DOE/ORO—2228/R12

ENVIRONMENTAL MONITORING PLAN FOR THE OAK RIDGE RESERVATION Calendar Year 2021

UNITED STATES DEPARTMENT OF ENERGY
Office of Science

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The controlled *Environmental Monitoring Plan for the Oak Ridge Reservation CY 2021*, United States Department of Energy Oak Ridge Office, DOE/ORO—2228/R12, is available at https://doeic.science.energy.gov/ASER/.

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Environmental Monitoring Plan for the Oak Ridge Reservation Calendar Year 2021

United States Department of Energy Office of Science

Prepared for the
US Department of Energy
Office of Science Consolidated Services Center

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CONTENTS

Page

FIGURES

Page

TABLES

Page

ACRONYMS

ASER	Annual Site Environmental Report
CAP-88 PC	Clean Air Act Assessment Package – 1988 (software)
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CES	Computational Earth Sciences
CNS	Consolidated Nuclear Security, LLC
CRK	Clinch River kilometer
DOE	US Department of Energy
ED	effective dose
EMP	environmental monitoring plan
EPA	US Environmental Protection Agency
EPSD	Environmental Protection Services Division
ESS	Environmental Sampling System
ETTP	East Tennessee Technology Park
F&O/I&C	Facilities and Operations/Instrumentation and Controls group
ICPT	Integrated Contractor Procurement Team
ITSD	Information Technology Services Division
MET	meteorological
NRC	US Nuclear Regulatory Commission
OREM	Oak Ridge Office of Environmental Management (Department of Energy)
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCB	polychlorinated biphenyl
PSS	plant shift superintendent
QA	quality assurance
QC	quality control

ACRONYMS (continued)

Rad NESHAPs	National Emission Standards for Hazardous Air Pollutants for Radionuclides
SBMS	Standards-Based Management System
SOP	standard operating procedure
TDEC	Tennessee Department of Environment and Conservation
Y-12	Y-12 National Security Complex

UNITS OF MEASURE AND CONVERSION FACTORS

Units of measure and their abbreviations

acre	acre	milliliter	mL
becquerel	Bq	millimeter	mm
centimeter	cm	million	M
curie	Ci	milliard	mrad
day	d	millirem	mrem
degrees Celsius	°C	millisievert	mSv
degrees Fahrenheit	°F	minute	min
disintegrations per minute	dpm	nanocurie	nCi
foot	ft	nephelometric turbidity unit	NTU
gallon	gal	parts per billion	ppb
gallons per minute	gal/min	parts per million	ppm
gram	g	parts per trillion	ppt
hectare	ha	picocurie	pCi
hour	h	pound	lb
inch	in.	pounds per square inch	psi
kilogram	kg	quart	qt
kilometer	km	rad	rad
kilowatt	kW	roentgen	R
liter	L	roentgen equivalent man	rem
megawatt	MW	second	s
meter	m	sievert	Sv
microcurie	μCi	standard unit (pH)	SU
microgram	μg	ton, short (2,000 lb)	ton
millicurie	mCi	yard	yd
milligram	mg	year	yr

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	$\times 10^{-1}$

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 (US liquid)	× 3.785	L	L	× 0.264	gal (US liquid)
Concentration					
ppm	× 1	mg/L	mg/L	× 1	ppm
Weight					
lb	× 0.454	kg	kg	× 2.205	lb
ton (short)	× 907.185	kg	kg	× 0.001	ton (short)
Temperature					
°C	°F = (9/5) °C + 32	°F	°F	°C = (5/9) (°F – 32)	°C
Activity					
Bq	× 2.7×10^{-11}	Ci	Ci	× 3.7×10^{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	× 0.45×10^9	$\mu Ci/cm^3$	$\mu Ci/cm^3$	× 2.22×10^9	dpm/L
pCi/L	× 10^{-9}	μCi/mL	μCi/mL	× 10^9	pCi/L
pCi/m^3	× 10^{-12}	$\mu Ci/cm^3$	$\mu Ci/cm^3$	× 10^{12}	pCi/m^3

1. INTRODUCTION

1.1 PURPOSE AND SCOPE

Oak Ridge Reservation (ORR) environmental surveillance is conducted to comply with Department of Energy (DOE) requirements to protect the public and the environment against undue risks associated with activities carried out by DOE. These requirements are established in DOE O 458.1 (DOE 2020a), *Radiation Protection of the Public and the Environment*, and related guidance is provided in DOE-HDBK-1216-2015 (DOE 2015), *Radiological Environmental Effluent Monitoring and Environmental Surveillance*. The objective of the ORR environmental surveillance program is to characterize environmental conditions in areas outside of ORR facility boundaries, both on and off the reservation, that could be impacted by DOE operations and to estimate the resulting public doses. Data from the ORR environmental surveillance program are also used to confirm public dose estimates based on effluent monitoring results, and, where appropriate, provide supplemental data to support compliance monitoring required by environmental laws and regulations. In accordance with DOE Order 231.1B (DOE 2012), *Environment, Safety and Health Reporting*, results from the ORR environmental surveillance program are made available to the public via the *Oak Ridge Reservation Annual Site Environmental* Report (DOE 2020b).

This environmental monitoring plan (EMP) documents the rationale, frequency, parameters, and analytical methods for the ORR environmental surveillance program and provides information on site characteristics, meteorological monitoring, environmental pathways, dose assessment methods, and quality management. ORR-wide monitoring activities cover a variety of media including air, surface water, vegetation, biota, and wildlife. Site-specific effluent, groundwater, and best management monitoring programs at the Oak Ridge National Laboratory (ORNL), Y-12 National Security Complex (Y-12), and East Tennessee Technology Park (ETTP) along with monitoring conducted for the DOE Oak Ridge Office of Environmental Management (OREM) are not within the scope of this EMP. In addition, environmental monitoring and surveillance programs conducted in support of privately owned facilities which were previously part of the ORR are also outside of the scope of this EMP. These privately held properties include commercial businesses, City of Oak Ridge facilities and utilities, and property that has been turned over to the Community Reuse Organization of East Tennessee for future commercial development at ETTP, and the Oak Ridge Science and Technology Park, a private business park at ORNL, managed by Halcyon LLC, a subsidiary of the Community Reuse Organization of East Tennessee.

1.2 ADMINISTRATION AND OVERSIGHT

The ORR EMP is reviewed, and as needed, updated annually by a task team representing the DOE Office of Science Consolidated Services Center; the ETTP, ORNL and Y-12 DOE Site Offices; and management, operating, and support contractors from each of the three major ORR facilities.

UT-Battelle, LLC's Environmental Protection Service's Division (EPSD) is responsible for the management and administration of the ORR environmental surveillance program. Program oversight, sampling, data management, and reporting are carried out by EPSD's Environmental Sampling and Data Evaluation (ESDE) Team. Several other groups and organizations, discussed in applicable sections of this plan, provide specific programmatic support for ORR environmental surveillance. In order to assure the citizens of Tennessee that DOE's activities on the ORR are performed in a manner that is protective of their health, safety, and environment, the State of Tennessee and DOE have entered into the *Oak Ridge Environmental Surveillance Agreement*. Through this voluntary agreement, the Tennessee Department of Environment and Conservation conducts environmental surveillance oversight of activities related to the ORR EMP including independent evaluation of results.

1.3 OAK RIDGE RESERVATION BACKGROUND INFORMATION

The ORR is managed by DOE and contains three major operating sites: ETTP, ORNL, and Y-12. Facilities at these sites were constructed as part of the Manhattan Project. Their primary missions have evolved over the years and continue to adapt to meet the changing research, defense, and environmental restoration needs of the United States.

Consolidated Nuclear Security, LLC (CNS), is the DOE prime contractor responsible for operating Y-12, a manufacturing facility that continues to play an integral role in the nation's nuclear weapons complex. The Y-12 site is undergoing significant modernization. Key considerations of the modernization strategy include incorporating sustainable environmental stewardship in planning, design, and construction; maintaining compliance with regulatory requirements; and coordinating modernization activities according to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements.

UT-Battelle, LLC, is the DOE prime contractor responsible for operations at ORNL, DOE's largest science and energy research laboratory. ORNL is an international leader in a range of scientific areas that support the DOE mission. Major mission roles are neutron science, energy, high-performance computing, systems biology, materials science, and national security.

UCOR (an ARMENTUM-led partnership with Jacobs) is the DOE OREM prime contractor responsible for operations at ETTP. The mission at ETTP is environmental cleanup and reindustrialization/reuse of the assets of the former gaseous diffusion plant. In addition, UCOR is responsible for waste management activities at the Environmental Management Waste Management Facility, Y-12 sanitary landfills, and ORNL with a work scope that includes liquid treatment facilities and Resource Conservation and Recovery Act permitted units. UCOR also conducts CERCLA facility surveillance and maintenance and CERCLA project actions at the ORNL and Y-12 sites.

DOE facilities on the ORR that are not contractual responsibilities of UT-Battelle, CNS, or UCOR include:

- Oak Ridge Institute for Science and Education
- The National Nuclear Security Administration Office of Secure Transportation, Agent Operations Eastern Command: Secure Transportation Center and Training Facility
- Transuranic Waste Processing Center
- Building 2026 at ORNL
- Building 3019 complex at ORNL

2. SITE CHARACTERISTICS

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. 2.1). The Cumberland Mountains are 16 km (10 miles) to the northwest; the Great Smoky Mountains are 51 km (31.6 miles) to the southeast.

