TENNESSEE DEPARTMENT
OF
ENVIRONMENT AND CONSERVATION

DIVISION OF REMEDIATION
OAK RIDGE OFFICE

ENVIRONMENTAL MONITORING PLAN

For Work to be Performed:

July 1, 2024, through June 30, 2025

December 2024

Tennessee Department of
Environment and Conservation,
Authorization No. 327023

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ACRONYMS

A	Ac-228	actinium-228
	Am-241	americium-241 (transuranic isotope)
	ANOVA	Analysis of variance in statistics
	ARA	Airborne Radiological Area
	ARARs	applicable or relevant and appropriate requirements
	As	arsenic (metal)
	ASER	Annual Site Environmental Report (ASER), Calendar Year, DOE
	ASWSP	Ambient Surface Water Sampling Project
	ATSDR	Agency for Toxic Substances and Disease Registry
	AWQC	Ambient Water Quality Criteria
B	Ba	barium (metal)
	Background site	reference site: background site located outside of a 5-mile radius of potential impact from the Oak Ridge Reservation
	BC	blue catfish
	BCAP	Bear Creek Assessment Project
	BCK	Bear Creek Station or Bear Creek Kilometer
	BC/BCK/BCV	Bear Creek/Bear Creek kilometer or station/Bear Creek Valley
	BCBGs	Bear Creek Burial Grounds
	Be-7	beryllium-7 (metal)
	Benthic Life	Organisms that live on or in the streambed (aquatic insects, amphibians, spiders, worms, etc.)
	Bi-214	bismuth-214
	Biocides	Any product or substance used in a cooling tower which is intended to destroy, control or prevent the effects of algae, bacteria, sulfate-reducing bacteria, protozoa, and fungi.
	BMP	Best Management Practices
	Bo	boron (metal)
C	CA	Contamination Area
	CAA	Clean Air Act
	CBSQGs	Consensus Based Sediment Quality Guidelines
	CC	channel catfish
	CC/CCK	Clear Creek/Clear Creek kilometer (background stream)
	CCME	Canadian Council of Ministers for the Environment
	Cd	cadmium (metal)
	CEC	Civil and Environmental Consultants
	CERCLA	*The Comprehensive Environmental Response, Compensation, and Liability Act* (commonly known as Superfund) enacted by Congress on December 11, 1980.

	Cm	curium-242/244
	CMP	Comprehensive Monitoring Plan
	Co-60	cobalt-60
	COC	Chain of Custody
	COCs	Contaminants of Concern
	COND	conductivity
	Cr_6	Hexavalent Chromium (metal)
	CR/CRK	Clinch River/Clinch River kilometer
	Cs-137	cesium-137 (metal)
	CSU	Combined Standard Uncertainty
	Cu	copper (metal)
	CW	Contact Water
D	D&D	Decontamination and Decommissioning
	DO	Dissolved oxygen
	DOE	U.S. Department of Energy
	DOE EM	U.S. Department of Energy Environmental Management
	DoR	Division of Remediation
	DOR-OR	Division of Remediation – Oak Ridge
	DWR	Division of Water Resources
E	EFPC/EFK	East Fork Poplar Creek/East Fork Poplar Creek Kilometer
	EFPCAP	East Fork Poplar Creek Holistic Watershed Assessment Program/ East Fork Poplar Creek Assessment Project/
	EFPC-PC	East Fork Poplar Creek - Poplar Creek Confluence
	EMDF	Environmental Management Disposal Facility
	EMP	Environmental Monitoring Plan
	EMR	Environmental Monitoring Report
	EMWMF	Environmental Management Waste Management Facility
	EPA	U.S. Environmental Protection Agency
	EPT	*Ephemeroptera* (mayflies*), Plecoptera (*stoneflies*), and Trichoptera (*caddisflies*)*
	%EPT – Cheum	Percent EPT - Cheumatopsyche (tolerant Trichoptera)
	ESOA	Environmental Surveillance Oversight Agreement
	ESD	Environmental Sciences Division
	ETA	Edgewater Technical Associates (DOE subcontractor)
	ETTP	East Tennessee Technology Park (formerly K-25)
F	FDA	Food and Drug Administration (Federal)

	FFA	Federal Facility Agreement
	FHC	flathead catfish
	FRMAC	Federal Radiological Monitoring and Assessment Center
G	GCN	greatest conservation need
	GPS	Global Positioning System
H	HAZWOPER	Hazardous Waste Operations and Emergency Response
	H_2SO_4	sulfuric acid
	H-3	tritium
	HAs	Health Advisory Values
	HCl	hydrochloric acid
	HEU	highly enriched uranium
	HFIR	High Flux Isotope Reactor
	Hg	mercury (metal)
	HQ	Hazard Quotient (noncarcinogenic risk equations)
	HNO_3	nitric acid
	HRE	Homogeneous Reactor Experiment
	HW	hazardous waste
I	I-129	iodine-129
	IACUC	Institutional Animal Care and Use Committee
	IC25	Inhibition Concentration 25% reduction in survival, growth and reproduction of test organism
	IH	Industrial hygiene
	ISM	Incremental Sampling Methodology
	ITRC	Interstate Technology Regulatory Council
J	J values	Result less than MQL but greater than or equal to MDL
K	K-25	Former site of Gaseous Diffusion Plant closed in 1987, now ETTP
	K-27	Sampling site on ETTP
	K-40	potassium-40
L	LLW	Low-level radioactive waste
	LMB	largemouth bass
	LSC	Liquid Scintillation Counting
	LLRW	low-level radioactive waste
M	MB/MBK	Mill Branch/Mill Branch kilometer (background stream)
	MCL	Maximum Contaminant Limit see NPDWR

	MDC	Minimum Detectable Concentration
	MDL	Minimum Detection Limit
	MeHg	methylmercury
	MH	manhole 1 (MH-1), manhole 2 (MH-2) at Y-12
	MIB	Mean Index Biomass
	MIK	Mitchell Branch/Mitchell Branch kilometer
	MQL	Minimum Quantification Limit
	MQL	Method Quantification Limit
	MSRE	Molten Salt Reactor Experiment
	MV	Melton Valley
	MV-OS	Melton Valley Offsite Subarea
N	NaI	sodium iodide (used in gamma scintillator probe)
	NAREL	National Air and Radiation Environmental Laboratory (EPA)
	NBG	North Boundary Greenway
	NCBI	North Carolina Biotic Index
	NCP	National Contingency Plan
	NEON	National Ecological Observatory Network
	NESHAPS	National Emissions Standards for Hazardous Air Pollutants
	Ni	nickel (metal)
	NNSA	National Nuclear Safety Administration
	NOAA	National Oceanic and Atmospheric Administration
	NORM	Naturally Occurring Radioactive Materials
	Np-237	neptunium-237 (transuranic isotope)
	NPDES	National Pollution Elimination System permit
	NPDWR	National Primary Drinking Water Regulations
	NPL	National Priority List
	NRC	Nuclear Regulatory Commission
	NSDWR	National Secondary Drinking Water Regulations
	NT-5	Bear Creek Northwest Tributary 5
	NTU	nephelometric turbidity units
	NUREG	NRC Regulation
O	OF-200 MTF	Outfall 200 Mercury Treatment Facility at Y-12
	ORAU	Oak Ridge Associated Universities
	OREIS	Oak Ridge Environmental Information System
	ORNL	Oak Ridge National Laboratory, also known as X-10
	ORP	Oxygen Reduction Potential
	ORR	Oak Ridge Reservation
	OS	Offsite Subarea

	OSL	Optically Stimulated Luminescence Dosimeter
	%OC	Percent *Oligochaeta* and *Chironomidae*
P	Pb	lead, Pb-212/214
	PC-CR	Poplar Creek – Clinch River Confluence
	PC/PCK/PCM	Poplar Creek/Poplar Creek kilometer/Poplar Creek mile
	PCBs	Polychlorinated Biphenyls
	PCCR	Phased Construction Completion Report
	PEC	Probable Effects Concentration
	POP	Persistent Organic Pollutants
	PPE	Personal Protective Equipment
	PRGs	Preliminary Remediation Goals
	Pu	plutonium-238/239/240 (transuranic isotope)
	PWTC	Process Waste Treatment Complex
Q	QA/QC	Quality Assurance/Quality Control
	QAPP	Quality Assurance Project Plan
	QEC	Quality Environmental Containers (Beaver, WI)
R	RA	Remedial Activities/ Radiological Area
	Ra	radium
	RADCON	Radiation Control Program
	RAIS	Risk Assessment Information System
	RBC	Risk-based criteria
	RCPs	Radiation Control Personnel
	RCS	Roving Creel Survey
	RER	Remediation Effectiveness Report
	ROD	Record of Decision
	RPM	Radiation Portal Monitor
	RPTs	Radiological Protection Technicians
	RSLs	Regional Screening Levels
	RWP	Radiation/Radiological Work Permit
S	SAIC	Science Applications International Corporation
	SAP	Sampling and Analysis Plan
	SD	storm drain
	SIOU	Surface Impoundment Operable Unit
	SMB	smallmouth bass
	SMCLs	Secondary Maximum Contaminant Levels same as NSDWRs
	SNS	Spallation Neutron Source

	SOP	Standard Operating Procedure
	Sr-90	strontium-90
	SRS	Southern Research Station
	SSL	Soil Screening Level
	Station	A specific location where environmental sampling or monitoring takes place.
	SU	standard units
	SW	Surface Water
	StW	Storm Water
	SWPPP	Storm Water Pollution Prevention Plan
	SWSA	Solid Waste Storage Area
T	T&E species	State- or Federally-listed threatened and endangered species as protected under the Endangered Species Act of 1973.
	Tc-99	technetium-99
	TDEC	Tennessee Department of Environment and Conservation
	TDEC-DoR	TDEC - Division of Remediation
	TDH	Tennessee Department of Health
	TDH-NEL	Tennessee Dept. of Health - Nashville Environmental Laboratory
	TECs	Threshold Effects Concentrations
	TEDE	Total Effective Dose Equivalent
	TENORM	Technically Enhanced Naturally Occurring Radioactive Materials
	Th	thorium-228/230/232
	THI	Target Hazard Index
	THQ	Target Hazard Quotient
	Tl-208	thallium-208
	TMI	Tennessee Macroinvertebrate Index
	TNUTOL	Total Nutrient Tolerant
	TN AWQC	State of Tennessee Ambient Water Quality Criteria
	TR	Target Risk
	TS	tree swallows
	TWQC	Tennessee Water Quality Criteria
	TWRA	Tennessee Wildlife Resources Agency
U	U	Result is less than Method Detection Limit (MDL)
	U-234/235/238	uranium-234/235/238
	UEFPC/UEFK	Upper East Fork Poplar Creek/Upper East Fork Creek Kilometer
	USDI	U.S. Department of the Interior
	USFWS	US. Fish and Wildlife Service
	UV	Ultraviolet

V	VOCs	volatile organic compounds
W	WAC	Waste Acceptance Criteria
	WB	white bass
	WC/WCK	White Oak Creek/White Oak Creek/White Oak Creek kilometer
	WD	wood duck
	WDNR	Wisconsin Department of Natural Resources
	WE	Walleye
	WET	Whole Effluent Toxicity
	WOCAP	White Oak Creek Assessment Project
	WOE/WOCE	White Oak Creek Embayment
	WOCE-CR	White Oak Creek Embayment - the Clinch River Confluence
	WOCW	White Oak Creek Watershed
	WOL	White Oak Lake
	WOL-CR	White Oak Lake-Clinch River
	WQPP	Water Quality Protection Plan
X	X-10	Historical name, renamed Oak Ridge National Lab (ORNL)
Y	Y-12	Y-12 National Security Complex (Building 9213, 9219, 9723-28)

UNITS OF MEASURE AND THEIR ABBREVIATIONS

°C	degrees Celsius/Centigrade
µS/cm	micro-Siemens per centimeter
mV	millivolts
DO	amount of gaseous (O_2) dissolved in water
pH	scale of acidity from 0 to 14
µg/L	micrograms per liter (parts per billion)
mg/L	milligrams per liter (parts per million)
ng/g	nanograms per gram (parts per billion)
µg/g	micrograms per gram (parts per million)
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
millirem	A millirem is one thousandth of a rem
rem	A rem is the unit of effective absorbed dose of ionizing radiation in human tissue, equivalent to one roentgen of X-rays
mrem	Abbreviation for millirem which is a unit of absorbed radiation dose

EXECUTIVE SUMMARY

The Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office (TDEC DoR-OR), provides the annual *Environmental Monitoring Plan* (EMP), for fiscal year 2025 (FY25) with a period of performance from July 1, 2024, through June 30, 2025. This EMP supports projects under two programs with in the DoR-OR office; the *Federal Facility Agreement (FFA),* and the *Environmental Surveillance and Oversight Agreement* (ESOA) programs.

Initial publication of this Environmental Monitoring Plan (EMP), intended for July 1, 2024, (at the start of the 2025 State fiscal year), was deferred due to delays in execution of the FY25 FFA grant. Due to a lack of grant approval at this time (current date of October 30, 2024), this EMP is specifically provided to clearly address for the stakeholders the goals for TDEC DOR-OR's FY25 EMP to be completed within the period of performance from July 1, 2024, through June 30, 2025. This document defines the oversight and verification work scopes (including independent monitoring and assessment of the U.S. Department of Energy's (DOE's) environmental monitoring and remediation actions across the Oak Ridge Reservation) that TDEC has determined to be necessary to ensure protectiveness of human health and the environment for this period (FY25).

DoR-OR performs independent monitoring and verification sampling as well as conducting oversight of current DOE activities across the Oak Ridge Reservation (ORR) to confirm existing DOE project results and assure the residents of Tennessee that DOE's activities are being performed in a manner that is protective of their health, safety, and environment. DoR-OR utilizes the data and information derived from these work scopes to support environmental restoration decisions, evaluate performance of existing remedies, and to investigate the extent and movement of legacy contamination. This monitoring program is designed to document current conditions for ORR related environmental media (i.e., air, surface water, soil, sediment, groundwater, drinking water, food crops, fish and wildlife and biological systems), by collecting data to evaluate or supplement DOE's environmental monitoring datasets. This State program is intended to monitor for potential emissions of any materials (i.e., hazardous, toxic, chemical, or radiological) from the ORR to its surrounding environment. Monitoring results from these activities will support TDEC's data needs for effective and efficient protectiveness decisions and agreements regarding the ORR.

While the inclusion of projects in this EMP does not associate projects with a specific funding source at this time, TDEC has determined all projects defined in this EMP are consistent with the National Contingency Plan (NCP) and are intentionally designed to be in compliance with the administrative and operational requirements of the ESOA and/or in support of the FFA.

Summaries of the FY25 independent monitoring projects, are provided below:

I. Air Monitoring:

Fugitive Radiological Air Emissions

The project team will independently sample air at a minimum of eight (8) ORR locations. The resulting data will be compared with DOE air monitoring data. Air samples will be screened for radiological emissions, which may have originated from ORR remedial actions and/or waste disposal activities. TDEC uses this program in conjunction with DOE's ambient air sampling program. TDEC gathers data to correlate or supplement data collected by the DOE at the ORR perimeter ambient air monitoring stations. These efforts help to provide independent verification of protectiveness to the public and the environment. All data will be evaluated for compliance with Federal Regulatory Standards.

RadNet Precipitation

RadNet is a national program funded by the U.S. Environmental Protection Agency (EPA). EPA performs radiochemical analysis of precipitation samples taken from monitoring stations at three Oak Ridge locations that are co-located with the RadNet Air stations. Two (2) stations are located at ORNL: one in Melton Valley and one in Bethel Valley. The third site is located on the east end of Y-12. RadNet precipitation monitoring around both ORNL and Y-12 is valuable as Decontamination and Decommissioning (D&D) activities have begun to focus on these two campuses. Samples will be collected by TDEC DoR-OR, and independent analysis will be performed at the EPA NAREL.

II. Biological Monitoring:

Benthic Macroinvertebrate Health

This project consists of benthic macroinvertebrate monitoring to ascertain the current stream health of primary ORR exit pathway streams. Two riffles will be sampled on each reach. Animals collected from both riffles will be combined, randomly sub-sampled, and identified to species level when possible. The overall biodiversity of a sample plus the assemblage of sensitive indicator taxa will help to quantify stream health. These stream statistics will be compared to previous sampling years and to corresponding DOE monitoring data. In addition, during FY25, sampling will help support the holistic *White Oak Creek Assessment Project* (WOCAP) with the contribution of benthic macroinvertebrate data obtained from White Oak Creek Watershed.

ORR Roving Creel Survey

This project documents angling efforts at three key areas where impaired ORR watersheds drain into publicly accessible waters. Public outreach surveys will be used to assess risk from exposure of anglers to ORR contamination through recreational use of the waterways immediately adjacent to the ORR. For FY25, DoR-OR staff plan to survey anglers at three stream confluence areas:

1. White Oak Creek Embayment - the Clinch River Confluence (WOCE-CR)
2. Poplar Creek – Clinch River Confluence (PC-CR)
3. East Fork Poplar Creek - Poplar Creek Confluence (EFPC-PC)

To further understand possible human exposure risks, recreators will be surveyed along the North Boundary Greenway (NBG). This will assist TDEC in better understanding and evaluating potential risk associated with recreation on the greenway. This greenway crosses streams that receive ORR discharges upstream of and connect to the three confluence areas described above. Data from this project helps to support discussions on associated public risk management during ongoing ORR remediation efforts.

CONTAMINANT UPTAKE IN BIOTA

Mercury and other legacy contaminants have the potential to bioaccumulate in biota impacted by contaminated ORR water resources (e.g., streams, stormwater, groundwater). DoR-OR staff will monitor potentially exposed biota for uptake of mercury (Hg), methylmercury (MeHg), and radiological contaminants. The collection of songbird eggs, flying insects, and snake scales and blood during this project will help discern if bioaccumulation of those contaminants is occurring along the selected areas of the EFPC and WOC. These assessments are expected to guide discussions on site specific conceptual site model details and ecological risk of the assessment areas in future work.

TERRESTRIAL INVERTEBRATE COMMUNITY HEALTH

Mercury is found at elevated levels throughout the ORR and continues to be a contaminant of concern (COC) especially in East Fork Poplar Creek (EFPC). EFPC is an ORR exit pathway stream, whose headwaters originate within the Y-12 campus and are fed by surface water, stormwater runoff and groundwater that has been in contact with mercury-contaminated structures. This project focuses on assessing ecological health and the environmental protectiveness of the food chain in this impacted area, by assessing terrestrial invertebrate communities including the ground beetle. Ground beetles, or carabids, will be passively collected, along with other terrestrial invertebrates, via pitfall traps placed within the three main impacted zones and a reference zone. Data results assist in understanding bioaccumulation and contaminant migration in this food web and provide data to support ongoing discussions and evaluations of ecological protectiveness.

RADIOLOGICAL UPTAKE IN FOOD CROPS

The project assesses possible radiological impacts of DOE ORR activities on food crops grown by local farmers and gardeners. While this project mirrors a similar DOE project, DoR-OR sampling will be conducted independently to verify and correlate DOE sample results. This food crops project will collect vegetables, hay, and milk samples within a five-mile radius of the ORR.

For each type of sample, a corresponding background location outside the study area will be analyzed to establish background (i.e., reference) levels.

Radiological Uptake in Vegetation – White Oak Creek

This project will assess possible radiological impacts to streamside vegetation within the White Oak Creek Watershed (WOCW). WOC is a heavily impacted exit-pathway, ORR stream. The stream flows adjacent to ORNL and receives effluent from on-site facilities. Legacy contaminants are also known to be present downstream of ORNL to the confluence with the Clinch River. The project team will collect vegetation samples adjacent to all four WOC sampling zones. These samples will be tested for radionuclides and relevant COCs.

III. Groundwater Monitoring:

Offsite Groundwater Monitoring Project

Delineation of the nature and extent of groundwater contamination is incomplete in many areas of the ORR (DOE, 2022b). Many contaminant plumes across the ORR are not well defined and require ongoing investigation by DOE to delineate their vertical and horizontal extent. The geologically complex bedrock found at the ORR, including highly faulted/fractured areas and massive carbonates that exhibit karst terrains with large sinkholes, require further DOE investigation to adequately evaluate contaminant transport flow pathways. Until that work is complete, TDEC DoR-OR will continue to support this *Offsite Groundwater Monitoring Project,* with the intention of sampling selected representative residential drinking water wells located offsite of the ORR, to assess that there remains no identified threat to human health based on current results.

IV. Landfill Monitoring:

EMDF: Surface Water Monitoring

DoR-OR staff will analyze surface water samples for a range of chemicals, radionuclides, and water quality parameters to characterize conditions prior to major construction and operation of the planned Environmental Management Disposal Facility (EMDF). This project will encompass seven (7) water quality parameter monitoring locations within the Central Bear Creek Watershed. These sites along Bear Creek tributaries are in and around the EMDF footprint. DoR-OR personnel will monitor these seven locations for water quality parameters (e.g., temperature, pH, conductivity, turbidity, oxidation-reduction potential, and dissolved oxygen) no less than monthly during FY25. Staff will also perform general monitoring and observations of the site during the monthly water quality parameters measurement events. Stream observations will include log entries on the status of the streams, any discharges, water conditions, streambank issues, and note any concerns. Concerns, if any, will then be brought to the attention of DOE/EMDF personnel.

EMWMF Surface Water Monitoring

Contaminated materials from the *Comprehensive Environmental Response, Compensation, and Liability Act* of 1980 (CERCLA) remediation activities on the ORR are approved for disposal in the Environmental Management Waste Management Facility (EMWMF), if waste meets acceptance criteria. DoR-OR independently monitors the water resources at the EMWMF, along with evaluating DOE's sampling activities. These efforts will provide independent assurance to the public that DOE operations at the EMWMF are, and remain, protective of public health and the environment, and that DOE continues to adhere to remedial action objectives within facility surface water discharge limits.

V. Radiological Monitoring:

Haul Road Surveys

DoR-OR will periodically survey the Haul Road and all associated landfill access roads. Surveys of these ORR routes were previously initiated following an unintended release of materials on to a publicly accessible roadway and have been continued annually since, to provide independent verification of the roads DOE Environmental Management has used for CERCLA waste hauling. For this period of performance, TDEC independent assessments will correspond with DOE's active waste hauling operations.

Ambient Gamma Radiation monitoring

The Ambient Gamma Radiation Monitoring Project is an ongoing TDEC project (formerly called Real Time Measurement of Gamma Radiation) that measures concentrations of ambient gamma radiation in real time, at five locations across the ORR. Specifically, the areas to be assessed during this period of performance include: the EMWMF, ORNL Building 3026 the Radioisotope Development Laboratory (Isotope Row), the Molten Salt Reactor Experiment (MSRE), the Spallation Neutron Source (SNS), and the background location in Lenoir City. These monitors allow for the assessment of conditions at locations where gamma emissions have been known to fluctuate substantially over relatively short periods of time. TDEC's monitoring at these locations is ongoing, and data provides independent verification of DOE's sampling and risk assessment procedures.

Surplus Sales Verification

At the request of either Y-12 or ORNL's Excess Properties Sales Group, DoR-OR provides staff to screen selected auction items prior to public auction. These radiological surveys are independent verifications that are used to help verify that potentially contaminated items are not released to the public through the surplus sales program.

VI. Surface Water Monitoring:

Ambient Surface Water Parameters

TDEC DoR-OR conducts monthly sampling to obtain primary water quality parameters (e.g., conductivity, pH, temperature, and dissolved oxygen) from three (3) ORR exit pathway streams. Exit pathway streams are specifically streams that leave (exit) the reservation and have the potential to be accessed by the public. DOE's current sampling focuses on the main branch of the Clinch River (CR) and has not collected parameter data on the three TDEC evaluated tributaries which serve as ORR exit pathway streams (DOE, 2021). The exit pathway streams that TDEC monitors under this project include East Fork Poplar Creek (EFPC), Bear Creek (BC), and Mitchell Branch (MIK), with Mill Branch (MB) serving as an offsite reference (or background) stream location. Part of an ongoing monitoring program which began in 2005, this supplemental TDEC dataset allows for TDEC to better verify and assess the protectiveness of the surface waters leaving the ORR and passing into publicly accessible spaces.

Ambient Surface Water Sampling

The purpose of this sampling project is to evaluate the impact of DOE ORR contamination on surface waters around and including the Clinch River (CR), a local source of municipal drinking water. TDEC DoR-OR will focus sampling efforts on the main channel of the CR, at Poplar Creek, and at two primary exit pathway streams that are Poplar Creek tributaries: (1) Bear Creek and (2) East Fork Poplar Creek.

Sampling sites located in the main channel of the CR will be co-sampled with DOE. TDEC's co-sampling provides independent verification and validation of DOE's samples. These independent samples directly support TDEC's independent assessments of DOE's sampling activities, allowing for public reassurance of those sample sets. Grab samples will be collected within the exit pathway streams semi-annually. Analytes will include those constituents listed in TN rule 0400-40-03 for both recreation and fish and aquatic life (TDEC, 2019a). The State employs these numerical values to assess potential impacts to human health and the environment and to identify any stream impairments that are not in accordance with the State's use classifications.

CERCLA Site Investigation

ORR stormwater runoff from construction activities and D&D of older facilities, has the potential to transport various contaminants, including sediments, nutrients, organic and inorganic chemicals, metals, and bacteria, into waterways. During this period of performance, DoR-OR will conduct a stormwater investigation (following qualifying precipitation events), which will include, (1) the quantification of the water quality of stormwater runoff, (2) the identification of potential pollutant sources, and (3) the effectiveness of stormwater Best

Management Practices (BMPs). The stormwater monitoring sites will include D&D sites at ORNL and Y-12 campuses. Sampling events are planned during three (3) stages of demolition, which are pre-demolition, demolition, and post-demolition periods. Additionally, turbidity and water quality data will be measured at 12 sampling sites in Bear Creek to compare turbidity differences upstream and downstream of the EMDF landfill construction site. TDEC will co-sample with DOE where possible and will compare DoR-OR stormwater monitoring data to available commensurate DOE data.

WHITE OAK CREEK RADIONUCLIDES

White Oak Creek's (WOC) ambient surface water will be monitored quarterly for strontium-90 (Sr-90) and other radiological COCs at selected monitoring locations. This project has been separated from the primary *Ambient Surface Water Sampling Project* to allow for a more in-depth quantification of elevated Sr-90 concentrations that were previously identified throughout the watershed (from WCK 3.9, downstream to the confluence at CRK 33.5) at levels above the EPA derived drinking water limit of 8 pCi/L. While DOE has had ongoing projects seeking to define the sources of the strontium releases to WOC, those sources have not been fully vetted or contained yet. This TDEC sampling is intended to allow the State to continue to complete independent assessments of the impacts in this creek which ultimately discharges into the publicly accessible portions of the CR, including into the fishing areas at the confluence (addressed in the Roving Creel Survey projects described above). As DOE continues to evaluate sources and historic releases onsite, these independent assessments will provide supplemental information to support ongoing TDEC DoR-OR evaluations of impacts in these public areas.

VII. SEDIMENT MONITORING:

SUSPENDED SEDIMENT (EAST FORK POPLAR CREEK – EFPC)

The suspended sediment program monitors for suspended sediment bound contaminants that are transported in impacted ORR waterways. Surface waters around the ORR have been adversely affected by past and present activities, and while sediment is an integral component of stream ecosystems, it often serves as a sink for many contaminants. Contaminants may attach to the sediment grains, and in natura conditions those grains can be mobile and entrained in the water column, actively moving through the water column and away from the site. The sediment traps used for this project collect suspended sediment particles from impacted waterways around the reservation to evaluate the sediment and contaminants being actively transported downstream (and potentially offsite) in the water column within the suspended sediment load.

During this period of performance, suspended sediments will be collected within Bear Creek and East Fork Poplar Creek.

VIII. Watershed Assessments (Holistic) Monitoring:

TDEC DoR-OR completes comprehensive watershed assessments around the ORR to provide the residents of the State of Tennessee a comprehensive evaluation of the watershed, assessing the interconnectedness of all the environmental media over an entire watershed collectively at a given point in time. The holistic understanding of all contaminants and their multiple inputs into one watershed allows for enhanced understanding of the health of the system and supports TDEC discussions regarding protectiveness to the public and prioritization of remediation project goals. Prior TDEC watershed assessments evaluated Bear Creek Valley and East Fork Poplar Creek. This fiscal year, the focal watershed is WOC.

White Oak Creek (WOCAP) Phase 2:

White Oak Creek (WOC) is one of the three main ORR exit-pathway streams, originating on the slope of Chestnut Ridge, flowing into Bethel Valley, around the ORNL, through Melton Valley and ultimately emptying into White Oak Lake, discharging into the Clinch River. Primary contaminants of concern (COCs) include strontium (Sr-89/90) and other radiological nuclides. The environmental data generated by this sampling and analysis of various environmental media will establish a snapshot of conditions that can be used to evaluate future impacts to the WOC ecosystem.

Phase 2 of the Holistic watershed assessment project for FY25 will include sampling and analysis of monitoring data. New sampling and analysis projects include (1) surface water, (2) toxicity/biomonitoring, (3) fish tissue, (4) benthic macroinvertebrate community health, (5) benthic macroinvertebrate chemical analysis, (6) terrestrial biota (bird eggs and flying insects), and (7) vegetation.

1.0 INTRODUCTION

1.1 PURPOSE OF THE ENVIRONMENTAL MONITORING PLAN (EMP)

The Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office (TDEC DoR-OR), provides the annual *Environmental Monitoring Plan* (EMP) for fiscal year 2025 (FY25) with a period of performance from July 1, 2024, through June 30, 2025. TDEC DoR-OR publishes its plan for DOE oversight so that this EMP is accessible to the public.

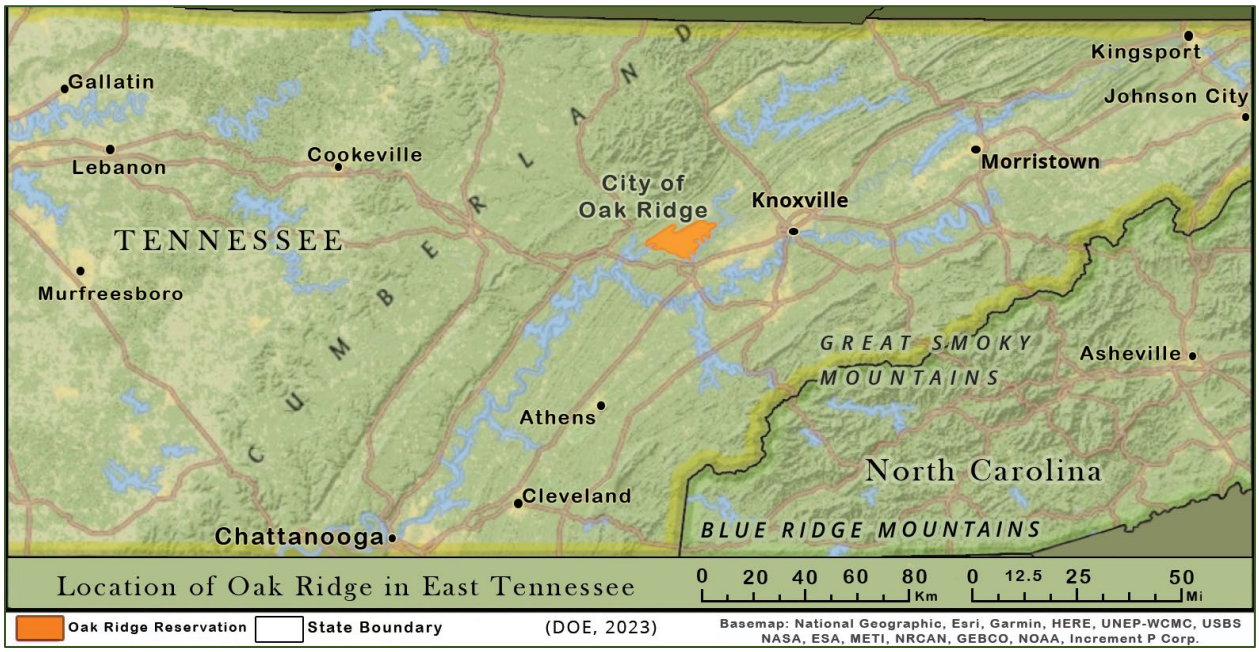

Figure 1.1.1: Location of Oak Ridge in East Tennessee

Initial publication of this EMP, intended for July 1, 2024, at the start of the 2025 state fiscal year, was delayed due to delays in execution of the FY25 *Federal Facility Agreement* (FFA) grant. The FFA and Environmental Surveillance and Oversight Agreement (ESOA) grants are the intended funding sources directly supporting these DoR-OR operations during this period of performance. The FY25 ESOA Grant funding was in place at the start of FY25 (July 1, 2024).

This DOR-OR EMP is specifically provided to clearly address and define the oversight and verification work scopes (including the independent monitoring and assessment of DOE's environmental monitoring and remediation actions across the Oak Ridge Reservation) that TDEC has determined to be necessary to ensure protectiveness of human health and the environment for the period of FY25 for the State of Tennessee. All projects defined in this EMP are found to be consistent with the NCP and are intentionally designed to comply with the administrative and operational requirements of the *Environmental Surveillance and Oversight Agreement* (ESOA) and, additionally, in support of the *Federal Facility Agreement (FFA*).

DoR-OR monitoring of current and upcoming DOE ORR activities is outlined in the ESOA, while the oversight / monitoring of DOE's legacy contamination management is addressed under the FFA. DoR-OR works collaboratively co-sampling and conducting oversight of field actions with the Office of Science, National Nuclear Safety Administration (NNSA), and DOE Environmental Management (DOE EM) and their contractors. The State also conducts independent environmental monitoring to ensure protection of human health and the environment and support independent protectiveness assessments if necessary. All DoR-OR collected data is available to the public, including to DOE or EPA for triparty consideration. Independent sampling is conducted by TDEC to support comparison and correlation of results with DOE's monitoring programs. DoR-OR's monitoring program is intentionally designed and reviewed annually to (1) support active and ongoing environmental restoration decisions, to (2) help evaluate the performance of existing remedies, and to (3) make effective decisions going forward, including assessments and decisions surrounding the extent and movement of legacy contamination.

With the critical goal to provide verification of DOE's data and to support collection of information needed by the State to support efficient and effective decisions, these monitoring and oversight programs have been key. With a primary focus on ensuring protectiveness of human health and the environment, all TDEC DOR-OR environmental monitoring is performed to meet TDEC's mission statement. All work outlined in this monitoring plan will be performed in accordance with the *TDEC DoR-OR Technical Standard Operating Procedures* (SOPs).

Under Federal Guidelines, and to fulfill TDEC mission goals, stakeholder interests take a priority in project planning (Table 1.1.1). The key Stakeholders for this EMP include:

Table 1.1.1: Stakeholders

Stakeholders	
Citizens of Tennessee (Tennesseans)	External
Tennessee Department of Environment and Conservation (TDEC)	External and Internal
Local Governments	External
DOE and Contractors	External

1.2 OBJECTIVE

The overarching objective of TDEC DoR-OR's Environmental Monitoring Program is to provide State led independent monitoring and verification sampling, as well as supporting independent State oversight of current DOE activities across the Oak Ridge Reservation. Comparable independent DoR-OR monitoring results will be used to confirm yearly DOE data, such as that published in the ASER, to confirm existing DOE project results as well as to support environmental restoration decisions; assess and evaluate performance of existing remedies, and to investigate the extent and movement of legacy contamination (including in selected

areas to evaluate the efficacy of DOE best management practices (BMPs)), to assure protectiveness of human health and the environment for the citizens of the State of Tennessee. This State led program is intended to provide independent assessment, for potential emissions of any materials (i.e., hazardous, toxic, chemical, or radiological) that may come from the ORR which could impact the surrounding populations or the environment. The environmental media and COCs to be sampled during FY25 are listed below in Table 1.2.1.

Tables 1.2.1: Types of Monitoring

Project Areas	Medium/Media	COCs *(Possible Assessments)*
Air	Particulates on Air Filters Particulates in Precipitation	**Radiological Materials:** Gamma spectrometry Uranium-234/235/238 Strontium (Sr-89/90) Technetium (Tc-99) Transuranic isotopes, Others **Chemical Pollutants:** PCBs and Pesticides VOCs and SVOCs Nitrates/Nitrates Nutrients **Mixed Waste** **Mercury** **Metals:** Chromium Arsenic Cadmium Uranium
Biota	Benthic Macroinvertebrate Taxa Fish Tissue Sampling [DOE data] Fathead Minnow and Water Flea - Biotoxicity Fish Consumption (Creel Surveys) Food Products (Vegetables/Milk/Eggs/Hay) Terrestrial Invertebrates Bird eggs, flying insects, by-catch	
Groundwater	Wells and Springs	
Landfill	Surface water Stormwater Groundwater Soil Sediment	
Radiological	Haul Road – dropped waste Gamma (Air Samplers) Surplus Equipment Sales	
Surface Water	Surface Water Parameters Stream Water Sampling Shallow Groundwater Stormwater Sampling	
Soil	Landfill Samples Floodplain Samples	
Sediment	Suspended Sediment Sediment (landfill runoff)	
Watershed (*Holistic)*	All Samples from Projects in Watershed	

1.3 THE OAK RIDGE RESERVATION (ORR)

The ORR is comprised of three major campuses:

- **ORNL**: Oak Ridge National Lab (Formerly X-10)
- **Y-12**: Y-12 National Security Complex
- **ETTP**: East Tennessee Technology Park (Formerly K-25)

ORNL currently conducts leading-edge research in advanced materials, alternative fuels, climate change, and supercomputing. Previous and ongoing ORNL research has been responsible for producing a fair amount of industrial waste. The following is a list of projects and processes that have been the source of accidental releases of contaminants into the environment:

- fuel reprocessing
- isotopes production
- waste management
- radioisotope applications
- reactor developments
- multi-program laboratory operations

Y-12 continues to be vital to maintaining the safety, security, and effectiveness of the U.S. nuclear weapons stockpile and reducing the global threat posed by nuclear proliferation and terrorism. As with ORNL, Y-12 operational processes have also resulted in the accidental release of radionuclides and hazardous chemicals into the environment. Additionally, as D&D remedial activities move forward, legacy contaminants may be disturbed and migrate into the surrounding environment.

ETTP, in contrast, has undergone a transition from a gaseous diffusion facility into an industrial technology park. Remediation activities continue and have reduced the amounts of legacy contaminants. DOE recently released portions of this area back to the local government, and now private businesses operate businesses in this region of the ORR. CERCLA Legacy contaminants remain on site in groundwater, burial grounds, sediments, and surface water with remedial decisions for those media to be addressed in current and future documents.

