TENNESSEE DEPARTMENT
OF
ENVIRONMENT AND CONSERVATION

DIVISION OF REMEDIATION
OAK RIDGE OFFICE

ENVIRONMENTAL MONITORING PLAN

For Work to be Performed:

July 1, 2022, through June 30, 2023

Tennessee Department of
Environment and Conservation,
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ACRONYMS

A	ACOs	Artificial cover objects (cover boards)
	ALARA	As Low as Reasonably Achievable
	ANOVA	Statistical test for analysis of variance
	APHA	American Public Health Association
	ARAR	Applicable or Relevant and Appropriate Requirements
	ASER	Annual Site Environmental Report
	ASTM	American Society for Testing and Materials
	AWQC	Ambient Water Quality Criteria
B	3BWMA	Three Bends Wildlife Management Area
	BC	Bear Creek
	BCAP	Bear Creek Assessment Project
	BCBG	Bear Creek Burial Grounds
	BCK	Bear Creek Station or Bear Creek Kilometer
	BCK 3.3	Bear Creek kilometer 3.3 (distance from mouth of stream)
	BCM	Bear Creek Mile
	BCV	Bear Creek Valley
	Benthic	Stream-bottom dwelling organisms.
	Bgs	Below ground surface
	BMP	Best Management Practices
C	°C	Degrees Celsius/Centigrade
	CAA	Clean Air Act
	CBSQGs	Consensus Based Sediment Quality Guidelines
	CCME	Canadian Council of Ministers for the Environment
	CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act

	CMP	Contaminant Migration Plan
	COC	Contaminants of Concern, Chain of Custody
	COND	Conductivity
	Constraints	Limitation or restrictions to project time, scope, cost, and quality.
	Cr_6	Hexavalent Chromium
	CRK	Clinch River kilometer
	Cs-137	cesium 137
	CSM	Conceptual Site Model
	CWA	Clean Water Act
D	D&D	Decontamination and Decommissioning
	DCG	Derived Concentration Guides
	Dichotomous	Dividing into two parts
	DOE	Department of Energy
	DOH	Department of Health
	DoR	Division of Remediation
	DWR	Division of Water Resources
E	EF	East Fork
	%EPT - Cheum	Percentage EPT - Cheumatopsyche
	EFK	East Fork Kilometer
	EFPC	East Fork Poplar Creek
	EMDF	Environmental Management Disposal Facility
	EML	Environmental Measurement Laboratory
	EMP	Environmental Monitoring Plan
	EMR	Environmental Monitoring Report
	EMWMF	Environmental Management Waste Management Facility

	EPA	Environmental Protection Agency
	EPT	Ephemeroptera, Plecop
		tera, and Trichoptera
	ESOA	Environmental Surveillance Oversight Agreement
	ETTP	East Tennessee Technology Park
F	FFA	Federal Facilities Agreement
	FRMAC	Federal Radiological Monitoring and Assessment Center
	ft	foot, feet
	FWS	US Fish and Wildlife Service
	FY	Fiscal Year
G	G	gram(s)
	GCN	greatest conservation need
	GIS	Geographical Information System (Mapping)
	Goals	A checklist of accomplishments necessary to meet requirements
	GPS	Global Positioning System
	GW	Groundwater
H	H_2SO_4	sulfuric acid
	HA	Health Advisory Values
	HASL	Health and Safety Laboratory
	HCl	hydrochloric acid
	HFIR	High Flux Isotope Reactor
	Hg	mercury
	HNO_3	nitric acid
	HRE	Homogeneous Reactor Experiment
I	In	inch
K	km	kilometer

L	LHAV	Lifetime Health Advisory Values
	LLW	Low-level radioactive waste
	LSC	Liquid Scintillation Counting
M	m	meter
	MB	Mitchell Branch
	MBK	Mill Branch Kilometer
	MBK 1.6	Mill Branch kilometer 1.6 (distance from mouth of stream)
	MCL	Maximum Contaminant Level
	MDC	Minimum Detectable Concentration
	MDL	Minimum Detection Limit
	MeHg	methylmercury
	Mg/kg	Milligrams per kilogram (=ppm; =µg/g)
	MIK	Mitchell Branch kilometer
	millirem	One thousandth of a rem.
	mm	millimeter
	MQL	Minimum Quantification Limit
	MSRE	Molten Salt Reactor Experiment
	mV	millivolts
N	NAREL	National Air and Radiation Environmental Laboratory
	NESHAPS	National Emission Standards for Hazardous Air Pollutants
	NNSA	National Nuclear Safety Administration
	NOAA	National Oceanic and Atmospheric Administration
	NPDES	National Pollutant Discharge Elimination System
	NPDWR	National Primary Drinking Water Regulations
	NPL	National Priorities List

	NSDWR	National Secondary Drinking Water Regulations
	NTU	nephelometric turbidity units
	NT-5	North Tributary 5
	NT	North Tributary
	NUREG	NRC Regulation
	NRC	Nuclear Regulatory Commission
O	OREIS	Oak Ridge Environmental Information System
	ORNL	Oak Ridge National Laboratory
	ORP	Oxygen Reduction Potential
	ORR	Oak Ridge Reservation
	OSL	Optically Stimulated Luminescence Dosimeter
	OU	Operable Unit
P	PCB's	Polychlorinated Biphenyls
	PEC	Probable Effects Concentration
	PFAS	Per- and Polyfluoroalkyl Substances
	PRGs	Preliminary Remediation Goals
Q	QA/QC	Quality Assurance/Quality Control
	QAPP	Quality Assurance Project Plan
	QEC	Quality Environmental Containers (Beaver, WI)
R	RA	Remedial Activities
	RADCON	Radiation Control Program
	RAIS	Risk Assessment Information System
	RER	Remedial Effectiveness Report
	ROD	Record of Decision
	RPM	Radiation Portal Monitor
	RSLs	Regional Screening Levels

S	SAIC	Science Applications International Corporation
	SAP	Sampling and Analysis Plan
	SD	storm drain
	SMCL	Secondary Maximum Containment Levels
	SNS	Spallation Neutron Source
	SOP	Standard Operating Procedure
	SRS	Savannah River Site
	ssMDC	sample specific Minimum Detectable Concentration
	Station	A specific location where sampling of surface water takes place
	SU	standard units
	SWPP	Storm Water Pollution Plan
	SWPPP	Storm Water Pollution Prevention Plan
	SWSA	Solid Waste Storage Area
	Tc-99	Technetium - 99
	TDEC	Tennessee Department of Conservation
	TDH	Tennessee Department of Health
	TDH-NEL	TN Department of Health-Nashville Environmental Laboratory
T	TLD	Thermoluminescent Dosimeters
	TN	State of Tennessee
	TRU	transuranic
	TS	tree swallows
	TWQC	Tennessee Water Quality Criteria
	TWRA	TN Wildlife Resources Agency
U	U	Uranium
	U-234	Uranium 234

	U-235	Uranium 235
	U-238	Uranium 238
	UEFPC	Upper East Fork Poplar Creek
	US	United States
	USDI	US Department of the Interior
	UV	ultraviolet
V	VOCs	volatile organic compounds
W	WAC	Waste Acceptance Criteria
	WCK	White Oak Creek kilometer
	WD	wood duck
	WEMA	West End Mercury Area
	WOC	White Oak Creek
Y	Y-12	Y-12 National Security Complex

UNITS OF MEASURE AND THEIR ABBREVIATIONS

°C	degrees Celsius/Centigrade
µS/cm	micro Siemens per centimeter
mV	millivolts
DO	amount of gaseous oxygen (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
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 (TDEC DoR-OR), provides the annual Fiscal Year 2023 (FY2023) Environmental Monitoring Plan (EMP) for the period of July 1, 2022, through June 30, 2023. This report is submitted as a comprehensive plan for TDEC DoR-OR monitoring and assessment activities across the Oak Ridge Reservation, Oak Ridge, Tennessee, (ORR) in accordance with the terms of both the Environmental Surveillance and Oversight Agreement (ESOA), as well as in support of activities being conducted under the Federal Facilities Agreement (FFA).

The objective of the TDEC DoR-OR EMP is to provide an independent, comprehensive, and integrated monitoring and surveillance program, designed to evaluate and assess the effectiveness of the existing Department of Energy (DOE) environmental monitoring program. This independent State of Tennessee program is designed to assess current conditions for all ORR related environmental media (i.e. air, surface water, soil, sediment, ground water, drinking water, food crops, fish and wildlife and biological systems), by collecting data to verify or supplement DOE's data sets. This program is intended to provide independent assessment as necessary, of potential emissions of any materials (hazardous, toxic, chemical, or radiological) from the ORR to its surrounding environment.

In support of TDEC DoR-OR's independent monitoring and oversight of the ORR for CERCLA legacy waste-related actions (i.e. the FFA grant related projects), these projects provide information and data to support environmental restoration decisions, evaluate performance of existing remedies, and investigate the extent and movement of existing legacy contamination to verify DOE's management of ORR contaminants is effective.

TDEC DoR-OR also participates in independent monitoring and oversight of ESOA grant related activities (i.e. the current and active ORR process activities not covered under other State permits or regulatory authority) to evaluate and verify that DOE is adequately monitoring the impacts of their activities to prevent adverse effects on people and the environment of the State of Tennessee.

While past and current DOE ORR operations have the potential to release a variety of constituents to the environment via atmospheric, surface water, and groundwater pathways, DOE "is committed to enhancing environmental stewardship and managing impacts its operations have and may have had on the environment. Each year extensive environmental monitoring is conducted across the ORR. In 2020, many thousands of samples and measurements of air, water, direct radiation, vegetation, fish and wildlife were

collected from across the reservation and analyzed for radioactive and nonradioactive contaminants." (DOE Annual Site Environmental Report 2020)

Likewise, TDEC DoR-OR is committed to assure the citizens of Tennessee that DOE operations and remedial activities on and around the ORR are being performed in a manner protective of human health and the environment. Accordingly, TDEC DoR-OR's Environmental Monitoring Program is crucial to ensure this important goal is achieved.

This FY2023 EMP presents summaries of twenty-three (23) independent projects. This monitoring plan focuses on the following seven (7) general areas: Air Monitoring, Biological Monitoring, Groundwater Monitoring, Landfill Monitoring, Radiological Monitoring, Surface Water Monitoring, and Watershed Assessment (Holistic) Monitoring.

All work is conducted according to the directives specified in the most recent TDEC DoR-OR Health and Safety Procedures.

Air Monitoring:

There are three (3) projects grouped under the air monitoring header for the purpose of this EMP.

- **Fugitive Radiological Air Emissions**

The project independently samples air at nine (9) ORR locations, compares the results with DOE's air monitoring program data, and ensures DOE is adequately monitoring airborne emissions of radiological contaminants associated with ORR remedial actions and/or waste activities. TDEC air samplers air placed within the ORR boundaries, focused on locations where the potential for the release of fugitive airborne emissions may be higher, and samples are composited at shorter time intervals compared to DOE's quarterly composited analyses to support a more focused observation of potential problems and provide an additional data source should release events occur.

- **RadNet Air**

RadNet is an EPA nationwide program that monitors the nation's air, precipitation, and drinking water to track radiation in the environment. The project provides radiochemical gross beta analysis of air samples taken from four (4) air monitoring stations on the ORR, with two (2) stations at Y-12 and two (2) stations at ORNL. RadNet samples are collected by TDEC DoR-OR and analysis is performed at the EPA NAREL in Montgomery, Alabama.

- **RadNet Precipitation**

The project provides radiochemical analysis of precipitation samples taken from

monitoring stations at three (3) locations co-located with RadNet Air stations, all on the ORR. One site is at the east end of Y-12 and two are at ORNL, one in Bethel Valley and the other in Melton Valley. Samples are collected by TDEC DoR-OR, and analysis of these samples is performed at the EPA NAREL.

Biological Monitoring:

There are four (4) projects grouped under the biological monitoring header for the purpose of this EMP.

- **Benthic Community Health**

The project will assess the overall health of ORR stream ecosystems and track any significant changes in benthic community populations, which act as indicators of stream health. Macroinvertebrates will be sampled in eight (8) ORR exit pathway streams and four (4) corresponding reference locations. Unlike toxicity analysis which assesses acute effects to biota, this project will assess the chronic effects to biota from primarily ORR legacy contamination.

- **Lower East Fork Poplar Creek – Mercury Uptake in Biota**

Various biota (bird eggs, adult flying insects, and spiders) will be collected from impacted floodplain and surrounding areas of Lower East Fork Poplar Creek (LEFPC). The samples will be analyzed for mercury (Hg) and methylmercury (MeHg). The resulting data will allow an evaluation of potential uptake of these contaminants in LEFPC biological communities. Currently, there is limited data for some of these ecological receptors to assess Hg and MeHg uptake in LEFPC biota. Available data indicate sampled biota, especially specimens from higher tropic levels, may contain levels of Hg that exceed EPA advisory limits for fish consumption for the protection of human health, as a conservative reference, and that may be linked to adverse impacts to ecological receptors.

In addition, human health is a concern as local residential and recreational activity may be higher than previously thought in these LEFPC areas. Accordingly, this project will address these two concerns.

- **ORR Roving Creel Survey**

The project measures angling efforts and recreational activities at four (4) key areas where impaired ORR watersheds drain into publicly accessible waters to ascertain if recreational fisherman are at risk of exposure to ORR contamination. The three (3) main study areas for angler surveys are located at the confluence of Bear Creek and Poplar Creek, the confluence of Poplar Creek and the Clinch River, and the confluence of White Oak Lake and the Clinch River. A fourth study area for recreational surveys, the North Boundary Greenway which crosses and follows Bear Creek downstream of a mixed waste landfill and multiple burial grounds, was added to the project scope at the request of DOE to determine if recreational users of the public greenway are at risk of exposure to contaminants discharged into Bear Creek upstream of the greenway.

In addition, the project assesses the effectiveness of fish consumption warning signs and other risk notifications posted in areas on and/or near the reservation which are subject to contamination from ORR activities and are used for recreational purposes by the public.

- **Radiological Uptake in Food Crops**

This project assesses possible radiological impacts from DOE's ORR activities to food crops grown by local farmers and gardeners. This project supports a similar project conducted by DOE. TDEC DoR-OR conducts independent sampling of vegetables (root vegetables, fruiting vegetables such as tomatoes and squash, and leafy greens), hay, and milk from areas on or near the ORR (within 5 miles of the ORR boundary) as well as at offsite reference locations thought unlikely to be impacted by ORR activities. Data from this sampling will be used to verify and correlate DOE's sample results.

Groundwater Monitoring:

There are two (2) projects grouped under groundwater monitoring for the purpose of this EMP.

- **Historical Groundwater**

The project will develop a comprehensive offsite groundwater database that can be easily accessed to evaluate data, perform trend analysis, support groundwater discussions and FFA decisions, and help guide future TDEC DoR-OR sampling efforts. The database will be comprised of all past available offsite aqueous data from groundwater (private water wells, springs, and seeps) samples collected by both TDEC DoR-OR and DOE.

- **Offsite Groundwater**

The project will assess offsite groundwater in private residential water wells and springs located downgradient, to the southwest and along strike, of the East Tennessee Technology Park (ETTP), and to the north of the ETTP. This continuing TDEC DoR-OR effort will ensure there is no threat to human health and the environment from potential offsite migration of DOE ORR legacy contamination through groundwater movement around this site.

In addition, the evaluation of potential additional ORR exit pathways will help guide future FFA groundwater decisions.

Landfill Monitoring:

There are three (3) projects grouped under landfill monitoring for the purpose of this EMP.

- **EMDF**

The Environmental Management Disposal Facility (EMDF) is proposed to dispose low-level radioactive waste and hazardous waste generated by ORR remedial activities. Before construction of the EMDF begins, surface water samples and water quality measurements will be collected to delineate the current site conditions in the proposed EMDF area and the associated Central Bear Creek Valley (CBCV) watershed. The project will ensure DOE's EMDF water quality parameter background criteria are appropriate for assessments of area stream health. In addition, the TDEC DoR-OR surface water data will provide a snapshot of baseline surface water contaminants at the proposed EMDF site before construction and operational activities begin.

- **EMWMF**

Surface water, wastewater, and sediment samples will be collected to ensure the EMWMF complies with regulatory and operational requirements. Contaminated materials from CERCLA remediation activities on the ORR are approved for disposal in the EMWMF if they meet waste acceptance criteria. There is concern that associated contaminants have the potential to migrate from the facility into the environment and be carried by ground and surface waters off site in concentrations above agreed-upon limits. TDEC DoR-OR conducts monitoring at the EMWMF to provide assurance, through independent sampling and comparison of the independent data with DOE's data, that operations at the EMWMF are protective of public health and the environment and facility surface water discharges adhere to defined remedial action objectives.

- **FCAP Vegetation, Sediment, and Water Sampling**

The project will monitor coal combustion contaminants of concern (COC) within the Filled Coal Ash Pond (FCAP) wetland vegetation, sediments, and water to determine if there are changes in COC concentrations due to seasonal uptake of contaminants by vegetation and cattail winter die off. Twice a year, samples will be collected and analyzed. Analyses will mainly focus on metals, where the primary COC is arsenic. The sample results will help determine if the wetland is adequately preventing COCs from entering McCoy Branch.

Oversight and Assessment:

As allowed by both the current Federal Facility Agreement (FFA) and Environmental Surveillance Oversight Agreement (ESOA), TDEC DoR-OR will conduct oversight and assessments (O&A) of DOE ORR CERCLA related operations. There is one (1) project for O&A for the purposes of this EMP.

- **CERCLA Assessment and Oversight**

As specified by the FFA and ESOA agreements, DOE ORR CERCLA activities (i.e. D&D, remedial actions, field sampling) require procedures which ensure the environment and human health are adequately protected. This project will evaluate if such O&A safeguards are being correctly implemented while attaining any required compliance criteria. O&A activities will include review of DOE and contractor standard operating procedures (SOPs), observe DOE field activities, review DOE sampling results, and review compliance procedures specified in FFA documents. In addition, TDEC DoR-OR will collect accumulated water discharge, rain event, surface water samples, or other samples as appropriate to cross-check DOE-associated sampling results.

Radiological Monitoring:

While all projects conducted on or around the ORR typically contain components of radiological monitoring or assessment, there are four (4) projects grouped under the radiological monitoring header for the purpose of this EMP.

- **Haul Road Surveys**

TDEC DoR-OR performs walk-over radiological surveys of different segments of the ORR Haul Road and associated access roads to ascertain if waste items have inadvertently fallen from transport trucks. The TDEC DoR-OR haul road surveys independently verify the effectiveness of DOE actions in controlling radiological impacts from these transportation activities.

- **Real Time Measurement of Gamma Radiation**

The project is conducted at five (5) locations across the ORR and one (1) offsite background location. Concentrations of gamma radiation are measured in real time, allowing for the assessment of conditions at locations where gamma emissions may fluctuate substantially over relatively short periods of time. Because some facilities on the ORR have been known to release variable amounts of gamma radiation, this project is used to monitor areas on the ORR that TDEC DoR-OR has determined may have the potential for an unplanned release of gamma emitting radionuclides into the environment.

- **Surplus Sales Verification**

At the request of the ORNL's Excess Properties staff, TDEC DoR-OR performs pre-auction verification surveys on items being auctioned by ORNL's Excess Properties Sales.

Surface Water Monitoring:

There are three (3) projects grouped under surface water monitoring for the purpose of this EMP.

- **Ambient Surface Water Parameters**

On a monthly basis, the primary water quality parameters (specific conductivity, pH, temperature, and dissolved oxygen) are measured at three ORR exit pathway streams, East Fork Poplar Creek, Bear Creek and Mitchell Branch. The parameter measurement data provides information to assess the impact of site remediation efforts through long-term monitoring of surface water parameters, as well as provide ambient parameter information for use in the event of a release requiring clean up decisions and guidance.

- **Ambient Surface Water Sampling**

This project will assess the presence and quantity of bio-accumulative contaminants such as metals and PCBs in surface water which may impact biological communities in two primary ORR exit pathway streams, Bear Creek (BCK) and East Fork Poplar Creek (EFPC). This evaluation will help to better understand possible pathways and contamination sources for biota uptake.

In addition, the Clinch River (CR) will be monitored in conjunction with DOE sampling. These co-sampling events will provide data validation and supplementary data for the DOE project.

All the BCK, EFPC, and CR sampling sites will be compared to TDEC AWQC and EPA MCLs to

determine stream impacts.

- **White Oak Creek Radionuclides**

The purpose of this project is to continue monitoring Sr-90 and other radiological contaminant inputs to White Oak Creek (WOC) and its tributaries, which joins the Clinch River (CR), while levels of these contaminants remain high. In the past, elevated strontium-90 (Sr-90) concentrations have been found at Clinch River CRK 33.5 which is the White Oak Creek / Clinch River confluence (WOC-CR Confluence). Specifically, Sr-90 concentrations were found to be nearly seven times the acceptable limit for drinking water, 8 pCi/L.

This project will ultimately seek to understand WOC's contribution of such contaminants to the CR, as it is of concern that recreational fishermen may catch fish that have bioaccumulated contaminants discharged from WOC to the CR. An assessment of WOC impacts to the CR will be performed by comparing results to EPA maximum contaminant levels (MCLs).

Watershed Assessments (Holistic) Monitoring:

The Watershed Assessments (Holistic) Monitoring program has been initiated by TDEC DoR-OR, to support a watershed focused evaluation of current site conditions in watersheds throughout the ORR. There are three (3) projects grouped under watershed assessments (holistic) monitoring for the purpose of this EMP.

- **Bear Creek Valley Assessment (Phase 4)**

Designed as a holistic assessment of the Bear Creek Valley Watershed, this project was initiated during FY2020 and has completed Phases 1-3 that have covered historical records and data review and data gap analysis; sampling of environmental media (surface water sediments, soils, vegetation, toxicity, fish, benthic macroinvertebrates, and other biota); and analysis, interpretation, and reporting of results.

Phase 4 will provide a follow-up evaluation of the health of the Bear Creek Watershed, with a focus on providing new sampling data to fill in data gaps left from the Phase 2 investigation of the Bear Creek Valley Watershed. Sampling efforts will include toxicity/biomonitoring of surface water, fish analysis, biota (bird eggs, spiders, and flying insects), and sediment collection.

With an intensive evaluation of Bear Creek, this project will provide a baseline for future reference after the EMDF is constructed. In addition, this overall assessment is intended to provide information about potential health threats, if they exist, associated with

recreational use of the public areas of Bear Creek.

- **East Fork Poplar Creek Assessment (Phase 1)**

Designed as a comprehensive assessment of the East Fork Poplar Creek (EFPC) Watershed, this project has been categorized into four progressive phases. Phase 1 will conduct an extensive historical records review and data gap analysis of the middle EFPC kilometer (EFK 23.4 to EFK 13.8) and lower EFPC kilometer (EFK 13.8 to EFK 0.0) sampling sites.

From past DOE Y-12 National Security (Y-12) operations, the EFPC watershed was considerably impacted by primarily mercury and uranium contamination. Many types of historical environmental data including surface water, sediment, soils, toxicity/biomonitoring, fish, benthic macroinvertebrates, and other biota (bird eggs, spiders, flying insects) will be examined. This study will provide a better understanding of such impacts to the environment and wildlife in the watershed.

In addition, this project will provide an environmental assessment baseline to ascertain the effects from future DOE remediation actions in the EFPC watershed, particularly, the Y-12 Mercury Treatment Facility and changes to the nearby Outfall 200 area.

- **East Fork Poplar Creek Assessment (Phase 2)**

Designed as a comprehensive assessment of the East Fork Poplar Creek (EFPC) Watershed, this project has been categorized into four progressive phases. Phase 2 will conduct sampling from the mouth of EFPC (EFK 0.0) to Station 17 (EFK 23.4), which is the integration point for EFPC at the DOE Y-12 National Security Complex (Y-12).

From past DOE Y-12 National Security (Y-12) operations, the EFPC watershed was considerably impacted by primarily mercury and uranium contamination. Several types of environmental samples including surface water, surface water toxicity, sediment, soil, benthic macroinvertebrates, and biota tissue (fish, bird eggs, adult insects, and spiders) will be collected and analyzed. This study will provide a better understanding of such impacts to the environment and wildlife in the watershed.

In addition, this project will provide an environmental assessment baseline to ascertain the effects from future DOE remediation actions in the EFPC watershed; particularly, the Y-12 Mercury Treatment Facility and changes to the nearby Outfall 200 area.

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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), submits its annual (FY2023) Environmental Monitoring Plan (EMP) for the period July 1, 2022, through June 30, 2023, in accordance with the terms of the Environmental Surveillance and Oversight Agreement (ESOA) and in support of activities being conducted under the Federal Facilities Agreement (FFA).

The Environmental Surveillance Oversight Agreement (ESOA) is designed to assure the citizens of the State of Tennessee that the Department of Energy's (DOE) current activities in Oak Ridge, Tennessee, are being performed in a manner that is protective of their health, safety, and environment. Through a program of independent environmental surveillance oversight and monitoring, the State advises and assesses DOE's environmental surveillance program. Working collaboratively with the Office of Science, National Nuclear Safety Administration (NNSA), and DOE Environmental Management, the State conducts independent monitoring and verification as well as project reviews and if applicable, suggests modifications to current activities.

TDEC DoR-OR personnel, in support of the tri-party (EPA, TDEC, and DOE) Federal Facilities Agreement (FFA), also conduct independent environmental monitoring to ensure legacy contamination is managed appropriately. Monitoring conducted under the FFA supports environmental restoration decisions, evaluates performance of existing remedies, and investigates the extent and movement of legacy contamination. TDEC DoR-OR will take appropriate actions to identify, prevent, mitigate, and abate the release or threatened release of hazardous substances, pollutants, or contaminants from the ORR which may pose an unacceptable risk to human health or the environment for the State of Tennessee.

DOE and the State, in a spirit of partnership and cooperation, are committed to assure DOE's Oak Ridge activities are performed in a manner that is protective of health, safety, and the environment. This document provides an annual plan for the FY2023 monitoring and assessment projects conducted by TDEC DoR-OR during this period of performance.

Each of the proposed TDEC DoR-OR projects for FY2023 were developed and will be executed to protect human health and the environment. Each project has a DOE oversight component and meets the requirements of the ESOA and FFA and in consideration of the stakeholders (Table 1.1.1).

In executing TDEC DoR-OR's EMP, the deliverables as listed in Table 1.1.2 will be provided to the Stakeholders identified in Table 1.1.1

Table 1.1.1 Stakeholders

Stakeholders	
Citizens of Tennessee	External
Tennessee Department of Environment and Conservation	External and Internal
Local Governments	External
DOE and Contractors	External

Table 1.1.2 Deliverables

Deliverables	Due Date
2023FY Environmental Monitoring Plan	6/30/2022
Quarterly Reports	Quarterly
2022FY Environmental Monitoring Report	12/30/2022

1.2 OBJECTIVE

The objective of the TDEC DoR-OR Environmental Monitoring Program is to provide a comprehensive and integrated monitoring and surveillance program for all media (i.e. air, surface water, soil, sediment, groundwater, drinking water, food crops, fish and wildlife and biological systems), as well as the emissions of any materials (hazardous, toxic, chemical, or radiological) on the ORR and its surrounding environment. These projects are also used to evaluate the effectiveness of the DOE environmental monitoring program, by collecting data to verify DOE data sets.

This FY2023 EMP presents summaries of twenty-three (23) independent projects. This monitoring plan focuses on the following seven (7) general areas: Air Monitoring, Biological Monitoring, Groundwater Monitoring, Landfill Monitoring, Radiological Monitoring, Surface Water Monitoring, and Watershed Assessment (Holistic) Monitoring.

1.3 THE OAK RIDGE RESERVATION

The ORR is comprised of three major facilities:

- Oak Ridge National Lab (ORNL), formerly X-10
- Y-12 National Security Complex (Y-12)

- East Tennessee Technology Park (ETTP), formerly K-25

Facilities at these sites were constructed initially as part of the Manhattan Project. The ORR was established for the purposes of enriching uranium for nuclear weapons components and pioneering methods for producing and separating plutonium. In the 70 years since the ORR was established, a variety of production and research activities have generated numerous radioactive, hazardous, and mixed wastes. These wastes, along with wastes from other locations, have been, and are being, disposed of on the ORR.

The primary missions of the three ORR facilities have evolved and continue to evolve to meet the changing research, defense, and environmental restoration needs of the United States. Current operations, like historical operations before them, continue to perform missions that have the potential to impact human health and the environment.

The Oak Ridge National Laboratory (ORNL) conducts leading-edge research in advanced materials, alternative fuels, climate change, and supercomputing. ORNL's activities of fuel reprocessing, isotopes production, waste management, radioisotope applications, reactor developments, and multi-program laboratory operations have produced waste streams that have resulted in environmental releases that contain both radionuclides and hazardous chemicals.

The Y-12 National Security Complex (Y-12) continues to be vital to maintaining the safety, security, and effectiveness of the US nuclear weapons stockpile and reducing the global threat posed by nuclear proliferation and terrorism. Residual waste streams from operational processes at this site have resulted in environmental releases that contain both radionuclides as well as hazardous chemicals.

The East Tennessee Technology Park (ETTP), a former uranium enrichment complex, is being transitioned into an industrial technology park. Even though the gaseous diffusion activities at ETTP have concluded, residual environmental waste streams and current decommissioning activities have resulted in environmental releases that contain both radionuclides and hazardous chemicals.

In accordance with the ESOA Agreement, the FFA Agreement and the TDEC mission statement, TDEC DoR-OR shall work to assure the citizens of Tennessee that the DOE's activities on and around the ORR, Oak Ridge, Tennessee, are being performed in a manner protective of human health and the environment.

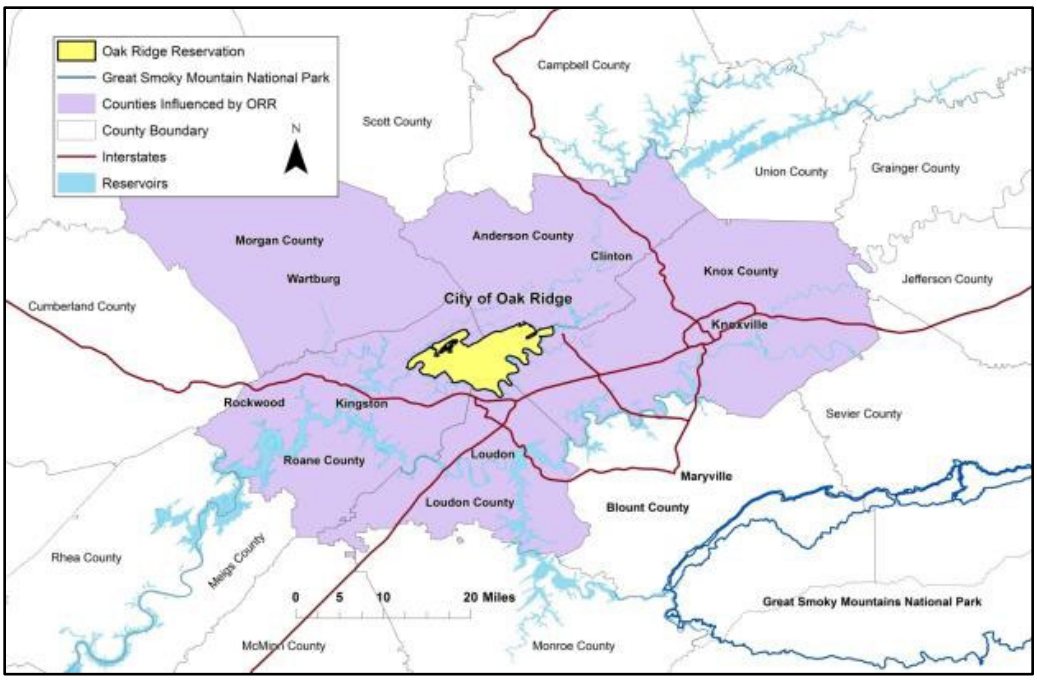

Figure1.3.1: Location of the Oak Ridge Reservation in Relation to Surrounding Counties

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 bordered partly by the Clinch River. The ORR is located in the counties of Anderson and Roane, and within the corporate boundaries of the city of Oak Ridge, Tennessee. The reservation is bound on the north and east by residential areas of the city of Oak Ridge and on the south and west by the Clinch River. Counties adjacent to the reservation include Knox to the east, Loudon to the southeast, and Morgan to the northwest. Portions of Meigs and Rhea counties are immediately downstream from the ORR on the Tennessee River. The nearest cities are 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 of southwest-to-northeast orientation. The Valley and Ridge Province is a zone of complex geologic structures dominated by a series of thrust faults. It is characterized by a succession of elongated southwest-to-northeast trending valleys and ridges. In general, sandstones, limestones, and dolomites underlie the ridges that are relatively resistant to erosion. Weaker shales and more soluble carbonate rock units underlie the valleys. Winds within the valleys can differ substantially in speed and direction from the winds at higher elevation.

1.3.2 Climate of the ORR Area

The climate of the ORR region is classified as humid and subtropical; and is characterized by a wide range of seasonal temperature changes between the summer and winter months. According to the DOE 2022 RER, the "total average rainfall in the ORR area during FY 2021 was 58.8 in. based on a composite of five rain gauge stations located throughout the ORR, and one located in Oak Ridge. The total rainfall during FY 2021 was approximately 2.8 in. more than the 56 in. determined as the 30-year moving average of rainfall measured in the City of Oak Ridge."

The Great Valley of East Tennessee (its shape, size, depth, and orientation), the Ridge-and-Valley physiography contained therein, the Cumberland Plateau, the Cumberland Mountains, and the Great Smoky Mountains all represent major landscape features that affect the wind flow regimes of Eastern Tennessee. Both the local terrain (for example: lithologic rock types in the subsurface and wind-directing regional landforms) as well as the regional climate (rainfall, etc.) are factors in determining the potential migration of contamination from the ORR to the surrounding areas.

1.3.3 Population of the ORR Area

More than one (1) million citizens reside in the counties immediately surrounding the ORR. Knoxville is the major metropolitan area near Oak Ridge. Except for Knoxville, the land is semi-rural. The area is used primarily for residences, small farms, and pastures. Fishing, hunting, boating, water skiing, and swimming are popular recreational activities in the area.

1.4 TENNESSEE'S COMMITMENT TO THE CITIZENS OF TENNESSEE

In accordance with the ESOA Agreement, the FFA Agreement and the TDEC mission statement, TDEC DoR-OR will work to assure the citizens of Tennessee that the DOE's historic and current activities on and around the ORR, Oak Ridge, Tennessee, 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

2.1.1 Background

ETTP, originally known as the K-25 site, began operations during World War II as part of the Manhattan Project. The site's original mission was producing uranium enriched in the uranium-235 isotope (U-235). This was used for manufacturing the first atomic weapons and later for fueling commercial and government-owned reactors. The enrichment plant was permanently shut down in 1987.

Consequential to operational practices and accidental releases, the facilities at ETTP were contaminated to some degree and have undergone decontamination and decommissioning (D&D). Uranium isotopes are the primary contaminants, but technetium-99 and other fission and activation products are also present, due to the periodic processing of recycled uranium, obtained from spent nuclear fuel.

Y-12 was constructed during World War II for enriching uranium in U-235 by using the electromagnetic-separation process. Later, the Y-12 mission was expanded and they began producing fuel for naval reactors, conducting lithium and mercury enrichment operations, manufacturing components for nuclear weapons, dismantling nuclear weapons, and storing enriched uranium. The Environmental Management Waste Management Facility (EMWMF) was constructed in Bear Creek Valley near the Y-12 plant for disposing of low-level, radioactive, and hazardous wastes generated by remedial activities on the ORR.

Construction of ORNL began in 1943. While the initial missions of K-25 and Y-12 were producing enriched uranium, ORNL focused on researching reactors and producing plutonium and other activation and fission products chemically extracted from uranium irradiated in ORNL's graphite reactor and later irradiated at other ORNL and Hanford reactors.

During early operations, leaks and spills within the facilities were common, and radioactive materials were released from operations as gaseous, liquid, and solid effluents with little or no treatment.

2.1.2 Related DOE Projects

DOE conducts high volume air sampling on and around the ORR, though most of the DOE ORR program only monitors the perimeter of the site. The results from this sampling are used in calculating the human dose exposure for those most at risk offsite the ORR. The Fugitive Air monitoring project sampling data can be compared to DOE results.

2.1.3 Problem Statements

Many ETTP, Y-12, and ORNL facilities scheduled for D&D are radiologically contaminated. D&D operations at these facilities, as well as the disposal of the waste at EMWMF from these facilities, can result in fugitive (non-point source) dispersal of contaminants. This dispersion is promoted by winds that tend to blow up the valleys (northeast) during the daytime and down the valleys (southwest) during the night. At Y-12, facilities contaminated with various uranium isotopes are scheduled for D&D. Many facilities at ORNL are contaminated with a long list of fission and activation products in addition to uranium and plutonium isotopes. Some facilities at ORNL are considered to be the highest risk facilities on the ORR due to their physical deterioration and because they exhibit the presence of loose contamination. The risk associated with these facilities is heightened by their close proximity to pedestrian and vehicular traffic, privately funded facilities, and active ORNL facilities.

2.1.4 Goals

To protect human health and the environment, TDEC DoR-OR will conduct independent air sampling, compare the results with the air sampling data published by DOE, and confirm DOE is adequately monitoring airborne emissions of radiological contaminants to be compliant with Federal regulatory standards and are not causing a member of the public to receive an effective dose greater than ten (10) mrem per year, specifically where remedial action or waste management activities are being accomplished.

2.1.5 Scope

The TDEC DoR-OR will conduct the Fugitive Radiological Air Emissions monitoring project by continuous air monitoring at each of the ORR sites (K-25, Y-12, ORNL) and a background location with a total of nine high volume air samplers (see Figure 2.1.1).