Fig. 2.1. Location of the Oak Ridge Reservation.

The ORR encompasses approximately 13,301 ha (32867 acres) of mostly contiguous land owned by the federal government and under the management of DOE in Anderson and Roane Counties (Fig. 2.2). The population of the 10-county region surrounding the ORR (Anderson, Blount, Campbell, Cumberland, Knox, Loudon, McMinn, Monroe, Morgan, and Roane) is approximately 1,010,000 (Census Bureau. 2019). Municipalities within 40 km (~25 miles) of the reservation include Oliver Springs, Clinton, Rocky Top, Lenoir City, Farragut, Kingston, Knoxville, and Harriman (Fig. 2.3).

Knoxville, the major metropolitan area nearest Oak Ridge, is located about 40 km (25 miles) to the east and had a population of approximately 187,603 at the time of the 2019 census (Census Bureau. 2019). Except for the city of Oak Ridge, the land within 8 km (5 miles) of the ORR is semirural and is used primarily for residences and small farms (primarily cattle, hay, and pasture). Fishing, hunting, boating, water skiing, and swimming are popular recreational activities in the area.

The topography, geology, hydrology, vegetation, and wildlife of the ORR provide a complex and intricate array of resources. Detailed information regarding the natural resources and physical characteristics of the ORR is available in *ORR Physical Characteristics and Natural Resources* (Parr and Hughes 2006).

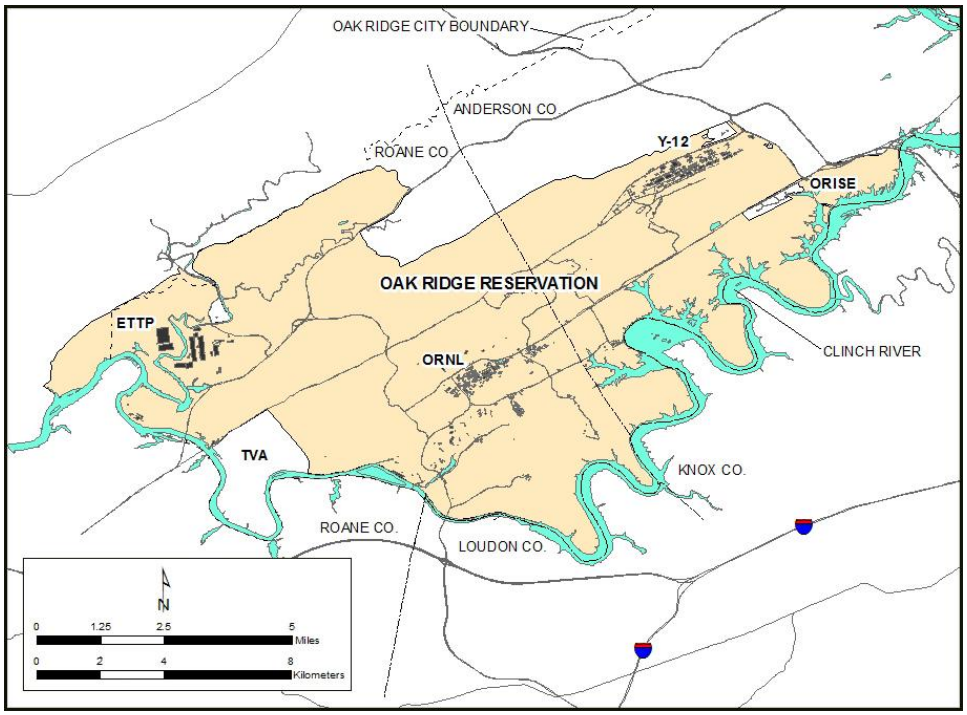

Fig. 2.2. Oak Ridge Reservation.

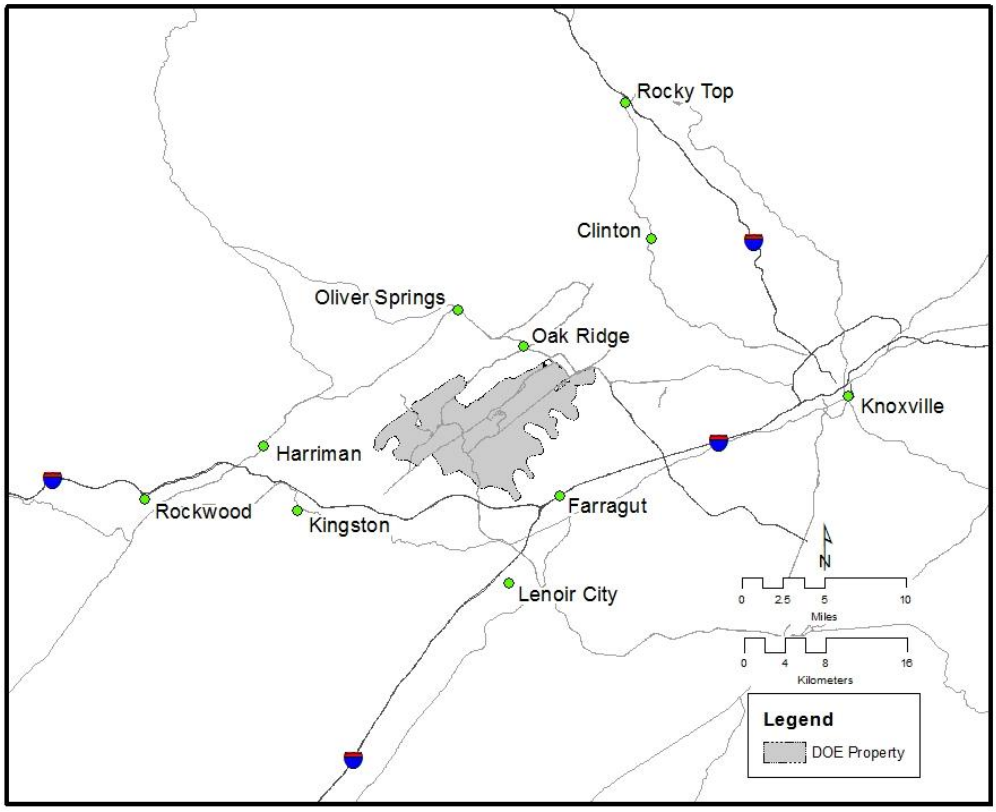

Fig. 2.3. Locations of towns nearest the Oak Ridge Reservation.

3. OAK RIDGE RESERVATION METEOROLOGICAL MONITORING

3.1 INTRODUCTION

Meteorological (MET) monitoring on the ORR is conducted by UT-Battelle's Computational Earth Sciences (CES) Group and supports the ORR environmental monitoring program as well as site specific monitoring programs at ETTP, ORNL, and Y-12. Dispersion models developed by CES estimate and predict downwind concentrations of air pollutants emitted from sources on the ORR and are used to determine monitoring locations that are representative of areas where members of the public could be exposed to worst case concentrations of these pollutants. ORR MET monitoring, which fulfills Environmental Protection Agency (EPA) and DOE requirements, also provides (1) environmental data to assist in emergency response and plume modeling, (2) real-time access to data, and (3) notification of severe weather conditions.

3.2 METEROLOGICAL SYSTEM DESCRIPTION

MET monitoring on the ORR includes 10 towers across the reservation (Fig. 3.1). Towers A (ORNL High Flux Isotope Reactor), B (ORNL 6500 area), D (ORNL 1000 area), F (Spallation Neutron Source water tank), M (west Bear Creek Road), and L (ETTP 1209) are operated by UT-Battelle, and CNS operates Towers J (Y-12 Emergency Operations Center at ETTP), S (South Ridge), W (West), and Y (Plant Shift Superintendent [PSS] Tower). Towers A, B, D, L, W, and Y have measuring capabilities at multiple vertical levels. Siting for most of the towers was based on a screening analysis conducted in the 1980s in collaboration with EPA guidance and/or DOE consultation.

