TENNESSEE DEPARTMENT
OF
ENVIRONMENT AND CONSERVATION

DIVISION OF REMEDIATION
OAK RIDGE OFFICE

ENVIRONMENTAL MONITORING PLAN

For Work to be Performed:

July 1, 2021 through June 30, 2022

Tennessee Department of
Environment and Conservation,
Authorization No. 327023
July 2021

Pursuant to the State of Tennessee's policy of non-discrimination, the Tennessee Department of Environment and Conservation does not discriminate on the basis of race, sex, religion, color, national or ethnic origin, age, disability, or military service in its policies, or in the admission or access to, or treatment or employment in its programs, services, or activities. Equal employment Opportunity/Affirmative Action inquiries or complaints should be directed to the EEO/AA Coordinator, Office of General Counsel, William R. Snodgrass Tennessee Tower 2nd Floor, 312 Rosa L. Parks Avenue, Nashville, TN 37243, 1-888-867-7455. ADA inquiries or complaints should be directed to the ADAAA Coordinator, William Snodgrass Tennessee Tower 2nd Floor, 312 Rosa Parks Avenue, Nashville, TN 37243, 1-866-253-5827. Hearing impaired callers may use the Tennessee Relay Service 1-800-848-0298.

To reach your local
ENVIRONMENTAL ASSISTANCE CENTER
Call 1-888-891-8332 or 1-888-891-TDEC

This plan was published
with 100% federal funds
DE-SC0019507
DE-EM0001621

TABLE OF CONTENTS

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, Plecoptera, 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
	NRC	Nuclear Regulatory Commission
	NSDWR	National Secondary Drinking Water Regulations
	NTU	nephelometric turbidity units

	NT-5	North Tributary 5
	NT	North Tributary
	NUREG	NRC Regulation
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 (TDEC), Division of Remediation, Oak Ridge (DoR-OR), submits this annual Fiscal Year 2022 (FY2022) Environmental Monitoring Plan (EMP) for the period of performance, from July 1, 2021 through June 30, 2022. This report is submitted as a comprehensive plan for TDEC DoR-OR monitoring and assessment activities across the Oak Ridge Reservation (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).

While this report discusses work scopes to be completed during the state Fiscal Year 2022, (July 1, 2021 through June 30, 2022), the release of the document was held until the Department of Energy (DOE) grant funding which supports this work was allocated. Those communications are expected to be finalized with DOE by early October 2021. These project descriptions correlate to the annual scopes of work outlined in that FY2022 Annual Grant Application request that was submitted to DOE in March of 2021.

The objective of the TDEC DoR-OR EMP is to provide an independent, comprehensive, and integrated monitoring and surveillance program, designed to support evaluation and assessment of the effectiveness of the existing DOE environmental monitoring programs. This independent State-led 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.

Specifically, 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. That information is used to help the State of Tennessee verify DOE's management of ORR contaminants is effective.

TDEC DoR-OR also participates in independent monitoring and oversight of the ESOA grant related activities (i.e. the current and active ORR process activities which are not covered under other State permits or regulatory authority). Through this monitoring program, TDEC collects information that aids in the independent evaluation and verification by the State that DOE's current activities and processes do not have an adverse effect on the people and environment of the State of Tennessee.

This FY2022 EMP presents summaries of twenty-one (21) proposed independent projects. This monitoring plan focuses on the following nine (9) general areas: Radiological Monitoring, Biological Monitoring, Air Monitoring, Surface Water Monitoring, Landfill Monitoring, Storm Water / Water Discharge Monitoring, Sediment Monitoring, Groundwater Monitoring, and Watershed Assessment (Holistic) Monitoring.

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.

- **Real Time Measurement of Gamma Radiation**

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 Nuclear Regulatory Commission (NRC) maximum dose limit for members of the public.

- **Surplus Sales Verification**

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

- **Haul Road Surveys**

TDEC DoR-OR performs periodic surveys of the Haul Road and other waste transportation routes on the ORR. TDEC DoR-OR Haul Road surveys work to independently verify the effectiveness of DOE actions to control impacts from those transportation activities.

- **Periodic Radiological Review of ORR CERCLA FFA Related Project Sites**

The project will conduct periodic evaluations / verifications utilizing walk over surveys, visual inspections and sampling as necessary at sites across the ORR. These reviews will "spot check" / assess the effectiveness of DOE's environmental radiological control operations including the use of Best Management Practices (BMPs) in use at CERCLA construction and demolition work sites or at any other site that may potentially release legacy contamination.

These reviews will assess effectiveness of measures being used to control potential sources of radiological contaminants and those controls in place intended to prevent the release and/or migration of such contamination to the environment.

Biological Monitoring:

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

- **Radiological Uptake in Food Crops**

This project assesses possible radiological impacts from DOE's ORR activities on food crops grown by local farmers and gardeners. This project supports a similar project conducted by DOE, with TDEC DoR-OR independent sampling being used to verify and correlate DOE's sample results.

- **Benthic Ecological Community Health**

The Benthic Ecological Community Health project consists of macroinvertebrate and diatom community sampling to monitor the current and changing condition of benthic health in Bear Creek. This project supports the ongoing holistic watershed assessment project for Bear Creek and is intended to document the current condition of the stream bottom communities, provide a baseline for that stream, and support identifying and documenting changes to the environment and eco health of these sites as remedial activities conducted under CERCLA continue.

- **ORR Roving Creel Survey**

The ORR Roving Creel Survey Project measures angling efforts 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 at the confluence of White Oak Lake and the Clinch River. Fish bioaccumulate mercury and other contaminants produced on the ORR, and fish consumption warnings may not be visible, may be missing, or may be disregarded by the public. It is the intent of this project to measure the angling effort at key locations on the ORR where potential human exposure to mercury and other contaminants may exist. Where possible, samples will be collected to measure the bioaccumulation of mercury and other contaminants in fish tissue at these key locations surrounding the ORR. This work shall link data from the roving creel survey to assess the efficacy of signage 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, as well as to provide data for use in future ORR decisions.

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 eight (8) ORR locations, locating samplers across the ORR at locations where the potential for the release of fugitive airborne emissions may be the greatest (for example, locations where contaminated soils are being excavated, contaminated facilities are being demolished, and near waste disposal operations). TDEC's sampling locations, supplement DOE's fugitive air monitoring program which focuses its evaluations and monitoring along the ORR perimeter boundaries.

- **RadNet Air Monitoring**

RadNet is an Environmental Protection Agency (EPA) nationwide program that monitors the nation's air, precipitation, and drinking water to track radiation in the environment. The project provides radiochemical analysis of air samples taken from four (4) air monitoring stations on the ORR. RadNet samples are collected by TDEC DoR-OR and analysis is performed at the EPA National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama.

- **RadNet Precipitation Monitoring**

The project provides radiochemical analysis of precipitation samples taken from monitoring stations at three (3) locations co-located with RadNet Air stations, on the ORR. Samples are collected by TDEC DoR-OR and analysis of these samples is performed at the EPA NAREL.

Surface Water Monitoring:

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

- **Ambient Surface Water Sampling**

This Surface Water Sampling Project will be used to assess and evaluate the impact of contamination from Poplar Creek, Bear Creek, and East Fork Poplar Creek near the East Tennessee Technology Park (ETTP). The Clinch River will also be monitored in conjunction with ongoing DOE sampling. Mill Branch will be used as a background comparison site to those sampled in the ETTP area. This project will ultimately seek to understand the loading and extent of contamination from Poplar Creek into the Clinch River, especially at publicly accessible areas. An assessment of each stream's impact will be performed by comparing sampling results to EPA-defined maximum contaminant levels (EPA, 2009).

This project will help to identify areas of concern across the ORR that may significantly impact the surface water resources, aiding in current remedial decision supporting assessments of remedial actions.

- **Ambient Surface Water Parameters**

On a monthly basis, 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.

- **White Oak Creek Radionuclides**

This project monitors Sr-90 and other radiological contaminant inputs to the White Oak Creek (WOC) / Clinch River confluence. To help monitor potential ORR contamination, an ambient surface water sampling project has been implemented each year since 1993.

Elevated Sr-90 concentrations have been found historically at Clinch River site CRK 33.5, which is the White Oak Creek /Clinch River confluence. The purpose of this project is to continue monitoring Sr-90 and other radiological contaminant inputs to WOC, which joins the Clinch River, while levels of these contaminants remain high.

Landfill Monitoring:

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

- **EMWMF**

Surface water, wastewater, and sediment samples will be collected to provide assurance through independent monitoring and evaluation that 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 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 comply with regulatory and operational requirements.

- **EMDF**

TDEC's monitoring of groundwater and surface water in central Bear Creek Valley (BCV) during FY22, will provide data to identify current site conditions along BCV in the Central BCV watershed area. Sampling will provide assurance through independent monitoring and coincident evaluation of DOE's data, that collected background or baseline data is appropriate for use in future stream health comparisons.

Surface water monitoring by TDEC DoR-OR will verify that DOE has determined background water quality parameter levels in the surface water by measuring the same water quality parameters.

Storm Water / Water Discharge Monitoring:

There are two (2) projects grouped under storm water / water discharge monitoring for the purpose of this EMP.

- **Rain Event**

The goal of this project is to obtain independent data to determine if DOE ORR storm water BMPs employed at remedial action (RA) sites are preventing offsite releases of legacy pollution, and to provide input for future cleanup decisions. As DOE RAs and demolition activities (D&D) occur throughout the ORR, storm water can accumulate in excavation pits, trenches, basins, sumps, and basements. This accumulated water (storm water and potentially groundwater intrusion) at these sites has the potential to become contaminated through contact with impacted materials and be dispersed further into the environment as runoff or storm water discharge. Currently, DOE employs a comprehensive storm water monitoring program at ORR RA sites to monitor such potential migration of contamination offsite. This project will support co-sampling activities with DOE to monitor potential releases into the environment, observe D&D and RA sampling activities, and will include review of DOE sampling results to ensure compliance with negotiated and agreed to release criteria. Where necessary this project may support creation of a baseline before D&D or RAs have begun. If possible, samples will be collected over the course of a year. Sample analysis will be aligned with the constituents of concern for buildings undergoing D&D or RA.

- **Accumulated Water Discharge**

This project will complement the Rain Event project. This project will monitor accumulated water at sites with ongoing CERCLA D&D and/or RA operations, including but not limited to, the Y-12 Outfall-200 Mercury Treatment Facility headworks construction and the ORNL Molten Salt Reactor Experiment basement groundwater sump and its free-released water. Furthermore, to evaluate DOE ongoing D&D and RA actions and provide input for future cleanup decisions, TDEC DoR-OR will review pertinent DOE sampling data, observe DOE sampling and monitoring activities, and co-sample as appropriate to confirm that relevant treatment and discharge criteria are met. As previously stated, DOE RA and D&D are ongoing throughout the ORR, accordingly, water can accumulate through either groundwater intrusion or stormwater accumulation, or both, in excavation pits, trenches, basins, sumps, and basements.

Accumulated water at these sites has the potential to become contaminated and then be dispersed into the environment.

Sediment Monitoring:

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

- **Trapped Sediment (Bear Creek Valley)**

The Bear Creek Valley (BCV) project is focused on determining stream health through sampling and analysis of suspended sediments. Suspended sediment analyses support long term monitoring and assessment of completed site remediation efforts, through long-term monitoring of suspended sediment in water columns. Evaluation of contamination within the suspended sediments allows for assessment of contamination which is found within the mobile sediment load migrating through the sampled exit pathway streams. The trapped sediment collected in Bear Creek from the western end of Y-12 to the west at EMWMF will be evaluated to determine the extent of contamination in this portion of the BCV watershed.

- **Trapped Sediment (East Fork Poplar Creek)**

As with BCV, the East Fork Poplar Creek (EFPC) project is also focused on determining stream health through sampling and analysis of suspended sediments. Sampling for the East Fork Poplar Creek watershed will occur at Station 17 (EFK 23.4) and will follow sampling protocols and schedules as proposed for the Break Creek Valley work scope.

