and radio waves. Particulate radiation is radiation in the form of particles. Examples include alpha and beta particles. Radiation also is characterized as ionizing or nonionizing because of the way in which it interacts with matter.

E.2.1 Ionizing Radiation

Normally, an atom has an equal number of protons and electrons; however, atoms can lose or gain electrons in a process known as ionization. Some forms of radiation (called ionizing radiation) can ionize atoms by “knocking” electrons off atoms. Examples of ionizing radiation include alpha, beta, and gamma radiation.

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.

E.2.2 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. Nonionizing radiation includes the spectrum of ultraviolet (UV), visible light, infrared (IR), microwave, radio frequency (RF), and extremely low frequency. Lasers commonly operate in the UV, visible, and IR frequencies. Microwave radiation is absorbed near the skin, while RF radiation may be absorbed throughout the body. At high enough intensities, both will damage tissue through heating. Excessive visible radiation can damage the eyes and skin (Department of Labor, OSHA *Safety and Health Topics* online). However, in the discussion that follows the term “radiation” is used to describe ionizing radiation.

E.3 Measuring Radiation

To determine the possible effects of radiation on the health of the environment and the public, the radiation must be measured. More precisely, its potential to cause damage must be ascertained.

E.3.1 Activity

To determine radiation in the environment, the rate of radioactive decay or activity is measured. The rate of decay varies widely among various radioisotopes. For that reason, 1 g 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) atomic disintegrations per second (dps). In the International System of Units, 1 dps equals 1 becquerel (Bq).

E.3.2 Absorbed Dose

The total amount of energy absorbed per unit mass of the exposed material as a result of exposure to radiation is expressed in a unit of measure known as a rad. The effect of the absorbed energy (the biological damage that occurs) is important, not the actual amount. In the International System of Units, 100 rad equals 1 gray (Gy).

E.3.3 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. For radiation protection purposes, 1 rem of any type of radiation has the same damaging effect. Because a rem represents a fairly large dose, it is usually expressed as millirem (mrem), which is 1/1,000 of a rem. In the International System of Units, 1 sievert (Sv) equals 100 rem; 1 millisievert (mSv) equals 100 mrem. The effective dose (ED) is the weighted sum of equivalent dose over specified tissues or organs. The ED is based on tissue-weighting factors for 12 specific tissues or organs plus a weight factor for the remaining organs and tissues. In addition, the ED is based on the recent lung model, gastrointestinal absorption fractions, and biokinetic models used for selected elements. Specific types of EDs are defined as follows:

- Committed ED—the weighted sum of the committed ED in specified tissues in the human body during the 50-year period following intake.
- Collective ED—the product of the mean ED for a population and the number of persons in the population.

E.4 Radiation Exposure Pathways

People can be exposed to radionuclides in the environment through a number of routes (Fig. E.2). Potential routes for internal and/or external exposure are referred to as pathways. For example, radionuclides in air could be inhaled directly or 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 people drinking the milk would be exposed to this radiation. 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.

Fig. E.2. Examples of radiation pathways.

E.5 Radiation Sources and Doses

Basically, radioactive decay, or activity, generates radiant energy. People absorb some of the energy to which they are exposed, either from external or internal radiation. The effect of this absorbed energy is responsible for an individual's dose. Whether radiation is natural or human-made, 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 for workers that results from their occupations

Figure E.3 gives the 2006 percent contributions of various sources of exposure to total collective dose for the US population. As shown, the major sources are radon and thoron (37%), computed tomography (24%), and nuclear medicine (12%) (NCRP 2009). Consumer, occupational, and industrial sources contribute about 2% to the total US collective dose.