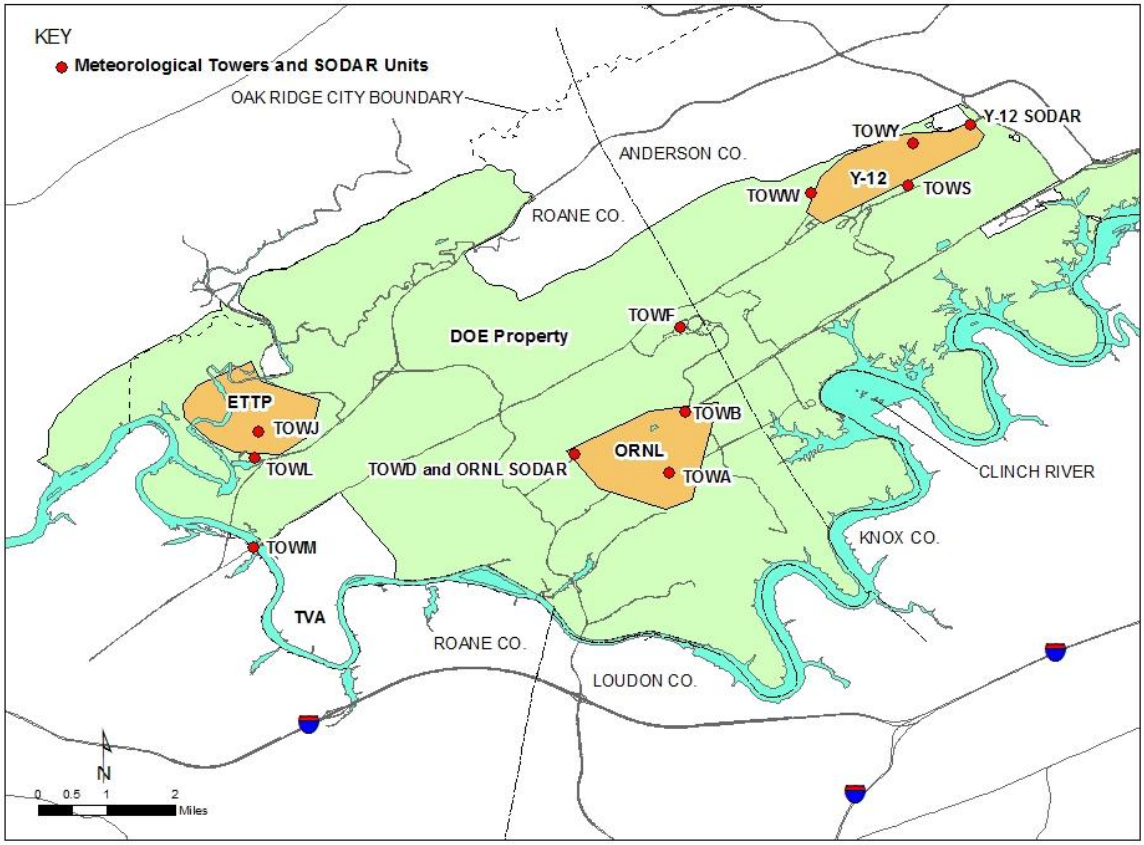

Fig. 3.1. Oak Ridge Reservation meteorological tower (TOW) and sonic detection and ranging (SODAR) device locations.

3.3 METEROLOGICAL DATA COLLECTION AND REPORTING

ORR MET data are collected continuously and 1-, 15-, and 60-minute data averages are calculated. MET data include temperature, dew point, relative and absolute humidity, vapor pressure, mixing ratio, precipitation, wind direction and speed, vertical wind speed, wind direction standard deviation, 1- and 10-second peak wind speed, air pressure, solar radiation, soil temperature, and stability.

Sonic detection and ranging SODAR devices at ORNL and Y-12 measure winds and turbulence at altitudes less than the typical daytime maximum boundary layer height. Therefore, a ceilometer is located adjacent to Tower D to provide boundary layer height data during the daytime, and to measure mixing height, cloud height, and other weather phenomena such as rain and fog. Additional data, which serves as backup to SODAR and ceilometer data, are collected via the Weather Research and Forecasting, Rapid Refresh, or Global Forecast System models.

In accordance with EPA guidance, data are made available to the public at least daily at http://metweb.ornl.gov//index.htm.

3.4 METEROLOGICAL MONITORING QUALITY ASSURANCE

CES integrates quality principles and methodologies into work planning and control processes in accordance with the ORNL Quality Assurance Plan to ensure work is completed safely and data are of a known and defensible quality. Detailed information on MET Quality Assurance (QA)/Quality Control

(QC) programs is available from CES. Elements of these programs that ensure representative MET data is used in environmental calculations and dose modeling include:

- routine quality checks on hourly data
- data validation and periodic comparisons to background readings
- quarterly or semiannual instrument calibrations traceable to National Institute of Standards and Technology standards
- daily monitoring of towers and SODAR devices
- biannual tower truing and tensioning at Towers A and B (Towers D, F, L, M, W, and Y are guy-less)
- biannual inspection of tower anchor connections

4. ENVIRONMENTAL PATHWAYS AND DOSE CALCULATIONS

4.1 INTRODUCTION

Operations at the three ORR facilities may result in emissions of airborne and waterborne radionuclides and chemicals. Once released, these substances migrate through the environment by applicable transport mechanisms, and some may reach and affect humans and biota. This section describes the methods used by dose assessment staff in EPSD's Air/RCRA and Transportation Group to characterize dispersion of released radionuclides and to estimate human exposures to and intakes of the dispersed substances. Human exposures to radionuclides are quantified in terms of effective dose[1] (ED) to maximally exposed on-site and/or off-site members of the public and the entire population residing within 80 km (50 miles) of the ORR. Impacts to terrestrial and aquatic biota are also evaluated. Regulatory standards and facility-specific permits for chemical releases to the environment typically specify release concentration criteria and limits and do not require dose or risk estimates. Therefore, only exposures from drinking water and consuming fish, characterized by hazard quotients for noncarcinogenic chemicals and risk estimates for carcinogenic chemicals, are evaluated.

4.2 CONFORMANCE WITH STANDARDS FOR PUBLIC DOSE CALCULATIONS

Dose calculations are performed to demonstrate compliance with EPA's *National Emission Standards for Hazardous Air Pollutants: Standards for Radionuclides* (Rad NESHAPs) (40 CFR 61, Subpart H) and DOE O 458.1 (DOE 2020a). A clean air assessment package model or other approved procedures are used to calculate doses to members of the public. The EPA Rad NESHAPs standard limits the annual ED to a member of the public from radionuclides released in the air from DOE facilities to 10 mrem (0.1 mSv).

DOE O 458.1 states that DOE radiological activities will not cause a total ED exceeding 100 mrem (1 mSv) in a year, an equivalent dose to the lens of the eye exceeding 1,500 mrem (15 mSv) in a year, or an equivalent dose to the skin or extremities exceeding 5,000 mrem (50 mSv) in a year from all sources of ionizing radiation and exposure pathways that could contribute significantly to the total dose.

DOE O 458.1 also states that models for dose evaluation calculations must be appropriate for their purpose, and dose evaluation models that are codified or approved for use by regulators of DOE or by DOE must be used where applicable.

4.3 ENVIRONMENTAL PATHWAY AND TRANSPORT MODELS

Members of the public have the potential to receive doses from internal and external exposures to radiological materials released to the atmosphere, ground and surface waters, soils and sediment, and cleared property. In addition, some members of the public may receive external radiation doses through direct external irradiation and radiation emanating from buildings and other objects (e.g., drum storage and burial areas) located within facility and ORR boundaries.

[1] Effective dose (ED), defined as $ED = \sum_T w_T H_T$, is the sum of the equivalent dose received by specific organs or tissues (H_T) multiplied by the tissue weighting factor (w_T) for the organ or tissue. The time integral of the effective dose rate is known as the committed effective dose. Total ED includes the committed effective dose from internal intakes as well as the effective dose from external exposures. In this document 'dose' is used synonymously with ED. The unit of effective dose is rem or sievert (Sv).

Table 4.1 lists environmental release and transport mechanisms that may apply to emissions from the ORR. These are not all evaluated as some may have limited impact compared to more dominant transport mechanisms. Models and computer codes for evaluating public exposures to released radionuclides will be selected based on regulatory requirements, the applicability of the model to a specific situation, the degree to which the model has been documented and verified, and the availability of the data needed to implement the model. Unless otherwise required by regulatory or legal mandates, the simplest model needed to characterize a situation will be used. Input data to the models will be either site-specific (e.g., collected via the environmental monitoring and surveillance activities described in this EMP), specific to national or regional data [e.g., national food consumption survey (EPA 2011), regional recreational data (UT 2017), etc.], or generic (default values). In the absence of nuclide-specific data, bounding dose calculations will be made.

Table 4.1. Environmental Transport Mechanisms Applicable to Releases from the Oak Ridge Reservation

Releases to air	Remain suspended in air Deposit on ground Deposit on vegetation Deposit on water surfaces
Releases to surface water	Remain dissolved or suspended in water Deposit in sediments Infiltrate to groundwater
Releases to groundwater	Remain dissolved or suspended in water Flow into surface water
Radionuclides in objects	Remain in fixed sources
Releases to ground surfaces	Remain on ground Dissolve or suspend in surface water Infiltrate to groundwater Become suspended in air

4.3.1 Atmospheric Transport and Pathway Analysis

Contaminants released into the atmosphere may remain suspended in the air and may deposit on soil, vegetation, and water surfaces (Table 4.1). Atmospheric transport models are used to calculate annual average ground-level airborne concentrations of contaminants and associated rates of deposition on the ground and vegetation.

To demonstrate compliance with Rad NESHAPs (40 CFR 61.93[a]) and DOE O 458.1 (DOE 2020a), the Clean Air Assessment Package (CAP-88 PC) computer software (EPA 2015) is used to calculate doses to members of the public from ORR radionuclide airborne emissions. CAP-88 PC includes some limiting criteria and assumptions (e.g., flat terrain is assumed and it is recommended for use when receptors are greater than 100 m from the source).