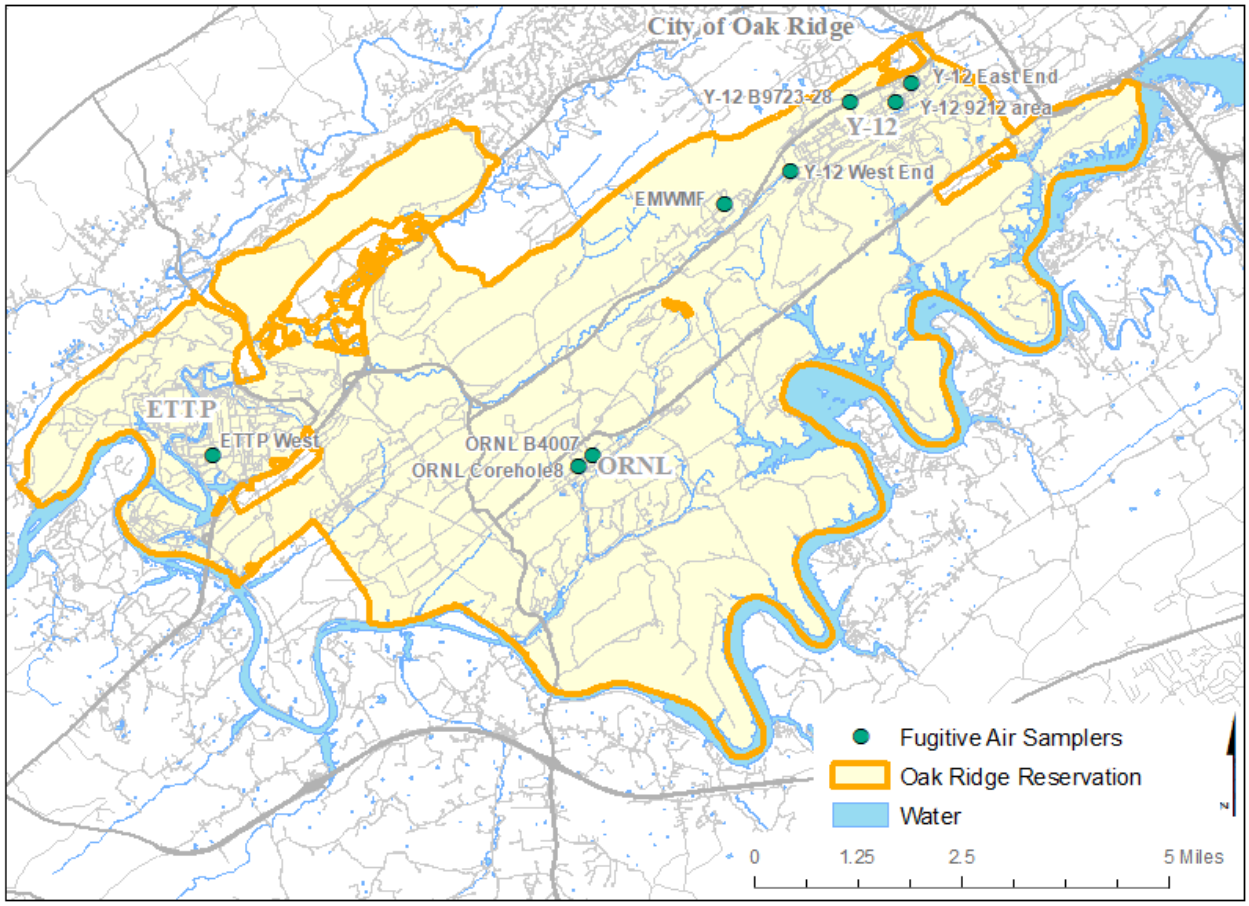

Figure 2.1.1: ORR Fugitive Air Sampling Locations

2.1.6 Assumptions

- Adequate budget will exist to support the methods and materials described for this project.
- Adequate staff will be available to assist with field duties.
- Air sampler locations will have access to electricity.
- Access to desirable air sampler locations will not be restricted due to site operations or security.

2.1.7 Constraints

- It will not be possible to collect and measure all fugitive emissions from any area.
- The 120-volt electrical power, required to operate an air sampler, is not always available at a desired sampling location.
- Sampler locations and their access could be restricted due to site operational or security concerns.

Within these limitations, air sampler locations will be selected to maximize the likelihood of collecting representative samples from potential sources of airborne contamination.

2.1.8 Methods, Materials, Metrics

The Fugitive Air monitoring project will use nine high volume air samplers to conduct continuous air monitoring on and near the ORR. One sampler will be stationed at Fort Loudoun Dam in Loudon County to collect background data for comparison while the remaining samplers will be placed at ORR locations where the potential for release of fugitive airborne emissions is the greatest. For example, such locations where contaminated soils are being excavated, contaminated facilities are being demolished, or wastes are being disposed. Each of the high-volume air samplers use 8 x 10-inch glass-fiber filters to collect particulates from air as it 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, using a Graseby General Metal Works variable resistance calibration kit, in accordance with the guidelines published for the air samplers.

Samples will be collected from each air sampler weekly, composited every four (4) weeks, and analyzed by the Tennessee Department of Health Nashville Environmental Laboratory. The analysis performed will be based on contaminants of concern and previous findings for the location being monitored.

To assess contaminant concentrations measured at each location, results will be compared with the background data and the standards provided in Title 40 of the Code of Federal Regulations Part 61 (40CFR61), NESHAPS, Subpart H (National Emission Standards for Emissions of Radionuclides other than Radon from DOE Facilities). 40CFR61 limits DOE 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 Environmental Monitoring Report.

2.1.9 References

Title 40 of the Code of Federal Regulations Part 61 (40CFR61), NESHAPS, Subpart H.

2.2 RADNET AIR

2.2.1 Background

Currently, air pollutants resulting from U.S. Department of Energy (DOE) Oak Ridge Reservation (ORR) activities, including the production of radioisotopes and the demolition of radioactively contaminated facilities, could pose a risk to public health and/or the surrounding environment.

While the average adult ingests less than two liters of water a day, they inhale about 16,000 liters of air a day, so the air we breathe is very important to human health (EPA 2011). Because of this, TDEC DoR-OR has implemented air monitoring programs to assess the impact of ORR air emissions to the surrounding environment and the effectiveness of DOE controls and monitoring systems. The TDEC DoR-OR RadNet Air Monitoring Project provides additional monitoring and independent third-party analytical analysis by the EPA.

The TDEC DoR-OR RadNet Air Monitoring Project on the ORR began in April of 1996. It provides twice weekly radiochemical analysis of air samples taken from four air monitoring stations on the ORR for a total of up to 416 samples each year. RadNet samples are collected by TDEC DoR-OR and analysis is performed at the EPA National Air and Radiation Environmental Laboratory (NAREL).

2.2.2 Related DOE Projects

The sampling for TDEC DoR-OR RadNet Air Monitoring Project does not correlate directly to DOE's ORR air sampling program.

- The RadNet Air Monitoring Project uses gross beta analysis as a screening tool. Gross beta analysis is useful as a screening tool because few isotopes of interest are pure gamma or pure beta emitters, so if there were a release on the ORR, most likely there would also be some beta radiation emitted either directly or from daughter products. If the beta concentration for a sample is greater than the 1 pCi/m^3 EPA RadNet screening level, gamma spectroscopy and possibly other analyses are performed by the EPA. If gross beta levels were elevated but less than the 1 pCi/m^3 screening level, these levels would be detected and reported in the analytical results.

- RadNet Air samples from four locations on the ORR are usually collected and sent for analysis twice a week, which is more frequent than the quarterly composite analysis of weekly samples collected by DOE. However, sampling by DOE varies by ORR site according to the DOE Annual Site Environmental Report (ASER).

2.2.3 Problem Statements

The three sites on the ORR, (ORNL, Y-12, and ETTP) can potentially release radioactive contaminants into the air from current operations, as well as from the deterioration of contaminated buildings on the sites, and the Deactivation and Decommissioning (D&D) of these facilities.

2.2.4 Goals

The goals for this project are as follows:

- Protect human health and the environment by assuring the public that the State of Tennessee independently evaluates gross beta activity in air on the ORR with the continuous monitoring of four RadNet Air monitoring stations, with up to 416 samples analyzed annually.
- Determine that levels of gross beta radioactivity are not above EPA regulatory levels for a beta emitter with stringent criteria, and preferably below EPA screening levels requiring additional analysis.
- Compare gross beta levels collected from the four ORR RadNet Air monitoring stations to the levels seen at a RadNet station not on the ORR, which is used as a background location. The RadNet Air station located in Knoxville is used as the primary background site, but the location in Nashville is used if data is not available for Knoxville.
- Complement the TDEC DoR-OR Fugitive Radiological Air Emissions Project by providing gross beta analysis and additional analysis if EPA screening levels are triggered, additional air monitors for greater coverage of the ORR, and more frequent analysis; specifically, twice weekly instead of weekly sampling with four-week composite analysis. DOE ORR and site-specific air sample analysis is done less frequently, with quarterly composites of weekly samples.

2.2.5 Scope

The RadNet Air Monitoring Program will use four high-volume air samplers to monitor the air for radiological contamination. Two of the samplers will be located at Y-12, with one near each end of the plant. Two more samplers will be located at ORNL, with one in Bethel Valley and one in Melton Valley. The four RadNet Air samplers on the ORR will be sampled Mondays and Thursdays except when a sample is skipped due to a holiday.

2.2.6 Assumptions

- Air from various locations on the ORR can be monitored with the particulate air samplers provided.
- Beta analysis of air filters will identify most releases of radiological contaminants; these results may trigger further analysis.
- Natural variations in gross beta levels will be similar at all ORR sites.
- Small variations due to weather and other factors will be seen at all stations with ambient conditions.
- Each sampler will remain operational with consistent power supply and site access.

2.2.7 Constraints

- It may not be possible to collect and measure all air emissions from each of the ORR sites with the four RadNet air samplers.
- The power needed to run the air samplers occasionally fails.
- Sampler motors and sampler electronics can fail.
- Sampler locations and access can be restricted due to site operational or security concerns.
- The EPA RadNet Air Program provides specific analysis, and no other analyses are available through this program.

2.2.8 Methods, Materials, Metrics

The locations of the four RadNet Air samplers are provided in Figure 2.2.1. The RadNet Air samplers run continuously, and suspended particulates are collected on synthetic fiber filters (10 centimeters in diameter) as air is drawn through the units by a pump at approximately 35 cubic feet per minute (or 60 m^3/hour). TDEC DoR-OR collects the filters twice weekly from each sampler. Following EPA protocol (EPA 1988, EPA 2006) the filters are then shipped to NAREL in Montgomery, Alabama, for analysis.

NAREL performs gross beta analysis on each sample collected. If the gross beta result for a sample exceeds one picocurie per cubic meter (1 pCi/m^3), then gamma spectrometry is performed on the sample. The results of NAREL's analyses of the nationwide RadNet Air data are available at NAREL's website in the Envirofacts RadNet searchable database, via either a simple or a customized search (EPA 2022).

The gross beta data from the RadNet Air Monitoring Project will be compared to background data from the RadNet Air monitor in Knoxville or Nashville, and to the EPA Clean Air Act environmental limit for strontium-90, which is a pure beta emitter with a conservative limit (EPA 2010a, EPA 2010b).

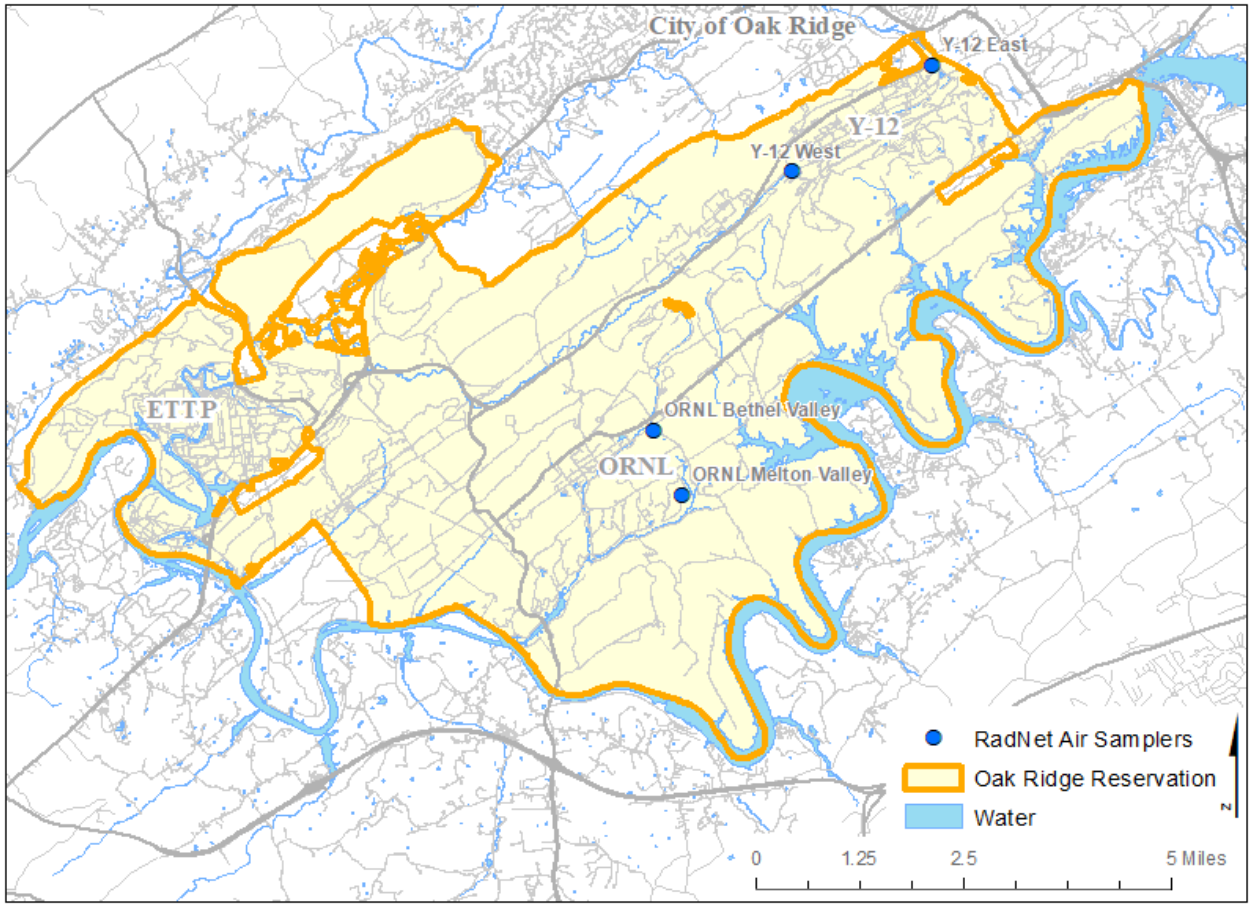

Figure 2.2.1: Locations of RadNet Air monitoring stations on the Oak Ridge Reservation

2.2.9 References

DOE (2021). Environmental Monitoring Plan for the Oak Ridge Reservation, Calendar Year 2022. DOE-SC-ORO/RM-2022-01.

DOE (2021). Oak Ridge Reservation Annual Site Environmental Report. DOE/CSC-2514. https://doeic.science.energy.gov/ASER/ASER2020/index.html

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EPA (2010a). Clean Air Act. Code of Federal Regulations. Title 40: Protection of Environment. Part 61: National Emission Standards for Hazardous Air Pollutants. Appendix E, Table 2: Concentration Levels for Environmental Compliance.

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National Emissions Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities.

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https://www.epa.gov/expobox/about-exposure-factors-handbook
https://www.epa.gov/sites/production/files/2015-09/documents/efh-chapter06.pdf

EPA (2022). NAREL RadNet data links
Envirofacts RadNet Searchable Database:
search https://enviro.epa.gov/enviro/erams_query_v2.simple_query
customized search https://www.epa.gov/enviro/radnet-customized-search

2.3 RADNET PRECIPITATION

2.3.1 Background

Nationwide, the EPA RadNet Precipitation Monitoring Program measures radioactive contaminants that are removed from the atmosphere and transported to the earth's surface by precipitation. On the Oak Ridge Reservation (ORR), the RadNet Precipitation Monitoring Project provides radiochemical analysis of precipitation samples taken from monitoring stations at three locations on the ORR, two at ORNL, and one at Y-12. Samples are collected by Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge (TDEC DoR-OR) personnel and gamma analysis is performed on monthly composite samples at EPA's National Air and Radiation Environmental Laboratory (NAREL).

The gamma analysis functions as a screening tool because few isotopes of interest are pure beta or pure gamma emitters, so if there were a release on the ORR, most likely there would also be some gamma radiation emitted either directly or from daughter products. Additional analysis may be conducted if a radiological release is known or is indicated by monthly gamma analysis results. For instance, with the Fukushima release in Japan in 2011, additional analyses were completed more frequently as there was a known release of radioactive materials. Interestingly, TDEC DoR-OR sampling was able to detect elevated levels of radioactive iodine-131 (I-131) at levels greater than EPA drinking water limits, despite the distance from the initial release.

While there are no regulatory standards that apply directly to contaminants in precipitation, the data from this project provides an indication of the presence of radioactive materials that may not be evident in the particulate samples collected by air monitors.

2.3.2 Related DOE Projects

The sampling for this project does not correlate directly to DOE's air sampling program described in the DOE 2022 EMP. This project uses precipitation to monitor radioactivity in air and uses gamma analysis as a screening tool, where extra analysis may be conducted if elevated gamma levels are observed.

2.3.3 Problem Statements

The three sites on the ORR (ORNL, Y-12, and ETTP) can potentially release radioactive contaminants into the air from current operations as well as from the deterioration of contaminated buildings and the decontamination and decommissioning (D&D) of ORR facilities.

This project measures radioactive contaminants that are removed from the atmosphere and are transported to earth's surface by precipitation. The results of the analysis provide an indication of the presence of radioactive materials that may not be evident in the particulate samples collected by air monitors.

2.3.4 Goals

The goal of the RadNet Precipitation Monitoring Project is to measure radioactive contaminants that are washed out of the atmosphere and reach the earth's surface through precipitation. It compares sampling results to drinking water limits used by EPA (as conservative reference values) to assure the public that human health and the environment are being protected. The results from the project can also be used to identify anomalies in radiological contaminant levels, to assess the significance of precipitation in contaminant pathways, to evaluate associated control measures, to appraise conditions on the ORR compared to other locations in the nationwide EPA RadNet Program, and to determine levels of local contamination in the case of a local or distant nuclear disaster.

2.3.5 Scope

Three precipitation samplers will be used to monitor the precipitation for radiological contamination. Each sampler is co-located with RadNet Air stations at three locations on the ORR. The first sampler is located at the east end of the Y-12 plant and could potentially provide an indication of any gamma radioisotopes moving east towards the City of Oak Ridge from ORNL or Y-12. The second unit is at ORNL in Bethel Valley. The third sampler is located at ORNL in Melton Valley near ORNL's High Flux Isotope Reactor (HFIR) and the Solid Waste Storage Area (SWSA) five burial grounds.

Samples will be measured and collected from the three ORR RadNet Precipitation samplers on Mondays and Thursdays, except when a sample is skipped due to a holiday. The samples will be composited monthly by the EPA NAREL and analyzed for gamma emitting radionuclides. Additional analysis on individual samples would likely be run in the event of a large radioactive release.

2.3.6 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.
- Sampling equipment will remain in good condition and the sampler will remain accessible.

2.3.7 Constraints

- This project only detects potential radiological emissions when there is a precipitation event that a plume passes through.
- Monthly composite analysis could potentially miss smaller releases. However, if a radiological release is known to have occurred, EPA will generally analyze each sample rather than a composite and will often expand the analyte list.
- Sampling equipment can fail over time.
- Sampler locations and access can be restricted due to site operational or security concerns.
- The EPA RadNet Precipitation program provides for specific analysis and no other analyses are available through the program.

2.3.8 Methods, Materials, Metrics

The locations of the three RadNet Precipitation samplers are depicted in Figure 2.3.1. The precipitation samplers provided by EPA's RadNet program are used to collect samples for the TDEC DoR-OR ORR RadNet Precipitation project. Each sampler drains precipitation that falls on a 0.5 square meter fiberglass collector into a five-gallon plastic collection bucket. A sample is measured and then collected from the bucket in a four-liter sample container. When a minimum of two liters of precipitation has accumulated in the sample container, or potentially less than that if it is the final sample of the month, the sample is processed as specified by EPA (EPA 1988, EPA 2013) and is shipped to the EPA NAREL in Montgomery, Alabama, for analysis. NAREL composites monthly samples for each station and analyzes

the samples for gamma emitting radionuclides.

Since there are no regulatory limits for radiological contaminants in precipitation, the results of the gamma analyses are compared to EPA drinking water limits as conservative reference values. EPA's Radionuclides Rule (EPA 2000) for drinking water allows gross alpha radioactivity levels of up to 15 picocuries per liter (pCi/L), while beta and photon emitters are limited to a dose of 4 millirem (mrem) per year and are radionuclide specific (EPA 2015). The results from the TDEC DoR-OR ORR sampling are compared to EPA's drinking water limits and can also be compared to data from other sites nationwide. 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. While the stations located on the ORR are in areas near nuclear sources, 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 2.3.1 shows the maximum contaminant levels (MCLs) of beta and photon emitters that EPA uses as drinking water limits, for select isotopes.

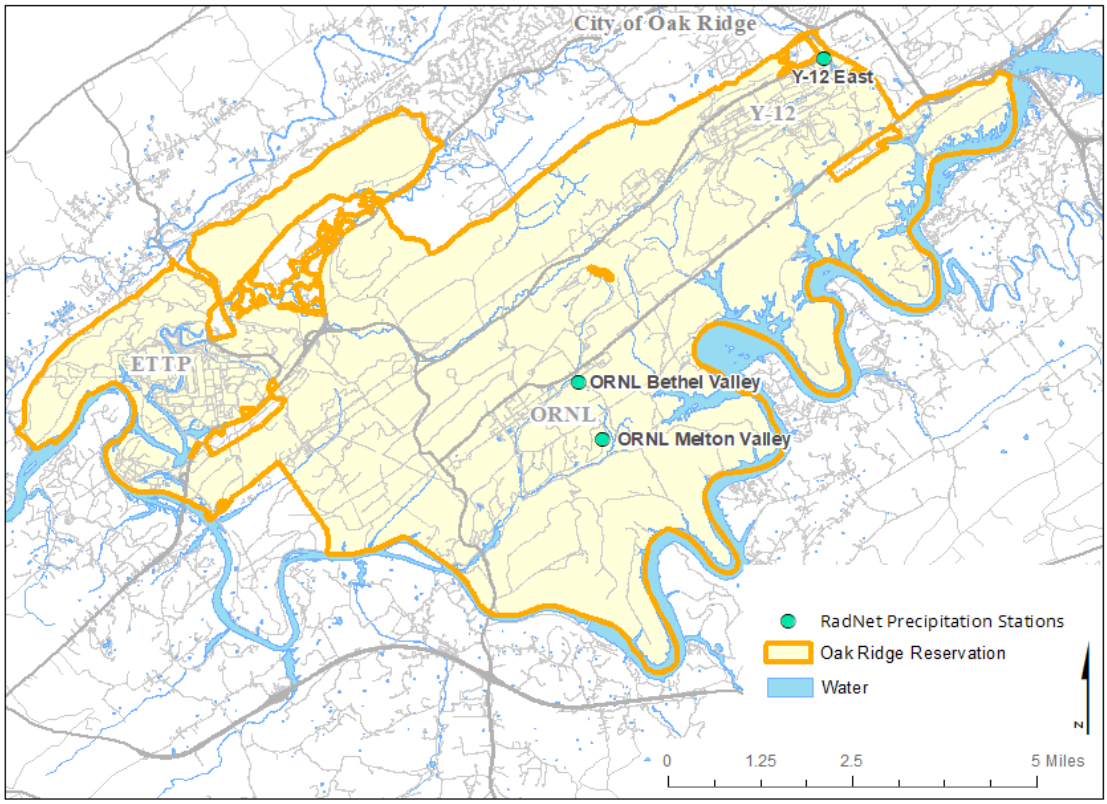

Figure 2.3.1: Locations of RadNet Precipitation monitoring stations on the ORR

The results of NAREL's analyses are available in the EPA Envirofacts RadNet searchable database, by either a simple or a customized search (EPA 2022).

The data can be used to identify anomalies in radiological contaminant levels, to appraise

conditions on the ORR compared to other locations in the RadNet project, and to determine levels of local contamination.

Table 2.3.1: 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

2.3.9 References

DOE (2021). Environmental Monitoring Plan for the Oak Ridge Reservation, Calendar Year 2022. DOE-SC-ORO/RM-2022-01.

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EPA (2015). Derived Concentrations of Beta and Photon Emitters in Drinking Water. https://www.epa.gov/sites/production/files/2015-09/documents/guide_radionuclides_table-betaphotonemitters.pdf

EPA (2022). NAREL RadNet data links
Envirofacts RadNet Searchable Database:
search https://enviro.epa.gov/enviro/erams_query_v2.simple_query
customized search https://www.epa.gov/enviro/radnet-customized-search

3.0 BIOLOGICAL MONITORING

3.1 BENTHIC COMMUNITY HEALTH

3.1.1 Background

The Benthic Community Health project consists of macroinvertebrate community sampling.

This project intends to document, monitor, and note any changes to the macroinvertebrate

community structure due to ongoing Oak Ridge Reservation (ORR) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remedial activities. The population structure and quantities of unique macroinvertebrate genera will be evaluated within the four main ORR watersheds. Understanding these population dynamics will aid in the evaluation of real effects from known contamination to the benthic ecosystem. Unimpacted reference streams will be used to determine the composition of healthy benthic communities. The macroinvertebrate communities will be compared between the impacted sites and their corresponding reference streams.

Four main watersheds will be studied at the three facilities on the ORR:

1. White Oak Creek is the primary watershed originating within the Oak Ridge National Laboratory (ORNL).

2. Mitchell Branch is the main watershed located within East Tennessee Technology Park (ETTP), formerly known as K-25.

3. East Fork Poplar Creek and Bear Creek are the main watersheds originating within the Y-12 National Security Complex (Y-12).

Aquatic macroinvertebrate species serve as indicators of the health of aquatic systems. These bioindicators both quantitatively and qualitatively assess biotic responses to environmental stress (Holt, 2010). As these organism's lives are spent primarily in water, they are continually exposed to any adverse conditions caused by direct or indirect discharges to these waters.

3.1.2 Related DOE Projects

DOE conducts benthic macroinvertebrate sampling throughout the ORR and reports their findings in both the Remediation Effectiveness Report (RER) and ORNL staff conducts benthic macroinvertebrate monitoring in some of the same streams as TDEC DoR-OR; however, the number of specific stream sites differ between the two organizations. Where specific sites are the same, TDEC DoR-OR's sampling serves as an independent check on ORNL's monitoring results. Determining impacts to stream bottom communities is a difficult task; consequently, results and interpretations may differ among different samplers and analysts. Thus, sampling and analysis by both TDEC DoR-OR and ORNL can help delineate actual conditions in ORR streams.

3.1.3 Problem Statements

- Past studies indicate the majority of benthic community sampling sites located in ORR streams have been negatively impacted when compared to healthy

communities in unimpacted reference streams (TDEC DoR-OR, EMR 2020; DOE ASER, 2020). Many of the impacts affecting these streams result from both historical Manhattan Project activities at the ORR facilities as well as current operational activities. The majority of these impacts are due to typical industrial contaminants (e.g., chlorine releases, toxic chronic and acute chemical releases, organic loading from point and non-point discharges). In areas where stream sections have been channelized, part of the problem may be due to a sparsity or lack of appropriate substrates for the establishment of healthy stream bottom communities.

- Sampling of benthic communities contains inherent variability. Part of this variability is due to the natural year to year fluctuations in benthic communities. Another part of this variability is due to variation among samplers. Because of these sources of variability, the sampling of benthic communities benefits from long-term sampling.

- Changing habitat due to severe weather events, such as flooding, or beaver activity may influence TDEC DoR-OR's sampling strategy. For example, the Bear Creek Kilometer 9.9 sampling site has recently been washed out from flash flood activity and is now backed up with a beaver dam. The once fast-moving shallow section of the stream is now a deep, slow-moving pool. The sampling location may need to be shifted.

- The Benthic Community Health project uses its findings to independently monitor overall stream health and provide verification of ORNL's benthic monitoring program. In the fall, ORNL follows TDEC benthic sampling protocols. In the spring, ORNL follows alternative sampling protocols. Although there is variation between TDEC and ORNL's spring sampling methods, overall community metrics are comparable.

3.1.4 Goals

- Assess the overall stream health of the four main watersheds on the ORR.

- Compare current health of each streams' ecosystem to their corresponding reference stations and to historical data, for each impacted site.

- Provide a QC check for DOE's ORR macroinvertebrate data.

- Provide recommendations based on the analysis of macroinvertebrate communities that could help improve overall health of the streams monitored.

3.1.5 Scope

The Benthic Community Monitoring Project includes nine impacted sites and four corresponding reference stations (Table 3.1.1, Figure 3.1.1, and Figure 3.1.2).

Macroinvertebrates will be collected from all sites. Macroinvertebrates will be processed in the TDEC-DoR-OR laboratory by trained staff. TDEC-DoR-OR staff will provide oversite for at least 25% of DOE's macroinvertebrate sampling activities in 2022.

Table 3.1.1: Benthic Sampling Locations

Site Description	Name	Latitude	Longitude
Bear Creek Kilometer 12.3	BCK12.3	35.973	-84.27814
Bear Creek Kilometer 3.3	BCK 3.3	35.94354	-84.34911
East Fork Poplar Creek Kilometer 23.4	EFK 23.4	35.99596	-84.24004
East Fork Poplar Creek Kilometer 13.8	EFK 13.8	35.99283	-84.13171
East Fork Poplar Creek Kilometer 6.3	EFK 6.3	35.96293	-84.35905
East Fork Poplar Creek Kilometer 2.2	EFK 2.2	35.95169	-84.3716
Clear Creek Kilometer 1.6	CCK 1.6	36.21346	-84.05983
Mitchell Branch Kilometer 0.45	MIK 0.45	35.93783	-84.38951
Mitchell Branch Kilometer 1.43	MIK 1.43	35.93784	-84.37747
White Oak Creek Kilometer 2.3	WCK 2.3	35.90834	-84.31856
White Oak Creek Kilometer 3.9	WCK 3.9	35.92431	-84.31583
White Oak Creek Kilometer 6.8	WCK 6.8	35.94151	-84.30161
Mill Branch Kilometer 1.6	MBK 1.6	35.98886	-84.28935

Sites highlighted green represent reference sites. Sites highlighted orange represent DOE impacted sites.

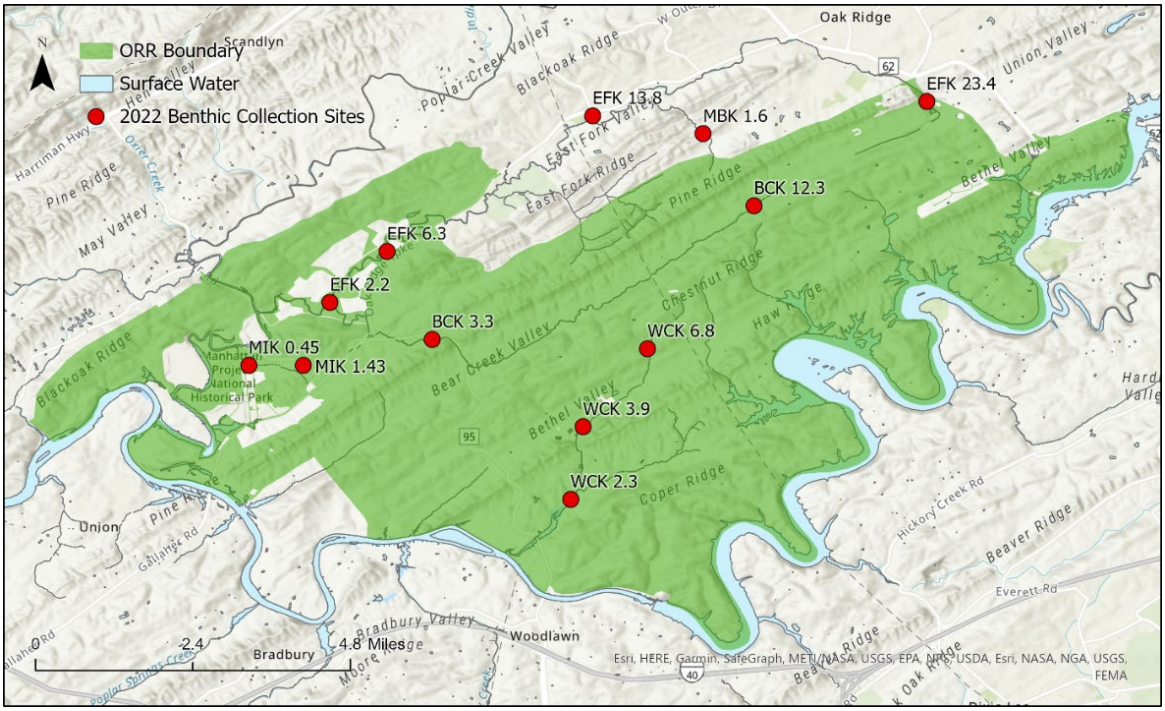

Figure 3.1.1: Benthic Sampling Locations

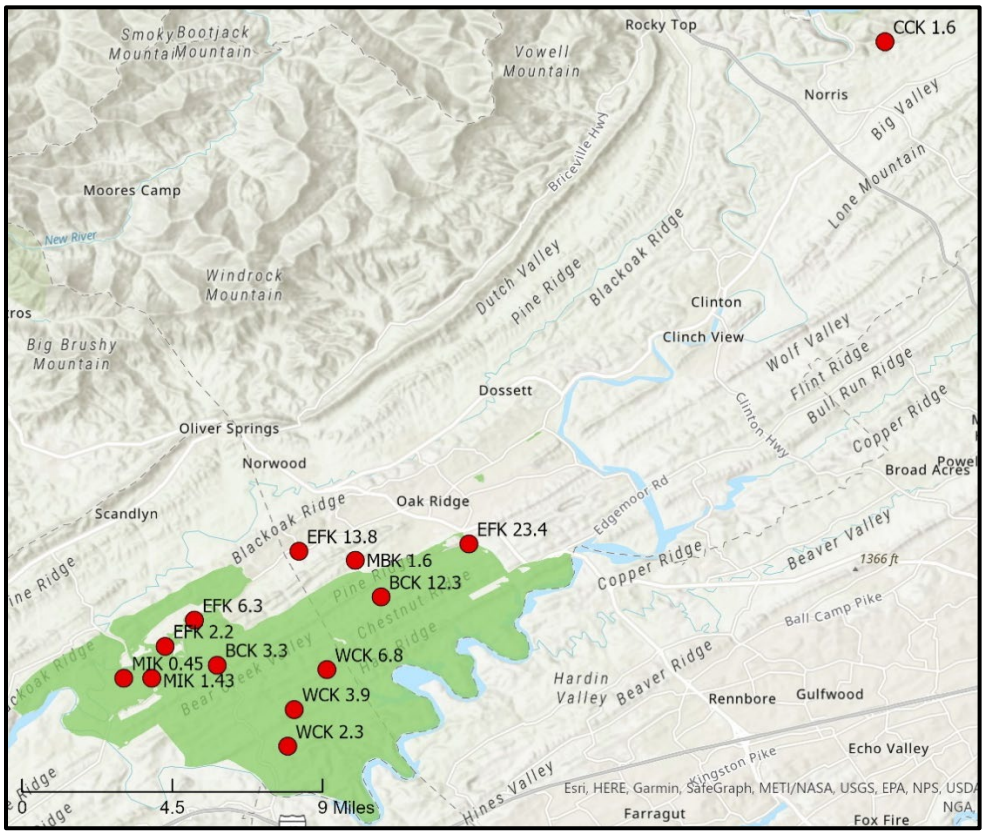

Figure 3.1.2: Benthic Sampling Locations including Reference Site CCK 1.6

3.1.6 Assumptions

- Weather will allow for timely collection of macroinvertebrate samples.

- Equipment and supplies will be available and in working condition.
- TDEC DoR-OR personnel will be adequately trained and physically able to conduct the Benthic Community Health Project.
- Chain of custody protocol will be followed.
- Adequate field time will be available to conduct the Benthic Community Health Project.

3.1.7 Constraints

- Sampling is seasonal and conducted between May and June.
- Samples may not be processed in the time allotted.
- Weather may not allow for field work to be conducted on schedule.
- TDEC DoR-OR personnel may not have the appropriate training to access the sampling sites.

3.1.8 Methods, Materials, Metrics

Macroinvertebrates will be collected at nine impacted sites on the Oak Ridge Reservation and four corresponding reference locations (Table 3.1.1). Duplicate samples will be collected at two of the sites to ensure consistent laboratory analysis.

Macroinvertebrate sampling will follow the guidance outlined in the TDEC Standard Operating Procedure for Benthic Macroinvertebrate Surveys (TDEC, 2021).

3.1.9 References

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3.2 Lower East Fork Poplar Creek – Mercury Uptake in Biota

3.2.1 Background

During the 1950's and early 1960's, processes and practices of the Oak Ridge Reservation (ORR) nuclear weapons program at the Y-12 National Security Complex (Y-12) led to the release of large amounts of contaminants to the surrounding environment (Brooks et al.,

2017). Lower East Fork Poplar Creek (LEFPC) originates within the northeast footprint of Y-12. Its headwaters are fed by runoff from the Y-12 main plant facilities, parking lots, as well as groundwater and surface water. Mercury was released in a wide range of concentrations to LEFPC surface waters, sediments, and floodplain soils (Pant et al., 2010). This created potential exposure risks to human health, the environment, and both terrestrial and aquatic wildlife.

Mercury is found in elevated levels throughout the Oak Ridge Reservation. Mercury in streams and wetlands often undergoes methylation and is transformed into toxic methylmercury (MeHg) in conjunction with the activity of microorganisms (Kalisinska et al., 2013). Methylmercury is particularly bioavailable to wildlife (and humans) and, if ingested, may cause serious neurological, reproductive, and other physical damage (Standish, 2016). Decreases in reproductive success of 35–50% have been observed in birds with high dietary methylmercury uptake including reduced hatching and fledging success (USDI, 1998; Hallinger and Cristol, 2011).

Methylmercury biomagnifies through food chains in higher-level organisms, such as songbirds and ducks, acquiring increasingly larger body burdens of MeHg through consumption of lower trophic-level prey items such as small invertebrates, salamanders, benthic larval-stage biota, terrestrial spiders, and emergent flying insects (Scheuhammer et al., 2007). Adults of some aquatic macroinvertebrates that emerge from the water are often eaten by terrestrial insectivores creating a key link of accumulation between aquatic environments to terrestrial ones (Henderson et al. 2012).

It is important that TDEC DoR-OR monitor key species from multiple trophic strata in order to assess the movement of contaminants through the food web. Sampling songbirds, adult flying insects, and spiders will clearly illustrate the bioaccumulation and transfer of mercury.