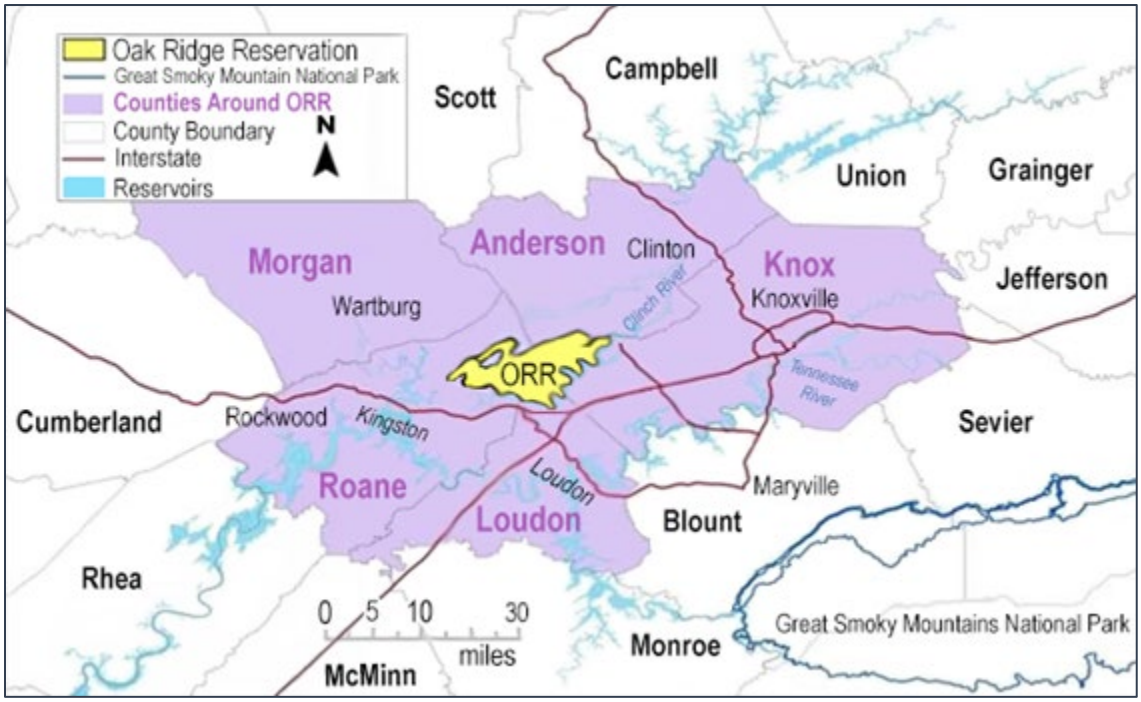

Figure 1.3.1: Location of the ORR in Relation to Surrounding Counties

1.3.1 Geography of the ORR Area

Located in the valley of East Tennessee, between the Cumberland Mountains and the Great Smoky Mountains, the ORR is partially bordered to the southeast and southwest by the Clinch River. The ORR is in the southwest corner of Anderson County and the northeast region of Roane County. The ORR is contained within the corporate boundaries of the City of Oak Ridge. Counties adjacent to the reservation include Knox, Loudon, and Morgan Counties. Knox County resides east of Anderson County and is just across the Clinch River from the ORR. Portions of Meigs and Rhea counties reside immediately downstream from the ORR on the Tennessee River. The nearest cities to the ORR include Oak Ridge, Oliver Springs, Clinton, Kingston, Harriman, Farragut, and Lenoir City. The nearest metropolitan area, Knoxville, lies approximately 20 miles to the east.

The ORR encompasses approximately 32,500 acres of mostly contiguous land of alternating ridges and valleys in a southwest-to-northeast orientation. This section of the Valley and Ridge Province is a zone of complex geologic deposits dominated by a series of thrust faults. Sandstone, limestone, and dolomite form the underlying structure of the ridges, which themselves are relatively resistant to erosion. Weaker shales and more soluble carbonate rocks form a less stable basin for the valleys. Also, valley wind currents can differ substantially in speed and direction from the winds at higher elevations along the ridges.

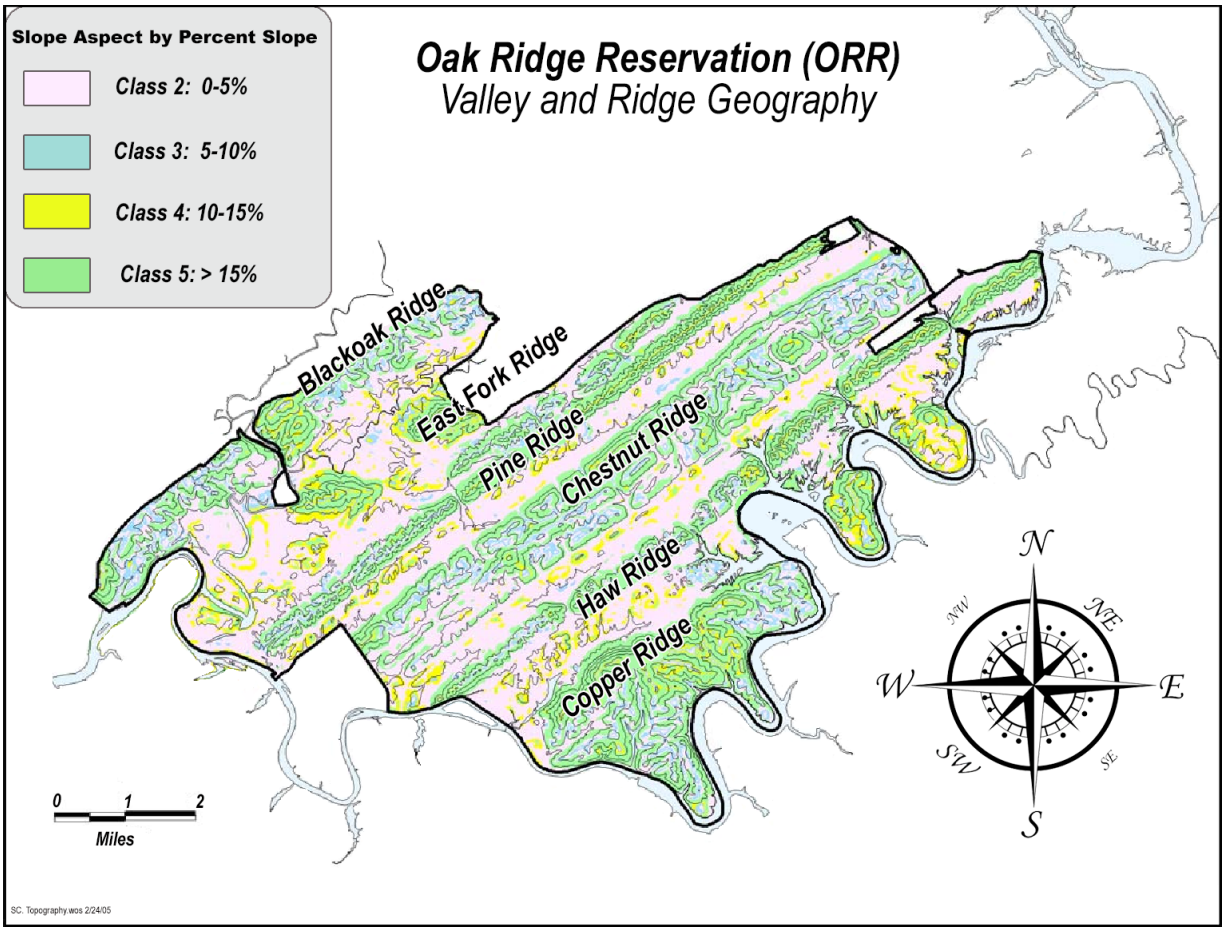

Figure 1.3.1.1: ORR Ridges (Southwest-to-Northeast Orientation)

1.3.2 Climate of the ORR Area

The climate of the ORR region is classified as humid and subtropical. Local climate is characterized by a wide range of seasonal temperature changes between the summer and winter months. During 2023, the National Weather Service recorded a total precipitation of 50.64 inches in Oak Ridge. The National Weather Service reports that this total rainfall is 4.83 inches below normal expected rainfall amounts. DOE last reported rainfall totals for 2022, as follows,

> *…the total average rainfall in the ORR area during FY 2022 was 56.4 in. based on a composite of four rain gauge stations located throughout the ORR and at one located in Oak Ridge. The total rainfall during FY 2022 was only 0.1 in. more than the 56.3 in. determined as the 30-year moving average of rainfall measured in the City of Oak Ridge (DOE, 2023).*

The geography of this region of *The Great Valley of East Tennessee* is shaped by the Ridge-and-Valley physiography, the Cumberland Plateau, and two mountain chains. These major landscape features also affect the wind flow regimes of Eastern Tennessee. Topography and climate are major factors in determining the potential for migration of contaminated media away from the ORR and into the surrounding areas.

1.3.3 Population of the ORR Area

More than one million Tennesseans reside in the counties immediately surrounding the ORR. Knoxville, in Knox County, is the only major metropolitan area near Oak Ridge. Excluding Knoxville, land use is semi-rural and made up of residences, small farms, and pastures. Popular recreation includes fishing, hunting, boating, water skiing, and swimming.

1.4 Tennessee's Commitment to Tennesseans

In accordance with objectives of the ESOA Agreement, the FFA Agreement, and in line with TDEC's mission statement, DoR-OR will conduct oversight of DOE ORR activities. Our purpose is to reassure all Tennesseans that activities on and around the ORR are being managed or performed in a manner protective of human health and the environment.

2.0 AIR MONITORING

2.1 FUGITIVE RADIOLOGICAL AIR EMISSIONS MONITORING

2.1.1 BACKGROUND

Historically, leaks and spills of radionuclide-contaminated materials were not uncommon on the ORR. Radioactive materials were released from operations as gaseous, liquid, and solid effluents with little to no treatment (ORAU, 2003). D&D and related remediation activities across the ORR have the potential to generate fugitive airborne contamination that could pose a risk if blown offsite or may also pose a risk to workers on the ORR.

2.1.2 RELATED DOE PROJECTS

DOE conducts high-volume air sampling around the perimeter of the ORR. The DOE contractors at ETTP also conduct high-volume air sampling at two locations onsite. Both sampling programs collect samples weekly and composite samples for analysis quarterly. The results from this air sampling are used to calculate the human dose exposure for vulnerable populations offsite. TDEC DoR-OR's *Fugitive Radiological Air Emissions Monitoring* sampling data will also be used to correlate and verify DOE results (DOE, 2023).

2.1.3 PROBLEM STATEMENTS

Fugitive (i.e., non-point source) dispersal of contaminants could accidentally occur within the ORR. Legacy contaminants could potentially become exposed during remediation activities or due to a severe weather event. Releases could also occur due to current research and manufacturing projects. Y-12 contains multiple deteriorated buildings with uranium contamination which must undergo D&D and removal. At ORNL, there are structures contaminated with various fission and activation products in addition to uranium and plutonium isotopes. Some structures at ORNL were identified as the highest risk buildings on the ORR (ORAU, 2003). These buildings are physically deteriorating and can contain loose radiological contamination. The risk is exacerbated by the proximity of these structures to pedestrian and vehicular traffic, to privately funded businesses, and to other active ORNL buildings.

2.1.4 GOALS

To verify protectiveness of human health and the environment, DoR-OR will conduct independent air sampling and compare these results to published DOE air sampling data to confirm that DOE is adequately monitoring airborne emissions of radiological contaminants. This independent monitoring is used to verify if DOE is compliant with Federal Regulatory Standards requiring that no member of the public receives an effective dose greater than 10 mrem per year (10 CFR 20, 2024).

2.1.5 SCOPE

DoR-OR will conduct the *Fugitive Radiological Air Emissions Monitoring Project* through continuous air monitoring at each of the three ORR sites plus a comparable background location. The ORR *RadNet Air Monitoring Project* was discontinued in June 2024, Due to the importance of ORR air monitoring, multiple fugitive air samplers were added in FY24 to provide required coverage under this fugitive air project. Some of these samplers were initially co-located with RadNet Air monitors and are intended to replace those monitors lost through discontinuation of the RadNet project.

For FY25, a total of fourteen air samplers will be located as follows: two at ETTP, one at EMWMF, five at Y-12, five at ORNL, and one sampler as a background site in Lenoir City (Figure 2.1.5.1). This background sampler is co-located with the DOE background monitoring station. One additional sampler will be held in reserve in case another monitoring site is needed. This sampler can also serve as a back-up sampler, which can quickly be exchanged in the event of equipment failure.

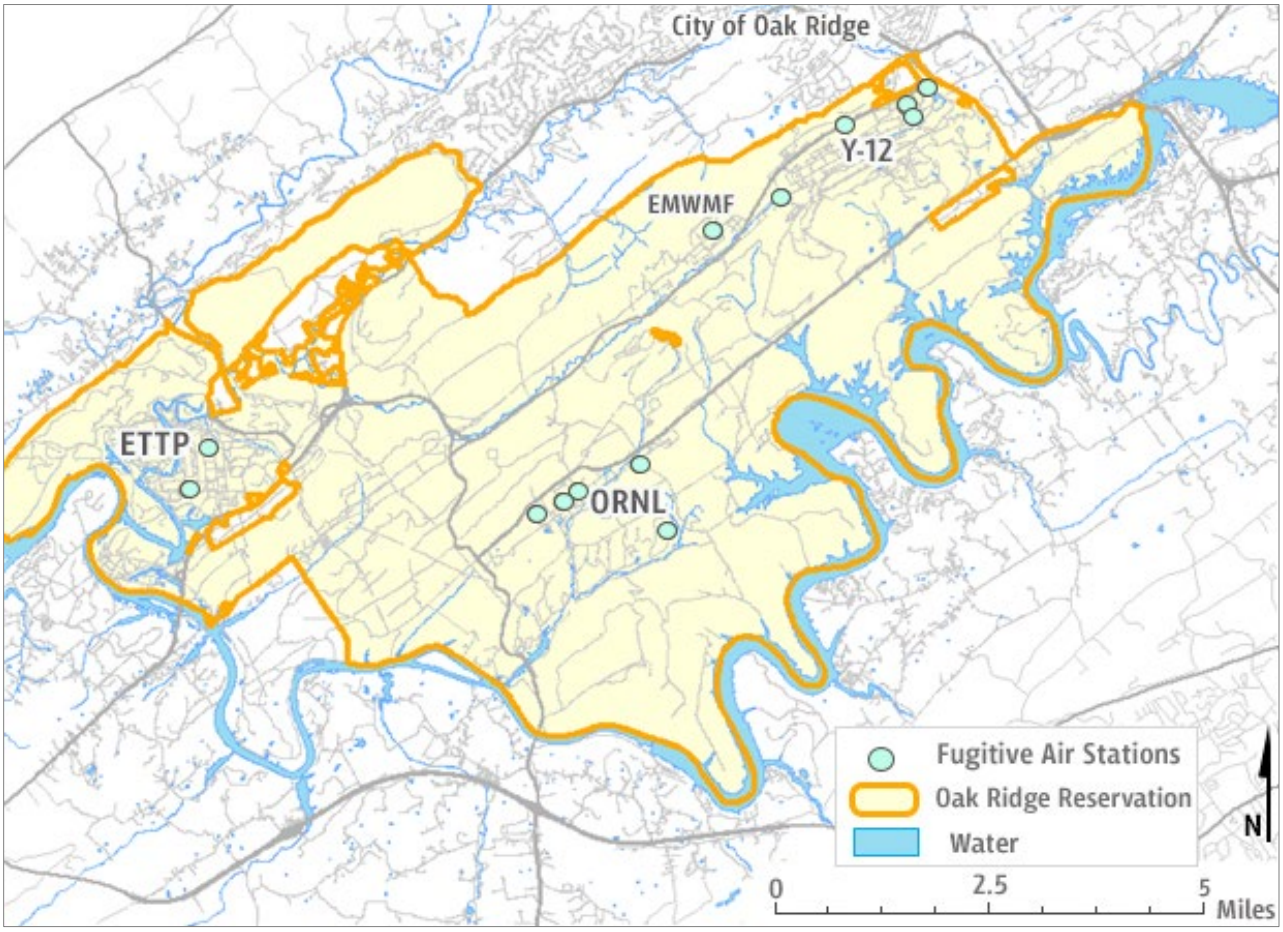

Figure 2.1.5.1: FY25 DoR-OR Fugitive Air Sampling Locations

2.1.6 ASSUMPTIONS

- The number of air samplers and their locations will be sufficient to detect any large increases in on-site ORR airborne contaminants.
- The requested analyses will adequately detect airborne radiological contaminants.
- Fugitive Air monitoring/sampling equipment is comparable to RadNet Air equipment.
- Air sampler locations and electricity to operate the samplers will remain accessible continuously throughout the FY.

2.1.7 CONSTRAINTS

- Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures and access.
- Any interruption to power supply or lack of availability of the 120-volt electrical power source required to operate an air sampler at the preferred locations.

2.1.8 METHODS, MATERIALS, METRICS

As shown in Figure 2.1.5.1, the *Fugitive Radiological Air Emissions Monitoring Project* will use 14 high-volume air samplers to conduct continuous air monitoring on the ORR and at a nearby background location. Samplers will be placed at ORR locations where the potential for release of fugitive airborne emissions is the greatest. For example, locations where contaminated soils are being excavated, sites with contaminated structures undergoing demolition, or at waste disposal sites. These types of site activities warrant consideration for air monitoring placement.

Samples will be collected according to the SOP *T-200 Operation and Use of a High-Volume Air Monitor* (TDEC, 2024). Each of the high-volume air samplers use 8 x 10-inch glass-fiber filters to collect particulates from the air. Air is drawn through the unit at a rate of approximately 35 ft^3 per minute. To ensure accuracy, airflow through each air sampler will be calibrated quarterly.

Samples will be collected from each air sampler weekly, with samples being composited every four (4) weeks and analyzed by Eberline Analytical or an alternative environmental analytical laboratory contracted by DoR-OR. The lab analyses requested will be based upon sampler location and the known contaminants at that campus or site. One set of radiological analyses will include isotopic uranium, gross alpha and gross beta, and gamma activity for samples from seven stations located at ORNL (5 stations), EMWMF, and Lenoir City (background). The other set of analyses will include isotopic uranium, gross alpha, and gross beta analysis requested for the seven stations located at ETTP (2 stations) and Y-12 (5 stations).

Facilities slated for D&D were reviewed by the project team to ensure the placement of the fugitive air monitoring stations was set to be compatible with current and planned DOE activities at ORNL and Y-12.

ORNL D&D:

1) Building 2523 (B2523): demolition slated to start in April 2024, with an expected completion date in December.
2) Isotope Row: completion of pre-demolition is expected in the 4th quarter of DOE CY24.
3) OGR Support Facilities (B3002, B3003, B3018): pre-demolition dates extending through April 2025.

Y-12 D&D:

1) 9201-2 (Alpha-2) with D&D scheduled to start in August 2024.
2) 9616-9 Steam Plant Wastewater Facility (CNS) in 2024.
3) 9720-17 (Ancillary Facility- CNS) with D&D scheduled to start in 2025.

Bear Creek Valley (EMWMF, EMDF):

1) EMWMF continues to accept rad waste from the ORR sites undergoing D&D.
2) Bear Creek Valley construction continues to prepare the new mixed waste rad landfill site (EMDF) and to re-route roads in this vicinity.

ETTP:

While the planned D&D of buildings at ETTP has been completed, and most of the planned soils work has been completed, some remedial actions remain. Also, the excavation of some radiologically contaminated soils has been staged for disposal and will still need to be moved off site. Final decisions have not yet been made for the ROD which will address contaminated surface water and sediment, as well as ecological risk. Groundwater decisions and remedies remain as well.

To assess contaminant concentrations measured at each location, results will be compared with the background data and to the standards provided in the National Emission Standards for Hazardous Air Pollutants (40 CFR 61H, 2024a). These standards associate radiological emissions to quantities that would not cause a member of the public to receive an effective dose equivalent greater than 10 millirem (mrem) in a year. Associated findings will be reported to DOE, its contractors, and the public in the annual TDEC DoR-OR EMR.

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Table 2 Concentration Levels for Environmental Compliance. National Archives. Washington, DC. https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-61/appendix-Appendix%20E%20to%20Part%2061

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2.2 RadNet Precipitation Monitoring Project (ORR)

2.2.1 Background

The nationwide EPA RadNet Precipitation Monitoring Program measures radioactive contaminants that are removed from the atmosphere and transported to the Earth's surface by precipitation. The *ORR RadNet Precipitation Monitoring Project* provides radiochemical analysis on precipitation samples taken from monitoring stations at two ORNL sites and one Y-12 site. Samples are collected by TDEC DoR-OR personnel, and gamma analysis is performed on monthly composite samples.

Gamma analysis is used as a screening tool because few isotopes of interest are pure beta or pure gamma emitters. Therefore, if a radiological release occurs on the ORR, some gamma radiation would likely be emitted either directly or indirectly from daughter products. Additional analysis may be conducted if a radiological release is known or is indicated by monthly gamma analysis results.

While there are no regulatory standards that apply directly to contaminants in precipitation, this project will provide analyses that could potentially indicate the presence of radioactive materials.

2.2.2 Related DOE Projects

Precipitation sampling techniques for this project do not directly correlate to any of DOE's air sampling programs per DOE's EMP for 2023 (DOE, 2022). This project seeks to fill a gap in DOE monitoring data by sampling a different medium that might capture COCs that are not collected by other methods.

2.2.3 Problem Statements

The three ORR campuses (ORNL, Y-12, and ETTP) could potentially release legacy radioactive contaminants into the air. Potential releases could be from current operations, the deterioration of contaminated buildings, D&D remedial efforts, and/or from construction of new buildings.

This project measures radioactive contaminants that are captured in precipitation and collected at each sampler. The analysis of the precipitation samples can show the presence of radioactive materials that may not be evident in the particulate samples collected by the co-located fugitive air monitors.

2.2.4 GOALS

The goal of the TDEC *RadNet Precipitation Monitoring Project* is to measure radioactive contaminants that are washed out of the atmosphere and reach the Earth's surface in precipitation on the ORR. This precipitation sampling data can be used as an additional indicator of the presence or absence of radiological contaminants that could potentially impact the ORR and nearby areas.

2.2.5 SCOPE

Three precipitation samplers will be used to monitor precipitation for radiological contamination. Each precipitation sampler will be co-located with a DoR-OR Fugitive Radiological Air Emissions sampler. The first precipitation sampler is located at the east end of Y-12. At this location, the sampler could potentially indicate if any gamma radioisotopes have been moving off the ORR, towards the City of Oak Ridge. The other two samplers are at ORNL, with one in Bethel Valley and the other in Melton Valley. The latter sampler is near the High Flux Isotope Reactor (HFIR) and the Solid Waste Storage Area (SWSA) 5 burial grounds. Samples from the three locations will be collected weekly.

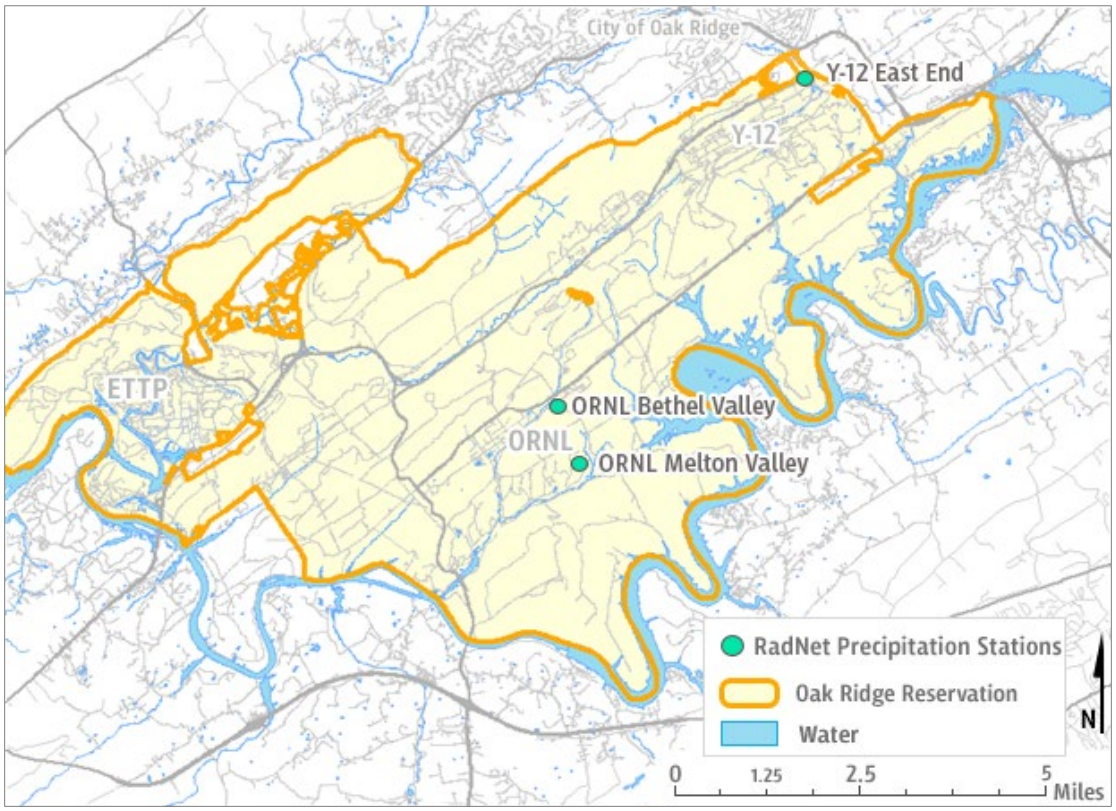

Figure 2.2.5.1: Locations of RadNet Precipitation Monitoring ORR Stations

2.2.6 ASSUMPTIONS

- Gamma analysis of monthly composite precipitation samples will indicate most releases of radiological contaminants.
- Anomalies in radiological contaminant levels can be detected.
- Natural variations in gamma levels will be similar at all ORR sites.

2.2.7 CONSTRAINTS

- Standard constraints, including equipment failure, funding, staffing, transportation, weather, site access.
- The plume must pass through the precipitation for radiological emissions to transfer from air to water and be collected.
- Monitoring is limited to three locations.
- A small, undocumented release could potentially be missed due to consolidation into a monthly composite for analysis. However, samples from a known release will be tested individually.
- The EPA RadNet Precipitation Program conducts all analysis. Only gamma analysis of monthly composites is standard.

2.2.8 METHODS, MATERIALS, METRICS

The three RadNet Precipitation samplers are mapped in Figure 2.2.5.1. All the samplers were provided by the EPA RadNet Program. Each sampler collects precipitation that falls on a 0.5 m^2 fiberglass collector and drains into a five-gallon plastic collection bucket. Each sample will be measured and then collected using a four-liter sample container per the TDEC RadNet Precipitation and EPA SOPs (TDEC, 2024; EPA, 1988; EPA, 2013). After two or more liters of precipitation accumulate, each sample is shipped to EPA NAREL for analysis. Once at NAREL, each station will have its samples combined into a monthly composite sample. Analysis for gamma emitting radionuclides will then be performed on the composite sample from each station.

Since there are no regulatory limits for radiological contaminants in precipitation, the results of the gamma analysis will be compared to EPA drinking water limits, which are considered conservative reference values. EPA's *Radionuclides Rule* (EPA, 2000) outlines water quality parameters for drinking water. Gross alpha radioactivity levels are limited to 15 pCi/L (picocuries per liter). Beta and gamma emitters are limited to 4 millirem (mrem) per year and are radionuclide specific (EPA, 2015). Not all gamma isotopes have EPA drinking water limits, so only those that do and have been seen in RadNet Precipitation samples are used for comparison. The EPA's maximum contaminant levels (MCLs) for select beta and gamma emitters are listed in Table 2.2.8.1.

Previous and current results of NAREL's analyses are available in the EPA Envirofacts RadNet searchable database (EPA, 2024). The data can be used to identify anomalies in radiological contaminant levels, to appraise conditions on the ORR as compared to other locations in the RadNet database (i.e., nationwide), and to determine levels of local contamination. However, while the ORR stations are in areas near sources of radiological contaminants, most of the other stations in the nationwide RadNet Precipitation Monitoring Program are located near major population centers, with no major sources of radiological contaminants nearby.

Table 2.2.8.1: EPA Drinking Water Limits (MCLs) for Select Isotopes

Isotope	***EPA limit (pCi/L)***
Beryllium-7 (Be-7)	6,000
Cobalt-60 (Co-60)	100
Cesium-137 (Cs-137)	200
Iodine-131 (I-131)	3
Note: From the *Derived Concentrations (pCi/l) of Beta and Photon Emitters in Drinking Water* table (EPA, 2015)	

2.2.9 REFERENCES

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3.0 BIOLOGICAL MONITORING

3.1 BENTHIC COMMUNITY HEALTH MONITORING

3.1.1 BACKGROUND

One key indicator of stream health is the biodiversity of macroinvertebrate species associated with the bottom of the stream, or within the benthic zone. The purpose of the *Benthic Community Health Monitoring Project* is to conduct macroinvertebrate sampling in impacted streams on the ORR. The biodiversity of macroinvertebrate species will be evaluated within the four (4) main watersheds on the ORR. This sampling data will aid in the evaluation of the real effects from known contamination on the macroinvertebrate community. Unimpacted reference streams will also be sampled to determine the ideal composition of a healthy benthic community for the Valley and Ridge Ecoregion. The macroinvertebrate community from each impacted stream reach will be compared with the communities found in an associated reference stream.

The four (4) main streams to be sampled are located within the three (3) ORR campuses:

1. ORNL: White Oak Creek (WOC)
2. ETTP: Mitchell Branch (MIK)
3. Y-12: East Fork Poplar Creek (EFPC) and Bear Creek (BC)

Aquatic macroinvertebrate species serve as both quantitative and qualitative indicators to assess biotic responses to environmental stressors (Holt, 2010). Quantitative indicators include assessment of the number of macroinvertebrates and the number of taxon present. Qualitative indicators include the assessment of pollution sensitive and pollution tolerant species.

In addition, benthic macroinvertebrates generally do not move or migrate. The longest life stage for macroinvertebrate species is usually aquatic or semi-aquatic, maximizing the potential contaminant exposure from surface water and sediments. Macroinvertebrates are continuously exposed to any adverse conditions caused by direct or indirect discharges to the ORR streams.

3.1.2 RELATED DOE PROJECTS

ORNL conducts benthic macroinvertebrate sampling for DOE throughout the ORR. After completion of the taxonomy and relevant calculations, ORNL reports their findings annually in both the *Remediation Effectiveness Report (RER)* and the *Annual Site Environmental Report (ASER)*.

As a DOE subcontractor, ORNL conducts benthic macroinvertebrate monitoring on some of the same streams as TDEC; however, the number of specific stream sites differs between the two agencies. At locations where specific sampling sites are shared, TDEC's sampling serves as an independent check on ORNL's monitoring results. Data from the remaining sites, those

sampled by TDEC but not by ORNL, serve to fill a data gap. For example, only TDEC samples at East Fork Poplar Creek kilometer 2.2 (EFK 2.2) for macroinvertebrates. This site is located just below the confluence of Bear Creek (BC) with East Fork Poplar Creek (EFPC) and is accessible by the public from the North Boundary Greenway. Sampling EFK 2.2 allows TDEC to determine the health of the macroinvertebrate community at the confluence point of two ORR streams.

Overall, determining impacts on benthic communities is an arduous task. It is important for different experts to sample the same sites annually and over time to delineate trends in ORR streams.

3.1.3 Problem Statements

1. Past studies in ORR streams indicate that most of the benthic macroinvertebrate communities have been negatively impacted when compared to healthy communities in unimpacted reference streams (TDEC, 2023; DOE, 2023). Many of the impacts affecting these streams result from both historical Manhattan Project activities as well as current operational activities.
2. In areas where stream sections have been channelized, there may be a lack of appropriate substrates for habitat diversity and thereby limit the establishment of healthy stream bottom communities.
3. Sampling of benthic communities contains inherent variability. There are natural, seasonal changes and year-to-year fluctuations in benthic communities. The knowledge and experience of the sampler is also a variable. Both are remedied with long-term sampling.
4. Sampling sites may need to be moved due to changes in habitat. Severe weather events exacerbated by climate change can lead to flash flooding. Human and animal activities, such as construction and beaver damming, can also cause habitat change or habitat loss within streams.
5. Macroinvertebrate diversity is at its highest in the spring. Any comparison of ORNL's fall sampling results with TDEC's spring sampling results will vary partially due to the differences in sampling seasons.
6. WOC receives radiological inputs from ORNL's main campus and Solid Waste Storage Areas (SWSAs). The macroinvertebrate communities have traditionally performed poorly downstream of these releases. In support of *White Oak Creek Assessment Project* (WOCAP), TDEC DoR-OR will collect and submit macroinvertebrates for radiological analysis and analysis for other contaminants of concern (COCs).

3.1.4 Goals

1. Assess the overall stream health of the four (4) main ORR streams.
2. Compare current stream health with previous sample years and with the reference stream to determine any changes over time.
3. Provide a quality check (QC) on DOE's ORR macroinvertebrate data.

4. Draft recommendations, based on the analysis of macroinvertebrate assemblages, on methods to improve the overall health of each watershed.
5. Analyze the levels of COCs in macroinvertebrates collected in WOC and tributaries of WOC sites and estimate the effects of COCs on the macroinvertebrate community.

3.1.5 SCOPE

Within the four (4) watersheds of the ORR, the *Benthic Community Monitoring Project* will collect samples at fifteen (15) impacted sites and three (3) reference sites during the spring of 2024 (Table 3.1.5.1). Macroinvertebrates will be collected for taxonomy following the TDEC Division of Water Resources' SOP (TDEC DWR, 2021). Additional samples will be collected from WOC and tributaries of WOC to be analyzed for arsenic, uranium, mercury, tritium, strontium-89, strontium-90, and isotopic gamma emitters. Quality control samples for taxonomy will be collected from White Oak Creek kilometer 6.8 (WCK 6.8) and Mill Branch kilometer 1.6 (MBK 1.6). TDEC DoR-OR staff will provide oversight to at least one DOE macroinvertebrate sampling event.

Table 3.1.5.1: Spring 2024 Benthic Health Community Sampling Locations

WATERSHED	STREAM NAME	Site	Latitude	Longitude	# Samples
BC	Bear Creek	BCK 3.3	35.943535	-84.349081	1
		BCK 7.6	35.951122	-84.314085	1
		BCK 12.3	35.973325	-84.377700	1
	North Tributary – 5 at Bear Creek	NT5@BCK	35.965400	-84.390400	1
EFPC	East Fork Poplar Creek	EFK 2.2	35.951471	-84.372062	1
		EFK 6.3	35.966300	-84.351500	1
		EFK 13.8	35.992792	-84.315036	1
		EFK 23.4	35.995928	-84.240062	1
(Background Streams)	Mitchell Branch	MIK 0.45	35.938088	-84.389625	1
		MIK 1.43	35.937840	-84.377470	1
	Mill Branch	MBK 1.6	35.987846	-84.287475	** 2
WOC	White Oak Creek	WCK 6.8	35.940482	-84.300912	** 3
		WCK 2.3	35.908072	-84.318720	*2
		WCK 3.4	35.917780	-84.316120	*2
		WCK 3.9	35.924400	-84.314290	*2
	First Creek	FCK 0.1	35.921338	-84.318546	*2
	Fifth Creek	FFK 0.2	35.927370	-84.314290	*2
	Melton Branch	MEK 0.3	35.911785	-84.312175	*2
		TOTAL SITES	**18**	**TOTAL SAMPLES**	**27**

***Green* – Reference Sites** ** 1 sample for taxa identification, 1 sample for lab analyses*
K – Stream Kilometer *** 1 regular sample, 1 quality control sample*

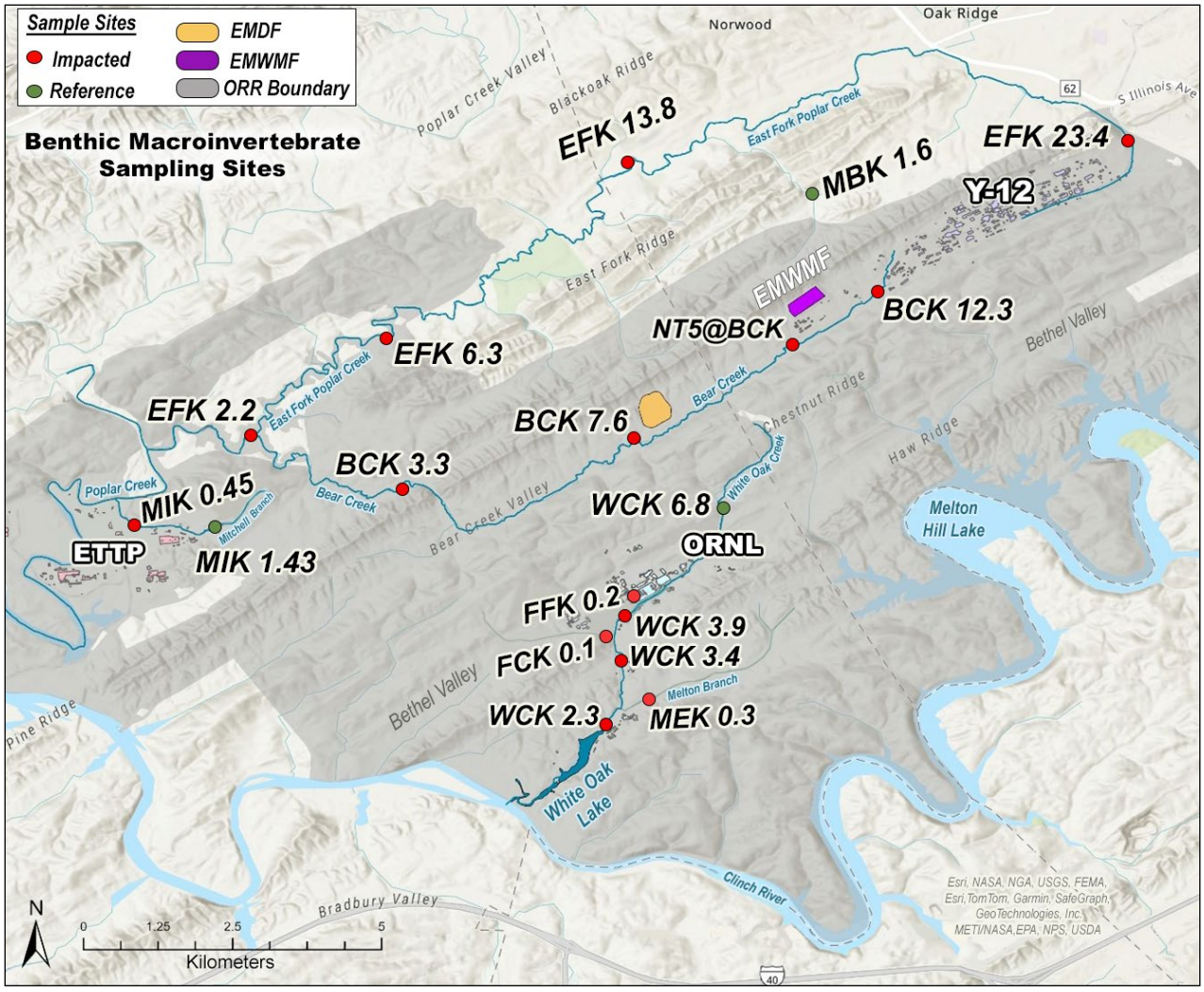

Figure 3.1.5.1: Spring 2024 Benthic Community Health Sampling Locations

3.1.6 Assumptions

1. Selected sites will provide an accurate assessment of each watershed.
2. Subsampling provides an accurate account of taxa present for analyses and to calculate the quantitative.

3.1.7 Constraints

1. Standard constraints: monitoring/processing time, availability of supplies, equipment failure, funding, staffing, training, transportation, weather, site access, and contract lab availability.
2. Sampling is seasonal and must be completed between May – June.
3. Macroinvertebrate samples can be collected, subsampled, and identified in the time allotted.

4. TDEC personnel have the appropriate certifications (i.e., HAZWOPER, Rad Worker 2, Practical Factors) to enter areas that require a Radiation Work Permit (RWP).
5. DOE will provide benthic data and allow DoR-OR to participate in the field oversight event.

3.1.8 METHODS, MATERIALS, METRICS

Macroinvertebrates will be collected at fifteen (15) impacted sites on the ORR and at three (3) corresponding reference locations. A total of twenty-seven (27) macroinvertebrate samples will be collected (Table 3.1.5.1). Each site will have at least one sample collected to identify the macroinvertebrates. WCK 6.8 and MBK 1.6 will have an additional sample (duplicate) collected at each site for quality control of field and lab procedures. WOC and its tributaries will each have one additional sample collected to perform analysis of heavy metals and radiological contaminants (Table 3.1.8.1).

Macroinvertebrate sampling for taxonomy will follow the guidance outlined in the TDEC DWR Macroinvertebrate Sampling SOP (TDEC DWR, 2021). Samples will be shipped to contracted laboratories to identify the macroinvertebrates down to genus level. Taxonomic results will be sent to DWR for upload to the TDEC DataViewer. The DataViewer automatically calculates the biometrics and Tennessee Macroinvertebrate Index (TMI) scores. Data collected from this project will be included in the TDEC DoR-OR *Environmental Monitoring Report (EMR), FY 2025.*

During FY25 sampling, the *Benthic Community Health Project* will assist the WOCAP by sampling benthic macroinvertebrates sites in WOC and its tributaries. These sites are in WOC, First Creek, Fifth Creek, and Melton Branch (Table 3.1.5.1). In addition to the samples collected for identification, these sites will have samples collected to analyze the levels of specific contaminants of concern (COCs). Samples will be sent to a contracted laboratory for analysis of COCs (Table 3.1.8.1).