CAP-88 PC calculates annual average ground-level air concentrations and deposition rates at selected environmental locations to allow identification of the maximally exposed individual for each source, each facility, and the entire ORR. Dose estimates for the population within 80 km (50 miles) of the ORR are also calculated**.**

When possible, site-specific parameter values are used to quantify radionuclide releases (e.g., release rates, particle size in terms of activity median aerodynamic diameter and chemical composition),

meteorological variables (e.g., wind speed and direction, atmospheric stability class, air temperature, rainfall rate, and mixing layer height), and source parameters (e.g., release height, stack diameter, exit gas velocity and temperature, and location with respect to exposed persons). These parameters are obtained from data collected for environmental monitoring and surveillance programs conducted on the ORR. An activity median aerodynamic diameter of 1.0 μm will be used unless otherwise requested. If lung absorption type data are not provided, the CAP-88 PC default lung absorption type classes are used. The dose estimates are applicable only to low-level chronic exposures because the health effects, and dosimetric data are based on low-level chronic intakes. If data on radionuclides identified through either sample analysis or laboratory usage inventory are not available in CAP-88 PC, EPA Region 4 must approve the use of surrogate radionuclides. The ED for business receptors, both on and off the site, is typically calculated with the method used for the residential exposure scenario (i.e., assuming full occupancy [8,760 hours/year] and the Rural Food Source Scenario in CAP-88 PC) and then dividing the resulting dose in half. However, there may be cases where the method of evaluation for business receptors may be revised to account for more site-specific parameters.

Doses calculated from data collected at ambient air monitoring stations on the ORR are compared to doses calculated by CAP-88 PC to confirm that the atmospheric dispersion codes are not significantly underestimating airborne concentrations of radionuclides around the ORR. There may be cases when calculations using ambient air monitoring data result in higher doses because the CAP-88 PC model is used primarily to estimate doses from point source emissions and may not include the impacts of fugitive emissions from demolition or construction activities.

4.3.1.1 Inhalation and Immersion Pathway

CAP-88 PC (EPA 2015) is used to calculate EDs from inhalation of and immersion in air containing radionuclides. The inhaled quantities and air concentrations are combined with inhalation and immersion dose coefficients to calculate inhalation and immersion doses, respectively, to an individual at selected locations. Inhalation dose coefficients are chosen based on particle size and lung absorption type. In the absence of actual data, a 1.0 μm particle size and default lung absorption type for inhalation are assumed. CAP-88 PC also calculates the collective ED from inhalation and immersion to the population residing within 80 km (50 miles) of the ORR.

4.3.1.2 Ingestion Pathway—Vegetables, Meat, and Milk

Contaminants may reach vegetation (food and feed crops) by deposition of airborne materials, uptake from soil, and deposition of materials contained in irrigation water. The significant potential direct pathway for human exposure to contaminants in food crops is ingestion. Indirect pathways involve ingestion of contaminated feed crops by terrestrial animals that are later ingested by humans.

CAP-88 PC (EPA 2015) uses the US Nuclear Regulatory Commission (NRC) Regulatory Guide 1.109 food chain accumulation model (NRC 1977) to estimate concentrations of radionuclides in beef, vegetables, and milk due to consumption of feed contaminated with radionuclides released to the atmosphere. National Council on Radiation Protection and Measurements transfer factors (NCRP 1996) and EPA intake rates (EPA 2011) are used to estimate the human intake values of milk and beef and associated radionuclides. The code assumes that radionuclide deposition has occurred for 100 years. The radionuclide intakes are combined with dose coefficients for ingestion to calculate EDs to an individual residing at each location and the population within 80 km (50 miles) of the ORR.

The ORR environmental surveillance program includes sampling of radionuclides in selected food crops and in milk if dairies and gardens in potential impact areas are located. These sampling data and the intake models described above will be used to provide additional estimates of doses from ingestion of

locally grown foods. Effective doses from the ingestion of selected food crops and milk, if sampled, are estimated using population-weighted ingestion rates and DOE-STD-1196-2011 (DOE 2011) reference person dose coefficients. The population-weighted ingestion rates are based on a nationwide food consumption survey of a hypothetical home gardener or milk consumer and are age-weighted based on the populations of Anderson, Knox, Loudon, and Roane Counties. Potential doses from ingesting deer, turkey, and waterfowl (e.g., geese) harvested from the reservation are also calculated.

4.3.1.3 External Radiation Pathway—Ground Deposition

Contaminants may reach soil by deposition of airborne materials, deposition of materials contained in irrigation water, and direct ground deposition. Potential direct pathways of human exposure to contaminants in soil include inhalation of resuspended soil, ingestion of soil, and direct exposure to (being near or in contact with) the soil. Indirect pathways involve uptake of contaminants from soil by crops.

The resuspension of soil and soil ingestion pathways are not evaluated because their potential consequences are considered less significant relative to those from inhalation of newly emitted contaminants and ingestion of foodstuffs. CAP-88 PC (EPA 2015) is used to calculate EDs due to direct irradiation by radionuclides on soil and assumes that deposition has occurred for 100 years and that a person remained unprotected at a location for an entire year. Ground concentrations and exposure times are combined with the dose coefficients for exposure to a contaminated ground surface to calculate EDs to an individual at selected locations. CAP-88 PC is also used to calculate the collective ED to the population residing within 80 km (50 miles) of the ORR from exposure to contaminated ground surfaces. Effective doses are also calculated based on measured radiation exposure data collected at ORR ambient air stations and at a reference location.

4.3.2 Surface Water Transport and Pathway Analysis

Two techniques based on methodology and equations from LADTAP XL (Hamby 1991), with modifications applicable to the ORR, are used to calculate individual and population doses for waterborne exposure pathways. The first uses radionuclide concentrations determined by laboratory analyses of water and fish samples. The second calculates possible radionuclide concentrations in water and fish from measured radionuclide discharges and known or estimated water flows. Both methods are used to estimate radionuclide concentrations in media and locations that are not sampled in conjunction with ORR environmental monitoring programs (e.g., downstream). Doses from groundwater ingestion are not estimated because groundwater from nearby off-site wells is not consumed. OREM conducts off-site groundwater monitoring west of the Clinch River according to a groundwater sampling strategy developed by OREM, EPA, and Tennessee Department of Environment and Conservation (TDEC).

4.3.2.1 Ingestion, Immersion, and External Radiation Pathway

Potential pathways of direct human exposure to contaminants in surface waters include drinking water, eating fish, immersion (swimming, wading, showering), boating, skiing, using the shoreline, and inhaling water (breathing water vapor while showering). Indirect pathways involve deposition on soil and crops by irrigation, deposition in sediments, and uptake by fish consumed by terrestrial animals.

The direct pathways for human exposure to contaminants from surface waters on or near the ORR that are evaluated for dose estimates include drinking water, swimming, boating, and using the shoreline. Doses associated with irrigation are also evaluated. NRC Regulatory Guide 1.109 (NRC 1977) equations are used to estimate radiation doses due to immersion in and direct irradiation from surface water. Measured results from samples collected at discharge points and in surface water and calculated radionuclide

concentrations are used in equations from LADTAP XL (Hamby 1991) or an equivalent methodology to estimate doses. The most recently published drinking water and creel survey data associated with the Clinch–Tennessee River system are used to quantify drinking water populations and fish harvests. Data on the population served from community water treatment systems located on the Clinch–Tennessee River system near and downstream of the ORR are obtained annually from the TDEC Division of Water Supply. Creel data are obtained from *Tennessee Statewide Creel Survey Results* (Black 2019), and provide information used to estimate the number of persons consuming fish from these water bodies.

EDs are calculated for radionuclides in drinking water drinking water plants near the ORR. Data from water samples collected before the water enters the drinking water plant are used; water plant outputs are not sampled. EDs from the ingestion of water and fish are estimated using population-weighted ingestion rates and DOE-STD-1196-2011 (DOE 2011) reference person dose coefficients. Dose coefficients for water immersion and shoreline use are from EPA-402/R18/001, Federal Guidance Report 15, *External Exposure to Radionuclides in Air, Water, and Soil* (EPA 2019). Population dose estimates are made for the population within 80 km (50 miles) of the ORR.

There are no known farmers or gardeners using irrigation sources that could be impacted by ORR activities. However, doses from irrigating food and feed crops are estimated at a location downstream of ORNL using the methodology and equations from NRC Regulatory Guide 1.109 (NRC 1977).

4.3.2.2 Nonradiological Contaminants in Surface Water

Hazard quotients for noncarcinogenic chemicals and risk estimates for carcinogenic chemicals are calculated for the drinking water and fish consumption pathways using measured concentrations in water and fish tissue where available.

4.4 RADIONUCLIDES IN OBJECTS

Sources of potential exposure to the public from radiation emanating from radionuclides contained in structures and other objects will be evaluated, as requested.

4.5 RADIATION DOSE TO NATIVE AQUATIC AND TERRESTRIAL ORGANISMS

DOE O 458.1 (DOE 2020a) requires the establishment of procedures and practices that ensure biota are protected and radiological activities are conducted in a manner that protects populations of aquatic animals, terrestrial plants, and terrestrial animals in local ecosystems from adverse effects due to radiation and radioactive material released from DOE operations. DOE-STD-1153-2019, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2019a) establishes a dose rate criterion of 0.1 rad/day for riparian and terrestrial animals and dose rate criterion of 1 rad/day for aquatic organisms and terrestrial plants.