There are concerns that contaminants migrate away from the known point sources through bioaccumulation up the food web. Bioaccumulation provides a key link between aquatic and terrestrial systems and some migratory birds may spread these contaminants over a larger area, perhaps transporting it over hundreds of miles from the point source of contamination.

3.2.2 Related DOE Projects

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

3.2.3 Problem Statements

- Migratory birds are highly mobile and therefore have the capability to travel great

distances and potentially disperse contaminants.

- Macroinvertebrate adults that emerge from larval stages and developed in contaminated aquatic environments are often eaten by terrestrial insectivores such as songbirds, waterfowl, bats, and spiders that create a key link of Hg and MeHg transfer and accumulation between biota in aquatic environments to those in terrestrial habitats.

3.2.4 Goals

- Determine the concentrations of mercury and methylmercury in biota samples collected from impacted LEFPC floodplain and aquatic monitoring plots.
- Evaluate bioaccumulation of mercury and methylmercury in biota samples collected from impacted LEFPC floodplain and aquatic monitoring plots.

3.2.5 Scope

This project consists of laboratory analysis of mercury and methylmercury in songbird eggs, adult flying insects, and wolf spiders. Specimen(s) will be captured on the ORR by TDEC DoR-OR personnel from three main study areas and one reference area over a one-year period or until enough biomass has been collected for laboratory analysis. Results from the three monitoring areas will be compared with results from the reference area.

Species that are state or federally listed as greatest conservation need (GCN), threatened, endangered, or deemed in need of management will not be sampled. If encountered, state or federal listed species will be reported to TWRA and USFWS within five working days.

- Zone 1 (Horizon Center) is located in the most downstream reach of LEFPC. TDEC-DoR-OR personnel will collect specimens at LEFPC sites spanning from EFPC kilometer (EFK) 0.0 to EFK 13.8 (Figure 3.2.1).

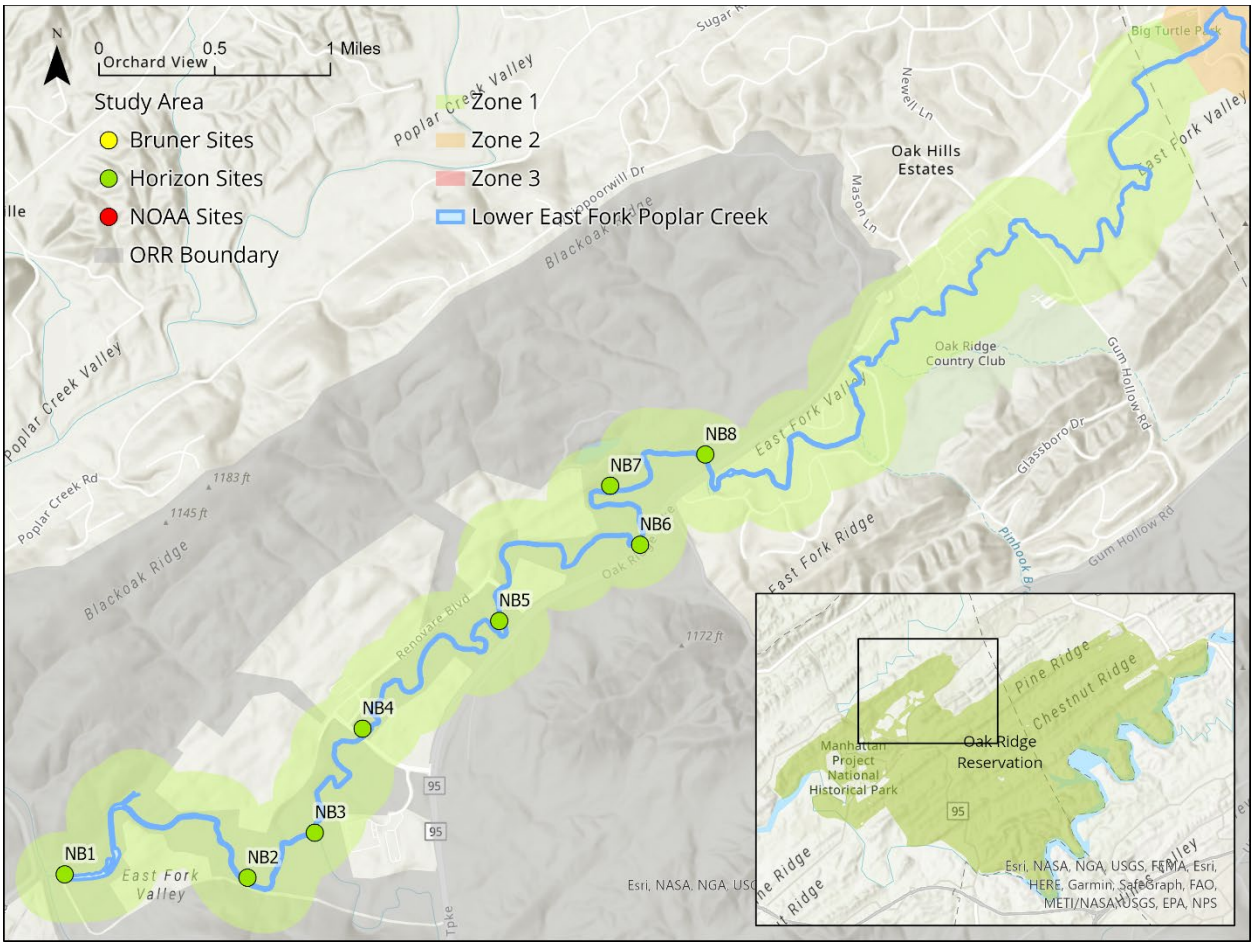

Figure 3.2.1: Zone 1 - Horizon Center Sample Locations

- Zone 2 (Bruner) is located where LEFPC flows through the City of Oak Ridge, following closely to the Oak Ridge Turnpike. TDEC-DoR-OR personnel will collect specimens at LEFPC sites spanning from EFK 13.8 to EFK 17.2 (Figure 3.2.2).

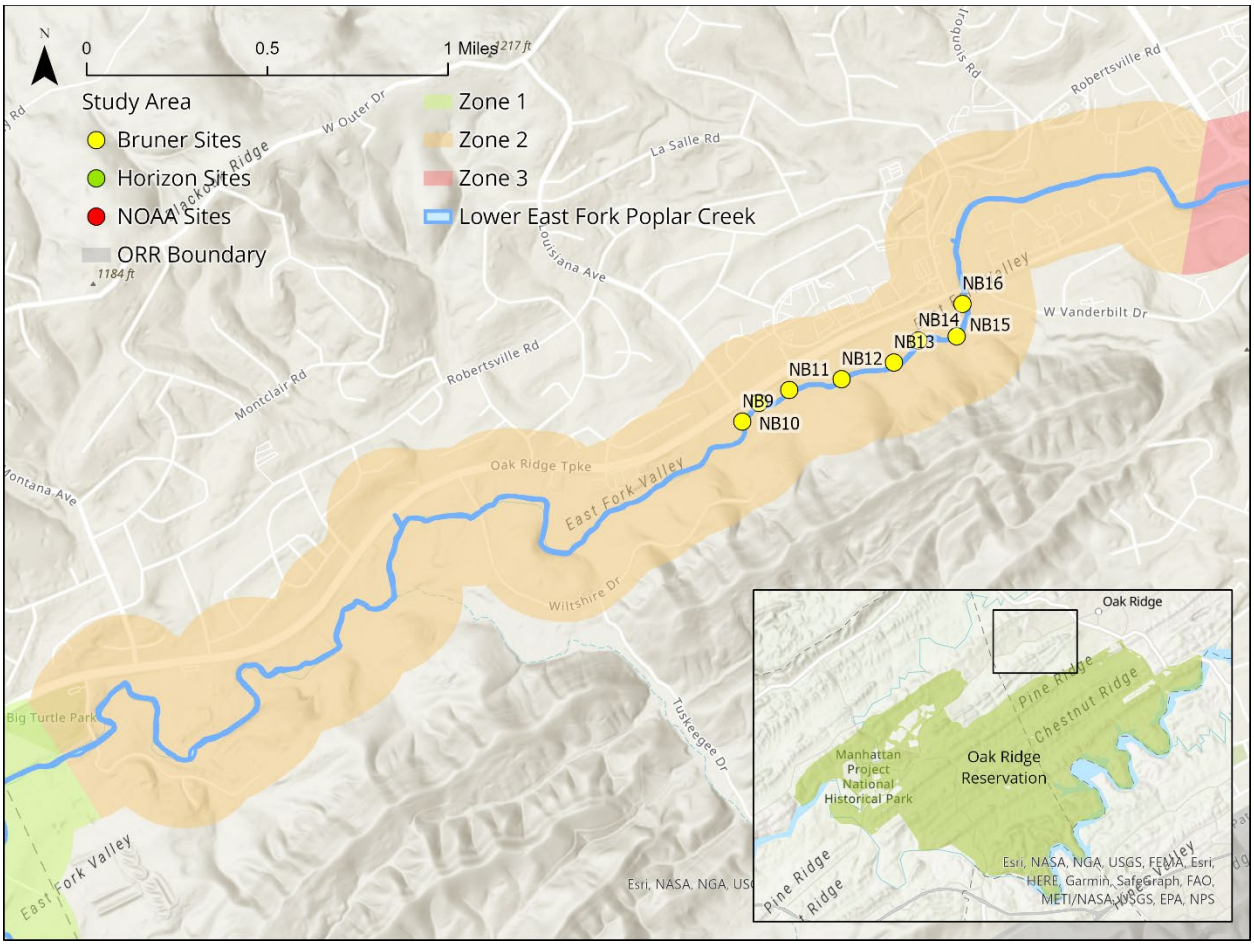

Figure 3.2.2: Zone 2 - Bruner Sample Locations

- Zone 3 (NOAA) is located in the most upstream reach of LEFPC and nearest in proximity to Y-12. In addition, in zone 3, LEFPC flows through the City of Oak Ridge. TDEC-DoR-OR Personnel will collect specimen at LEFPC sites spanning from EFK 17.2 to EFK 22.6 (Figure 3.2.3).

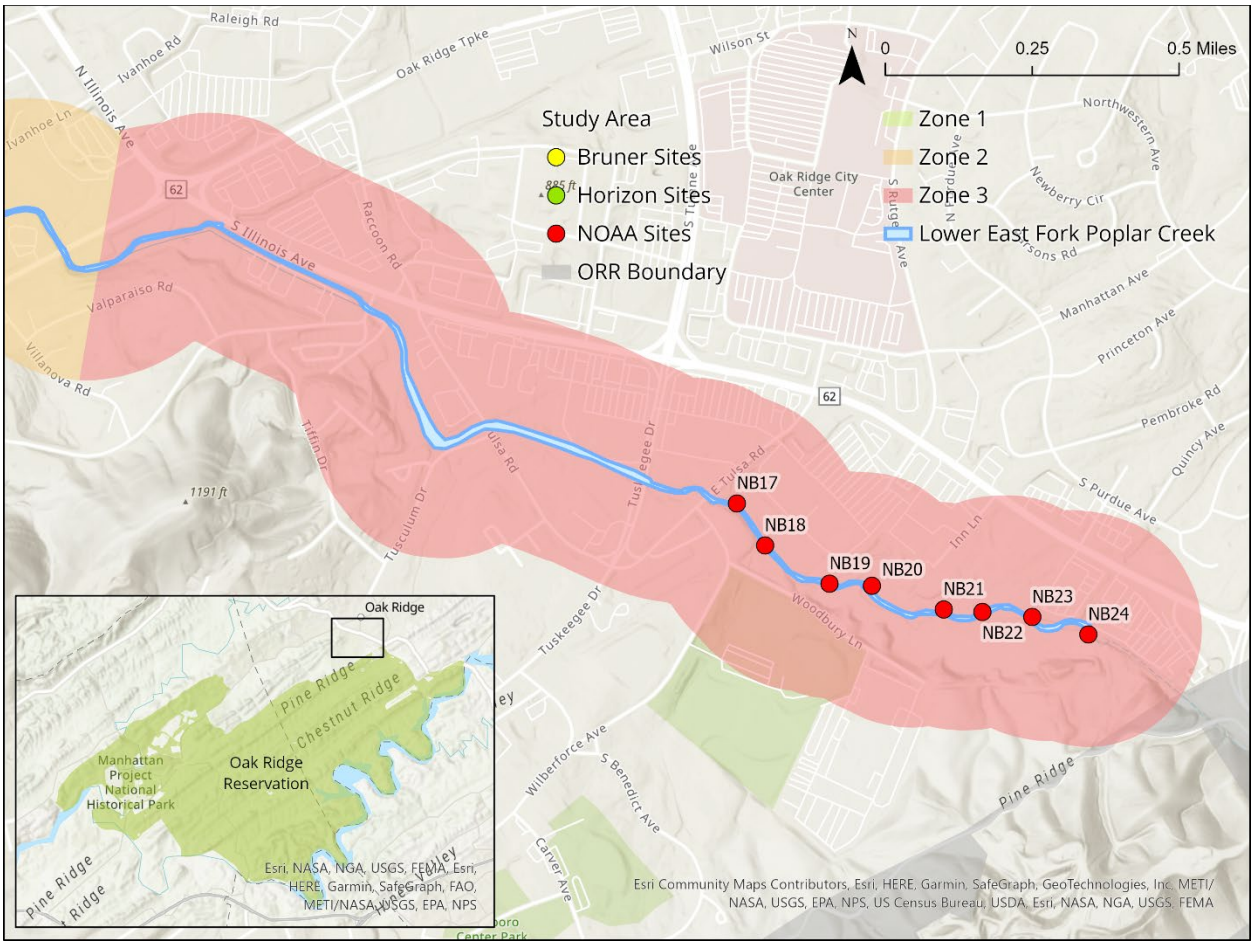

Figure 3.2.3: Zone 3 - NOAA Sample Locations

- Reference Locations are comprised of seven sites east of the ORR boundary. These sites are not within the floodplain of East Fork Poplar (Figure 3.2.4).

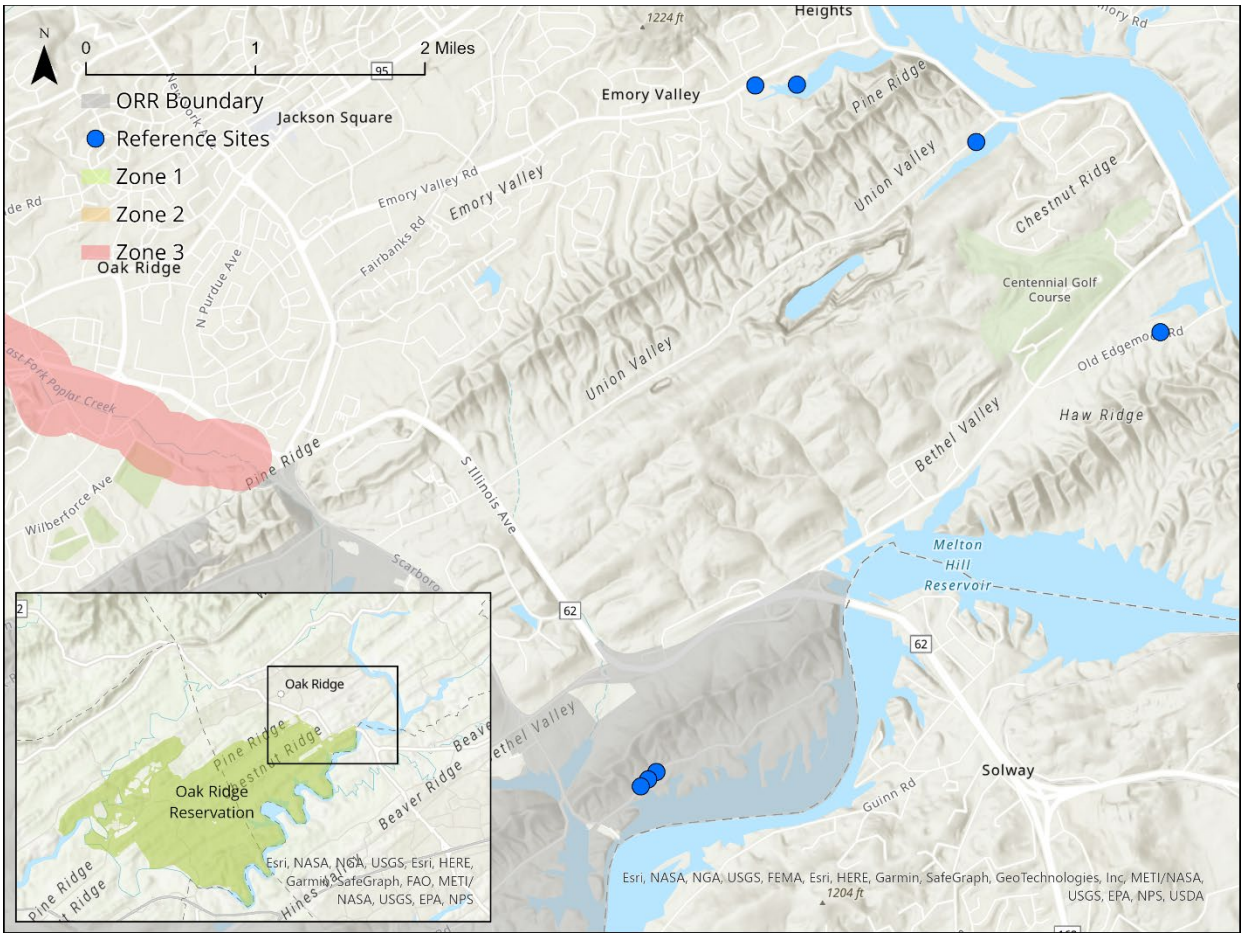

Figure 3.2.4: Reference Site Locations

3.2.6 Assumptions

- Female songbirds will occupy the nest boxes. Active nests will yield enough biomass to conduct accurate laboratory analysis.
- Adult flying insects will emerge during the scheduled field event and are attracted to blacklight traps. TDEC-DoR-OR personnel will capture adequate biomass to conduct accurate laboratory analysis.
- Wolf spiders will be present during the scheduled field events. TDEC-DoR-OR personnel will capture adequate biomass for accurate laboratory analysis.
- Songbirds, adult flying insects, and spiders on LEFPC are exposed to higher levels of mercury and methylmercury than the corresponding reference area.

3.2.7 Constraints

- Project success is dependent on the availability and the collection of adequate biomasses for laboratory analysis.

- Songbird nest boxes and other deployed sampling equipment may be vulnerable to theft or vandalism.

3.2.8 Methods, Materials, Metrics

Songbird Eggs:

Songbird nest boxes have been installed on LEFPC and reference locations. Songbird nest boxes will be checked routinely in the spring to determine occupancy. Once a nest box is confirmed to have an occupant, then the box is checked twice per week in an effort to collect the initial eggs for analysis. As the breeding season for songbirds runs from March through June, there may be a second brood. All eggs collected from the same zone will be composited into one sample. There will be four total songbird egg samples sent to the laboratory for analysis.

Spiders:

Wolf Spiders will be sampled by TDEC DoR-OR staff at LEFPC and reference stations. Sampling activities will occur between June and October 2022. During night hours, flashlights held at eye level will locate the reflective spider eyes near the stream shoreline or adjacent floodplain area. Then, the spider will be retrieved using either the aquarium net or forceps. During collection, spider specimens will be placed into plastic cups with lids.

Adult Insects:

Insects will be sampled by TDEC-DoR-OR staff at LEFPC and reference stations. Insects will be collected between June and October 2022. The adult insect trap is comprised of a device with a white mesh globe (no-see-um material) with a black light inside that attracts the insects after dark. Nocturnal insects are attracted to black light which provides maximum insect response from as far away as 500 meters from the light source. After numerous insects have landed on the globe, they are hand collected using an aspirator-vacuum tool which sucks the bugs off the white no-see-um mesh globe and secures them in replaceable sample vials.

Sampling and Handling at the TDEC DoR Laboratory (all biota samples):

- At the TDEC DoR laboratory, all biota samples will be weighed to the nearest 0.01 gram and recorded on the laboratory sample logbook.
- All 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 -18ºC in the TDEC DoR-OR laboratory freezer until shipment to the laboratory for processing.

Data Analysis:

- TDEC DoR-OR biota data results will be compared to available DOE biota datasets in OREIS.
- Where applicable, the Hg, MeHg, and radiological analytical data will be normalized to account for differences in body mass between species.
- Total Hg vs. MeHg graphs and figures will be generated to compare among sites on the ORR and reference sites.
- Total Hg and MeHg concentrations and radiological contaminants will be compared among feeding guilds (by diet): Insectivores, omnivores, herbivores.

3.2.9 References

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Scheuhammer, A.M., M.W. Meyer, M.B. Sandheinrich and M.W. Murray. (2007). Effects of environmental methylmercury on the health of wild birds, mammals and fish. Ambio 36:12-18.

3.3 ORR Roving Creel Survey

3.3.1 Background

The Roving Creel Survey is a continuing project that measures angling effort at three key locations where impaired Oak Ridge Reservation (ORR) watersheds drain into publicly accessible waters. Fisherman interviews will be conducted at the confluence of Bear Creek and Poplar Creek, the confluence of Poplar Creek and the Clinch River, and the confluence of White Oak Lake and the Clinch River. These streams have been negatively impacted by Manhattan Project activities as well as current operational activities. Fish consumption is a likely human exposure pathway for contamination uptake.

Additionally, fishing and recreation activity will be actively and passively surveyed in the lower reaches of Bear Creek (BC) and East Fork Poplar Creek (EFPC). These lower stream reaches are located within the North Boundary Greenway, receive discharges from mixed waste landfills and burial grounds upstream in Bear Creek, and feed Poplar Creek. The North Boundary Greenway is a popular recreation attraction for City of Oak Ridge citizens. People have been observed on the North Boundary Greenway year-round.

BC and EFPC originate within the confines of the Y-12 Nuclear Industrial Complex (Y-12) and are fed by springs and numerous outfalls from various plant facilities. During the 1950's and early 1960's, activity related to the ORR nuclear weapons program at Y-12 led to the release of large amounts of mercury and other contaminants to the local environment (Brooks et al., 2017). Mercury and other contaminants such as uranium were released in a wide range of concentrations to surface waters, sediments, and floodplain soils (Pant et al. 2010). Mercury in streams and wetlands often undergoes methylation and is transformed into toxic methylmercury (MeHg) in conjunction with the activity of microorganisms (Kalisinska et al., 2013). Methylmercury is particularly bioavailable to wildlife and humans and, if ingested, may cause serious neurological, reproductive, and other physical damage (Standish, 2016).

White Oak Creek (WOC) originates just north of the Oak Ridge National Laboratory (ORNL). Radionuclides released from ORNL to WOC are leaked from ponds and waste disposal areas and include contaminants such as strontium-90 (Sr-90) and cesium-137 (Cs-137), as

well as other byproducts from nuclear and industrial activities (DOE, 1988). These contaminants are significant because of their radiotoxicity, their mobility in the environment, and the quantities released. Other radionuclides of significance include tritium and transuranics (DOE, 1988). The availability of Cs-137 for biological uptake is a major public health concern as it can be transferred to humans through food webs (Ashraf et al., 2014). Even in the most mobile aquatic habitats (i.e., flowing rivers), Cs-137 may persist in a biologically available form for several years after release (Ashraf et al., 2014).

3.3.2 Related DOE Projects

There have been no DOE investigations in over 15 years to ascertain the level of human exposure to contamination through angling efforts on the ORR.

3.3.3 Problem Statements

- Fish bioaccumulate mercury and other contaminants (Murphy, 2004).
- Fish consumption warnings are not visible, missing, or disregarded by the public.
- Little is known about current human engagement with natural areas on and near the ORR.

3.3.4 Goals

- Quantify the angling effort in key locations on the Oak Ridge Reservation.
- Determine if recreational fishing is a pathway for exposure to contaminants.
- Provide data that is pertinent to CERCLA requirements and future ORR decisions regarding human health and environmental protection.
- Observe human recreation activity in the lower reaches of BC and the portion of EFPC within the North Boundary Greenway.

3.3.5 Scope

Roving angler interviews will be limited to three areas where surface waters exit the ORR boundary and are accessible by the public: the confluence region of Bear Creek and Poplar Creek (Figure 3.3.1), the confluence region of Poplar Creek and the Clinch River (Figure 3.3.2), and the confluence region of White Oak Lake and the Clinch River (Figure 3.3.3). There will be 20 survey events, spread out over a year (5 per quarter). Specific survey event dates will be selected using non-uniform probability based on the guidelines from Pfeiffer (1966).

Observable data collected from anglers includes:

- Date/Time

- Type – boat/bank fishing, private/commercial
- Location – Latitude/Longitude coordinates
- Number of people in party

Angler reported data includes:

- County and state residence
- Total amount of time anglers plan to fish that day
- An estimate of personal time fishing per month
- Targeted fish species
- Consumption of fish harvested from these areas of concern
- Knowledge of posted signage in these areas of concern

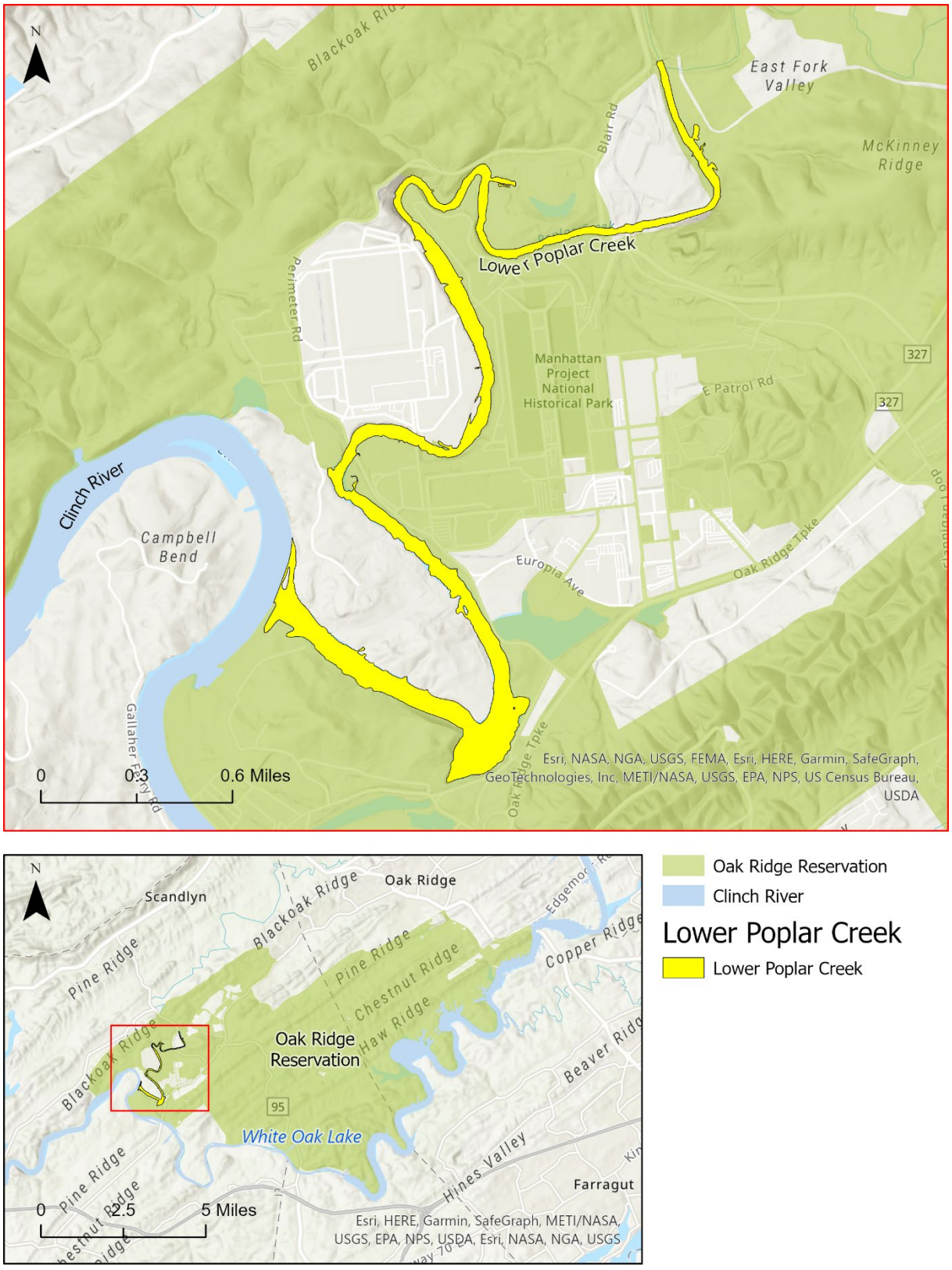

Figure 3.3.1: Poplar Creek Study Region

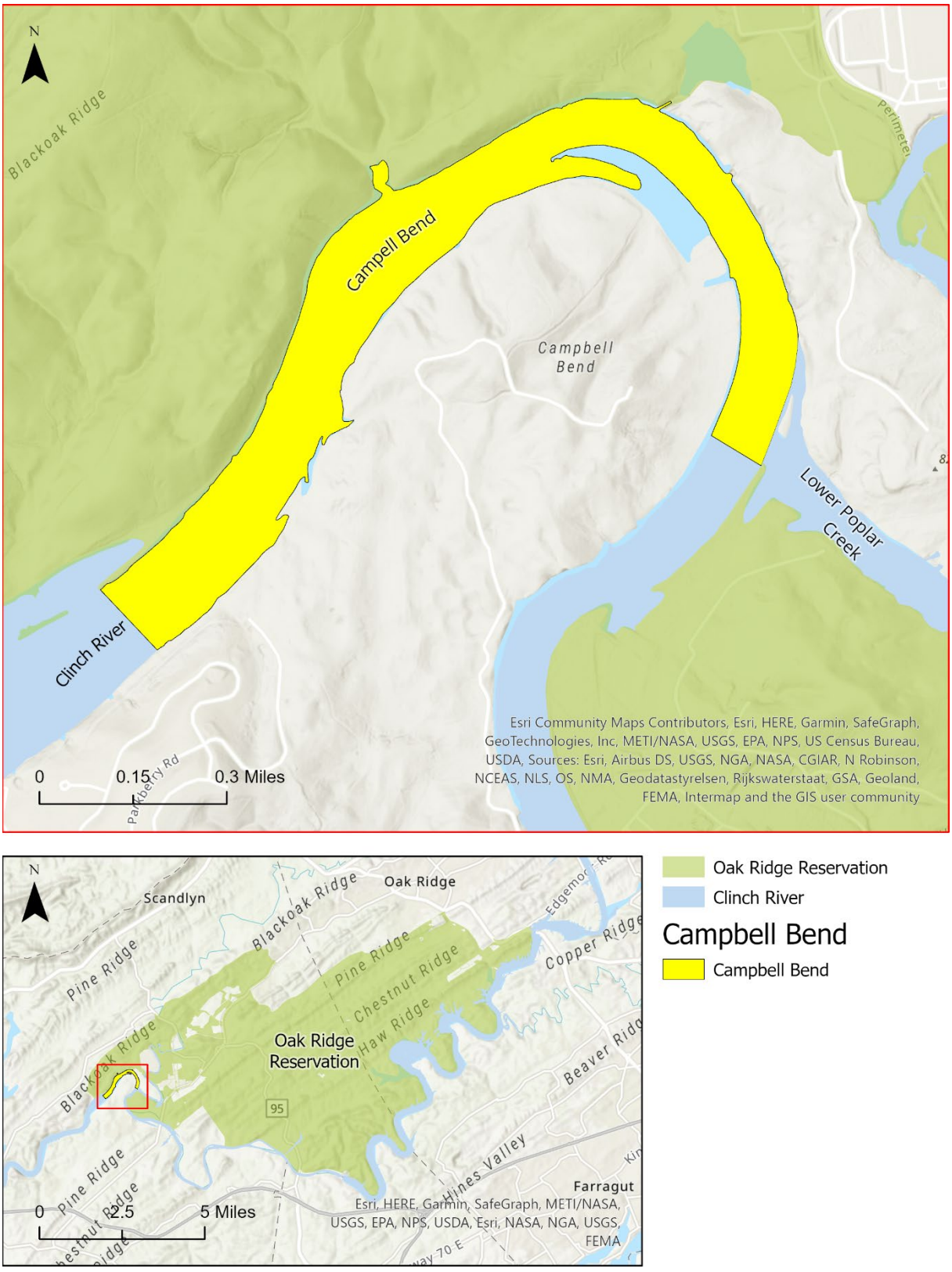

Figure 3.3.2: Campbell Bend Study Region

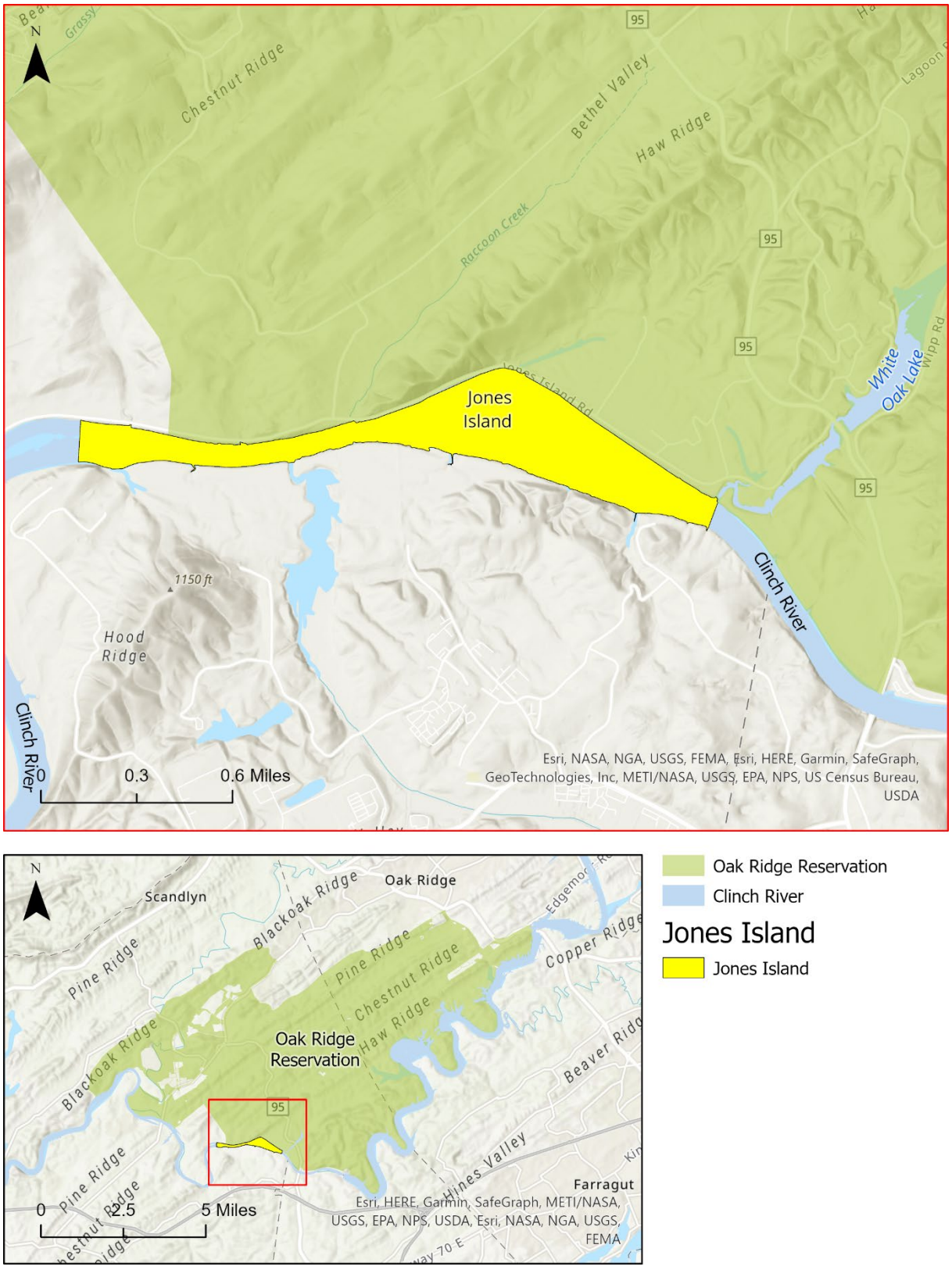

Figure 3.3.3: Jones Island Study Region

Recreation activity in the North Boundary Greenway will be monitored for one year using active and passive monitoring techniques. TDEC-DoR-OR will observe activity on the North Boundary Greenway concurrent with the scheduled roving survey events. Additionally, voluntary surveys will be available year-round to visitors via paper and online survey methods posted at three locations (Figure 3.3.4 and Table 3.3.1).