Collection of the seven (7) samples for analysis of COCs will follow a slightly different protocol. These samples will be collected using a Surber sampler instead of a kick net. The Surber will be used to collect more macroinvertebrates and attempt to meet the biomass requirements in Table 3.1.8.1. Macroinvertebrates will be removed from detritus and sent to a contracted laboratory. The analytical suite of COCs will include arsenic, uranium, mercury, tritium, strontium-89, strontium-90, and isotopic gamma emitters (Table 3.1.8.1). A subset of the analytical suite will be performed on samples with limited biomass. Results will be discussed in the TDEC DoR-OR *Environmental Monitoring Report (EMR), FY 2025.*

Table 3.1.8.1: Biomass Requirements per COC Sample

Analyte	Min(g)	EPA Method
Gamma	10*	901.1
Sr-89/90	*	905.0
Tritium	*	906.0
**10g will be used for all three analyses*		
Arsenic	0.5 - 1	6020
Uranium	0.5 - 1	6020
Mercury	0.5 - 1	6020

3.1.9 REFERENCES

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3.2 ORR Roving Creel Survey Project

3.2.1 Background

The three main ORR streams, White Oak Creek (WOC), Bear Creek (BC), and East Fork Poplar Creek (EFPC), are impacted by both historical and ongoing DOE activities. These waterways contain contaminants of concern (COCs) that have been shown to bioaccumulate in fish tissue (EPA, 2020). Since these streams discharge into publicly accessible waters, fish consumption is a likely pathway for human exposure to COCs. The *Roving Creel Survey* (RCS) is an ongoing project that measures angling effort just outside the ORR boundaries.

There are three key confluence zones included in the *Roving Creel Surveys* (RCSs). During FY25, angler interviews will be conducted via boat at the following three confluence zones: (1) East Fork Poplar Creek-Poplar Creek (EFPC-PC), (2) Poplar Creek-Clinch River (PC-CR), and (3) White Oak Lake-Clinch River (WOL-CR) (Figure 3.2.5.1). Anglers encountered while traveling between the confluences will also be interviewed. Both catch-and-release fishing and fishing for consumption will be documented.

BC and EFPC originate within the confines of the Y-12. Both streams are fed by springs and numerous outfalls from the Y-12 National Security Complex. Uranium in BC and mercury (Hg) in EFPC are the main COCs in these streams. Considering the risk posed by these COCs on human and environmental health, fishing and recreational activities will be passively surveyed in the lower reaches of BC and EFPC. Survey drop boxes have been placed along the North Boundary Greenway (NBG) since 2022. Numerous paper and online surveys are submitted at these boxes every year. The NBG is a popular recreation attraction for Oak Ridge citizens. Based on previously submitted surveys, fishing occurs in both BC and EFPC. Surveying along the NBG remains important because COCs have continued to be found in higher concentrations here than in the Clinch River.

In addition to surveys, FY25 will include a corresponding collection of fish tissue samples from areas with high angler activity, as determined from previously collected survey data. Analysis for COCs will be performed on species that are popular among anglers in those areas. Tissue analysis will also depend on COCs that could be found in the area (Table 3.2.8.1).

3.2.2 Related DOE Projects

No DOE investigations have taken place for over 20 years on or near the ORR to ascertain the level of human exposure risk through angling efforts and/or recreational activities. The RCSs and NBG surveys seek to fill a gap in the environmental monitoring of DOE.

DOE collects fish tissue samples at locations downstream of the confluence points (WOL-CR and PC-CR), where dilution of ORR discharges has significantly reduced contaminant concentrations. Surface water contaminant concentrations at DOE sampling locations fall below the human health risk limits. While both DOE and DoR-OR sample fish tissue data using similar methodology, DoR-OR will collect fish tissue samples from areas of high angler activity at each confluence. Additionally, DoR-OR will target species that anglers in the area commonly catch and consume. DOE's sampling efforts focus on target species identified in the associated ROD and watershed CMP, which may not directly reflect the species that recreational anglers report as target species in recent years (e.g., striped bass and crappie). DoR-OR may also utilize alternate standard methods used by the TDEC Division of Water Resources or Tennessee Wildlife Resources Agency (TWRA) during annual fish sampling efforts. This will help supplement DOE data and provide more specific data related to angling activity in the areas of concern.

3.2.3 PROBLEM STATEMENTS

1) Bioaccumulation: Fish have been shown to bioaccumulate mercury and other contaminants (Murphy, 2004). If contaminated, ingestion of these fish could harm people and other piscivores.
2) Warning Signage: Fish consumption warning signs and postings are either not visible, not legible, or they are missing. In addition, residents who have fished these waters for many years may disregard warnings.
3) Human Exposure: Little is known about the extent of human engagement with natural areas on and near the ORR.

3.2.4 GOALS

1) Quantify the angling effort in the 5 key locations just outside ORR boundaries (EFPC and BC along the NBG, confluence points of EFPC-PC, PC-CR, and WOL-CR).
2) Determine if recreational fishing is a significant pathway for human exposure to contaminants.
3) Provide data that is pertinent to CERCLA requirements and future ORR decisions regarding human health and environmental protection.
4) Document the amount of human recreational activity in the lower reaches of BC and EFPC within the North Boundary Greenway.
5) Analyze the levels of specific COCs in fish tissue collected from areas with high angling activity.

3.2.5 SCOPE

Angler interviews will be conducted via boat during RCSs at and between the three stream confluences of concern: EFPC-PC, PC-CR, and WOL-CR (Figure 3.2.5.1). There will be 15 survey

events throughout the fiscal year, excluding the cooler months (November through February). These months are excluded due to decreases in fish activity, thus a decrease in angler activity. Specific survey dates are randomly selected. There is also a survey drop box at the Gallaher boat ramp to passively collect data from anglers via paper or digital surveys.

Recreational activities along the public NBG will be monitored through passive efforts to better understand public interactions with natural resources that may be impacted by DOE activities and contaminants. There are three survey drop boxes along the NBG to collect paper and digital surveys from recreators (Figure 3.2.5.1).

Fish tissue samples will be collected from areas of high angler activity within each confluence zone. DoR-OR staff will attempt to collect fish that anglers typically target in those areas. Samples will be sent to a contracted laboratory for analysis of COCs (Table 3.2.8.1).

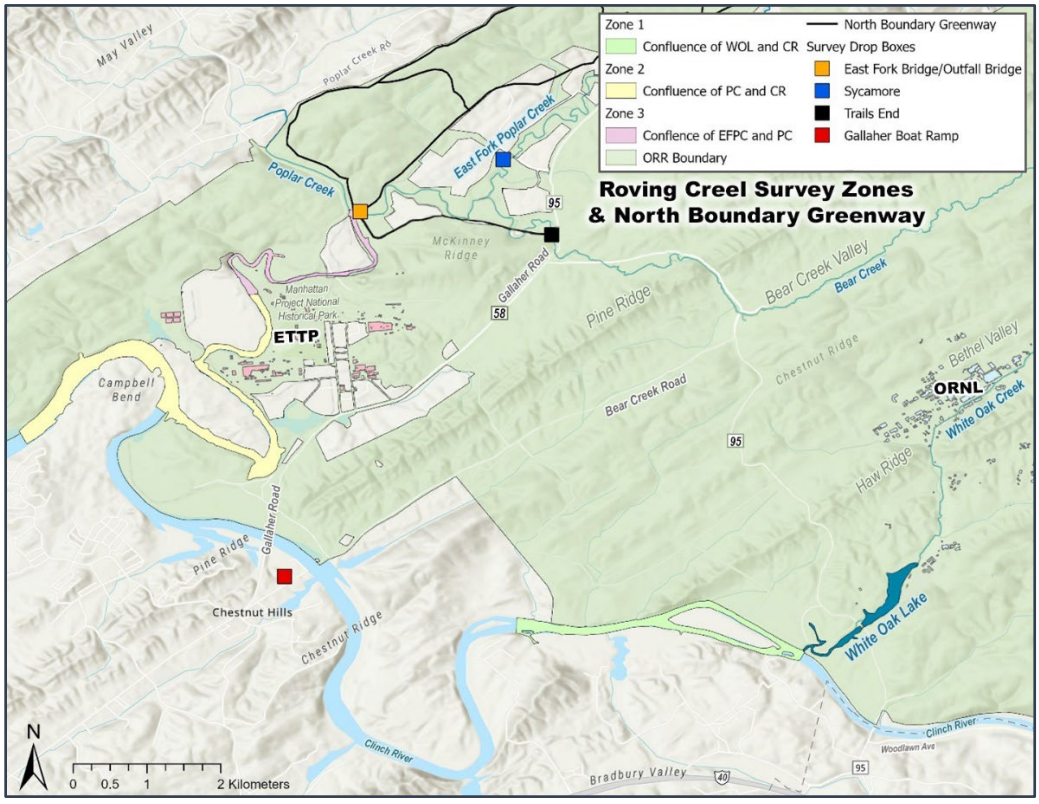

Figure 3.2.5.1: Map of Study Zones and Drop Box Locations

3.2.6 ASSUMPTIONS

1) When exposed, fish can bioaccumulate contaminants discharged from the ORR into public waters.
2) Migration of contaminants outside the ORR boundary could pose a risk to human health.

3.2.7 CONSTRAINTS

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.
2) The number of people available and willing to answer the surveys cannot be predicted.
3) Collection of fish for fish tissue samples depends on the ability to catch fish in each study zone.

3.2.8 METHODS, MATERIALS, METRICS

DoR-OR staff will conduct angler interviews at and between the three study zones (Figure 3.2.5.1). Angler interviews will use active, on-site methods whereby anglers are interviewed before, during, or immediately after fishing trips. Methods are outlined in the *TDEC DoR-OR Roving Creel Survey SOP* (TDEC, 2023). Additionally, angler information will be collected, voluntarily, via digital surveys using Survey123 and/or paper surveys posted year-round at the Gallaher Boat Ramp. Survey information that will be collected is listed below.

Observable data collected from anglers includes:

1. Date/Time
2. Type – boat/bank fishing, private/commercial
3. Location – Lat/Long
4. Number of people in party

Angler reported data includes:

1. County and state residence
2. Total amount of time spent fishing for that trip
3. An estimate of days spent fishing per month
4. Target species of fish
5. Consumption of fish harvested from the areas of concern
6. Provision of fish to sensitive populations (i.e., pregnant women, nursing mothers, or children) for consumption
7. Knowledge of posted signage in these areas of concern

Recreational activities along the NBG will be monitored using drop boxes with paper surveys and digital surveys accessible via QR codes posted on boxes. Surveys will be available year-round to recreators posted at the three locations on Figure 3.2.5.1.

Recreator reported data includes:

1. Date/Time
2. Recreation activity – hiking, biking, fishing, kayaking, etc.
3. Number of people in party

4. County and State residence
5. Total amount of time spent recreating for that trip
6. Estimate of time spent fishing per month along the NBG (days/month)
7. Target species of fish
8. Consumption of fish harvested from the areas of concern
9. Provision of fish to sensitive populations (i.e., pregnant women, nursing mothers, or children) for consumption
10. Knowledge of posted signage in these areas of concern

Fish for tissue samples will be collected via boat electro-shocker, or other DWR or TWRA approved methods, or by collection of deceased fish found within the study area. Fish that are commonly targeted for consumption in areas of high angler activity will be sampled. If standard fish sampling methods do not yield sufficient sample sizes of anglers' target species, angling with a fishing pole may be considered to mimic the recreational activities on the CR. Fish will be filleted and sent to a contracted laboratory for analysis of specific COCs for each study zone (Table 3.2.8.1).

Table 3.2.8.1: Analysis for Contaminants of Concern per Study Zone

Zone	Confluence Point	Analyses
1	WOL-CR	Metals*, Methylmercury, Low-level mercury, PCBs, **Isotopic Gamma, Sr-89/90**
2	PC-CR	Metals*, Methylmercury, Low-level mercury, PCBs
3	EFPC-PC	Metals*, Methylmercury, Low-level mercury, PCBs
** strontium, arsenic, selenium*		

3.2.9 REFERENCES

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3.3 Mercury and Contaminant Uptake In biota

3.3.1 Background

Mercury (Hg) is found in elevated levels throughout the ORR resulting from processes and spills dating back to Manhattan Project and Cold War era activities. Mercury in ORR streams and wetlands often undergoes methylation and is transformed into toxic methylmercury (MeHg) in conjunction with the activity of specific microorganisms (Kalisinska et al, 2013). MeHg is particularly bioavailable to wildlife (and humans) and, if ingested, may cause serious neurological, reproductive, and other physiological damage (Standish, 2016). Decreases in reproductive success of 35–50% have been observed in birds with high dietary methylmercury uptake (USDI, 1998; Hallinger and Cristol, 2011) including reduced hatching and fledging success (Chin et al, 2017).

MeHg biomagnifies throughout the food web. Organisms at higher levels in the food web, such as songbirds and snakes, might accumulate increasingly larger body burdens of MeHg through consumption of prey items. Small invertebrates, small mammals, benthic larval-stage biota, terrestrial spiders, and emergent flying insects are examples of possible local prey items. (Scheuhammer et al, 2007).

Evidence of bioaccumulation will provide key links between aquatic and terrestrial systems. Based on the above bioaccumulation studies, key species from multiple chains or links within the food web should be monitored to document any movement of these contaminants. By sampling songbirds, adult flying insects, and snakes, the pathways of the bioaccumulative transfer of mercury will become clearer.

Additionally, there are concerns that contaminants could potentially migrate away from the known point sources via movement of mobile consumers. Some migratory birds and snakes may even spread these contaminants over a larger area. Monitoring the migration of heavy metal contaminants through environmental biotic media helps inform potential human exposure risks. Project teams have encountered homeless encampments within impacted watersheds. As homeless citizens are more transient, they have higher potential to encounter contaminants that occur within stream systems. Ecological receptors may potentially act as a proxy to assess human exposure risk.

3.3.2 Related DOE Projects

During the CERCLA-driven Five-Year Review, biota such as turtles, spiders, earthworms, and adult insects are sampled by DOE and analyzed for mercury and other contaminants (DOE, 2021).

3.3.3 PROBLEM STATEMENTS

1) Mobile ORR consumers, like migratory songbirds, could bioaccumulate and spread contaminants offsite.
2) Many adult flying insects in the ORR began life in contaminated water as nymphs. They accumulate contaminants from aquatic environments and are consumed by terrestrial predators as adults (e.g., songbirds and bats). Sampling flying insects may reveal bioaccumulation and represent a transfer point for Hg, MeHg, and other contaminants.
3) Studies have demonstrated a correlation between contaminant levels in herpetological species and humans (Pelallo-Martinez et al, 2011), supporting the use of snakes to assess potential exposure risks to humans within those areas. Little to no data has been collected in the last 10–15 years on the ORR on the role(s) of snakes in mercury bioaccumulation. As an intermediate and top-level consumer, snakes have the potential to accumulate higher levels of Hg and MeHg through the consumption of exposed prey items. Additionally, with their larger home ranges, snakes have the capacity to disperse contaminants over larger distances.
4) DoR-OR staff have recently observed homeless encampments along the banks of the upper reaches of East Fork Poplar Creek (EFPC), and at a new public greenway farther downstream. These sightings suggest that the human exposure risk to Hg and MeHg along EFPC may be higher than previously thought. Investigation of how much Hg and MeHg is travelling through trophic levels is relevant to assess protectiveness in these areas for both human health and the environment.

3.3.4 GOALS

Sampling goals for Fiscal Year 2025 (FY25) are:

1) Document the bioaccumulation of Hg, MeHg, and other contaminants through the trophic levels in biota species living along EFPC and WOC.
2) Support the EFPC Holistic Assessment Project by providing snake data and the WOC Holistic Assessment Project (Section 9.1) by providing biota (e.g., songbird egg, adult flying insect) data to supplement the findings of the watershed assessments and better understand both ecological and human health risks.

3.3.5 SCOPE

Biota specimens will be captured from eight sites, including three impacted WOC study areas, three impacted EFPC study areas, and two reference sites (e.g., upstream WOC, Freels Bend) (Figure 3.3.8.1-3.3.8.2).

Samples will be collected from all study areas over a one-year period, starting spring 2024, or until enough biomass has been collected for laboratory analysis.

3.3.6 ASSUMPTIONS

1) Terrestrial biota can transfer Hg/MeHg and other contaminants from the water to the land via consumption and bioaccumulation.
2) The chosen biota sampled are exposed to higher levels of contaminants than the corresponding reference area.

3.3.7 CONSTRAINTS

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.
2) Adequate biomass per sample may be difficult to obtain for laboratory analysis.
3) Theft or vandalism of deployed sampling equipment left in the field can occur.
4) Institutional Animal Care and Use Committee (IACUC) approval and appropriate permit(s) from TWRA and US. Fish and Wildlife Service (USFWS) must be granted to evaluate the Hg and MeHg contamination in snake species and songbirds.
5) Radiological support team will be available to escort project team, allowing access to the WOC sample sites.

3.3.8 METHODS, MATERIALS, METRICS

Terrestrial biota collected to obtain biomass for contaminant testing are listed below.

Biota

SONGBIRD EGGS

Songbird nest boxes have been installed along WOC and at reference locations (Figure 3.3.8.1) following *TDEC SOP: Songbird Nest Box Construction and Deployment. DoR-OR-T-290B* (TDEC, 2023a). Songbird nest boxes will be checked weekly in the spring of 2025 to determine occupancy. Once a nest box is confirmed to have an occupant, the box will be checked twice per week to collect the first laid eggs of the clutch for analysis following *TDEC SOP: Egg Sampling for Mercury and Radionuclide Bioaccumulation. DoR-OR-T-291* (TDEC, 2023b). The breeding season for songbirds runs from March through June, and this protocol will allow songbirds time to produce a second brood. All eggs collected from the same zone will be composited into one sample. There will be four total composite songbird egg samples for WOC sent for analysis.

ADULT INSECTS

Adult insects will be collected from WOC and reference sites (Figure 3.3.8.1) between April and August 2024 following *TDEC SOP: Insect Sampling Using Light Traps. DoR-OR-T-331* (in revision) (TDEC, 2023d). The SOP has been modified to include the use of Malaise and Lindgren Style funnel traps to accommodate safety concerns associated with potential radiation exposure at WOC. Insects will be trapped in a combination of Lindgren Style funnel traps and Malaise traps.

Traps will be set and checked one week later; any insects in the traps will be collected and traps reset for the following collection. Traps will be sampled weekly. All insects collected from the same zone will be composited into one sample. There will be four total composite insect samples for WOC sent for analysis.

SNAKES

From April to October 2024, snakes will be sampled along EFPC and at reference sites (Figure 3.3.8.2) following *TDEC SOP: Herpetofauna Trapping and Sampling. DoR-OR-T-312. Draft* (TDEC, 2023c). Snake boards will be used to attract snakes. Snakes resting under boards will then be captured by hand. Trained staff will record morphological measurements to assess snake body condition and collect blood samples from captured snakes (IACUC 2987-0623). Snakes will be released unharmed at the site of capture. Due to safety concerns, venomous snakes will not be sampled. Opportunistic snakeskin shed samples will also be collected if available.

Site Descriptions

WHITE OAK CREEK

To ensure enough biomass is obtained without impacting local populations, WOC is divided into the following sampling zones (Figure 3.3.8.1):

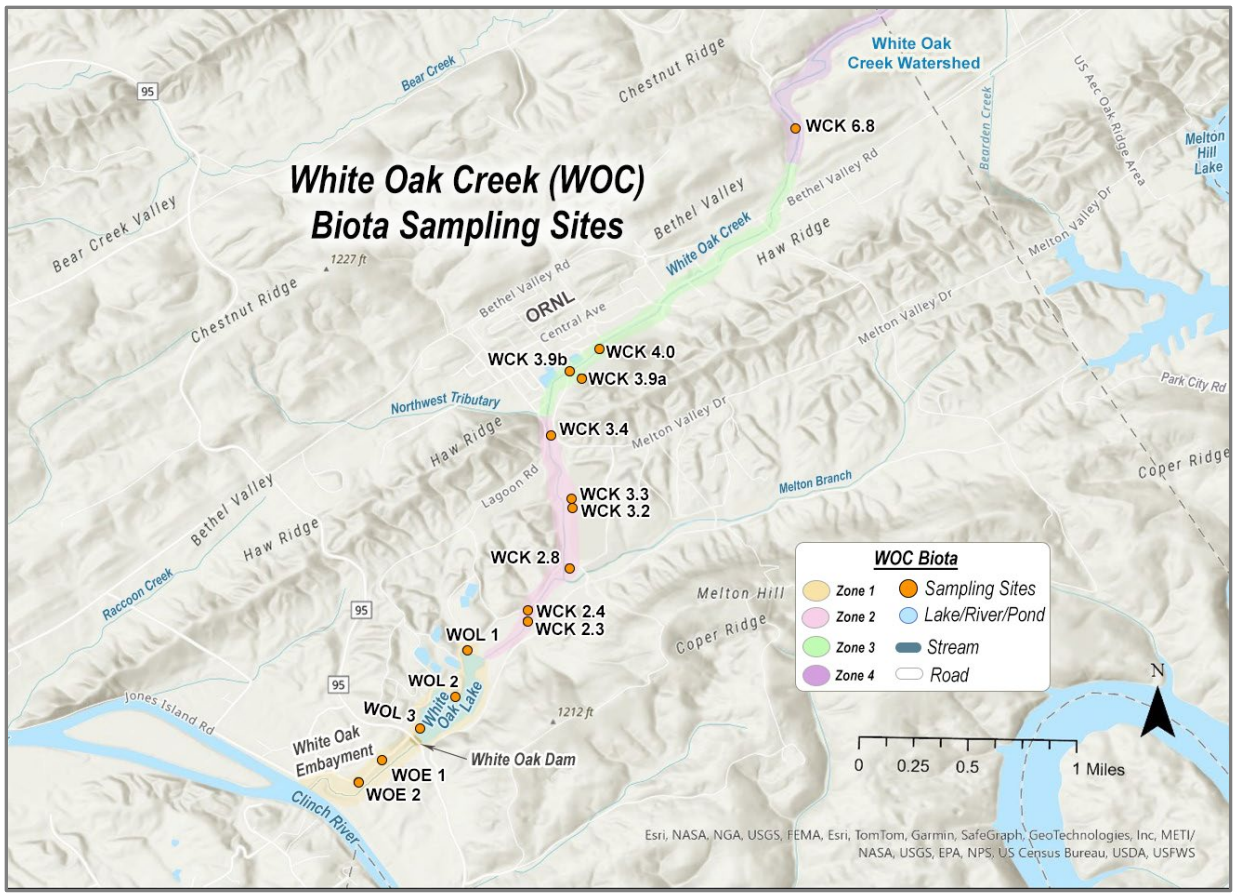

Figure 3.3.8.1: Proposed Biota WOC Sampling Sites

1) **WOC Zone 1**: White Oak Embayment (WOE) and White Oak Lake (WOL) comprise Zone 1 of the WOC watershed and is the most downstream reach. DoR-OR personnel will collect songbird egg and insect samples from five sites within the WOE and WOL reaches.
2) **WOC Zone 2**: Zone 2 includes the lower reaches of WOC, encompassing Bethel Valley. TDEC DoR-OR personnel will collect songbird egg and insect samples from three to five sites from WCK 0.0 (the confluence of WOL) to WCK 3.7.
3) **WOC Zone 3**: Zone 3 includes the upper reaches of WOC that flows through Melton Valley. TDEC DoR-OR personnel will collect songbird egg and insect samples from three to five sites from WCK 3.7 to WCK 4.2.
4) **WOC Zone 4:** Zone 4 contains the WOC reference site, WCK 6.8. This site is located upstream of ORNL inputs into WOC. This site is not within the contaminated floodplain of WOC and has not been affected by radionuclide contaminants. WCK 6.8 will be used as a reference site for insect samples.

5) **Additional Reference Locations**: are comprised of seven songbird sites within Freels Bend (not included in the above Figure 3.3.8.1) and a peninsular area along the Clinch River. These sites are not within the floodplain of WOC and have not been affected by radionuclide or heavy metals contamination associated with ORNL and WOC. The eight reference sites will be used to provide reference samples for songbird eggs.

EAST FORK POPLAR CREEK

EFPC is also divided into sampling zones to obtain adequate amounts of biomass without impacting local populations. The EFPC are as follows (Figure 3.3.8.2):

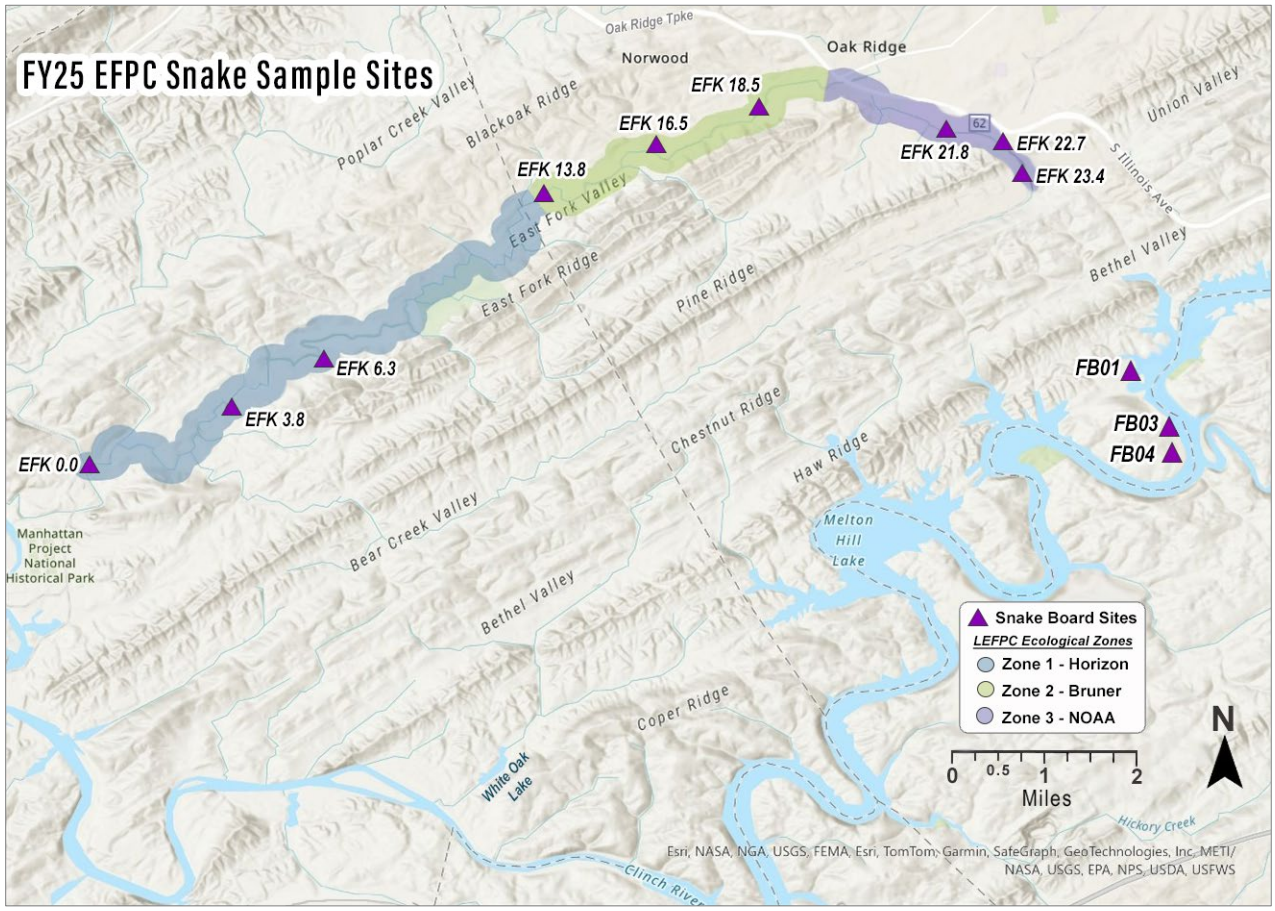

Figure 3.3.8.2: EFPC Snake Sampling Sites and Freels Bend Reference Sites

1) **EFPC Zone 1**: *Horizon Center reach* is the most downstream reach of EFPC. DoR-OR personnel will collect snake specimens at three sites on EFPC from EFPC kilometer EFK 0.0 to EFK 13.7.
2) **EFPC Zone 2**: This reach, containing the *Bruner Site*, flows through the City of Oak Ridge, following closely to the Oak Ridge Turnpike. The project team will collect specimens at three sites on EFPC from EFK 13.8 to EFK 19.1.

3) **EFPC Zone 3**: The *National Oceanic and Atmospheric Administration* (*NOAA) Site* reach is the most upstream reach of EFPC, in closest proximity to Y-12, and flows through the City of Oak Ridge. DoR-OR personnel will collect specimens at three sites on EFPC from EFK 19.2 to EFK 23.4.
4) **Reference Locations**: are comprised of three sites within Freels Bend and one peninsular area along the Clinch River. These three sites are not within the floodplain of EFPC and have not been affected by mercury or methylmercury contamination.

Species that are State or Federally listed as greatest conservation need (GCN), threatened, endangered, or deemed in need of management will not be sampled. State or Federally listed species (if encountered) will be reported to TWRA and USFWS within 5 working days.

Biota Sampling and Handling

PROTOCOL FOR TDEC DOR-OR LAB

1) Biota samples will be weighed to the nearest 0.01 gram and recorded on the laboratory sample log.
2) Bird egg and flying insect biota samples will be placed into Level 2 pre-cleaned glass jars with labels and screw-top plastic lids. These sample jars will be stored at -20ºC in the TDEC DoR-OR lab freezer until shipped to an external lab for analysis.
3) Upon assessment of total biomass per zone, snake blood samples will either remain in original collection tubes or be composited into Level 2 pre-cleaned glass vials with labels and screw-top plastic lids. These samples will be stored at -20ºC in the TDEC DoR-OR lab freezer until shipment to an external laboratory for processing.

DATA ANALYSIS

1) Biota data results will be compared to available DOE biota datasets in Oak Ridge Environmental Information System (OREIS).
2) The Hg, MeHg, and radiological analytical data results will be normalized to account for differences in body mass, where applicable, among and between species.
3) Total Hg vs. MeHg graphs and figures will be generated to compare among sites on the ORR and reference sites.
4) Total Hg and MeHg concentrations and radiological contaminants will be compared among feeding guilds, as possible: insectivores, omnivores, herbivores, carnivores.
5) Results from the monitoring zones will be compared with results from the reference zone(s) for each respective biota group.

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3.4 TERRESTRIAL INVERTEBRATE COMMUNITY HEALTH

3.4.1 BACKGROUND

As a direct result of historical releases from the Y-12 Complex (Brooks et al, 2017), mercury (Hg) remains a focal contaminant of concern (COC) in East Fork Poplar Creek (EFPC). Today, this stream's headwaters are fed by surface water runoff and groundwater exposed to mercury-contaminated structures. Hg in streams and wetlands around Y-12 undergoes methylation and is transformed into toxic methylmercury (MeHg) through microbial activity (Kalisinska et al, 2013). MeHg is detrimental to local biota (i.e., wildlife and humans). If ingested, MeHg may cause serious neurological, reproductive, and other life-altering physiological damage (Standish, 2016). Hg and MeHg contamination and its migration through ORR streams and into terrestrial food webs continue to elevate the potential exposure risks to humans and other biota living in and around EFPC.

Key bioindicator species from multiple trophic strata should be assessed for a better understanding of the impacts of mercury subsidies in the environment. A critical first step for this process is evaluating impacts of contaminants on habitat quality and organismal community health. For example, benthic macroinvertebrate species are key bioindicators used to monitor stream health and assess impacts of human disturbance to aquatic environments. Extrapolating from the role of aquatic bioindicators, terrestrial bioindicators should be monitored for a better understanding of industrial and ORR impacts to the surrounding terrestrial environment. This project plans to address the terrestrial biota sampling gap and will focus on ground beetles (i.e., carabids).

Carabids are ideal bioindicators given their close contact with contaminants present in soils and leaf litter (Hunter et al, 1987; Pizzolotto et al, 2013; Ghannem et al, 2018). Contaminated soils and leaf litter provide a link between aquatic and terrestrial environments Carabids are ground-dwelling arthropods throughout their life cycle. Considering this increased exposure time during the larval stage, these beetles have a strong potential to uptake mercury and other heavy metals in their immediate environment (Ghannem et al, 2016). Also, carabids are generalist consumers that occupy multiple trophic levels and have the potential to be impacted through multiple contaminant pathways. They are additionally ideal bioindicators due to their sensitivity to environmental change. Carabids exhibit relatively rapid and measurable changes within species and community composition in response to anthropogenic impacts on local environments (Pearce and Venier, 2006; Avgin and Luff, 2010; Ghannem et al, 2018).

To date, heavy metals and other contaminant concentrations have been analyzed in some terrestrial invertebrate communities along EFPC at sites downstream of the ORR. However, no ORR studies have evaluated the impacts of contaminants on terrestrial invertebrate community composition. More specifically, no study has looked at carabid communities to evaluate heavy

metal impacts on community composition.

In addition to filling a data gap in terrestrial systems monitoring, this project will contribute to a separate, larger EFPC Holistic Watershed Assessment Program (EFPCAP). The EFPCAP aims to complete a comprehensive evaluation of the ecological health of the entire watershed. As a valuable data gap project, ground beetle community assessments will establish a more complete analysis on watershed ecological health.

To further aid in the success of this project, open-sourced data from the National Ecological Observatory Network (NEON) will be leveraged. NEON has collected data on carabids from multiple unimpacted sites around the ORR for 8 years. This database will serve as a robust reference data source.

3.4.2 Related DOE Projects

During the CERCLA Five-Year Review, biota such as turtles, spiders, earthworms, and adult insects are sampled by DOE and analyzed for mercury and other contaminants. However, there are no projects that sample or monitor terrestrial invertebrate assemblages to evaluate environmental health.

Considering the lack of terrestrial community health analysis, the data from this DoR-OR project will provide important information. Data will also supplement DOE's current dataset and fill the data gap.

3.4.3 Problem Statements

1) Hg inputs into EFPC from Y-12 continue to be a concern, especially as it becomes bioavailable through methylation.
2) Quantification of impacts from Hg and MeHg on terrestrial biotic assemblages is absent.
3) DOE does not directly monitor Hg and MeHg pathways from aquatic to terrestrial habitats.
4) Terrestrial bioindicators equivalent to aquatic bioindicators (i.e., benthic macroinvertebrates) have not yet been analyzed for contaminant migration.

3.4.4 Goals

1) Establish biometrics for ground beetle diversity (i.e., community health) that indicate contaminant impacts on terrestrial biota communities, equivalent to aquatic community health biometrics.
2) Support the DoR-OR EFPCAP by providing data that identify areas that continue to be impacted by historical Hg contamination and focus future sampling efforts.
3) Provide novel community health data to augment DOE contaminant investigations of terrestrial biota.

3.4.5 SCOPE

Carabid specimens will be collected from three main impacted study zones along EFPC and from one reference zone in Freels Bend (Figure 3.4.5.1). Sampling will take place from April – August 2024. Each zone will consist of three sample sites with three invertebrate pitfall traps per site (i.e., nine samples each per four zones). Results from each of the three impacted zones will be compared to results from the reference zone. Carabid community data collected by NEON Domain 07 (NEON, Released-2024) will be utilized to strengthen data collected from the Freels Bend reference zone and provide additional reference data for sites that represent similar habitat to those from the EFPC impacted zones.

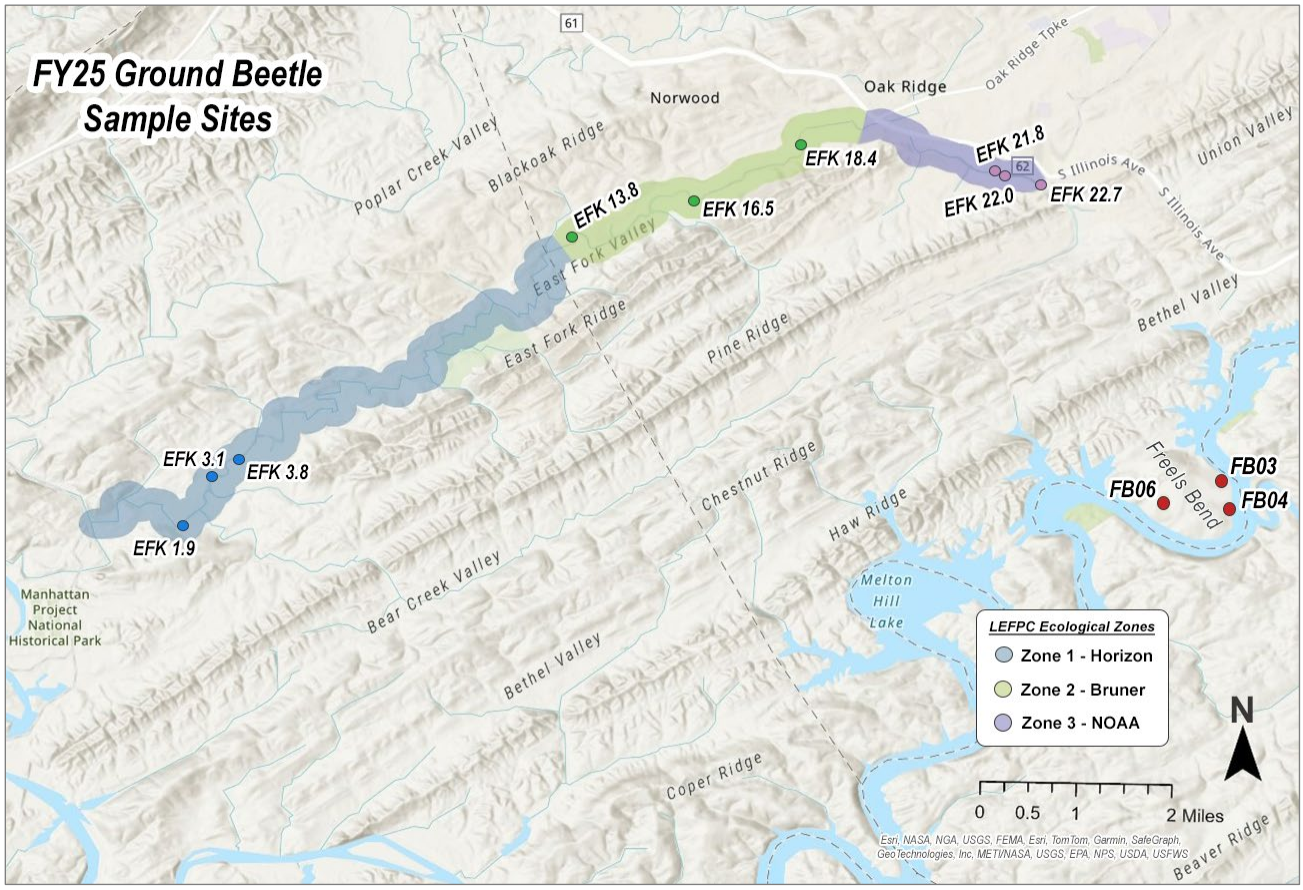

Figure 3.4.5.1: **East Fork Poplar Creek Ground Beetle Sampling Sites**

3.4.6 ASSUMPTIONS

1) An active representative sample of the carabid community will be captured using pitfall traps.
2) Carabids on EFPC are exposed to higher levels of mercury, methylmercury, and other contaminants than the corresponding reference area.

3) Carabid populations exhibit measurable changes when exposed to environmental contaminants.
4) Changes in carabid communities directly reflect impacts in other terrestrial communities (i.e., non-beetle insects, birds, small mammals, etc.).

3.4.7 CONSTRAINTS

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.
2) Pitfall traps are left unattended.
    1. Wildlife might disturb or destroy traps.
    2. Traps may be damaged or vandalized.

3.4.8 METHODS, MATERIALS, METRICS

Terrestrial Invertebrate Field Sampling

Insect pitfall traps will be installed along EFPC and at the corresponding reference zone (Figure 3.4.5.1) (TDEC 2023, Levan 2022). These traps will contain propylene glycol, a preservative that is non-toxic to wildlife and people. All specimens trapped in the preservative will be collected in solution from each trap every two weeks. New unused propylene glycol will be added during each field event to reset the pitfalls traps until the removal of the traps at the end of the sampling season. The pitfall traps from all sites will be left open from April through August 2024. State or Federally listed species (if encountered) will be reported to TWRA within 5 working days.