Groundwater Monitoring:

There is one (1) project grouped under groundwater monitoring for the purpose of this EMP.

- **Offsite Groundwater Monitoring (Bear Creek Valley, ETTP, and the Tuskegee Neighborhood)**

This project will assess offsite groundwater located southwest of the ORR in Bear Creek Valley and ETTP and located to the northeast of the ORR in the Tuskegee Oak Ridge neighborhood. These two focus areas will support the Bear Creek Valley Watersheds Holistic Assessment Project. To protect these groundwater resources and area residents, the intent of this project is to identify if detected contaminants exist in groundwater samples at these locations specifically that are offsite of the ORR, and that are used as residential drinking water sources for these residents. The evaluation and assessment of potential ORR exit pathways in groundwater will help guide future FFA groundwater decisions.

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 is one (1) project grouped under watershed assessments (holistic) monitoring for the purpose of this EMP.

- **Bear Creek Valley Assessment**

Designed as a holistic assessment of the Bear Creek Valley Watershed, this project was initiated during FY2020. Phase 1 included an extensive historical records review, preliminary sampling, and data gap analysis. Phase 2 incorporated field sampling of surface water, sediment, soils, vegetation, toxicity, fish, benthic macroinvertebrates, and other biota. For FY2022, Phase 3 will interpret Phase 2 data and will identify any remaining data gaps. This project will provide a baseline for future reference about the status of Bear Creek valley and the environmental media found here at this point in time. This data may be used to benchmark site conditions at this time to be utilized for comparison purposes in the future. This overall assessment is intended to further assure the public that recreational areas of Bear Creek fall within compliance of identified remedial goals and do not pose health threats or concerns for the identified land use and public user groups.

1.0 INTRODUCTION

1.1 PURPOSE OF THE ENVIRONMENTAL MONITORING PLAN (EMP)

The Tennessee Department of Environment and Conservation (TDEC), Division of Remediation Oak Ridge Office (DoR-OR), submits its annual (FY2022) Environmental Monitoring Plan (EMP) for the period July 1, 2021 through June 30, 2022, 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 suggests modifications to current activities, if applicable.

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 FY2022 monitoring and assessment projects conducted by TDEC DoR-OR during this period of performance.

Each of the proposed TDEC DoR-OR projects for FY2022 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. This EMP will be performed in accordance with the TDEC DoR-OR Health and Safety Plan (TDEC, 2020/21).

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**
2022FY Environmental Monitoring Plan	6/30/2021
Quarterly Reports	Quarterly
2021FY Environmental Monitoring Report	10/30/2021

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 FY2022 EMP presents summaries of twenty-one (21) proposed independent projects. This monitoring plan focuses on the following nine (9) general areas: Radiological Monitoring, Biological Monitoring, Air Monitoring, Surface Water Monitoring, Landfill Monitoring, Storm Water / Water Discharge Monitoring, Sediment Monitoring, Groundwater 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.

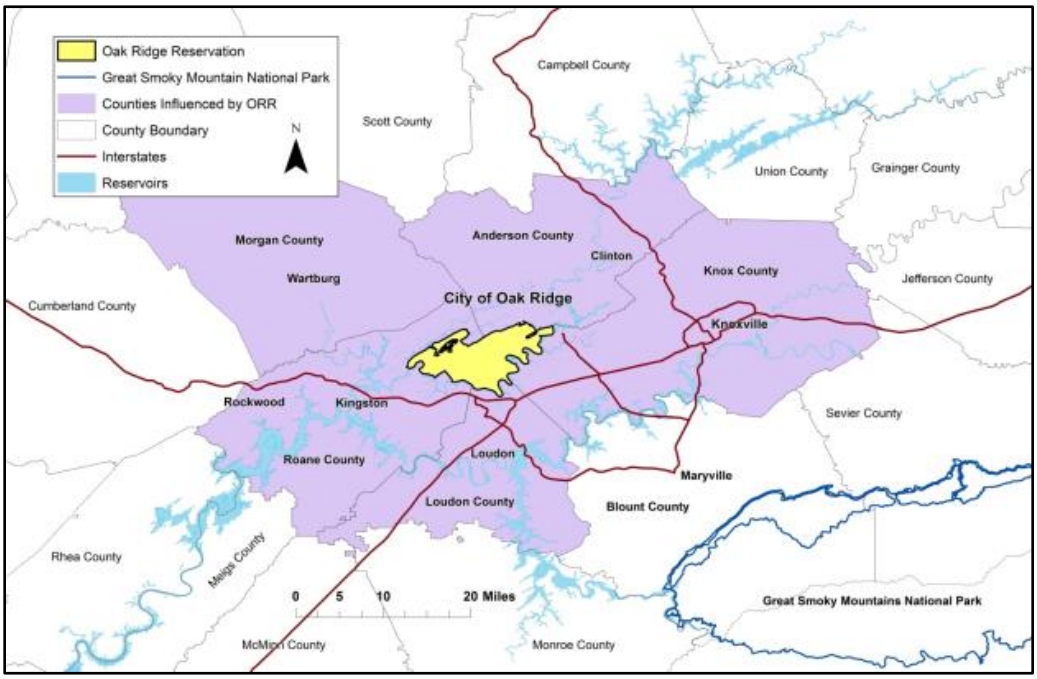

Figure1.3.1: Location of the Oak Ridge Reservation in Relation to Surrounding Counties

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. 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 2021 RER, the "total average rainfall in the ORR area during FY 2020 was 75.9 in. based on a composite of four rain gauge stations located throughout the ORR and one located in Oak Ridge. The total rainfall during FY 2020 was approximately 20 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 RADIOLOGICAL MONITORING

2.1 REAL TIME MEASUREMENT OF GAMMA RADIATION

2.1.1 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, many of the facilities at ETTP are contaminated to some degree and scheduled for 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.

2.1.2 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 Real Time Measurement of Gamma Radiation Program 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.

2.1.3 Problem Statements

Facilities on the ORR have the potential to release variable amounts of gamma radiation. The 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.

2.1.4 Goals

Results from monitored sites will be compared to the State of Tennessee (State) and NRC limit of two (2) millirem (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).

2.1.5 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.

2.1.6 Assumptions

Sampling locations are accessible to download measured data.

2.1.7 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 an untimely response to anomalies.

2.1.8 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 are planned for monitoring from July 1, 2021 to June 30, 2022 (Figure 2.1.1).

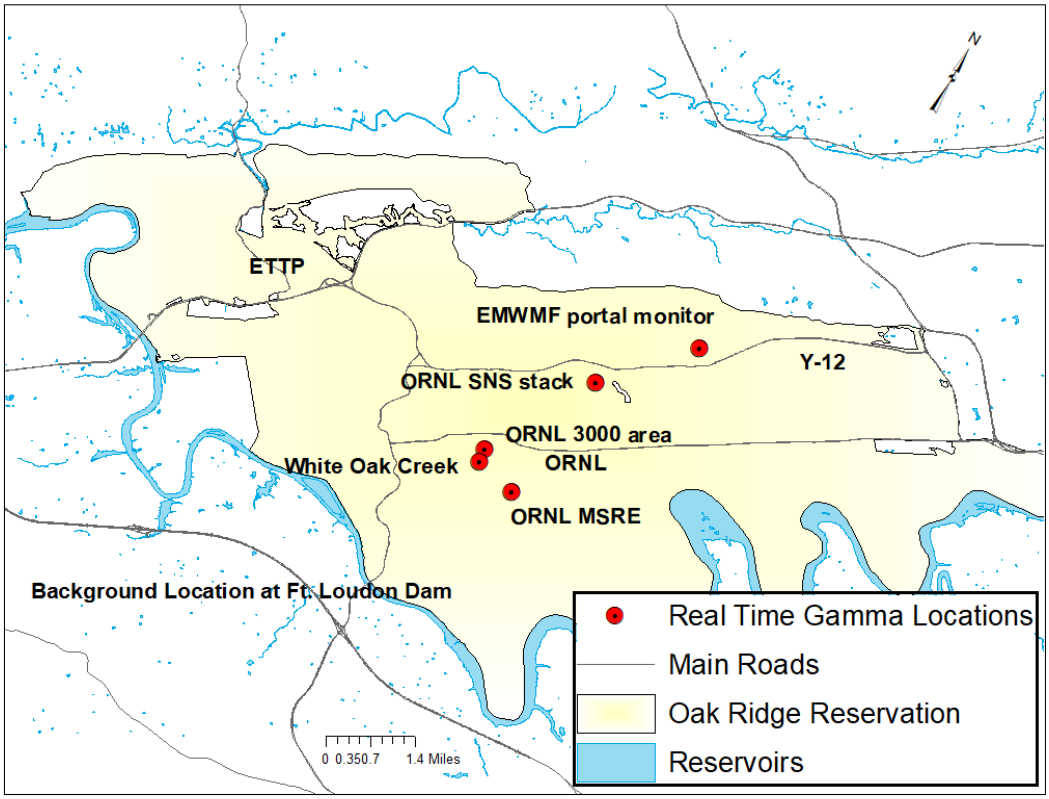

Figure 2.1.1: Current sampling Locations

2.1.9 References

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

2.2 SURPLUS SALES VERIFICATION

2.2.1 Background

The TDEC DoR-OR provides verification by conducting radiological surveys of surplus materials from the ORR that are designated for sale to the public. 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 most 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. 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 that appropriate steps (i.e., removal of items from sale, resurveys, etc.) are taken to protect the public.

2.2.2 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.

2.2.3 Problem Statements

- The source of incidental radioactive contamination on any surface, if present, 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 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 Rn (radon) daughter isotopes (Pb [lead], Po [polonium], and Bi [bismuth]) that can originate from Technically Enhanced Naturally Occurring Radioactive Materials (TENORM).

2.2.4 Goals

Although DOE made great progress in the reduction of contaminated material for Surplus Sales, in 2020 TDEC DoR-OR staff continued to identify contaminated material or material with elevated 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 addition, this project prevents the release of potentially contaminated materials to the public in rare instances where items of concern are found.

2.2.5 Scope

TDEC DoR-OR staff performs pre-auction verification surveys on items being auctioned 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. TDEC DoR-OR has had no difficulty responding to all requests.

2.2.6 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
- Sufficient number of alpha/beta scintillation meters will be available for the survey
- TDEC DoR-OR will follow up on resolution of the identified potential issues

2.2.7 Constraints

- State vehicle not available for the survey
- Adequate staff may not be available for the survey
- Sufficient number of appropriate radiological 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 state or natural emergencies

2.2.8 Methods, Materials, Metrics

Surplus sales verification work is performed under the guidance of TDEC DoR-OR's 2020 Health and Safety Plan (TDEC 2020). Prior to sales of surplus items from ORNL or Y-12 to the public, TDEC DoR-OR conducts a pre-auction survey. The intent of this survey is to spot check with appropriate radiation survey instruments items that are for sale in order to ensure that no radioactively contaminated items are released to the public. 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 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.

2.2.9 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 from https://www.nrc.gov/docs/ML0630/ML063000252.pdf

TDEC. (2017, January). 2018 Health and Safety Plan Including Related Policies. Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office. Oak Ridge, Tennessee.

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.

2.3 HAUL ROAD SURVEYS

2.3.1 Background

The Tennessee Division of Environment and Conservation's (TDEC) Division of Remediation (DoR) Oak Ridge Office (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 assess potential impacts from wastes that may have fallen from the trucks in transit, TDEC DoR-OR personnel perform walk over inspections of different segments of the Haul Road and associated access roads. Anomalous items noted along the roads are scanned for radiation, logged, and marked with contractor's ribbon. Subsequently, their descriptions and locations are submitted to the Department of Energy (DOE) for disposition.