Visitor reported data includes:

- Date/Time
- Recreation activity – hike, bike, fish, kayak… etc.
- Number of people in party
- County and State residence
- Total amount of time planned for recreation today
- Estimate of days spent at the greenway per month
- Estimate of days spent fishing per month near Oak Ridge
- Target fish species
- Type of fishing – boat/bank fishing, private/commercial
- Consumption of fish harvested from this area
- Knowledge of posted signage in these areas of concern

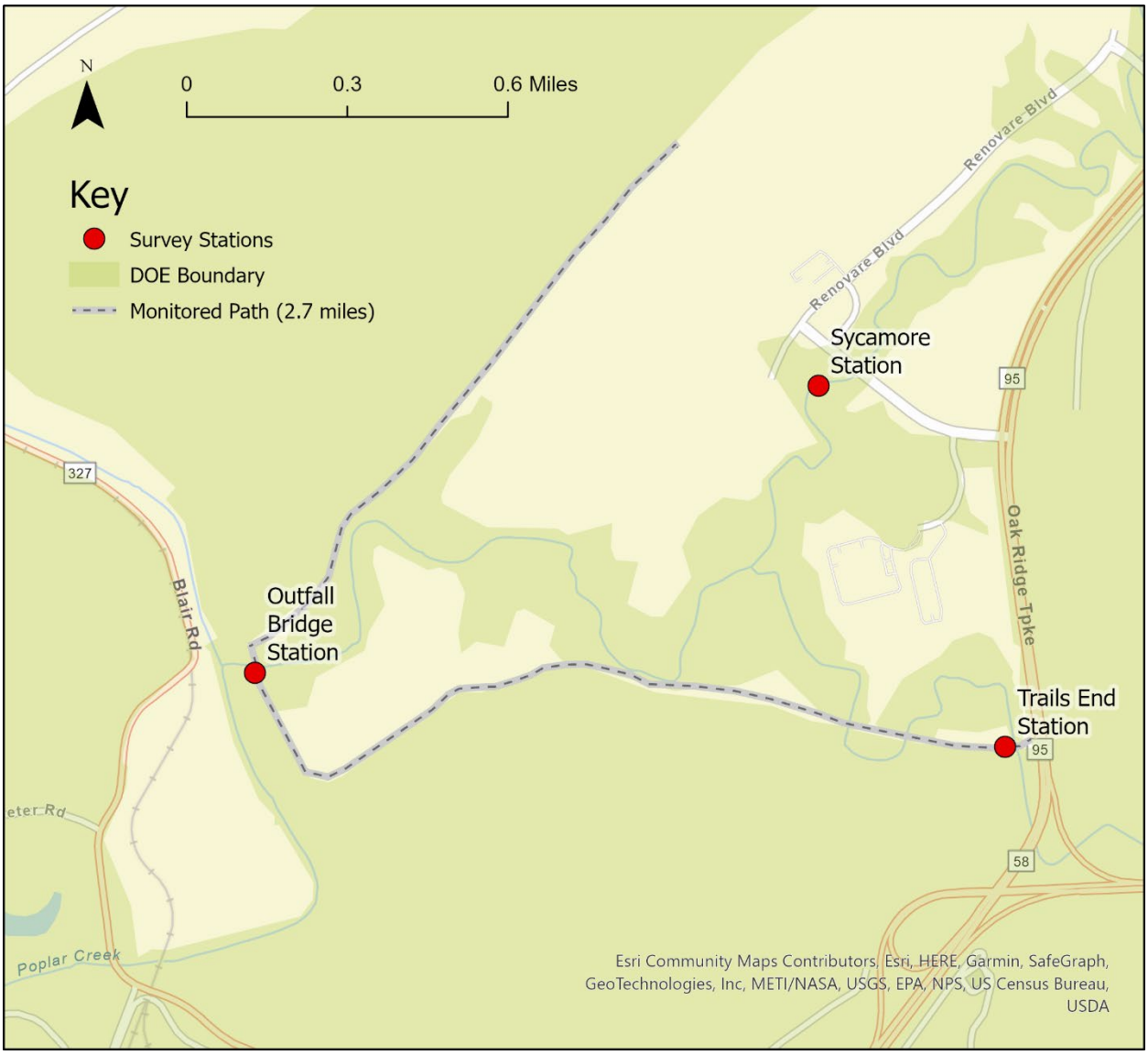

Figure 3.3.4: Survey Station Locations

Table 3.3.1: Survey Station Locations

Station Name	*lat*	*long*	*Description*
Trails End Station	35.94715	-84.36383	North Boundary - HWY 95 West Parking/Entrance
Outfall Bridge Station	35.94930	-84.38671	East Fork Poplar Creek exit point to Poplar Creek
Sycamore Station	35.95619	-84.36935	Historic Sycamore Landmark - Novus Dr. Trailhead

3.3.6 Assumptions

- Anglers will be present and willing to participate in the survey.
- Visitors of the North Boundary Greenway will voluntarily participate in the survey.
- Adequate field time will be available to carry out the mission.

- Equipment will be available and properly functioning.
- TDEC DoR-OR personnel will have the appropriate training and safety qualifications to conduct the survey.

3.3.7 Constraints

- Time, equipment, and personnel may be limited.
- The weather on pre-selected sampling dates may not be safe.

3.3.8 Methods, Materials, Metrics

TDEC DoR-OR personnel will conduct surveys at three locations with active, on-site methods whereby anglers are interviewed either during, before, or immediately following fishing trips. Fishery information collected will include location, angler effort, trip duration, target fish preferences, county of residency, angler consumption habits, and knowledge of posted signage. Waterbodies will be sampled using roving creel survey methods as outlined in the TWRA 2007 Fisheries Report.

Recreation activity in the North Boundary Greenway will be monitored for one year using active and passive monitoring techniques. TDEC-DoR-OR will observe activity on the North Boundary Greenway concurrent with the pre-determined TDEC-DoR-OR Roving Creel Survey Project schedule. Five times per quarter, TDEC-DoR-OR personnel will walk the North Boundary Greenway to observe and record recreation activity. Additionally, voluntary surveys will be available year-round to visitors via paper and online survey methods posted at three locations.

Temporary survey structures will be constructed at three locations within the North Boundary Greenway area. They will consist of a wooden frame, a weatherproof overhang, and a locking drop box. TDEC-DoR-OR personnel will collect surveys on a bi-weekly basis and perform maintenance as necessary.

3.3.9 References

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3.4 RADIOLOGICAL UPTAKE IN FOOD CROPS

3.4.1 Background

The Radiological Uptake in Food Crops project was recommended to TDEC DoR-OR by DOE to verify DOE's results and independently determine if either agency's results indicate consumers are receiving radiation doses resulting from DOE's activities on the Oak Ridge Reservation (ORR). DOE also conducts radiological analysis on locally grown and harvested food crops, hay, and milk (as available) to look at the possible uptake of airborne releases of radiation in food crops. This project will serve to better understand the levels of radiation uptake in locally grown and harvested food crops.

The TDEC DoR-OR Radiological Uptake in Food Crops project will sample food crops, hay, and milk from multiple locations thought to be potentially impacted by the ORR, either on or nearby the DOE site. A sample of each type will also be collected from a reference location that is unlikely to be impacted by ORR activities. Food crop and hay samples will be analyzed for select radiological contaminants to monitor for potential impacts of radiological releases from the ORR. This project will include both independent sampling and assessment as well as comparison to the results from DOE's related sampling.

3.4.2 Related DOE Projects

DOE looks for inadvertent releases of ORR radiation which may have contaminated locally grown and harvested food crops, hay, and milk. Consequently, the health of local residents may be negatively impacted by consuming such products. According to the 2022 DOE EMP, DOE intends to sample food crops from broad-leaf systems (lettuce, turnip greens, etc.), root-plant-vegetable systems (tomatoes), and root-system vegetables (turnips, potatoes, etc.). They intend to perform this sampling at three locations potentially impacted by ORR activities: north of Y-12 (Scarboro community), southeast of ORNL (Gallaher Bend area), southeast of ETTP/southwest of ORNL (Jones Island area), and a reference location not impacted by the ORR. Hay will be sampled annually from the southeastern edge of the ORR. Vegetation samples are analyzed for gross alpha, gross beta, gamma emitting radionuclides, and isotopic uranium. If available, DOE collects milk samples bi-monthly from areas that could be potentially impacted by ORR activities and analyzes the samples for gamma emitting radionuclides, strontium-90, and tritium.

3.4.3 Problem Statements

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

3.4.4 Goals

The goals of this project include:

- To collect and analyze samples to determine if there is radiological contamination in food crops because of DOE activities on the ORR.
- To verify DOE's findings as they relate to food crops.

3.4.5 Scope

This project will collect and analyze samples of hay, milk, and food crops (root crop, fruit crop, leafy crop) from within a five-mile radius of the ORR. These samples will be compared to samples taken from a reference location. The reference location will be greater than five miles from the ORR boundary and not thought to be impacted by ORR operations. Vegetable and hay samples will be analyzed for gross alpha, gross beta, and gamma emitting radionuclides, with additional strontium-90 and isotopic uranium analysis if indicated by the original analyses. Milk samples will be analyzed for tritium, gamma emitting radionuclides, strontium-90, and isotopic uranium.

3.4.6 Assumptions

- Food crops will be available for collection and analyses.
- Food crops uptake radiological contamination.
- Radiological contamination originates from DOE ORR activities.
- DOE's data will be comparable to TDEC DoR-OR's data.

3.4.7 Constraints

- The availability of food crops, hay, and milk to sample.
- Weather, as well as predation by insects and animals, can affect the production and availability of food crops.
- Adequate funding will be available for this project, including funds to purchase food crops, hay, milk, and seeds.
- Laboratory costs can impact the scope of the project.

3.4.8 Methods, Materials, Metrics

For the TDEC DoR-OR Radiological Uptake in Food Crops project, staff will collect yearly samples of hay, milk, and food crops (root crop, fruit crop, leafy crop), preferably from within five miles of or on the ORR. Up to five samples will be collected from each food crop type (root crop, fruit crop, leafy crop), with one of the samples from each type being collected at a reference location. The reference locations are more than five miles from the boundary of the ORR and not thought to be radiologically impacted by the ORR. Up to six hay or grass samples and up to six milk samples will be collected with one sample of each from a reference location. Vegetable and hay samples will be analyzed for gross alpha, gross beta, and gamma emitting radionuclides.

If the initial gross beta or gross alpha results are elevated, additional strontium-90 (Sr-90), technetium-99 (Tc-99), or isotopic uranium analysis may be requested. Milk samples will be analyzed for tritium, gamma emitting radionuclides, strontium-90, and isotopic uranium.

In order for additional analysis to be requested, the initial results must meet certain requirements:

- Results must all be above specific sample detection limits.
- Gross alpha results must be over 1.5 pCi/g and more than twice the levels seen from samples collected at reference locations in order for isotopic uranium analysis to be added.
- Gross beta results must be over 5.0 pCi/g, have a potassium-40 value less than the gross beta level, and be more than twice the levels seen from samples collected at reference locations to have Sr-90 or Tc-99 analysis added. Any samples with Tc-99 analysis added should only be from an area thought to be impacted by ETTP or EMWMF, or another ORR area where documentation indicates it is a contaminant of concern.
- A maximum of five additional Sr-90, Tc-99, and isotopic uranium analyses can be done for vegetation samples and up to five Tc-99 analyses can be done for milk samples.

The TDEC DoR-OR Radiological Uptake in Food Crops project analytical results will be reviewed and compared to DOE's most recently available food crop data as published in the annual ORR ASER.

Figure 3.4.1 shows the proposed sample area, with reference locations beyond the five-mile buffer area.

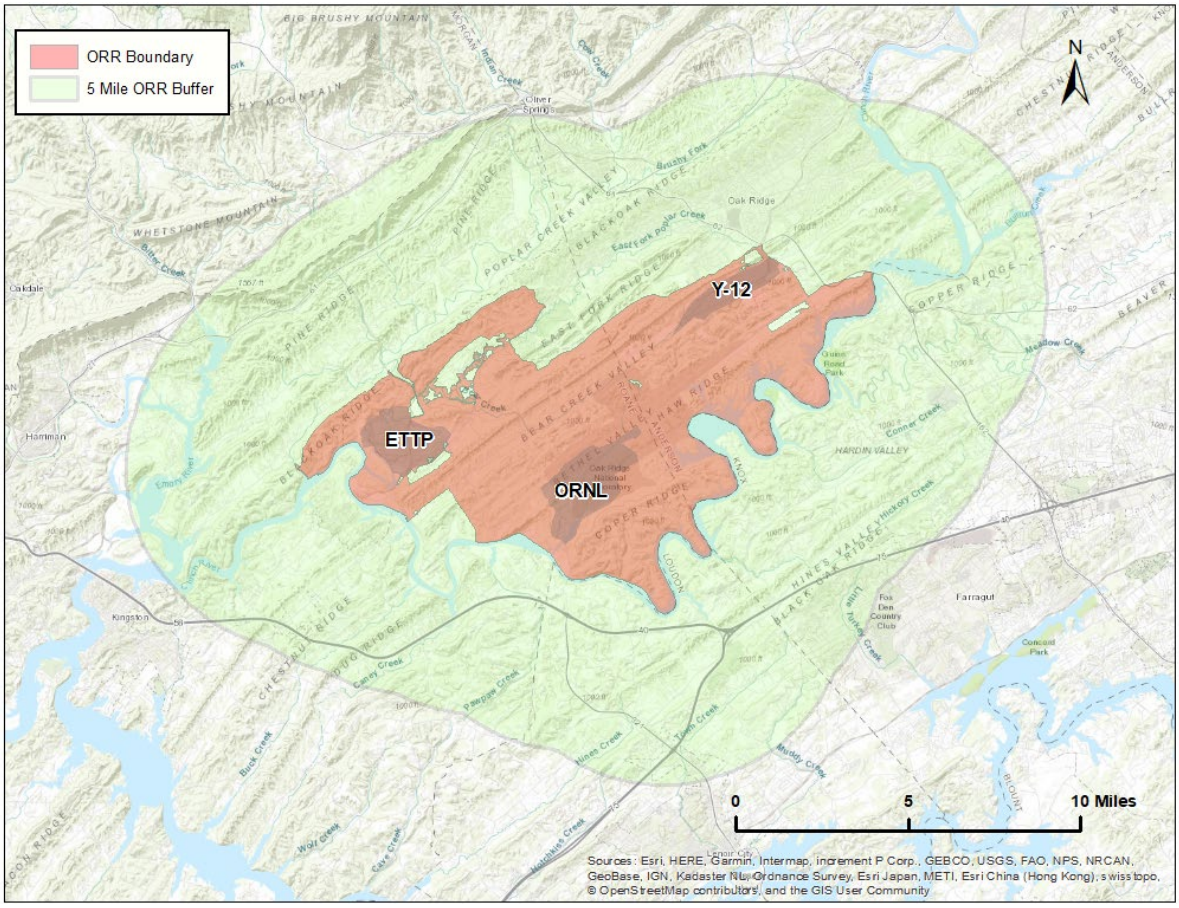

Figure 3.4.1: Proposed food crop sampling area

3.4.9 References

DOE (2021). Environmental Monitoring Plan for the Oak Ridge Reservation, Calendar Year 2022. DOE-SC-ORO/RM-2022-01.

DOE (2021). Oak Ridge Reservation Annual Site Environmental Report. DOE/CSC-2514. https://doeic.science.energy.gov/ASER/ASER2020/index.html

4.0 GROUNDWATER MONITORING

4.1 HISTORICAL GROUNDWATER

4.1.1 Background

The Historical Groundwater Project's (Project) primary focus is to compile all offsite aqueous data (private water wells, springs, and seeps) collected by both the Tennessee Department of Environment and Conservation (TDEC) Division of Remediation Oak Ridge office (DoR-OR) and the U.S. Department of Energy (DOE) into a TDEC DoR-OR Microsoft (MS) Access database. TDEC DoR-OR's offsite sampling efforts date back to the late 1990s. The data from this sampling has been stored in TDEC DoR-OR's data management system (TOREIS). This Project will compile the data stored in TOREIS with offsite data collected by DOE to develop a comprehensive offsite groundwater database that can be easily accessed to evaluate data, perform trend analysis, and inform future TDEC DoR-OR led sampling efforts. The sampling sites (private water wells, seeps, and springs) that are currently identified in TOREIS, the DOE Oak Ridge Environmental Information System (OREIS), and/or the DOE managed Project Environment Measurements System (PEMS) are illustrated in Figure 4.1.1.

4.1.2 Related DOE Projects

DOE's ORR groundwater strategy includes identifying and addressing potential threats to off-site public health and the environment (DOE, 2014). Historically, DOE and its contractor(s) have collected groundwater samples from numerous offsite private water well locations and springs, many of which have been collected alongside TDEC DoR-OR scientists. Recent DOE evaluations of offsite groundwater data have typically focused on data sets within a small timeframe and are not a comprehensive presentation of data. The two most recent offsite groundwater monitoring programs implemented by DOE are summarized below.

- An Offsite Groundwater Assessment (GWA) Remedial Site Evaluation (RSE) (DOE, 2017) was conducted by DOE between FY2014 and FY2016. As part of the GWA RSE, three groundwater sampling events were conducted and an evaluation of the resulting data from these three sampling events was performed.

- DOE is currently completing the reporting portion for field activities conducted as part of the Remedial Site Evaluation (RSE) Phase 2 Offsite Detection Monitoring (DM) (DOE, 2018). The Phase 2 Offsite DM included three years of annual sampling conducted on a subset of wells sampled during the GWA RSE. On February 10, 2022, TDEC DoR-OR received the D1 version of the Phase 2 Offsite Detection Monitoring Remedial Site Evaluation (DOE, 2022). The data set evaluated within this document was specific to the GWA RSE and RSE DM time frame.

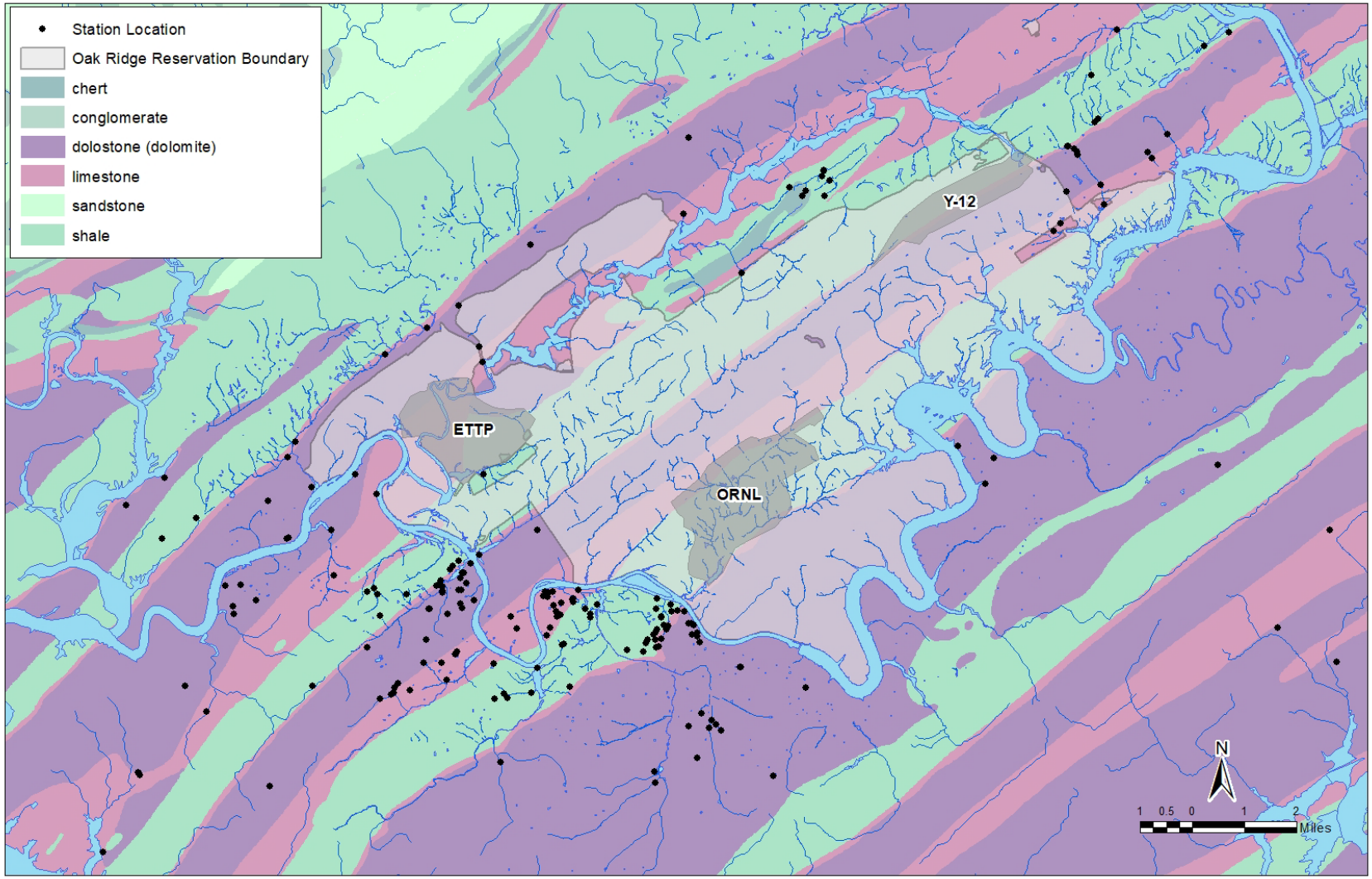

Figure 4.1.1: Oak Ridge Reservation Offsite Groundwater Sampling Sites (TDEC DoR-OR and DOE)

4.1.3 Problem Statements

Due to past DOE mission activities, numerous groundwater contaminant plumes associated with the three primary DOE facilities (ETTP, Y-12, and ORNL) are present on the ORR. Many of these contaminant plumes are not well defined and require ongoing investigation to delineate the vertical and horizontal extent of these plumes and to identify contaminant flow paths (DOE, 2021a). To ensure there is no threat to human health and the environment from potential offsite migration of DOE ORR legacy contamination, TDEC DoR-OR and DOE have completed numerous offsite groundwater projects. These projects have produced a large amount of aqueous analytical data. A comprehensive offsite groundwater data set is necessary for evaluating long term trends and will be beneficial for future planning of offsite groundwater sampling projects.

4.1.4 Goals

A primary role of TDEC's DoR-OR office is to ensure there is no threat to human health and the environment from potential offsite migration of DOE ORR legacy contamination. The objective of this Project is to compile a comprehensive and accessible data set of all (TDEC DoR-OR and DOE) offsite groundwater (wells and springs) data. The data set will be evaluated to determine if further analysis is warranted for a subset of wells.

4.1.5 Scope

This Project will utilize a customized TDEC DoR-OR database (MS Access) to compile and evaluate existing TDEC DoR-OR and DOE offsite groundwater data. The scope includes the following:

- Data compilation
- Development of database
- Comprehensive summary table generation
- Data evaluation and trend analysis
- Report generation

4.1.6 Assumptions

A primary assumption is that DOE readily provides analytical data from their offsite sampling efforts.

4.1.7 Constraints

Constraints that may impact this project include:

- Lack of complete datasets may make interpretation and analysis difficult.

- Lack of information on well construction, such as depth, may complicate data interpretation and analysis.

4.1.8 Methods, Materials, Metrics

To achieve the project goals, the following tasks will be conducted:

- Compile all offsite groundwater data collected by both TDEC DoR-OR and DOE into an MS Access database. Specifically, the following data will be included: TDEC DoR-OR data currently in TOREIS, additional well and spring/seep data not currently in TOREIS, and DOE data extracted from PEMS and OREIS.
- Generate a comprehensive summary table of the sample locations, constituents analyzed, and the frequency of sampling efforts. Based on this preliminary evaluation, additional assessment will be conducted for selected sample locations.
- Conduct a detailed data evaluation, trend analysis, and/or geochemical assessment on the subset of sample locations identified during the preliminary evaluation.
- Create graphs and maps to identify possible temporal and/or spatial trends.

4.1.9 References

DOE, 2014. Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee (DOE/OR/01-2628/V1&D2). US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee. February 2014.

DOE, 2017. Offsite Groundwater Assessment Remedial Site Evaluation, Oak Ridge, Tennessee (DOE/OR/01-2715&D2_R). US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee. October 2017.

DOE, 2018. Offsite Detection Monitoring Work Plan, Oak Ridge, Tennessee (DOE/OR/01-2788&D2). US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee. December 2018.

DOE, 2021a. 2021 Remediation Effectiveness Report for the US. Department of Energy, Oak Ridge Site, Oak Ridge, Tennessee (DOE/OR/01-2869&D2), US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee.

DOE, 2022. Phase 2 Offsite Detection Monitoring Remedial Site Evaluation, Oak Ridge, Tennessee (DOE/OR/01-2917&D1). US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee. February 2022. Pending Approval.

4.2 OFFSITE GROUNDWATER

4.2.1 Background

Historically, offsite groundwater downgradient of the U.S. Department of Energy (DOE) Oak Ridge Reservation (ORR) has been monitored by both the Tennessee Department of Environment and Conservation (TDEC), Division of Remediation, Oak Ridge Office (DoR-OR) and the DOE. The purpose of TDEC's DoR-OR offsite groundwater monitoring program is to monitor groundwater quality at offsite locations for possible DOE legacy contamination that may have migrated off the ORR into the adjacent surrounding area. The location of sampling efforts for the Fiscal Year 2023 (FY23) Offsite Groundwater Project (Project) will be private resident water wells and springs located downgradient, to the southwest and along strike, of the East Tennessee Technology Park (ETTP) and to the north of the ETTP. This general area will be referred to herein as the ETTP Offsite Subarea (URS and CH2M, 2017) whose boundary is illustrated on Figure 4.2.1 and Figure 4.2.2.

The ETTP encompasses approximately 5,000 acres of the ORR, of which approximately 2,200 acres was heavily industrialized, and was the home of the Oak Ridge Gaseous Diffusion Plant (ORGDP). Between 1942 and 1964, the ETTP's primary mission was to supply enriched uranium material for nuclear weapons. After 1964, the mission shifted towards the supply of low-enriched uranium for fabricating fuel elements for commercial and research reactors and recycling of uranium recovered from spent fuel. Subsequently, the ORGDP was permanently shut down in 1987 (DOE, 2021a). Documented historical releases from the numerous facilities at the ETTP include uranium isotopes, technetium-99, and other fission and activation products due to the processing of recycled uranium from spent nuclear reactor fuel; various releases from legacy operations, burial grounds, historical disposal, and waste storage; and accidental releases from various facilities following decades of operations. The demolition of the historical facilities and associated soil assessment/cleanup is nearing completion at the ETTP, and portions of the ETTP are being transferred to industrial or public use. For these reasons, TDEC-DoR-OR elected to focus on the ETTP Offsite Subarea for the FY23 Project.

4.2.2 Related DOE Projects

Historically, DOE and its contractor(s) have collected groundwater samples from numerous offsite private water well locations, many of which have been collected alongside TDEC DoR-OR scientists. Within the last five (5) years, DOE has completed or is the process of completing the following offsite groundwater activities:

- 2017 – DOE submitted the *Offsite Groundwater Assessment Remedial Site Evaluation* (DOE, 2017) which documents the collection of water samples between FY2014 and

FY2016 at 34 private water wells and 15 springs located outside the ORR boundary.

- 2022 – DOE is currently completing the reporting portion for field activities conducted as part of the Remedial Site Evaluation (RSE) Phase 2 Offsite Detection Monitoring (DM) (DOE, 2018). The Phase 2 Offsite DM included three years of annual sampling conducted during the wet season at 14 offsite private water wells/springs within all four subareas (Figure 4.2.1). Of these 14 sample locations, five (5) of these sample locations fell within the ETTP Offsite Subarea: Love Spring, RWA-127, RWA-129, SYN-164, and SYN-172. In addition to measuring water quality parameters (temperature, pH, specific conductivity [SpC], dissolved oxygen [DO], oxidation-reduction potential [ORP], and turbidity) in the field, the water samples were analyzed for volatile organic compounds (VOCs), gross alpha, gross beta, uranium-233/234, uranium-235/236, uranium-238, and select fission products/transuranic elements. On February 10, 2022, TDEC DoR-OR received the D1 version of the *Phase 2 Offsite Detection Monitoring Remedial Site Evaluation* (DOE, 2022).

Although not within the ETTP Offsite Subarea, DOE collects groundwater samples from exit pathway monitoring wells, specifically within Bear Creek Valley and Melton Valley, to monitor groundwater quality within the western boundary of the ORR. These exit pathway wells are known to contain concentrations of VOCs and manmade radionuclides which suggests westward contaminant migration.

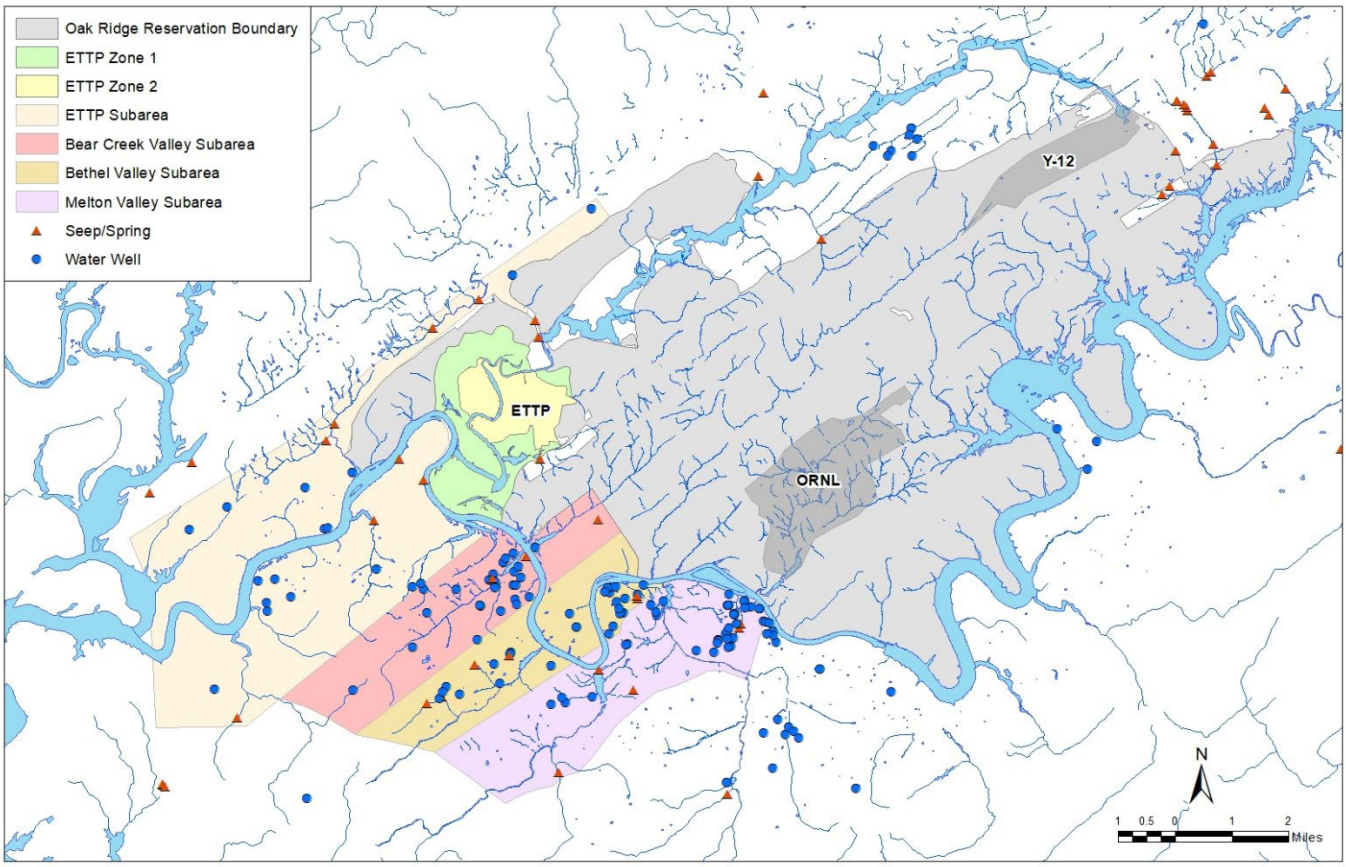

Figure 4.2.1: Oak Ridge Reservation Offsite Groundwater Subareas Map

4.2.3 Problem Statements

Delineation of the nature and extent of groundwater contamination is incomplete in many areas of the ORR (DOE, 2021b). Figure 4.2.1 shows the reservation boundary and the three primary DOE facilities: ETTP, Y-12, and ORNL. Each of these facilities have numerous groundwater contaminant plumes associated with them due to past DOE mission activities where many are not well defined and require ongoing investigation to delineate the vertical and horizontal extent of the contaminant plumes.

The ETTP is an area with complex bedrock containing many faults and carbonates that exhibit a karst terrain with large sinkholes. Little is understood about the contaminant flow paths within the bedrock and further investigation is necessary to evaluate these flow paths. It is known that groundwater can move long distances rapidly in all fractured-rock settings (Worthington, 2004) and in channels and conduits. Accordingly, it is important to monitor groundwater/spring water quality offsite the ORR.

This Project will continue TDEC DoR-OR's efforts towards monitoring water quality of private water wells and springs in the area surrounding the ORR to ensure there is no

threat to human health and the environment from potential offsite migration of DOE ORR legacy contamination.

4.2.4 Goals

The primary goal of this Project is to protect human health and the environment though monitoring groundwater offsite the ORR. This Project involves collecting groundwater samples at private water wells and springs within the ETTP Offsite Subarea at the locations illustrated on Figure 4.2.2.

The objectives of this Project include the following:

- Monitor water quality of private water wells and springs in the area surrounding the ORR to ensure there is no threat to human health.
- Support the potential interpretation of onsite ETTP groundwater data collected by DOE to allow for comparisons between onsite groundwater and offsite groundwater.
- Assist with FFA ETTP site-wide groundwater decisions by evaluating potential exit pathways.

The collection of these data will support the inclusion of current site conditions in future decision processes that support TDEC DoR-OR's mission of protecting human health and the environment.

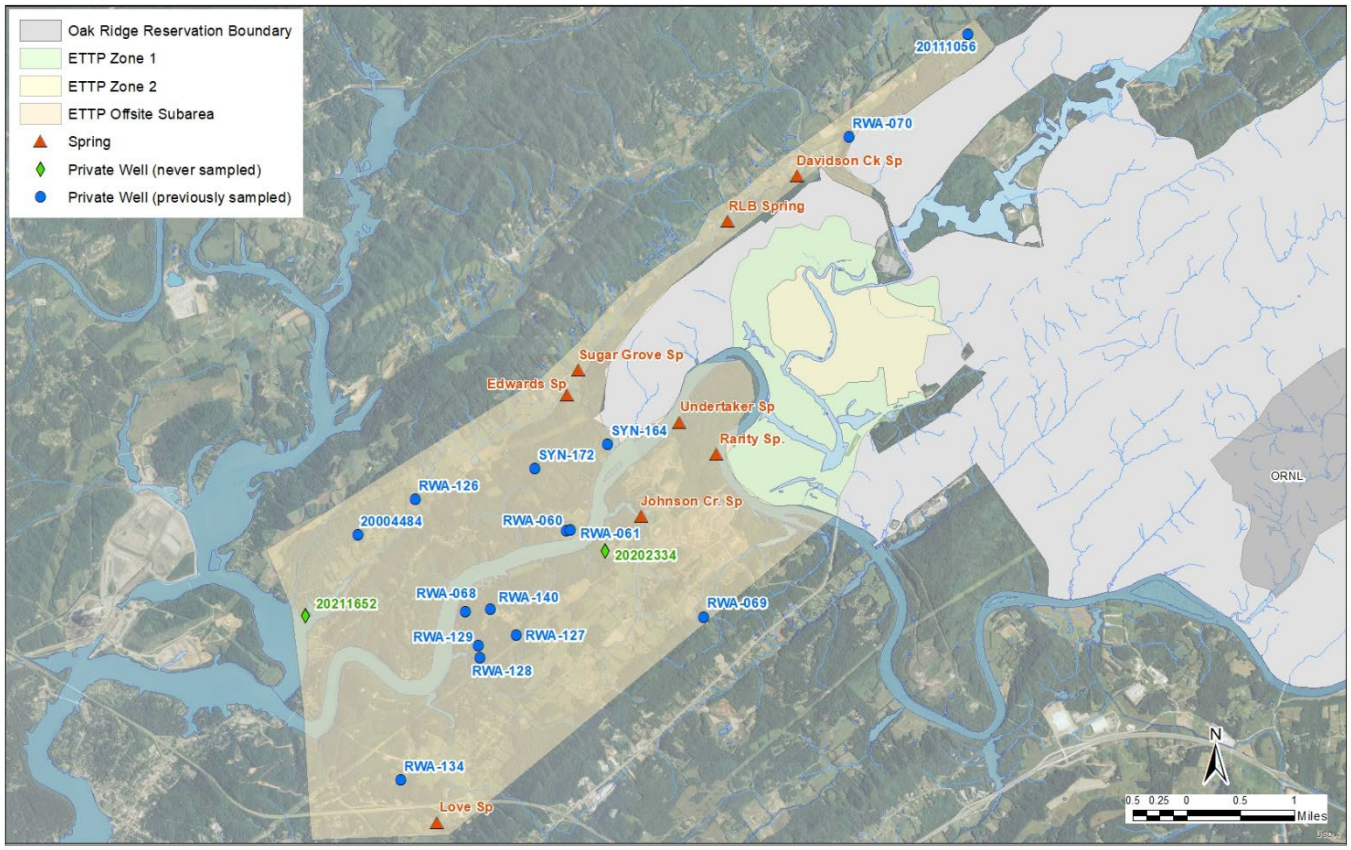

Figure 4.2.2: Proposed ETTP Offsite Subarea Sample Locations

4.2.5 Scope

The scope of this Project is to collect groundwater samples during the dry season from 17 private water wells and during the wet and dry season at springs within the ETTP Offsite Subarea (Figure 4.2.2) and within Zone 1 of ETTP. Field water quality parameter measurements and laboratory analysis will be conducted. Additionally, a monitoring event at 15 outfalls which act as conduits for groundwater will also occur.

Additional work may be completed if resources are available to address identified data gaps, generate a more robust dataset, and further support the goals of this project.

4.2.6 Assumptions

The scope of this Project is based on the following assumptions:

- Private well owners provide consent to collect groundwater samples.
- Private wells contain pumps to allow for groundwater sample collection or well conditions allow for use of a peristaltic pump or bladder pump.
- Groundwater samples will be shipped to the State of Tennessee Department of Health Environmental Laboratory (TDH) for analysis.

- Groundwater samples will arrive intact and will be analyzed within their respective analytical method holding times.
- Analytical laboratory costs do not increase during FY23.
- Equipment, vehicles, and trained personnel are available to complete field work events.
- TDEC DoR-OR funds are available for analysis of the groundwater samples.

4.2.7 Constraints

Constraints that may impact this project include:

- Contacted residents may not want to participate in the groundwater sampling project.
- It may be difficult or impossible to bypass filtration systems, water softeners, etc., which affect the quality and usefulness of the data.
- The infrequent sampling of the private water wells and springs will not capture the potential temporal variability of water quality.
- Lack of information on well construction, such as depth, may complicate data interpretation and analysis.

4.2.8 Methods, Materials, Metrics

Sample Collection

The Project includes collecting groundwater samples from a minimum of 17 private water wells and eight (8) springs within the ETTP Offsite Subarea (Figure 4.2.2, Table 4.2.1) during the dry season (June, July, August). The private water well samples will be collected using each wells dedicated submersible pump from an outside tap located as close to the well as possible, and ideally, before water passes through any filtration and/or water softener systems. Wells that are not in use and have no viable dedicated pump system may be sampled using a peristaltic pump or bladder pump depending on well conditions. 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 four consecutive readings, a groundwater sample will be collected. Field parameter stabilization is specified in Table 4.2.3. Field water quality parameter measurements and laboratory samples will be collected from the springs using a dipper or peristaltic pump.