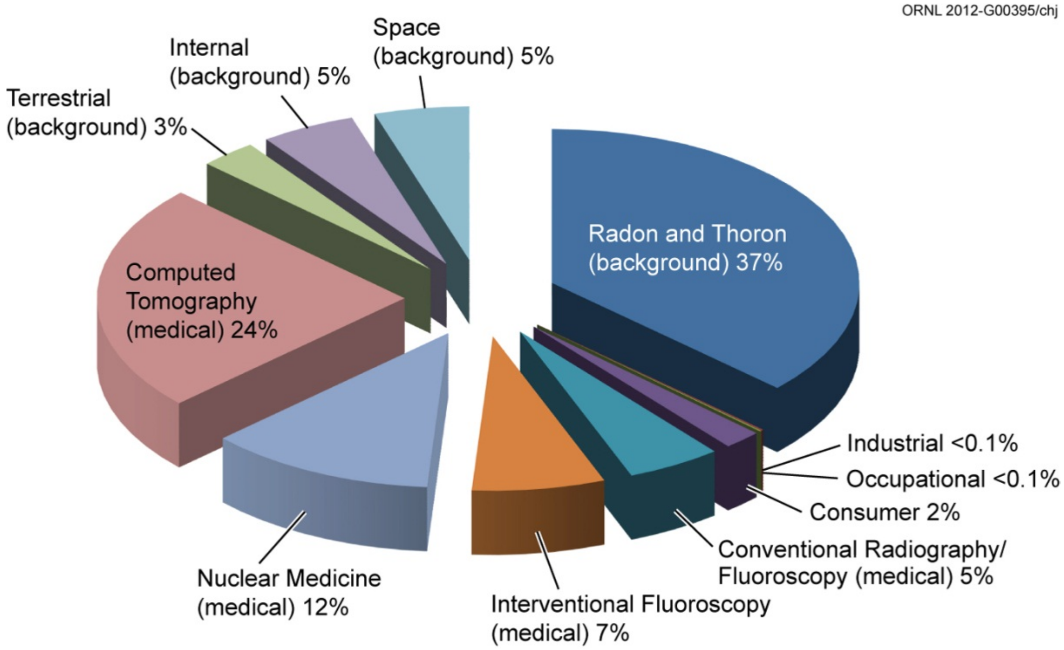

Fig. E.3. All exposure categories for collective effective dose for 2006 (NCRP 2009).

E.5.1 Background Radiation

Naturally occurring radiation is the major source of radiation in the environment. Sources of background radiation exposure include

- 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. 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 (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 varies geographically across the country (NCRP 2009). Typical reported values are about 23 mrem (0.23 mSv) on the Atlantic and Gulf coastal plains, about 90 mrem (0.9 mSv) on the eastern slopes of the Rocky Mountains, and elsewhere about 46 mrem (0.46 mSv) (EPA 2014).

E.5.1.2 Internal Exposures

Radionuclides in the environment enter the body with the air people breathe and the foods they eat. They also can enter through an open wound. Natural radionuclides that can be inhaled and ingested include isotopes of uranium and its 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 Fig. E.3, 37% of the dose from all exposure categories is from radon and thoron and decay products, which contribute an average dose 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 lung 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 and ^{232}Th and ^{238}U series. The primary source of ^{40}K in body tissues is food, and it comes primarily from fruits and vegetables. The sources of radionuclides from ^{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 Human-Made Radiation

In addition to background radiation, there are human-made sources of radiation to which most people are exposed. Examples include consumer products, medical sources, fallout from atmospheric atomic bomb tests, and industrial by-products. No atmospheric testing of atomic weapons has occurred since 1980 (NCRP 1987).

E.5.2.1 Consumer Products

Some consumer products are sources of radiation. The radiation in these products, such as 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 1987, NCRP 2009).

The US average annual dose to an individual from consumer products and activities is 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% of this dose. Other important sources are building materials (27%), commercial air travel (26%), mining and agriculture (6%), miscellaneous consumer-oriented products (3%), combustion of fossil fuels (2%), highway and road construction materials (0.6%), and glass and ceramics (<0.003%). Television and video, sewage sludge and ash, and self-illuminating signs all contribute negligible doses (NCRP 2009).

E.5.2.2 Medical Sources

Radiation is an important tool of diagnostic medicine and treatment, which are the main sources of exposure to the public from human-made radiation. Exposure is deliberate and 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. Thus, not all body organs are irradiated uniformly. Nuclear medicine examinations and treatments involve the internal administration of radioactive compounds, or radiopharmaceuticals, by injection, inhalation, consumption, or insertion. Even then, radionuclides are not distributed uniformly throughout the body. Radiation and radioactive materials also are used in the preparation of medical instruments, including the sterilization of heat-sensitive products such as plastic heart valves.