2.3.2 Related DOE Projects

DOE conducts radiological surveys of the Haul Road utilizing radiological detection instrumentation attached to a tractor, but. the tractor does not stop to manually survey anomalous objects found on or beside the road.

Throughout the history of the haul road survey project, numbers of anomalous items have been identified such as waste debris, personal protection equipment, tarp patches, waste stickers, and steel pipe.

2.3.3 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 to the EMWMF.

Only low-level radioactive waste, as defined in TDEC 0400-02-11.03(21) with radiological concentrations below limits imposed by 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 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. The State and EPA oversee and periodically audit associated activities related to this work, including the review of the decisions authorizing waste lots for disposal.

2.3.4 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 assure that DOE and their contractors continue their waste transportation in a manner that limits potential environmental concerns for the Haul Road and the surrounding areas.
- To verify DOE surveys of the Haul Road and associated access roads.

2.3.5 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.

2.3.6 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.

2.3.7 Constraints

- There may be a shortage of available staff to conduct these surveys.
- Weather is a limiting factor; surveys should not be conducted in the rain or snow.

2.3.8 Methods, Materials, Metrics

The nine-mile-long Haul Road is surveyed in segments, typically consisting of one to two miles. Since ETTP is no longer transporting waste to the EMWMF, this main section will only be surveyed if the hauling of waste is resumed. 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 stem of the Haul Road. This 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. Should excessive traffic present a safety concern, the survey is postponed to a later date. Alternate entrances are sometimes used to survey the road with DOE approval, but the basic requirements remain the same.

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 cm^2 removable beta, 1000 dpm/100 cm^2 total beta, 20 dpm/100 cm^2 removable alpha, and/or 100 dpm/100 cm^2 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, staff members perform a follow-up inspection of items found and reported during previous weeks. If any items remain on the road, they are included in subsequent reports until removed or staff members are advised by DOE that the item(s) have been determined to be free of radioactive and hazardous constituents.

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.

2.3.9 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.

Tennessee Department of Environment and Conservation (TDEC) ,2017, Division of Remediation, Oak Ridge Office (DoR OR) 2017 Health and Safety Plan Including Related Policies, January 2017. Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office, Oak Ridge, TN.

2.4 Periodic Radiological Review of ORR CERCLA FFA Related Project Sites

2.4.1 Background

The Department of Energy's Oak Ridge Reservation began operations in the early 1940's during the Manhattan Project primarily on three sites:ETTP (formally K-25), ORNL (formally X-10), and Y-12. During early operations, releases of radioactive and other hazardous substances were common within and from the facilities. Contaminants were released into the environment in the form of gases, liquids, and solids. The remediation of past contaminant releases is regulated by CERCLA. Much of the low-level radioactive and other hazardous wastes generated from environmental remediations are disposed of in EMWMF near Y-12 in Bear Creek Valley.

ETTP's original mission was enriching uranium in the Gaseous Diffusion facility for manufacturing the first atomic weapons and later for fueling commercial-reactors and government-owned reactors. The weapons production facility was permanently shut down in 1987. Consequential to operational practices and accidental releases, many of the facilities at ETTP were contaminated to some degree.

Uranium and its progeny are the primary contaminants, but due to the periodic reprocessing of spent fuel to recycled uranium, technetium-99, other fission, and activation products are also present.

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

Construction of the ORNL site began in 1943. Initially, ORNL focused on research reactors to produce plutonium and other activation and fission products chemically extracted from irradiated uranium in ORNL's graphite reactor and later at other ORNL and Hanford reactors. Through the years, ORNL's research mission expanded into many areas, consequently, a variety of radiological and other hazardous wastes were produced, that may have been released into the environment.

2.4.2 Related DOE Projects

- CERCLA facility remediations and D&Ds.
- Current CERCLA operations.
- ORR CERCLA waste disposal and storage site boundaries.
- CERCLA site investigations.

2.4.3 Problem Statements

Legacy releases of CERCLA radioactive wastes and other hazardous wastes are still present on the ORR in standing facilities, soils, and sediments. Demolition of facilities as well as disturbance of unremediated soils and sediments may cause releases on or off the ORR.

2.4.4 Goals

The goal of the project is to verify if radiological contaminants are present at demolition sites and to ensure DOE is employing effective Best Management Practices (BMPs) to prevent the migration of contaminants from work sites.

2.4.5 Scope

- Support field sampling for site investigations for TDEC DoR-OR.
- Scoping of facilities being slated for D&D.
- Evaluation of BMPs for ongoing D&D and environmental restoration activities.

- Post restoration confirmation evaluations.
- Review of radiological data.
- CERCLA activities that may result in radiological releases to the public.

2.4.6 Assumptions

- Funding for this project will be sufficient.
- State vehicle is available.
- Staff has the adequate training, clearances, and escorts to access areas.
- Notification of TDEC DoR-OR sampling events will be given with adequate advance notice.
- Adequate staff are available to conduct the assessments.

2.4.7 Constraints

- The availability of the appropriate radiation-measuring equipment.
- Project budget is subject to reprioritization.
- Radiation levels are expected to change in certain area's being remediated.
- Levels of radiation may vary in active work areas based on movement of materials.

2.4.8 Methods, Materials, Metrics

In coordination with DOE and site core teams, the project will consist of walkdowns, radiological surveys with the appropriate field instrument, and sampling to assess pre- and post-remedial radiological conditions and other hazardous waste conditions on the ORR.

Methods will consist of site walkdowns where observations are documented in trip reports. Radiological field surveys will be integrated into the trip reports. Sampling will consist of media determined by elevated radiological measurements or suspect areas based on visual inspection or historical knowledge to be analyzed for radioactive contaminants or other contaminates of concern. Sample analytical results will be attached to the trip reports.

Materials will consist of the appropriate radiation instruments to detect radiological isotopes of concern. Removable radiological conditions will be assessed by analyzing collected large area wipe or smear tab samples in the field with radiological instruments. Intrusive, soil, and sediment samples will be sent to approved vendors for analysis, if appropriate.

Metrics will consist of comparing radiological and sampling data to the appropriate TDEC standards or limits. Interpretation and recommendations will be based on the data and visual inspections and included in the trip report.

2.4.9 References

US EPA. (August 2000). NUREG-1575 Rev 1. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).

3.0 BIOLOGICAL MONITORING

3.1 RADIOLOGICAL UPTAKE IN FOOD CROPS

3.1.1 Background

DOE conducts studies on locally grown and harvested food crops, hay, and milk to analyze airborne releases of radiation and its possible effects on food crops and their consumption. The Radiological Uptake in Food Crops Project was recommended to TDEC DoR-OR by DOE to verify DOE's results to determine the possibility of consumers receiving radiation doses resulting from DOE's activities on the Oak Ridge Reservation (ORR).

This project will serve to better understand the effects of radiation uptake in locally grown and harvested food crops.

The TDEC DoR-OR Radiological Uptake in Food Crops project will sample, as available, food crops, hay, and milk from multiple locations thought to be potentially impacted by the ORR, either on or nearby, as well as one sample of each type 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.

3.1.2 Related DOE Projects

DOE conducts sampling of locally grown and harvested food crops, hay, and milk, as available, to look for releases of radiation and its possible effects on food crops and their consumption. According to the 2021 DOE EMP, they intend to sample food crops from broad-leaf systems (lettuce, turnip greens, etc.), root-plant-vegetable systems (tomatoes), and root-system vegetables (turnips, potatoes, etc.), at three locations potentially impacted by ORR activities, north of Y-12 (Scarboro community), southeast of ORNL (Gallaher Bend area), and southeast of ETTP/southwest of ORNL (Jones Island area), as well as 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.

3.1.3 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

3.1.4 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

3.1.5 Scope

As available, this project will collect and analyze samples of hay, milk, and food crops (root crop, fruit crop, leafy crop) from within five miles off or on the ORR. These samples will be compared to samples taken from a reference location 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.

3.1.6 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

3.1.7 Constraints

- Availability of food crops, hay, and milk
- 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
- Laboratory costs can impact the scope of the project
- Availability of funds to purchase food crops, hay, milk, and seeds

3.1.8 Methods, Materials, Metrics

For the TDEC DoR-OR Radiological Uptake in Food Crops project, staff will collect samples of hay, milk, and food crops (root crop, fruit crop, leafy crop), as available, preferably from within five miles off or on the ORR. Up to four samples from each food crop type (root crop, fruit crop, leafy crop) and milk will be collected, with one of the samples from each type being collected at a reference location more than five miles from the boundary of the ORR and not thought to be radiologically impacted by the ORR. Up to five hay or grass samples will be collected with one from a reference location at least five miles from the ORR boundary. 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 the initial gross beta or gross alpha results are elevated. Milk samples will be analyzed for tritium, gamma emitting radionuclides, strontium-90, and isotopic uranium.

The TDEC DoR-OR Radiological Uptake in Food Crops project analytical results will be reviewed and compared to DOE's food crop data.

Figure 3.1.1 shows the proposed sample area, with reference locations beyond the five- mile buffer area. Table 3.1.2 shows the analyses to by run for each sample type.

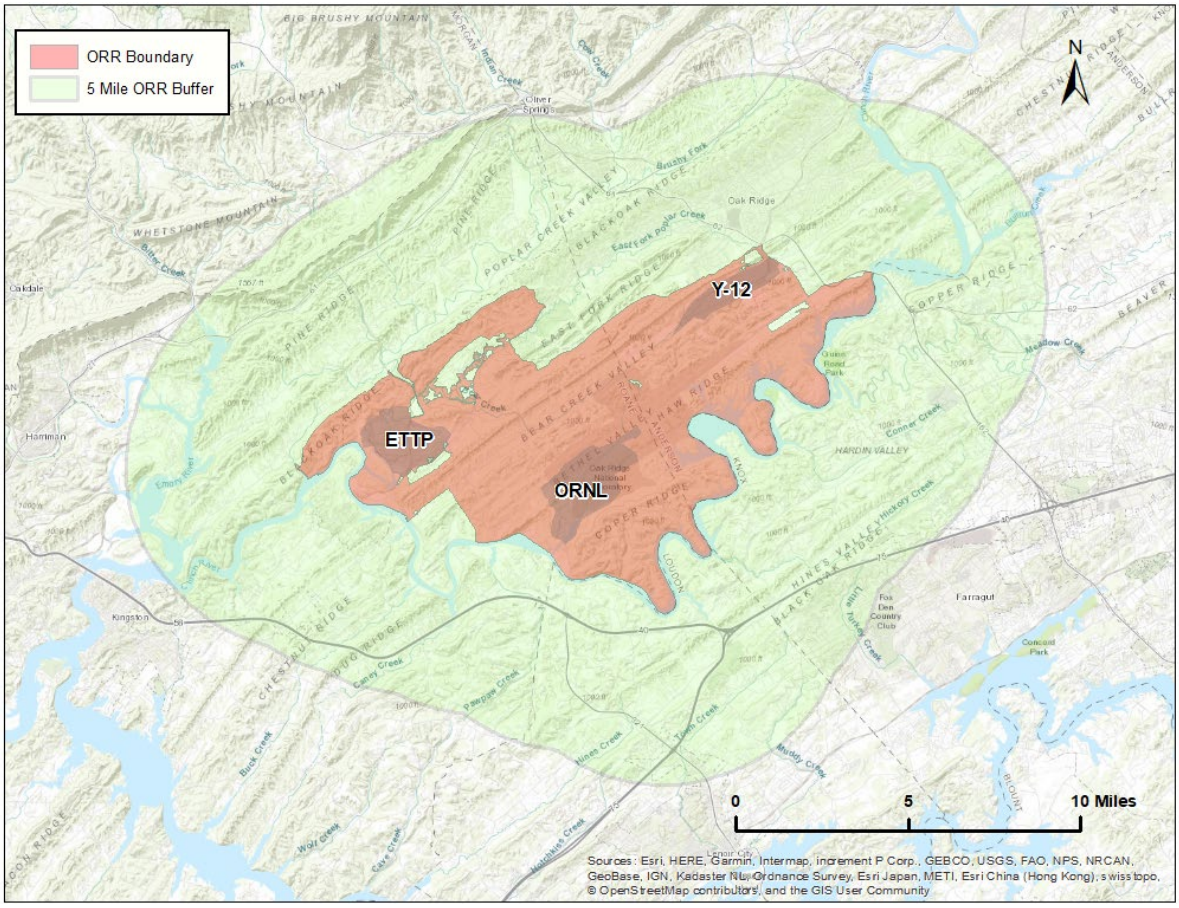

Figure 3.1.1: Proposed food crop sampling area

Table 3.1.2 Analyses for each sample type

	leafy crop	root crop	fruit crop	hay	milk
gross alpha, gross beta					
gamma					
strontium-90					
isotopic uranium (U-234, 235, 238)					
tritium					
max # samples	4	4	4	5	4

initial analysis run for each sample

conditional analysis

3.1.9 References

DOE (2020). Environmental Monitoring Plan for the Oak Ridge Reservation, Calendar Year 2021. DOE/ORO—2228/R12.