TDEC DoR-OR Laboratory Processing

Samples will be rinsed and stored in 95% ethanol at the DoR-OR Lab until sorting is complete. Sorting will involve separating carabid beetles from invertebrate bycatch for taxonomic identification to species-level where possible. Once identified, samples will be composited by taxonomic groups (carabids or bycatch) by site and stored at the DoR-OR Lab.

Data Analysis

1) Carabid communities will be assessed by various diversity metrics (e.g., richness, abundance, diversity) along with comparisons between impacted sites and reference zones.
2) Graphs will be used to compare ORR sites to references sites.
3) Mean Index Biomass (MIB), Shannon Diversity, and Simpson's Diversity metrics will be evaluated to identify measurements that can be used to describe environmental health.

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3.5 Radiological Uptake in Food Crops

3.5.1 Background

DOE has conducted monitoring of food sources since 1992, "to evaluate potential radiation doses to consumers of local food crops, fish, and harvested game and to monitor trends in environmental contamination and possible long-term accumulation of radionuclides." (ASER 2022) The DoR-OR *Radiological Uptake in Food Crops Project* was initially requested by DOE, with the first samples collected in the summer of 2019. The resulting independent food crop data collected by DOR-OR under this project shall serve to supplement and independently verify DOE sampling data published in the ASER each year.

DOE food crops sampling has changed over the years, with DOE initially conducting vegetable sampling at their perimeter monitoring stations on the ORR from 1992 to 1996. The focus then shifted to sampling at farms and gardens near the ORR. DOE hay sampling later shifted from multiple locations on and near the ORR to one location at the far eastern edge of the ORR that is also harvested for hay by an offsite operation. Prior to 2017, cow milk was sampled from a dairy in Claxton, near the ORR, and at a few other farther dairies as reference sites. Milk has not been sampled by DOE since 2016 because the Claxton Dairy shut down. There have been no other dairy options found near the ORR by DOE staff, although they check each year (DOE, 2023).

3.5.2 Related DOE Projects

Currently, DOE conducts sampling of locally grown food crops and hay to look for the uptake of radiological contaminants in these products due to previous and ongoing ORR activities. Sampling is performed to assess if local food crops may have been affected by potential current or historical activities on the reservation, including potential airborne releases, soil uptake, etc. According to the *2023 DOE Environmental Monitoring Plan for the Oak Ridge Reservation*, DOE intends to sample vegetables from broad-leaf systems (e.g., lettuce, turnip greens, etc.), root-plant-vegetable systems (e.g., tomatoes), and root-system vegetables (e.g., turnips, potatoes, etc.). Sampling is planned for three potentially impacted sites and one reference site. If harvested and available, hay will be sampled annually from the southeastern edge of the ORR. Hay and vegetable samples will be analyzed for gross alpha, gross beta, gamma emitting radionuclides, and isotopic uranium. DOE checks for dairy farms near the ORR annually, and if found, will resume milk sampling. (DOE, 2023).

In practice, DOE sampling in 2022 was only able to obtain tomato samples from three locations near the ORR, a corresponding background location, and one hay sample (DOE, 2023). The DoR-OR project team has the opportunity to augment DOE data by sampling a wider variety of plant types and animal products, as well as hay or grasses, at more locations proximate to the ORR

on an annual basis.

3.5.3 Problem Statements

- ORR radiological contaminants have been released into the atmosphere, groundwater, surface water, soils, and sediment.
- Any contaminated airborne releases from DOE ORR activities can be disturbed and transported beyond the boundaries of the ORR.
- Members of the public have the potential to be exposed to doses of ORR radiological contaminants through the consumption of locally grown food crops or animal products.

3.5.4 Goals

- Collect and analyze samples to determine if there is radiological contamination in food crops, hay, or animal products on or near the ORR.
- Compare TDEC DoR-OR results to the corresponding DOE ORR sampling results.
- Supplement DOE data by collecting and analyzing a variety of food crops, hay, and animal products.

3.5.5 Scope

This project will collect and analyze food products within a five-mile radius of the ORR boundary (Figure 3.5.8.1) for bioaccumulated radiological contaminants. These samples will be compared to samples taken from unimpacted reference locations (i.e., areas considered unimpacted by ORR operations and outside of the monitoring area). FY25 samples will be collected starting in July 2024 and continuing through the primary summer growing season, or as available.

3.5.6 Assumptions

- Vegetation, including vegetables and hay, can potentially uptake radiological constituents from contaminated soil, water, and/or air. People who consume herbivores or animal products (milk, eggs) from livestock on or near the ORR may be exposed to radiological contamination.
- Any radiological contamination originated from DOE ORR activities.
- DOE data will be comparable to DoR-OR data.
- Vegetable, hay, and animal product samples will be available for analyses.

3.5.7 Constraints

- Standard constraints include equipment failure, funding, staffing, transportation, weather, ORR closures, and sample availability.
- Availability of farming and gardening products on or near the ORR cannot be predicted or guaranteed.

3.5.8 METHODS, MATERIALS, METRICS

Project staff will collect samples of hay, animal products (eggs, milk), and food crops (root vegetables, fruiting vegetables, leafy vegetables) from locations within a five-mile radius of the ORR perimeter (Figure 3.5.8.1). Sampling will be conducted according to the *DoR-OR SOP for Food Crops* (TDEC, 2024). The actual sampling locations will not appear in this project report because many locations are at private residences. Locations will be generally described, but otherwise not specified due to privacy concerns.

During FY25, up to ten samples will be collected per each of four vegetation types. In addition, approximately six animal product samples will be collected. Included for each set of samples will be at least one corresponding reference sample (see Table 3.5.8.1). While multiple types of samples may be collected at a single garden or farm, multiple sampling locations will be used within the main sample collection area. Final numbers of each type of sample will be based on sample availability and the extent to which costs can be covered by the lab budget.

Table 3.5.8.1: Vegetable and Animal Product Sample Quantities & Analyses

Food Product	*Type*	*Approximate # Samples **	*Analyses*
Vegetable	*Root*	*10*	*gross alpha, gross beta, gamma*
	Fruiting	*10*	
	Leafy	*10*	
Livestock Forage	*Hay/Grasses*	*10*	
Animal Products	*Milk or Eggs*	*6*	*gross alpha, gross beta, gamma, isotopic uranium*
**Includes at least one reference sample of each type* *If RAD levels elevated in any sample, can request additional analyses: Sr-90, Tc-99, isotopic uranium*			

Vegetable and hay samples will be analyzed for gross alpha, gross beta, and gamma emitting radionuclides. Animal product samples, most likely eggs, will be analyzed for gross alpha, gross beta, gamma emitting radionuclides, and isotopic uranium.

Additional analyses may be requested if the sample results meet either of the following criteria:

- *Isotopic Uranium Analysis:* If gross alpha results are over 1.5 pCi/g and more than twice the levels at the corresponding reference site.
- *Sr-90 Analysis:* If gross beta results are over 5.0 pCi/g and more than twice the levels at the corresponding reference site.
    - *Tc-99 Analysis:* If gross beta results are over 5.0 pCi/g, but Sr-90 levels are not elevated, and Tc-99 contamination is possible at the location, Tc-99 analysis may be run.

The analytical results for this project will be reviewed and compared to DOE's most recent food crop data as appropriate.

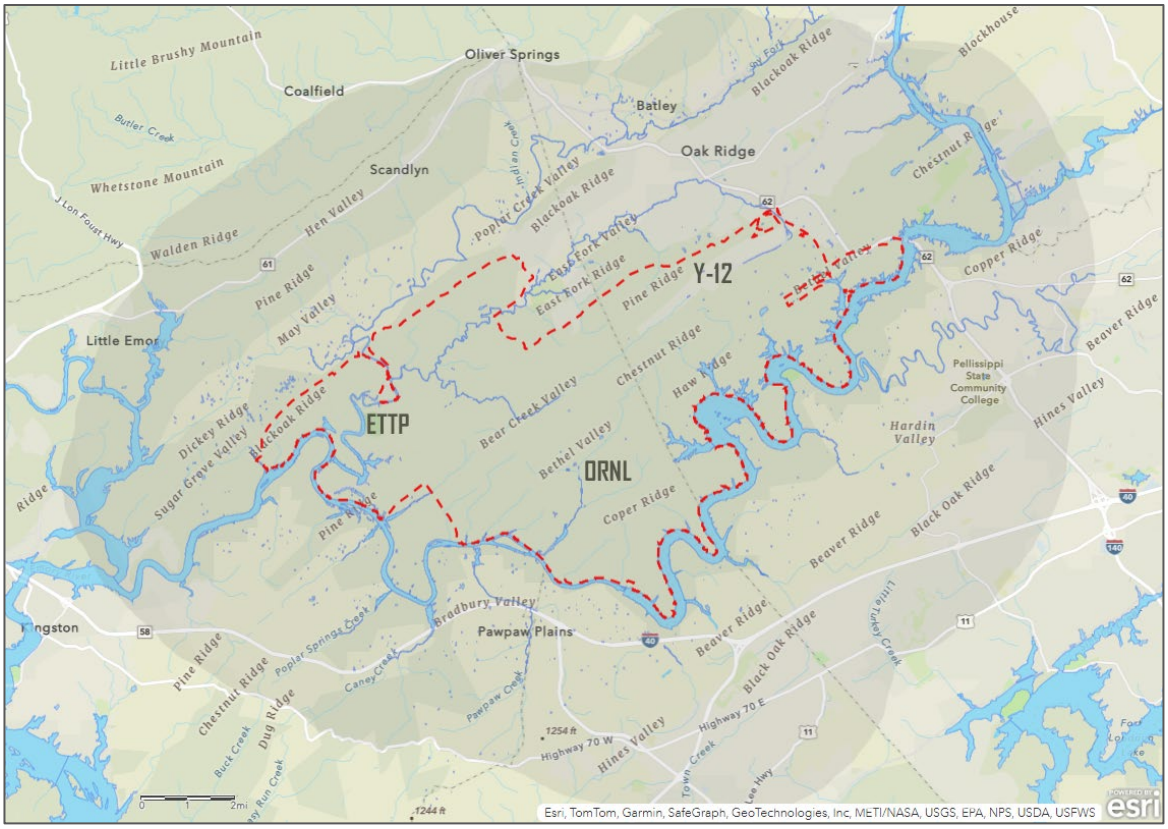

Figure 3.5.8.1 Food Crop Sampling Area (5-mi Radius Around ORR Boundary)

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3.6 Radiological Uptake in WOC Vegetation

3.6.1 Background

Throughout the ORR, there are areas with radiological contamination. Much of this existing contamination comes from past operations and buried waste. Current cleanup and other ongoing activities can contribute to the re-distribution of radiological contamination on the ORR. If surface water bodies have been impacted by radioactivity, vegetation in the immediate vicinity can uptake radionuclides, causing the bioaccumulation of radiological contaminants. This bioaccumulation shows that radiological contamination is present in these areas, and the vegetation can be sampled as a proxy without disturbing the soils.

The White Oak Creek (WOC) headwaters originate on Haw Ridge, flow into ORNL's Bethel Valley and then flow through the gap in the ridge into Melton Valley. WOC then flows through Melton Valley and into White Oak Lake before entering the White Oak Embayment and ultimately the Clinch River. The primary radiological contaminants of concern (COCs) in and along WOC are tritium (H-3), strontium-90 (Sr-90), cesium-137 (Cs-137), and cobalt-60 (Co-60). This project will look at radiological uptake in vegetation along WOC. Data will also be incorporated into the White Oak Creek Assessment Project (WOCAP), which is a comprehensive evaluation of the ecological health of the WOC watershed.

3.6.2 Related DOE Projects

DOE completes other sampling in and near WOC, but does not sample vegetation near WOC, or in other contaminated areas on the ORR as part of the work described in the ASER (DOE, 2023). This project will provide TDEC DoR-OR valuable information about levels of radiological environmental contaminant uptake by vegetation along White Oak Creek, including in more contaminated areas where sediment and soil samples are not (or cannot be) currently collected.

3.6.3 Problem Statements

- ORR radiological contaminants have been released into the environment, including the surface water, soils, and sediment.
- Vegetation in the immediate vicinity of radiologically contaminated lakes and streams can potentially uptake radionuclides, causing the bioaccumulation of radiological contaminants in plant tissue which is a pathway to exposure via the food web.

3.6.4 Goals

- Obtain samples to determine the level of radiological contamination in herbaceous vegetation along four WOC stream zones, including three contaminated zones and one upstream background zone location.

- Provide monitoring data for the DoR-OR WOCAP.

3.6.5 SCOPE

The *Radiological Uptake in White Oak Creek (WOC) Vegetation Project* will sample herbaceous vegetation in four zones along WOC outlined in different colors to differentiate in the map below (Figure 3.6.5.1). Approximately five samples will be collected per impacted zone.

The three impacted zones run though Bethel and Melton Valleys (Zones 1-3). Zone 4, in green, is used as the background zone as it is the most upstream section of WOC and is not impacted by ORNL activities.

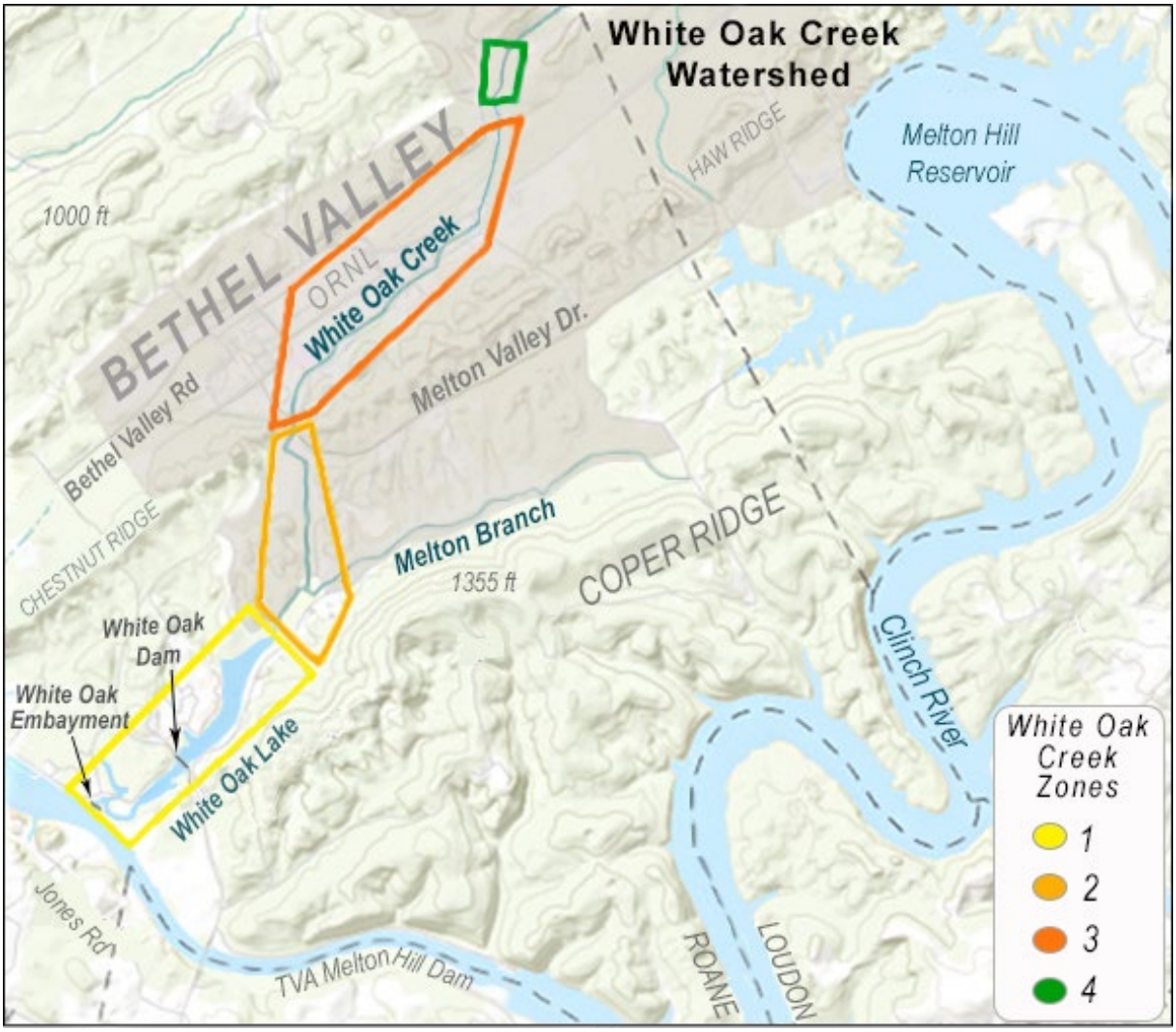

Figure 3.6.5.1: WOC Vegetation Sampling Zones

Table 3.6.5.1: Vegetation Zones

Zone	*Description*
1	From the Clinch River through the WOE and WOL
2	Upstream of WOL through Melton Valley
3	WOC in Bethel Valley
4	Upstream of Bethel Valley onto Chestnut Ridge, includes WCK 6.8

3.6.6 Assumptions

- Vegetation can uptake radiological constituents from contaminated soil and water.
- Vegetation near WOC is exposed to radiological contamination.
- Any radiological contamination originated from DOE ORR activities.
- Herbaceous vegetation samples will be available for collection and analysis.
- If radiological contamination is present, vegetation will uptake that contamination to an extent visible in analysis of the samples.

3.6.7 Constraints

- Standard constraints include equipment failure, funding, staffing, transportation, weather, ORR closures, and sample availability.
- Vegetation growth and availability cannot be fully predicted or guaranteed.
- Much of WOC watershed has known radiological contamination and care must be taken when collecting and processing the samples for analysis.

3.6.8 Methods, Materials, Metrics

The *Radiological Uptake in White Oak Creek (WOC) Vegetation Project* will sample herbaceous (non-woody) vegetation in three impacted zones along WOC and at an unimpacted, upstream WOC location used as a background site. Samples will be collected according to the vegetation sampling SOP (TDEC, 2024).

Staff will collect approximately 18 samples for this project, with five samples per impacted zone, two QA/QC samples, and one background sample. Ideally, each of these samples will be collected at different locations in each zone. However, if one zone has fewer good sampling locations two types of vegetation might be collected at one location, such as one grass sample and one cattail sample. The plant types sampled are chosen based on availability and consistency across the sample zones.

In addition to the five samples per zones 1 to 3, two duplicate samples will be collected from separate zones, provided that enough vegetation is available. Duplicate samples will be used to check for consistency in lab results, although some variation is expected. Each sample will consist of approximately 500-1,000 grams of vegetation and will be kept cool after collection to

prevent spoilage while in the field.

The WOC vegetations samples will be taken to a lab for radiological analysis. Analyses will include gross alpha, gross beta, gamma isotopes, strontium 90, tritium, and isotopic uranium. Data from the three contaminated zones will be compared to the data collected at the upstream background location. Data from this project will also be used in the DoR-OR WOC Assessment Project. Samples will be collected in FY25, starting in July 2024, and will be collected during the primary summer growing season, or as available.

3.6.9 REFERENCES

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4.0 GROUNDWATER MONITORING

4.1 OFFSITE GROUNDWATER MONITORING

4.1.1 BACKGROUND

Due to the nature of the geology and presumed subsurface connectivity at this site, any water flowing underground through, or proximate to, the ORR could potentially mix with legacy contaminants present in Reservation water and/or soils. Each campus has numerous associated groundwater contaminant plumes which have been documented by DOE mission activities. To date, many contaminant plumes are not well defined and require ongoing investigation to delineate their vertical and horizontal extent as required. This challenge is more pronounced due to the complex bedrock found on the ORR, containing many faults and carbonates that exhibit a karst terrain with large sinkholes, potentially facilitating plume migration through fractures and conduits. Currently, little is understood about the contaminant flow paths within the bedrock and further investigation is necessary to evaluate these flow pathways. Without plume extent defined, it is unclear the distances that onsite contamination may have traveled. Due to the potential risk of contaminant migration through ORR groundwater into local water wells and springs, downgradient groundwater is monitored by both DoR-OR and DOE.

The overarching purpose of this DoR-OR *Offsite Groundwater Monitoring Project* is to evaluate potential impacts to human health and the environment through verification monitoring of groundwater that could be used by area residents. The sampling locations addressed in the DoR-OR offsite program rotate to cover different offsite areas around the ORR each fiscal year, with site selection potentially guided by ORR activities and TDEC mission support such as the current holistic watershed project. This year, in FY25, the WOC Watershed (WOCW) is the focal watershed. Groundwater data from WOCW offsite area will be incorporated into the WOCAP (Section 9.1).

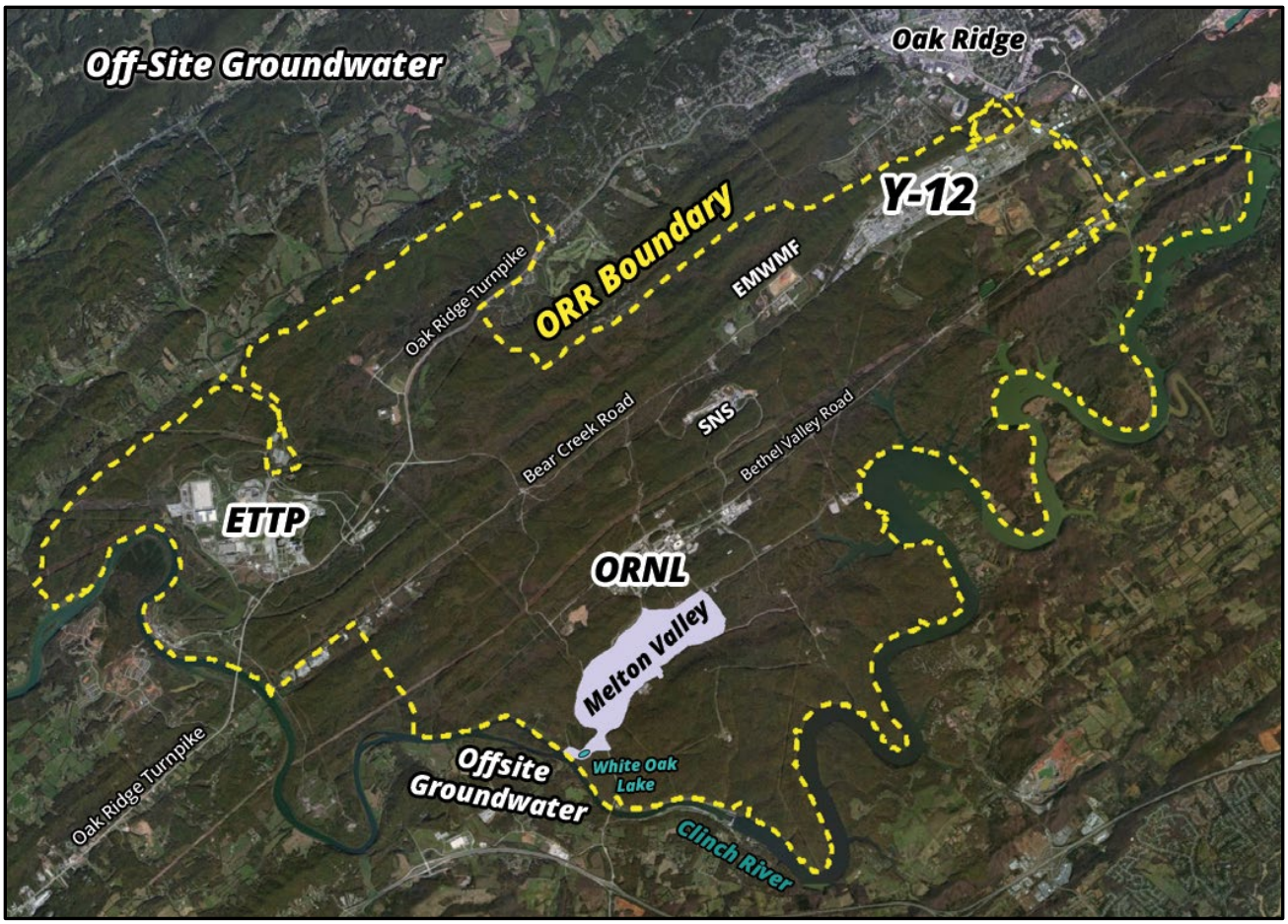

Figure 4.1.1.1: Offsite Groundwater Sites – Melton Valley (MV-OS)

4.1.2 Related DOE Projects

Within the last five (5) years, DOE has completed, or is in the process of completing, the following offsite groundwater activities:

1) 2017: DOE submitted the *Offsite Groundwater Assessment Remedial Site Evaluation* (DOE, 2017) which documents the collection of water samples between FY14 and FY16 at 34 private water wells and 15 springs located outside the ORR boundary.
2) 2022: DOE completed field activities as outlined in the *Remedial Site Evaluation Phase 2 Offsite Detection Monitoring Work Plan* (DOE, 2018). These field activities included three (3) years of annual sampling conducted during the wet season at 14 offsite private water wells/springs within all four subareas (Figure 4.1.5.1). Measurements were taken for water quality parameters in the field (e.g., temperature, pH, specific conductivity [SpC], dissolved oxygen [DO], oxidation-reduction potential [ORP], and turbidity). In addition, the water samples were also analyzed for potential contaminants like volatile organic compounds (VOCs), gross alpha, gross beta, uranium-233/234, uranium-235/236, uranium-238, and select fission products/transuranic elements. DOE documented the results of these

monitoring efforts in the *Phase 2 Offsite Detection Monitoring Remedial Site Evaluation* (DOE, 2022a). DOE plans to conduct annual monitoring at these same 14 locations moving forward (DOE, 2023).

3) DOE collected groundwater samples from exit pathway wells and springs, specifically those within Bear Creek Valley and Melton Valley. The purpose was to monitor groundwater water quality within the western boundary of the ORR. These exit pathway wells and/or springs contained concentrations of VOCs and manmade radionuclides which suggests westward contaminant migration (DOE, 2022b).

4.1.3 PROBLEM STATEMENTS

1) Delineation of the nature and the extent of groundwater contamination is incomplete in many areas within each ORR campus (DOE, 2022b).
2) Each of these facilities have numerous groundwater contaminant plumes associated with them due to past DOE mission activities. Many contaminant plumes are not well defined and require ongoing investigation to delineate their vertical and horizontal extent.

4.1.4 GOALS

1) The primary goal of this project is to evaluate risk to human health and the environment through sampling and analysis of groundwater offsite of the ORR.
2) Obtain access and collect groundwater samples from up to 35 private water wells within the Melton Valley Offsite Subarea and surrounding area to the southeast.
3) Form a rapport with private well and spring owners for continuous sampling access.
4) Obtain access and collect groundwater samples from up to 5 springs within the MV Offsite Subarea (OS).
5) Perform monthly field parameter monitoring of the springs (inclusive of the spring sampling event) throughout FY25.

4.1.5 SCOPE

The locations of sampling efforts for FY25 will consist of several selected private water wells and springs located downgradient, to the southwest and along the geologic strike, of WOC confluence with the Clinch River (WOC-CR). The WOC offsite area is downstream of ORNL and is located in Melton Valley (MV). This subarea will be referred to herein as the Melton Valley Offsite Subarea (MV-OS), whose boundary is defined by DOE (DOE/OR/01-2715&D2_R) and later documents (URS et al, 2017) (Figure 4.1.1.1 and Figure 4.1.5.2). Of note, some of the proposed wells are not officially within the defined MV-OS but are immediately adjacent to the southeast (Figure 4.1.5.2).

The scope of the project will be to collect groundwater samples from selected wells and springs within the MV-OS and surrounding area to the southeast. The proposed sample locations

include 35 offsite private water wells, 5 offsite springs, and 8 quality control samples for a total of 48 potential samples. For project planning purposes, it is assumed that only 35 samples will be ultimately collected due to potential site access issues. The project will focus on obtaining access and collecting groundwater samples from 35 private water wells (Figure 4.1.5.1 and Figure 4.1.5.2). These water samples will be submitted for laboratory analysis (e.g., inorganics, volatile organic compounds (VOCs), radionuclides, and metals) using the analytical methods specified in Table 4.1.8.1.

There are currently DOE offsite well clusters (i.e., residential wells that were converted to monitoring well clusters; OMW-3 and OMW-4) located in the study area that are not proposed to be included in this evaluation.

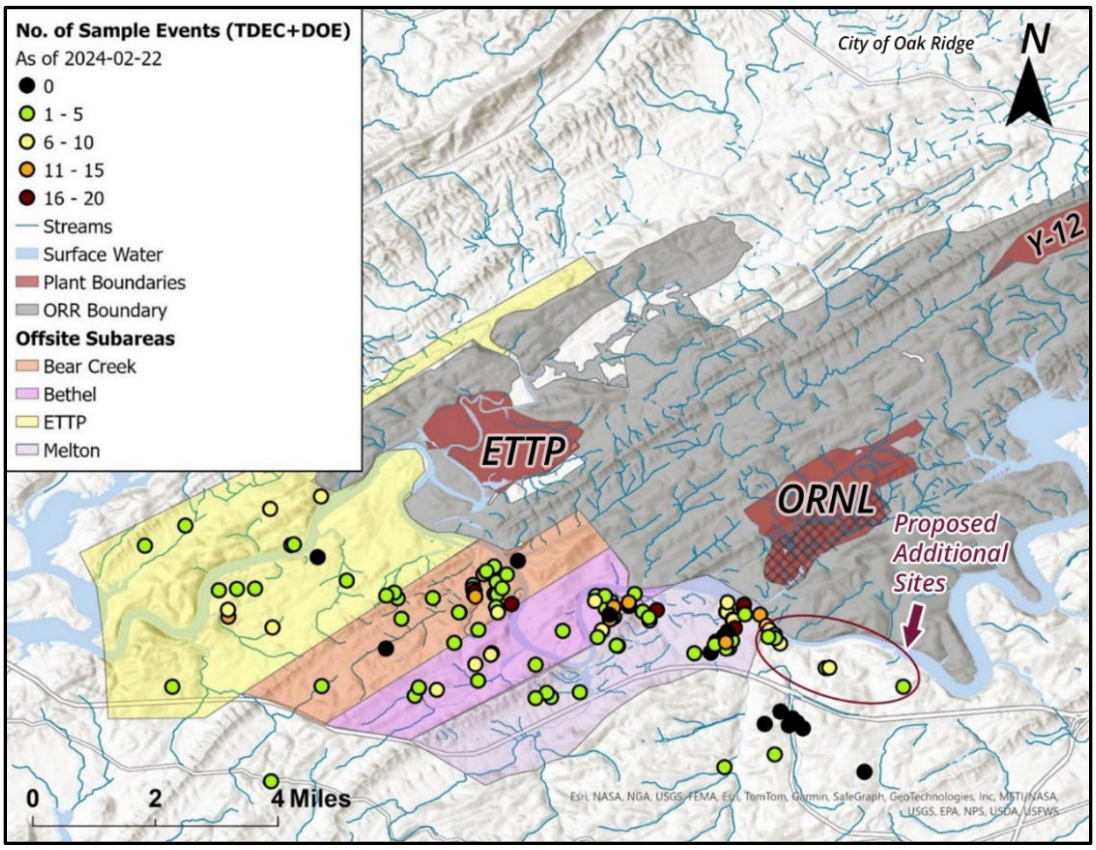

Figure 4.1.5.1: Historical & Proposed Private Water Well Sites in all Offsite Subareas

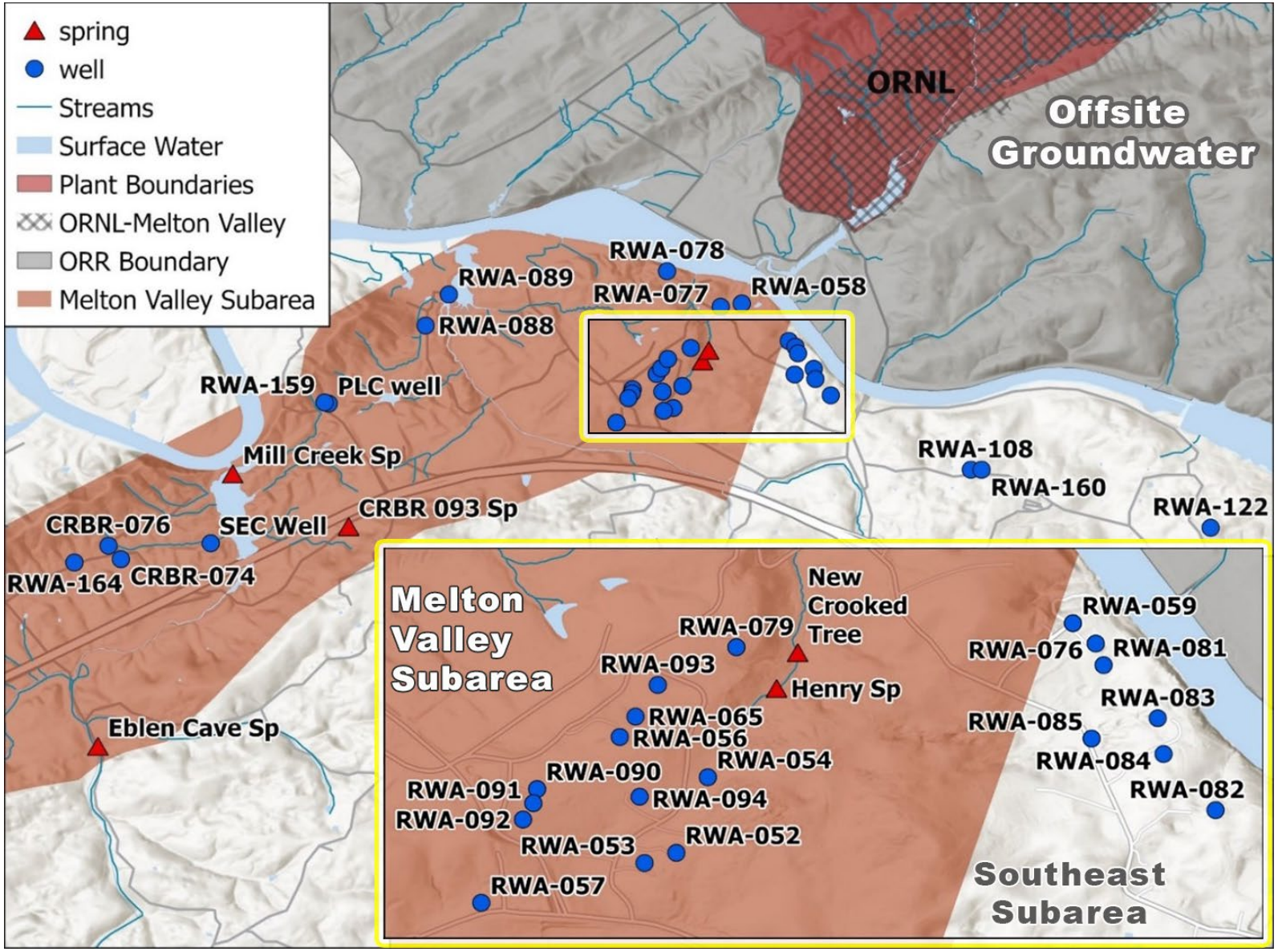

Figure 4.1.5.2: FY25 Proposed MV-OS and Adjacent FY25 Offsite Groundwater Sites

4.1.6 Assumptions

This project is based on the following assumptions:

1) Available data is accurate enough to locate wells and springs.
2) A minimum of 35 well owners will allow project team to collect water samples.
3) The infrequent sampling of the private water wells and springs will not capture the potential temporal variability of water quality.

4.1.7 Constraints

Constraints that may impact this project include:

1) Standard constraints; including equipment failure, funding, staffing, transportation, weather.
2) Contacted residents may not want to participate in the groundwater sampling project. The minimum of 35 wells might not get sampled this fiscal year.
3) Some water wells might have filtration systems that are difficult or impossible to bypass, add water softeners, etc., any of which effect the quality and usefulness of the data.
4) Water wells have working pumps to obtain samples.
5) Lack of information on well construction, such as depth, may complicate data interpretation and analysis.

4.1.8 Methods, Materials, Metrics

The project will focus on obtaining access and collecting groundwater samples from private water wells (Figure 4.1.5.1 and Figure 4.1.5.2) and springs. The samples will be submitted for laboratory analysis for inorganics, volatile organic compounds (VOCs), radionuclides, and metals using analytical methods specified in Table 4.1.8.1. The sampling will take place during the groundwater high season (i.e., January, February, March). A supplemental spring monitoring event will occur sometime during the groundwater dry months (i.e., August, September, October) and will only consist of measuring water quality parameters and documenting flow conditions (Table 4.1.8.1).

The wells will be sampled in accordance with the TDEC SOP for sampling of wells with pumps already in place (TDEC. 2023a). Per this protocol, samples will be collected by using the homeowner's existing submersible well pump from an outside tap. This tap needs to be located as close to the well as possible, and ideally, the spigot placement is before water passes through any filtration and/or water softener systems. The volume of water purged prior to sample collection will depend on frequency of use for each well. Once the appropriate volume of water has been purged, and water quality parameters have stabilized for three consecutive readings, a groundwater sample will be collected. This field parameter stabilization protocol is specified in Table 4.1.8.2.

At the springs, the field water quality parameter measurements and laboratory samples will be collected using a peristaltic pump. The springs will be sampled in accordance with the TDEC SOP for sampling of Seeps and Springs (TDEC. 2023b). During the sampling event, a minimum of five springs will be sampled. Additional water quality measurements will be taken during a second event during the dry season at those sites with ample flow.

The water samples collected from the private water wells and springs will be analyzed for volatile organic compounds (VOCs), gross alpha/beta, inorganics, and metals using the analytical methods specified in Table 4.1.8.2 or equivalent analytical methods. If gross alpha activity is detected in any of the groundwater samples at a concentration greater than or equal to (≥) 5 picocuries per liter (pCi/L), then those groundwater sample(s) will be analyzed for isotopic uranium. To ensure that water is available from each site for possible isotopic uranium analysis, a dedicated sample bottle will be filled during each sampling event. The project team will note on the Chain of Custody (COC) for the lab to hold the sample pending the results of the gross alpha activity (≥ 5 pCi/L).

Quality control (QC) samples will be collected at a frequency of 10% of samples (e.g., 35 samples, 4 QCs/duplicates). For planning purposes, it is assumed that 4 field duplicates and 4 field blanks will be collected and analyzed. At least one trip blank will be included in each batch of samples submitted to the laboratory.

The resulting analytical data will be evaluated and compared against numerical standards set forth in TDEC's *General Water Quality Criteria Chapter 0400-40-03-.03* (TDEC, 2019) and EPA's *National Priority Drinking Water Regulations* (EPA, 2009) to evaluate risk to human health. The data will be reviewed to evaluate if the private water wells and springs have been impacted from DOE ORR legacy contamination, and to what extent. Additional analysis will be conducted and may include using graphs, maps, statistics, and/or geochemical tools to display data and compare the major ion chemistry between the groundwater samples (e.g., Stiff Diagram). The results of the groundwater sampling will be incorporated into the TDEC's FY25 Environmental Monitoring Report (*EMR)*.