Nuclear medicine examinations, which involve internal administration of radiopharmaceuticals, generally account for the largest portion of dose from human-made sources. However, the radionuclides used for specific tests are not distributed uniformly 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.

E.5.2.3 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 nuclear fuel cycle facilities, such as uranium mines, mills, fuel-processing plants, nuclear power plants, and transportation routes, has been estimated at less than 1 mrem (0.01 mSv) per year (NCRP 1987).

Small doses to individuals occur because of radioactive fallout from atmospheric atomic bomb tests, emissions of radioactive materials from nuclear facilities, emissions from certain mineral extraction facilities, and transportation of radioactive materials. The combination of these sources contributes less than 1 mrem (0.01 mSv) per year to an individual's average dose (NCRP 1987).

E.6 References

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Appendix F. Chemicals

Appendix F. Chemicals

This appendix presents basic information about chemicals. The information is intended as a basis for understanding the dose or relative toxicity assessment associated with possible releases from the Oak Ridge Reservation (ORR), and is not a comprehensive discussion of chemicals and their effects on the environment and biological systems.

F.1 Perspective on Chemicals

The lives of modern humans have been greatly improved by the development of chemicals such as pharmaceuticals, building materials, housewares, pesticides, and industrial chemicals. Through the use of chemicals we can increase food production, cure diseases, build more efficient houses, and send people to the moon. At the same time, we must be cautious to ensure that our own existence is not endangered by uncontrolled and over-expanded use of chemicals (Chan et al. 1982).

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, exposures to many more hazardous chemicals result from the direct or indirect actions of humans. Building materials used in the construction of homes may contain chemicals such as formaldehyde (in some insulation materials), asbestos (formerly used in insulations and ceiling tiles), and lead (formerly used in paints and gasoline). Some chemicals are present as a result of the application of pesticides and fertilizers to soil. Other chemicals may have been transported long distances through the atmosphere from industrial sources before being deposited on soil or water.

F.2 Pathways of Chemicals from Oak Ridge Reservation to the Public

“Pathways” refers to the route or way in which a person can come into contact with a chemical substance. Chemicals released to the air may remain suspended for long periods, or they may be rapidly deposited on plants, soil, and 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 (eating exposed plants and animals or drinking water), or direct contact (touching the soil or swimming in water). For example, fish that live in a river that receives effluents may take in some of the chemicals present in the water. People eating the 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 Definitions

F.3.1 Toxicity

Chemicals have varying types of effects. Chemical health effects are divided into two broad categories: adverse or systemic effects (noncarcinogens) and cancer (carcinogens). Sometimes a chemical can have both noncarcinogenic and carcinogenic effects. The toxic effect can be acute (a short-term, severe health effect) or chronic (a longer term, persistent health effect). Noncarcinogenic toxicity is often evident in a shorter length of time than a carcinogenic effect. The potential health effects of noncarcinogens range from skin irritation to death (or mortality). Carcinogens cause or increase the incidence of malignant neoplasms or cancers.

Toxicity refers to an adverse effect of a chemical on human health. Every day we ingest chemicals in food, water, and sometimes medications. Even those chemicals typically considered toxic are usually nontoxic or harmless below a certain concentration.

Concentration limits or advisories are set by government agencies for some chemicals that are known or thought to have adverse effects on human health. These concentration limits can be used to calculate chemical doses that would not harm even those individuals who are particularly sensitive to the chemical.

F.3.2 Dose Terms for Noncarcinogens

F.3.2.1 Reference Dose

A reference dose is an estimate of a daily exposure level for the human population, including sensitive subpopulations. These reference doses are likely to be without appreciable risk of deleterious effects during a lifetime. Units are expressed as milligrams of chemical per kilogram of an adult's body weight per day (mg/kg-day). Values for reference doses are derived from doses of chemicals that resulted in no adverse effect, or the lowest dose that showed an adverse effect on humans or laboratory animals.