DOE (2020). Oak Ridge Reservation Annual Site Environmental Report. DOE/CSC-2513. https://doeic.science.energy.gov/ASER/ASER2019/index.html

3.2 Benthic Ecological Community Health

3.2.1 Background

Bear Creek has been negatively impacted by World War II Manhattan Project activities as well as current operational activities. The Environmental Management Waste Management Facility (EMWMF), located near upstream reaches of the creek, receives low-level radiological and hazardous wastes generated from Oak Ridge's cleanup projects. As this landfill nears capacity, a new landfill has been proposed nearby which may have unintended impacts on the aquatic ecosystem in Bear Creek.

The Benthic (stream bottom) Monitoring Project consists of macroinvertebrate and diatom community sampling. This project aims to document, monitor, and note any changes to their conditions due to ongoing CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act) remedial activities. The populations and quantities of tolerant and intolerant species will be evaluated within the Bear Creek watershed. Understanding these population dynamics will aide in the evaluation of real effects from known contamination on the benthic ecosystem. Additionally, it will help establish a clear baseline within the Bear Creek watershed, allowing more accurate comparisons if or when new construction activity begins in this region. An unimpacted reference stream will be used to determine the composition of a healthy benthic community.

Aquatic macroinvertebrate and diatom 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. Diatoms and detritus, the primary food source for macroinvertebrates, have been found to readily absorb methylmercury and facilitate the upward movement of the toxic substance through higher trophic levels of the food web (Lopez et al., 2013). Diatoms reproduce and respond rapidly to environmental change and provide early warnings of both pollution increases and habitat restoration success (Round, 1991; Kelly et al., 1998).

All work on this project follows the requirements of TDEC Division of Remediation Oak Ridge Office's (TDEC DoR-OR) Health and Safety Plan (TDEC 2020).

3.2.2 Related DOE Projects

DOE conducts benthic macroinvertebrate sampling throughout the ORR and reports their findings in both the Remediation Effectiveness Report (RER) and the Annual Site Environmental Report (ASER).

ORNL staff conducts benthic macroinvertebrate monitoring on 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, different perspectives can help delineate actual conditions in ORR streams.

DOE does not currently collect diatom community samples.

3.2.3 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 EMR 2019, DOE ASER 2019). Many of the impacts affecting these streams result from both historical Manhattan Project activities on 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 and sampling with different groups of samplers.
- Changing habitat due to severe weather events, such as flooding, or beaver activity may influence TDEC DoR-OR's sampling behavior.

3.2.4 Goals

- Assess the overall health of the stream ecosystem in Bear Creek and provide baseline benthic macroinvertebrate data to support the Bear Creek Assessment Project.
- Compare current health of the stream ecosystem to historical data in Bear Creek and its corresponding reference station.
- Provide a QC check on DOE's ORR Macroinvertebrate data.
- Provide recommendations that could help improve the stream ecosystem in Bear Creek.

3.2.5 Scope

The physical boundary of the Benthic Community Monitoring Project includes five locations in Bear Creek and one corresponding reference station in Mill Branch (Figure 3.2.1). Macroinvertebrates and diatoms will be collected from all sites. Macroinvertebrates will be processed in the TDEC DoR-OR laboratory by trained staff. Diatoms will be sent to a contracted lab for identification (Table 3.2.1).

TDEC DoR-OR staff will provide oversite to at least 25% of DOE's macroinvertebrate collection in 2021.

Table 3.2.1: Bear Creek sampling locations and Mill Branch sampling location

Benthic Community Health			
Site Description	**Name**	**latitude**	**longitude**
Bear Creek Kilometer 12.3	BCK 12.3	35.97300	-84.27814
Bear Creek Kilometer 9.9	BCK 9.9	35.96032	-84.29741
Bear Creek Kilometer 7.6	BCK 7.6	35.95096	-84.31395
Bear Creek Kilometer 4.5	BCK 4.5	35.93731	-84.34013
Bear Creek Kilometer 3.3	BCK 3.3	35.94354	-84.34911
Mill Branch Kilometer 1.6	MBK 1.6	35.98886	-84.28935

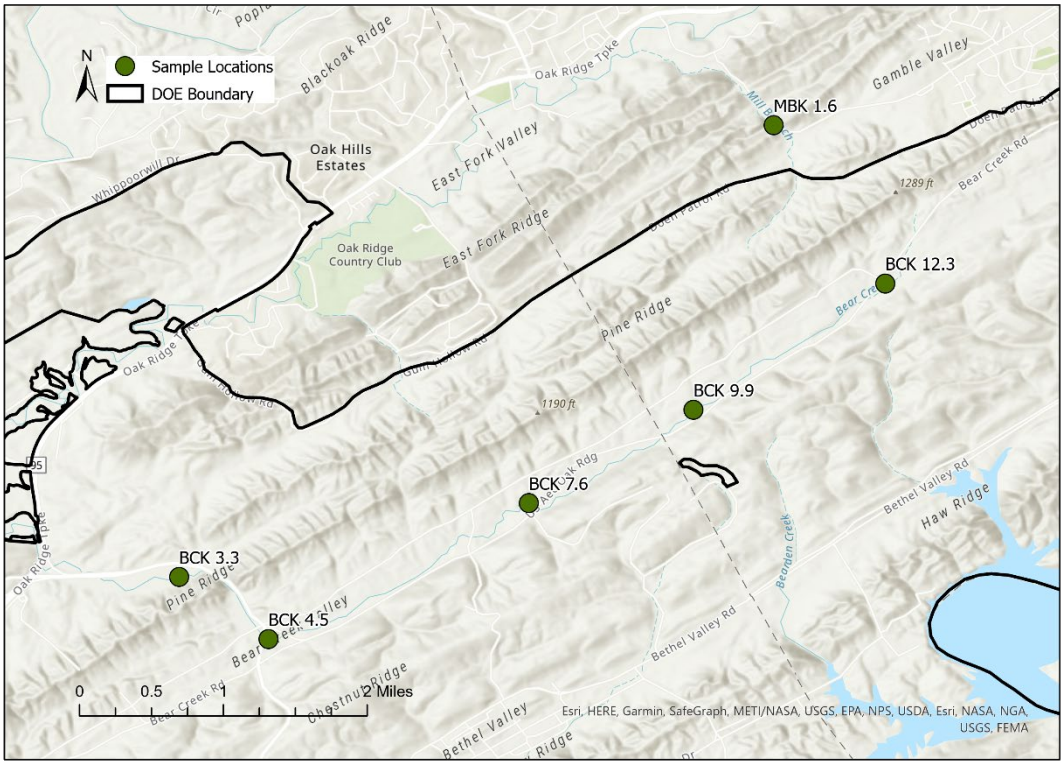

Figure 3.2.1: Benthic Community Health sampling locations

3.2.6 Assumptions

- Weather will allow for timely collection of macroinvertebrate and diatom samples.
- Equipment will not be lost or damaged.
- 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.

3.2.7 Constraints

- Sampling is seasonal and can only be completed between May – June.
- Requires procurement of one carboy of 95% ethanol for sample preservation.
- Samples can be processed in the time allotted.
- Weather will allow for field work to be conducted on schedule.
- TDEC DoR-OR personnel have the appropriate certifications (HAZWOPER, Rad Worker 2, Practical Factors) to enter areas that require an RWP.

3.2.8 Methods, Materials, Metrics

Macroinvertebrates:

Macroinvertebrates will be collected at five sites on the Oak Ridge Reservation and one corresponding reference location (Table 3.2.1).

Macroinvertebrate sampling will follow the guidance outlined in the TDEC Oak Ridge Office Standard Operating Procedure for Benthic Macroinvertebrate Sampling (TDEC, 2019).

Diatoms:

Diatoms will be collected in conjunction with macroinvertebrate collection (May – June) by gently removing the periphyton layer from benthic substrates with a toothbrush. Diatom samples will be collected from five sites on the Oak Ridge Reservation and one reference location.

Diatom sampling will follow the guidance outlined in the TDEC Division of Water Pollution Control, Quality System Standard Operating Procedure for Periphyton Stream Surveys (TDEC, 2010).

3.2.9 References

DOE. (2019). Department of Energy, Oak Ridge Reservation Annual Site Environmental Report. DOE/CSC-2513.

Holt, E. A. & Miller, S. W. (2010). Bioindicators: Using Organisms to Measure Environmental Impacts. Nature Education Knowledge 3(10):8.

Kelly, M.G., Cazaubon, A., Coring, E. et al. (1998). Recommendations for the routine sampling of diatoms for water quality assessments in Europe. Journal of Applied Phycology, 10: 215.

López van Oosterom, María V., Ocón, Carolina S., Brancolini, Florencia, Maroñas, Miriam E., Sendra, Eduardo D., & Rodrigues Capítulo, Alberto. (2013). Trophic relationships between macroinvertebrates and fish in a pampean lowland stream (Argentina). Iheringia. Série Zoologia, 103(1), 57-65.

Round Fe. (1991). Diatoms in river water-monitoring studies. Journal of Applied Phycology, 3: 129-145.

TDEC. (2010). Tennessee Department of Environment and Conservation Division of Water Pollution Control, Quality System Standard Operating Procedure for Periphyton Stream Surveys.

TDEC. (2019). Tennessee Department of Environment and Conservation, Oak Ridge Office (DoR-OR) 2019 Environmental Monitoring Report. Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office, Oak Ridge, TN.

TDEC. (2019). Standard Operating Procedure for Benthic Macroinvertebrate Sampling. SOP # DoR OR-T-260. Tennessee Department of Environment and Conservation, Division of Remediation-Oak Ridge Office, Oak Ridge, TN.

TDEC. (2020). Tennessee Department of Environment and Conservation Division of Remediation, Oak Ridge Office (DoR OR) 2020 Health and Safety Plan Including Related Policies, 2020. Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office, Oak Ridge, TN.

3.3 ORR Roving Creel Survey

3.3.1 Background

The Roving Creel Survey 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.

Bear Creek (BC) and East Fork Poplar Creek (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, processes and practices of 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).

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 Sr-90 and 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).

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). Fish are especially vulnerable to mercury bioaccumulation due to their habitat and diet.

Consumable fish tissue samples will be collected from targeted species on a semi-annual basis and sent to a laboratory for analysis. The 2018 annual TWRA Fisheries Report suggests that White Bass (Morone chryops) and White Crappie (Pomoxis annualris) are the most commonly harvested fish from the Melton Hill Reservoir (TWRA, 2017). The Melton Hill Reservoir is the closest reservoir to the sites selected for this study. Currently, TDEC DoR-OR's data are not sufficient to determine if enough protective measures are being implemented to limit human exposure to contaminated fish.