Table 4.1.8.1: Groundwater Sampling Plan

Station Name[1]		*Historical # Samples*[1]	*Analytical Parameters*[2]				
			VOCs	*Inorganics*	*Metals*	*Sr- 89/90*	*Gross α/β*
RWA	052	3	1	1	1	1	1
	053	1	1	1	1	1	1
	054	0	1	1	1	1	1
	056	13	1	1	1	1	1
	057	0	1	1	1	1	1
	058	18	1	1	1	1	1
	059	9	1	1	1	1	1
	065	15	1	1	1	1	1
	076	21	1	1	1	1	1
	077	2	1	1	1	1	1
	078	7	1	1	1	1	1
	079[3]	9	1	1	1	1	1
	081	9	1	1	1	1	1
	082	2	1	1	1	1	1
	083	1	1	1	1	1	1
	084	1	1	1	1	1	1
	085	1	1	1	1	1	1
	088	3	1	1	1	1	1
	089	16	1	1	1	1	1
	090	1	1	1	1	1	1
	091	1	1	1	1	1	1
	092	1	1	1	1	1	1
	093	0	1	1	1	1	1
	094	2	1	1	1	1	1
	108	1	1	1	1	1	1
	122	1	1	1	1	1	1
	159	3	1	1	1	1	1
	160	5	1	1	1	1	1
	164[4]	9	1	1	1	1	1
CRBR	074	2	1	1	1	1	1
	076	2	1	1	1	1	1
	093	0	1	1	1	1	1
Well	SEC	2	1	1	1	1	1
	PLC	2	1	1	1	1	1
Spring	*Henry*	0	1	1	1	1	1
	New Crooked Tree	2	1	1	1	1	1
	Elben Cave	0	1	1	1	1	1
	Mill Creek	1	1	1	1	1	1

Table 4.1.8.1 *(Continued):* Groundwater Sampling Plan

Sampling Summary	Analytical Parameters[2]				
	VOCs	*Inorganics*	*Metals*	*Sr-89/90*	*Gross α/β[7]*
Total Primary Samples	38	38	38	38	38
Field Blank	4	4	4	4	4
Field Duplicate	4	4	4	4	4
Trip Blanks	10	--	--	--	--
Total Samples (FY25)	**56**	**46**	**46**	**46**	**46**
Assumed Actual Samples[5]	**43[6]**	**35**	**35**	**35**	**35**

Notes: All water samples will be collected during the FY25 groundwater high season (January, February, March). Spring samples months will be collected in later during groundwater low months (August, September, October) depending on flow conditions.

[1] – Total number of sampled events either conducted by TDEC and/or DOE. The number of historic spring sample events is estimated.

[2] – The list of analytes and their analytical methods are defined in Table 4.1.8.2.

[3] – Well sampled by DOE during Q2 of their fiscal year. TDEC will attempt co-sampling for this well.

[4] – Well is sampled by DOE during Q2 of their fiscal year under the alias well name CRBR-071.

TDEC will attempt co-sampling for this well.

[5] - Total samples estimated to be collected.

[6] - Assumes 6 trip-blanks

[7] – Isotopic uranium analysis will be run on samples with a gross alpha activity concentration greater than or equal to 5 picocuries per liter (pCi/L).

*** Table above assumes 75% are accessible (35 wells, 5 springs).*

Table 4.1.8.2: Analytical Test Suite

Parameter Type	*Analytes*	*Analytical Method*
Inorganics	alkalinity	*SM 2320-B*
	ammonia as N	*EPA Method 350.1*
	nitrate/nitrite as N	*EPA Method 353.2*
	chloride	*EPA Method 300.0*
	fluoride	*EPA Method 300.0*
	sulfate	*EPA Method 300.0*
	total dissolved solids (TDS)	*SM 2540-C*
Metals	calcium, iron, magnesium, potassium, sodium, total hardness	*EPA Method 200.7*
	aluminum, **antimony**, **arsenic**, **barium**, **beryllium**, boron, **cadmium**, **chromium**, **copper**, **lead**, lithium, manganese, **nickel**, **selenium**, silver, strontium, **thallium**, **uranium**, vanadium, zinc	*EPA Method 200.8*
	low level mercury	*EPA Method 1631*
Volatile Organic Compounds	**EPA 8260B full list VOCs**	*EPA Method 8260B Low Level*
Radionuclides	**gross alpha**/gross beta	*D7283-17*
	Sr-89/90	*EPA Method 905.0*
	Isotopic Uranium	*HSL-300*
Water Quality Parameters	pH	*±0.1*
	temperature (°C)	±10%
	specific conductivity (µS/cm)	±5%
	dissolved oxygen (mg/L)	NA
	oxidation-reduction potential (mV)	±10 mV
	turbidity (NTU)	±10%

Notes: ***Bolded*** *values have a numerical standard.* *°C – degrees Celsius* *mV - millivolt*
µS/cm – microSiemens per centimeter *mg/L – milligram per liter*
NA – not applicable *NTU – nephelometric turbidity unit*

4.1.9 REFERENCES

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5.0 LANDFILL MONITORING

5.1 EMDF SURFACE WATER SAMPLING

5.1.1 BACKGROUND

The EMDF is the proposed landfill for the disposal of low-level radioactive waste (LLRW) and hazardous waste generated by remedial activities on the ORR. This landfill, like EMWMF, will be operated under the authority of CERCLA and DOE. While the EMDF facility will not hold a permit from the State of Tennessee, the EMDF is required to comply with DOE orders and substantive portions of the applicable or relevant and appropriate requirements (ARARs) listed in the signed CERCLA Record of Decision (ROD).

5.1.2 RELATED DOE PROJECTS

DOE currently monitors Bear Creek and some of its northern tributaries (NT-3, NT-4, NT-5) for potential releases from the existing EMWMF (Section 5.2). The wastewater released from the EMWMF sediment basin is collected by an automatic sampler using a weekly flow-weighted composite sample. Annually, the results from these sampling efforts are published in the EMWMF Phased Construction Completion Report (PCCR).

5.1.3 PROBLEM STATEMENTS

1) After EMDF construction, the disposal of waste materials from CERCLA remediation activities could potentially leach out of the landfill and enter the environment.
2) Contamination from wastes placed in the EMDF may migrate offsite through surface water and/or groundwater at concentrations or radiological activities above agreed limits.
3) Currently there is no pre-construction monitoring by DOE to speak to existing site-conditions to compare with future impacts.

5.1.4 GOALS

1) Implement a continuous surface water monitoring via in-situ probe at two locations.
2) Independently monitor surface water to evaluate effects of construction activity at the EMDF on water resources.
3) Assess compliance with ARARs listed in the EMDF ROD.
4) Collect relevant analytical and water quality parameter data to monitor water resources that could potentially be impacted by EMDF early construction.

5.1.5 SCOPE

The scope of the FY25 *EMDF Monitoring Project* will encompass seven (7) water quality parameter monitoring sites within the Central Bear Creek Watershed. These sites along Bear Creek tributaries are in and around the EMDF Landfill footprint. This project proposes to collect

water samples twice per year (semi-annually) at four (4) locations: three locations downgradient of the EMDF Surface Water Flume sites (SF-1, SF-5R, and SF-6) and one upgradient location (Spring D10W) to better understand contaminant conditions during the initial stages of construction of EMDF.

Table 5.1.5.1: EMDF Surface Water / Groundwater Sampling Sites

DOE/TDEC Sample ID	**Sampling Frequency**		***Sampling Site Description and Rationale***
	Analytical	*Parameters*	
SF-1	Semi-annually	Continuous In-situ probe	*Most downstream point of NT-11; captures surface water & groundwater from the site*
SF-5R			*Most down stream point of NT10. Captures surface water along the eastern landfill footprint flowing from NT-10 into Bear creek. Sample collected at the confluence with Bear Creek*
SF-2	none	Monthly	*Collects water along the western landfill footprint; confluence of NT-11 & Bear Cr*
SF-3			*Most upstream point of NT-11; captures surface water & groundwater*
SF-4			*Collects water from NT-10W at midpoint of landfill*
SF-6	Semi-annually		*Upstream site on NT-10W, captures surface water potentially impacted by landfill*
SP-D10W			*Background or reference spring. Source waters of NT-D10W*

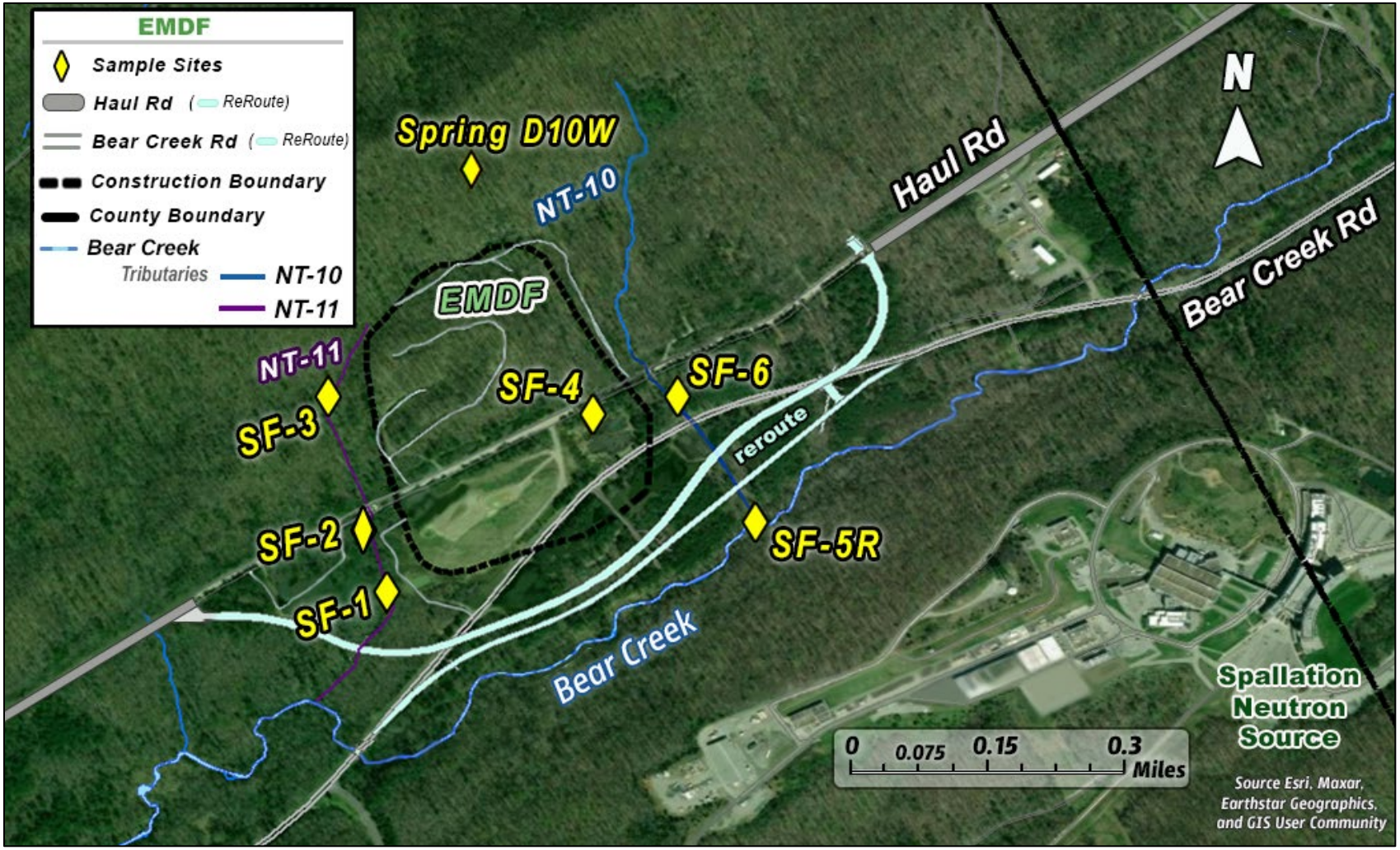

Figure 5.1.5.1: EMDF Surface Water Project Site and Monitoring Locations

5.1.6 ASSUMPTIONS

1) The selected monitoring sites and constituents will be adequate to determine any impacts to water resources from construction at EMDF.
2) The frequency of sampling events will accurately show any trends in water quality and/or migration of contaminants.

5.1.7 CONSTRAINTS

1) Standard constraints; including equipment failure, funding, staffing, transportation, weather, access to sample sites on the ORR.
2) EMDF construction will impact site access at some point.
3) Collected samples may contain radiological contamination and require assessment by DOE Radiological Protection Technicians (RPTs) to be removed from site; DOE's contracted RPTs do not work on Fridays at this site.
4) Monitoring and sampling are contingent upon the presence of adequate surface/ groundwater.

5.1.8 METHODS, MATERIALS, METRICS

This project will provide data to identify current water quality conditions in the Central Bear Creek Watershed EMDF area, using site specific physical parameters (i.e., pH, DO, Conductivity, ORP, Turbidity), and analytical results, collected from spring/surface water samples during the FY25 EMDF site preparation activities. This sampling will provide assurance through independent monitoring and coincident evaluation of DOE's data, that future baseline data determinations are appropriate for use in future stream evaluations. The project monitoring protocol will include obtaining surface water quality parameters from surface water flumes (SF) along three (3) Bear Creek tributaries that are located in the vicinity of the EMDF Landfill: North Tributary-11 (NT-11), NT-10, and D-10W.

Table 5.1.7.1: EMDF - Bear Creek Sample Sites by Tributary

Bear Creek Tributary	***Location with Respect to EMDF***	***Monitoring Sites*** *7 locations*
NT-11	Western Edge	*SF-1, SF-2, SF-3*
NT-10	Eastern Edge	*SF-6*
D-10W	Eastern Edge	*SF-4, SF-5R*
** Headwaters D-10W*	Northern Edge	*Spring D10W*

DoR-OR personnel will monitor these seven locations for the water quality parameters (i.e., temperature, pH, conductivity, turbidity, oxidation-reduction potential, and dissolved oxygen) at least monthly during FY25. The project team will utilize a water quality instrument for these measurements. Confidence checks and/or calibration of this instrument shall be performed

prior to field use. Parameter measurements follow the *TDEC DoR-OR Quality Assurance Project Plan* (2015) and the *Sampling and Analysis Plan* (2016).

Staff will perform general monitoring and observations of the site during the monthly water quality parameters measurement events. Stream observations will include log entries on the status of the streams, any discharges, water conditions, streambank issues, and list any concerns. Concerns, if any, will then be brought to the attention of DOE/EMDF personnel. Field notes will be recorded in a field log and submitted for digital storage. All sampling events will also be included and tracked in TDEC internal Monthly Status Reports.

During the ongoing EMDF site preparation activities, the project team will sample twice during FY25 as noted in Table 5.1.5.1. This sampling and monitoring will be used to verify DOE's utilization of best management practices (BMPs) to limit possible contaminant migration associated with construction activities. Sampling will also collect data that can be used to support establishment of baseline surface water conditions.

DoR-OR and DOE monitoring results will be entered into a database for comparison and evaluation in the FY25 EMR. For long-term archival storage, these data will be entered into TDEC's TOREIS database. This comprehensive database will allow staff to expedite the availability of data to other projects and/or for other evaluation purposes.

Table 5.1.8.2: EMDF Analyte List

EMDF Analyte List					
Radionuclides					
Americium-241	*Cobalt-60*	*Neptunium-237*	*Thorium-228*		
Carbon-14	*Europium-154*	*Plutonium-238, 239/240*	*Uranium-234/235*		
Cesium-137	*Iodine-129*	*Radium-226/228*	*U-235/236*		
Chlorine-36	*Lead-210*	*Technetium-99*	*U-238*		
Metals					
Arsenic	*Cadmium*	*Cobalt*	*Lead*	*Nickel*	*Vanadium*
Barium	*Chromium*	*Copper*	*Mercury*	*Uranium*	*Zinc*
Inorganics					
Nitrite	*Nitrate*				
Organics					
PCBs	*Volatile Organics*				

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5.2 EMWMF SURFACE WATER MONITORING PROJECT

5.2.1 BACKGROUND

The EMWMF was constructed for the disposal of low-level radioactive waste (LLRW), as defined in TDEC 0400-20-11.03(21) in the "Rules of TDEC DRH Licensing Requirements for Land Disposal of Radioactive Waste, Chapter 0400-20-11" document. The EMWMF also accepts hazardous waste (HW) generated by remedial activities on the ORR. LLRW is screened to ensure radiological concentrations are below limits enumerated by Waste Acceptance Criteria (WAC) and are at levels agreed to by the FFA tri-parties (DOE, EPA and TDEC). This landfill is operated under the authority of CERCLA. While this facility holds no permit from any State agency, operations are required to comply with ARARs contained in the CERCLA ROD (DOE 1999) and substantive requirements in DOE Orders and directives. These regulations were developed to address responsibilities delegated to the agency by the *Atomic Energy Act* of 1954.

Currently, the only authorized discharge from EMWMF is contaminated storm water and non-contaminated stormwater.[1] As designated by the *EMWMF Sampling and Analysis Plan/Quality Assurance Project Plan* (SAP/QAPP), contact water is derived from precipitation that falls into an active cell, contacts waste, and collects in the disposal cells above the leachate collection system. The contact water is routinely pumped from the disposal cells to holding ponds and tanks where it is then sampled. Next, the water is either treated and/or released to a stormwater sedimentation basin based on DOE analytical results. Water discharges flow into a tributary of Bear Creek (BC) known as North Tributary 5 (NT-5).

For contaminants other than radionuclides, TDEC monitors the discharge point for the contact water ponds. The *Tennessee Ambient Water Quality Criteria for Fish and Wildlife* [400-40-03-.03(3)] outlines the limits for the releases of contact water to the sediment basin and via the basin to Bear Creek through NT-5. Bear Creek's designated uses currently include recreational uses. It is also important to note that DOE has not yet incorporated potential recreational exposure into the EMWMF release criteria contained in the EMWMF SAP/QAPP.

For radionuclides, the limits on releases from the holding ponds/tanks to the sedimentation basin (SB) are currently based on requirements contained in DOE Order 5400.5. This order restricts the release of liquid wastes containing radionuclides to an average concentration

[1] "Contaminated stormwater" is designated "contact water" in the EMWMF Sampling and Analysis Plan (SAP)/Quality Assurance Program Plan (QAPP) [DOE/OR/01-2734&D1]. The EMWMF ROD does not include legal definitions for landfill wastewater, such as those in 40 CFR 445.2(b), (f); 40 CFR 260.10; and TDEC 0400-11-01-.01(2). This omission should be corrected when the ROD is revised in accordance with the EPA Administrator's December 31, 2020, dispute resolution decision.

equivalent to a dose of 100 mrem/year. The limit for discharges from the sedimentation basin to NT-5, which subsequently empties into Bear Creek, is based on TDEC 0400-20-11-.16(2) [10 CFR 61.41]. This regulation restricts public dose from radioactive material released from LLRW disposal facilities to 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of any member of the public. EPA has deemed this rule to be protective under CERCLA. EPA provides an approximate Total Effective Dose Equivalent (TEDE) of 10 mrem/year to assist with applying this requirement to radiation risk assessment at CERCLA sites.[2]

Table 5.2.1.1: ARARs for Contact Water/Surface Water / Storm Water (EMWMF SAP/QAPP)

EMWMF Regulations for Contact Water (CW) and Surface Water (SW)			
Required Action		*Performance Objectives*	*ARARs (Performance Measures at EMW-VWEIR)*
CW SW	*Monitor discharges*	**TDEC 0400-40-03-.03(3)*	*EMW-VWEIR, CW ponds and tanks: compare analytical results to AWQC*
		TDEC 0400-20-11-.16	
StW	*Check RAD*	*10 CFR 20.1301(a)*	*SW samples from EMW-VWEIR: analyzed RAD COCs Use for sum of fractions required for dose calculations*
		TDEC 0400-20-22-.16	
CW – Contact Water SW – Surface Water StW – Storm Water RAD - radioactive activity or radioactive materials Contact Water: mixture of contaminated and uncontaminated stormwater			

The TDEC DoR-OR initiated water monitoring at the EMWMF in 2006, and it has persisted to the present day. Since 2006, surface water, groundwater, and sediment samples, where conditions allowed, have been collected, analyzed, and published annually in the TDEC DoR-OR Environmental Monitoring Report (EMR). DoR-OR's monitoring of groundwater and surface water provides regulatory oversight for the requirements stated in the EMWMF ROD (DOE 1999) and Tennessee General Water Quality Criteria (TDEC 2019).

5.2.2 Related DOE Projects

Currently, DOE monitors two (2) of Bear Creek's North Tributaries, NT-5 and NT-3, on a quarterly basis. This sample frequency is conducted to identify any contaminated releases from the landfill. Figure 5.2.5.1 shows their sampling locations (light gray, italics text).

DOE collects samples routinely from the underdrain (EMWMF-2), and the V-weir (EMWMF-3), while releases from the sediment basin are continuously monitored. using an automatic sampler. Compilation of the sediment basin data begins with the calculation of a weekly flow-rated composite sample as storm water is discharged. DOE calls this the "VCOMP" sample in their database. The composite levels are used to calculate the volume weighted sum of

[2] See Footnote 11 in *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*, OSWER No. 9200.4-18, August 22, 1997. Available at https://semspub.epa.gov/work/HQ/176331.pdf.

fractions for discharge. The remainder of scheduled DOE sampling includes EMWNT-03B, EMWNT-05, NT-4 (Bear Creek Tributary) and the V-weir (EMWMF-3). The additional V-weir (EMWMF-3) sampling is completed semi-annually after a qualifying precipitation event (> 0.1 inches). DOE will also collect a suspended solids sample at EMWMF-3 after a qualifying precipitation event (> 0.5 inches).

Each year, DOE publishes its monitoring results in the *Phased Construction Completion Report* (PCCR) (DOE 2023) and enters all data into the Oak Ridge Environmental Information System (OREIS).

The DoR-OR sampling analysis results are designed to provide comparable data for DOE oversight and to fill in data gaps with respect to EMWMF water discharges into the environment.

5.2.3 PROBLEM STATEMENTS

Contaminated materials from CERCLA remediation activities are buried and continue to be placed in the EMWMF. Over time, associated mobile contaminants have the potential to migrate from the facility into the environment and be carried by groundwater and surface water pathways.

5.2.4 GOALS

Overall, the EMWMF Monitoring Project aims to protect human health and the environment by:

1) Monitoring discharges from the landfill into the Bear Creek Watershed.
2) Conducting independent monitoring to verify DOE monitoring data.
3) Providing oversight to ensure that operational requirements and remedial action objectives are met for the EMWMF.
4) Continuing evaluation of the effectiveness of the Underdrain (EMWMF-2) for lowering the groundwater table.

Specific FY25 monitoring goals:

1) Perform continuous independent monitoring and use results to reassure stakeholders that DOE landfill operations are protective of public health and the environment.
2) Augment DOE's surface water data and fill potential gaps in DOE's monitoring actions.
3) During each year of the project, calculate the approximate amount of discharged water volume from the contact water ponds/tanks. Maintain an accurate record of discharged volumes for an evaluation of contaminant loading.

5.2.5 SCOPE

The scope of the *EMWMF Surface Water Monitoring Project* will include conducting sampling, collecting water quality parameters and/or making observations at six (6) main landfill sites by DoR-OR. Data will then be compared against DOE monitoring data. Analytical sampling and water quality measurements will be collected to determine if any contaminants are being released into the surrounding area. Onsite observations are also conducted weekly at the landfill. Any concerns noted will be logged into the field log and reported to EMWMF/DOE personnel. Table 5.2.5.1 and Figure 5.2.5.1 depict monitoring and sampling locations and sample rationale at the EMWMF.

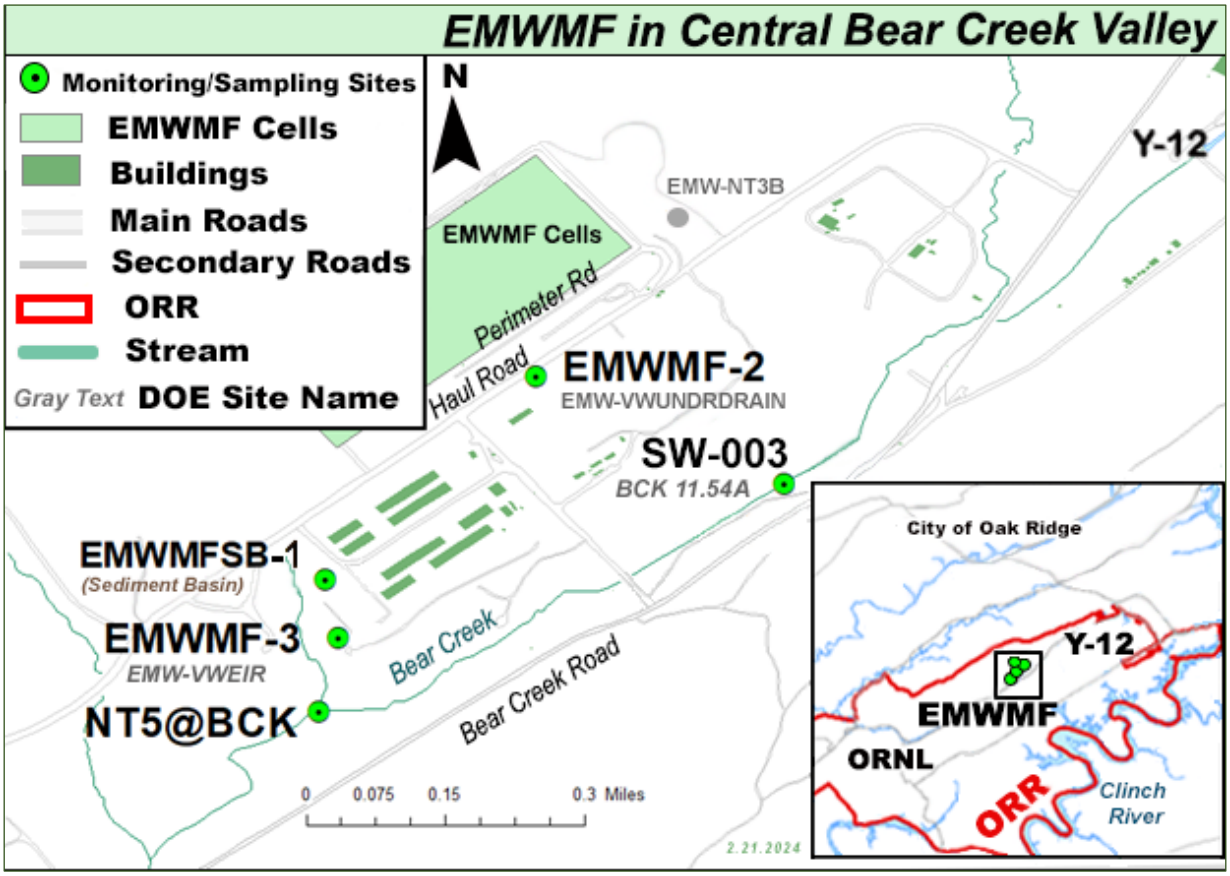

Figure 5.2.5.1 EMWMF Surface Water Sampling Locations

Table 5.2.5.1: EMWMF Monitoring and Sampling Sites

DOE Station ID	DoR-OR Sample ID	Frequency		Site Description/Sampling Rationale
		Analytical	Parameters	
EMW-VWUNDRDRAIN *Underdrain water below liner*	**EMWMF-2**	Semi-Annually	Continuous (*monthly in-situ probe downloads)*	*NT-4 discharge below the landfill. The underdrain was installed below Cell 3, and it is hypothesized that if cells 1, 2, and 3 were to leak contaminants, they would first be observed at the underdrain.*
EMW-VWEIR *effluent discharge*	**EMWMF-3**			*Provides confirmation of contaminant levels being discharged from the sediment basin.*
Sedimentation Basin **dry sediment*	**EMWMFSB-1**	Annually	Annually ***either*** *basin or pond/tank*	*Typically, this location is only sampled when the sediment basin is dry. The results are used to observe the loading of radionuclides in the sediment of the basin.*
Ponds/Tanks *Contact Water*	**Pond or Tank**			*Provides confirmation of contaminant levels being discharged to the sediment basin.*
BCK 11.54A	**SW003**	*None*	Monthly	*Upstream surface water location to be used as a water quality reference.*
EMWNT-05	**NT5 @ BCK**	Annually	Monthly	*Collection of water along landfill footprint, released to Bear Creek.*

5.2.6 ASSUMPTIONS

1) The selected number of sample sites and constituents and the frequency of sampling is sufficient to identify any contaminants migrating away from the landfill via stormwater.
2) Water quality parameters are measured monthly, at minimum, and represent a good screening method to discern any migration of contaminants in stormwater. Parameters like pH, dissolved oxygen, conductivity, and /or temperature will change in such a way to be noticeable.

5.2.7 CONSTRAINTS

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, and/or ORR closures.
2) Availability of DOE radiological technicians to escort DoR-OR staff to contaminated areas. Technicians do not work on Fridays.
3) Access to certain areas require DOE staff to unlock facilities.
4) Coordination of co-sampling with DOE field teams can be problematic due to staff turnover and differing schedules.

5.2.8 METHODS, MATERIALS, METRICS

Groundwater, surface water, and sediment sampling will follow the *TDEC DoR Quality Assurance Project Plan* (2015) and the *Sampling and Analysis Plan* (2016). The protocol to perform EMWMF surface water sampling is outlined in *TDEC Standard Operating procedure T-704 Collection of Surface Water Samples*, TDEC Quality Systems *Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water Revision 6* (TDEC 2022.)

A summary of the yearly sampling at EMWMF is discussed in the bullet points below. Different samples are on different schedules so please refer to Table 5.2.5.1 for the sampling frequencies.

1) Measure water quality parameters in EMWMF discharges at four locations, EMWMF-2 (Underdrain), EMWMF-3 (Sediment Basin v-weir discharge), weir SW-003 (upstream of EMWMF at BCK 11.54), and NT5@BCK (confluence of NT-5 and Bear Creek) (Figure 5.2.5.1). The measured water quality parameters are temperature, pH, specific conductivity, dissolved oxygen, and oxidation-reduction potential, and turbidity. TDEC DoR-OR personnel will monitor these locations at least weekly with the use of a YSI-Professional Plus water quality instrument or equivalent.
2) Groundwater sampling at EMWMF-2 (underdrain) will be conducted semi-annually to complement DOE sampling.
3) Sampling at EMWMF-3 (V-weir) conducted semi-annually to confirm DOE analyses and to coincide with a weekly “VCOMP” collection by DOE at EMWMF-3.

4) Sampling of sediments at the sediment basin (EMWMFSB-1) will be conducted annually. If the bed of the sediment basin is dry enough to safely walk on, sample aliquots will be collected and composited into one sample for analysis.
5) Sampling of one contact water pond and/or tank either by co-sampling with DOE contractors or upon discharge will be conducted annually to confirm DOE analyses.
6) As operations warrant, observations of landfill operations and surface water parameter measurements will be made at least once a week.
7) InSitu™ multiparameter probes were installed at EMWMF-2 and EMWMF-3. These probes collect water quality parameters on an hourly basis and will be downloaded for later analysis and will be discussed during the environmental report for this project. The water quality parameters collected are the same as those measured by the YSI instrument with turbidity added.
8) Samples will be shipped to and analyzed by contracted laboratories.

Table 5.2.8.1: Laboratory Methods and Analyses

Method Designation	***Test Name***	***Analytes***
Method 200.8	*ICP-MS*	*Metals*
Method 1631	*Low Level Mercury (LLHg)*	*Mercury (Hg)*
Method 901.1	*Gamma water*	*Gamma radiation (γ)*
Method ASTM D7283-17	*Gross Alpha-Beta water by LSC*	*Gross alpha-beta activity (α-β)*
Method TDH SOP 402	*Sr-89/90 water by LSC*	*Strontium-89/90 (Sr-89/90)*
Eichrom Method TCW02	*Technetium-99 water*	*Technetium-99 (Tc-99)*
Method 906.0	*Tritium water*	*Tritium (H^3)*
Method U-02-RC	*Isotopic Uranium environmental materials*	*U-234, U-235, U-238*

The results of laboratory analyses will be entered into a database for interpretation. This evaluation of results will include visuals to show any changes in water quality parameters and contaminant levels. Levels will be compared to established limits. Table 5.2.8.1 lists the analytical methods and analyses that will be performed on each sample collected.

The EPA human and aquatic life criteria and the State of Tennessee aquatic life criteria will be used to compare the possible effects that discharged surface water could have on the environment (Table 5.2.8.2).

Table 5.2.8.2: EMWMF Surface Water Monitoring Criteria Comparison

	Human Life Criteria		***TN Aquatic Life Criteria***		***EPA Aquatic Life Criteria***	
EMWMF ANALYTE LIST (µg/L)	*Human Health for the consumption of Water + Organism*	*Human Health for the consumption of Organism ONLY*	*Freshwater CCC (acute)*	*Freshwater CCC (chronic)*	*Freshwater CMC (acute)*	*Freshwater CCC (chronic)*
Gamma Activity	-	-	-	-	-	-
Sr-89/90 in water	-	-	-	-	-	-
Technetium-99	-	-	-	-	-	-
Tritium in water	-	-	-	-	-	-
Transuranics/IsoU	-	-	-	-	-	-
Arsenic	0.018	0.14	340	150	340	150
Chromium	MCL	-	570	74	570	74
Cobalt	-	-	-	-	-	-
Copper	1300	-	13	9	-	-
Lead	-	-	65	2.5	82	3.2
Mercury	-	-	1.4	0.77	1.4	0.77
Nickel	610	4600	470	52	470	52
Uranium	-	-	-	-	-	-
Vanadium	-	-	-	-	-	-
Zinc	7400	25000	120	120	120	120
CMC Criterion Maximum Concentration *CCC Criterion Continuous Concentration*						

The criteria for sediment comparisons (Table 5.2.8.3) include EPA's Regional Screening Levels (RSLs) for the soil to groundwater pathway using the Soil Screening Level (SSL) tool. Migration of contaminants from soil to groundwater can be envisioned as a two-stage process where contaminants in soil are first leached from soil and then the contaminants are transported through the underlying soil and aquifer to a receptor well. Another sediment comparison criterion is the Consensus-Based Sediment Quality Criteria from the Wisconsin Department of Natural Resources which provides a threshold effects concentration (TEC) and a probable effect concentration (PEC) (MacDonald et al 2000).

Table 5.2.8.3: EMWMF Sediment Monitoring Criteria

Sediment MDLs for Risk Comparison ***(mg/kg)***			
Analyte	*EPA RSL Soil to GW SSL*	*TEC**	*PEC***
Aluminum	*30000*	*n/a*	*n/a*
Arsenic	*0.0015*	*9.8*	*33*
Antimony	*0.35*	*2*	*33*
Barium	*160*		
Beryllium	*20*		
Cadmium	*0.69*	*0.99*	*5*
Chromium	*4.00E+07*	*43*	*110*
Cobalt	*0.27*		
Copper	*28*	*32*	*150*
Iron	*350*	*20000*	*40000*
Lead	*14 MCL based*	*36*	*130*
Manganese	*28*	*460*	*1100*
Mercury	*14*	*0.18*	*1.1*
Nickel	*26*		
Selenium	*0.52*		
Silver	*0.8*	*1.6*	*2.2*
Thallium	*0.014*		
Uranium	*1.8*		
Vanadium	*86*		
Zinc	*370*	*120*	*460*

1. Use EPA MDLs for the following analytes:
Gamma, Sr-90, Tc-99, Tritium, Isotopic Uranium in soils or solids.
2. Calcium, Manganese, Potassium, & Sodium values are n/a at all three levels
3. Consensus Based Sediment Quality Criteria (McDonald et al, 2000)
** Threshold Effects Concentration*
*** Probable Effects Concentration*
n/a: criteria not established for that characteristic.

5.2.9 REFERENCES

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6.0 RADIOLOGICAL MONITORING

6.1 HAUL ROAD SURVEYS

6.1.1 BACKGROUND

In 2004, contaminated waste was lost from a DOE contractor's dump truck on a state highway in Tennessee. DOE conducted a Type B Accident Investigation to determine preventative measures. This investigation resulted in an agreement with the State of Tennessee to construct a separate transportation route for these dump trucks. The Haul Road was constructed and is reserved solely for trucks transporting CERCLA low-level radioactive (LLRW) and hazardous waste (HW).

DoR-OR staff perform surveys of the Haul Road and other waste transportation routes on the ORR used for carrying waste to the EMWMF for disposal to account for wastes or material that may have fallen from the trucks in transit. DoR-OR personnel perform walk over inspections of different segments of the nine-mile-long Haul Road and associated access roads on a bimonthly basis. Anomalous items noted along the roads are scanned for radiation, logged, marked with contractor's ribbon, and their descriptions and locations submitted to the DOE for disposition.

6.1.2 RELATED DOE PROJECTS

DOE conducts radiological surveys of the Haul Road using a tractor with radiological detection instrumentation attached. There is some concern that the distance from the road surface to the radiation detectors on the tractor is too far for effective detection of beta radiation. The tractor does not stop to survey anomalous objects found on or beside the road.

6.1.3 PROBLEM STATEMENTS

Throughout the history of the Haul Road surveys project, numbers of anomalous items have been identified such as waste debris, personal protection equipment, tarp patches, waste stickers, steel pipe, etc., that could potentially be contaminated.

6.1.4 GOALS

The primary goal of the project is to conduct independent oversight to identify potentially contaminated items resulting from the transportation of radioactive and hazardous waste from the ORR clean up locations to the EMWMF, along the Haul Road corridor.

In particular, the objectives include the following:

- Assess the radiological conditions of the Haul Road and objects that may have fallen from trucks.

- Ensure, through monitoring and oversight, that DOE and their contractors continue waste transportation in a manner that limits potential environmental impacts to the Haul Road and the surrounding areas.

6.1.5 SCOPE

The scope of this Haul Road project includes routine radiation walk over surveys of nine (9) mile-long segments of the Haul Road, Reeves Road, and associated access roads used for transportation of CERCLA waste to the EMWMF.

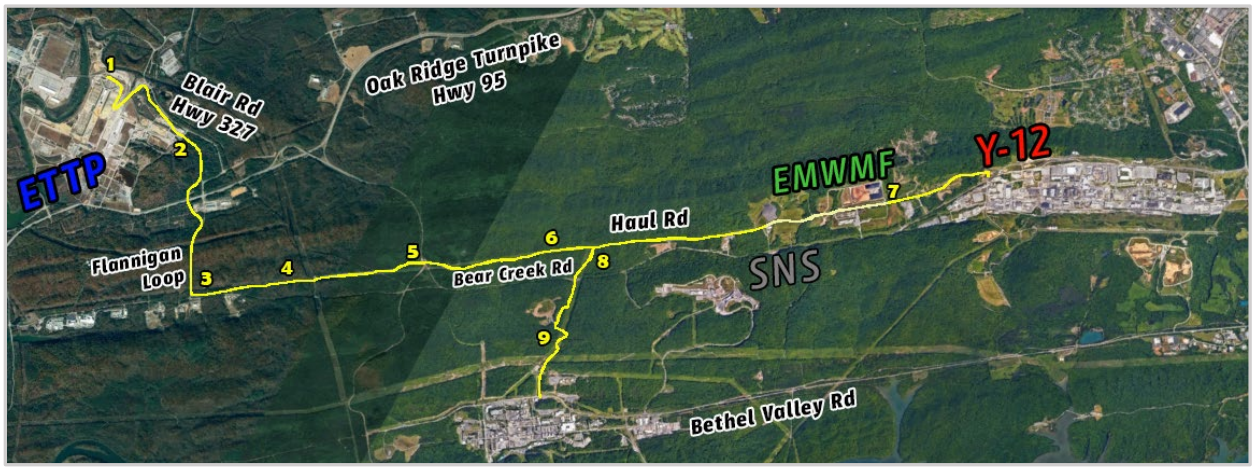

Figure 6.1.5.1: Haul Road Monitoring Sections

Figure 6.1.5.2: Haul Road Section 1

Figure 6.1.5.3: Haul Road Section 2

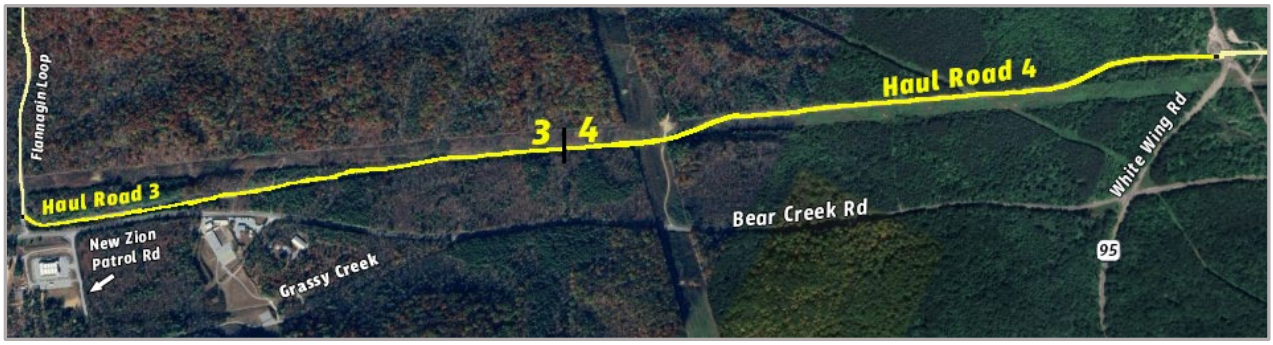

Figure 6.1.5.4: Haul Road Sections 3 and 4

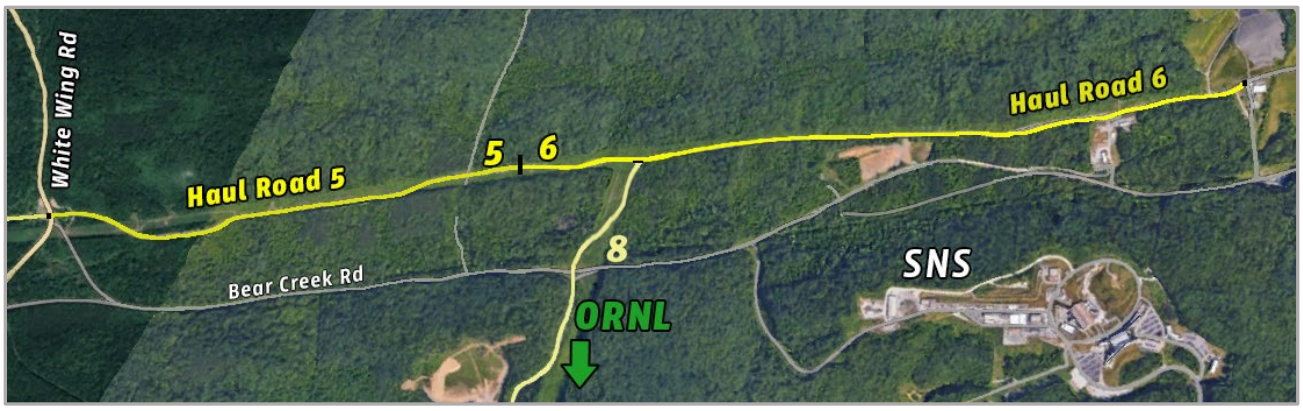

Figure 6.1.5.5: Haul Road Sections 5 and 6

Figure 6.1.5.6: Haul Road Section 7

Figure 6.1.5.7: Haul Road Sections 8 and 9

6.1.6 Assumptions

1) The Haul Road, Reeves Road, and other associated access roads will continue to be used for waste transportation during FY25 as D&D and related clean-up activities transition to ORNL and Y-12.
2) The frequency of planned walk over surveys will be sufficient to identify potential contamination or other anomalies related to waste transportation.
3) Available radiological instrumentation is adequate to detect radiological contamination if it exists.