To demonstrate compliance with these limits, the method described in DOE-STD-1153-2019 is used to estimate absorbed dose rates to aquatic organisms and terrestrial organisms. Absorbed doses are generally calculated using the RESRAD-BIOTA computer code (DOE 2019b), but other methods may also be used. The graded approach consists of a three-step evaluation that begins with a conservative general screening and, if needed, ends with a rigorous analysis using site-specific information. The general screening involves comparing maximum radionuclide concentrations from water, sediment, and/or soil to default biota concentration guides. If the general screening indicates further evaluation is needed, a site-specific screening is performed. This typically includes comparing average radionuclide concentrations in water and sediment (for aquatic biota) or soil (terrestrial) with default biota concentration guides. If these

comparisons indicate additional evaluations are needed, more rigorous site-specific analysis and site-specific biota dose assessment may be required.

4.6 DOSE ASSESSMENT QUALITY ASSURANCE

EPSD uses UT-Battelle's Standards Based Management System (SBMS) to provide a systematic approach to integrating QA and environmental and safety considerations into all activities. 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 their work. SBMS translates laws, orders, directives, policies, and best management practices into laboratory-wide subject areas and procedures.

In addition to applicable guidance and instructions in SBMS subject areas (e.g., Work/Project Planning and Control, Personnel Training and Qualifications, Records Management, and Assessments), approved procedures and technical directives for dose assessment are controlled and maintained through the ORNL Integrated Document Management System along with descriptions of models used, implementing computer codes, values and sources of input data, and underlying assumptions.

5. OAK RIDGE RESERVATION ENVIRONMENTAL SURVEILLANCE

In addition to environmental monitoring conducted at the three major DOE ORR installations, reservation-wide surveillance monitoring is performed to directly measure radiological and nonradiological parameters in environmental media adjacent to the facilities. Data from these environmental monitoring and surveillance programs are analyzed to assess the environmental impact of DOE operations on the entire reservation and the surrounding area.

5.1 AMBIENT AIR

5.1.1 Purpose and Scope

Ambient air monitoring is performed to directly measure radiological parameters in the ambient air adjacent to ORR facilities; this monitoring supplements data from exhaust stack monitoring conducted at Y-12, ORNL, and ETTP. Ambient air monitoring also provides a means to verify that fugitive and diffuse sources are insignificant, serves as a check on dose modeling calculations, and allows determination of contaminant levels at monitoring locations in the event of emergencies.

5.1.2 Sampling Locations

The ORR ambient air monitoring network includes 10 stations on or near the reservation and a reference station in an area not affected by Oak Ridge operations. Atmospheric dispersion modeling, evaluations of land ownership, and accessibility of areas that once were not available to the public were used to select appropriate sampling locations (Fig. 5.1).

5.1.3 Frequency

Continuous sampling is performed with weekly to biweekly collection of sampling media. Quarterly composites are submitted for laboratory analyses.

5.1.4 Parameters and Methods

Samples are analyzed for gross alpha, gross beta, gamma-emitting radionuclides, and specific radionuclides that contribute ≥0.1 mrem to the ORR ED from airborne emissions. Tests for other isotopes that are significant contributors to the ORR ED may also be performed periodically to confirm that dose models are not underestimating dose to the public. The sampling system consists of two separate instruments, one for particulates and one for tritiated water vapor. Particulates are captured on glass-fiber filters in a high-volume air sampler. Tritiated water vapor is captured using a sampler that consists of a prefilter followed by an adsorbent trap consisting of indicating silica gel. The samples are collected weekly or biweekly, composited quarterly, and then submitted to the laboratory for analysis (Table 5.1).

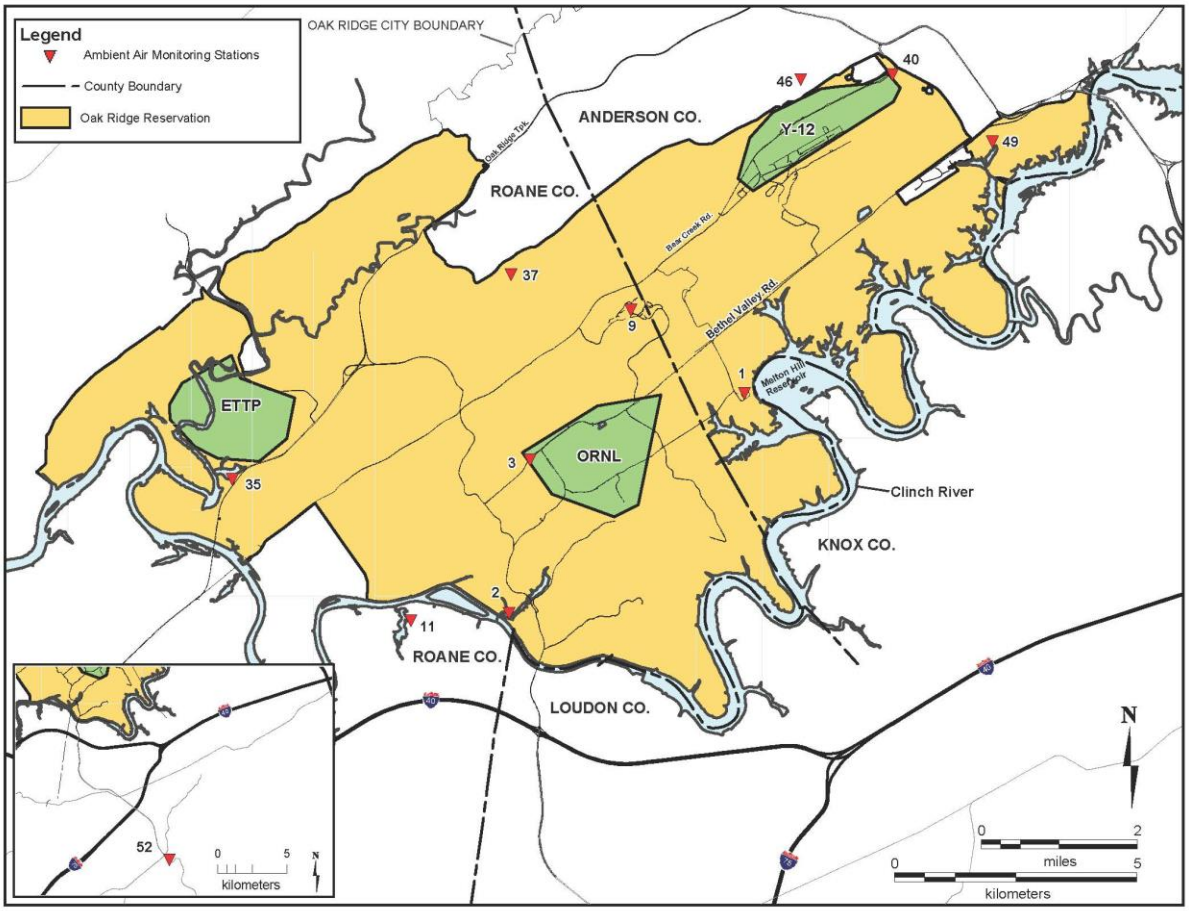

Fig. 5.1. Oak Ridge Reservation perimeter ambient air monitoring stations.

Table 5.1. Ambient Air Parameters Analytical Methods, and Report Levels

Parameter	Media	Method	Report Level
Gross alpha	Glass-fiber filter	EPA 900.0	4.7 pCi
Gross beta	Glass-fiber filter	EPA 900.0	7.5 pCi
Gamma scan[a]	Glass-fiber filter	EPA 901.1	^{7}Be—90 pCi ^{40}K—180 pCi
^{234}U	Glass-fiber filter	Lab specific	0.1 pCi
^{235}U	Glass-fiber filter	Lab specific	0.1 pCi
^{238}U	Glass-fiber filter	Lab specific	0.1 pCi
^{99}T[b]	Glass-fiber filter	Lab specific	35 pCi
Tritium	Silica gel	EPA 906.0	100 pCi

[a] Report ^{40}K, ^{7}Be, and all detectable manmade isotopes.
[b] Report ^{99}Tc only for stations 35 and 52.

5.2 EXTERNAL GAMMA RADIATION

5.2.1 Purpose and Scope

Members of the public could hypothetically be exposed directly to gamma radiation from radionuclides released into the environment; previously released radionuclides deposited on soil and vegetation or in sediments; radiation-generating facilities, especially high-energy accelerators; and the storage of radioactive materials.

5.2.2 Sampling Locations and Methodology

Direct radiation levels are monitored continuously with dual-range Geiger-Müller detectors at seven ORR ambient air stations (2, 3, 9, 11, 40, 46, and 49) and the Fort Loudoun reference location, station 52 (Fig. 5.2).