3.3.2 Related DOE Projects

There have been limited DOE investigations to ascertain the level of human exposure through angling efforts on the ORR. Those studies (Campbell et al. 2002, Burger and Campbell 2008), conducted more than 10 years ago, focused heavily on land interviews with anglers fishing from the bank or shore and noted that despite over 80% of those interviewed being aware of fish consumption advisories, only about 1/3 did not eat fish from the study area.

3.3.3 Problem Statements

- Fish bioaccumulate mercury and other contaminants produced on the ORR
- Frequently, fish consumption warnings are not visible, missing, or disregarded by the public
- There are no data to assess the extent of human interface with fish taken from exit water pathways on the ORR
- There are no data to assess the amount of bioaccumulation in fish at these key confluence locations

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
- Analyze fish tissue at watershed outfall locations
- To link data from the roving creel survey to efficacy of signage and other risk notifications in areas on/near the reservation to contamination from ORR activities and that are used for recreational purposes by the public
- To provide data that is pertinent to CERCLA requirements and future ORR decisions regarding human health and environmental protection

3.3.5 Scope

Angler interviews will be limited to three locations, the confluence region of Bear Creek and Poplar Creek (Figure 3.3.2), the confluence region of Poplar Creek and the Clinch River (Figure 3.3.3), and the confluence region of White Oak Lake and the Clinch River (Figure 3.3.4). 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).

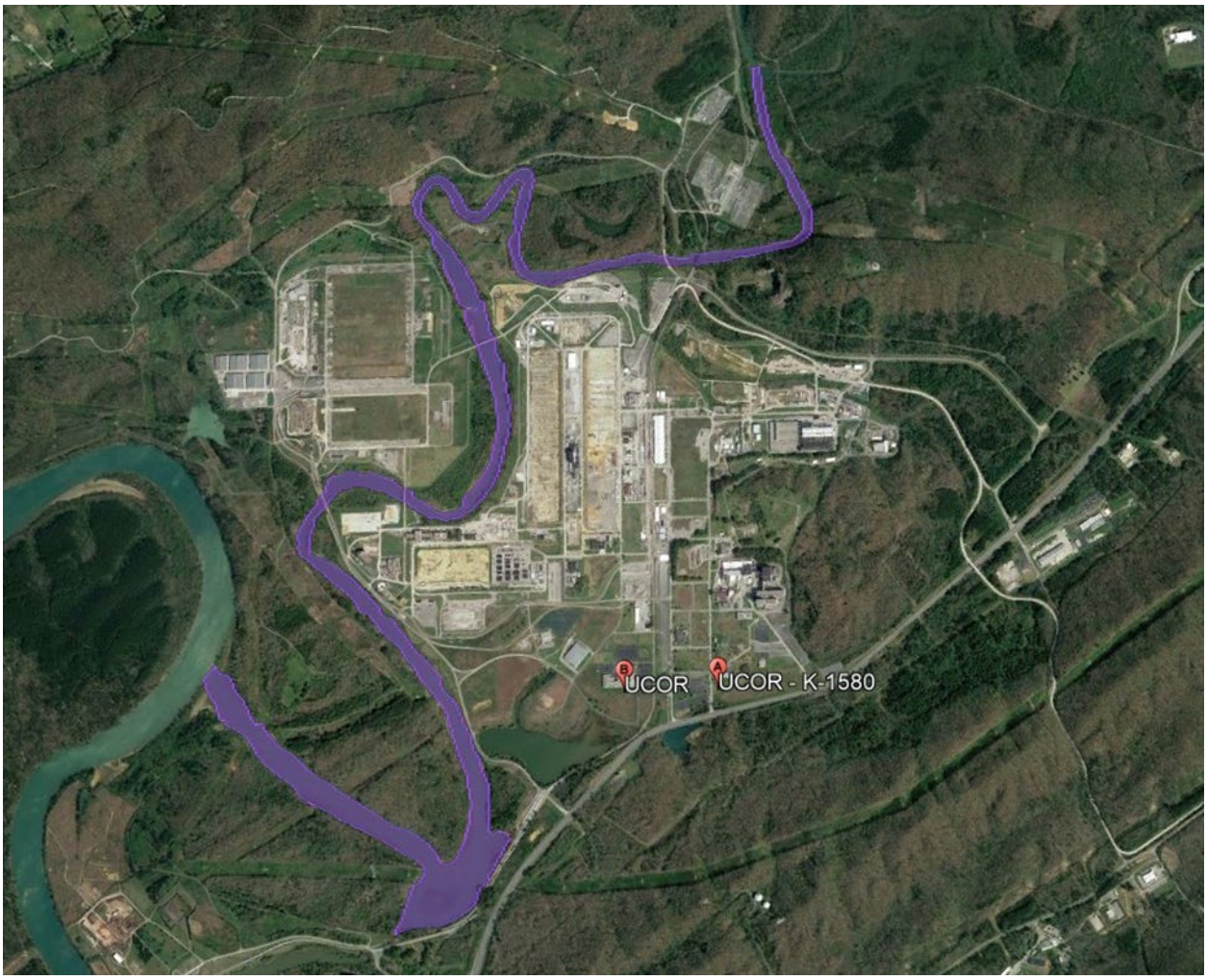

Figure 3.3.2: Bear Creek and Poplar Creek Confluence Region (highlighted in purple)

Figure 3.3.3: Poplar Creek and Clinch River Confluence Region (highlighted in purple)

Figure 3.3.4: White Oak Lake and Clinch River Confluence Region (highlighted in purple)

In addition to fisherman surveys, consumable fish tissue collection will be conducted twice, August-September 2021 and April-May 2022 (Table 3.3.2). Total field sampling time will be approximately 4-8 days or less, depending on time to acquire target species and defined sample size. Individual fish from the same location will be combined, or pooled, in the same sample container. Target sampling will include a minimum of 500g pooled fish tissue per site,

with an ideal target of 3 pooled tissue samples per site.

Table 3.3.2: Sample Schedule

Aug-Sept 2021		
Event 1	CRK 70.8	500 g filet (min300 g)
Event 2	CRK 33.8	500 g filet (min300 g)
	CRK 19.3	500 g filet (min300 g)
	PCK 8.9	500 g filet (min300 g)
Apr-May 2022		
Event 1	CRK 70.8	500 g filet (min300 g)
Event 2	CRK 33.8	500 g filet (min300 g)
	CRK 19.3	500 g filet (min300 g)
	PCK 8.9	500 g filet (min300 g)

To evaluate human health risk from consuming fish that may be contaminated, consumable fish tissue harvested from game species will be sampled for an expanded suite of radionuclides, metals, and PCBs identified in waste inventories or CERCLA documents (Table 3.3.3).

Table 3.3.3: Focal Analytes

Parameter	Matrix	ALS LAB	Analytical Method	Turnaround Time	Sample Quantity
Gross Alpha-Beta	TISSUE	Fort Collins	SW 9310	28 days	4
Gamma (Cs137, Co60, K40 + others)	TISSUE	Fort Collins	EPA901.1	28 days	4
Sr89/90	TISSUE	Fort Collins	ASTM D5811	28 days	4
Isotopic Uranium	TISSUE	Fort Collins	ASTM D3972	28 days	4
Isotopic Plutonium	TISSUE	Fort Collins	ASTM D3972	28 days	4
Pu241	TISSUE	Fort Collins	D3972/EPA	28 days	4
C14	TISSUE	Fort Collins	EERF	28 days	4
Po210	TISSUE	Fort Collins	ASTM D3972	28 days	4
Tc-99	TISSUE	Fort Collins	LSC	28 days	4
Hg	Tissue	Fort Collins	SW7471	7-10 days	4
MeHg	Tissue	Kelso	GC/AF	15 days	4
PCBs	TISSUE	Fort Collins	SW8082	7-10 days	4
METALS*	TISSUE	Fort Collins	SW6020/SW602	7-10 days	4
Dioxin Furans PCDD/PCDF	TISSUE	Burlington	1613B	15 days	4

Fish will be sampled from the following locations (Figure 3.3.5)

- **CRK 33.8 (CRM 21):** Exit point for White Oak Creek into the Clinch River– this location will capture contaminant inputs from sources in Melton Valley and Bethel Valley. WOC receives inputs from historical and ongoing nuclear and industrial operations from

ORNL.

- **CRK 19.3 (CRM 12):** Exit point for Poplar Creek into the Clinch River – this location will capture contaminant inputs from Mitchell Branch as well as Bear Creek and East Fork Poplar Creek. East Fork Poplar Creek receives contaminant input from the east end of Y-12, as well as inputs from the City of Oak Ridge.
- **PCK 8.9 (PCM 5.5):** Exit point for East Fork Poplar Creek into Poplar Creek – this location will capture contaminant inputs from Bear Creek and East Fork Poplar Creek. East Fork Poplar Creek receives contaminant input from the east end of Y-12, as well as inputs from the City of Oak Ridge.
- **CRK 70.8 (CRM 44)**: this location is upstream of the ORR and does not receive inputs from DOE activity.

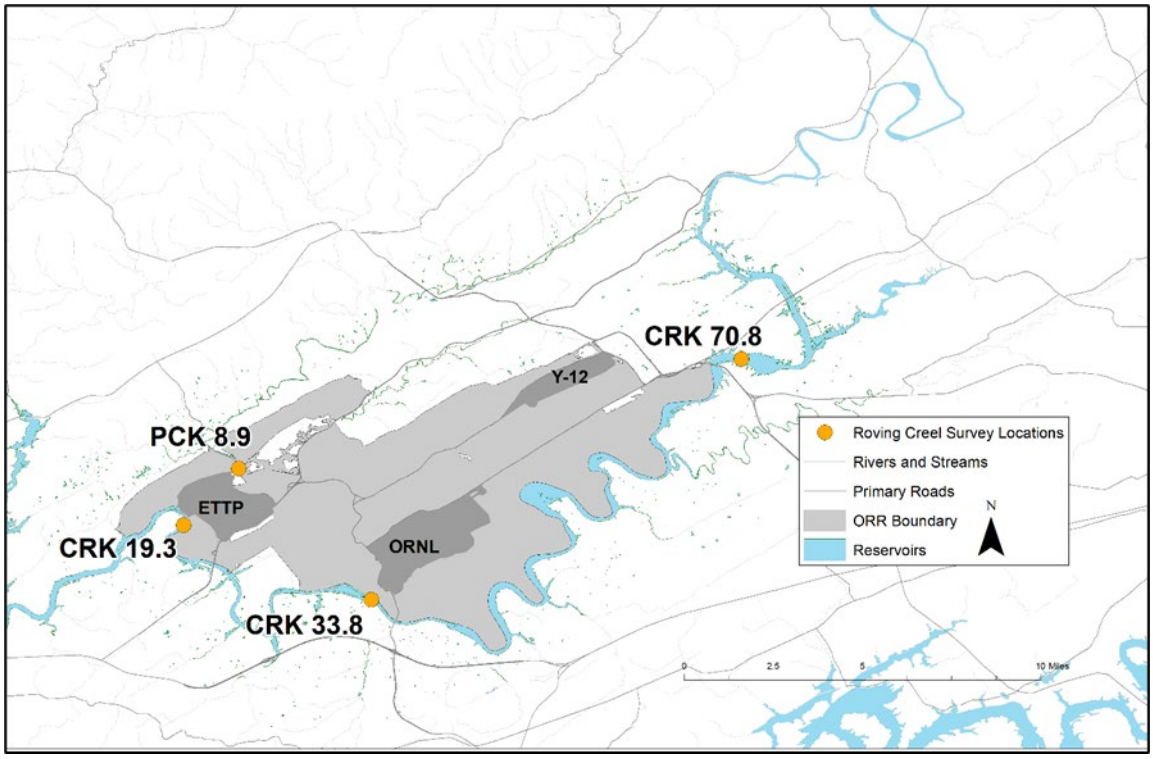

Figure 3.3.5: Focal Sampling Locations

3.3.6 Assumptions

- Anglers will be present and willing to participate in the survey.
- Adequate funding will exist for laboratory analysis of Hg, MeHg, and radiological samples.