6.1.7 Constraints

1) Standard constraints; including equipment failure, funding, staffing, transportation, weather, access to sample sites on the ORR.
2) Timing surveys during low traffic patterns.
3) Adjacent project areas may impact time surveys can be completed.

6.1.8 Methods, Materials, Metrics

As previously noted, the nine-mile length of Haul Road is surveyed in segments, typically consisting of approximately one mile. Prior to arriving on site to conduct each survey, the project team will notify the DOE contractor about the scheduled event. The DOE contractor will provide safety and status briefings on road conditions to DoR-OR. When excessive traffic presents a safety concern, the survey will be rescheduled.

When conducting a radiation walk over survey on a section of concern, the project team will walk in a serpentine pattern across the width of the road with a NaI Gamma Scintillator probe held approximately six inches above ground surface. This radiological instrument is used to scan for radioactive contaminants that may have fallen from a truck on the road. If elevated radiation is detected or anomalous items are found, an Alpha/Beta dual detector is used to investigate potential surface contamination. Any road areas or items with contamination levels exceeding action levels that require further investigation are noted, and DOE's contractor is notified for disposition.

The planned Haul Road Survey schedule is:

- Six surveys will be completed over a 12-month period.
- Conduct one survey on the Y-12 segment of the Haul Road.
- Conduct two surveys on Reeves Road.

Table 6.1.8.1: Haul Road Survey Coordination

Haul Road Survey Coordinators	Affiliation/Job Title	Email Address
Courtney Thomason	TDEC DoR-OR	Courtney.Thomason@tn.gov
Roger Parker	DOE Contractor (Haul Rd)	Roger.Parker@ettp.doe.gov
Christopher Lehman	DOE/DOE Contractor	Christopher.Lehman@ettp.doe.gov
Steven Foster	DOE/DOE Contractor	Steven.Foster@ettp.doe.gov

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6.2 AMBIENT GAMMA RADIATION MONITORING

6.2.1 BACKGROUND

During early operations, leaks and spills were common at industrial facilities within the three ORR campuses. Contaminants, including radioactive materials, were released from operations as gaseous, liquid, and solid effluents, sometimes with little to no treatment (ORAU, 2003).

Recently, DOE has increased its ORR remedial activities, with the goal to remove contamination of the environment and make space available for reuse. For example, the ORNL and Y-12 campuses are currently undergoing D&D and demolition, and radionuclides could become airborne and spread outward. Due to these concerns, TDEC conducts continuous gamma air monitoring within proximity to D&D structures to verify and help ensure that BMPs managed by DOE at these areas are protective of human health and the environment.

6.2.2 RELATED DOE PROJECTS

DOE conducts ambient gamma sampling at the ORR perimeters. This area is monitored to ensure that DOE's *primary dose limit* for protecting members public of 0.1 rem/yr. (0.001 Sv/yr.) during a consecutive 12-month period, is not exceeded. This limit can also be expressed as 100 mrem/yr.

DOE also conducts separate industrial hygiene (IH) radiological monitoring at remediation and D&D sites to monitor radiation exposures to the industrial workers.

6.2.3 PROBLEM STATEMENTS

1) Facilities on the ORR have the potential to emit variable amounts of gamma radiation. The TDEC DoR-OR Ambient Gamma Radiation Monitoring project focuses on measuring and determining radiological exposure rates under conditions across the ORR where gamma radiation can be expected to fluctuate substantially over relatively short periods of time. D&D and demolition activities would most likely increase this variability.
2) Constant, ongoing monitoring in areas of variable emissions would help evaluate overall impacts in these areas.

6.2.4 GOALS

1) TDEC's *Ambient Gamma Radiation Monitoring Project* will allow TDEC to independently evaluate / monitor gamma emissions near select internal ORR source areas.
2) The project data will continuously track gamma emissions overtime at specific areas of concern within the ORR.
3) Data will be collected in a manner allowing for correlation with existing radiological standards, including the State of Tennessee (State) and NRC limit of two mrem in one hour

and the State and DOE primary dose limits for protecting members of the public to ensure 0.1 rem (0.001 Sv) in a year is not exceeded.

4) Assessment should allow for evaluation of protectiveness of active IH controls in select publicly accessible areas around the ORR.

6.2.5 SCOPE

The project team will collect data from a minimum of five *GammaTRACER*® Stations. Stations shall be located in the following areas:

1) FORT LOUDOUN DAM (BACKGROUND): This station will be used to record naturally occurring gamma data, to be used as background concentrations during data evaluations.
2) EMWMF: Located in Bear Creek Valley, this site is the landfill used for waste disposal from CERCLA activities.
3) ORNL BUILDING 3026: This building is centrally located on ORNL's main campus and in proximity to pedestrian and vehicular traffic. Its location will be used to evaluate /monitor for potential radiological releases during the demolition of high-risk facilities in the near proximity of this site.
4) MRSE (MOLTEN SALT REACTOR EXPERIMENT): Located at ORNL, MSRE has been shut down but is actively monitored and maintained. MSRE has seen fluctuating concentrations in the past, and this sampling will allow for temporal comparisons of prior data sets.
5) SNS (SPALLATION NEUTRON SOURCE): A facility located on ORNL that produces neutrons with an accelerator based system.
6) TBD: Additional location may be determined as needed. Additional site selection will occur once equipment is procured, anticipated during FY25/FY26 timeframe.

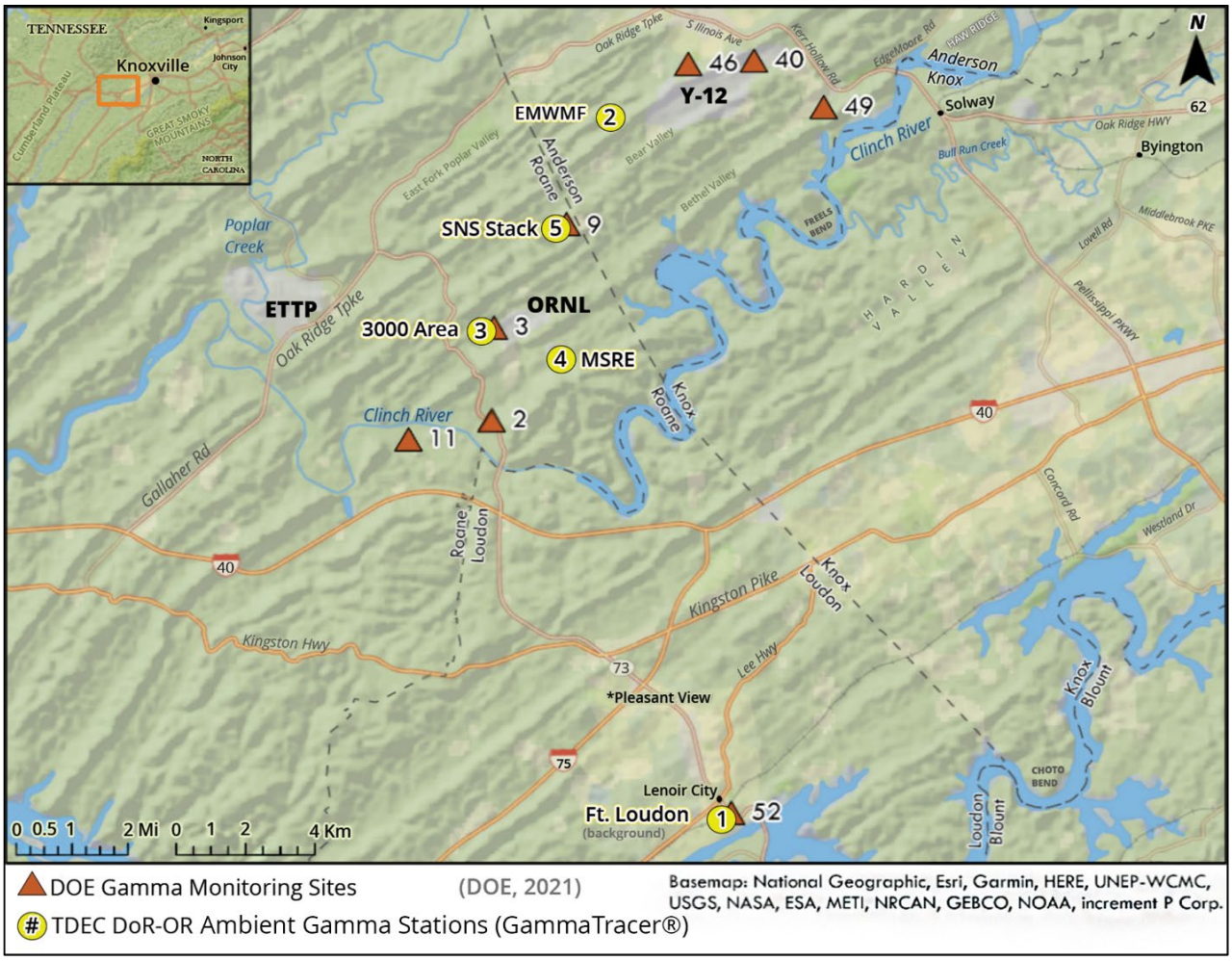

Figure 6.2.5.1: DOE Stations and DoR-OR GammaTRACER® Stations

As described above, ambient gamma monitoring will be conducted at four ORR stations and one background location, as shown in Figure 6.2.5.1. These stations were placed near areas where D&D, remediation, waste disposal, or active operations are most likely to contribute dose to the environment or human receptors.

Of note, as additional GammaTRACER® monitors become available, more stations may be added to active D&D sites within the ORNL campus. If new stations are incorporated into this program in FY25, the EMR will incorporate these new data sets.

6.2.6 Assumptions

1) Continuous monitoring will capture gamma emissions fluctuations adequately.
2) Strategic placement of GammaTRACER® monitors near sites with known or suspected radiation emissions will capture elevated emissions and accurately quantify dose.

6.2.7 CONSTRAINTS

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures or access.
2) Gamma radiation detector placement may be less than optimal due to DOE facility operational constraints. Detectors cannot interfere with traffic, facility access, or facility operations. Their placement is limited to locations where the security of the instrument can be assured.
3) Radiological data must be manually downloaded which requires TDEC Personnel to visit the sampling location. Consequently, delays may result in a timely response to anomalies.

6.2.8 METHODS, MATERIALS, METRICS

The gamma exposure rate detectors have already been deployed. Each of these *Genitron Instruments GammaTRACER® Units* contain (1) two Geiger-Mueller tubes for gamma detection, (2) a microprocessor-controlled data logger to store exposure rates, and (3) lithium batteries, all sealed in a (4) weather resistant case to protect internal components. The detectors are programmable and will be recording at a 5-minute interval, with an automatic shift to 1-minute intervals above a set threshold of radiological activity based on site-specific parameters. Data will be downloaded at least once per month following established DoR-OR protocols (TDEC, 2023).

The results will be derived by averaging the gamma exposure rates and examining minimum and maximum dose rates for each location on a daily basis. ORR detector data will be quantified to determine the maximum dose exposure per station. ORR results will also be compared to the background station at Fort Loudoun Dam, which is co-located with the DOE background gamma monitor.

In addition, the gamma dose exposure rates will be compared to the State of Tennessee (State) and NRC limit of 2 mrem per hour. This comparison will determine the maximum dose exposure to an unrestricted, or publicly accessible area. The results will also be compared to the State and DOE primary dose limits for protecting members public to ensure 0.1 rem (0.001 Sv) in a year (i.e., consecutive 12-month period) is not exceeded.

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6.3 Surplus Sales Verification

6.3.1 Background

As remediation and clean-up work continues, there is a continual need for DOE to update and replace existing equipment as it becomes worn and/or is no longer ideal for a project. Operating under the goal to recycle and reuse equipment and materials whenever possible, DOE staff collects ORR surplus items for resale at auction. Verification that ORR surplus materials are safe to be sold to the public is an important protective measure is an important protective measure. When requested by DOE, DoR-OR conducts a, independent radiological survey of specified ORR surplus items.

DOE Radiation Control Personnel (RCPs) are tasked with the initial survey of all items. The goal is to isolate any equipment with elevated radiation levels or removable contamination. Radiological detection meters are used for these thorough scans by RCPs. DOE seeks to prevent the spread of contaminants from surplus equipment to members public.

Once items are checked, and cleaned if warranted, they are displayed for resale. DoR-OR is then invited to perform an additional scan on surplus items. Finally, DOE staff invite contractors that have been pre-approved to bid on surplus materials.

DoR-OR staff occasionally find material with elevated radiological activity. Based on these rare finds, DoR-OR will work collaboratively with DOE to verify through spot checks and secondary surveys that all materials staged for auction are free of radiological contamination.

6.3.2 Related DOE Projects

As mentioned above, DOE RCPs scan most materials before they are submitted for auction at ORNL and Y-12.

6.3.3 Problem Statements

Items for auction resale have a potential to have been used in radiologically controlled areas. Prior to release to the public, DOE and the State strive to verify that no radiologically contaminated equipment is accidentally sold.

6.3.4 Goals

The overarching goal of this project is to adequately screen surplus items for potential radiological surface contamination and prevent contaminated items from being sold to the public.

6.3.5 Scope

Upon request, DoR-OR staff will perform pre-auction radiological screening verification surveys. On average, no more than eight (8) events occur during the fiscal year.

6.3.6 Assumptions

1) DOE will conduct a complete survey of items identified for auction prior to contacting DoR-OR.
2) Radiological scans conducted by DoR-OR serve as "spot checks" and will be sufficient to identify any anomalous items with elevated radiation if they exist.
3) DOE staff will follow-up with further scans to review conditions of any anomalous items identified and reported by DoR-OR prior to making the specific item or sale lot available for auction.

6.3.7 Constraints

Standard constraints apply to this project and across all DoR-OR projects: these include, but are not limited to, equipment failure, funding, staffing, transportation, weather, and access to sites on the ORR.

6.3.8 Methods, Materials, Metrics

Upon receiving a survey request from the DOE Property Excessing Team, DoR-OR project staff will schedule a verification survey. Calibration of radiological detection instruments will be performed just prior to the survey appointment. The intent of a radiological verification survey is to spot check items that have been identified and cleared for sale by DOE. Accordingly, not all items or surfaces of a specific item will be surveyed for potential radioactive contamination. Biased measurements will be used, where specific attention is paid to well-used items. Surplus items with damaged, unclean, or stained areas will be targeted by scans. Well-maintained items will be scanned based on their prior usage and former location.

If radiological activity (alpha or beta/gamma) is detected above the contamination limits, that item will be flagged, and the Property Excessing Staff will be notified.

Based on previous experiences, the Property Excessing Staff will then decide whether or to have an item rechecked by ORNL RCPs. DoR-OR does not attempt to determine if an item meets DOE release criteria.

6.3.9 REFERENCES

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7.0 SURFACE WATER MONITORING

7.1 AMBIENT SURFACE WATER PARAMETERS

7.1.1 BACKGROUND

While legacy waste across the ORR is responsible for a large portion of the contamination to surface water via releases of hazardous wastes (e.g., metals, organics, and radioactive materials), current projects and processes at these sites also have the potential to significantly contribute to surface water contamination (DOE, 1992; DOE, 2021; Pickering et al, 1970; Turner et al, 1999). DOE performs environmental surveillance around the ORR facility boundaries to comply with their internal requirements to protect the public and the environment from undue risks associated with DOE activities (DOE, 2022). As part of the *Environmental Surveillance Oversight Agreement* (ESOA) between DOE and TDEC, the State can perform additional monitoring in and around the ORR to assess impacts to human health and the environment. The TDEC-DoR *Ambient Surface Water Parameter Project* was first implemented in 2005, to supplement DOE's monitoring effort by measuring general physical water quality parameters of several streams that exit the ORR. By measuring water quality parameters (e.g., conductivity, dissolved oxygen, pH, turbidity, and temperature), a general understanding of stream health and positive or negative trends can be gained. This project has been ongoing for nearly 19 years and provides a baseline from which to evaluate changes in water quality that may be impacted from DOE activities. For FY25 (July 2024-June 2025), DoR-OR will continue this project, measuring stream water quality parameters monthly to establish and build upon a database of physical stream parameters on three (3) ORR exit-pathway streams (Bear Creek, East Fork Poplar Creek, and Mitchell Branch) and one (1) background stream (Mill Branch).

7.1.2 RELATED DOE PROJECTS

DOE conducts surface water monitoring quarterly which includes sample collection and analysis from various locations on the Clinch River. This DOE project has a goal of assessing impacts of past and current DOE operations on the quality of surface water. As part of this program, stream water quality parameters are measured at the time of sampling (DOE, 2022). However, while this DOE program focuses on the Clinch River (CR), many ORR surface water exit-pathway streams that flow into the Clinch River remain infrequently monitored. This TDEC-DoR-OR project seeks to fill part of this surface water quality monitoring data gap while complementing the DOE environmental monitoring program.

7.1.3 PROBLEM STATEMENTS

ORR exit-pathway streams and the Clinch River are subject to contaminant releases from previous and current ORR activities at ETTP, ORNL, and Y-12. These releases can be detrimental to both the environment and to human health.

Identified concerns include, but are not limited to, the following:

- Approximately 100 metric tons of ***Mercury (Hg)*** was released from Y-12 into East Fork Poplar Creek (EFPC) from 1950 to 1963. Mercury exited Y-12 via spills, leakage from subsurface drains, purposed discharge of wastewater, and leaching from contaminated building foundations and soils (Turner and Southworth, 1999).
- Other ***metals*** (e.g., cadmium, chromium, lead, nickel, silver, and zirconium) are present in elevated concentrations in exit pathway streams (DOE, 1992).
- ***Uranium*** contaminated nitric acid wastes and other liquid wastes (roughly 7.5 million L/yr) were disposed of in the S3 ponds from 1951 to 1984 near the headwaters of Bear Creek (Moss et al, 1999).
- Solid and liquid wastes, including approximately 18 million kg of ***uranium metal*** and 1 million L of ***waste oils and chlorinated solvents***, were disposed of in the unlined Bear Creek Burial Grounds (BCBG) between 1955 and 1989. BCBG is adjacent to Bear Creek (Moss et al, 1999).
- The ORR has a history of undesired releases of contaminants such as ***chlorine*** and ***mercury*** from activities on the ORR.
    - In November 1986 and July 1987, fish kills related to chlorine and mercury extended over a period of 2 to 3 weeks killing 1148 and 747 fish, respectively (ORNL, Etnier et al, 1994).
    - On June 8, 2013, a high-volume release of chlorinated water from a line break occurred leading to a fish kill where 8,318 dead fish were counted (DOE, 2013).
    - A large fish kill occurred during June through August of 2018 due to releases of mercury to East Fork Poplar Creek from demolition activities at Y-12 (DOE, 2020).
    - Additionally, fish kills from chlorine leaks or releases occurred on January 10, 2021, March 9, 2021, and March 15, 2021, where 2,186 dead fish, 376, and 1,346 dead fish were identified respectively (ORNL, 2021).

While DOE's surface water monitoring program focuses largely on the Clinch River (DOE, 2022), a data gap exists for exit pathway streams, which received infrequent or limited routine monitoring.

7.1.4 GOALS

The goal of DoR-OR's *Ambient Surface Water Parameters Project* is to measure surface water parameters in EFPC, Bear Creek (BC), and Mitchell Branch (MIK) within the ORR. Project staff will collect and provide data that can assist in the evaluation of site activities. This water quality data will also be used to supplement DOE's surface water monitoring program. In addition to yearly monitoring goals, this project will compile a record of ambient conditions for future use as a baseline of *expected* conditions for each stream reach. This database can then be used in the event of an unintentional release to determine impacts to surface water. While water

quality parameters are taken in conjunction with other surface water projects (e.g., *Ambient Surface Water Sampling*), this project will function as a routine monthly monitoring, which provides more effective data for analyzing statistical trends on ORR streams.

7.1.5 SCOPE

This project specifically focuses on the characterization of physical stream parameters of three (3) ORR exit-pathway streams (EFPC, BC, and MIK) and one (1) offsite background stream (MB). Ten (10) stream locations (EFK 24.4, EFK 23.4, EFK 13.8, MBK 1.6, BCK 12.3, BCK 9.6, BCK 9.2, BCK 7.6, BCK 4.5, and MIK 0.1) will be measured monthly during the July 2024 – June 2025 period. See Figure 7.1.5.1 below for sampling locations.

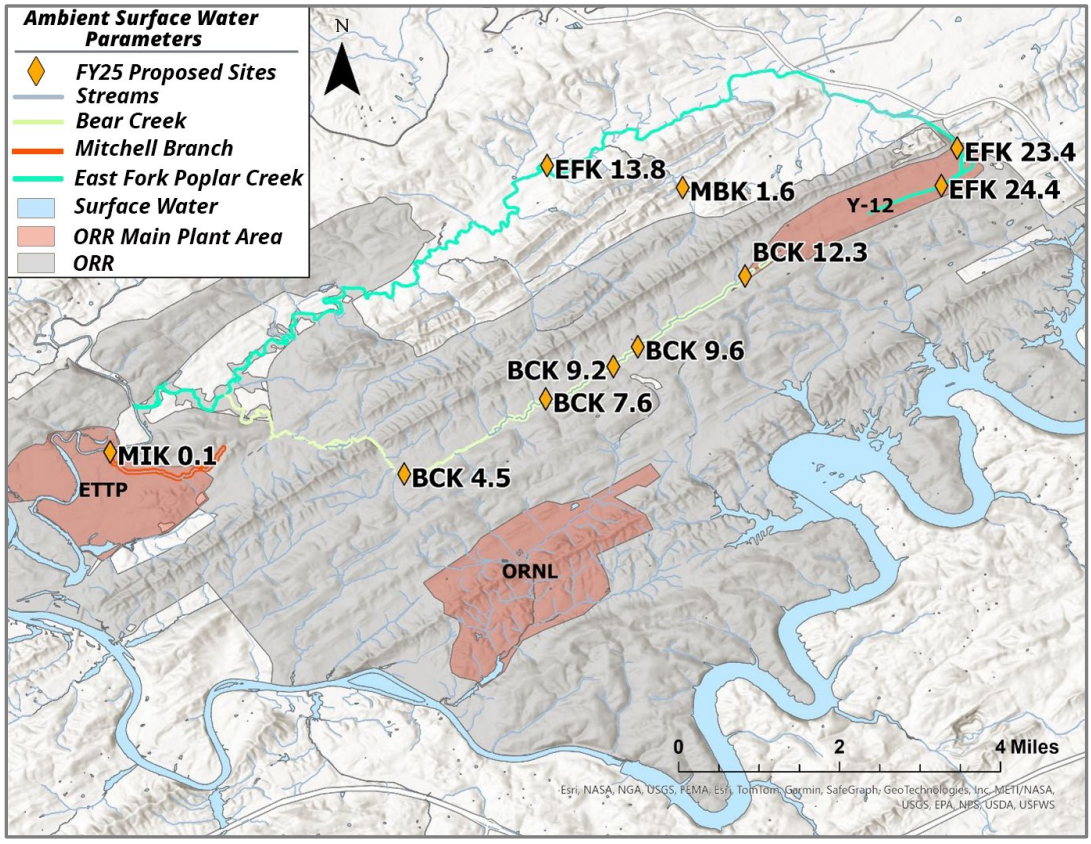

Figure 7.1.5.1: Proposed Surface Water Parameter Sites

7.1.6 ASSUMPTIONS

The assumptions for this project include:

- Ambient physical parameters at the Mill Branch background station are indicative of a geographically similar stream without contamination.
- Baselines or trends are stable for the physical parameters at the sampling stations.
- Water quality parameter data will indicate changes in surface water after impacts to a stream.

7.1.7 CONSTRAINTS

- This project is contingent on funding, manpower, and access to ORR controlled areas.
- Supply Chain Issues: Equipment availability and calibration, including calibration solutions etc.

7.1.8 METHODS, MATERIALS, METRICS

Field Parameter Measurements

At each site, physical water parameters will be measured and recorded. Physical parameters will be measured using a multiple parameter water quality meter. Conductivity (µS/cm), dissolved oxygen (mg/L), pH, turbidity (NTU), and temperature (°C) will be recorded along with the time of measurement. Measurements will be taken in accordance with internal SOP *DoR-OR T-703 Field Use for Water Quality Parameters Instrument* (TDEC, 2023).

Data Evaluation

Recorded measurements will be stored in a database. Using R programming language, several statistical analyses will be performed to better understand the results. Trend analysis will be performed using linear regression to identify any increasing or decreasing trends in data. Anomalous data will also be identified. Basic descriptive statistics (mean, median, minimum, maximum, etc.) will also be assessed.

The selected ORR streams will be compared to the Mill Branch (MB) background stream. Project staff will use statistical approaches, such as an analysis of variance, to determine if corresponding water quality measurements are significantly similar. Lastly, data will be compared to TN general water quality criteria (TDEC, 2019).

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7.2 AMBIENT SURFACE WATER SAMPLING

7.2.1 BACKGROUND

Legacy waste across the ORR is responsible for a large portion of the contamination to surface water via releases of hazardous wastes (e.g., metals, organics, and radioactive materials). Current projects and processes at these sites also have the potential to significantly contribute to surface water contamination (DOE, 1992; DOE, 2021; Pickering et al, 1970; Turner et al, 1999). DOE performs environmental surveillance around the ORR facility boundaries to comply with their internal requirements to protect the public and the environment from undue risks associated with DOE activities (DOE, 2022). As part of the *Environmental Surveillance Oversight Agreement* (ESOA) between DOE and TDEC, the State can perform additional monitoring in and around the ORR to assess impacts to human health and the environment. This surface water project has been an ongoing project for several years, shifting focus from year to year. During FY25, this project will focus on a rigorous analysis of ORR exit pathway streams, based on the Ambient Water Quality Criteria (AWQCs). The State employs AWQCs to assess potential impacts to human health and the environment and to identify any stream impairments that are not in accordance with the State's use classifications. In addition to providing oversight to DOE's monitoring of the Clinch River, this project will collect semiannual surface water samples at streams across the ORR (i.e., Bear Creek, East Fork Poplar Creek, and Mitchell Branch).

7.2.2 RELATED DOE PROJECTS

The DOE surface water monitoring program samples the Clinch River quarterly. Program staff collect water samples for lab analysis and perform on-site water quality parameter measurements. This DOE project has a goal of assessing impacts of past and current DOE operations on the quality of surface water (DOE, 2022). However, while this DOE program focuses on the Clinch River (CR), many ORR surface water exit-pathway streams that flow into the Clinch River remain infrequently monitored or are only monitored when part of a CERCLA investigation or action. Most site related surface water sampling efforts focus on major contamination from legacy waste, but do not focus on TN AWQCs or contamination from current projects.

7.2.3 PROBLEM STATEMENTS

As discussed above, the Clinch River and its tributaries on the ORR are subject to (1) legacy contaminants and (2) current operational contaminant releases.
Identified concerns include, but are not limited to, the following:

- Approximately 100 metric tons of ***Mercury (Hg)*** was released from Y-12 into East Fork Poplar Creek (EFPC) from 1950 to 1963. Mercury exited Y-12 via spills, leakage from subsurface drains, purposed discharge of wastewater, and leaching from contaminated

building foundations and soils (Turner and Southworth, 1999).

- Other ***metals*** (e.g., cadmium, chromium, lead, nickel, silver, and zirconium) are present in elevated concentrations in exit pathway streams (DOE, 1992).
- ***Uranium (U)*** contaminated nitric acid wastes and other liquid wastes (roughly 7.5 million L/yr) were disposed of in the S3 ponds from 1951 to 1984 near the headwaters of Bear Creek (Moss et al. 1999).
- Solid and liquid wastes, including approximately 18 million kg of ***uranium metal*** and 1 million L of ***waste oils and chlorinated solvents***, were disposed of in the unlined Bear Creek Burial Grounds (BCBG) between 1955 and 1989. BCBG is adjacent to Bear Creek (Moss et al. 1999).
- The ORR has had several instances of undesired releases of contaminants such as ***chlorine*** and ***mercury*** from activities on the ORR.
    - In November 1986 and July 1987, fish kills related to chlorine and mercury extended over a period of 2 to 3 weeks killing 1148 and 747 fish, respectively (ORNL, Etnier D, et al., 1994).
    - On June 8, 2013, a high-volume release of chlorinated water from a line break occurred leading to a fish kill where 8,318 dead fish were counted (DOE, 2013).
    - A large fish kill occurred during June through August of 2018 due to releases of mercury to East Fork Poplar Creek from demolition activities at Y-12 (DOE, 2020).
    - Additionally, fish kills from chlorine leaks or releases occurred on January 10, 2021, March 9, 2021, and March 15, 2021, where 2186 dead fish, 376, and 1346 dead fish were identified respectively (ORNL, 2021).
    - The TDEC Division of Water Resources (DWR) performs assessments of streams across Tennessee to determine stream impairment as required by Section 303(d) of the Clean Water Act. DWR identifies a stream as impaired when TN AWQCs "are violated with enough frequency and magnitude that the public's uses are no longer maintained" (TDEC, 2022). All ORR streams are listed in TN Rule 0400-40-04-.04 for use classifications of fish and aquatic life, recreation, livestock watering and wildlife, and irrigation (TDEC, 2019b). However, DWR does not sample within the ORR. While the ORR has evidence of contamination as listed above, sampling has not been performed to allow a proper assessment of stream impairment against all TN AWQCs.

7.2.4 GOALS

This project has several goals, including:

- Provide oversight and verification of DOE's environmental sampling program on the Clinch River by collecting comparable Clinch River water quality data.
- Perform surface water analytical analyses (for AWQC analytes) of several ORR streams.
- Evaluate contaminant loading of AWQC analytes in different reaches of ORR streams (e.g., upper, middle, lower).

7.2.5 SCOPE

This project will focus on surface water sampling and measurements of physical water parameters of the Clinch River, Bear Creek, East Fork Poplar Creek, Mitchell Branch, and White Oak Creek. Samples and measurements will also be taken from Clear Creek, which is a reference stream outside of the ORR.

Samples will be collected semi-annually at all locations with one sampling event occurring in the drier months (July – November) and one event occurring in the wetter months (December – June). The only exception is the Clinch River, which will be sampled quarterly. See sampling frequency and location descriptions below and Figure 7.2.5.1 for proposed sampling locations.

- *Clinch River (CR):* The CR will be co-sampled with UT-Battelle quarterly at one (1) of the four (4) sites CRK 66, CRK 58, CRK 32, and CRK 16.1 with each site sampled at least once throughout the project.
- *Bear Creek (BC):* BC will be sampled semi-annually at four (4) locations. These include the headwaters at BCK 12.3, BCK 9.2 which is downstream of EMWMF inputs, BCK 4.5 off highway 95, and BCK 1.61 which is located along the North Boundary Greenway.
- *East Fork Poplar Creek (EFPC):* EFPC will be sampled semi-annually at four locations along the stream including the headwaters at EFK 25.1 and the DOE integration point at EFK 23.4, which are both located within Y-12. In residential areas downstream of Y-12, the middle and lower sections of EFK 15.7 and EFK 6.3 will be sampled.
- *Mitchell Branch (MIK):* Mitchell Branch will be sampled semi-annually at three locations along the stream including MIK 1.43, MIK 0.71, and MIK 0.1. This stream flows through the northern part of ETTP. MIK 0.71 is near the Chromium Water Treatment System and MIK 0.1 is located at the K-1700 Weir, which is near the confluence with Poplar Creek.
- *White Oak Creek (WOC):* WOC will be sampled semi-annually at three locations along the stream including the headwaters at WCK 6.8, WCK 3.4 near the 7500 Bridge, and WCK 2.3 just upstream of White Oak Lake.
- *Clear Creek (CCK):* Clear Creek will be sampled semi-annually and will be used as a clean background reference stream to compare with samples taken within the ORR. This location is not shown on Figure 7.2.5.1. CCK 1.6 is located nearly 20 miles to the northeast of the ORR and is near Norris Dam State Park.

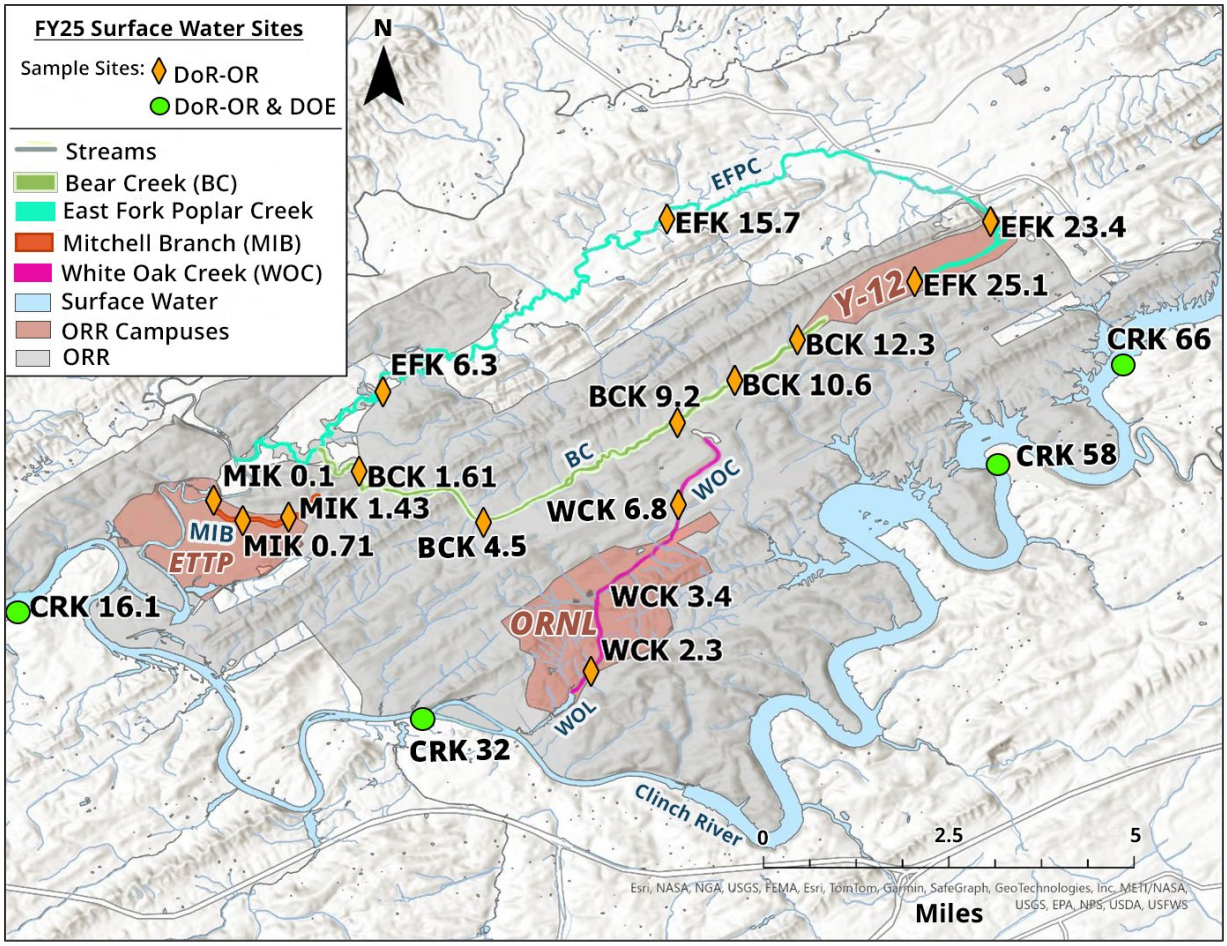

Figure 7.2.5.1: Proposed ORR Surface Water Sampling Sites

7.2.6 Assumptions

This project has the following assumptions:

- Potential stream contamination is attributable to DOE activities on the ORR.
- Scheduling will allow for co-sampling with DOE.
- Clear Creek is suitable to be used as a non-contaminated background stream.

7.2.7 Constraints

Constraints that may impact this project include:

- Standard constraints; including equipment failure, funding, staffing, transportation, weather, access to sample sites on the ORR.
- Demolition and construction activities at Y-12 may inhibit EFPC access near the Outfall 200 area, in particular.
- Excessive rain or drought may prevent the ability to adequately sample.

7.2.8 METHODS, MATERIALS, METRICS

Sample Collection

Grab samples will be collected, semi-annually, from the top few inches of the stream. Analytes will include TN AWQCs listed in *TN rule 0400-40-03* for both recreation and fish and aquatic life (TDEC, 2019a). Table 7.2.8.1 shows sample frequency, and 7.2.8.2 below shows a list of proposed analytes and respective methods. If lab methods are required to be changed due to unforeseen circumstances, equivalent alternative methods will be used. Quality assurance/quality control (QA/QC) samples will be collected for every 10th sample of any given analyte (Table 7.2.8.1). Surface water sampling protocols will follow internal standard operating procedures (SOPs) including *DoR-OR T-704 Collection of Surface Water Samples* (TDEC, 2023c).

Field Parameter Measurements

At each site, during the time of sampling, physical water quality parameters will be measured using a properly calibrated multiple parameter water quality meter. Parameters of conductivity (µS/cm), dissolved oxygen (mg/L), pH, temperature (°C), ORP (mV), and turbidity (NTU) will be recorded along with the time of measurement. Measurements will be taken in accordance with internal SOP *DoR-OR T-703 Field Use for Water Quality Parameters Instrument* (TDEC, 2023b). In addition to field parameters, instantaneous discharge measurements will be taken where possible using a FlowTracker2™ flow meter by following internal SOP *DoR-OR T-702 Operation of FlowTracker 2 Flow Meter* (TDEC, 2023a).