Uncertainty factors are typically used in deriving reference doses. Uncertainty adjustments may be made if animal toxicity data are extrapolated to humans, to account for human sensitivity; extrapolated from subchronic to chronic no-observed-adverse-effect levels; extrapolated from lowest-observed-adverse-effect levels to no-observed-adverse-effect levels; and to account for database deficiencies. The use of uncertainty factors in deriving reference doses is thought to protect sensitive human populations. The US Environmental Protection Agency (EPA) maintains the Integrated Risk Information System (IRIS) database, which contains verified reference doses and up-to-date health risk and EPA regulatory information for numerous chemicals.

F.3.2.2 Primary Maximum Contaminant Levels

For chemicals for which reference doses are not available in IRIS, Tennessee Water Quality Criteria, which reflect maximum contaminant levels expressed in milligrams of chemical per liter of drinking water, are converted to reference dose values by multiplying by 2 L (the average daily adult water intake) and dividing by 70 kg (the reference adult body weight). The result is a "derived" reference dose expressed in milligrams per kilogram per day (mg/kg-day).

F.3.3 Dose Term for Carcinogens

F.3.3.1 Slope Factor

A slope factor is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical during a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular level of a chemical. Units are expressed as risk per dose (mg/kg-day).

The slope factor converts the estimated daily intake averaged over a lifetime exposure to the incremental risk of an individual developing cancer. Because it is unknown for most chemicals whether a threshold (a dose below which no adverse effect occurs) exists for carcinogens, units for carcinogens are set in terms of risk 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). In other words, a certain chemical concentration in food or water could cause a risk of one additional cancer for every 10,000 (10^{-4}) to 1,000,000 (10^{-6}) exposed persons, respectively.

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. Typically, chemical concentrations in liquids are expressed in terms of milligrams or micrograms of chemical per liter of water; concentrations in solids (soil and fish tissue) are expressed in terms of milligrams or micrograms of chemical per gram or kilogram of sample material.

The instruments used to measure chemical concentrations are sensitive; however, there are limits below which they cannot detect chemicals of interest. Concentrations detected 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. Health effect calculations that use these estimated values are indicated by the less-than symbol (<), which indicates that the value for a parameter was not quantifiable at the analytical detection limit.

F.5 Risk Assessment Methodology

F.5.1 Exposure Assessment

To evaluate an individual's exposure by way of a specific exposure pathway, the intake amount of the chemical must be determined. For example, chemical exposure by drinking water and eating fish from the Clinch River is assessed in the following manner: Clinch River surface water and fish samples are analyzed to estimate chemical contaminant concentrations. It is assumed that individuals drink about 2 L (0.5 gal) of water per day directly from the river, which amounts to 680 L (180 gal) per year, and that they eat 0.07 kg (roughly 0.2 lb) of fish per day from the river (27 kg or 60 lb per year). Estimated daily intakes or estimated doses to the public are calculated by multiplying measured (statistically significant) concentrations in water by 2.55 L, or those in fish by 0.07 kg. This intake is first multiplied by the exposure duration (30 years) and exposure frequency (350 days/year) and then divided by an averaging time (30 years for noncarcinogens and 70 years for carcinogens). These assumptions are conservative, and in many cases they result in higher estimated intakes and doses than an individual would actually receive.

F.5.2 Dose Estimate

When the contaminant oral daily intake has been estimated, the dose is determined. For chemicals, the dose to humans is measured as milligrams per kilogram-day (mg/kg-day). In this case, the “kilogram” refers to the body weight of an adult. When a chemical dose is calculated, the length of time an individual is exposed to a certain concentration is important. To assess off-site doses, it is assumed that the exposure duration occurs over 30 years. Such exposures are called “chronic” in contrast to short-term exposures, which are called “acute.”

F.5.3 Calculation Method

Current risk assessment methodologies use the term “hazard quotient” to evaluate noncarcinogenic health effects. Because intakes are calculated in milligrams per kilogram per day in the hazard quotient methodology, they are expressed in terms of dose. Hazard quotient values of less than 1 indicate an unlikely potential for adverse health effects, whereas hazard quotient values greater than 1 indicate a concern for adverse health effects or the need for further study.

To evaluate carcinogenic risk, slope factors are used instead of reference doses.

To estimate the risk of inducing cancers from ingestion of water and fish, the estimated dose or intake (I) is multiplied by the slope factor (risk per mg/kg-day). As mentioned earlier, 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).

F.6 References

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