- Adequate field time will be available to carry out the mission.

- Equipment will be available and properly functioning.
- Additional 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 will be safe

3.3.8 Methods, Materials, Metrics

Part 1: Angler Interviews

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, and county of residency data. All waterbodies will be sampled using roving creel survey methods as outlined in the TWRA 2007 Fisheries Report.

Part 2: Consumable Fish Tissue Collection and Processing

Fish will be collected via electroshock fishing from a boat in the predetermined areas, approximately one acre centered on the focal point. The samples will be placed in a cooler with ice water for euthanization. The samples will be transported in the cooler to a secondary location for processing. A composite fish tissue sample will be frozen and shipped overnight on dry ice to a contracted laboratory for analysis, and the data received from the laboratory will be compared against State or federal regulatory limits and compiled in a technical report for review. These data will also be compared to a reference location upstream of the ORR inputs at CRK 70.8.

3.3.9 References

Ashraf, Muhammad & Khan, Aysha & Ahmad, Mushtaq & Akib, Shatirah & Balkhair, Khaled & Abu Bakar, N.K. (2014). Release, deposition, and elimination of radiocesium (Cs-137) in the terrestrial environment. Environmental geochemistry and health. 36. 10.1007/s10653-014-9620-9.

Brooks, S., V. Eller, J. Dickson, J. Earles, K. Lowe, T. Mehlhorn, T. Olsen, C. DeRolph, D. Watson, D. Phillips, & M. Peterson. (2017). Mercury content of sediments in East Fork Poplar Creek: current assessment and past trends. ORNL/TM-2016/578. Environmental Sciences

Division, Oak Ridge National Laboratory, Oak Ridge, TN.

Burger, J. and Campbell, K.R. (2008). Fishing and consumption patterns of anglers adjacent to the Oak Ridge Reservation, Tennessee: higher income anglers ate more fish and are more at risk. Journal of Risk Research. 11: 335-350.

Campbell, K.R., Dickey, R.J., Sexton, R., and Burger, J. (2002). Fishing along the Clinch River arm of Watts Bar Reservoir adjacent to the Oak Ridge Reservation, Tennessee: behavior, knowledge and risk perception. The Science of the Total Environment. 299: 145-161.

DOE. (1988). Historic radionuclide releases from current DOE Oak Ridge Operations Office facilities. OR-890 / DOE ORO / 76 Report. US Department of Energy, Oak Ridge, TN.

Kalisinska, E., D.I. Kosik-Bogacka, P. Lisowski, N. Lanocha and A. Jackowski. (2013). Mercury in the body of the most commonly occurring European game duck, the mallard (Anas platyrhynchos L. 1758), from northwest Poland. Archives of the Environmental Contamination and Toxicology 64:583-593.

Pant, P., M. Allen, & B. Tansel. (2010). Mercury uptake and translocation in Impatiens walleriana plants grown in the contaminated soil from Oak Ridge. International Journal of Phytoremediation 13:168-176.

Standish, C. L. (2016). Evaluation of total mercury and methylmercury concentrations of terrestrial invertebrates along Lower East Fork Poplar Creek in Oak Ridge, Tennessee.

St. John, T. (1992). Methods for deriving Annual Creel Reports. Tennessee Wildlife Resources Agency, Fisheries Report 92-24. Nashville, Tennessee.

TWRA. Black, Wm. Patrick. (2007) Tennessee Reservoir Creel Survey 2007 Fisheries Results, Tennessee Wildlife Resources Agency. P. ii-v. Nashville, Tennessee.

TWRA. Black, Wm. Patrick. (2017) Tennessee Statewide Creel Survey 2016 Results. Tennessee Wildlife Resources Agency. Nashville, Tennessee.

4.0 AIR MONITORING

4.1 FUGITIVE RADIOLOGICAL AIR EMISSIONS

4.1.1 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.

Due to the original operational practices as well as accidental releases, many of the facilities at ETTP are contaminated to some degree and are scheduled for or have already 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 and daughter products due to natural decay of radioactive isotopes.

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 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.

4.1.2 Related DOE Projects

DOE also conducts high volume air sampling on and around the ORR, though most of the DOE ORR program monitors the perimeter of the site. The results from this sampling are used in calculating the dose exposure for those most at risk off site. TDEC DoR-OR Fugitive Air monitoring project sampling data will be compared to DOE results.

4.1.3 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 from these facilities at EMWMF, 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.

4.1.4 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 evaluate DOE's compliance with the Code of Federal Regulations regulatory standards to ensure DOE's radiological emissions would not cause a member of the public to receive an effective dose greater than ten mrem per year, specifically where remedial action or waste management activities are being accomplished.

4.1.5 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 eight high volume air samplers (see Figure 4.1.1).

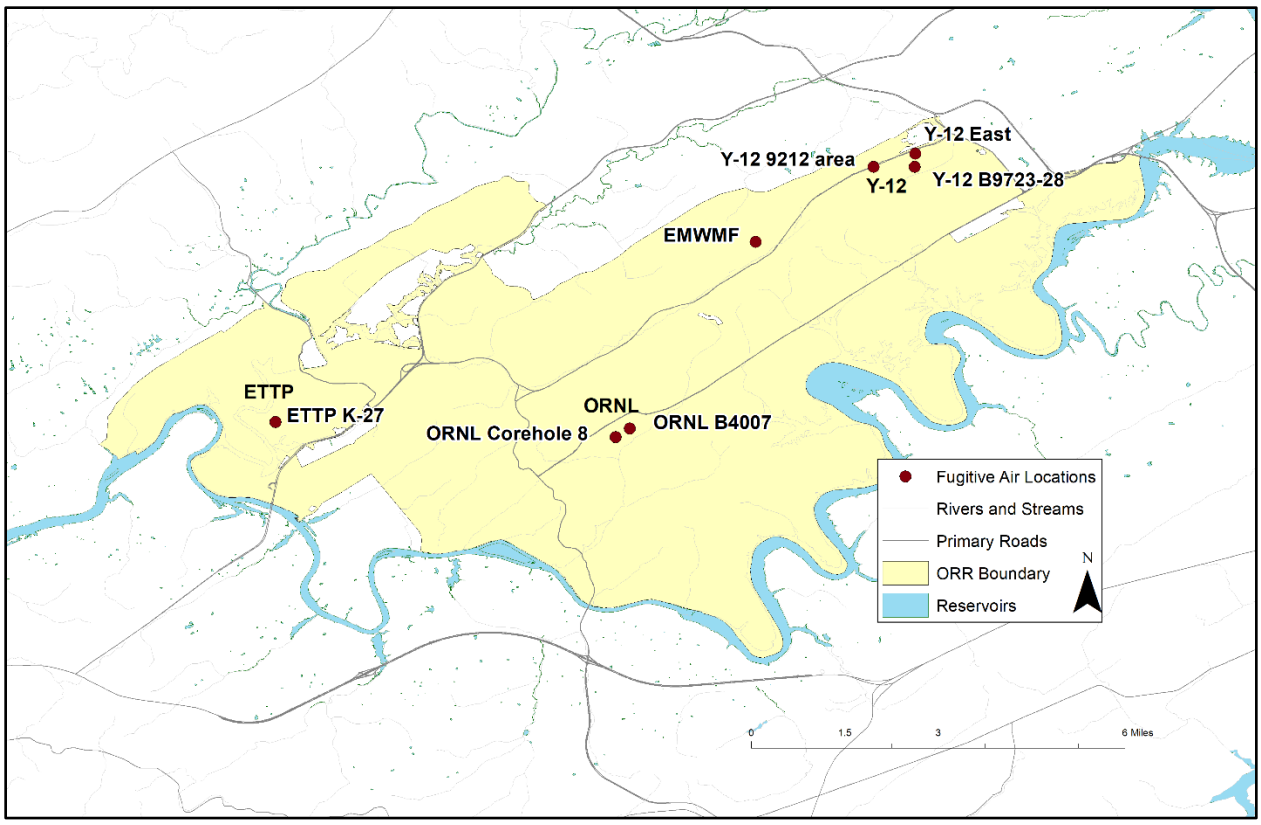

Figure 4.1.1: Fugitive Air Sampling Locations

4.1.6 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.

4.1.7 Constraints

- It will not be possible to collect and measure all fugitive emissions from all areas.
- 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.

4.1.8 Methods, Materials, Metrics

The Fugitive Air monitoring project will use eight 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, and 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's 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 Tennessee Department of Health Nashville Environmental Laboratory. The analysis preformed 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) which 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.*

4.1.9 References

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

4.2 RADNET AIR

4.2.1 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. 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 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).

4.2.2 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 seen in the 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 run by DOE. However, sampling by DOE varies by ORR site according to the DOE Annual Site Environmental Report (ASER).

4.2.3 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.

4.2.4 Goals

The goals for this project are as follows:

- Protect the 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 the RadNet station in Knoxville, which is used as a background location.
- 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.

4.2.5 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 samplers will be located at ORNL, with one in Bethel Valley and one in Melton Valley. An additional air sampler is located and operated by the TDEC field office in Knoxville, which will be used for background comparison. The four RadNet Air samplers on the ORR will be sampled Mondays and Thursdays except when a sample is skipped due to a holiday.

4.2.6 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 at ambient conditions
- Each sampler will remain operational with consistent power supply and site access

4.2.7 Constraints

- It is not 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 goes down
- 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 as defined by the EPA program in the way they define. Flexibility is limited as no other analyses are available to be requested through this program.

4.2.8 Methods, Materials, Metrics

The locations of the four RadNet Air samplers are provided in Figure 4.2.1. 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. 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 2021).

The gross beta data from the RadNet Air Monitoring Project will be compared to background data from the RadNet Air monitor in Knoxville, Tennessee, 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).

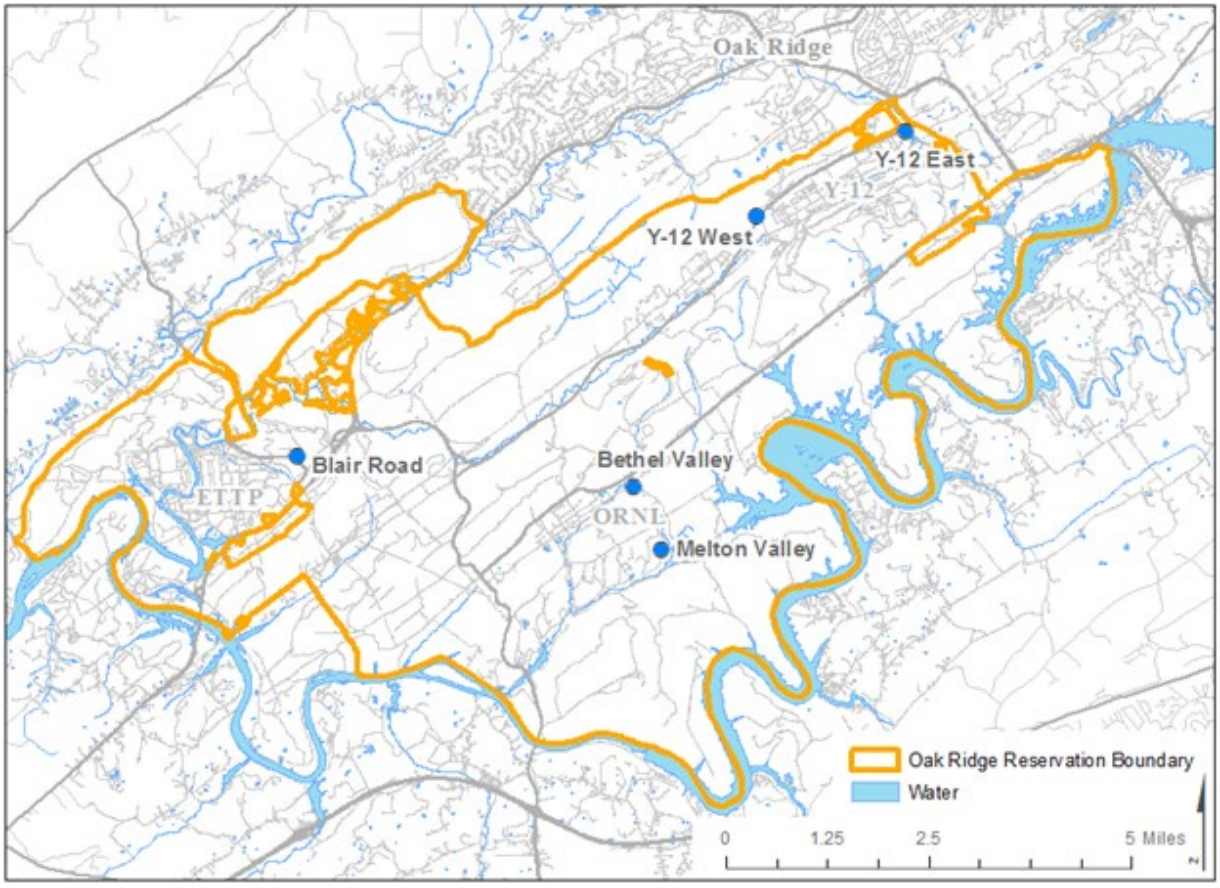

Figure 4.2.1: Locations of RadNet Air monitoring stations on the Oak Ridge Reservation

4.2.9 References

EPA (1988). Environmental Radiation Ambient Monitoring System (ERAMS) Manual. EPA 520/5-84-007, 008, 009.