Data Evaluation

Several statistical analyses will be performed to better understand the results. Results will be compared with any available DOE available data from co-sampling or historical TDEC DoR-OR data. Applicable methods such as analysis of variance (ANOVA) or the Kruskal-Wallis test may be used to see if project results are statistically significantly different from available data sets. Basic descriptive statistics (e.g., mean, median, minimum, maximum, etc.) and any increasing or decreasing trends in data will also be analyzed. Data will be screened using TDEC AWQCs as listed in *TN 0400-40-03(4)(j)* for protection of recreation and TN 0400-40-03 (3)(g) for protection of fish and aquatic life to determine if there is a potential impact to human health and the environment (TDEC, 2019a). Any exceedances may invoke further investigation.

Table 7.2.8.1: Planned Samples Per Analyte Per Site

	Stream Name	Site Designation		FY25 Sampling Plan			
		DOE *Miles*	***DoR-OR*** *Kilometers*	***Sr-90***	***α/β***	***Hg***	****TN AWQC***
Co-Samples	**Clinch River (CR)**	CRM 10.0	CRK 16.1		**1**	**1**	
		CRM 19.7	CRK 32.0	**1**	**1**	**1**	
		CRM 36.0	CRK 58.0		**1**	**1**	
		CRM 41.0	CRK 66.0		**1**	**1**	
QAPP	**QA/QC Samples (10%)**						**3**
Ambient Samples	**Bear Creek (BC)**	BCM 7.6	BCK 12.30				**2**
		BCM 5.7	BCK 9.20				**2**
		BCM 4.7	BCK 4.50				**2**
		BCM 1.0	BCK 1.61				**2**
	East Fork Poplar Creek (EF)	EFM 15.6	EFK 25.1				**2**
		EFM 14.5	EFK 23.4				**2**
			EFK 15.7				**2**
			EFK 6.3				**2**
	Mitchell Branch (MIK)		MIK 1.43				**2**
			MIK 0.71				**2**
			MIK 0.10				**2**
	White Oak Creek (WC)		WCK 6.8				**2**
			WCK 3.4				**2**
			WCK 2.3				**2**
	Clear Creek		CCK 1.6				**2**
TOTAL SAMPLES				**1**	**4**	**4**	**33**

Notes: ** AWQCs: TN Rule 0400-40-03 Water Use - Recreation and Fish & Aquatic Life*

Table 7.2.8.2: Planned Analytical Methods

Type	*Analyte*	*Description*	*Method*
Inorganics	*Dissolved Solids (TDS)*	*TTL Dissolved Solids in water*	***2540C-2011***
	Chlorine, Total Residual	*TTL Residual Chlorine Colorimetric Method*	***45000G1 G-2011***
	Hardness	*TTL Hardness by Spectrophotometer*	***EPA 130.1***
Metals	*Chromium, hexavalent (Cr_6)*	*Cr_6 Colorimetric Method*	***3500Cr B-2011***
	Antimony *Arsenic* *Cadmium* *Chromium* *Copper* *Lead* *Nickel* *Selenium* *Silver* *Thallium* *Zinc*	*ICP-MS*	***EPA 200.8***
	Mercury	*Mercury in Water CVAF Spectrometry*	***EPA-1631***
Organics	*Hexachlorocyclohexane-Technical (HC)*	*Pesticides by Gas Chromatography*	***8081***
	Diazinon *Ethion*	*Organophosphorus by Gas Chromatography*	***8141***
	8260 VOC List	*Volatile Organic Compounds by GC/MS*	***EPA 8260 VOC***
	8270 SVOC List	*Semi-Volatile Organic Compounds by Oasis HLB Disk & GC/GM*	***EPA 8270 SVOC***
	Cyanide	*Cyanide (Automated Colorimetric, Off-line Distillation)*	***EPA 9012B***
	PCB (Total)	*Chlorinated Biphenyl Congeners HRGC/HRMS*	***EPA-1668***
	2,3,7,8-Tetrachlorodbenzo-p-dioxin	*PCDDs and PCDFs by HRGC/HRMS*	***SW846-8290***
Radio-chemical	*Alpha Activity* *Beta Activity*	*Gross Alpha Activity* *Gross Beta Activity*	***EPA 900.0***
	Strontium-90	*Radioactive Strontium in Water*	***EPA 905.0***

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7.3 WHITE OAK CREEK RADIONUCLIDES SAMPLING PROJECT

7.3.1 BACKGROUND

White Oak Creek (WOC) was previously monitored under the *Ambient Surface Water Sampling Project (ASWSP)* through 2019. Beginning in fiscal year 2020, DoR-OR moved the WOC surface water monitoring under a separate project. The focus on WOC, along with the subsequent expansion of monitoring sites, was largely due to specific concerns regarding the elevated concentrations of the radionuclide strontium-90 (Sr-90) in the stream. The WOC Sediment Retention Structure was built as one of the first remedial actions implemented on the ORR to prevent sediments contaminated with Sr-90 from entering the Clinch River, but Sr-90 continues to be measured in water at the CR-WOC confluence (i.e., CR 33.5), immediately downstream of the WOC Embayment (WOCE) sediment retention structure (Figure 7.3.1.1). This area is publicly accessible.

WOC and the other ORR exit-pathway streams have historically, and are currently, being subjected to contaminant releases from activities at Y-12, ORNL, and ETTP. Monitoring WOC will help provide a better understanding of surface water contamination and may provide insight into helping protect human health and the environment, especially with respect to an important resource, the CR. These independent monitoring data results will also be available to supplement DOE's ongoing investigations.

7.3.2 RELATED DOE PROJECTS

DOE has implemented a surface water monitoring program for several years that consists of monitoring surface water at a few locations along the Clinch River (DOE, 2022a). The purpose of DOE's surface water monitoring project is to assess impacts of site operations, both past and present, on surface water bodies.

Other DOE projects specific to WOC include the following:

1) Sampling WOC at the 7500 Bridge (Bethel Valley Watershed Integration Point) as part the *Record of Decision (ROD) for Interim Actions in Bethel Valley Watershed, Oak Ridge, Tennessee*, DOE/OR/01-1862&D4. (DOE, 2020).
2) Investigating source(s) of ungauged Sr-90 contributions to WOC (flow/flux study) to evaluate potential remedial actions to offset ungauged Sr-90 discharges (DOE, 2022b).
3) Evaluating potential Sr-90 surface water impacts to 5th Creek if the sump pump at Building 3042 is turned off. Sampling along 5th Creek (DOE station name = "*5TH CR*" aka "*FFK 0.2*") has been conducted since at least 1987, with semi-annual sampling currently being conducted (DOE, 2022c).

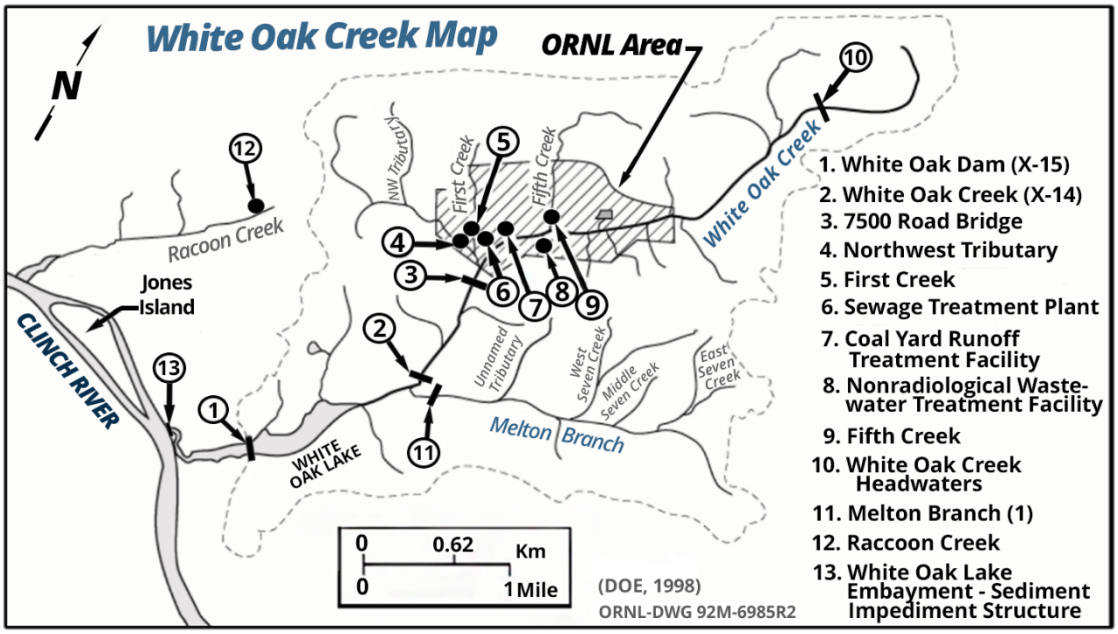
While the current DOE projects only sample the CR and one location along WOC, this DoR-OR project will complement DOE's sampling by monitoring specific points along WOC and its tributaries. The intent is to provide a representative evaluation of the contaminants entering WOC, and ultimately entering the CR.

7.3.3 Problem Statements

It is estimated, based on 2020 U.S. census data, that nearly 1.1 million people live in the counties surrounding the ORR (DOE, 2020). A large portion of these people have the potential of being affected by streams that flow through the ORR and eventually flow into the Clinch River, which is an important drinking water source for the surrounding communities.

Identified concerns for WOC include, but are not limited to the following:

- ORNL has released low-level radioactive liquid wastes to the Clinch River via White Oak Creek since 1943. (Pickering, 1970).
- Release of approximately 665 curies of cesium-137 (Cs-137) to the CR from WOC between 1954 and 1959 (DOE, 1992).
- Groundwater containing elevated levels of strontium-90 is collected from the solid waste storge areas in Melton Valley and transferred to the Process Waste Treatment Complex (PWTC) in Bethel Valley for treatment. The PWTC does not entirely remove strontium-90 from the waste stream and ultimately discharges treated wastewater containing elevated levels of strontium-90 into White Oak Creek at Outfall X12 (Figure 7.3.3.1) (DOE, 2022c).
- Historic and ongoing discharges of strontium-90 and cesium-137 into White Oak Creek are impacting surface water quality. Known sources include, but are not limited to, impacted floodplain soils from the former Surface Impoundment Operable Unit (SIOU) area (Figure 7.3.3.1) and baseflow groundwater seepage into White Oak Creek (DOE, 2022).
- TDEC's Roving Creel Study has determined that the Clinch River near the White Oak Creek and Clinch River confluence is used for recreational fishing.



7.3.3.1 ORNL and White Oak Creek Watershed

7.3.4 GOALS

The goal of the *White Oak Creek Radionuclides Monitoring Project* is to evaluate the impacts of DOE ORR contamination to WOC, its tributaries, and the CR at the WOC confluence. This Project involves collecting surface water samples at the locations illustrated on Figure 7.3.7.1.

7.3.5 SCOPE

The scope of this project consists of collecting both (1) water samples quarterly and (2) water parameter measurements monthly at eight monitoring locations. During the quarterly sampling events, both water samples and parameters measurements will be taken in tandem, along with the collection of QA/QC samples (one duplicate sample each quarter).

The surface water collection sites include four WOC monitoring locations (WCK 6.8, WCK 3.9, WCK 3.4, WCK 2.3), one Clinch River (CR) monitoring location (CRK 33.5) at the confluence (WOC-CR) (Figure 7.3.8.1), and the remaining three monitoring locations (FFK 0.2, HRT-3, MEK 0.3) are on tributaries of WOC (Figure 7.3.5.1).

7.3.6 ASSUMPTIONS

This project is based on the following assumptions:

- Potential contamination in WOC is attributable to activities on the ORR.
- WOC is a main pathway of Sr-90 entering the CR.
- Detectable concentrations of contaminants are present in WOC surface water.

7.3.7 CONSTRAINTS

Physical constraints that may impact this project include:

- Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.
- Scheduling RCP escort for sampling on WOC.
- Work at WOC is performed under a Radiological Work Permit (RWP). TDEC assumes that no changes will be made to the RWP to effect this project.
- Streams have adequate flow for sampling.

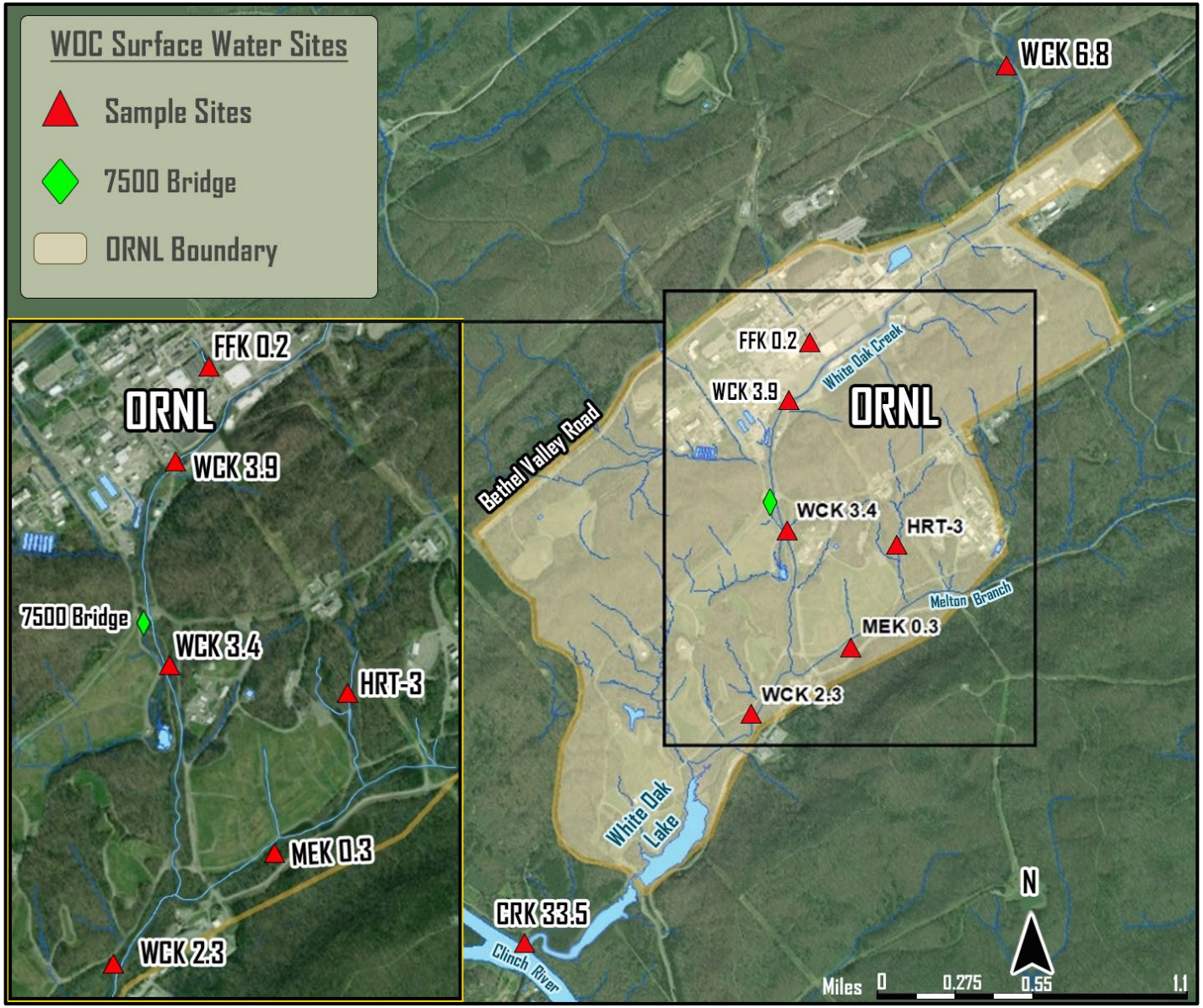


Figure 7.3.7.1: FY25 White Oak Creek Surface Water Sampling Locations

7.3.8 METHODS, MATERIALS, METRICS

Surface Water Sample Collection

The Project includes collecting surface water samples at eight (8) monitoring sites (WCK 6.8, WCK 3.9, WCK 3.4, WCK 2.3, CRK 33.5, FFK 0.2, HRT-3, MEK 0.3) whose locations are illustrated on Figure 7.3.5.1. Surface water samples will be collected quarterly (Table 7.3.8.1) and in accordance with TDEC-DoR-OR-T-704 *Standard Operating Procedure for Collection of Surface Water Samples* (TDEC, 2023).

Table 7.3.8.1.1: Surface Water Sampling Plan

Station Name	Stream Name	Analytical Parameters[1]	
		Sr-89/90	*Gamma*
WCK 6.8	White Oak Creek	4	4
WCK 3.9	White Oak Creek	4	4
WCK 3.4	White Oak Creek	4	4
WCK 2.3	White Oak Creek	4	4
CRK 33.5	Clinch River	4	4
FFK 0.2	Fifth Creek	4	4
HRT-3	Homogeneous Reactor Test Tributary	4	4
MEK 0.3	Melton Branch	4	4
Total Primary Samples		32	32
Field Duplicate		4	4
Total Samples (FY 24)		**36**	**36**

Notes: All water samples will be collected quarterly.

[1] *– The list of analytes and their analytical methods are defined in Table 7.3.8.1.2.*

Samples will be submitted for analysis of strontium-90, and gamma radionuclides using the analytical methods specified in Table 7.8.3.1.2 (or equivalent analytical methods). At each site, water quality parameters will be measured in the field at the time of sampling using a properly calibrated multi-parameter water quality meter. The following water quality parameters will be measured and recorded: pH, temperature, specific conductivity, dissolved oxygen, oxidation-reduction potential, and turbidity. Quality assurance/quality control (QA/QC) samples will be collected at a frequency of no less than 10%.

Monthly Field Parameter Collection

The Project also includes monthly measurement of surface water parameter readings at the same eight (8) monitoring sites (WCK 6.8, WCK 3.9, WCK 3.4, WCK 2.3, CRK 33.5, FFK 0.2, HRT-3, MEK 0.3), shown on Figure 7.3.5.1. At each site, water quality parameters will include pH, temperature, specific conductivity, dissolved oxygen, oxidation-reduction potential, and

turbidity. Monthly field parameter readings will be inclusive of the quarterly sampling events (12 events total).

Table 7.8.3.1.2: Analytical Laboratory and Field Methods

Parameter Type	Analytes	Analytical Method or Equivalent
Radionuclides	**strontium-89/90**	EPA Method 905.0
	gamma radionuclides	EPA Method 901.1
Field Water Quality Parameters	pH	Monthly Field Measurements *(inclusive of each sample event)*
	temperature (°C)	
	specific conductivity (µS/cm)	
	dissolved oxygen (mg/L)	
	oxidation-reduction potential (mV)	
	Turbidity (NTU)	

Notes:
Bolded values have a numerical standard.
°C – degrees Celsius
µS/cm – microSiemens per centimeter
mg/L – milligram per liter
mV – millivolt
NA – not applicable
NTU – nephelometric turbidity unit

DATA

The resulting analytical data will be evaluated and compared against numerical standards set forth by the EPA's *National Priority Drinking Water Regulations* (EPA, 2009). EPA has established a maximum contaminant level (MCL) of 4 millirems per year for beta particle and photon radioactivity from manmade radionuclides in drinking water. For strontium-90, a derived concentration of 8 picocuries per liter (pCi/L) is assumed to yield 4 millirems per year. If other radionuclides that emit beta particles and photon radioactivity are present, the resulting concentration will be compared to the corresponding derived concentrations of the detected radionuclide. The results of the surface water sampling will be incorporated into the TDEC's FY25 Environmental Monitoring Report (EMR).

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7.4 CERCLA ORR SITE INVESTIGATION

7.4.1 BACKGROUND

ORR stormwater runoff has the potential to transport various contaminants, including sediments, nutrients, organic and inorganic chemicals, metals, and bacteria, into waterways. Unmitigated runoff causes water quality issues and environmental degradation (Marsalek, 2002). To reduce or eliminate the negative impacts of stormwater runoff on surface water and groundwater, best management practices (BMPs) are implemented prior to and throughout building demolition and remediation activities.

During FY25, the project team will perform sampling to evaluate DOE's adherence to CERCLA regulations, requirements, and associated SOPs. DoR-OR will also conduct stormwater investigations which will include: (1) the evaluation of the water quality of stormwater runoff, (2) the identification of potential pollution sources, and (3) the evaluation of BMP effectiveness at the sites. The stormwater monitoring sites will include D&D sites at ORNL and Y-12 campuses. Sampling events are planned during three (3) stages of demolition, (pre-demolition, demolition, and post-demolition). During FY25, the stormwater assessment will be performed at five D&D sites: ORNL (1) Bldg. 2523 and Annex 2523A, (2) Bldgs. 3002 & 3003, (3) Bldg. 3544, and at Y-12, (4) Alpha-2 and (5) 9720-17. This project will also be monitoring stormwater and water turbidity at the EMDF before, during, and after construction. Pre-construction sampling of stormwater turbidity is ongoing.

ORR Stormwater Investigation includes five D&D sampling sites and one construction site (6 sites total). Site descriptions are as follows:

Site 1): Complex 2523/2523A, ORNL

- Location: Bldg. 2523 and Annex 2523A are located together in the southern portion of ORNL (Figure 7.4.1.1). The nearest surface water conveyances to Complex 2523/2523A are First Creek to the west and White Oak Creek (WOC) to the south.
- Purpose: Bldg. 2523 was a laundry house used for decontamination of radiologically contaminated clothes and respirators. Annex 2523A is a small, add-on trailer on the north side of Bldg. 2523. This trailer served as a general storage area.
- Demolition: July 2024.
- COCs: Both buildings together are considered a low-level radiological facility. The potential COCs for this site include radionuclides (U-isotopes, gross alpha/beta), metals (beryllium, lead, cadmium, copper, zinc, low-level mercury), suspended solids, and Polychlorinated Biphenyls (PCBs).

Figure 7.4.1.1: ORNL Complex 2523/2523A

Site 2): Buildings 3002 & 3003, ORNL

- Location: Bldgs. 3002 & 3003 are located at the north side of ORNL (Figure 7.4.1.2). The nearest surface water conveyance is Fifth Creek, which is located approximately 500 ft. east of Bldgs. 3002 & 3003. Fifth Creek flows southward and eventually discharges to WOC.
- Purpose: Bldg. 3002 was a *graphite filter house* and 3003 was a *graphite fan house*. Cooled air from a graphite reactor was filtered inside Bldg. 3002 and drawn through underground ducts into 3003. The fan house moved air through a graphite reactor stack to the outside.
- Demolition: August 2025.
- COCs: The potential COCs for Bldgs. 3002/3003 are the same as Bldg. 2523/2523A and include radionuclides (U-isotope, gross alpha/beta), metals (beryllium, lead, cadmium, copper, zinc, low-level mercury), suspended solids, and PCBs (DOE, 2023b).

Figure 7.4.1.2: Buildings 3002 & 3003

Site 3): Building 3544, ORNL

- Location: Bldg. 3544 is the Process Waste Treatment Plant. It is located on the south side of ORNL and immediately adjacent to WOC (Figure 7.4.1.3).
- Purpose: Bldg. 3544 is composed of an Office and Control Room (contains an instrument panel), Chemical Make-up Area (chemical storage and laboratory facility where titrations were performed), and shielded area (contains ion-exchange equipment and concentrated waste tank).
- Demolition: December 2025.
- COCs: Radiologically contaminated wastewater generated at ORNL was treated in this building (DOE, 2023c).

Figure 7.4.1.3: Building 3544

Site 4: Alpha-2, Y12

- Location: The Alpha-2 complex is a three-story building located north of Upper East Fork Poplar Creek (Figure 7.4.1.4).
- Purpose: Alpha-2 was initially used for uranium separation and then used for groundwater treatment in the mid-1990s. Currently, demolition is set for late summer early fall 2024.
- COCs: Initial DOE stormwater monitoring at this site indicated potential environmental concerns related to contaminants such as U-isotopes, mercury, beryllium, and PCBs. Consequently, it is necessary to continue monitoring the stormwater discharged from the Alpha-2 site as the demolition work is initiated and progresses.

Figure 7.4.1.4: Location of Alpha-2

Site 5): BLDG. 9720-17, Y-12

- Location: Bldg. 9720-17 is on the north side of Upper East Fork Poplar Creek (Figure 7.4.1.5).
- Purpose: This facility was initially used to store highly enriched uranium (HEU) and other hazardous and mixed waste. The RWP identifies this facility a Radiological Area (RA), Contamination Area (CA), High Contamination Area (HCA), and Airborne Radiological Area (ARA).
- Demolition: Proposed for early spring 2025.
- COCs: COCs include uranium, thorium, lead, chromium, and PCBs.

Figure 7.4.1.5: Building 9720-17

Site 6): EMDF, Y-12 Landfill Construction

Stormwater may carry construction debris and sediments from the EMDF site and discharge into the nearby stream. In FY25, the turbidity survey from FY24 in Bear Creek near EMDF will be continued. Turbidity is used as an indicator of water quality changes from both physical and chemical constituents.

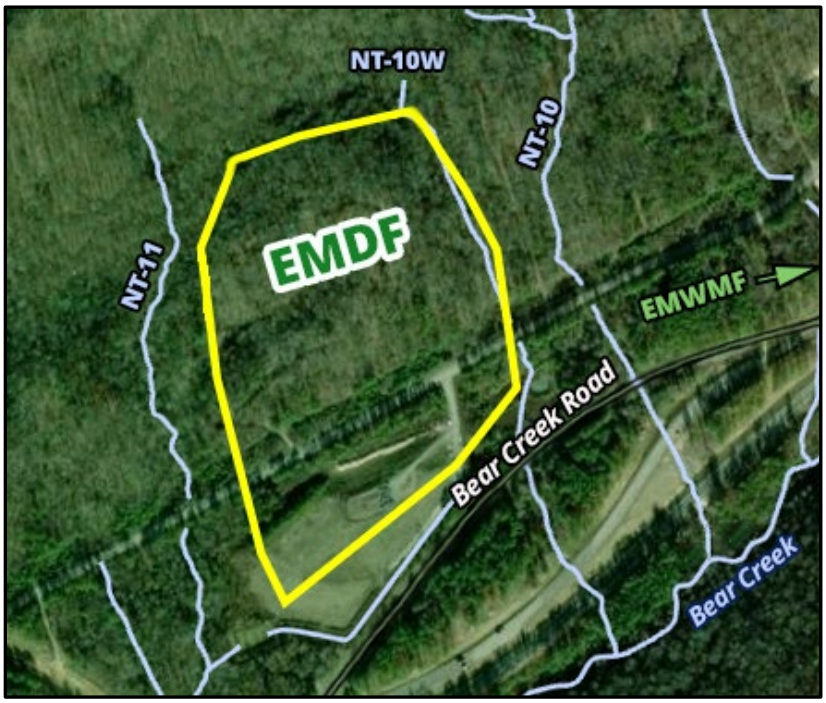

Figure 7.4.1.6: EMDF Stormwater Turbidity Investigation

7.4.2 Related DOE Projects

At Y-12 DOE operates under an NPDES permit issued to Y-12 NNSA with an effective date of October 2022. This permit emphasizes stormwater management controls that should be implemented to reduce or eliminate the discharge of pollutants. These requirements are reflected in the Y-12 *Stormwater Pollution Prevention Plan* (SWPPP), which requires:

1) Characterization of stormwater by sampling during storm events.
2) Implementation of measures to reduce stormwater pollution.
3) Conducting facility inspections.
4) Requires employee training at demolition sites.

At ORNL the NPDES permit also requires DOE to develop and implement a *Water Quality Protection Plan* (WQPP), which includes a SWPPP and the monitoring plan. These current plans are found in the ORNL WQPP (DOE, 2023a).

DOE conducts internal evaluations of compliance with their NPDES permits, including environmental monitoring procedural compliance and work planning and controls. Compliance results are discussed in the annual DOE ASER.

Direct comparisons will be made between DOE and DoR-OR sampling results at most locations. One exception is ORNL Bldg. 3544. DOE intends to sample stormwater for ORNL Bldg. 3544 at the catch basin near the D&D site, whereas DoR-OR will be sampling WOC just below the D&D site to assess run off that may reach the creek.

7.4.3 Problem Statements

D&D / demolition of older, contaminated buildings on the ORR is of concern due to potential contamination from those buildings / structures being transported into surrounding water resources (e.g., surface water, groundwater) during remediation events through storm impacts.

To reduce or eliminate the negative impacts of stormwater runoff on surface water and groundwater, best management practices (BMPs) are implemented prior to and throughout building demolition and remediation activities. If BMPs are not implemented or are implemented incorrectly, impacts to local surface water bodies may occur.

Stormwater runoff has the potential to transport various contaminants, including sediments, nutrients, organic and inorganic chemicals, metals, and bacteria, into waterways, resulting in water quality issues and environmental degradation (Marsalek, 2002).

Stormwater may carry construction debris and sediments from sites and discharge into nearby streams.

7.4.4 GOALS

This project has five main objectives:

1) Conduct stormwater assessments of various remediation projects across the reservation and evaluate COC levels discharged/mobilized from D&D sites.
2) Establish stormwater water quality conditions before D&D is initiated (pre-demolition).
3) Assess the effectiveness of the BMPs selected and implemented at demolition sites.
4) Compare stormwater data collected during and post-demolition to pre-demolition conditions.
5) Co-sample with DOE where possible. Compare DoR-OR stormwater monitoring data to sampling DOE data.

7.4.5 SCOPE

The scope of this project is to conduct comprehensive sampling at five ORR D&D sites. Additionally, turbidity and water quality data will be measured at one landfill construction site, EMDF, on the ORR.

The independent data analysis at D&D sites will be used to evaluate the COC levels in stormwater runoff, which discharges to nearby surface water. Data will be collected and compared across three phases: pre-demolition, demolition, and post-demolition periods.

For the sixth sample site, the EMDF site, the turbidity and water quality parameter data will be measured from NT-9 to NT-12 along Bear Creek after each qualified storm, as defined in Section 7.4.8.

Figure 7.4.5.1: FY25 ORNL D&D Sites for Stormwater Investigation

Figure 7.4.5.2: FY25 Y-12 D&D Sites for Stormwater Investigation

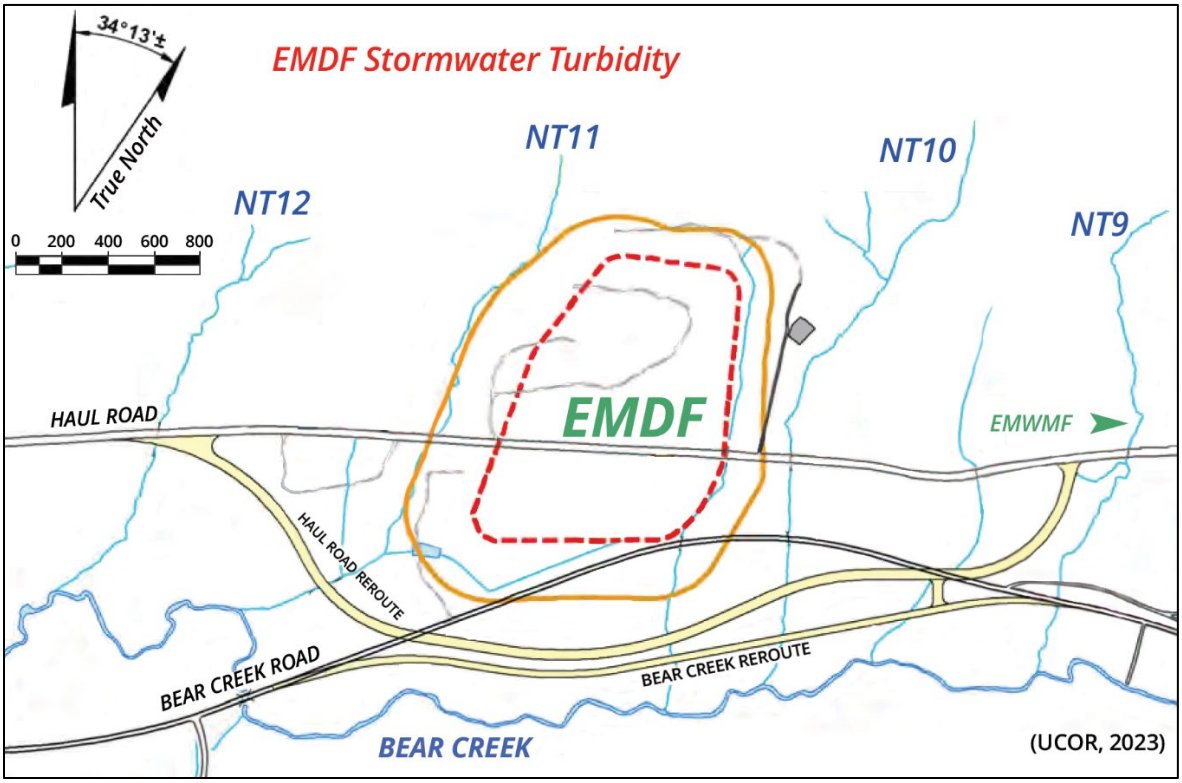

Figure 7.4.5.3: EMDF North Tributaries (NT9-NT12)

7.4.6 Assumptions

The assumptions for this project include:

1) D&D Sites: Chosen monitoring locations will be representative of potential discharges from D&D sites. Sampling frequency will be adequate to capture elevated COC concentrations if they occur as a result of D&D and demolition activities.

2) EMDF Sites: The selected monitoring sites will be adequate to determine any impacts to Bear Creek from construction at EMDF. Turbidity monitoring will indicate if construction activities at the EMDF are directly impacting Bear Creek.

7.4.7 Constraints

This project's constraints include:

1) Standard constraints; including equipment failure, funding, staffing, transportation, weather, access to sample sites on the ORR.
2) D&D and demolition schedules may be postponed or altered by DOE.
3) Monitoring and sampling are contingent on rain events occurring and availability of DOE contracted radiation protection technicians to support sampling at/near areas impacted by radiological contamination.

7.4.8 Methods, Materials, Metrics

Stormwater Investigation Protocol: ORNL and Y-12 Stormwater Sampling

Sampling protocols, site selection, sampling intervals, and sample sizes will follow the guidelines of the *EPA NPDES Storm Water Sampling Guidance (EPA 833-8-90-001 July 1992)*. QA/QC measures, safety protocols, and data analyses will follow the procedures outlined in DOE's *Annual Stormwater Report for the Y-12 National Security Complex, Oak Ridge, Tennessee* (DOE, 2023d) and TDEC's *Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2022). Specific sampling locations for each site are listed in the figures below (Figure 7.4.8.1, 7.4.8.2, 7.4.8.3, and 7.4.8.4).

Figure 7.4.8.1: Complex 2523/2523A Proposed Sites

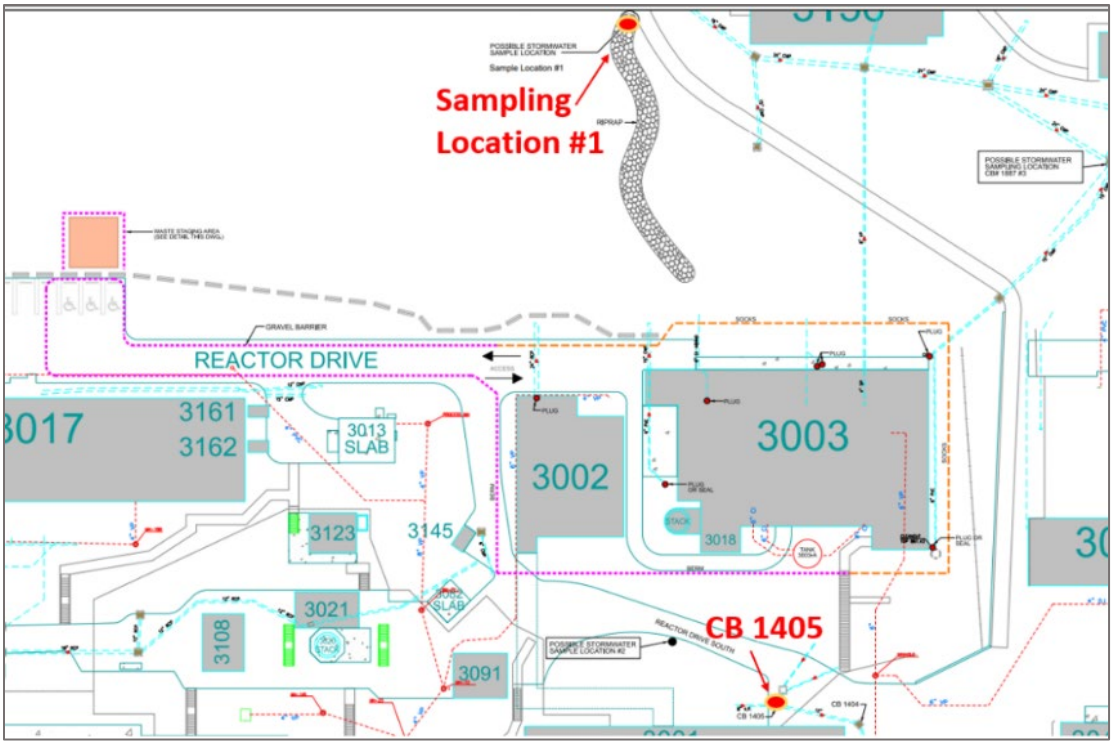

Figure 7.4.8.2: Bldgs. 3002 & 3003 Proposed Sites

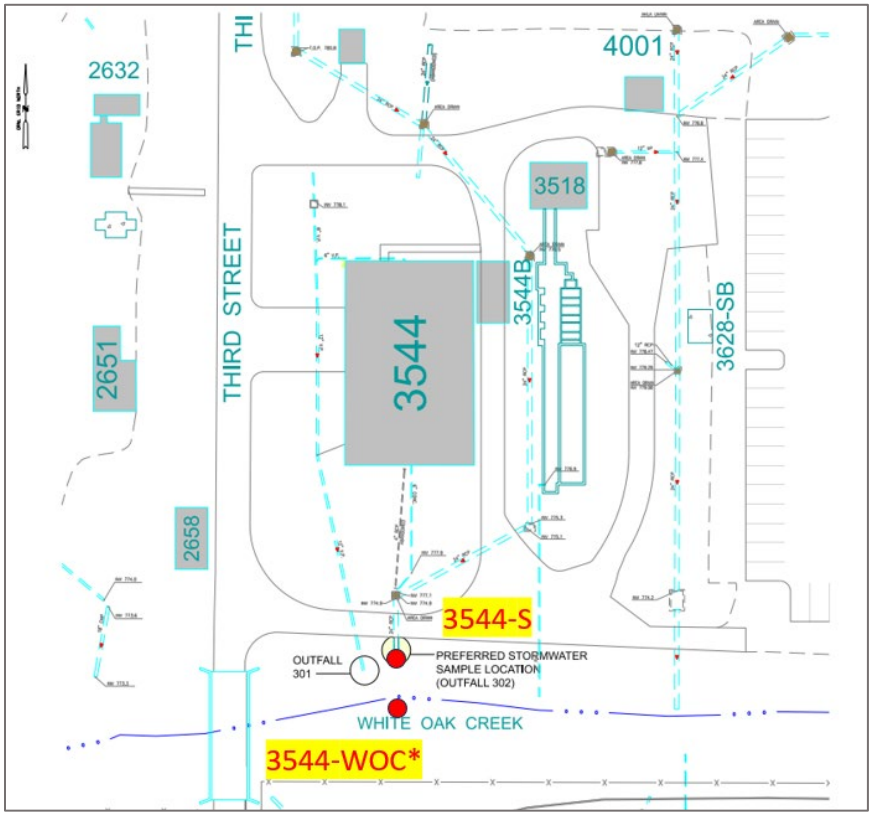

Figure 7.4.8.3: Bldg. 3544 Proposed Sites

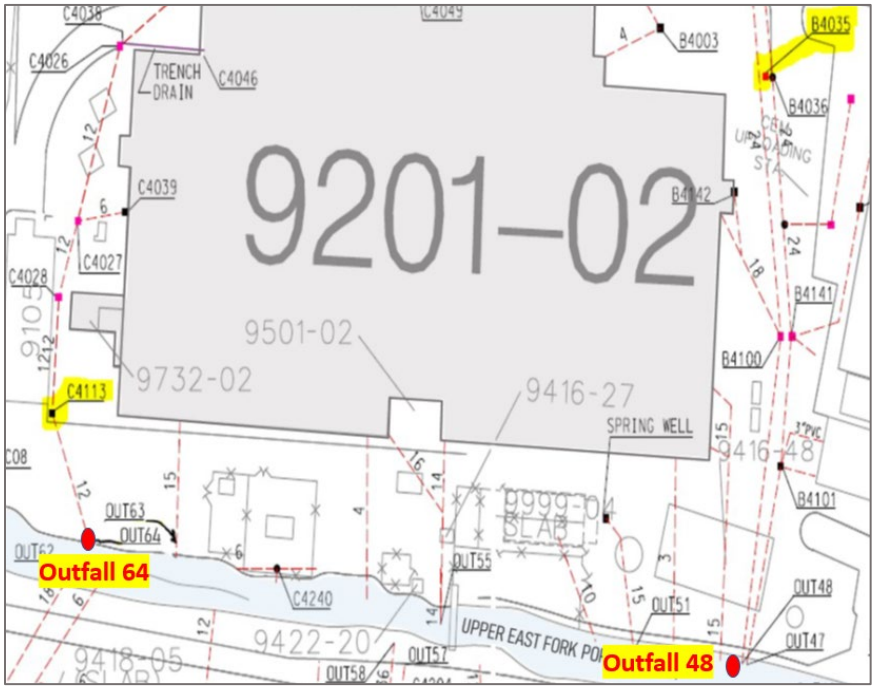

Figure 7.4.8.4: Proposed Sampling Sites of Alpha-2

Stormwater sampling will be conducted after qualifying precipitation events. A qualifying event is defined as a rain event that, (1) produces 1 inch or more of measured rainfall within a 24-hour period, (2) causes runoff toward the outfall, and (3) occurs after a dry period, defined as no measurable rainfall (i.e., < 0.1 inch) within a 72-hour period.