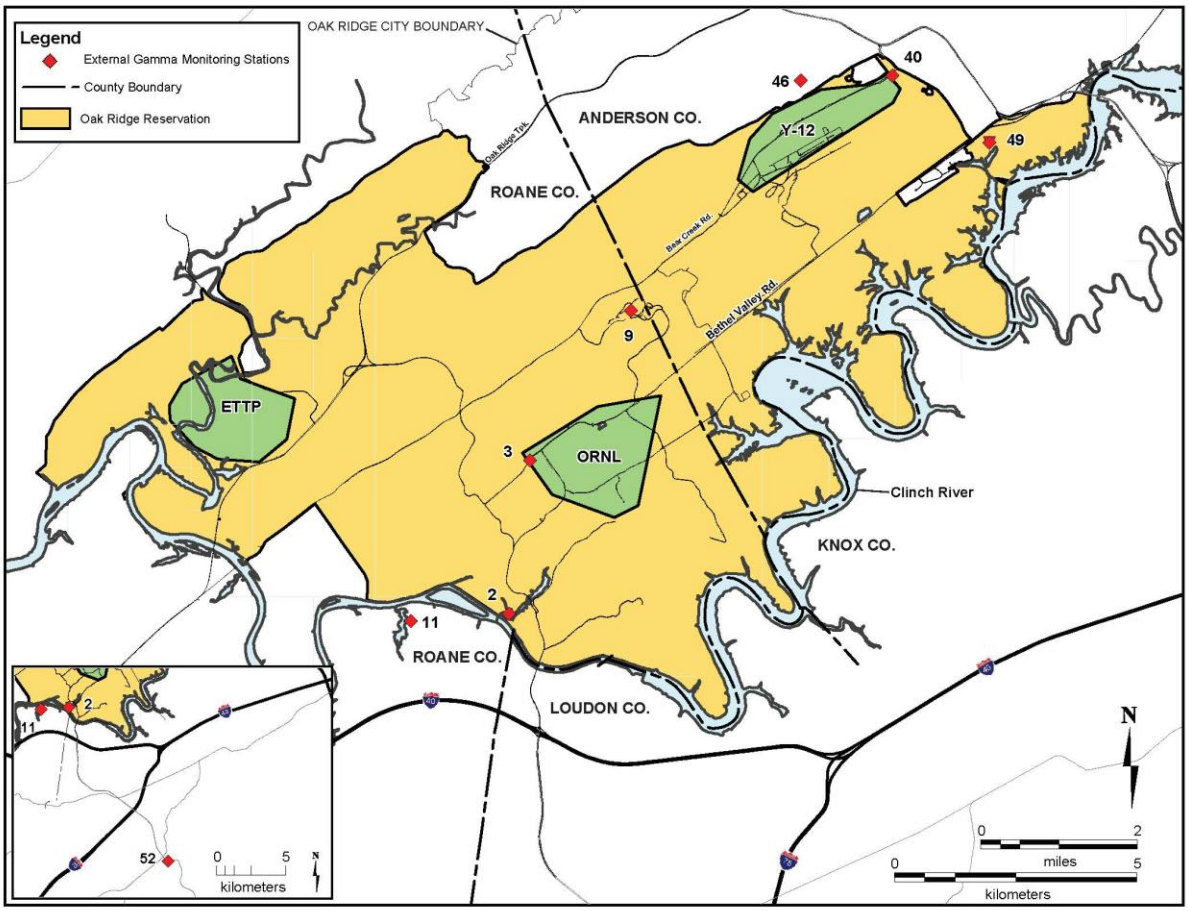

Fig. 5.2. Oak Ridge Reservation external gamma radiation monitoring locations.

5.3 SURFACE WATER

5.3.1 Purpose and Scope

Members of the public could potentially be exposed to waterborne pollutants released from the ORR through drinking water, irrigation, and recreational activities such as boating, fishing, or swimming. ORR surface water monitoring is conducted at four locations on the Clinch River.

5.3.2 Sampling Locations

The four surface water sampling locations are as follows (Fig. 5.3):

- Clinch River above DOE inputs at Oak Ridge water supply intake (Clinch River kilometer [CRK] 66)
- Clinch River at Knox County water supply intake (CRK 58)
- Clinch River downstream from ORNL at Jones Island (CRK 32)
- Clinch River downstream of DOE inputs at Brashear Island (CRK 16)

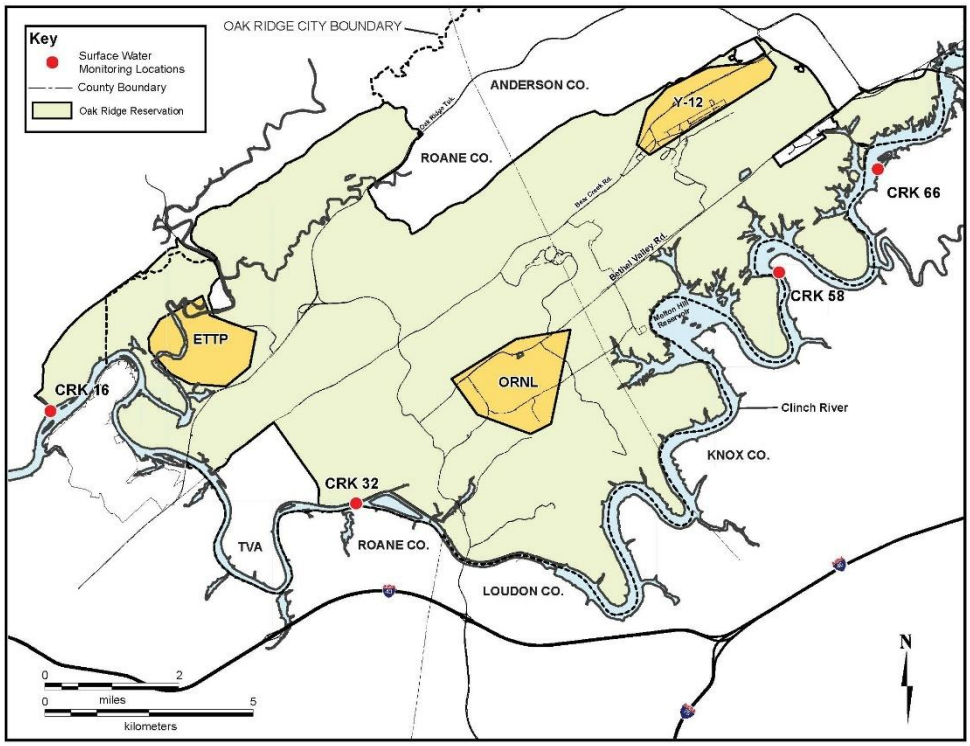

Fig. 5.3. Oak Ridge Reservation surface water surveillance sampling locations.

5.3.3 Parameters and Methods

Table 5.2 indicates the locations included in the surface water program, parameters, and required analytical methods. Additional analyses for other isotopes may be performed periodically to confirm that routinely monitored parameters are adequately characterizing doses associated with offsite surface water. All samples are grab samples.

Table 5.2. Surface Water Locations, Parameters, Methods, and Report Levels

Location	Parameter	Analytical Method	Report Level
CRK[a] 16, 32, 66	Mercury	EPA 7470A	0.07 ug/L
All	Gross alpha[b]	EPA 900.0	3 pCi/L
All	Gross beta[c]	EPA 900.0	3 pCi/L
All	Gamma scan[d]	EPA 901.1	^{7}Be—100 pCi/g ^{40}K—50 pCi/g
CRK 16, 32, 66	Total strontium	EPA 905.0	2 pCi/L
All	Tritium	EPA 906.0	270 pCi/L
All	Field measurements[e]		

[a] CRK = Clinch River kilometer.
[b] Specific isotopic analyses are performed when gross alpha measurements exceed 15 pCi/L.
[c] Specific isotopic analyses are performed when gross beta measurements exceed 50 pCi/L and are not accounted for by other monitoring results (e.g., beta activity from total strontium, ^{40}K, etc.).
[d] Report ^{40}K, ^{7}Be, and all detectable manmade isotopes.
[e] Temperature, dissolved oxygen, and pH.

5.4 VEGETATION AND MILK

5.4.1 Vegetables

5.4.1.1 Purpose and Scope

As available, food crops are sampled annually from garden locations that have the potential to be affected by airborne releases from the ORR to evaluate possible radiation doses received by consumers because of DOE activities in the area. Samples are also obtained from a reference location in an area not impacted by ORR activities for comparison. Surveys of areas of potential impact will be performed and, if available, crops that represent broad-leaf systems (lettuce, turnip greens, etc.), root-plant-vegetable systems (tomatoes), and root-system vegetables (turnips, potatoes, etc.) will be obtained from each location sampled.

5.4.1.2 General Locations

The following general locations will be surveyed for availability:

- Reference location
- Southeast of ETTP/Southwest of ORNL (Jones Island area)
- Southeast of ORNL (Gallaher Bend area)
- North of Y-12 (Scarboro community)

5.4.1.3 Parameters, Analytical Methods, and Report Levels

All samples are analyzed for gross alpha, gross beta, gamma-emitting radionuclides, and specific radionuclides that contribute ≥0.1 mrem to the ORR ED from airborne emissions (Table 5.3). Additional analyses for other isotopes may be performed periodically to confirm that routinely monitored parameters are adequately characterizing doses from consuming food crops.

Table 5.3. Vegetable Parameters, Analytical Methods, and Report Levels

Parameter	Method	Report Level
Gross alpha	EPA 900.0	0.0007 pCi/g
Gross beta	EPA 900.0	0.020 pCi/g
Gamma spec[a]	EPA 901.1	^{7}Be—2.1E1 pCi/g ^{40}K—2 pCi/g
^{234}U	Lab specific	0.010 pCi/g
^{235}U	Lab specific	0.010 pCi/g
^{238}U	Lab specific	0.010 pCi/g

[a] Report ^{40}K, ^{7}Be, and all detectable manmade isotopes.