EPA (2006). Andersen™ Flow Manager High Volume (FMHV) Air Particulate Sampler Operation Procedure. RadNet/SOP-3. Monitoring and Analytical Services Branch, National Air and Radiation Environmental Laboratory. Montgomery, Alabama.

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.

EPA (2010b). Clean Air Act. Code of Federal Regulations. Title 40: Protection of Environment. Part 61: National Emission Standards for Hazardous Air Pollutants. Subpart H: National Emissions Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities.

EPA (2011). Exposure Factors Handbook - Chapter 6: Inhalation Rates.
https://www.epa.gov/expobox/about-exposure-factors-handbook
https://www.epa.gov/sites/production/files/2015-09/documents/efh-chapter06.pdf

EPA (2021). 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

4.3 RadNet Precipitation

4.3.1 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 (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 the TDEC DoR-OR air monitors.

4.3.2 Related DOE Projects

The sampling for this project does not correlate directly to DOE's air sampling program described in the DOE 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.

4.3.3 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 these 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.

4.3.4 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.

4.3.5 Scope

Three precipitation samplers will be used to monitor the precipitation for radiological contamination. Each sampler is co-located at 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 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.

4.3.6 Assumptions

- Gamma analysis of monthly composite precipitation samples will identify or detect 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

4.3.7 Constraints

- This project only detects potential radiological emissions when there is a precipitation event that the 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 specific analysis as defined by the EPA program in the way they define. Flexibility is limited as no other analyses are available to be requested through this program.

4.3.8 Methods, Materials, Metrics

The locations of the three RadNet Precipitation samplers are depicted in Figure 4.3.1. 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 Cubitainer®.

When a minimum of two liters of precipitation has accumulated in the Cubitainer®, or potentially less than that if it is the final sample of the month, the sample is processed as specified by EPA (US EPA 1988, US 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 (U.S. 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 four millirem (mrem) per year and are radionuclide specific (U.S. 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 RadNet Precipitation monitoring program are located near major population centers, with no major sources of radiological contaminants nearby. Table 4.3.1 shows the maximum contaminant levels (MCLs) of beta and photon emitters that EPA uses as drinking water limits for select isotopes.

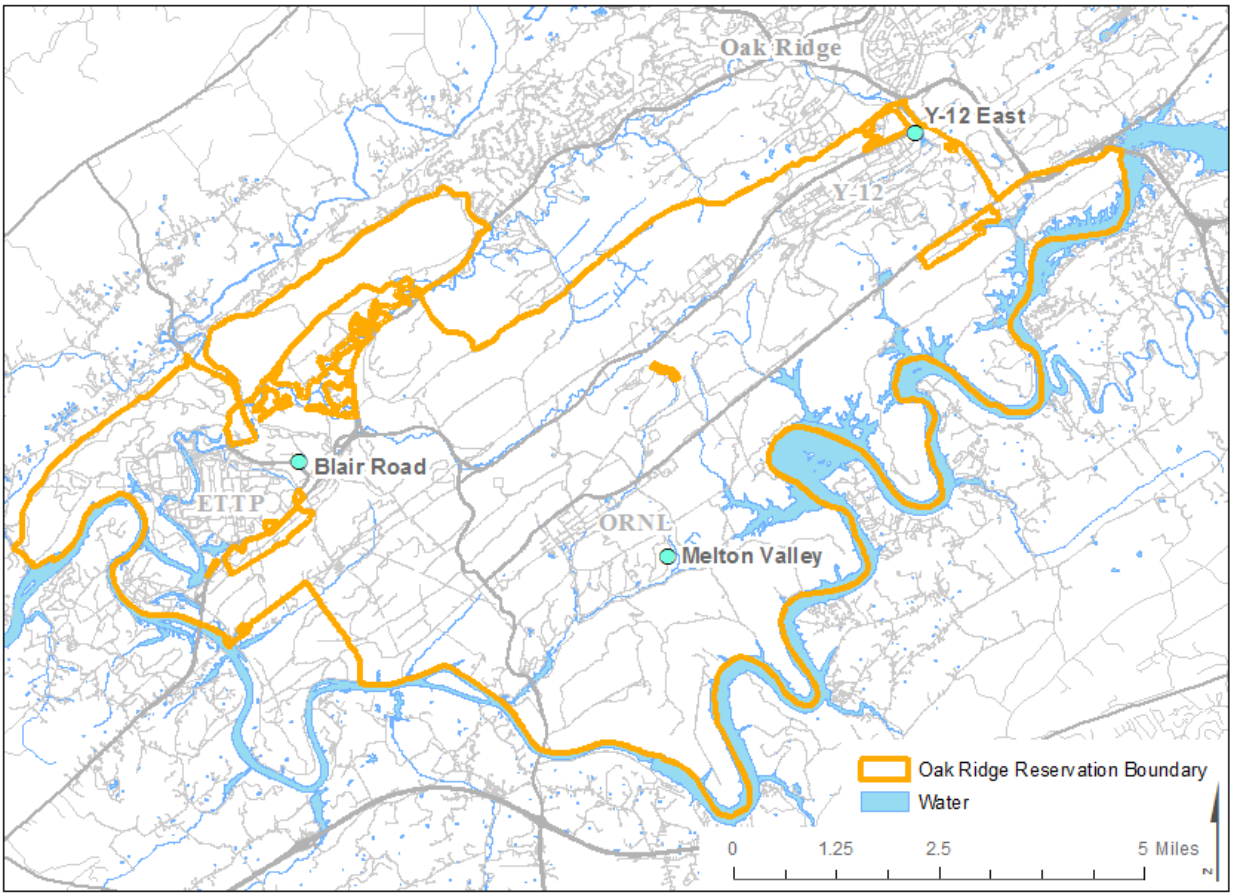

Figure 4.3.1: Locations of RadNet Precipitation monitoring stations on the ORR

The results of NAREL's analyses are available at the EPA Envirofacts RadNet searchable database, by either a simple or a customized search (U.S. EPA 2021). The data can 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 RadNet project, and to determine levels of local contamination.

Table 4.3.1: EPA Drinking Water Limits (MCLs) for select isotopes

Isotope	EPA limit (pCi/L)
Barium-140 (Ba-140)	90
Beryllium-7 (Be-7)	6,000
Cobalt-60 (Co-60)	100
Cesium-134 (Cs-134)	80
Cesium-137 (Cs-137)	200
Tritium (H-3)	20,000
Iodine-131 (I-131)	3

4.3.9 References

EPA (1988). Environmental Radiation Ambient Monitoring System (ERAMS) Manual. EPA 520/5-84-007, 008, 009.

EPA (2000). Radionuclides in Drinking Water. Radionuclide Rule. http://water.epa.gov/lawsregs/rulesregs/sdwa/radionuclides/

EPA (2013). NAREL Standard Operating Procedure for Collecting RadNet Precipitation Samples. SC/SOP-2. National Analytical Radiation Environmental Laboratory, Office of Radiation and Indoor Air. Montgomery, Alabama.

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 (2021). 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

5.0 SURFACE WATER MONITORING

5.1 AMBIENT SURFACE WATER SAMPLING

5.1.1 Background

The ORR consists of three (3) 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) leading to the 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 help 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 two (2) primary ORR exit-pathway streams as well as the Clinch River. This project monitors surface water by sampling for contaminants in waterways that have been impacted by past and present activities on the ORR.

5.1.2 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). Currently, DOE collects samples quarterly at four (4) sites along the Clinch River at river kilometers 16, 32, 58, and 66 (Figure 5.1.1) (DOE, 2020). 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 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 intake, and downstream of the ORR.

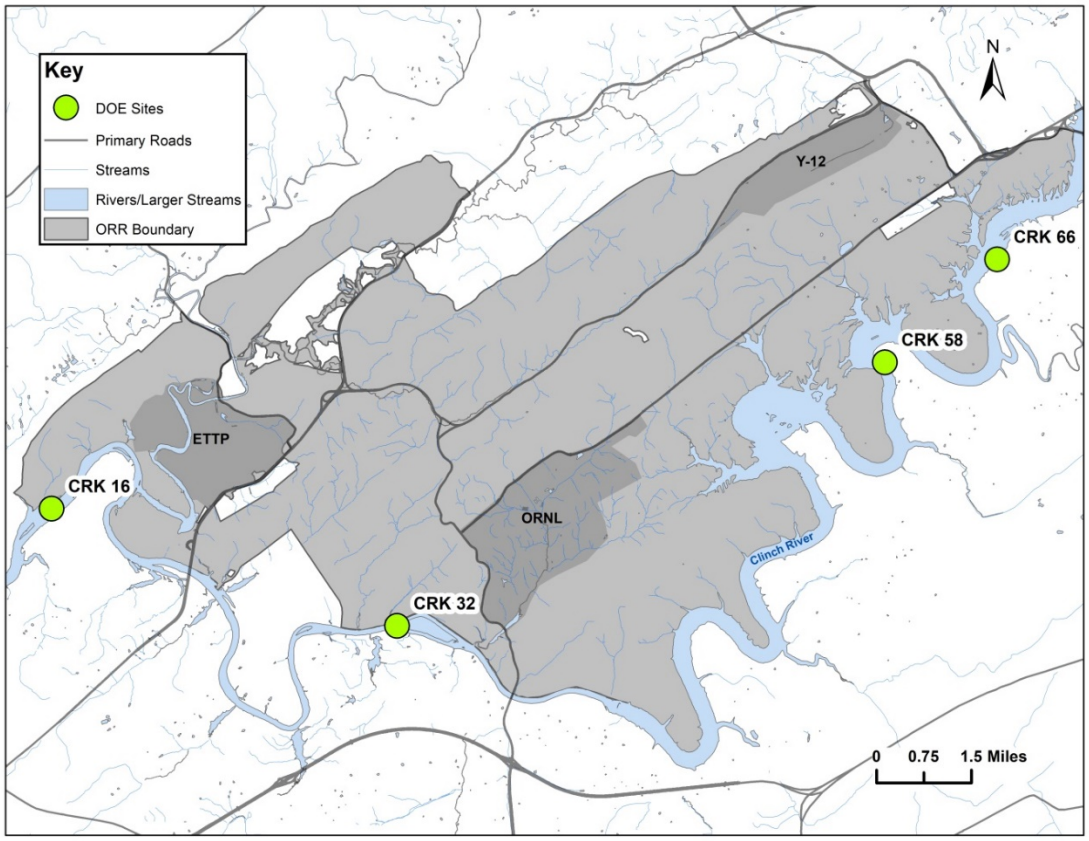

Figure 5.1.1: Map showing DOE sampling sites

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 outlined in this report would build upon DOE's sampling by looking at three ORR exit-pathway streams. These streams include Bear Creek (BC), East Fork Poplar Creek (EFPC), and Poplar Creek (PC). Samples and will be collected at several locations in the Poplar Creek ETTP area with the intent to provide a more representative evaluation of the loading of contaminants from ORR facilities to offsite locations. 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 MCLs defined by EPA to determine stream impacts.