Table 4.2.1. ETTP Offsite Subarea Groundwater Sampling Plan

Station Name	No. of Sample[1] Events - Historical	FY23 Analytical Parameters[2]			
		VOCs	Inorganics[2]	Metals[2]	Gross Alpha/Gross Beta[3]
SYN-164	5	1	1	1	1
SYN-172	6	1	1	1	1
RWA-060	3	1	1	1	1
RWA-061	5	1	1	1	1
RWA-068	1	1	1	1	1
RWA-069	1	1	1	1	1
RWA-070	1	1	1	1	1
RWA-126	3	1	1	1	1
RWA-127	6	1	1	1	1
RWA-128	6	1	1	1	1
RWA-129	6	1	1	1	1
RWA-134	2	1	1	1	1
RWA-140	4	1	1	1	1
20004484	2	1	1	1	1
20111056	2	1	1	1	1
20202334	0	1	1	1	1
20211652	0	1	1	1	1
Springs					
Davidson Ck Sp.	1	2	2	2	2
Edwards Sp.	9	2	2	2	2
Johnson Cr. Sp.	1	2	2	2	2
Love Sp.	7	2	2	2	2
Rarity Sp.	2	2	2	2	2
RLB Spring	25	2	2	2	2
Sugar Grove Sp.	9	2	2	2	2
Undertaker Sp.	1	2	2	2	2
Total Primary Samples		33	33	33	33
Field Blank		2	2	2	2
Field Duplicate		4	4	4	4
Total Samples (FY 23)		**39**	**39**	**39**	**39**

Notes:

All analytical samples will be collected during the FY23 dry season (June, July, August).

[1] – Total number of sample events either conducted by TDEC DoR-OR and/or DOE. The number of historic spring sample events is approximate.

[2] – The list of analytes and their analytical methods are defined in Table 4.2.3. Equivalent analytical methods may be employed.

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

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 4.2.3 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. A second monitoring event will be conducted at the spring locations during the wet season (January, February, March).

Quality assurance/quality control (QA/QC) samples will be collected at a frequency of every 10%. Trip blanks will be included in coolers and one field blank will be submitted for analysis each season (Table 4.2.1). All water samples will be collected in accordance with internal standard operating procedures (SOPs).

Additional field samples, QA/QC samples, or contaminants may be collected and analyzed as appropriate if resources are available.

Table 4.2.2 ETTP Zone 1 Springs / Supplemental Groundwater Data Sampling Plan

Station Name	FY23 Analytical Parameters[1]			
	VOCs	Inorganics[1]	Metals[1]	Gross Alpha/Gross Beta[2]
Springs				
USGS 10-895	2	2	2	2
PCO Seep	2	2	2	2
JA Jones Spring	2	2	2	2
21-002 Spring	2	2	2	2
Blair Rd landfill 1	2	2	2	2
Pwrhouse Spring	2	2	2	2
Cross Spring	2	2	2	2
Cedar Spring	2	2	2	2
Z-Boil Spring	2	2	2	2
WB Spring	2	2	2	2
Envy Seep	2	2	2	2
Treehole Spring	2	2	2	2
Syncline Spring	2	2	2	2
USGS 8-900-Sp	2	2	2	2
Groundwater from Outfalls				
15 locations	15	15	15	15
Total Primary Samples	43	43	43	43
Field Blank	2	2	2	2
Field Duplicate	4	4	4	4
Total Samples (FY 23)	49	49	49	49

Notes:

[1] – The list of analytes and their analytical methods are defined in Table 4.2.3. Equivalent analytical methods may be employed.

[2] – Isotopic uranium analysis will be done for samples with a gross alpha activity.

Table 4.2.3. Analytical Test Suite

Parameter Type	Analytes	Analytical Method/Stabilization Criteria
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
	mercury	EPA Method 245.7
Volatile Organic Compounds	**numerous**	EPA Method 8260B Low Level
Radionuclides	**gross alpha**/gross beta	D7283-17
	isotopic uranium	HSL-300
Field 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
µS/cm – microSiemens per centimeter
mg/L – milligram per liter
mV - millivolt
NA – not applicable
NTU – nephelometric turbidity unit

Data Evaluation

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 and U.S. Environmental Protection Agency's (EPA) National Priority Drinking Water Regulations to

evaluate risk to human health and to confirm the private water wells and springs have not been impacted from DOE ORR legacy contamination. Additional analysis will be conducted and may include using graphing, mapping, and 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 DoR-OR's FY23 Environmental Monitoring Report.

4.2.9 References

DOE, 2017. Offsite Groundwater Assessment Remedial Site Evaluation, Oak Ridge, Tennessee (DOE/OR/01-2715&D2_R). US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee. October 2017.

DOE, 2018. Offsite Detection Monitoring Work Plan, Oak Ridge, Tennessee (DOE/OR/01-2788&D2). US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee. December 2018.

DOE, 2021a. Oak Ridge Reservation Annual Site Environmental Report 2020 (DOE/CSC-2514), US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee. September 2021.

DOE, 2021b. 2021 Remediation Effectiveness Report for the US. Department of Energy, Oak Ridge Site, Oak Ridge, Tennessee (DOE/OR/01-2869&D2), US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee.

DOE, 2022. Phase 2 Offsite Detection Monitoring Remedial Site Evaluation, Oak Ridge, Tennessee (DOE/OR/01-2917&D1). US Department of Energy, Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee. February 2022. Pending Approval.

Worthington, S.R.H., 2004, Depth of conduit flow in unconfined carbonate aquifers, Geology, 29 (4) p. 335-338.

5.0 LANDFILL MONITORING

5.1 EMDF

5.1.1 Background

The Environmental Management Disposal Facility (EMDF) is proposed for the disposal of low-level radioactive waste, hazardous waste, and toxic waste generated by remediation activities on the ORR and will be operated under the authority of CERCLA and DOE directives. While the EMDF will hold no permit from the State of Tennessee, the landfill will be required to comply with DOE orders and substantive portions of Applicable or Relevant

and Appropriate Requirements (ARARs) listed in the upcoming CERCLA EMDF Record of Decision (ROD). The EMDF will be located within the Central Bear Creek Valley (CBCV) area; specifically, slightly to the west of the existing Environmental Management Waste Management Facility (EMWMF).

The TDEC DoR-OR will monitor surface water along the portion of Bear Creek where the proposed EMDF landfill will be constructed. Furthermore, TDEC DoR-OR's monitoring of one groundwater spring and surface water will support the TDEC DoR-OR Bear Creek Assessment Project, as well as anticipated future data collection efforts in the CBCV.

5.1.2 Related DOE Projects

DOE currently monitors Bear Creek and some of its northern tributaries (NT-3, NT-4, and NT-5) for potential releases from the EMWMF landfill. 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).

The TDEC DoR-OR CBCV EMDF monitoring project is intended to complement and supplement DOE's monitoring of the surface water in the CBCV area.

5.1.3 Problem Statements

- Contaminants in the waste materials from CERCLA remediation activities will be buried in the EMDF and may leach out into the environment.
- Surface water or groundwater may carry contaminants off site in concentrations or radiological activities above agreed-to limits.

5.1.4 Goals

- This project will provide data to identify current water quality conditions in the CBCV EMDF area. Sampling will provide assurance through independent monitoring and coincident evaluation of DOE's data, that collected baseline data are appropriate for use in future stream evaluations.
- Surface water monitoring by TDEC DoR-OR will verify that DOE has determined baseline water quality conditions in the surface water by measuring the same parameters.
- Surface water monitoring will complement DOE's sampling and analysis.

5.1.5 Scope

- Within the proposed CBCV EMDF footprint, staff will measure water quality parameters in streams at six flume discharge locations and a spring: SF-1, SF-2, SF-3, SF-4, SF-5 and SF-6 and spring D10W (Figure 5.1.1). Staff members will monitor these locations using a YSI Professional Plus water quality instrument or equivalent.
- Observations of site conditions and surface water parameter measurements will be made once a month or as conditions warrant.
- Staff will collect surface water samples at four of the seven above locations to complement DOE actions in characterizing baseline conditions (Table 5.1.1).

5.1.6 Assumptions

- Currently, mercury, radionuclides, and volatile organics are constituents of concern. The analytical results data from the collected water samples may identify more constituents of concern.

5.1.7 Constraints

- Monitoring may be contingent upon availability of a DOE escort.
- Inclement weather may preclude conducting parameter measurements.
- Sampling depends on availability of equipment for conducting water quality parameter measurements.

5.1.8 Methods, Materials, Metrics

Tasks for this program include monitoring water quality parameters at seven locations, six stream discharge flumes, SF-1, SF-2, SF-3, SF-4, SF-5, SF-6, and one spring D10W (Figure 5.1.1). Utilizing a YSI Professional Plus water quality meter or its equivalent, at least once a month, TDEC DoR-OR personnel will measure temperature, pH, conductivity, dissolved oxygen, and oxidation reduction potential at these locations. Calibration and/or a confidence check of this instrument will be performed prior to field use. Multi-parameter probes will be used to monitor the flumes at SF-1 and SF-5 on a more frequent basis.

TDEC DoR-OR will monitor the streams, note discharges, water conditions, observe the condition of the banks, and note any concerns. Any concerns will be brought to the attention of DOE. Field notes will be recorded in a dedicated field book, and events will be reported in a monthly TDEC DoR-OR project report.

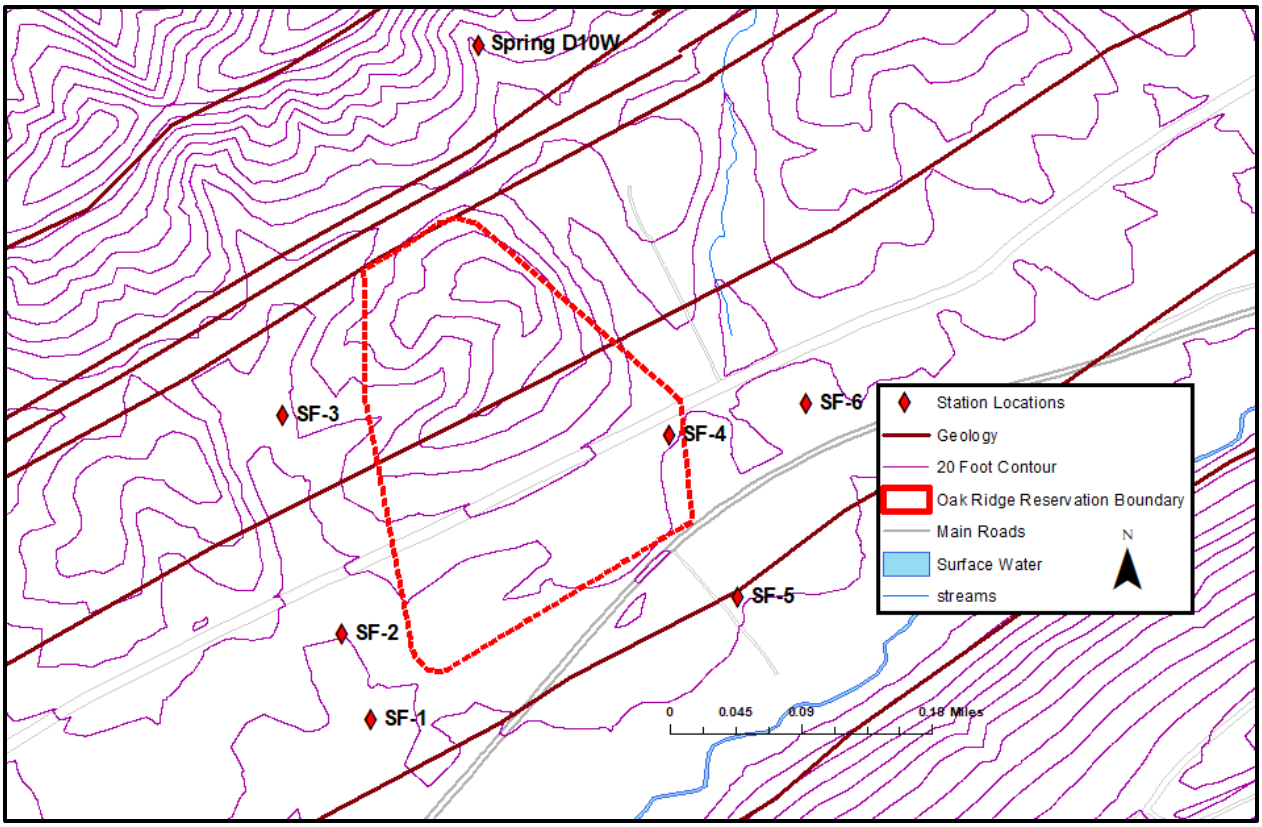

Figure 5.1.1: Sampling Locations CBCV Site 2021 Monitoring

Data collected from these key locations by TDEC DoR-OR and DOE will be entered into an Excel database for evaluation. Evaluation will include construction of tables and graphs illustrating ranges, limits of constituents and parameters and identifying potential trends over the course of the project. Table 5.1.1 presents the four locations where surface water samples will be collected for analytical analysis. In addition, the sampling frequency and rationale for each station is listed. The analytical test suite is presented in Table 5.1.2. Pertinent water quality regulatory criteria from the EPA and TDEC will be included in the graphs.

Table 5.1.1: Sampling Locations and Frequency of TDEC DoR-OR Sample Collection

Station	Sample ID	Frequency	Sampling Rationale
Flume 1	SF-1	Semi-Annually	Flume 1 is the most downstream point of NT-11
Flume 5	SF-5	Semi-Annually	Flume 5 captures upstream NT-10 West
Flume 6	SF-6	Semi-Annually	Flume 6 captures upstream NT-10
Spring 10W	SP10W	Semi-Annually	Background Spring

NT - North Tributary

SF - Surface Water Flume

Table 5.1.2: TDEC DoR-OR EMDF Monitoring Analyte List

EMDF ANALYTE LIST	
Water	
Gamma Activity	**Sr-89,90 in water**
Technetium-99	**Tritium in water**
Isotopic Uranium	
Arsenic	**Barium**
Chromium	**Cobalt**
Copper	**Lead**
Mercury	**Nickel**
Uranium	**Vanadium**
Zinc	
Polychlorinated Biphenyls (PCBs)	

5.1.9 References

TDEC 2019, Rules of the Tennessee Department of Environment and Conservation. Chapter 0400-40-03, General Water Quality Criteria, Tennessee Department of Environment and Conservation. (2019)

Tennessee Department of Environment and Conservation, Environmental Sampling of the ORR and Environs Quality Assurance Project Plan. Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office, Oak Ridge, TN, 2015.

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Tennessee Department of Environment and Conservation. Division of Water Resources. Quality System Standard Operating Procedure For Chemical and Bacteriological Sampling of Surface Water, DWR-WQP-P-01-QSSOP-Chem-Bact-082918-update-2022-jan.pdf)

United States Environmental Protection Agency. Regional Screening Levels for Chemical Contaminants at Superfund Sites. (March 2020).

5.2 EMWMF

5.2.1 Background

The Environmental Management Waste Management Facility (EMWMF) was constructed for the disposal of low-level radioactive waste and hazardous waste generated by remedial activities on the ORR and is operated under the authority of CERCLA and DOE. While the EMWMF facility holds no permit from the State of Tennessee, the EMWMF is required to comply with DOE orders and applicable or relevant and appropriate requirements (ARARs) listed in the CERCLA EMWMF Record of Decision (ROD) (DOE, 1999).

Currently, the only authorized discharge from EMWMF is potentially contaminated storm water (contact water), which ponds in the disposal cells above the leachate collection system. The contact water is routinely pumped from the disposal cells to holding ponds and tanks, and then it is sampled for subsequent chromium (VI) analysis (Figure 5.2.1). Depending on the chromium VI concentrations, it is either treated onsite or if above published criteria limits, the water is treated offsite at the Liquid Gaseous Waste Operation (LGWO). If the levels are all below criteria limits, the water is released to a storm water sedimentation basin which discharges into the NT-5 Bear Creek tributary.

The limits on waste discharge releases from the holding ponds to the sedimentation basin are published in DOE Order 435.1 (formerly DOE Order 5400.5) which restricts the release of liquid wastes containing radionuclides to an average concentration equivalent of 100 mrem/year. The limit for discharges from the sedimentation basin to NT-5 are based on State of Tennessee regulations (TDEC 0400-20-11-.16{2}) (TDEC 2012) which restrict concentrations of radioactive material released to the general environment in groundwater, surface water, air, soil, plants, or animals to an annual dose equivalent of 25 mrem (TDEC 0400-20-11-.16{2}). In addition, DOE Order 458.1 limits gross alpha and gross beta activity of settleable solids in liquid effluents to 5.0 pCi/g and 50 pCi/g, respectively.

The TDEC DoR-OR Water Monitoring at the EMWMF Project began in 2006 and has continued until the present. Each year since 2006, samples of surface water, groundwater, and sediment have been collected, if possible, analyzed, and the results published in the annual TDEC DoR-OR EMR. TDEC DoR-OR's monitoring of groundwater and surface water assists DOE in their efforts to comply with the requirements stated in the EMWMF ROD (DOE 1999) and Tennessee General Water Quality Criteria (TDEC 2019).

5.2.2 Related DOE Projects

TDEC DoR-OR currently monitors surface water quarterly at NT-5, NT-4, and NT-3 (Bear Creek Tributaries) for potential releases from the landfill. Figure 5.2.1 shows the sampling locations described in this plan. Monthly samples from the Underdrain and the V-weir are also collected. DOE collects the water released from the Sediment Basin at the V-weir

(EMWMF-3) using an automatic sampler based on a weekly flow-rated composite sample as it is discharged (named VCOMP). This is used to calculate the volume weighted sum of fractions. Additional DOE sampling of surface water takes place at EMWNT-03B, EMWNT-05, NT-4 (Bear Creek Tributary) and the V-weir semi-annually after a qualifying precipitation event (> 0.1 inches), and DOE collects a suspended solids sample at the V-weir after a qualifying precipitation event (> 0.5 inches).

Annually, DOE's results from this sampling are published in the Phased Construction Completion Report (PCCR) (DOE 2020) which are entered into the DOE Oak Ridge Environmental Information System (OREIS).

TDEC DoR-OR sampling and analysis results are intended to complement DOE's monitoring of the water discharges to the environment.

5.2.3 Problem Statements

- Only low-level radioactive solid waste, as defined in TDEC 0400-02-11.03(21) with radiological concentrations below limits imposed by Waste Acceptance Criteria (WAC) and agreed to by the FFA tri-parties (DOE, EPA and TDEC), is approved for disposal in the EMWMF. DOE is accountable for compliance with the WAC and has delegated responsibility of WAC attainment decisions to its prime contractor.
- Contaminants in the waste materials from CERCLA remediation activities are buried in the EMWMF and may leach out and enter the environment.
- Surface water or groundwater may carry these contaminants off site in concentrations or activities above agreed-to limits.

5.2.4 Goals

The goals of the Water Monitoring at the EMWMF Project follow:

- Provide assurance through independent monitoring and evaluation that DOE operations at the EMWMF are protective of public health and the environment.
- Verify DOE's remedial effectiveness objectives for the EMWMF.
- Provide independent data on discharges from the Underdrain.
- Surface water monitoring will verify that DOE is adhering to published (DOE 2017, DOE/OR/01-2734&D1/R1) agreed-to-limits. These ARARs listed in the EMWMF SAP/QAPP, DOE 2017, are currently under review by DOE and the EPA (Table 5.2.2). Should an updated SAP/QAPP be submitted and approved those limits will be used.
- Surface water monitoring will complement DOE's monitoring actions.

- Determine an estimate of discharged water volume from the Contact Water ponds/tanks. Keep a record of discharged volumes for evaluation of contaminant loading.

5.2.5 Scope

The scope of the Water Monitoring at the EMWMF Project includes the following:

- 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 5.2.1). The measured water quality parameters are temperature, pH, specific conductivity, dissolved oxygen, and oxidation reduction potential. TDEC DoR-OR personnel will monitor these locations once per month with the use of a YSI-Professional Plus water quality instrument or equivalent.

- To ensure best practices are used by DOE to limit possible contaminant migration, multi-parameter probes with logging capabilities will be obtained to measure water quality parameters on a more frequent basis.

- On a routine basis, TDEC DoR-OR will collect nine confirmation samples identified in Table 5.2.1 and shown in Figure 5.2.1 to ensure contaminants from the landfill are not adversely affecting the downstream environment.

- Sediment samples will be collected annually from sediment basin areas that are sufficiently dry to facilitate collection by hand. These samples will be composited into a single sample for analysis.

- To ensure EMWMF is meeting its operational requirements, discharge data collected by EMWMF personnel will be reviewed weekly by TDEC DoR-OR.

5.2.6 Assumptions

- Sampling and monitoring are contingent upon active, if any, Radiological Work Permits and availability of DOE Radiological Protection Technicians to measure for possible radioactive contamination deposited on TDEC DoR-OR sampling equipment, collected samples, or personal protective equipment (PPE).

- Equipment is available for conducting water quality parameter measurements.

- Mercury, radionuclides, and volatile organics are constituents of concern (COC).

5.2.7 Constraints

- Inclement weather may preclude conducting water quality parameter

measurements.

- Equipment may not be available for water parameter measurement.
- Vehicles and trained support staff may not be available.
- TDEC DoR-OR funds for analysis of collected samples may not be available.
- Revision of sampling schedules may occur to reflect staffing or funding limitations.

5.2.8 Methods, Materials, Metrics

Surface water grab samples will be collected on a routine basis for laboratory analysis, and the site will be monitored at least monthly to measure water quality parameters and observe landfill conditions (Table 5.2.1).

- Table 5.2.3 presents the analytical test suite for this project. Collected samples will be analyzed for radionuclides (gamma radionuclides, strontium-89/90, technetium-99, tritium, transuranics and isotopic uranium), volatile organics, perfluoroalkyl substances (PFAS), metals (arsenic, chromium, cobalt, copper, lead, nickel, uranium, vanadium, zinc, mercury [low-level]), PCBs (low-level), and inorganics. The sampling and monitoring locations are shown on Figure 5.2.1. In addition, the rationale for sampling these sites is also presented in Table 5.2.1.
- Samples will be collected using criteria specified in the TDEC Quality Systems *Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water Revision 6* (TDEC 2022), and the EPA *SESD Operating Procedure for Surface Water Sampling,* SESDPROC-201-R4.
- Sampling at EMWMF-2 (Underdrain) will be conducted bi-monthly to complement DOE sampling.
- Sampling at EMWMF-3 (VWEIR) will be conducted semi-annually to confirm DOE analyses and to coincide with a weekly "VCOMP" collection by DOE at EMWMF-3.
- Samples from a contact water pond or tank will be comprised of water to be discharged and will be a replicate of DOE sampling prior to discharge.
- As conditions allow 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.
- In the absence of a groundwater monitoring well, the NT-3 tributary (EMWNT-3B) will be sampled downgradient of the waste cells at the locations currently monitored by the DOE EMWMF surface water program (Figure 5.2.1). This sampling

will be once a year.

- An annual sample will also be collected at station NT5@BCK (Figure 5.2.1) as this is downgradient of all EMWMF surface operations.
- Samples will be shipped to the Nashville State Laboratory or to contracted lab(s) for analysis.
- As operations warrant, observations of landfill operations and surface water parameter measurements will be made once a month. Additional locations for parameter measurements are NT5@BCK and BCK11.54A at the flume (SW-003) (Figure 5.2.1).
- On a quarterly basis, DOE Project Environmental Measurement System (PEMS) sediment basin discharged water data will be downloaded and evaluated, if the data is available.

TDEC DoR-OR laboratory analytical results data will be entered into an office database for evaluation. Evaluation may include construction of tables and graphs illustrating ranges and limits of constituents over the course of the project. Pertinent EPA and TDEC water quality criteria will be included in the graphs (Tables 5.2.4 and 5.2.5). In certain circumstances, DOE criteria may be used for additional illustration.

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 5.2.4).

The criteria for sediment comparisons include EPA's Regional Screening Levels 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 5.2.5).

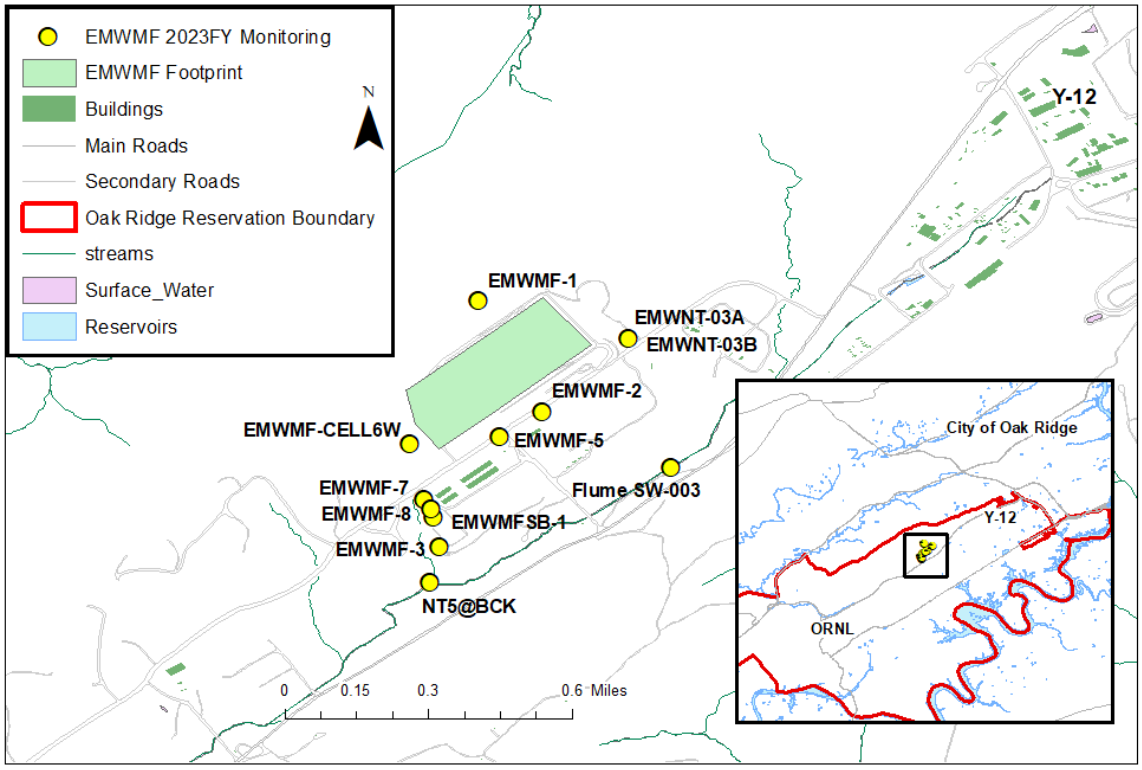

Figure 5.2.1: TDEC DoR-OR EMWMF Sampling Locations for 2023FY Monitoring

Table 5.2.1: Sampling Locations and the Typical Frequency of TDEC DoR-OR Sample Collection

Station	Sample ID	Frequency	Sampling Rationale
EMWMF Underdrain	EMWMF-2	Bi-Monthly	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.
Contact Water Ponds/Tanks	EMWMF-5, EMWMF-7, EMWMF-8	1 Location Bi-Monthly	Provides confirmation of contaminant levels being discharged to the sediment basin.
Sediment Basin Effluents (VWEIR)	EMWMF-3	Bi-Monthly	Provides confirmation of contaminant levels being discharged from the sediment basin.
Sedimentation Basin Sediment	EMWMFSB-1	One Composite	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.
NT-3 Tributary	EMWNT-03A or EMWNT-03B	Annually as funds permit	Up-stream surface water location to be used as a baseline.
Cell 6 Drainage	EMWMF Cell-6W	Annually as funds permit	This location is used as a verification that water collected in Cell 6 (prior to waste placement) is storm water.
NT5 at Bear Creek	NT5 @ BCK	Annually as funds permit	Collection for baseline of biological accumulation constituents

GW - groundwater

EMWMF - Environmental Management Waste Management Facility

NT - North Tributary

Table 5.2.2: ARARs for Contact Water/Surface Water from the EMWMF SAP/QAPP DOE/OR/01-2734&D1/R1

Monitored medium	Required action	Performance objectives	Performance measures
Contact Water	Monitor the quality of contact water discharges	TDEC 0400-40-03-.03(3) and 0400-20-11-.16* 10 *CFR* 20.1301(a) TDEC 0400-20-11-.16*	EMW-VWEIR, contact water ponds, and contact water tanks: Compare analytical results to AWQC under TDEC-40-03-.03(3) Surface water samples from EMW-VWEIR are analyzed for radiological COCs to perform the sum of fractions required for dose calculations

*Formerly TDEC 1200- 04-03-.3(3) and TDEC 1200-2-11-.16(2)

Table 5.2.3: TDEC DoR-OR EMWMF Analytical Test Suite

EMWMF ANALYTE LIST		
Water	**Sediment**	
Gamma Activity	**Gamma, Sediments**	**Iron**
Sr-89,90 in water	**Sr-89,90 in solids**	**Lead**
Technetium-99	**Technetium-99**	**Magnesium**
Tritium in water	**Tritium in solids**	**Manganese**
Transuranics/Isotopic Uranium	**Isotopic Uranium in solids**	**Mercury**
Arsenic	**Aluminum**	**Nickel**
Chromium	**Arsenic**	**Potassium**
Cobalt	**Antimony**	**Selenium**
Copper	**Barium**	**Silver**
Lead	**Beryllium**	**Sodium**
Mercury	**Cadmium**	**Thallium**
Nickel	**Calcium**	**Uranium**
Uranium	**Chromium**	**Vanadium**
Vanadium	**Cobalt**	**Zinc**
Zinc	**Copper**	
Polychlorinated Biphenyls (PCBs)	**Polychlorinated Biphenyls (PCBs)**	
Perfluoroalkyl Substances (PFAS)		

Table 5.2.4: EMWMF Surface Water Monitoring Criteria Comparison

Surface Water Criteria Comparison						
	Human Life Criteria		TN Aquatic Life Criteria		EPA Aquatic Life Criteria	
EMWMF ANALYTE LIST Water	Human Health for the consumption of Water + Organism (µg/L)	Human Health for the consumption of Organism Only (µg/L)	Freshwater CMC1 (acute) (µg/L)	Freshwater CCC2 (chronic) (µg/L)	Freshwater CMC1 (acute) (µg/L)	Freshwater CCC2 (chronic) (µg/L)
Gamma Activity	—	—	—	—	—	—
Sr-89, 90 in water	—	—	—	—	—	—
Technetium 99	—	—	—	—	—	—
Tritium in water	—	—	—	—	—	—
Transuranics/Isotopic Uranium	—	—	—	—	—	—
Arsenic	0.018	0.14	340	150	340	150
Chromium III	MCL	—	570	74	570	74
Cobalt	—	—	—	—	—	—
Copper	1,300	—	13	9	—	—
Lead	—	—	65	2.5	82	3.2
Mercury	—	—	1.4	0.77	1.4	0.77
Nickel	610	4,600	470	52	470	52
Uranium	—	—	—	—	—	—
Vanadium	—	—	—	—	—	—
Zinc	7,400	26,000	120	120	120	120

1/ CMC: Criterion Maximum Concentration

2/ CCC: Criterion Continuous Concentration

Table 5.2.5: EMWMF Sediment Monitoring Criteria Comparison

Sediment Levels for Risk Comparisons			
	EPA RSL Soil to Goundwater SSL mg/kg	TEC* mg/kg	PEC** mg/kg
Aluminum	30000	n.a	n.a
Arsenic	0.0015	9.8	33
Antimony	0.35	2	33
Barium	160	n.a	n.a
Beryllium	20	n.a	n.a
Cadmium	0.69	0.99	5
Calcium	n.a	n.a	n.a
Chromium	4.00E+07	43	110
Cobalt	0.27	n.a	n.a
Copper	28	32	150
Iron	350	20000	40000
Lead	14 MCL based	36	130
Magnesium	n.a	n.a	n.a
Manganese	28	460	1100
Mercury	14	0.18	1.1
Nickel	26	23	49
Potassium	n.a	n.a	n.a
Selenium	0.52	n.a	n.a
Silver	0.8	1.6	2.2
Sodium	n.a	n.a	n.a
Thallium	0.014	n.a	n.a
Uranium	1.8	n.a	n.a
Vanadium	86	n.a	n.a
Zinc	370	120	460
Gamma, Sediments	Use EPA PRGs for comparison	n.a	n.a
Sr-89, 90 in solids	Use EPA PRGs for comparison	n.a	n.a
Technetium 99	Use EPA PRGs for comparison	n.a	n.a
Tritium in solids	Use EPA PRGs for comparison	n.a	n.a
Istopic Uranium in solids	Use EPA PRGs for comparison	n.a	n.a

*Consensus Based Sediment Quality Criteria, Threshold Effects Concentration (McDonald et al. 2000)

**Consensus Based Sediment Quality Criteria, Probable Effects Concentration (McDonald et al. 2000)

n.a. - criteria not established for that characteristic

5.2.9 References

DOE 1999, Department of Energy. 1999. Record of Decision for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste (DOE/OR/01-1791&D3)

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DOE Order 435.1, 2021, Department of Energy Order 435.1 Radiation Waste Management, Aug. 2021, U.S. Department of Energy Office of Health, Safety and Security

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5.3 FCAP VEGETATION, SEDIMENT, AND WATER SAMPLING

5.3.1 Background

The wetland at the Y-12 Filled Coal Ash Pond (FCAP) site located near Chestnut Ridge is used as a passive treatment system to treat leachate from the coal ash retention pond through a subsurface drainage system. This wetland, located at the base of the dam that was constructed to create the pond, discharges to Upper McCoy Branch. Upper McCoy Branch then flows into Rogers Quarry. Using the S19 National Pollutant Discharge Elimination System (NPDES) outfall site, surface water flows out of the quarry, underneath Bethel Valley Road, and becomes Lower McCoy Branch. About one mile downstream of Bethel Valley Road, the Lower McCoy Branch drains into the Clinch River/Melton Valley Lake.

The 2016 Five Year Review identified reduced arsenic uptake through the wetland system due to channelization around the edges of the wetland and invasive plants displacing the cattails which are utilized for the uptake of arsenic and other metals. In 2019, work was concluded to restore the flow in the wetland and the cattail community, thus improving the wetland efficiency in removing metals, particularly arsenic, from McCoy Branch.

5.3.2 Related DOE Projects

Currently, semiannual surface water sampling is conducted where the untreated leachate water enters the wetland (influent) and where the treated water exits the wetland weir/outfall (effluent). These influent and effluent samples are monitored for metals, anions, radionuclides, and other water quality parameters.

5.3.3 Problem Statements

Contamination from the FCAP site continues downstream and is hazardous to fish, the environment, and humans. This project will determine if cattail seasonal die off is increasing overall contaminant of concern (COC) loading to the wetland, and ultimately to downstream locations. Arsenic is the primary COC at the FCAP site. Cattails within the wetland are primarily utilized for the uptake of arsenic.

Currently, DOE does not conduct surface water, vegetation, or sediment sampling within the wetland treatment system near the weir prior to discharge. Without this information, it is unknown whether additional COC removal via wetland vegetation (cattail) maintenance would occur, thus benefiting the downstream biological communities.

5.3.4 Goals

The goal of this project is to monitor COC levels within the FCAP wetland vegetation, sediments, and water to determine if there are changes in COC amounts due to seasonal uptake of contaminants and cattail winter die off.

5.3.5 Scope

This project includes collecting vegetation (cattails), sediment, and surface water samples within the FCAP wetland to sample for coal combustion residual COCs. Sampling will occur twice per year, once during the summer growing season and once after the vegetation has died off. These sample results will be analyzed to examine wetland efficiency in preventing additional COCs from entering McCoy Branch.

5.3.6 Assumptions

Contamination of water and sediments within the treatment wetland are associated with coal ash at FCAP. Sampling during the different seasons will provide information regarding the possible re-release of COC's into the wetland once the cattails die off during the winter season.

5.3.7 Constraints

Constraints associated with this project include obtaining access to the site and DOE's permission to sample vegetation, sediments and water in the wetland, as well as adequate funding and field sampling support.

5.3.8 Methods, Materials, Metrics

Twice a year, once during the growing season and once after vegetation die off, vegetation (cattails), sediment, and water samples will be collected within the FCAP wetland (Figure 5.3.1). All the samples will be analyzed for the following analytical test suite:

- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Fluoride
- Lead
- Lithium
- Mercury
- Molybdenum

- Selenium
- Thallium
- Radium 226/ 228

Surface water sample collection will be conducted following the *TDEC, DWR, Quality System SOPs for Chemical and Bacteriological Sampling of Surface Water* (TDEC DWR-WQP-P-01-QSSOP-Chem-Bact-082918, January 2022 Update). Sediment sample collection will follow established EPA methods for sediment sampling, *EPA Region 4, LSASD Operating Procedure, Sediment Sampling* (LSASDPROC-200-R4, 2020). Vegetation sample collection will follow methods established by USDA-APHIS, *Collection of Vegetation Samples* (SOP No. EM-07, revision 10, 9/13/2019), and by the Nevada National Security Site Federal Radiological Monitoring and Assessment Center, *Operator Aid FRMAC Early Phase Vegetation Sample 2020-05*, or similar. Once collected, samples will be submitted to the laboratory for analysis. Results from samples collected during the growing season will be compared to those collected in the winter for each of the following matrices: vegetation (cattails), sediments, and water.