5.4.2 Milk

An availability assessment of dairy operations in areas surrounding the ORR will be performed annually. Milk samples will be collected bimonthly if cooperating commercial or family dairy operations are identified in areas that could potentially be impacted by ORR activities. The parameters, analytical methods, and detection levels applicable to milk samples, when available, are presented in Table 5.4. Additional analyses for other isotopes may be performed periodically to confirm doses from consuming milk are adequately characterized.

Table 5.4. Milk Parameters, Analytical Methods, and Report Levels

Parameter	Method	Report Level
Tritium	EPA 906.0	710 pCi/L
Total rad strontium	EPA 905.0	2.1 pCi/L
Gamma scan[a]	EPA 901.1	^{7}Be—75 pCi/L ^{40}K—100 pCi/L

[a] Report ^{40}K, ^{7}Be, and all detectable manmade isotopes.

5.4.3 Hay

Hay from the southeastern edge of the ORR is made available to an offsite farming operation and is sampled annually, typically during or soon after the first cutting. Parameters, analytical methods, and detection levels applicable to hay are listed in Table 5.5. Additional analyses for other isotopes may be performed periodically to confirm that routinely monitored parameters are adequately characterizing doses traceable to hay grown on the ORR.

Table 5.5. Hay Parameters, Analytical Methods, and Report Levels

Parameter	Method	Report Level
Gross alpha	EPA 900.0	0.7 pCi/g
Gross beta	EPA 900.0	1.5E+01 pCi/g
Gamma spec[a]	EPA 901.1	^{40}K—2.0E+01 pCi/g
^{234}U	Lab specific	0.010 pCi/g
^{235}U	Lab specific	0.010 pCi/g
^{238}U	Lab specific	0.010 pCi/g

[a] Report ^{40}K, ^{7}Be, and all detectable manmade isotopes.

5.5 WILDLIFE MONITORING

The ORR Surveillance Program will continue to conduct annual screenings of Canada geese and to analyze data collected by wildlife management staff from radiological screenings and samples of deer and turkey harvested during hunts on the ORR as available.

5.5.1 Deer Hunts

Deer hunts are held annually in November and December on the ORR. Deer are screened for radioactivity before release to hunters. Screening data and any data available from laboratory analyses will be used to estimate doses to consumers of deer harvested on the ORR. Currently deer are screened in the field for gross beta in a sample of leg bone and a sample of muscle tissue is screened for ^{137}Cs. Analyses for other isotopes may be performed periodically to confirm that ^{137}Cs and ^{90}Sr are the only contaminants of concern.

5.5.2 Turkey Hunts

Turkey hunts are held annually in April on the ORR. Turkeys are screened for radioactivity before release to hunters. Screening data and any data available from laboratory analyses will be used to estimate doses to consumers of turkey harvested on the ORR.

5.5.3 Goose Roundup

An annual goose roundup is conducted on the reservation in the June–July period. Canada geese undergo live screenings for gamma-emitting radionuclides to confirm that radionuclide levels remain negligible. No geese will be sacrificed for laboratory analyses based on historical results which show that field radiological screening results and laboratory analyses are in good agreement.

5.5.4 Fish

5.5.4.1 Purpose and Scope

Members of the public could be exposed to contaminants originating from DOE ORR activities through consumption of fish caught in area waters. To monitor this human exposure pathway, sunfish and catfish are collected annually from three locations on the Clinch River, and edible fish flesh is analyzed for selected parameters.

5.5.4.2 Sampling Locations

The three sampling locations are as follows (Fig. 5.4):

- Clinch River upstream from all DOE ORR inputs (near CRK 70)
- Clinch River downstream from ORNL (near CRK 32)
- Clinch River downstream from all DOE ORR inputs (near CRK 16)

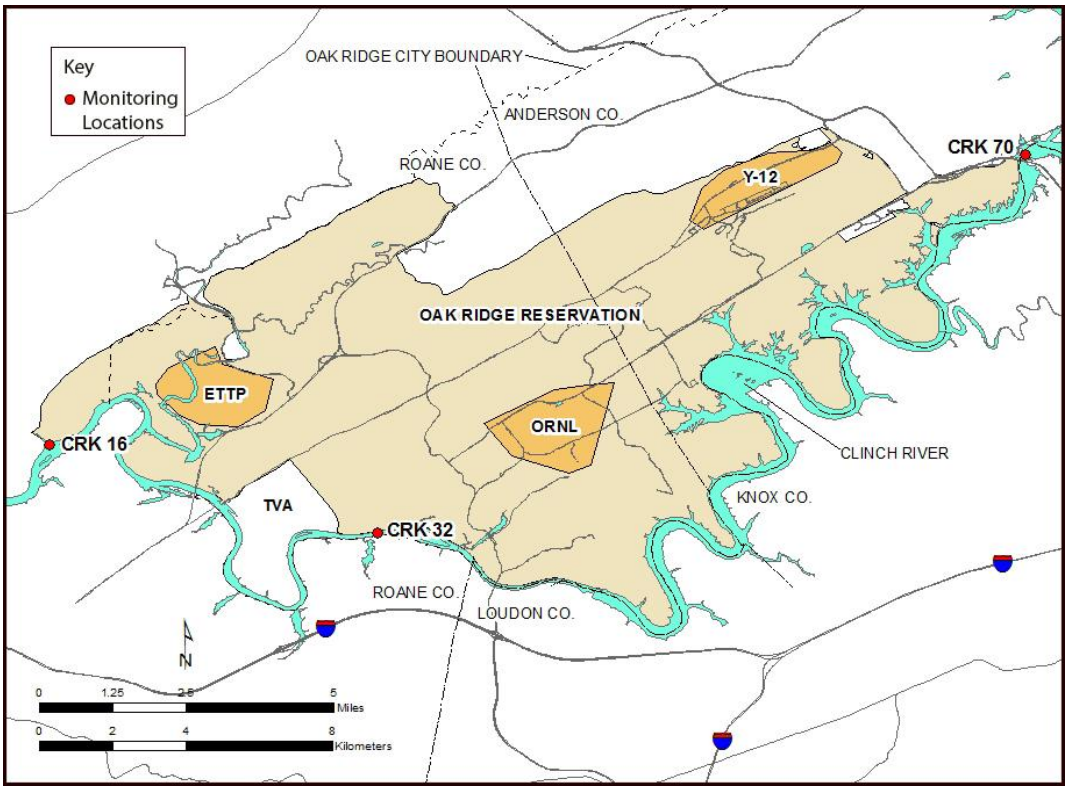

Fig. 5.4. Oak Ridge Reservation fish sampling locations.

5.5.4.3 Parameters, Analytical Methods, and Detection Levels

Fish are segregated by species and composited for analyses. Samples consist of edible fish tissue (filets) from fish that are in the size ranges recreational fishermen would be expected to harvest. A sufficient number of fish are collected from each location to meet analytical requirements. Table 5.6 lists the parameters that are included in the fish sampling program, required analytical methods, and analytical detection levels. Additional analyses for other isotopes may be performed periodically to confirm that routinely monitored parameters are adequately characterizing doses from consumption of fish.

Table 5.6. Fish Parameters, Analytical Methods, and Report Levels

Parameter	Method	Detection Level
Tritium	EPA 906.0	12 pCi/g
Total radiostrontium	ASTM D5811	0.031 pCi/g
Gross alpha	EPA 900.0	0.0011pCi/g
Gross beta	EPA 900.0	0.031 pCi/g
Gamma spec[a]	EPA 901.1	^{7}Be—6.48 pCi/g ^{40}K—0.26 pCi/g
Mercury	EPA 7471	0.04 mg/kg
Metals	EPA 6010/6020	[b]
PCBs	EPA 8082	0.02 mg/kg (all aroclors)

[a] Report ^{40}K, ^{7}Be, and all detectable manmade isotopes.
[b] Methods 6010/6020 are applicable to the determination of a large number of individual elements, including metals. Method report limits vary for individual elements and with sample matrix. Laboratory contracts include requested detection levels for a large number of metals based on these considerations.

5.6 ADDITIONAL MONITORING

A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota (DOE 2019a) and RESRAD-BIOTA are used to demonstrate compliance with DOE Order 458.1 (DOE 2013) and the 1 rad/day DOE recommended dose rate criteria for aquatic organisms and terrestrial plants and the 0.1 rad/day rate criteria for riparian animals.

5.6.1 Aquatic Biota Sampling Strategy

To demonstrate compliance with the dose rate criteria of 0.1 rad/day for riparian animals (those residing on or near natural waterways) and 1 rad/day for aquatic organisms, radiological results from surface water and sediment (when available) samples collected for ORR, ORNL, ETTP, and Y-12 environmental monitoring programs are evaluated annually using RESRAD-BIOTA (DOE 2019b). This dose evaluation tool uses screening and analysis methods to determine if radiological biota doses are less than the limits.

At ORNL, instream water sampling locations for aquatic biota currently include Melton Branch (Headwaters and X13), White Oak Creek (X14, X15), Fifth Creek, Northwest Tributary, and Clinch River (CRK 23 and CRK 66). At ETTP, instream water sampling locations include Mitchell Branch (K1700), Poplar Creek (K-716, K1007-B, K-1710, K-702A, and K901-A) and Clinch River (CRK 16). At Y-12, instream water sampling locations include East Fork Poplar Creek (Surface Water Hydrological Information Support System monitoring location 9422-1) and outfalls S24 (Bear Creek), S17 (tributary to Clinch River), and S19 (Rogers Quarry). These locations may vary from year to year.