The proposed analytical methods, field methods, and stormwater sampling plan are listed in Tables 7.4.8.1, 7.4.8.2, and 7.4.8.3, respectively. Field measurements will be collected following the *DoR-OR T-703 Field Use for Water Quality Parameters Instrument* (TDEC, 2023a) and *DoR-OR T-153 Water Quality Field Instrument Calibration and Maintenance* (TDEC, 2023b) SOPs. Stormwater and surface water samples will be collected following *DoR-OR T-704 Collection of Surface Water Samples* (TDEC 2023c).

Table 7.4.8.1: Analytical Laboratory and Field Methods

Parameter Type	Analytes	Analytical Method
Radionuclides	Strontium-89/90	EPA Method 905.0
	Gamma radionuclides	EPA Method 901.1
	Isotopic uranium	DOE-HASL-300
	Isotopic plutonium	DOE HASL 300
	Gross alpha/beta	EPA Method 900.0
	Carbon 14	EPA EERF
	Tc-99	EPA Method 906.0
Organics	PCBs	EPA 1668
Metals	Cadmium	EPA-200.8
	Copper	EPA-200.8
	Lead	EPA-200.8
	Low-level Mercury	EPA-1631
	Mercury	SW846-7470, SW846-7471
	Zinc	EPA-200.8
	Beryllium	EPA-200.8
	Chromium	EPA-200.8
	Uranium	EPA-200.8
	Thorium	EPA-200.8
Inorganics	Total Suspended Solids	SM-2540-D
Field Water Quality Parameters	pH	Field measurements
	Temperature	
	Specific conductivity	
	Dissolved oxygen	
	Oxidation-reduction potential	

Table 7.4.8.2: ORNL Stormwater Sampling Plan

ORNL D&D Stormwater Sampling									
BLDG.	***Demo Period***	***FY25*** *Sample Events/ Demolition Stage*			***Sample Sites***	***COCs***			
		Pre	*Demo*	*Post*		***Organics***	***RADS***	***Metals***	***Inorganics***
2523/ 2523A	*4/24-12/24*		*2*		*2523-S* *2523-SE* *2523-W*	*PCBs* **Semi-VOCs*	*Iso-U* *Gross Alpha* *Gross Beta* **Ce-137* **Sr-90* **Eu-152/154* **C-14* **Co-60* **Tritium*	*Beryllium* *Lead* *Cadmium* *Copper* *Zinc* *LL Hg*	*TTL Suspended Solids*
3002/ 3003	*8/25*	*2*			*CB 1450* *SL 1*				
3544	*12/25-11/26*	*1*			*3544-S* *355-WOC*				
*Notes: Total number of sampling events for each facility: **2** pre-demo, **3** early-dem, and **2** post-demo.* ** Additional analyses for Bldg. 3544.*									

Table 7.4.8.3: Y-12 Stormwater Sampling Plan

Y-12 D&D Stormwater Sampling								
Demo Period	***FY25*** *Sample Events/ Demolition Stage*			***Sample Sites***	***COCs***			
	Pre	*Demo*	*Post*		***Metals***	***Organics***	***RAD***	***Inorganics***
9201-2 Alpha-2		*3*		*OF-64* *OF-48*	*Mercury* *Lead* *Copper* *Thallium* *Zinc*	*PCBs*	*U-isotopes* *Gross Alpha* *Gross Beta*	*TTL Suspended Solids*
9720-17 Axillary	*1*	*2*		*(TBD)*	*Mercury* *Lead* *Uranium* *Chromium* *Thorium*			
Notes: *Total number of sampling events for each facility: **2** pre-demo, **3** amid-demo, and **2** post-demo.*								

EMDF Turbidity Sampling

For the EMDF turbidity survey, there are 12 sampling sites in Bear Creek. This project will compare the turbidity difference upstream and downstream of each tributary from NT-9 to NT-12. Sampling sites include NT-9-U, NT-9-D, NT-10-U, NT-10-D, NT-10W-U, NT-10W-D, NT-11-U, NT-11-D, NT-12-U, and NT-12-D (Table 7.4.8.4). Sampling locations are identified in Figure 7.4.8.5. Measurements are taken in accordance with the DWR *Chemical and Bacteriological Surface Water Sampling Standard Operating Procedure* (TDEC, 2022).

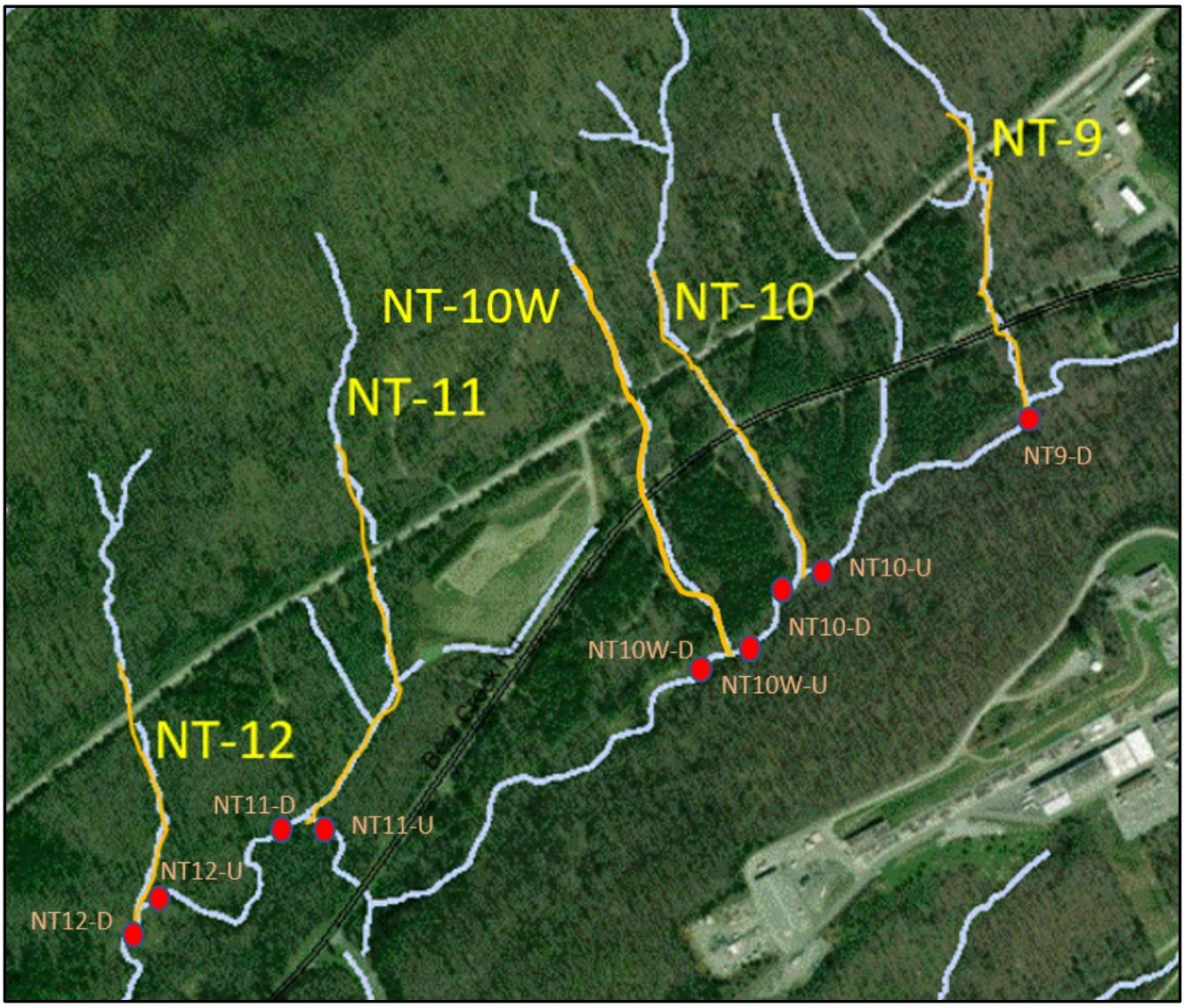

Figure 7.4.8.5: EMDF Turbidity Survey Sites NT-9 to NT-12

Table 7.4.8.4: EMDF Survey Plan

EMDF Construction Site Turbidity Survey			
	Sampling Frequency	Sampling Sites	Parameters
Surface Water	Each qualifying rain event: (July 2024-June 2025)	• NT-9-U • NT-9-D • NT-10-U • NT-10-D • NT-10W-U • NT-10W-D • NT-11-U • NT-11-D • NT-12-U • NT-12-D	■ DO ■ Conductivity ■ pH ■ ORP ■ Temperature ■ Turbidity

7.4.9 REFERENCES

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TDEC. 2023c. *Collection of Surface Water Samples*. DoR-OR-T-704, State of Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office

8.0 SEDIMENT SAMPLING

8.1 SUSPENDED SEDIMENT SAMPLING

8.1.1 BACKGROUND

Contaminated sediments can directly impact benthic life and may pose detrimental indirect effects on other organisms, including humans, through bioaccumulation and subsequent transfer of contaminants through the food web.

This program monitors for suspended sediment bound contaminants transported in impacted ORR waterways. Surface waters have been adversely affected by past and present activities on the ORR. The sediment traps used for this project collect suspended sediment particles from impacted waterways around the reservation. The information gathered from the chemical analysis of these sediments can reveal presence of contaminants being transported downstream in the water column in the suspended sediment load.

Data from this project will be used in the *East Fork Poplar Creek Assessment Project* (EFPCAP) report. Sites for sediment traps are located in areas where they can best evaluate the lower EFPC to track any migration of sediment entrained contaminants.

8.1.2 RELATED DOE PROJECTS

DOE collects grab samples but does not currently sample suspended sediments in the water column. Based on the data available in the OREIS Spatial Query Tool, the last time DOE sampled sediment in Bear Creek and East Fork Poplar Creek was in 1995 and 1992, respectively.

For the 1995 Bear Creek sediment sampling, an Ekman Dredge was used. These devices grab all components of the stream bed where they are deployed, including gravel, sand, silt, and clay. The predominant sample fractions for a grab sample in Bear Creek or East Fork Poplar Creek are gravel and sand. Gravel and sand have very little binding capacity as compared to the silt and clay fractions, and as such that sample may underrepresent the contribution of the contaminant load that is mobile and able to be transported offsite in the water column.

8.1.3 PROBLEM STATEMENTS

Sediment is an integral component of stream ecosystems but often serves as a ‘sink’ for many contaminants. There is no DOE-led program in place to monitor suspended sediment transport of contaminants through ORR watersheds.

8.1.4 GOALS

The goal of the project is to detect contaminants in suspended sediments potentially sourced from releases within the DOE facilities which may be migrating through the surface water

system and have the potential to exit into publicly accessible areas.

The data obtained from the sediment traps will be used to assess the extent of sediment contamination that is transported in Bear Creek (BC) and East Fork Poplar Creek (EFPC), to provide a current snapshot of stream transport data to compare to future data.

8.1.5 SCOPE

Collection of sediment samples on BC and EFPC. Sample sites are shown in Figure 8.1.8.4. Data will be shared with the corresponding holistic watershed project.

1) Bear Creek
    1. NT-5: drains EMWMF
    2. BCK 7.6: near planned EMDF landfill
    3. BCK 3.3: a publicly accessible location
2) EFPC
    1. EFK 23.4: drains Y-12
    2. EFK 2.2: below BC confluence
3) Mill Branch (background site)

Samples will be retrieved from all sediment trap locations twice during the fiscal year; in October 2024, and in April 2025.

Sediment traps will be used to collect metal, organic, and radiological contaminants that might be migrating in both watersheds of Bear Creek and East Fork Poplar Creek via suspended particles. The information gathered from the laboratory analysis of these sediments will reveal what contaminants are being transported downstream within the water column. Data will also be used to detect changes in sediment contaminants that may not be discernable in other sediment sampling methods. The particle size of suspended sediments is very small as compared to grab sediment samples. Suspended sediment samples are predominantly silts and clays. Silts and clays are very fine particles with much greater surface area and binding capacity per unit mass than sand and gravel particles, which commonly comprise grab sediment samples.

This project will provide data to assist in the evaluation of Bear Creek and East Fork Poplar Creek downstream of Y-12.

8.1.6 ASSUMPTIONS

- Design of sediment traps allows for the collection of sediment particles suspended in the water column.
- Timing of sampling collection is appropriate and allows for the most comprehensive sediment sample.

8.1.7 CONSTRAINTS

- Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.
- Weather affecting in-stream flow.
  - Flooding: exceptionally high flows during flooding events may damage the sediment trap installations and result in loss of sediment traps.
  - Drought: sustained low flows may result in insufficient yield of sediment for analysis.

8.1.8 METHODS, MATERIALS, METRICS

To monitor for changes in contaminant flow through sediment transport, passive sediment samplers (sediment traps) have been deployed. As mentioned above, samples will be retrieved from all sediment trap locations twice during the fiscal year. The first set of samples will be collected in October 2024, while the second set of samples will be collected in April 2025.

Sediment samples will be analyzed for metals (cadmium, lead, mercury, uranium) and radiological activity (gross alpha/beta, isotopic uranium). The metals data will be compared to the *Consensus-Based Sediment Quality Guidelines (CBSQGs)* (MacDonald et al, 2000). Radiological data will be compared to data from background locations and risk-based screening levels. The data from Mill Branch will serve as the main reference.

During the previous holistic watershed project, sediment traps were placed at three (3) major locations in Bear Creek Valley; two on Bear Creek (BCK) and one on the North Tributary (NT). These locations include NT-5, BCK 7.6, and BCK 3.3. The continuation of sampling at these sites in FY25 will be used for pollutant monitoring and additional analyses as needed.

Data from the EFPC sites will be shared with the *EFPCAP* holistic watershed study. On EFPC, sediment traps are deployed at EFK 23.4 and EFK 2.2 to continue to understand contributions from Y-12 and potential impacts off the ORR.

Method Summary

The procedure used for this project is the TDEC DoR-OR *Standard Operating Procedure for Sediment Sampling* (TDEC, 2022). Suspended sediment samples will be collected by the use of fixed sediment collection devices (sediment traps). Sediment traps are installed in a stream bed and oriented so that considerable water flows through the body of the trap. Suitable sites are limited in a stream and careful consideration must be given to selecting installation locations for these devices. The sediment traps must be placed in stream locations with sufficient flow and adequate depth to completely immerse the sediment traps. The passive sediment samplers are modeled after a design described by Phillips *et al* (2000).

Figure 8.1.8.2: Tandem sediment trap installation in East Fork Poplar Creek

Following a collection period of a minimum of six months, the sediment is emptied from a sediment trap and is transferred to a clean bucket where the sediment is allowed to settle on ice for 48 to 72 hours. After the sediment settles, the supernatant water is carefully drawn off the sample with a peristaltic pump. Sediment samples are spooned from the bucket into sample containers and sent to an analytical laboratory for analysis.

Table 8.1.8.3: Sediment Sampling Stations

Site Description ***(K and Km: kilometers)***	**Site ID**	**Latitude**	**Longitude**
East Fork Poplar Creek Km 23.4	EFK 23.4	35.99596	-84.24004
East Fork Poplar Creek Km 2.2	EFK 2.2	35.95169	-84.37160
Bear Creek Km 3.3	BCK 3.3	35.94354	-84.34911
Bear Creek Km 7.6	BCK 7.6	35.95094	-84.31455
North Tributary-5 at Bear Creek	NT5@BC	35.96633	-84.29331
Mill Branch Km 1.6	MBK 1.6	35.98560	-84.28722

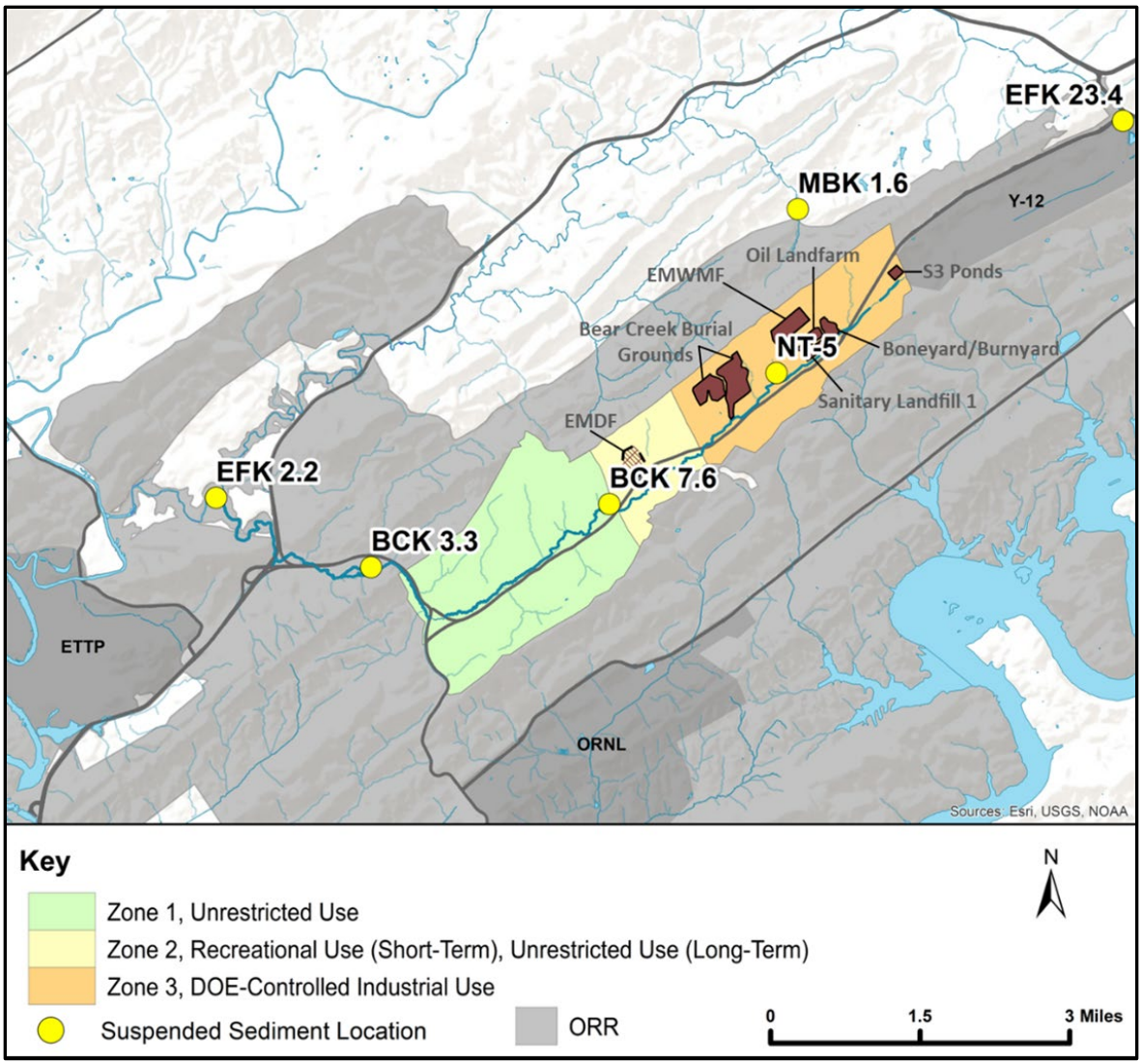

Figure 8.1.8.4: Map of Sediment Trap Sampling Stations

8.1.9 REFERENCES

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9.0 WATERSHED ASSESSMENTS (HOLISTIC) MONITORING

TDEC DoR-OR completes comprehensive watershed assessments around the ORR to provide the citizens of the State of Tennessee a comprehensive evaluation of that watershed, assessing the interconnectedness of all the environmental media over an entire watershed collectively at a given point in time. The holistic understanding of all contaminants and their multiple inputs into one watershed allows for enhanced understanding of the health of the system and supports discussions regarding prioritization of remediation project goals. Prior TDEC watershed assessments evaluated Bear Creek Valley and East Fork Poplar Creek. This fiscal year, the focal watershed is White Oak Creek (WOC).

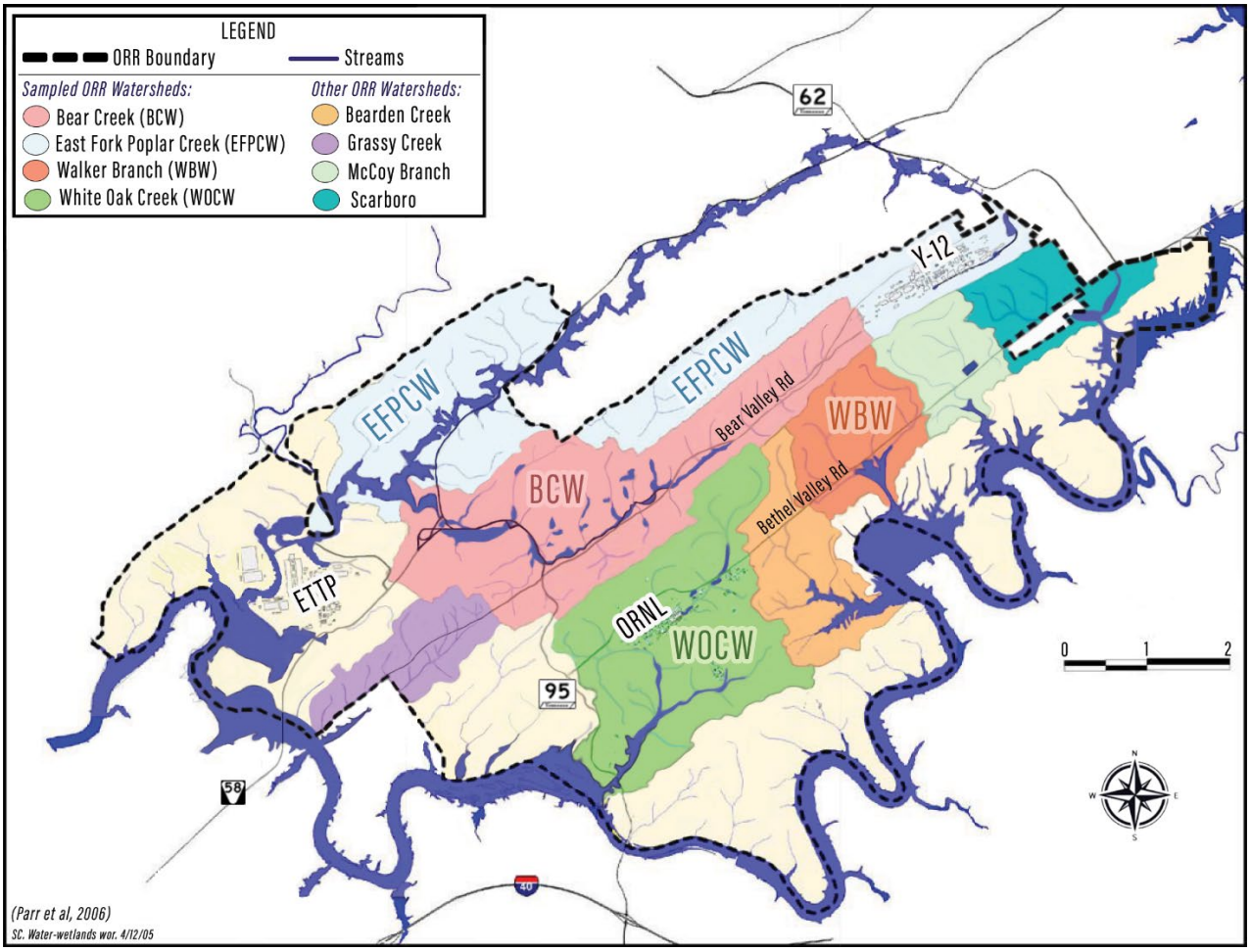

Figure 9.0.1: ORR Watersheds

9.1 WHITE OAK CREEK ASSESSMENT PROJECT (WOCAP) – PHASE 2

9.1.1 BACKGROUND

The ORR resides in the Valley and Ridge physiographic province. This province is distinguished by a series of northeast-southwest trending ridges and interceding valleys (Figure 1.3.1.1) (Miller, 1974).

White Oak Creek Watershed (WOCW) is located in the south-central part of the ORR. WOC originates on the slope of Chestnut Ridge and flows into Bethel Valley and around the ORNL. From the ORNL campus, the stream flows south through the gap at Haw Ridge and enters Melton Valley. WOC empties into White Oak Lake (WOL) and ultimately the Clinch River (i.e., CRK 33.5, CRM 20.8) (Figure 9.1.1.1). The WOCW drainage area is 6.45 miles^2 (USGS, 2024).

The *White Oak Creek Assessment Project* (WOCAP) is necessary to establish a current benchmark of environmental conditions in the WOCW. The environmental data generated by this sampling and analysis of various environmental media will establish a snapshot of conditions that can be used to evaluate future impacts to the WOCW ecosystem. In 1996, DOE's comprehensive *White Oak Creek Remedial Investigation Report: Melton Valley Area* provided an assessment of the Melton Valley segment of the WOC (DOE, 1996). While this holistic assessment contains valuable data, the study is outdated, and an updated holistic assessment is warranted.

There are numerous data gaps that this WOCAP is intended to address. WOC data in the Oak Ridge Environmental Information System (OREIS) is limited. More specifically, monitoring data are scarce for the following: (1) Whole Effluent Toxicity (WET) testing with aquatic organisms such as *Ceriodaphnia dubia* (water flea) and *Pimephales promelas* (fathead minnow), (2) radiological uptake in WOC vegetation, (3) bioaccumulation of known contaminants in higher trophic level terrestrial organisms.

The primary contaminants of concern (COCs) within ORNL (campus or footprint) are tritium (H-3), strontium-90 (Sr-90), cesium-137 (Cs-137), and cobalt-60 (Co-60). The WOCAP involves a comprehensive evaluation of the ecological health of this entire watershed and will focus on the primary COCs. To accomplish this holistic assessment, the WOCAP has been organized into several progressive phases.

1) **Phase 1** (FY24) involves researching and compiling existing data.
    a. Data acquisition, review, summarization, and interpretation of historical data for the WOCW.
    b. Examine and compile available types of environmental data including: (1) surface water, (2) groundwater, (3) sediment, (4) soils, (5) toxicity/biomonitoring, (6) fish tissue, (7) benthic macroinvertebrates, (8) terrestrial biota (bird eggs, spiders, and flying insects).

2) **Phase 2** (FY25) will include new sampling and subsequent analysis of monitoring data collected in Phase 1. In Phase 2, new sampling and analysis projects include (1) surface water, (2) toxicity/biomonitoring, (3) fish tissue, (4) benthic macroinvertebrate community health, (5) benthic macroinvertebrate chemical analysis, (6) terrestrial biota (bird eggs and flying insects), and (7) vegetation.
3) **Phase 3** will use the analytical data obtained from Phases 1 and 2 to produce a comprehensive report. If data gaps are present after Phase 2, there will be further sampling and analysis.
4) **Phase 4** will address any areas requiring additional field sampling for a more comprehensive analysis and interpretation of all watershed data.

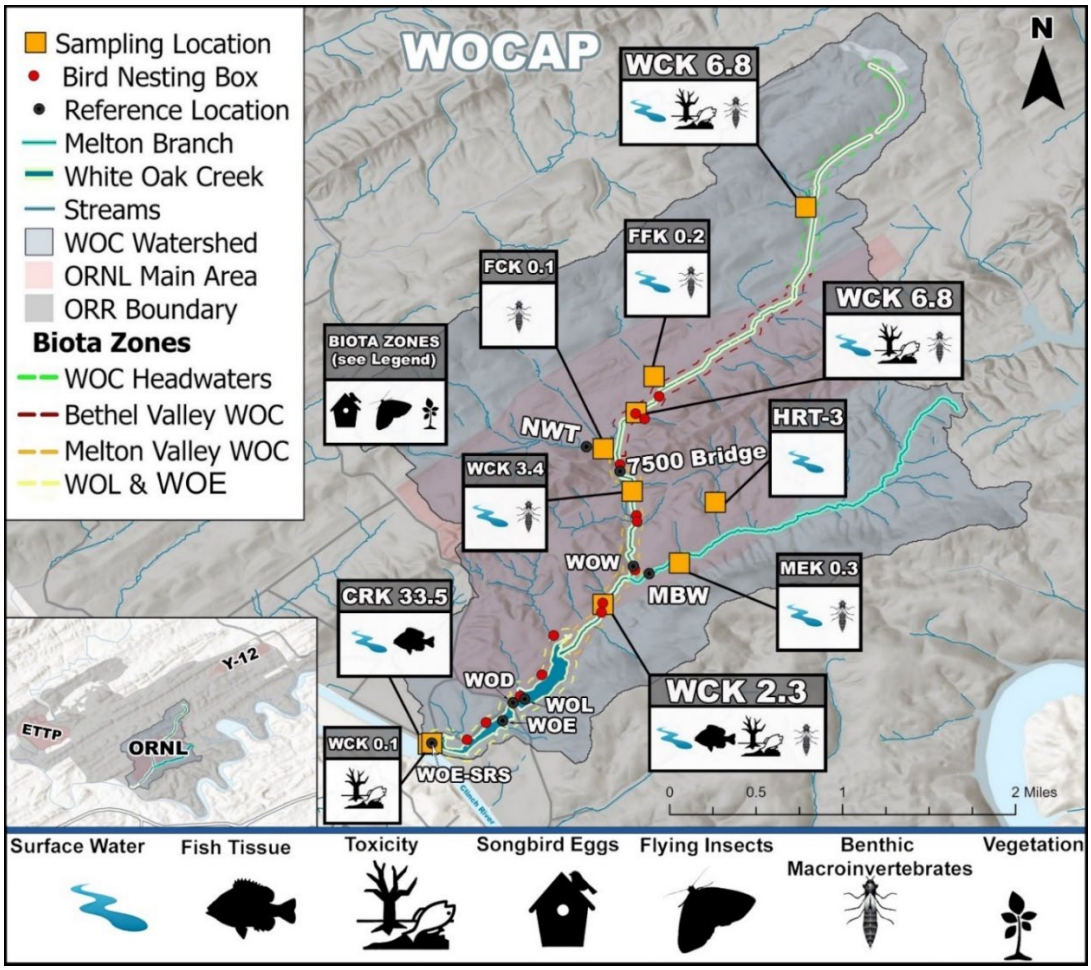

Figure 9.1.1.1: WOCAP Phase 2 Sampling Sites

Table 9.1.1.1: WOCAP Stream Names

Site Abbreviation & Kilometer	Stream Name
CRK 33.5	Clinch River
FCK 0.1	First Creek
FFK 0.2	Fifth Creek
HRT – 3 (Homogenous Reactor Test)	West Seven Creek (East Fork)
MBW	Melton Branch Weir
MEK 0.3	Melton Branch
NWT	Northwest Tributary
WCK 0.1, 2.3, 3.4, 3.9, 6.8	White Oak Creek
WOE	White Oak Embayment
WOW	White Oak Weir
WOD	White Oak Dam
WOL	White Oak Lake

9.1.2 Related DOE Projects

DOE has a few projects that can be incorporated into the WOCAP Phase 2 assessment. For example, ORNL's Environmental Sciences Division (ESD) samples fish and benthic macroinvertebrates in WOC. In addition, DOE samples WOC surface water at the 7500 Bridge (Bethel Valley Integration Point) and at several other locations on WOC, including Fifth Creek, a tributary of WOC.

9.1.3 Problem Statements

Melton Valley is a major waste storage area on the ORR. Contaminant releases from Melton Valley can potentially become mobilized via surface water, which flows into WOC and ultimately empties into the Clinch River (DOE, 2000). The primary contaminants of concern (COCs) are H-3, Sr-90, Cs-137, and Co-60. In the early years of ORNL plant operation, these COCs were discharged to nearby streams. Industrial waste disposal areas have also contributed to the contamination of the watershed through leaks, spills, and subsurface leaching (DOE 1995).

As a result of these ORNL discharges, WOC floodplain soils and sediments have extensive deposits of Cesium-137 (Cs-137). Cs-137 is of particular concern because of the high potential for release of sediment bound Cs-137 into the waters of the Clinch River (DOE, 2000).

These COCs have also resulted in elevated gamma radiation activity along WOC from ORNL to the White Oak Embayment (WOE) at the Clinch River confluence (WOC-CR). Melton Branch, a tributary of WOC, has lower levels of gamma radiation in the reach that spans from the High Flux Isotope Reactor (HFIR) to the confluence with White Oak Creek (MB-WOC).

9.1.4 GOALS

The goals of this **Phase 2** project include the following:

- Provide a comprehensive evaluation of WOCW to provide a current benchmark for future reference.
- Assess the impacts that historical and ongoing contamination of WOC may be having on wildlife in the watershed. Use monitoring data to assess ongoing human health risk.
- Provide a benchmark to gauge the impacts of future remediation activities in the WOCW.

9.1.5 SCOPE

WOC sample sites are depicted on Figure 9.1.1.1, shown above, and cover the length of WOC from the headwaters to the confluence with the Clinch River, as well as including major tributaries of WOC. Sampling will focus on WET testing (quarterly), one time collection of fish tissue and benthic macroinvertebrate tissue for contaminant analysis, as well as analysis of songbird eggs, terrestrial flying insects, and floodplain vegetation samples. Other monitoring data used to support this holistic watershed assessment will be collected and provided by the following projects: *Benthic Community Health*, *White Oak Creek Radionuclides,* surface water sampling, and the *Roving Creel Survey*.

9.1.6 ASSUMPTIONS

This project has a few assumptions, including:

1) Sampling results from different WOC projects are comparable.
2) The media examined is sufficient to determine the health of WOCW in an actionable way.

9.1.7 CONSTRAINTS

This project has the following constraints:

1) Standard constraints: equipment failure, funding, staffing, transportation, weather, ORR closures.
2) Biomass of samples may be insufficient for analysis.
3) RCP support must be scheduled and available to DoR-OR staff for all field activities.

9.1.8 METHODS, MATERIALS, METRICS

Surface Water

Surface water samples will be collected quarterly at four (4) sites on WOC, three (3) sites on tributaries of WOC and at one (1) site on the Clinch River at the mouth of WOC. The most upstream site on WOC (WCK 6.8) is the reference stream site. Surface water samples from WOC will be analyzed for Sr-90 and gamma radionuclides. For information about the WOC surface water sampling project, refer to the *White Oak Creek Radionuclides Surface Water* EMP in this document. Surface water sampling will be conducted according to *TDEC Standard Operating*

Procedure (SOP) T-700 Surface Water Monitoring.

Toxicity

Biotoxicity monitoring will be conducted by Civil and Environmental Consultants (CEC) during the months of July 2024, October 2024, January 2025, and April 2025 at four locations on WOC. The test organisms used will be fathead minnows (survival and growth) and water flea (survival and reproduction). In addition, surface water samples collected during each sampling event will be analyzed for arsenic (As), low-level mercury (Hg), uranium (U), strontium-90 (Sr-90), tritium (H-3), gamma radionuclides, and isotopic uranium. This project follows *EPA Operating Procedure LSASDPROC-201-R6 Surface Water Sampling*.

Fish Tissue – ORNL

DoR-OR has already requested a WOC sample of non-game fish from ORNL-ESD. ESD typically samples fish in May and November of each year. If a fish tissue sample is obtained, the tissue will be analyzed for a suite of COCs; mercury (Hg), methylmercury (MeHg), arsenic (As), cadmium (Cd), uranium (U), Polychlorinated Biphenyls (PCBs), dioxins/furans, gross alpha/beta, gamma radionuclides, strontium-89,90 (Sr-89,90), uranium (U) isotopic, plutonium (Pu) isotopic, carbon-14 (C-14), polonium-210 (Po-210), and technetium-99 (Tc-99).

The fishes collected may include golden redhorse, striped shiners, bigeye chub, and central stoneroller. The fish collection by ORNL ESD follows the internal DOE SOP. In addition, fish collection at Clinch River kilometer 33.5 (CRK 33.5) will be conducted by DoR-OR in FY25. This location is at the mouth of White Oak Creek on the Clinch River (i.e., WOC-CR confluence). The fish collected here will be analyzed for gamma radionuclides, Sr-89/90, strontium (Sr), arsenic (As), selenium (Se), methylmercury (MeHg), low-level mercury (Hg), and PCBs.

Benthic Macroinvertebrates

Benthic macroinvertebrates will be sampled in spring of 2024 at seven (7) locations in the WOCW (Figure 9.1.1.1). Macroinvertebrate sampling will follow the guidance outlined in the TDEC *Standard Operating Procedure for Benthic Macroinvertebrate Sampling (TDEC 2021).* For information about the benthic macroinvertebrate sampling project, refer to the separate EMP in this document. There will be two samples collected at each site. One sample will be used to assess benthic community health and the second sample will be analyzed for arsenic, mercury, uranium, tritium, Sr-89/90, and gamma radionuclides.

Biota

Biota samples will be collected within four specified biota zones in the WOCW (Figure 9.1.1.1) during the spring and summer of 2024 (flying insects) and spring 2025 (songbird eggs). These zones are WOC Headwaters (reference), Bethel Valley WOC, Melton Valley WOC, and White Oak

Lake (WOL) and White Oak Embayment (WOE). Songbird eggs and adult insects will be sampled and analyzed for gross alpha/gross beta, gamma radionuclides, Sr-89/Sr-90, and tritium.

Vegetation

Vegetation samples will also be collected in each of the four biota zones during June of 2024 and analyzed for gross alpha/gross beta, gamma radionuclides, Sr-90, tritium, and isotopic uranium.

Table 9.1.8.1: Field Sampling Timeline

Media		Surface Water	Biotoxicity	Fish Tissue ORNL	Fish Tissue DoR-OR	Benthics BMIs	Flying Insects	Songbird Eggs	Vegetation
Schedule		**Quarterly**	**Quarterly**	**Nov 2024**	**FY25**	**Spr. 2024**	**Spr./Su 24**	**Spr. 2025**	**June 2024**
Arsenic	As		X	X	X	X			
Mercury	Hg			X	X	X			
Low-Level Mercury	LL Hg		X						
Methyl Mercury	MeHg			X	X				
Cadmium	Cd			X					
Selenium	Se				X				
Uranium	U		X	X		X			
Polychlorinated Biphenyls	PCBs			X	X				
Dioxins/Furans				X					
Strontium-89/90	Sr-89/90	X	X	X	X	X	X	X	X
Technetium-99	Tc-99			X					
Alpha/Beta Activity	α/β			X			X	X	X
Gamma Activity	Y	X	X	X	X	X	X	X	X
Tritium	H-3		X			X	X	X	X
Isotopic Uranium	IsoU		X	X			X	X	X
Isotopic Plutonium	IsoPu			X					
Carbon-14	C-14			X					
Polonium-210	Po-210			X					
Biodiversity (Health)	TBI					X			

9.1.9 REFERENCES

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END OF EMP FY25