Figure 5.3.1: FCAP Sampling Location

5.3.9 References

DOE/OR/01-2718&D2. 2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments, 40 C.F.R. § 257 (2015)

TDEC, DWR, Quality System SOPs for Chemical and Bacteriological Sampling of Surface Water, DWR-WQP-P-01-QSSOP-Chem-Bact-082918 (January 2022 Update) https://www.tn.gov/content/dam/tn/environment/water/policy-and-guidance/dwr-wqp-p-01-qssop-chem-bac-082918-update-2022-jan.pdf

USDA-APHIS, Collection of Vegetation Samples (SOP No. EM-07, revision 10, 9/13/2019) https://www.aphis.usda.gov/plant_health/plant_pest_info/emt/downloads/07-vegetation.pdf

National Nuclear Security Administration (2012). Operator Aid FRMAC Early Phase Vegetation Sample 2012-03. Federal Radiological Monitoring and Assessment Center. http://nnss.gov/pages/programs/FRMAC/FRMAC_DocumentsManuals.html http://nnss.gov/docs/docs_FRMAC/Operator%20Aid%20FRMAC%20Early%20Phase%20Vegitation%20Sample%202012-03.doc

6.0 OVERSIGHT AND ASSESSMENT

6.1 CERCLA ASSESSMENT AND OVERSIGHT

6.1.1 Background

The Environmental Surveillance Oversight Agreement (ESOA) provides funding for the State *"to perform independent monitoring and oversight of the DOE ORR environmental surveillance program"* including associated data, and further states that evaluation and oversight of DOE's programs may include review of *"monitoring protocol, system design, construction, operation and maintenance; sampling methodology, locations, frequency, procedures and parameters; quality assurance and quality control (QA/QC) methodology, plans and implementation; data collection, verification and management systems; chain-of-custody procedures and implementation; and reporting methods."*

The Federal Facility Agreement (FFA) for the Oak Ridge Reservation states that *"The EPA and TDEC will be permitted to enter the …. Site at reasonable times previously arranged and coordinated for the purpose of inspecting records, logs, and other documents relevant to implementation of this Agreement; reviewing the progress of the DOE, its contractors, and lessees in carrying out the activities under this Agreement; conducting, with prior notice to the DOE, tests which EPA or TDEC deem necessary; and verifying data submitted to EPA and TDEC by DOE." "Upon request by EPA or TDEC, the DOE shall submit to EPA and TDEC copies of records, and other documents, including sampling and monitoring data, that are relevant to oversight activities."*

The milestones listed in Appendix E of the FFA include over 25 projects and subprojects that have a milestone date ranging from March 2022 to September 2024. These projects are associated with Oak Ridge Reservation (ORR) CERCLA activities.

Both planned and potential DOE ORR activities require sufficient environmental safeguards, such as use of administrative and land use controls, management of wastewater and stormwater, and adherence to standard operating procedures (SOPs), among others. This TDEC DoR-OR CERCLA Assessment and Oversight Project will determine if the required FFA protective actions are being implemented.

6.1.2 Related DOE Projects

The 2021 Fifth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site Oak Ridge, Tennessee presents a technical assessment of various DOE environmental programs conducted across the ORR. The annual Remediation Effectiveness Report also provides information on site conditions and remediation progress across the ORR, and Remedial Action Report Comprehensive Monitoring Plans (RAR CMPs) document required site controls and monitoring for administrative watersheds or other designated areas on the ORR.

6.1.3 Problem Statements

To ensure contaminants are not released to the environment during ORR operations, FFA guidelines and the CERCLA process must be followed.

- Failure to follow these guidelines can lead to release of contaminants which can negatively impact human health and the environment.
- In addition, neglecting to follow required sampling procedures, may cause subsequent analytical results data to be indefensible and inaccurate.

6.1.4 Goals

The goal of this project is to conduct CERCLA-based assessments of various DOE ORR projects. Actions to achieve this overall goal are:

- Review DOE and/or contractor documentation for required sampling procedures.
- Create TDEC DoR-OR assessment documents to evaluate DOE and/or contractor ORR activities.
- Observe DOE and/or contractor field activities to assess whether procedures are properly conducted.
- Review DOE and/or contractor field instrument calibration and maintenance logs.
- If feasible, collect quarterly samples for primary contaminants of concern (COC) to compare against parallel DOE sampling analytical data results.
- Review DOE analytical sampling results, to ensure compliance with negotiated and agreed to release criteria.
- Ensure that DOE and/or their contractors follow required SOPs for their various operations.

- TDEC DoR-OR assessments will include but are not limited to oversight of the following DOE activities: accumulated water treatment systems, storm event sampling, surface water sampling, well sampling/monitoring, and sampling referenced in DOE documentation.
- ORR CERCLA activities will dictate DOE environmental program areas to be assessed by TDEC DoR-OR.

6.1.5 Scope

TDEC DoR-OR will conduct assessments for DOE ORR CERCLA related operations to evaluate their compliance with the aforementioned FFA documents and applicable State permits and regulations.

6.1.6 Assumptions

- Documents needed for the project will be submitted to TDEC DoR-OR in a timely manner.
- Adequate staff will be available to monitor and observe DOE field activities.
- TDEC DoR-OR staff will have the necessary training and clearance credentials to enter areas where secured field operations are being conducted.
- DOE sampling analytical results will be submitted to TDEC DoR-OR on a quarterly basis.

6.1.7 Constraints

- Availability of DOE documents relating to project oversight.
- Lack of communication between DOE and/or contractor field samplers and TDEC DoR-OR.
- TDEC DoR-OR staff will have access to DOE and/or contractors records, and data for the projects being monitored.
- Inadequate TDEC DoR-OR funding and/or changes in DOE sample COCs may impact the scope of the project.

6.1.8 Methods, Materials, Metrics

TDEC DoR-OR sample collection will be conducted following the guidelines set forth in the *TDEC, DWR, Quality System SOPs for Chemical and Bacteriological Sampling of Surface Water,* (TDEC DWR-WQP-P-01-QSSOP-Chem-Bact-082918, January 2022 Update).

- DOE analytical results submitted to TDEC DoR-OR will be compared to NPDES permit discharge limits, DOE, EPA, and TDEC DoR-OR agreed-upon-limits or TDEC water quality standards for the receiving body of water.
- Trends in COC concentrations will be reviewed before, during, and after DOE CERCLA operations are undertaken.
- Oversight will be conducted through site visits, field observations, and interviews with DOE and/or contractor site leads, and project managers as needed.
- TDEC DoR-OR field observations, assessments, and sample collection will be conducted while DOE contractors are sampling the same locations.
- If an ORR location is sampled by TDEC DoR-OR, the requested analyte suite will be based on COCs listed in the applicable site ROD, CMP, or the SWPP.

6.1.9 References

TDEC, DWR, Quality System SOPs for Chemical and Bacteriological Sampling of Surface Water, DWR-WQP-P-01-QSSOP-Chem-Bact-082918 (January 2022 Update).

Federal Facility Agreement for the Oak Ridge Reservation, May 19, 1994, FFA-PM/94-009

DOE-TN Oak Ridge Reservation Environmental Surveillance Oversight Agreement

7.0 RADIOLOGICAL MONITORING

7.1 HAUL ROAD SURVEYS

7.1.1 Background

The Tennessee Division of Environment and Conservation's Division of Remediation Oak Ridge Office (TDEC DoR-OR) staff perform surveys of the Haul Road and associated waste transportation routes on the Oak Ridge Reservation (ORR). The Haul Road was constructed and reserved for trucks transporting Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) radioactive and hazardous waste resulting from remedial activities on the ORR to the Environmental Management Waste Management Facility (EMWMF) for disposal.

To account for wastes that may fall from the trucks in transit, Division of Remediation-Oak Ridge (DoR-OR) personnel perform walk-over radiological surveys of different segments of the Haul Road and associated access roads. This project involves performing radiological surveys of the road and any anomalous items found using Sodium Iodide radiation detectors for environmental contamination and Dual Phosphorus radiation detectors for surface contamination.

7.1.2 Related DOE Projects

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

Throughout the history of the Haul Road surveys project, many anomalous items have been identified such as waste debris, personal protection equipment, repair patches for waste tarps, waste stickers, crimped steel pipe from D&D projects, etc.

7.1.3 Problem Statements

Oak Ridge National Laboratory (ORNL) waste was lost from a DOE contractor dump truck on a Tennessee public highway on Friday, May 14, 2004. This event resulted in a DOE Type B Accident Investigation. As a corrective action and in agreement with the State of Tennessee under CERCLA, a dedicated Haul Road for transporting hazardous waste to onsite disposal facilities was constructed. Since then, the State of Tennessee has performed radiological verification surveys of the Haul Road. This project is a CERCLA verification of an ongoing Remedial Action Work Plan for the transportation of waste from East Tennessee Technology Park (ETTP) and occasionally from ORNL and Y-12 to the EMWMF.

Only low-level radioactive waste, as defined in TDEC 0400-02-11.03(21) with radiological concentrations below the limits imposed by the Waste Acceptance Criteria (WAC), as agreed to by the FFA tri-parties, (DOE, EPA and TDEC), is approved to be transported on the Haul Road for disposal in the EMWMF. DOE is accountable for compliance with the EMWMF WAC and has delegated responsibility of WAC attainment decisions to its prime contractor. The WAC attainment decisions include waste characterization and ultimate approval for disposal in the EMWMF (DOE, 2001). TDEC and EPA oversee and periodically audit associated activities related to this work, including the review of the decisions authorizing waste lots for disposal.

7.1.4 Goals

The primary goal is to prevent the spread of contamination, resulting from the transportation of radioactive and hazardous waste, being transported from the originating clean up locations on the ORR to the EMWMF. In particular, the objectives include the following:

- To locate waste that may have been dropped from waste-hauling trucks in transit.
- To assess the radiological conditions of the Haul Road and associated access roads.
- To allow DOE and their contractor to continue their waste transportation in a manner that limits the environmental harm to the Haul Road and surrounding areas.
- To verify DOE surveys of the Haul Road and associated access roads.

7.1.5 Scope

The scope of this project is limited to locating, surveying, and reporting to DOE any ORR derived waste materials that may have been lost from waste-hauling trucks on the EMWMF Haul Road and any associated access roads that are currently being used to transport waste.

7.1.6 Assumptions

- Radioactive spills or materials found along ORR Haul Road and associated access roads can be attributed to the transportation activities on the ORR.
- DOE will continue to use the ORR Haul Road and associated access roads to transport waste.
- DOE waste shipments on the ORR Haul Road and associated access roads have the potential to spread radiological contamination.

- TDEC DoR-OR will have enough manpower to conduct these surveys.
- Radiological instruments will be available to TDEC DoR-OR staff to conduct surveys.

7.1.7 Constraints

- There may be a shortage of available staff to conduct these surveys.
- Instrumentation may not be available when other staff have detectors signed out or being calibrated.
- Reserving a vehicle may not be possible, particularly with impromptu scheduling.
- Weather is a limiting factor; surveys should not be conducted in the rain, snow, or extreme temperatures.

7.1.8 Methods, Materials, Metrics

The nine-mile-long Haul Road is surveyed in segments, typically consisting of one to two miles (Figures 7.1.1 – 7.1.6). Since ETTP has reduced transporting waste to the EMWMF, this main section will only be surveyed when hauling of waste is occurring. A baseline survey of the approximately 1.1-mile extension of the Haul Road from EMWMF to Y-12 will be performed when the appropriate approvals are obtained from DOE and its contractors. The Reeves Road access to the Haul Road connects ORNL with the main section of the Haul Road. Reeves Road will be surveyed should it be used for hauling waste. For safety and by agreement with DOE and its contractors, TDEC DoR-OR staff coordinate with Haul Road site personnel when TDEC DoR-OR personnel intend to perform a survey on the Haul Road. The DOE contractor is responsible for providing briefings on road conditions and any known situation that could present a safety hazard while on the road. When the DOE contractor is not available, staff members call into the designated DOE site safety office for the segment being surveyed. Alternate entrances are sometimes used to survey the road with DOE approval, but the basic requirements remain the same. Should excessive traffic or road dust present a safety concern, the survey can be postponed to a later date.

When TDEC DoR-OR staff members arrive at the segment of the road to be surveyed, the vehicle is parked completely off the road, as far away from vehicular traffic as possible. No fewer than two people perform the surveys, each walking in a serpentine pattern along opposite sides of the road to be surveyed or one person walking in a serpentine pattern across the entire road accompanied by an approved safety buddy. Typically, a Ludlum Model 2221 Scaler Ratemeter with a Model 44-10 2”X2” NaI Gamma Scintillator probe, held approximately six inches above ground surface, is used to scan for radioactive contaminants as the walkover proceeds. A Ludlum 2224 Scaler with a Model 43-93 Alpha/Beta dual detector is used to investigate potential surface contamination on the road surfaces or anomalous items found along the road that may be associated with waste

shipments. Any areas or items with contamination levels exceeding 200 dpm/100 cm2 removable beta, 1000 dpm/100 cm2 total beta, 20 dpm/100 cm2 removable alpha, and/or 100 dpm/100 cm2 total alpha are noted for further investigation.

Anomalous items from potential waste lots, found during the survey, are marked with contractor's ribbon at the side of the road and a description of each item and its location are logged and reported to DOE and its contractors for disposition. Anomalous items may have the potential of containing non-radiological hazardous constituents. A survey form is completed for each walkover and is retained at the TDEC DoR-OR office. When staff members return to the road for the subsequent inspection, a follow-up inspection of items found and reported during previous weeks is performed. If any items remain on the road, they are included in subsequent reports until removed by DOE or staff members are advised by DOE that the item(s) have been determined to be free of radioactive and hazardous constituents. The planned road survey walk down schedule is:

- Six surveys will be completed over a 12-month period, dependent on waste hauling activity on the Haul Road or any of the access roads.

Figure 7.1.1: Haul Road Section 1, K-25 to Zirconium Street

Figure 7.1.2: Haul Road Section 2, Zirconium Street to the firing range cut off

Figure 7.1.3: Haul Road Section 3, firing range cut off to the heavy equipment staging area

Figure 7.1.4: Haul Road Section 4, heavy equipment staging area to Highway 95

Figure 7.1.5: Haul Road Section 5, Highway 95 to Reeves Road

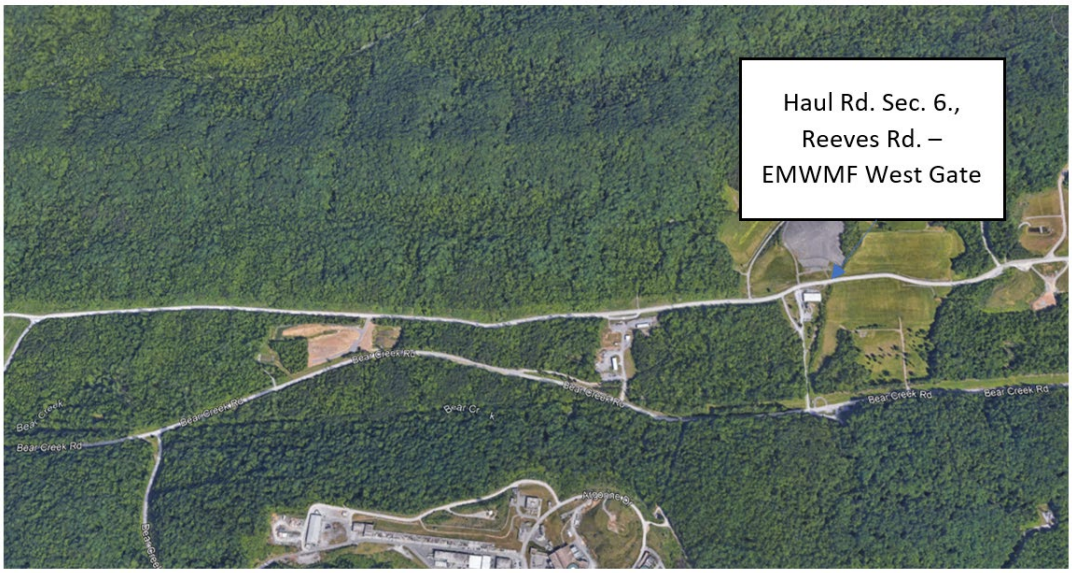

Figure 7.1.6: Haul Road Section 6, Reeves Road to the EMWMF west gate

7.1.9 References

Remedial Action Work Plan for the Operation of the East Tennessee Technology Park to Environmental Management Waste Management Facility (ETTP-EMWMF) Haul Road on the Oak Ridge Reservation, Oak Ridge, Tennessee. (2005) DOE/OR/01-2220&D1. U.S. Department of Energy.

Tennessee Department of Environment and Conservation (TDEC), Division of Remediation. Operation and Use of a Ludlum Model 2224 (-1) and 43-93 Probe (Dual Phosphorus Meter) (SOP T-532). 2019.

Tennessee Department of Environment and Conservation (TDEC), Division of Remediation. Operation and Use of a Ludlum Model 2221 and 44-10 Probe (NaI Meter) (SOP T-540). 2019.

7.2 Real Time Measurement of Gamma Radiation

7.2.1 Background

ETTP began operations during World War II as part of the Manhattan Project. Its original mission was producing uranium, enriched in the uranium-235 isotope (U-235), for manufacturing the first atomic weapons and later for fueling commercial- and government-owned reactors. The weapons production facility permanently shut down in 1987.

Consequential to operational practices and accidental releases, the facilities at ETTP were contaminated to some degree and have undergone decontamination and decommissioning (D&D). Uranium isotopes are the primary contaminants, but technetium-99 and other fission and activation products are also present, due to the periodic processing of recycled uranium, obtained from spent nuclear fuel.

The Y-12 site was constructed during World War II for enriching uranium in the U-235 isotope by using the electromagnetic separation process. In ensuing years, Y-12 was expanded and used for producing fuel for naval reactors, conducting lithium and mercury enrichment operations, manufacturing components for nuclear weapons, dismantling nuclear weapons, and storing enriched uranium.

Construction of the ORNL site began in 1943. While the initial missions of K-25 and Y-12 were producing enriched uranium, ORNL focused on researching reactors and producing plutonium and other activation and fission products chemically extracted from uranium irradiated in ORNL's graphite reactor and later at other ORNL and Hanford reactors.

During early operations, leaks and spills were common within the facilities and resulting radioactive materials were released from operations as gaseous, liquid, and solid effluents, with little or no treatment. The EMWMF near Y-12 in Bear Creek Valley was constructed for the disposal of low-level radioactive and hazardous wastes generated by Remedial Actions on the ORR.

7.2.2 Related DOE Projects

The DOE conducts ambient gamma sampling at the ORR perimeter sampling locations to ensure DOE's primary dose limit for protecting members of the public (100 mrem/year) is not exceeded. The TDEC DoR-OR Real Time Measurement of Gamma Radiation Project is conducted closer to potential sources and would be an indication of potential offsite influences. Sampling closer to the sources would more likely give an indication of the effect to onsite members of the public.

7.2.3 Problem Statements

Facilities on the ORR have the potential to release variable amounts of gamma radiation. The TDEC DoR-OR Real Time Monitoring of Gamma Radiation Project focuses on measuring and determining radioactive exposure rates under conditions where gamma emissions can be expected to fluctuate substantially over relatively short periods of time because the potential for an unplanned release of gamma emitting radionuclides into the environment exists.

7.2.4 Goals

Results from monitored sites will be compared to the State of Tennessee (State) and NRC limit of two mrem in one hour to determine the maximum dose exposure to an unrestricted area. The results will also be compared to the State and DOE primary dose limits for protecting members of the public (100 mrem/year).

7.2.5 Scope

This project measures ambient gamma radiation dose/exposure rates at areas on the ORR more likely to have variable dose rates over time. Candidate monitoring locations include sites on the ORR with remedial activities, waste disposal operations, pre and post operational investigations, and environmental response activities. Data recorded by the monitors will be evaluated by comparing it to background concentrations and to the State and NRC maximum dose limit for members of the public.

7.2.6 Assumptions

Sampling locations may not always be accessible due to operational or security concerns.

7.2.7 Constraints

Placement of the gamma radiation monitors can be less than optimal due to facility operational constraints. The gamma radiation monitors cannot interfere with traffic, facility access, or facility operations. Their placement is limited to locations where the security of the instrument can be assured. At most locations, but not all, the monitors can be chained and locked for security.

Monitoring data must be manually downloaded which requires the technician to visit the site. Consequently, delays may result in a timely response to anomalies.

7.2.8 Methods, Materials, Metrics

The gamma exposure rate monitors deployed for this project are manufactured by Genitron Instruments and are marketed under the trade name, GammaTRACER®. Each monitor contains two Geiger Mueller tubes, a microprocessor-controlled data logger, and lithium batteries sealed in a weather resistant case to protect internal components. Each monitor can be programmed to measure gamma exposure rates from one μrem/hour to one rem/hour for predetermined intervals from one minute up to two hours.

The results reported by this project are derived from averaging the values of the data recorded by the two Geiger Mueller detectors. The data for any interval from either detector can be independently accessed and used. The results recorded by the data loggers are downloaded monthly, except for the semiannual downloads at the background location, to a TDEC DoR-OR computer using an infrared transceiver and associated

software. Results from monitored sites will be compared to the State and NRC limit of two mrem in one hour to determine the maximum dose exposure as well as to the results from the exposure rate monitor at the background location at Fort Loudoun Dam. The following locations (Figure 6.4.1) are planned for monitoring.

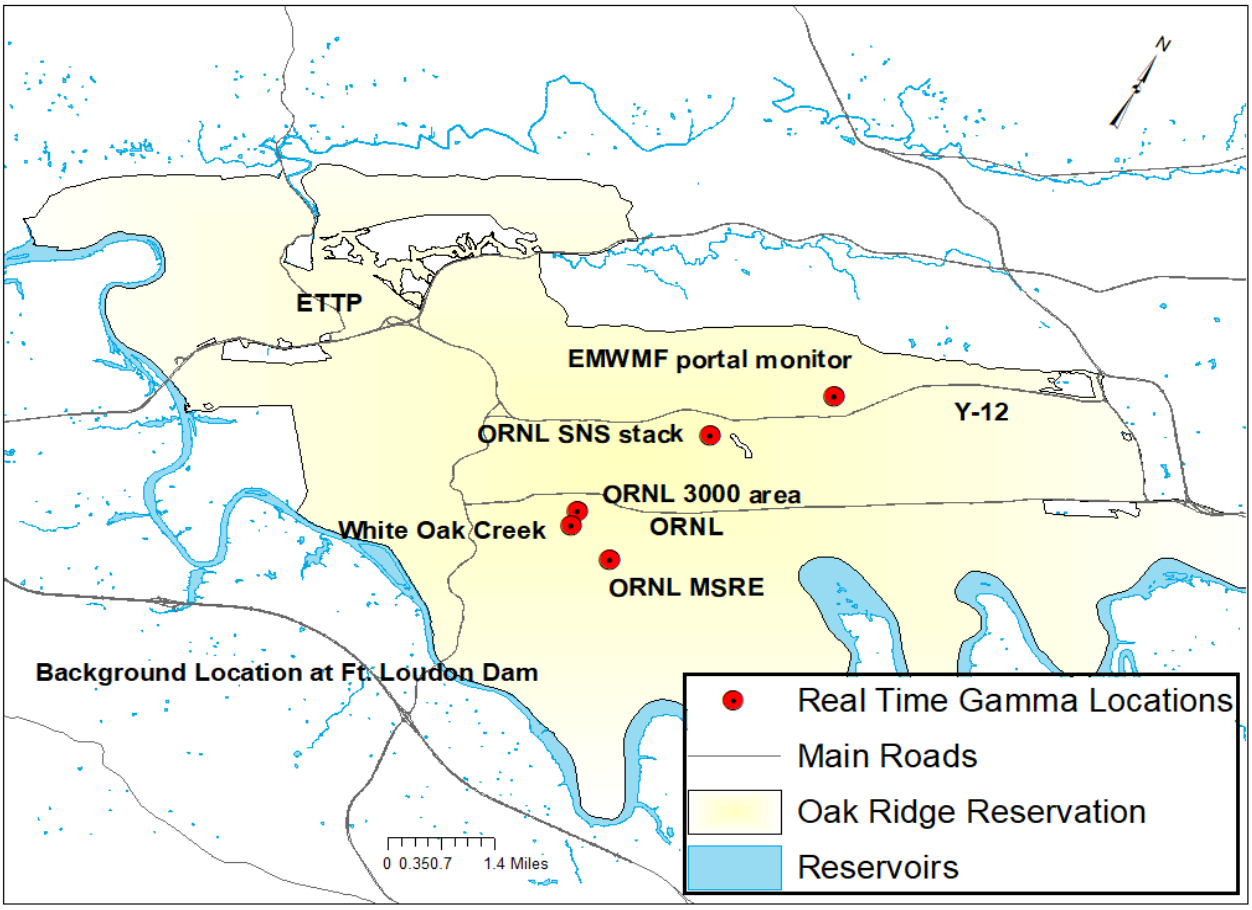

Figure 7.2.1: Current sampling Locations

7.2.9 References

NRC Regulations (10 CFR) >Part Index > § 20.1301 Dose limits for individual members of the public

7.3 SURPLUS SALES VERIFICATION

7.3.1 Background

To verify DOE ORR surplus materials are safe to be sold to the public, TDEC DoR-OR conducts radiological surveys of these surplus items. In addition to performing the surveys, TDEC DoR-OR reviews DOE procedures used for the release of materials in accordance with DOE radiological regulations, DOE O 458.1 Admin Chg. 3, *Radiation Protection of the Public*

and the Environment. The project will utilize the guidance set forth in the *Multi-Agency Radiation Survey and Assessment of Materials and Equipment* (MARSAME) manual. Some materials, such as scrap metal, may be sold to the public under annual sales contracts, whereas other materials are staged at various sites around the ORR awaiting auction i.e., sale.

Y-12 now uses an out-of-state contractor to handle the majority of their sales. ORNL has a list of organizations approved to bid on sales of materials by the truckload.
TDEC DoR-OR, at the request of ORNL and Y-12 Property Excessing staff, conducts radiological verification screening surveys to help ensure that no potentially contaminated materials reach the public. In the event a surveyed item's radiological activity is detected above the contamination limits set forth in NUREG-1757, Volume 1, Revision 2, Section 15.11.1.1 Release of Solid Materials with Surface Residual Radioactivity (Schmidt et al., 2006) or Reg. Guide 1.86, a quality control check is made with measurements from a second meter. If both meters show elevated activity, TDEC DoR-OR immediately reports the finding(s) to the surplus sales program supervisor. A removable contamination assessment may be performed on the item. Radiological activity is recorded in dpm/100 cm^2 (dpm = disintegrations per minute) and then reported. TDEC DoR-OR then follows the response of the sales organizations to see those appropriate steps (i.e., removal of items from sale, resurveys, etc.) are taken to protect the public.

7.3.2 Related DOE Projects

DOE Radiation Control personnel scan most materials before they are submitted for auction at ORNL or Y-12 surplus sales. Process knowledge may also be used for judging the appropriateness of release of equipment or materials to the public.

7.3.3 Problem Statements

- If present, the source of incidental radioactive contamination on any surface is most likely related to activities in the building or area from which the material was being used. Material and/or equipment from such locations should be scanned to ensure that no accidental transfer of contaminated equipment occurs during surplus equipment sales. DOE and its contractors follow procedures for unrestricted release of material and equipment and process knowledge. TDEC DoR-OR is invited to, and routinely elects to do an additional scan before an auction.

- Even if items of concern are found with surface activity, they may not ultimately prove to be problematic as it could be attributed to naturally-occurring radon (Rn) daughter isotopes, Naturally Occurring Radioactive Material (NORM), or Technically Enhanced Naturally Occurring Radioactive Materials (TENORM).

7.3.4 Goals

Although DOE made great progress in the reduction of Surplus Sales contaminated material from 2021 through 2022, TDEC DoR-OR staff continued to identify contaminated material or material with elevated radiological activity. TDEC DoR-OR's goal is to verify materials that have been staged for sale at ORNL's 115 Union Valley Road Property Excessing Facility or other locations are free of radiological surface contamination exceedances. The project attempts to locate any contaminated items that may have evaded detection prior to being staged for sale. In rare instances where items of concern are found, it prevents the release of potentially contaminated materials to the public.

7.3.5 Scope

TDEC DoR-OR staff conduct pre-auction verification surveys on items being surplused by ORNL's Excess Properties Sales. These surveys are performed at the request of ORNL's Excess Properties staff. When a request is received, every attempt is made to fulfill that request. Typically, no more than eight events occur during a calendar year. Since the inception of the project, TDEC DoR-OR has had no difficulty responding to all requests.

7.3.6 Assumptions

- Funding and budget will be sufficient.
- State vehicle will be serviceable and available for the survey.
- Adequate staff will be available for the survey.
- A sufficient number of appropriate surface contamination meters will be available for the survey.
- TDEC DoR-OR will follow up on resolution of the identified potential issues.

7.3.7 Constraints

- A State vehicle not available for the survey.
- Adequate staff may not be available for the survey.
- A sufficient number of appropriate surface contamination meters may not be available for the survey.
- The budget and equipment calibration costs may change during the fiscal year.
- There may be circumstances where work is suspended because of natural events or emergencies.

7.3.8 Methods, Materials, Metrics

Prior to sales of surplus items from ORNL or Y-12 to the public, TDEC DoR-OR conducts a pre-auction survey. Depending on the availability of staff, typically one to three staff members perform a verification survey. The intent of a survey is to spot check items that are for sale with appropriate radiation survey instruments in order to help ensure that no radioactively contaminated items are released to the public. Accordingly, not all items or surfaces of a specific item are surveyed for potential radioactive contamination. Specific (targeted) often referred to as *biased* measurements are often used where specific attention is paid to well-used items where material damage, uncleanliness, or staining is present. However, clean looking items may also be checked. When radiological activity (alpha or beta/gamma) above the contamination limits is detected, the item is brought to the attention of Property Excessing staff.

Based on TDEC DoR-OR's survey results, it is the Property Excessing's decision whether or not to have the item rechecked by ORNL RADCON. TDEC DoR-OR does not attempt to determine if a particular item meets DOE release criteria, but does try to locate items where, depending on the isotopes involved, there is a potential for the item to not meet release criteria.

7.3.9 References

Schmidt, D.W, K.L. Banovac, J.T. Buckley, D.W. Esh, R.L. Johnson, J.J. Kottan, C.A. McKenney, T.G. McLaughlin, S. Schneider. (2006) Consolidated Decommissioning Guidance, NUREG-1757, 2. Retrieved fromhttps://www.nrc.gov/docs/ML0630/ML063000252.pdf

TDEC. (2018). Standard Operating Procedure: T-525 Radiation Instrument Correction Factors, Pre-checks, and Survey Documentation (Draft). Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office. Oak Ridge, Tennessee.

TDEC. (2018). Standard Operating Procedure: T-532 Operation and Use of a Ludlum Model 2224 and 44-10 Probe (Dual Phosphorus Meter) (Draft). Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office. Oak Ridge, Tennessee.

8.0 SURFACE WATER MONITORING

8.1 AMBIENT SURFACE WATER PARAMETERS

8.1.1 Background

The ORR consists of three (3) major sites: ORNL, Y-12, and ETTP. Activities at these sites, both historically and now, have resulted in the discharge of hazardous substances (e.g., metals, organics, and radioactive materials) leading to the contamination of waterbodies on the ORR and in the surrounding areas (DOE, 1992; DOE, 2021; Pickering, 1970; Turner & Southworth, 1999). While legacy waste across the ORR may be responsible for a large portion of the contamination to surface water, current projects and processes at these sites also have the potential to significantly contribute to surface water contamination.

In an effort to both complement and verify the DOE environmental program and to ensure the health of citizens and environmental resources of Tennessee are not severely impacted by surface water contamination, this Ambient Surface Water Parameter Project has been implemented each year since 2005. This Project aims to assess the degree of surface water impact relative to potential contamination displacement. To accomplish this, stream monitoring data are proposed to be collected monthly to establish and build upon a database of physical stream parameters (specific conductivity, pH, temperature, and dissolved oxygen).

8.1.2 Related DOE Projects

DOE has conducted a surface water monitoring program for several years that consists of sample collection and analysis from various locations on the Clinch River. As part of this program, stream water quality parameters are measured at the time of sampling (DOE, 2019). However, as this DOE program is focused on the Clinch River, many ORR surface water exit-pathway streams that flow into the Clinch River are not frequently monitored. Thus, this complementary TDEC DoR-OR project allows for further monitoring of water quality parameters on various exit-pathway streams from the ORR.

8.1.3 Problem Statements

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

Identified concerns include but are not limited to the following:

- From 1950 to 1963, Y-12 released approximately 100 metric tons of elemental mercury into East Fork Poplar Creek (EFPC). Mercury has been released into the environment by spills, leakage from subsurface drains, and purposed discharge of

wastewater. Contaminated building foundations and soils also contributed to these mercury releases (Turner and Southworth, 1999).

- EFPC is believed to contribute approximately 0.2 metric tons of mercury into the Clinch River each year (DOE, 1992).
- Besides mercury, other metals that have been found in ORR exit pathway streams at levels greater than background include cadmium, chromium, lead, nickel, silver, and zirconium (DOE, 1992).
- Roughly 7.5 million L/yr of uranium contaminated nitric acid wastes and other liquid wastes were disposed in the S3 ponds, at the headwaters of Bear Creek, between 1951 and 1984 (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 in the unlined Bear Creek Burial Grounds between 1955 and 1989 which are adjacent to Bear Creek (Moss et al. 1999).

As DOE's current surface water monitoring program focuses solely on the Clinch River (DOE, 2021), TDEC DoR-OR's Ambient Surface Water Parameters project will complement DOE's project by helping to identify any shifts or changes in water quality parameters in three (3) ORR exit-pathway streams. An additional background stream will also be measured for comparison to the selected ORR streams.

8.1.4 Goals

The goal of TDEC DoR-OR's Ambient Surface Water Parameters project is to measure surface water parameters in EFPC, Bear Creek (BC), and Mitchell Branch within the ORR to complement DOE's surface water monitoring program, generate and provide data that can assist in the evaluation of site activities, and record ambient conditions that can be used for comparisons in the event of unexpected releases that may have impacted surface water bodies. Mill Branch will also be measured to serve as an offsite background stream. See Figure 7.1.1 and Table 7.1.1 below for sample locations.

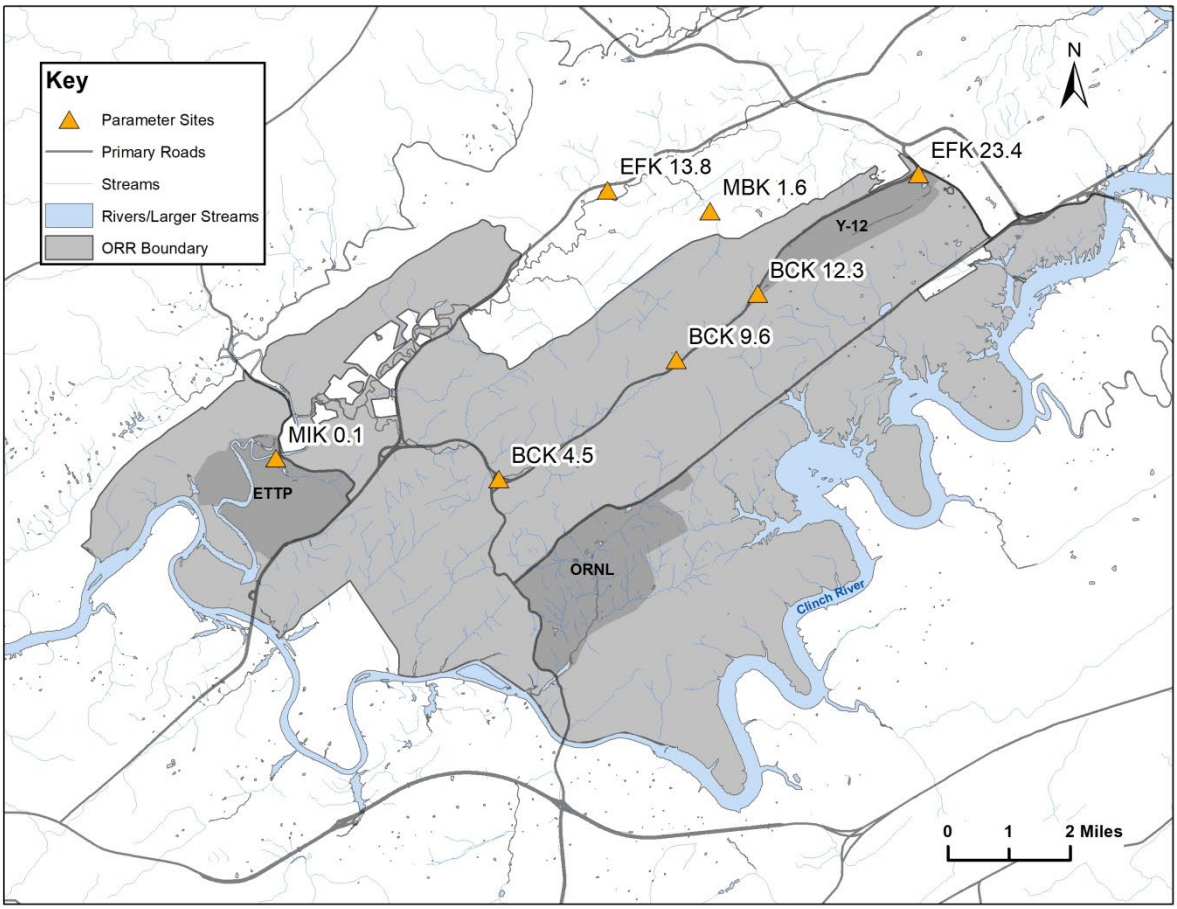

Figure 8.1.1: Map showing TDEC DoR-OR proposed surface water parameter sites

Table 8.1.1: Proposed site locations

Site DWR Name	DOE-O Site Description	DOE-O Site	Site Latitude	Site Longitude
EFPOP014.5AN	East Fork Poplar Creek Mile 14.5	EFK 23.4	35.99596	-84.24004
EFPOP008.6AN	East Fork Poplar Creek Mile 8.6	EFK 13.8	35.99283	-84.31371
BEAR007.6AN	Bear Creek Mile 7.6	BCK 12.3	35.973	-84.27814
BEAR006.0AN	Bear Creek Mile 6.0	BCK 9.6	35.96032	-84.29741
BEAR002.8RO	Bear Creek Mile 2.8	BCK 4.5	35.9375	-84.33938
MITCH000.1RO	Mitchell Branch Mile 0.1	MIK 0.1	35.94146	-84.3922
FECO67I12	Mill Branch Mile 1.0	MBK 1.6	35.98886	-84.28935

Each month, physical water parameters (e.g., conductivity, dissolved oxygen, pH, and temperature) will be measured at each site. Results will be analyzed using statistical programming software to identify trends as well as any anomalous data.

8.1.5 Scope

This project is limited to the characterization of physical stream parameters of three ORR exit-pathway streams (EFPC, BC, and Mitchell Branch) and one (1) offsite background stream (Mill Branch).

8.1.6 Assumptions

The assumptions for this project include:

- Ambient physical parameters at the Mill Branch background station are indicative of a normal healthy stream.
- Baselines or trends are already established for the physical parameters at the sampling stations.
- The background stream will be sufficient in providing a baseline for comparison to the selected ORR streams.

8.1.7 Constraints

This project is contingent on funding, manpower, and access to ORR controlled areas.

8.1.8 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, and temperature (°C) will be recorded along with the time of measurement. Measurements will be taken in accordance with the Tennessee Department of Environment and Conservation Division of Water Resources Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2018).

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 background stream using statistical approaches such as an analysis of variance to determine if they are significantly similar in water parameter measurements.