5.6.2 Terrestrial Biota

To demonstrate compliance with the dose rate criteria of 0.1 rad/day for terrestrial and riparian animals and 1 rad/day for terrestrial plants, a graded approach was implemented: (1) soil sampling to estimate doses based on radionuclide concentrations in soil and (2) site-specific sampling of biota when the

benchmark of 0.1 rad/day for terrestrial biota or 1 rad/day for terrestrial plants is exceeded in soil screening.

Soil sampling locations have included White Oak Creek floodplain, Bear Creek Valley floodplain, Mitchell Branch floodplain, and a background location. Site-specific sampling of biota on the White Oak floodplain and a background location was conducted in 2009. Deer mice (*Peromyscus maniculatus*) were selected as the representative species due to habitat and feeding behavior. Results from this sampling indicated that dose rate limits had not been exceeded.

Examples of sampling locations and parameters used in soil screenings are listed in Table 5.7. Biota analyses have focused primarily on radionuclides that contribute to the terrestrial biota dose (^{137}Cs) but may also include radionuclides detected in previously collected soil samples. Sampling locations and parameters may vary dependent on previous sampling results and facility operations.

Evaluation of terrestrial biota doses based on soil sampling is anticipated to be conducted periodically or following abnormal events that could have adverse impacts on terrestrial organisms.

Table 5.7. Examples of Soil Sampling Locations and Parameters for Terrestrial Biota Dose Screening

Location	Parameters
White Oak Creek floodplain	^{241}Am, $^{243/244}$Cm, ^{60}Co, ^{137}Cs, ^{40}K, ^{238}Pu, $^{239/240}$Pu, $^{89/90}$Sr, $^{233/234}$U, ^{235}U, and ^{238}U
Bear Creek Valley floodplain	^{241}Am, $^{243/244}$Cm, ^{60}Co, ^{137}Cs, ^{40}K, ^{238}Pu, $^{239/240}$Pu, $^{89/90}$Sr, $^{233/234}$U, ^{235}U, and ^{238}U
East Fork Poplar Creek	^{241}Am, $^{239/240}$Pu, $^{233/234}$U, and ^{238}U
Melton Branch	^{241}Am, $^{243/244}$Cm, ^{60}Co, ^{137}Cs, ^{40}K, ^{238}Pu, $^{239/240}$Pu, $^{89/90}$Sr, $^{233/244}$U, ^{235}U, ^{238}U
Mitchell Branch floodplain	^{241}Am, $^{239/240}$Pu, $^{233/234}$U, and ^{238}U
Background locations	^{241}Am, $^{243/244}$Cm, ^{60}Co, ^{137}Cs, ^{40}K, ^{238}Pu, $^{239/240}$Pu, ^{90}Sr, ^{234}U, and ^{238}U

5.7 ENVIRONMENTAL SAMPLING AND DATA EVALUATION QUALITY ASSURANCE

5.7.1 Introduction

The application of QA/ QC programs for environmental monitoring activities on the 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. ESDE uses SBMS (described in Section 4.6) to provide a systematic approach to integrating QA, environmental, and safety considerations into every aspect of ORR environmental monitoring.

5.7.2 Work/Project Planning and Control

UT-Battelle's Work/Project Planning and Control Management System establishes 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
- work planning-analyzing hazards and defining controls
- work execution
- provide feedback

In addition, ESDE has approved project-specific standard operating procedures (SOPs) for all activities that are controlled and maintained through the ORNL Integrated Document Management System. Environmental sampling SOPs developed for ORR environmental surveillance programs provide detailed instructions on maintaining chain of custody; sample identification; sample collection and handling; sample preservation; equipment decontamination; and collection of QC samples such as field and trip blanks, duplicates, and equipment rinses.

5.7.3 Personnel Training and Qualifications

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

A functional training matrix has been defined for all ESDE job functions and is maintained on a controlled EPSD internal training requirements web page. Functional Training Matrixes were derived using several resources, including verification analysis (i.e., similar job positions on the Internal Training Requirements Matrix), document analysis (i.e., SBMS procedures, internal division and specific group standard operating procedures), and functional job analysis (i.e., interviews with staff and management). Training status is routinely monitored by the division training officer, and notices of training needs or deficiencies are automatically sent to individual employees.

The training program is supplemented by a division-wide Required Reading program. This program ensures that staff members have reviewed new/revised documents (procedures, lessons learned, etc.) applicable to their jobs.

5.7.4 Equipment and Instrumentation

Calibration

The UT-Battelle Quality Management System includes subject area directives that establish the standard that all ORNL staff shall 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 Controls group (F&O/I&C) tracks sampling equipment used by ESDE personnel in ORR environmental monitoring programs through a maintenance recall program to ensure equipment is functioning properly and within defined tolerance ranges. Upon receipt, each instrument is clearly identified and entered into the recall system. The determination of calibration schedules and frequencies is based on a graded approach at the activity planning level. ESDE 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. At a minimum, equipment manufacturer recommendations are followed. F&O/I&C project plans and work control evaluations incorporate all calibration requirements.

Standardization

ESDE sampling procedures include requirements and instructions for the proper standardization and use of monitoring equipment. These requirements include 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. Sampling SOPs also include instructions for designating nonconforming instruments as "out-of-service" and initiating requests for F&O/I&C maintenance.

5.7.5 Visual Inspection, Housekeeping, and Grounds Maintenance

ESDE 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.

5.7.6 Assessment

Independent audits, surveillance, and internal management assessments are performed to verify that requirements have been accurately specified and activities conform to expectations and requirements. The EPSD assessment schedule is developed in the UT-Battelle Assessments and Commitments Tracking System and includes information on both external and internal assessments. External assessments are scheduled based on requests from auditing agencies. In addition, internal management assessments of ORR environmental monitoring procedural compliance, safety performance, and work planning and control are also conducted. This includes surveillances by both direct line management and organizations independent of the group performing work. As part of the required management observation activities, DOE ORNL site office representatives participate in several surveillance assessments annually. Surveillance results, recommendations, and completion of corrective actions (if required) are also documented and tracked in the Assessments and Commitments Tracking System.

EPSD uses a Problem Event Reporting System that enables staff to document and disseminate information on any unplanned or unexpected event. This includes events that do not meet any reporting thresholds and enables early detection and correction of any low-level problems or trends. This system also captures positive events and observations and provides a means for sharing information on improvement opportunities.

5.7.7 Analytical Quality Assurance

The contract laboratories that perform analyses of environmental samples from ORR environmental monitoring programs are required to have documented QA/QC programs, trained and qualified staff, appropriately maintained equipment and facilities, and applicable certifications.

UT-Battelle uses a competitive award system to select laboratories, which are contracted under basic ordering agreements when available, to perform analytical work to characterize ORR environmental samples. Commercial laboratories contracted under the Integrated Contractor Procurement Team (ICPT) Basic Ordering Agreement are required to comply with the quality requirements set forth in the terms and conditions. Laboratories not covered by an active ICPT Basic Ordering Agreement are required to have a QA/QC program consistent with analytical chemistry industry standards and are required to participate in a blind performance testing program. When possible, laboratories are reviewed by the DOE Consolidated

Audit Program. This program, administered by DOE and subcontractors from across the DOE complex, establishes required internal and external laboratory control and performance evaluation programs, conducts on-site laboratory reviews that monitor the performance of all subcontracted laboratories, and verifies all quality requirements are met. The ICPT process achieves efficiencies across the DOE complex by providing leveraged procurement and the use of the consolidated audit program to eliminate the need for individual purchasers to conduct quality audits.

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 with ORR environmental samples to provide an additional check on analytical laboratory performance.

5.7.8 Data Management and Reporting

ORR environmental surveillance and monitoring data management is accomplished using the Environmental Sampling System (ESS), a web interface data management tool developed by UT-Battelle's Information Technology Services Division (ITSD). ITSD performs routine system maintenance and completes modifications and upgrades through work authorizations with EPSD. In managing ESS, ITSD adheres to the SBMS Information Technology Management System subject area, *Software Quality Assurance*, which defines the minimum requirements for development and acquisition of software at ORNL. This subject area requires that all software products incorporate a level of formal QA that is commensurate with the potential impact of the software on the environment, safety, health, security, legal requirements, costs, or mission of the laboratory.

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 compliance screening is performed on each file during loading to ensure all required analyses were performed, appropriate analytical methods were used, holding times were met, and specified detection levels were achieved.

Following the compliance 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 are within required limits. More in-depth investigations are conducted to explain questionable results. This involves examining field- and laboratory-generated records and log sheets, communicating with analytical laboratory and/or sampling personnel, and determining any other factors that may account for the unexpected result (e.g., atypical weather or site activity that may have affected the sampling).

ORR environmental surveillance data are summarized and reported annually in the ASER.

5.7.9 Records Management

The UT-Battelle Records Management System provides the requirements for managing all ORNL records. Requirements include creating and identifying record material; scheduling, protecting, and storing records in both office areas and the ORNL Inactive Records Handling Area; and destroying records.

6. REFERENCES

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