8.1.9 References

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8.2 AMBIENT SURFACE WATER SAMPLING

8.2.1 Background

The ORR consists of three (3) primary site facilities including ORNL, Y-12, and ETTP. Activities at these facilities have resulted in the discharge of hazardous substances (e.g., metals, organics, and radioactive materials) causing contamination of waterbodies on the ORR and in the surrounding areas (DOE, 1992; DOE, 2018; Pickering, 1970; Turner & Southworth, 1999).

While legacy waste across the ORR may be responsible for a large portion of contamination to surface water, current projects and processes at these sites also have the potential to significantly contribute to surface water contamination. To monitor potential contamination, an ambient surface water sampling project has been implemented each

year since 1993. This monitoring Project began by investigating the water quality of the Clinch River (CR) at five (5) locations near the ORR. The sampling locations for this project have been modified throughout the years, sometimes adding, or discontinuing sampling at particular locations. Most recently, monitoring focused on Poplar Creek (PC) as well as the Clinch River. This project monitors surface water conditions by sampling for contaminants in waterways that have been impacted by past and present activities on the ORR.

8.2.2 Related DOE Projects

DOE has implemented a surface water monitoring program for several years that consists of sample collection and analysis from a few locations along the Clinch River (DOE, 2017; DOE, 2019; DOE, 2020; DOE, 2021). Currently, DOE collects samples quarterly at four (4) sites along the Clinch River at river kilometers 16, 32, 58, and 66 (Figure 7.2.1) (DOE, 2021). Of these sites, CRK 58 is near the water supply intake for Knox County, and CRK 66 is upstream of the Oak Ridge City water supply intake. Grab samples are collected at these four (4) sites and are analyzed for water quality parameters such as dissolved oxygen, pH, and water temperature. Samples are also screened for radioactivity by investigating gross alpha, gross beta, and gamma disintegrations. At three (3) of the four (4) sites, analyses are performed to investigate concentrations of mercury. However, mercury samples are not collected by DOE from the Knox County water supply site (CRK 58). Strontium-90 is analyzed at three (3) of the sites: at the confluence of the White Oak Creek (WOC) and Clinch River near ORNL, upstream of the Oak Ridge City water supply intake, and downstream of the ORR.

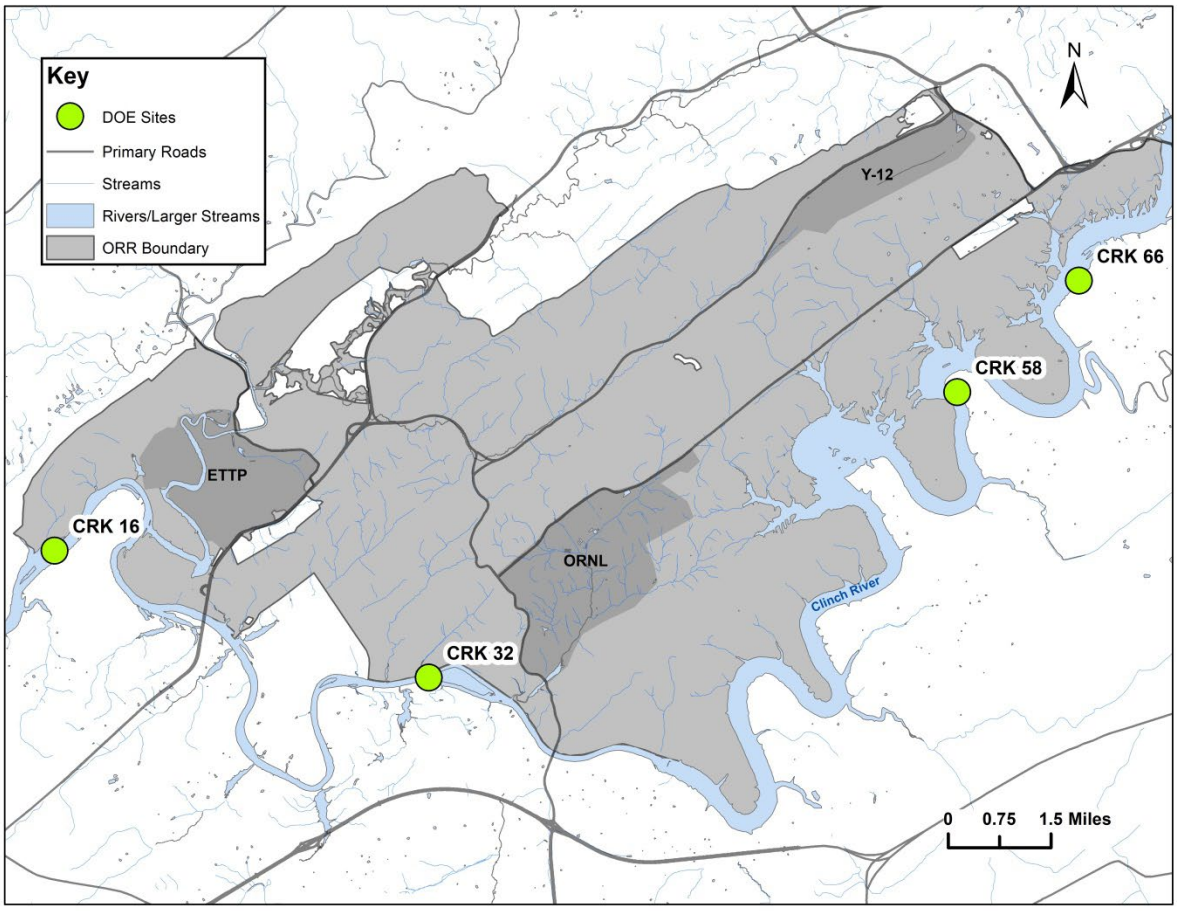

Figure 8.2.1: Map showing DOE sampling sites

The purpose of the current DOE Surface Water Monitoring Project is to assess the impacts from both past and present site operations to surface water bodies as well as to assess the impact of radioactivity to human health. Respective analyte maximum contaminant levels (MCLs) as defined by the EPA are used to determine potential impacts (EPA, 2009).

While the current DOE project solely samples the Clinch River, the TDEC DoR-OR Surface Water Sampling Project will build upon DOE's sampling by looking at two ORR exit-pathway streams. These streams are Bear Creek (BC) and East Fork Poplar Creek (EFPC). Samples will be collected at several locations in these streams with the intent to provide a more representative evaluation of the potential bio-accumulative contaminants from ORR facilities. Additional co-sampling will also be performed at each of the four (4) DOE Clinch River sites (CRK 16, 32, 58, 66) with one site co-sampled quarterly. These co-sampling events will provide data validation and supplementary data for the DOE project. All sites will be compared to EPA MCLs to determine stream impacts.

8.2.3 Problem Statements

This Project will supplement DOE's study of the Clinch River to better understand impacts of exit-pathway streams to human health and the environment. It is estimated, based on 2017 US census data, that nearly 1.2 million people live in the counties surrounding the ORR (DOE, 2017). A large portion of these people have the potential of being exposed to streams that drain from the ORR. All of the exit-pathway streams on the ORR eventually flow into the Clinch River. In turn, the Clinch River ultimately flows into the Tennessee River. Twelve water supplies are located on these rivers within 170 river miles downstream of WOC (DOE, 1992). The Clinch River alone provides drinking water as well as water for industrial use to many municipalities near and downstream of the ORR. These include Anderson County, Knox County, Roane County, the City of Clinton, the City of Kingston, the City of Norris, and the City of Oak Ridge. The Clinch River surface waters are also used for facilities at Y-12, ORNL, and ETTP. It is important to monitor these exit-pathway streams, as well as the Clinch River, to better understand the ORR's impact on the region's widely used water resources.

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

Identified concerns include but are not limited to the following:

- From 1950 to 1963, Y-12 released approximately 100 metric tons of elemental mercury to EFPC by spills and leakage from subsurface drains, building foundations, and contaminated soil, as well as purposed discharge of wastewater containing mercury (Turner and Southworth, 1999).
- EFPC is believed to contribute approximately 0.2 metric tons of mercury to the Clinch River each year (DOE, 1992).
- In addition to mercury, other metals that have been found in ORR exit pathway streams at levels greater than background are cadmium, chromium, lead, nickel, silver, and zirconium (DOE, 1992).
- Regarding Bear Creek, DOE has stated, "The primary contaminants in the surface water are uranium, nitrate, and cadmium. The S-3 site currently contributes approximately 26% of the risk at the [Bear Creek Valley] Watershed Integration Point through releases of uranium" (DOE, 1999).
- Roughly 7.5 million L/yr of uranium contaminated nitric acid wastes and other liquid wastes were disposed in the S3 ponds, at the headwaters of Bear Creek, between 1951 and 1984 (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 in the unlined Bear Creek Burial Grounds between 1955 and 1989 which are adjacent to Bear Creek (Moss et al. 1999).

Monitoring ORR exit-pathway streams will help assess which ORR facilities are contributing to surface water pollution. This monitoring will provide insight to help protect human health and the environment from potential ORR surface water pollution.

8.2.4 Goals

The goal of this Surface Water Monitoring Project is to evaluate the presence and quantity of bio-accumulative contaminants from Bear Creek and East Fork Poplar Creek. The Clinch River will also be monitored in conjunction with DOE sampling (Figure 7.2.2). Mill Branch (MB) will be used as a background comparison site. This project will ultimately seek to understand the presence and quantity of bio-accumulative metals and compounds such as PCBs in surface water to better understand possible pathways and sources for biota intake. PCB analysis method (EPA 8082) used by DOE does not allow the proper resolution to compare results to the TN water quality criteria (TDEC, 2019). Thus, this project will use the EPA 1668A-C method for PCBs, which has a much lower detection limit than EPA 8082. By using this method, a significant data gap will be addressed which may help to address the presence of PCBs in BC and EFPC. An assessment of each stream, including the Clinch River, will be performed by comparing sampling results to general water quality criteria for organisms (TDEC, 2019) and the EPA defined maximum contaminant levels (EPA, 2009). This project will help to identify areas of concern on the ORR that may significantly impact the surface water resources of Tennessee's citizens.

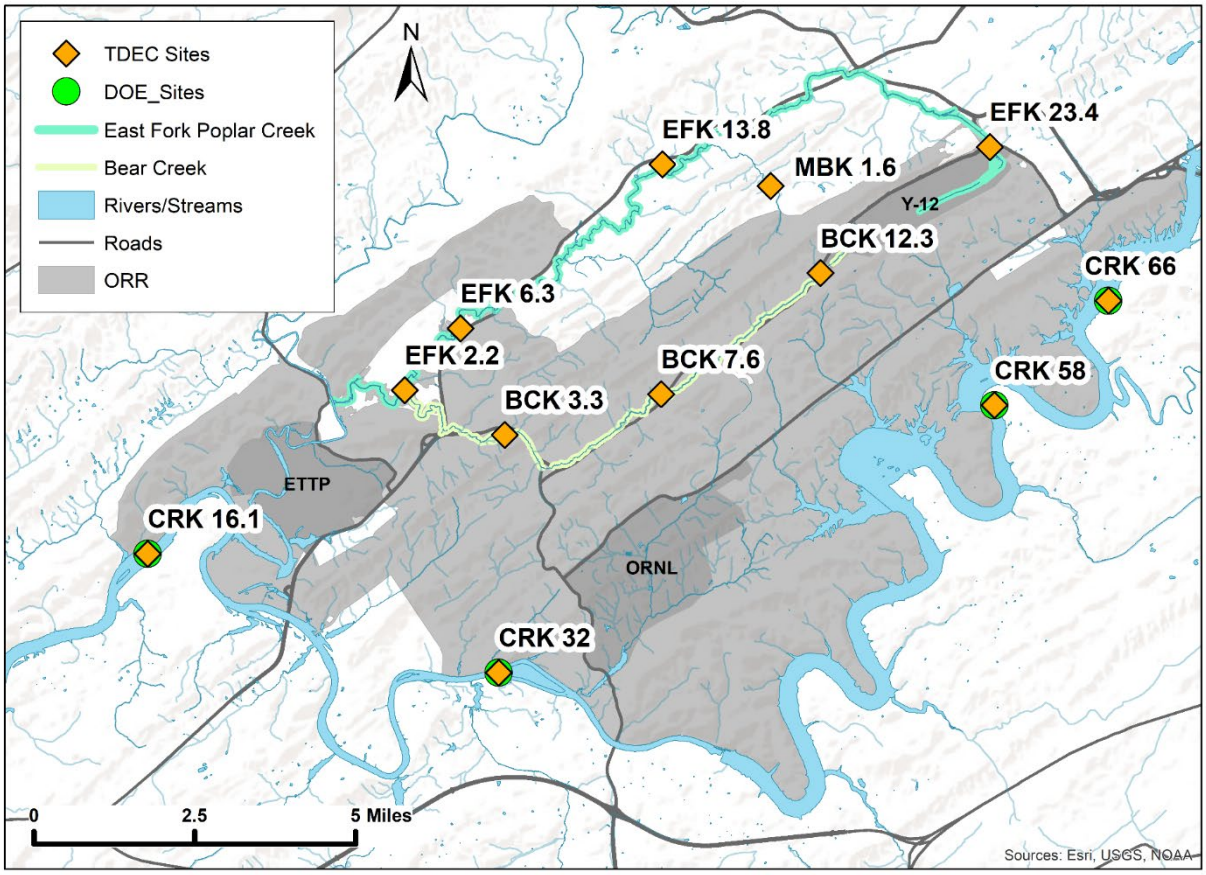

Figure 8.2.2: Map showing proposed TDEC DoR-OR sites and DOE sampling sites. The number associated with each site represents the distance in kilometers from the mouth of the stream or river to that location. EFK represents (East Fork Poplar Creek Kilometer) and BCK represents (Bear Creek Kilometer). CRK and MBK represent (Clinch River Kilometer) and (Mill Branch Kilometer), respectively.

To accomplish this goal, several objectives need to be completed. These objectives include:

1. Collect surface water samples quarterly at Bear Creek, East Fork Poplar Creek, one ORR background stream (Mill Branch), and the Clinch River (Figure 7.2.2).

    - Bear Creek (BCK): sample three (3) locations at (BCK 12.3, BCK 7.6, and BCK 3.3) for metals and nutrients quarterly. Radionuclide samples and PCBs will be collected in the spring quarter sampling.

    - East Fork Poplar Creek (EFK): sample four (4) locations at (EFK 23.4, EFK 13.8, EFK 6.3, and EFK 2.2) for metals and nutrients quarterly. Radionuclide samples and PCBs will be collected in the spring quarter sampling.

- Mill Branch (MBK): sample one (1) location at MBK 1.6 for metals and nutrients quarterly. Radionuclide samples and PCBs will be collected in the spring quarter sampling. This information is to be used as a background comparison stream to the onsite streams.

- Clinch River (CRK): co-sample 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. These sites will be sampled for gross alpha/beta, isotopic uranium, mercury, and strontium-90.

2. Measure physical water parameters (e.g., conductivity, dissolved oxygen, pH, and temperature) at each site at time of sampling.

3. Evaluate resulting data

    - Results from CR sites will be compared with DOE co-sampling results (statistical methods such as analysis of variance may be used to show any significant differences).

    - Results will be compared to historical TDEC DoR-OR data. Statistical methods such as an analysis of variance may be used to show significant differences from historical data.

    - Statistical programming software and mapping technology will be used to identify increasing or decreasing trends in data.

8.2.5 Scope

The scope of this project is to characterize stream conditions and assess contaminant presence through sampling and analysis of surface water from Bear Creek and East Fork Poplar Creek, which ultimately flow into the CR. A segment of the CR will also be assessed spanning from the Oak Ridge City water supply intake at CRK 66 downstream to CRK 16.1 which is downstream of all ORR exit stream inputs.

8.2.6 Assumptions

The scope of this project is based on the following assumptions:

- Metal and PCB contamination of EFPC is attributable to activities at Y-12.

- Potential stream contamination is attributable to DOE activities on the ORR.

- Scheduling will allow for co-sampling with DOE.

- The TDEC DoR-OR physical parameter water quality meter remains operational.

8.2.7 Constraints

Constraints that may impact this project include:

- Availability of funding, manpower, and access to controlled areas on the ORR.
- Laboratory costs remain the same throughout the project.
- Streams have adequate flow for sampling.
- Excessive rain or drought which may prevent the ability to adequately sample.

8.2.8 Methods, Materials, Metrics

Sample Collection

Surface water samples will be collected quarterly at three (3) sites on BC, four (4) sites on EFPC, and one (1) site on MB, the background stream. Each quarter, one (1) of four (4) CR sites will be co-sampled, with each CR site being sampled once throughout the project. Samples from BC and EFPC will be sampled and analyzed for bio-accumulative metals and for nutrients. Additionally, the BC and EFPC sites will be analyzed for radionuclides (gross alpha and beta activity) as well as PCBs in the spring quarter sampling. Samples collected from the CR sites will be analyzed for gross alpha/beta, mercury, and strontium-90 (Table 7.2.1). Quality assurance/quality control (QA/QC) samples will be collected for every 10th sample of any given analyte (Table 7.2.1). Sampling protocols will follow the Tennessee Department of Environment and Conservation Division of Water Resources Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water (TDEC, 2022).

Table 8.2.1: Planned samples and site information

		Planned (in EMP)					
DOE-O Site Description	**DoR-OR Site**	**Sr-90**	**PCBs**	**Rads***	**Mercury**	**Nutrients***	**Metals***
Clinch River Mile 10.0	CRK 16.1			1	1		
Clinch River Mile 19.7	CRK 32	1		1	1		
Clinch River Mile 36.0	CRK 58			1	1		
Clinch River Mile 41.0	CRK 66			1	1		
Bear Creek Mile 7.6	BCK 12.3		1	1	1	4	4
Bear Creek Mile 4.7	BCK 7.6		1	1	1	4	4
Bear Creek Mile 2.0	BCK 3.3		1	1	1	4	4
East Fork Poplar Creek Mile 14.5	EFK 23.4		1	1	1	4	4
East Fork Poplar Creek Mile 8.6	EFK 13.8		1	1	1	4	4
East Fork Poplar Creek Mile 3.9	EFK 6.3		1	1	1	4	4
East Fork Poplar Creek Mile 1.4	EFK 2.2		1	1	1	4	4
Mill Branch Mile 1.0	MBK 1.6		1	1	1	4	4
DOE Co-Sample	FD		1	1	3	3	3
Ambient	**Total for FY**	**1**	**9**	**13**	**15**	**35**	**35**
QA/QC							

***Note:**

Rads: Gross alpha, Gross Beta

Nutrients: Nitrate/Nitrite and Total Phosphorus (Bear Creek sampled for Nitrates each quarter; No phosphorus sampled)

Metals: Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Copper, Lead, Nickel, and Uranium

Field Parameter Measurements

At each site, during the time of sampling, physical water parameters will be measured using a multiple parameter water quality meter. Parameters of conductivity (µS/cm), dissolved oxygen (mg/L), pH, and temperature (°C) will be recorded along with the time of measurement.

Data Evaluation

Using R programming language, several analyses will be performed to better understand the results. First, results will be compared with any available co-sampled DOE data. Applicable methods such as analysis of variance or the Kruskal-Wallis test may be used to see if sample results from TDEC DoR-OR and DOE are statistically significantly different. Second, results will be compared with TDEC DoR-OR's historical data for selected streams excluding CR sites. Again, an analysis of variance or the Kruskal-Wallis test may be used to compare these two (2) data sets. Along with basic descriptive statistics: mean, median, minimum, maximum, etc., increasing or decreasing trends in data will be analyzed. Data will be assessed using TDEC and EPA defined MCLs to determine if there is a potential impact to human health and the environment (EPA, 2009, TDEC, 2019). Any exceedances may invoke further investigation.

8.2.9 References

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8.3 WHITE OAK CREEK RADIONUCLIDES

8.3.1 Background

To monitor potential contamination, an ambient surface water sampling project has been implemented each year since 1993. This monitoring project began by investigating the water quality of the Clinch River at five locations on or near the ORR.

The purpose of this project is to continue monitoring strontium-90 (Sr-90) and other radiological contaminant inputs to White Oak Creek and its tributaries, which joins the Clinch River, while levels of these contaminants remain high.

8.3.2 Related DOE Projects

DOE has implemented a surface water monitoring program for several years that consists of sample collection and analysis from locations along the Clinch River (DOE, 2017; DOE, 2019). Currently, on a quarterly basis, DOE collects Clinch River samples at river kilometers 16, 32, 58, and 66 (Figure 7.3.1) (DOE, 2019). Of these sites, Clinch River Kilometer (CRK) 58 is near the water supply intake for Knox County, and CRK 66 is upstream of the City of Oak Ridge water supply intake. Grab samples are collected at these four locations and are analyzed for water quality parameters such as dissolved oxygen, pH, and water temperature. Samples are also screened for radioactivity by analyzing for gross alpha, gross beta, and gamma isotopes. Samples are analyzed for Sr-90 at three of the sites: below the confluence of White Oak Creek and the Clinch River near ORNL (CRK 32), upstream of the City of Oak Ridge water supply intake (CRK 66), and downstream of the ORR (CRK 16).

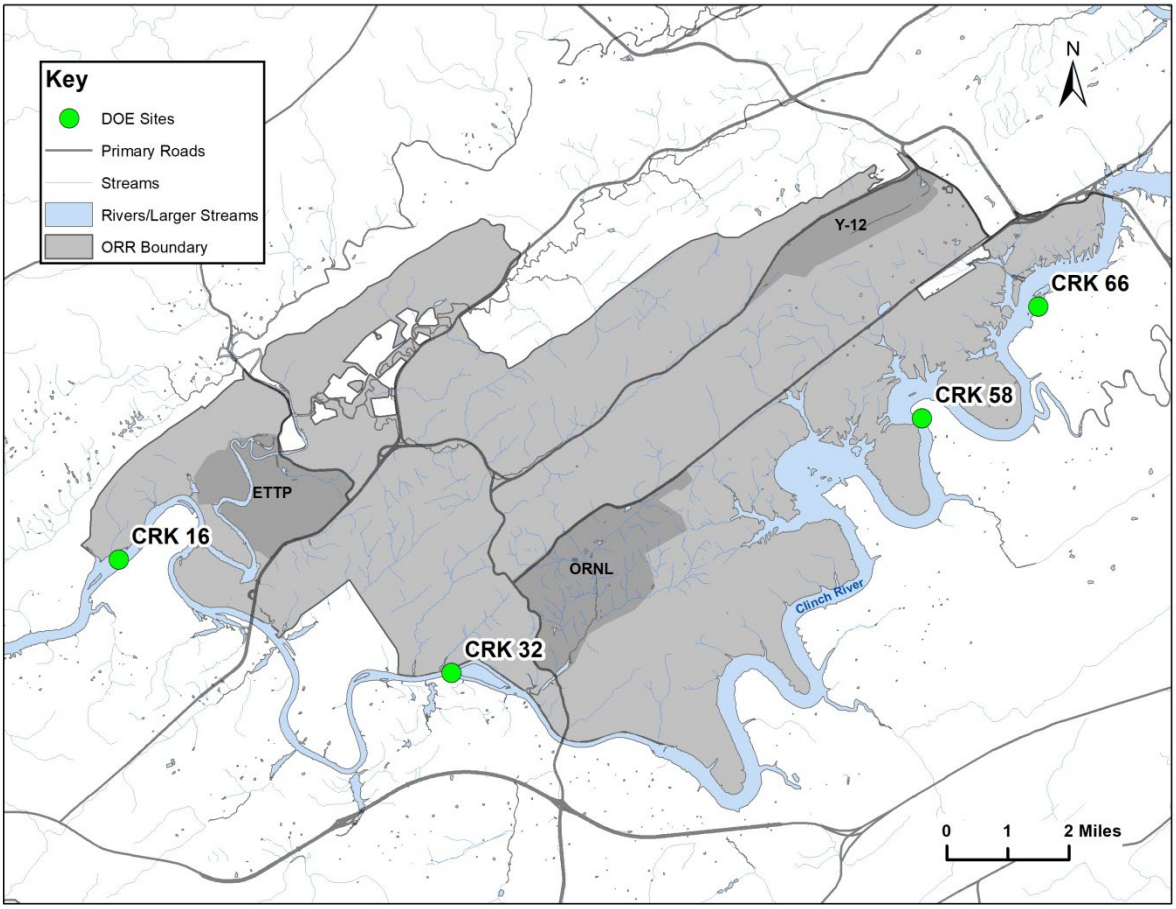

Figure 8.3.1: DOE quarterly water monitoring sample locations

The purpose of the current DOE project is to assess impacts of site operations, both past and present to surface water bodies as well as to assess the impact of radioactivity to human health. Maximum contaminant levels (MCLs) for measured analytes, as defined by the Environmental Protection Agency (EPA), are used to determine potential impacts (EPA, 2009).

While the current DOE project samples the Clinch River, the TDEC DoR-OR project will complement DOE sampling by monitoring specific points along White Oak Creek and the Clinch River. Samples will be collected at points along White Oak Creek and its tributaries with the intent to provide a more representative evaluation of the contaminants entering the Clinch River. Like the DOE project, all site analytical results will be compared to EPA MCLs to determine stream impacts.

8.3.3 Problem Statements

This project will supplement DOE's study of the Clinch River to better understand impacts to human health. It is estimated, based on 2017 US census data that nearly 1.2 million people live in the counties surrounding the Oak Ridge Reservation (ORR) (DOE, 2017). A large portion of the population have the potential of being influenced by streams that drain

the ORR. All the exit-pathway streams on the ORR eventually flow into the Clinch River. In turn, the Clinch River ultimately flows into the Tennessee River. Twelve domestic water supplies are located on these rivers within 170 river miles downstream of White Oak Creek (DOE, 1992). The Clinch River provides drinking water as well as water for industrial use to many municipalities near and downstream of the ORR. These include Anderson County, Knox County, Roane County, the City of Clinton, the City of Kingston, and the City of Oak Ridge. The Clinch River surface waters are also used for facilities at the Y-12 National Security Complex (Y-12), the Oak Ridge National Laboratory (ORNL), and the East Tennessee Technology Park (ETTP). Thus, it is important to monitor White Oak Creek, as well as DOE's Clinch River monitoring, to better understand the ORR's impact on this widely used resource.

The ORR exit-pathway streams and the Clinch River have been and are currently subject to contaminant releases from activities at ETTP, ORNL, and Y-12. These releases can be detrimental to the environment and human health. Identified concerns include the following:

- ORNL has been releasing low-level radioactive liquid wastes to the Clinch River via White Oak Creek since 1943 (Pickering, 1970).
- The Clinch River received approximately 665 curies of cesium-137 (Cs-137) from White Oak Creek between 1954 and 1959 (DOE, 1992).
- Elevated levels of radioactive strontium have been seen in White Oak Creek after a 2015 ruptured pipe mobilized the contaminant at the Process Waste Treatment Complex (DOE, 2018).

By monitoring White Oak Creek and its tributaries, TDEC DoR-OR can better assess what locations on the ORR are contributing to surface water pollution and provide insight to help protect human health and the environment, especially for the important resource of the Clinch River.

8.3.4 Goals

The goal of the White Oak Creek radionuclides monitoring project is to evaluate the impacts of DOE ORR radiological contamination to White Oak Creek and the Clinch River (Figure 7.3.2). This project will ultimately seek to understand White Oak Creeks contribution of such contaminants to the Clinch River. An assessment of White Oak Creek impacts to the Clinch River will be performed by comparing results to EPA maximum contaminant levels (MCLs) (EPA, 2009). Overall, this project will define areas of concern on the ORR that may be significantly impacting the surface water resources of Tennessee.

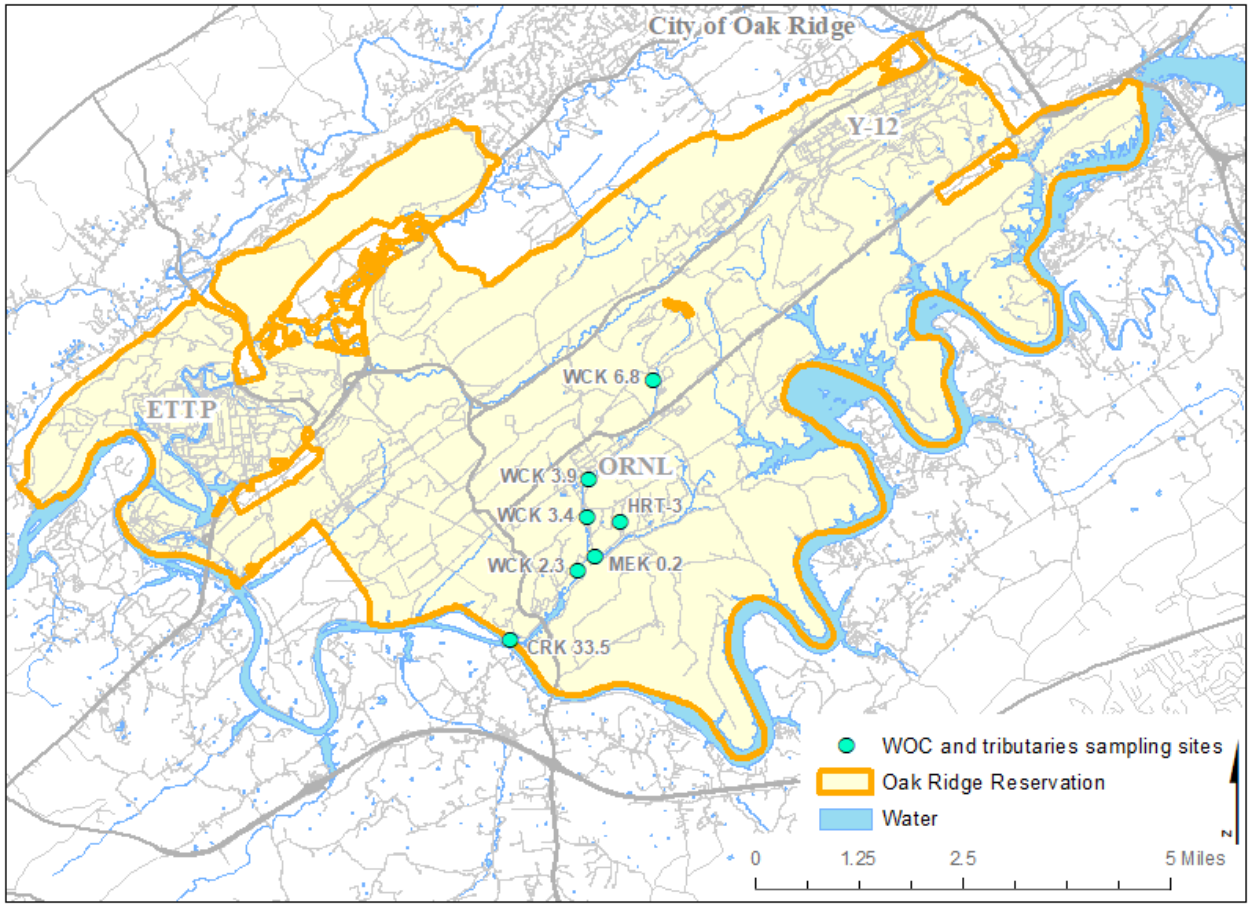

Figure 8.3.2: TDEC DoR-OR quarterly water monitoring sample locations

To accomplish this goal, several objectives need to be completed. These objectives include:

1. Collect quarterly surface water samples at six sites along White Oak Creek and its tributaries and one at its confluence with the Clinch River. The samples will be analyzed for gamma emitting radionuclides, cesium-137 (Cs-137), isotopic plutonium, strontium-90 (Sr-90), and isotopic uranium (Figure 7.3.2 and Table 7.3.1).

2. During sampling, physical waters parameters (e.g., conductivity, dissolved oxygen, pH and temperature) will be measured.

3. Evaluate resulting data and identify increasing or decreasing trends.

8.3.5 Scope

The scope of this project is limited to quarterly sampling for radiological analysis at seven locations along White Oak Creek, its tributaries, and its confluence with the Clinch River.

8.3.6 Assumptions

- Radiological contamination in White Oak Creek is due to activities at ORNL.

- The water quality meter used to measure the physical parameters will remain operational.
- Funding is available to cover the time and analysis required for this project.

8.3.7 Constraints

Constraints that may impact this project include:

- Availability of funding, manpower, and access to controlled areas on the ORR.
- Laboratory costs remain the same and as projected throughout the project.

8.3.8 Methods, Materials, Metrics

Sample Collection

Surface water samples will be collected quarterly at six sites along White Oak Creek and its tributaries and one at its confluence with the Clinch River (Figure 7.3.2). The samples will be analyzed for gamma emitting radionuclides (gamma), cesium-137 (Cs-137), isotopic plutonium (iso-Pu), strontium-90 (Sr-90), and isotopic uranium (iso-U) (Table 7.3.1).

Table 8.3.1: Sampling locations and analysis

	DoR-OR Site	Analysis
1	WCK 6.8	gamma, Cs-137, iso-Pu, Sr-90, iso-U
2	WCK 3.9	gamma, Cs-137, iso-Pu, Sr-90, iso-U
3	WCK 3.4	gamma, Cs-137, iso-Pu, Sr-90, iso-U
4	WCK 2.3	gamma, Cs-137, iso-Pu, Sr-90, iso-U
5	MEK 0.2	gamma, Cs-137, iso-Pu, Sr-90, iso-U
6	HRT 0.3	gamma, Cs-137, iso-Pu, Sr-90, iso-U
7	CRK 33.5	gamma, Cs-137, iso-Pu, Sr-90, iso-U

Field Parameter Measurements

At each site, using a water quality meter, physical water parameters (conductivity (µS/cm), dissolved oxygen (mg/L), pH, and temperature (°C) will be measured and recorded at the time of sampling the water quality meter will be used according to manufacture specifications.

Data

Upon receiving sampling results, the data will be stored in a database maintained in the TDEC DOR-OR office. Results will be compared with any available DOE data. Increasing or decreasing trends in data will be analyzed. Data will be screened by the EPA defined MCLs to assess impact to human health (EPA, 2009). EPA has established a MCL of 4 millirems per

year for beta particle and photon radioactivity from manmade radionuclides in drinking water. For Sr-90, the 8 pCi/L criterion is the average concentration assumed to yield 4 millirems per year. If other radionuclides that emit beta particles and photon radioactivity are present in addition to this contaminant, the sum of the annual dose from all the radionuclides cannot exceed 4 millirems per year.

8.3.9 References

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TDEC, DWR, Quality System SOPs for Chemical and Bacteriological Sampling of Surface Water, DWR-WQP-P-01- QSSOP-Chem-Bact-082918.pdf

9.0 WATERSHED ASSESSMENTS (HOLISTIC) MONITORING

9.1 BEAR CREEK VALLEY ASSESSMENT (PHASE 4)

9.1.1 Background

The Oak Ridge Reservation (ORR) is located in the Valley and Ridge physiographic province. This province is distinguished by series of northeast-southwest trending ridges and interceding valleys (Miller, 1974). The Bear Creek Valley topography is flat to rolling with elevations ranging from 750 to 1000 feet above sea level. The Bear Creek Valley is approximately ½ mile wide and is bounded by Chestnut Ridge to the Southeast and Pine Ridge to the Northwest. Pine Ridge is about 300 feet above the valley floor and is higher than Chestnut Ridge. Both ridges are heavily wooded on the Bear Creek Valley facing slopes (USGS 1991).

The Bear Creek Valley spans from Scarboro Road in Oak Ridge southwest to Highway 95 and on to the Clinch River. The uppermost 8 km of the valley is in a restricted access area of the Y-12 NNSA facility. Bear Creek starts on the west side of the Bear Creek/East Fork Poplar Creek surface water divide in the western end of the Y-12 NSA facility. For approximately 8 kilometers, Bear Creek flows through Bear Creek Valley. Near stream kilometer 4.5, Bear Creek turns to the Northwest and flows through a water gap in Pine Ridge and on to its mouth at East Fork Poplar Creek (EFPC) km 2.2. From its mouth at East Fork Poplar Creek, Bear Creek has a drainage area of approximately 7.58 square miles (Figure 8.1.1) and has an estimated mean annual flow of 12.4 cubic feet/second (Law et al., 2009). The average precipitation of the Bear Creek Valley is 54 inches per year (DOE 2019).

The Bear Creek Valley watershed drains the region encompassing several closed Oak Ridge Y-12 Plant waste disposal facilities. Former waste disposal practices in the 2800-acre Bear Creek Valley Watershed have caused contamination of Bear Creek and its tributaries. More than 44 million pounds of uranium and an estimated 3 million gallons of waste oils and solvents have been disposed of in the watershed (DOE 2019). Approximately 7.5 million L/yr. of uranium contaminated nitric acid wastes and other liquid wastes were disposed in the S-3 ponds between 1951 and 1984 (Moss et al. 1999). At the Oil Landfarm, about 3.8 million liters of machine coolants and waste oils were treated by landfarming between 1973 and 1982 (Moss et al. 1999). The Boneyard/Burnyard was where uranium metal and other wastes were disposed (some burned) in unlined trenches between 1943 and 1970. About 18 million kg of uranium metal and 1 million L of chlorinated solvents and waste oils were disposed at the Bear Creek Burial Grounds between 1955 and 1989 (Moss et al. 1999). In addition, groundwater contamination is evident downstream of the Bear Creek Valley disposal areas. Remedial actions for the waste sites have been proposed and several have been completed or are now in progress, though many remain to be addressed.

The Bear Creek Assessment Project, or BCAP, involves a comprehensive environmental evaluation of the Bear Creek Watershed, covering both current ecological health and potential for human health risk associated with the downstream reaches of Bear Creek. The BCAP examines many types of environmental data: surface water, sediment, soils, surface water toxicity, fish, and benthic macroinvertebrates. This assessment project is categorized into four progressive phases:

1. Phase 1 of this project involved data acquisition, review, summarization, and interpretation of historical Bear Creek Valley data from the last 10 years. This phase was completed in 2020; the findings are incorporated in the Phase 3 Report.

2. Phase 2 involved a comprehensive evaluation of the environmental health of the Bear Creek Watershed. It included field sampling of surface water, sediment, soil, fish, benthic macroinvertebrates, and other biota (bird eggs, flying insects, and spiders) at selected Bear Creek sites. This phase was completed in 2021.

3. Phase 3 is the production of the summary report of the findings of the various Phase 2 sampling projects. This report is in the editing process: TDEC DoR-OR. 2022. Bear Creek Assessment Project Phase 3 Report (Draft).

4. Phase 4 of the BCAP is now the primary focus of the project. This phase will address data gaps remaining from the Phase 2 sampling activities. The Phase 2 biota sampling activities did not provide useful data due to insufficient sample mass for analysis. Suspended sediment sampling will be continued in Phase 4 to monitor possible changes in the concentrations of contaminants of concern. The surface water toxicity/biomonitoring Phase 2 results require more sampling for validation. This follow-up project will provide new data for surface water toxicity/biomonitoring, biota (bird eggs, spiders, and flying insects), and sediment. This phase is anticipated to be completed by June 2023.

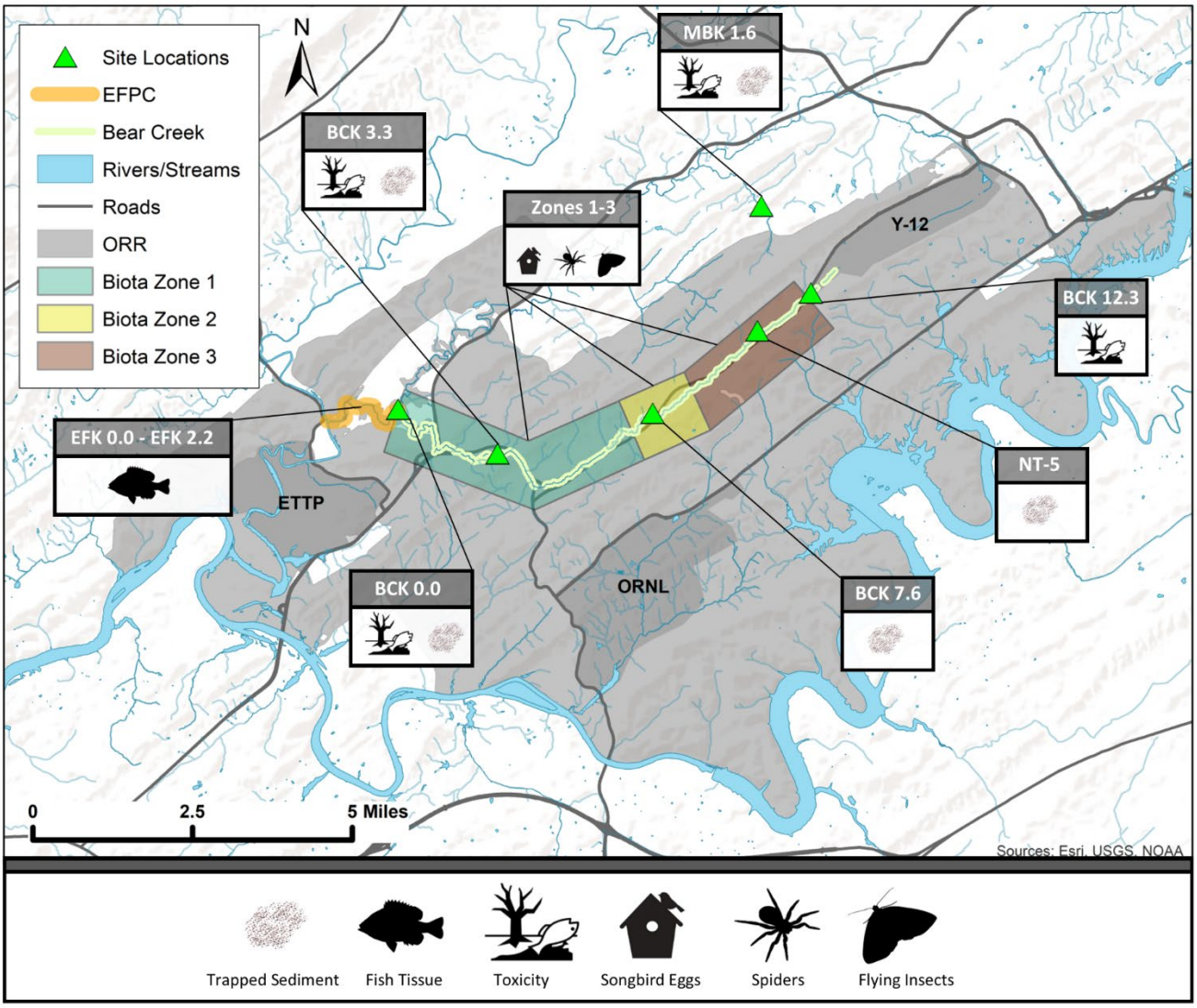

Figure 9.1.1: Map of Phase 4 Sampling Sites

Table 9.1.1: Biota Sampling Zones

Biota (adult insects, spiders, bird eggs)	
Zone	**Site Description**
Zone 3	From BCK 12.1 to BCK 9.0
Zone 2	From BCK 9.0 to BCK 7.0
Zone 1	From BCK 7.0 to BCK 0.0
Background	Melton Lake, Three Bends WMA

The BCK 12.3 site is representative of Bear Creek's headwaters region. BCK 9.6 is located at the downstream end of Bear Creek Remediation Zone 3. Similarly, BCK 7.6 is located at the downstream end of Bear Creek Valley Zone 2. The offsite region of Bear Creek is

represented by BCK 3.3; this section of the stream from BCK 4.5 downstream to Poplar Creek is not restricted from public access by the Department of Energy (DOE). Mill Branch MBK 1.6 is a Bear Creek background site for most environmental media sampled, except for songbird egg sampling which uses the Three Bends Wildlife Management Area and Melton Hill Lake as reference locations.

Biota samples will be collected from specified zones in Bear Creek Valley, as shown in Figure 8.1.1 and Table 8.1.1, to better ensure sufficient biomass is collected for analysis. Zone 1 represents DOE's Remediation Zone 1 but extends beyond to BCK 0.0 in order to assess the unrestricted downstream portion of Bear Creek. Biota zone 2 approximates DOE's Remediation Zone 2. Biota zone 3 encompasses DOE Remediation Zone 3.

9.1.2 Related DOE Projects

Although DOE conducts environmental sampling for surface water toxicity, they do not currently sample suspended sediment or biota (bird eggs, adult insects, and spiders) in the Bear Creek Watershed. G.R. Southworth and others conducted an ecological study of Bear Creek that included surface water, sediments, fish, benthic macroinvertebrates, and toxicity/biomonitoring. The report, *Biological Effects of Contaminants and Remedial Actions in Bear Creek*, was published in January of 1992.

9.1.3 Problem Statements

The Bear Creek Valley watershed drains the region encompassing several closed Oak Ridge Y-12 Plant waste disposal facilities. Former waste disposal practices in the 2800-acre Bear Creek Valley Watershed have caused contamination of Bear Creek and its tributaries. More than 44 million pounds of uranium and an estimated 3 million gallons of waste oils and solvents have been disposed of in the watershed (DOE 2019). In addition, groundwater contamination is evident downstream of the Bear Creek Valley disposal areas. Remedial actions for the waste sites have been proposed and several have been completed or are now in progress, though many remain to be addressed. Bear Creek's primary contaminants are uranium, nitrate, and cadmium (DOE 1999).

9.1.4 Goals

There are two main goals of this project. These goals are:

1. Conduct an intensive evaluation of Bear Creek in order to provide an environmental baseline assessment for future reference after the construction of the proposed EMDF landfill.

2. Assure that the sections of Bear Creek accessible to the public do not pose a health threat to those using the area for recreation.

9.1.5 Scope

The scope of this project is limited to the environmental assessment of Bear Creek through sampling and analysis of surface water toxicity, sediment, and biota tissue (bird eggs, adult insects, and spiders). The stream reach being assessed is from the mouth of Bear Creek at East Fork Poplar Creek km 2.2 (EFK 2.2) to the headwaters region of Bear Creek (BCK 12.3).

Additional work may be completed if resources are available to address identified data gaps, generate a more robust dataset, and further support the goals of this project.

9.1.6 Assumptions

There are several assumptions for this project to be successful. These include:

- Phase 4 sampling and analysis activities are dependent on adequate funding and staffing.
- Scheduling will allow for co-sampling with DOE.
- Availability of funding, manpower, and access to controlled areas on the ORR.
- Laboratory costs remain the same throughout the project.
- Biota sampling yields sufficient sample size for analysis.

9.1.7 Constraints

This project has the following constraints:

- Phase 4 sampling and analysis activities are dependent on adequate funding and staffing.
- Scheduling must allow for DOE co-sampling.
- Phase 4 sampling is dependent on access to controlled areas on the ORR.
- Laboratory costs could rise during the project.
- Heavy precipitation and increased stream flow may damage or dislodge sediment traps.
- Collected biota sample size may be insufficient for analysis.

9.1.8 Methods, Materials, Metrics

Toxicity and biomonitoring tests will be conducted for surface water at the following sampling sites: BCK 12.3, BCK 3.3, EFK 2.2, and MBK 1.6. *Ceriodaphnia dubia* (water flea) is the organism that will be used to test survival and reproduction for Bear Creek effluent

samples. *Pimephales promelas* (fathead minnow) will be used to test survival and growth for the same samples. In addition to the toxicity/biomonitoring testing, samples will also be collected each sampling day for metals analysis (cadmium, mercury, and uranium). Surface water samples are collected three times during a work week on Monday, Wednesday, and Friday and sent to the laboratory for testing. This sampling will be conducted by Civil & Environmental Consultants (CEC).

Sediment traps will be deployed in streams at NT-5 of Bear Creek, BCK 7.6, BCK 3.3, BCK 0.0, and MBK 1.6 for approximately five months before sampling. The suspended sediment samples from the sediment traps will be collected in five-gallon buckets which will be stored on ice in coolers. The samples will be allowed to settle for approximately 72 hours or until the supernatant water becomes clear. The coolers will have ice replenished every 12 hours during this settling period. After the settling period, the supernatant water of the sediment samples will be pumped off with a peristaltic pump. Each sediment sample will be stirred thoroughly and spooned into various sample containers, labeled, and sent to the laboratory for analysis. Depending on the yield of sediment from the samples, the analyses will include metals (arsenic, cadmium, mercury, uranium), PCBs, and radiochemistry (gross alpha/beta, gamma radionuclides, Sr-89,90, uranium) parameters. Sampling will be conducted two times during the year, first in November/December 2022 and then in May/June 2023.

Biota samples will be collected within specified zones in the Bear Creek Valley (Figure 8.1.1 and Table 8.1.1). Songbird nest boxes have been installed at various locations within the Bear Creek biota zones and at reference locations on the ORR. Songbird nest boxes will be checked periodically to determine occupancy. Once a nest box is confirmed to have a bird occupant, the box is checked twice per week to collect the 1st-laid and 2nd-laid eggs for analysis. Songbird breeding season runs from March to August and may have two broods per season.

Spiders, mainly Wolf and Fishing spiders, will be sampled by TDEC DoR-OR staff within the biota zones of the Bear Creek Valley and at Mill Branch MBK 1.6. During night hours, flashlights held at eye level will locate the reflective spider eyes near the stream shoreline or adjacent floodplain area (Northam et al., 2011). Then, the spider will be retrieved using either the aquarium net or 12-inch forceps. During collection, spider specimens will be placed into plastic cups with lids, to prevent escape, until ≥ 5 grams of biomass is achieved per sample.

Flying Insects will be sampled by DoR-OR staff at the Bear Creek biota zones and at Mill Branch MBK 1.6. The insects will be collected with a black light collector device ("Larry's Lighthouse"-BioQuip Products, Inc.). Nocturnal insects are attracted to the black light which provides maximum insect response from as far away as 500 meters from the light source. The Larry's Lighthouse device has a white mesh globe, no-see-um material, with the black light inside that attracts the insects after dark. After numerous insects have landed on the globe, they are hand collected using an aspirator vacuum tool which sucks the bugs off the white no-see-um mesh globe and secures them in replaceable sample vials.

9.1.9 References

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9.2 EAST FORK POPLAR CREEK ASSESSMENT (PHASE 1)

9.2.1 Background

The Oak Ridge Reservation (ORR) is located in the Valley and Ridge physiographic province. This province is distinguished by series of northeast-southwest trending ridges and interceding valleys (Miller, 1974). The headwaters of East Fork Poplar Creek (EFPC) are located within the Y-12 plant. The primary contaminants of concern in East Fork Poplar Creek are mercury and uranium.

The East Fork Poplar Creek Assessment Project (EFPCAP) involves a comprehensive evaluation of the ecological health of the East Fork Poplar Creek Watershed. To accomplish this holistic assessment, the EFPCAP has been categorized into several progressive phases. Phase 1 involves data acquisition, review, summarization, and interpretation of historical data for upper and lower EFPC. In addition, the EFPCAP Phase 1 will examine many types of environmental data including surface water, groundwater, sediment, soils, toxicity/biomonitoring, fish, benthic macroinvertebrates, and other biota. Phase 2 will include sampling and analysis of sediment, soil, surface water, toxicity/biomonitoring, benthic macroinvertebrates, fish, and other biota (bird eggs, spiders, and flying insects). Phase 3 will analyze and interpret the data obtained from Phases 1 and 2 and produce a comprehensive report. If data gaps are present after Phase 2, there will be a Phase 4 which will address these areas with additional field sampling, analysis, and interpretation of data.

9.2.2 Related DOE Projects

DOE has a few projects that are related to the EFPCAP Phase 1 assessment. For example, the Oak Ridge National Lab (ORNL) Environmental Sciences Division (ESD) programs sample fish and benthic macroinvertebrates in EFPC. Furthermore, the DOE Y-12 Environmental Division monitors mercury and surface water flow at EFK 23.4 and other locations in EFPC.

9.2.3 Problem Statements

In the years from 1950 to 1963, an estimated 100 metric tons of elemental mercury were inadvertently released to EFPC from Y-12 (Turner and Southworth, 1999). Mercury continues to leak into EFPC from Y-12 subsurface drains, contaminated building foundations and soils. It is estimated that EFPC discharges approximately 0.2 metric tons of mercury to the Clinch River every year (DOE, 1992). This mercury has migrated into soils in the floodplain and into the food web. Although mercury concentrations in EFPC water have decreased 85% from the 1980s, methylmercury concentrations in water and fish have not declined, even with efforts to improve water quality (Brooks and Southworth, 2011). In addition to mercury, uranium is also a contaminant of concern in EFPC. Uranium was released from the Y-12 plant into the air from vents and stacks and into surface water via EFPC.

9.2.4 Goals

The goals of this phase 1 project include the following:

- Provide a comprehensive evaluation of EFPC historical data from the last 10 years.
- Assess the impacts that historical and ongoing ORR contamination of EFPC may be having on wildlife in the watershed.
- Provide an environmental assessment benchmark to gauge the effects of future DOE remediation activities in the EFPC watershed, including the Y-12 Mercury Treatment Facility and changes to the nearby Outfall 200 area.

9.2.5 Scope

The EFPCAP Phase 1 is limited to an environmental assessment of East Fork Poplar Creek through the review and interpretation of historical EFPC environmental data. The stream reach being assessed spans from the mouth of EFPC (EFK 0.0) to Station 17 (EFK 23.4) (Figure 8.2.1).

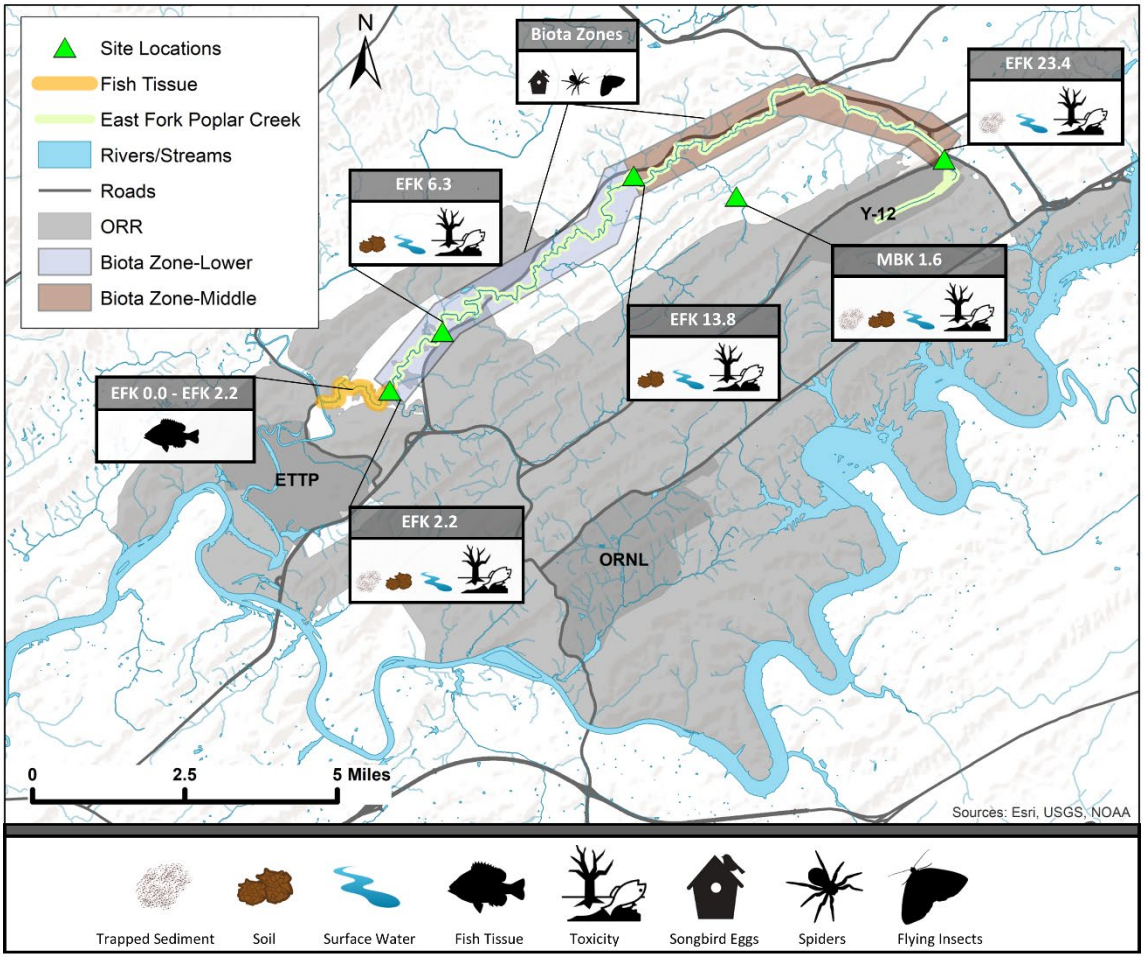

Figure 9.2.1: Map of EFPC Phase 1 Sampling Sites

9.2.6 Assumptions

This project has a few assumptions, including:

- Phase 1 activities will have adequate funding and staffing.
- The DOE OREIS database will remain operational and accessible.

9.2.7 Constraints

While not anticipated, it is possible that TDEC DoR-OR staff may be unavailable to research the various subprojects.

9.2.8 Methods, Materials, Metrics

To achieve the EFPC Phase 1 goals, a background summary will be prepared. In addition, an environmental assessment of EFPC surface water, sediment, geohydrology, groundwater, soils, surface water toxicity/biomonitoring, fish community and bioaccumulation, benthic macroinvertebrates, and other biota will be conducted. The following sections provide additional details regarding the overall assessment.

BACKGROUND

- Prepare a summary of the major sources of ORR contamination to groundwater and surface water in the East Fork Poplar Creek watershed.
    - Present maps, tables, etc. as needed.

- Summarize DOE's remediation actions for the above sources (completed and planned).
    - Present maps, tables, etc. as needed.

- Cite references used in the text and provide a list of references.

SURFACE WATER

- Assemble East Fork Poplar Creek surface water quality chemistry data obtained from both internal sources (TDEC DoR-OR) and external sources (DOE).

    - This data should not be more than ten years old.

    - Limit data to three locations – EFK 23.4, EFK 13.8, and EFK 6.3.
        - If data is not available at these locations, include relevant data from East Fork Poplar Creek sites which are located within approximately one mile of each listed location.

    - Compare data to applicable water quality criteria and interpret findings.

    - Use this assemblage of data to identify temporal and spatial trends for any parameters that are contaminants of concern.
        - Use graphs to present any trends discovered and provide data used to create graphs in an Excel file.

        - Present maps, tables, etc. as needed.

SEDIMENT

- Assemble East Fork Poplar Creek sediment chemistry data obtained from both internal sources (TDEC DoR-OR) and external sources (DOE).

    - This data should not be more than ten years old.

    - Limit data to three locations – EFK 23.4, EFK 13.8 and EFK 6.3
        - If data is not available at these locations, include relevant data from East Fork Poplar Creek sites which are located within approximately one mile of each listed location.

    - Use this assemblage of data to identify temporal and spatial trends for any parameters that are contaminants of concern.

GEOHYDROLOGY

- Prepare a summary of the geohydrology of the East Fork Poplar Creek Valley.

    - Include topics relevant to EFPC such as geological formations, drought effects, solution-cavity systems, losing/gaining reaches of the stream, and the importance of springs.
    - Include information about contaminant transport through groundwater to springs, if applicable.
    - Present maps, tables, etc. as needed.

- Cite references used in the text and provide a list of references.

GROUNDWATER

- Obtain, review, interpret, and summarize East Fork Poplar Creek groundwater well sampling data.
    - This data should not be more than ten years old.
    - Limit data to two zones:
        - Middle: from EFK 23.4 to EFK 13.8
        - Lower: from EFK 13.8 to EFK 2.2

    - Include in the summary such factors as:
        - Locations
        - Analytical Results Data
            - Arsenic
            - Cadmium
            - Methylmercury
            - Mercury, total
            - Other mercury species, if available
            - Uranium
            - PCBs, if detected
            - Gross alpha
            - Gross beta
            - Gamma radionuclides, if man-made (Cesium-137, Cobalt-60, etc.)
            - Strontium-89/90, if detected
            - Technetium-99, if detected

        - Results
            - Use text, maps, tables, charts, etc. as needed.
            - For graphs presented, provide data in Excel file(s).

SOILS

- Assemble East Fork Poplar Creek Valley soils chemistry (including radiochemistry) data obtained from OREIS or other DOE sources.
    - This data should not be more than ten years old.
    - Limit data to two zones:
        - Middle: from EFK 23.4 to EFK 13.8
        - Lower: from EFK 13.8 to EFK 2.2

- Obtain, review, interpret and summarize the data
    - Include in the summary:
        - Locations
        - Analytical Results Data
            - Arsenic
            - Cadmium
            - Methylmercury
            - Mercury, total
            - Other mercury species, if available
            - Uranium
            - PCBs, if detected
            - Gross alpha
            - Gross beta
            - Gamma radionuclides, if man-made (Cesium-137, Cobalt-60, etc.)
            - Strontium-89/90, if detected
            - Technetium-99, if detected
        - Results
            - Use text, graphs, tables, maps, etc. as needed.
            - For graphs presented, provide data in Excel file(s).

SURFACE WATER TOXICITY/BIOMONITORING

- Obtain, review, interpret, and summarize East Fork Poplar Creek toxicity/biomonitoring data collected by DOE.
    - This data should not be more than ten years old.
    - Limit data to two zones:
        - Middle: from EFK 23.4 to EFK 13.8
        - Lower: from EFK 13.8 to EFK 2.2
    - Use text, graphs, tables, maps, etc. as needed.
        - For graphs presented, provide data in Excel file(s).

FISH COMMUNITY AND BIOACCUMULATION

- Obtain, review, and interpret and summarize East Fork Poplar Creek fish community and bioaccumulation studies provided by DOE.
    - Attempt to obtain fish community and bioaccumulation data from DOE fish sampling sites on EFPC.
    - This data should not be more than ten years old.
    - If available, include mercury and PCB concentrations in fish.
    - If available, include such factors as species richness, composition, density, biomass, condition factors, and length-frequency.
    - For graphs presented, provide data in Excel file(s).

BENTHIC MACROINVERTEBRATES

- Obtain, review, interpret, and summarize East Fork Poplar Creek benthic macroinvertebrate surveys from both TDEC DoR-OR and DOE sources.
    - Use benthic macroinvertebrate data from EFK 23.4, EFK 13.8, and EFK 6.3.
    - This data should not be more than ten years old.
    - For graphs presented, provide data in Excel file(s).
    - Include in the summary such factors as:
        - Taxonomic Composition
            - Density and Biomass
            - Temporal and Spatial Patterns
            - East Fork Poplar Creek vs Reference Sites
            - Dominant Taxa
        - Community Structure
            - Taxa Richness
            - EPT Richness
            - % EPT
            - % OC
            - NCBI
            - % Clingers
            - % Nutrient Tolerant
            - Intolerant Taxa
            - TMI Scores

OTHER BIOTA

- Obtain, review, interpret, and summarize East Fork Poplar Creek biota (spiders, earthworms, insects, small mammals, bird eggs, etc.) sampling data.
    - Use biota data from DOE sources such as OREIS and ORNL ESD publications.
    - This data should not be more than ten years old.
    - For graphs presented, provide data in Excel file(s).
    - Include in the summary such factors as:
        - Taxonomy of species studied
        - Methodology of sampling
        - Parameters analyzed
        - Results (text, graphs, tables, maps, etc.)
        - References

9.2.9 References

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9.3 EAST FORK POPLAR CREEK ASSESSMENT (PHASE 2)

9.3.1 Background

The Oak Ridge Reservation (ORR) is located in the Valley and Ridge physiographic province. This province is distinguished by series of northeast-southwest trending ridges and interceding valleys (Miller, 1974). The headwaters of East Fork Poplar Creek (EFPC) are located within the Y-12 plant. The primary contaminants of concern in EFPC are mercury and uranium.

The East Fork Poplar Creek Assessment Project (EFPCAP) involves a comprehensive evaluation of the ecological health of the East Fork Poplar Creek Watershed. To accomplish this holistic assessment, the EFPCAP has been categorized into several progressive phases. Phase 1 involves data acquisition, review, summarization, and interpretation of historical data for upper and lower EFPC. In addition, the EFPCAP Phase 1 will examine many types of environmental data including surface water, groundwater, sediment, soils, toxicity/biomonitoring, fish, benthic macroinvertebrates, and other biota. Phase 2 will include sampling and analysis of sediment, soil, surface water, toxicity/biomonitoring, benthic macroinvertebrates, fish, and other biota (bird eggs, spiders, and flying insects) (Figure 8.3.1). Phase 3 will analyze and interpret the data obtained from Phases 1 and 2 and produce a comprehensive report. If data gaps are present after Phase 2, there will be a Phase 4 which will address these areas with additional field sampling, analysis, and interpretation of data.

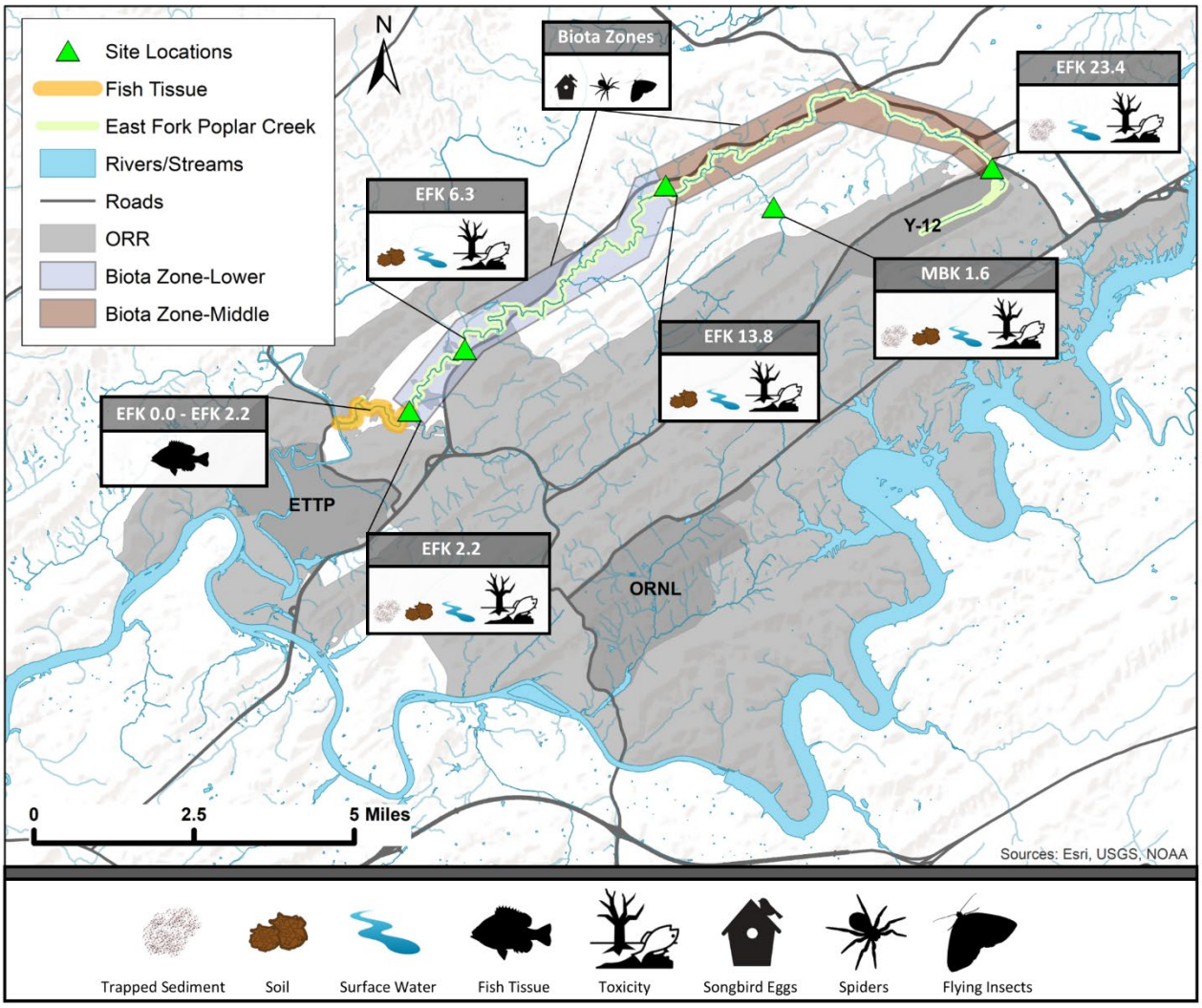

Figure 9.3.1: Map of EFPC Phase 2 Sampling Sites

9.3.2 Related DOE Projects

DOE has a few projects that are related to the EFPCAP Phase 2 assessment. For example, the Oak Ridge National Lab (ORNL) Environmental Sciences Division (ESD) programs sample fish and benthic macroinvertebrates in EFPC. Furthermore, the DOE Y-12 Environmental Division monitors mercury and surface water flow at EFK 23.4 and other locations in EFPC.

9.3.3 Problem Statements

In the years from 1950 to 1963, an estimated 100 metric tons of elemental mercury were lost to EFPC from Y-12 (Turner and Southworth, 1999). Mercury continues to leak into EFPC from Y-12 subsurface drains, contaminated building foundations, and soils. It is estimated that EFPC discharges approximately 0.2 metric tons of mercury to the Clinch River every year (DOE, 1992). This mercury has migrated into soils in the floodplain and into the food web. Although mercury concentrations in EFPC water have decreased 85% from the 1980's,

methylmercury concentrations in water and fish have not declined, even with efforts to improve water quality (Brooks and Southworth, 2011). In addition to mercury, uranium is also a contaminant of concern in EFPC. Uranium was released from the Y-12 plant into the air from vents and stacks and into surface water via EFPC.

9.3.4 Goals

The goals of this phase 2 project include the following:

- Provide an intensive evaluation of EFPC in order to establish a current baseline for future reference.
- Assess the impacts that historical and ongoing ORR contamination of EFPC may be having on wildlife in the watershed.
- Provide an environmental assessment benchmark to gauge the effects of future DOE remediation activities in the EFPC watershed, including the Y-12 Mercury Treatment Facility and changes to the nearby Outfall 200 area.

9.3.5 Scope

The EFPCAP Phase 2 scope is limited to an environmental assessment of East Fork Poplar Creek through sampling and analysis of surface water, surface water toxicity, sediment, soil, benthic macroinvertebrates, and biota tissue (fish, bird eggs, adult insects, and spiders). The stream reach being assessed spans from the mouth of EFPC (EFK 0.0) to Station 17 (EFK 23.4), which is the integration point for EFPC at the DOE Y-12 Security Complex.

Additional work may be completed if resources are available to address identified data gaps, generate a more robust dataset, and further support the goals of this project.

9.3.6 Assumptions

This project has a few assumptions, including:

- Phase 2 sampling and analysis activities will have adequate funding and staffing.
- Scheduling will allow for co-sampling with DOE.
- Laboratory costs remain the same throughout the project.
- Biota sampling yields sufficient sample size for analysis.
- Sediment traps yield sufficient sample size for analysis.
- Fish sampling yields sufficient sample size for analysis.

9.3.7 Constraints

This project has the following constraints:

- Phase 2 sampling and analysis activities may not have adequate funding.
- Staff may be unavailable for fulfillment of the various subprojects.
- Scheduling may not allow for DOE co-sampling.
- Laboratory costs may increase during the project.
- Heavy precipitation and increased stream flow may damage or dislodge sediment traps.
- Biota, fish, and sediment sample size may be insufficient for analysis.

9.3.8 Methods, Materials, Metrics

Toxicity and biomonitoring tests will be conducted for surface water at the following sampling sites: EFK 23.4, EFK 13.8, EFK 6.3, EFK 2.2, and MBK 1.6. *Ceriodaphnia dubia* (water flea) is the organism that will be used for testing survival and reproduction in EFPC effluent. *Pimephales promelas* (fathead minnow) will be used for testing survival and growth for the same sampling sites. In addition to the toxicity/biomonitoring testing, samples will also be collected each sampling day for cadmium, mercury, and uranium analysis. Surface water samples are collected three times during a work week on Monday, Wednesday, and Friday and sent to the laboratory for testing. This sampling will be conducted four times in FY 2023 by Civil & Environmental Consultants (CEC).

Surface water sampling will be conducted at EFK 23.4, EFK 13.8, EFK 6.3, and EFK 2.2. Also, MBK 1.6 will be sampled as the background site. Samples will be analyzed for metals, radiological parameters, and some nutrients.

Soil sampling will be conducted by CEC using Incremental Sampling Methodology (ISM) at EFK 13.8, EFK 6.3, EFK 2.2, and at MBK 1.6. The parameters to be analyzed include arsenic, cadmium, mercury, uranium, gross alpha/beta, gamma radionuclides, and PCBs. Preliminary surveys will determine the optimal location for each site's soil sampling grid. At each site, a grid will be staked out to delineate a grid consisting of 30 cells where each cell's measured area is 1 meter^2. The sampling crew will collect soil cores (~6" deep X 1" diameter) from cell quadrants that have been chosen by the Microsoft Excel random number generator. The samples will be deposited in sample bottles that will be transported directly to the laboratory for ISM processing and analysis.

Before sampling, sediment traps will be deployed in streams at EFK 23.4, EFK 2.2, and MBK 1.6 for approximately five months. The suspended sediment trap samples will be collected in five-gallon buckets which will be stored on ice in coolers. The samples will be allowed to settle for approximately 72 hours or until the supernatant water becomes clear. The coolers will have ice replenished every 12 hours during this settling period. After the settling period is done, the supernatant water of the sediment samples will be removed with a peristaltic pump. Subsequently, the remaining sediment for each sample will be stirred thoroughly and spooned into various sample containers, labeled, and sent to the laboratory for analysis. Depending on the yield of sediment from the samples, the analyses will include metals (arsenic, cadmium, mercury, uranium), PCBs, and radiochemistry (gross alpha/beta, gamma radionuclides) parameters. Sampling will be conducted in November/December 2022 and in May/June 2023.

Biota samples will be collected within specified zones in the EFPC Valley (Figure 8.3.1). The middle biota zone spans from EFK 23.4 to EFK 13.8, and the lower zone spans from EFK 13.8 to EFK 2.2. As the upper EFPC stream reach is within the Y-12 plant, this portion of the stream is not in the scope of the EFPCAP.

Songbird nest boxes have been installed at various locations within the two EFPC biota zones and at reference locations on the ORR. The nest boxes will be checked periodically near the start of the breeding season to determine occupancy. Once a nest box is confirmed to have a bird occupant, the box is checked twice per week to collect the 1st-laid and 2nd-laid eggs for analysis for arsenic, cadmium, methylmercury, mercury, uranium, and PCBs. Songbird breeding season runs from March to August and may have two broods per season.

Spiders, mainly Wolf and Fishing spiders, will be sampled by TDEC DoR-OR staff within the EFPC biota zones and at MBK 1.6. During night hours, flashlights held at eye level will locate the reflective spider eyes near the stream shoreline or adjacent floodplain area. Then, the spider will be retrieved using 12-inch forceps. During collection, spider specimens will be placed into plastic cups with lids, to prevent escape, until ≥ 5 grams of biomass is achieved per sample. Samples will be analyzed for arsenic, cadmium, methylmercury, mercury, uranium, and PCBs.

Flying Insects will be sampled by TDEC DoR-OR staff at the EFPC biota zones and at MBK 1.6. Insects will be collected with a black light collector device ("Larry's Lighthouse"-BioQuip Products, Inc.). Nocturnal insects are attracted to the black light which provides maximum insect response from as far away as 500 meters from the light source. The Larry's Lighthouse device has a white mesh globe, no-see-um material, with the black light inside that attracts the insects after dark. After numerous insects have landed on the globe, they are hand collected using an aspirator vacuum tool which sucks the bugs off the white no-see-um mesh globe and secures them in replaceable sample vials. Samples will be analyzed for arsenic, cadmium, methylmercury, mercury, uranium, and PCBs.

In order to assess for eco risk associated with mercury and other potential contaminants of concern in the food chain, fish tissue analysis will be conducted on fish samples collected in the stream reach from EFK 0.0 to EFK 2.2. The whole-body minnow analysis will be conducted on a composite sample of central stonerollers (*Campostoma anomalum*). Samples will be analyzed for gross alpha, gross beta, gamma radionuclides, strontium-89,90, uranium isotopic, plutonium isotopic, plutonium-241, carbon-14, polonium-210, technetium-99, mercury, methylmercury, arsenic, cadmium, uranium, PCBs, and dioxins/furans. This sampling project will be conducted by CEC using electrofishing techniques. Depending on the water level of the stream, sampling the lower portion of the stream reach may require a small boat.

Additional field samples or contaminants may be collected and analyzed as appropriate if resources are available.

9.3.9 References

Brooks, S.C., and Southworth, G.R. (2011). History of Mercury Use and Environmental Contamination at the Oak Ridge Y-12 Plant. Environmental Pollution 159 (2011) 219-228.

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