5.1.3 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 influenced by 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).
- 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.

5.1.4 Goals

The goal of this Surface Water Monitoring Project is to evaluate the impact of contamination from Poplar Creek, Bear Creek, and East Fork Poplar Creek near ETTP. The Clinch River will also be monitored in conjunction with DOE sampling (Figure 5.1.2). Mill Branch (MB) will be used as a background comparison site to those sampled in the ETTP area. This project will ultimately seek to understand the loading and extent of contamination from Poplar Creek into the Clinch River, especially at publicly accessible areas. An assessment of each stream's impact, including the Clinch River, will be performed by comparing sampling results to 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.

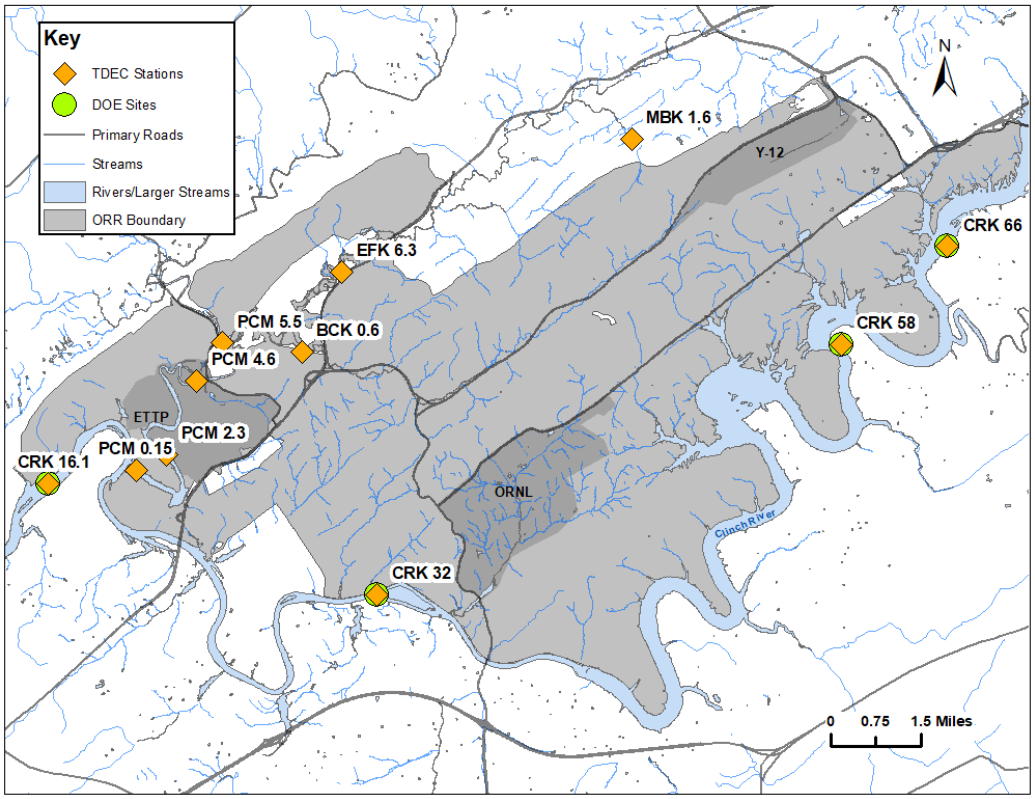

Figure 5.1.2 Map showing proposed TDEC DoR-OR sites and DOE sampling sites. The number associated with each site represents the distance in kilometers from the mouth of the stream or river to that location.

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

1. Collect surface water samples quarterly at three streams in the ETTP area (Bear Creek, East Fork Poplar Creek, and Poplar Creek), one ORR background stream (Mill Branch), and the Clinch River (Figure 5.1.2)

- Poplar Creek (PC): sample four (4) locations at PCM 5.5, PCM 4.6, PCM 2.3, and PCM 0.15 for metals, radionuclides, and major cations and anions. These locations will be sampled by boat and are dependent on water levels allowing navigation to each site
- Bear Creek (BCK): sample one (1) location at BCK 0.6 for metals and radionuclides
- East Fork Poplar Creek (EFK): sample one (1) location at EFK 6.3 for metals and radionuclides
- Mill Branch (MBK): sample one (1) location at MBK 1.6 for metals and radionuclides. 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

5.1.5 Scope

The scope of this project is to characterize stream conditions and assess contaminant presence through sampling and analysis of surface water from Poplar Creek, which flows into the CR. East Fork Poplar Creek and Bear Creek will also be characterized near their respective mouths.

A segment of the CR will also be assessed spanning from the Oak Ridge City water intake at CRK 66 downstream to CRK 16.1 which is downstream of all ORR exit stream inputs.

5.1.6 Assumptions

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

- Mercury and uranium contamination of EFPC is attributable to activities at Y-12
- Potential stream contamination is attributable to activities on the ORR
- Scheduling will allow for co-sampling with DOE
- Physical parameter water quality meter remains operational
- TDEC DoR-OR boat remains operational

5.1.7 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 measurable flow
- Excessive rain or drought which may prevent the ability to adequately sample and affect the ability to maneuver the boat to the collection locations

5.1.8 Methods, Materials, Metrics

Sample Collection

Surface water samples will be collected quarterly at one (1) site on BC, one (1) site on EFPC, one (1) site on MB, the background stream, and four (4) sites on PC. 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, EFPC, and PC will be sampled and analyzed for metals and radionuclides. Additionally, the BC and EFPC sites will be analyzed for major cations and anions. Samples collected from the CR sites will be analyzed for gross alpha/beta, isotopic uranium, mercury, and strontium-90 (Table 5.1.1). Quality assurance/quality control (QA/QC) samples will be collected for every 10th sample of any given analyte. If fewer than ten (10) samples of a given analyte are collected, at least one (1) QA/QC sample will still be taken (Table 5.1.1). 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, 2018).

Table 5.1.1: Planned samples and site information

			Planned Sampling						
Latitude	Longitude	DoR-OR Site	Sr-90	TRU*	Rads*	Mercury	Metals*	Major Cat*	Major An*
35.92186	-84.42942	CRK 16.1			1	1			
35.9002	-84.35049	CRK 32	1		1	1			
35.94891535	-84.23902273	CRK 58			1	1			
35.967958	-84.213382	CRK 66			1	1			
35.949173	-84.38759	PCM 5.5		4	4	4	4	4	4
35.941844	-84.393869	PCM 4.6		4	4	4	4	4	4
35.927427	-84.401154	PCM 2.3		4	4	4	4	4	4
35.924484	-84.408234	PCM 0.15		4	4	4	4	4	4
35.94747	-84.36855	BCK 0.6		4	4	4	4		
35.96293	-84.35905	EFK 6.3		4	4	4	4		
35.98886	-84.28935	MBK 1.6		4	4	4	4		
DOE Co-Sample		FB			2	2	2	1	1
Ambient		FD	1	2	3	3	3	1	1
QA/QC		Total for FY	**2**	**30**	**37**	**37**	**33**	**18**	**18**

***Note:**

Major Cat: sodium, potassium, calcium, magnesium

Major An: fluoride, chloride, sulfate, total phosphorus, nitrate/nitrite, total alkalinity

Metals: Antimony, Arsenic, Beryllium, Cadmium, Chromium, Lithium, Lead, Nickel, Thallium, Uranium

Rads: Isotopic Uranium, Gross alpha, Gross Beta

TRU: Am-241, Cm-243/244, Np-237, Iso-Pu

Field Parameter Measurements

At each site, physical water parameters will be collected during the time of sampling. Physical 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 samples 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, 2013). Any exceedances may invoke further investigation.

5.1.9 References

DOE. (1992). Federal Facility Agreement (FFA). Appendices for the Oak Ridge Reservation. Oak Ridge Site Description – UCOR, Appendix B (2017 revision). DOE/OR-1014. U. S. Department of Energy. Retrieved from http://www.ucor.com/docs/ffa/appendices/AppendixB.pdf

DOE. (1999). Annual Site Environmental Report. United States Department of Energy Oak Ridge Office. Retrieved from https://doeic.science.energy.gov/ASER/aser99/chap3.pdf

DOE. (2017). Annual Site Environmental Report. DOE/ORO-2511. United States Department of Energy Oak Ridge Office. Retrieved from https://doeic.science.energy.gov/aser/aser2017/01%202017%20ASER_Ch%201%20FINAL.pdf

DOE. (2018). Remediation Effectiveness Report. DOE/OR/01-2757&D1. U.S. Department of Energy. Retrieved from https://doeic.science.energy.gov/uploads/A.0100.064.2575.pdf

DOE. (2019). Environmental Monitoring Plan for the Pak Ridge Reservation, CY 2019. DOE/ORO – 2227/R10. United States Department of Energy Oak Ridge Office. Retrieved from https://doeic.science.energy.gov/aser/ORR_EMP_CY2019_Final.pdf

DOE. (2020). Environmental Monitoring Plan for the Pak Ridge Reservation, CY 2021. DOE/ORO—2228/R12. United States Department of Energy Oak Ridge Office. Retrieved from https://doeic.science.energy.gov/aser/ORR_EMP_CY2021_Final.pdf

EPA. 2009. National Primary Drinking Water Regulations Complete Table. EPA 816-F-09-004. US Environmental Protection Agency, Washington, DC. Retrieved from https://www.epa.gov/sites/production/files/2016-06/documents/npwdr_complete_table.pdf

Pickering, R. (1970). Composition of Water in Clinch River, Tennessee River, and Whiteoak Creek as Related to Disposal of Low-Level Radioactive Liquid Wastes. (Geological Survey Professional Paper No. 433–J). Retrieved from https://pubs.usgs.gov/pp/0433j/report.pdf

TDEC. (2018). Tennessee Department of Environment and Conservation. Division of Water Resources. Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water. Nashville, Tennessee. Retrieved from https://www.tn.gov/content/dam/tn/environment/water/policy-and-guidance/DWR-WQP-P-01-QSSOP-Chem-Bact-082918.pdf

TDEC. (2013). RULES OF THE TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION CHAPTER 0400-40-03 GENERAL WATER QUALITY CRITERIA retrieved from https://www.epa.gov/sites/production/files/2014-12/documents/tn-chapter1200-4-3.pdf

Turner, R. R., & Southworth, G.R. (1999). Mercury-Contaminated Industrial and Mining Sites in North America: an Overview with Selected Case Studies. In R. Ebinhaus, R. R. Turner, L. D. de Lacerda, O. Vasilev, & W. Salomons (Eds.), Environmental Science: Mercury Contaminated Sites. Springer-Verlag.

5.2 AMBIENT SURFACE WATER PARAMETERS

5.2.1 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, 2018; 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 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).

5.2.2 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.

5.2.3 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).

As DOE's current surface water monitoring program focuses solely on the Clinch River (DOE, 2020), 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 streams. An additional background stream will also be measured for comparison to the selected ORR streams.

5.2.4 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 5.2.1 and Table 5.2.1 below for sample locations.

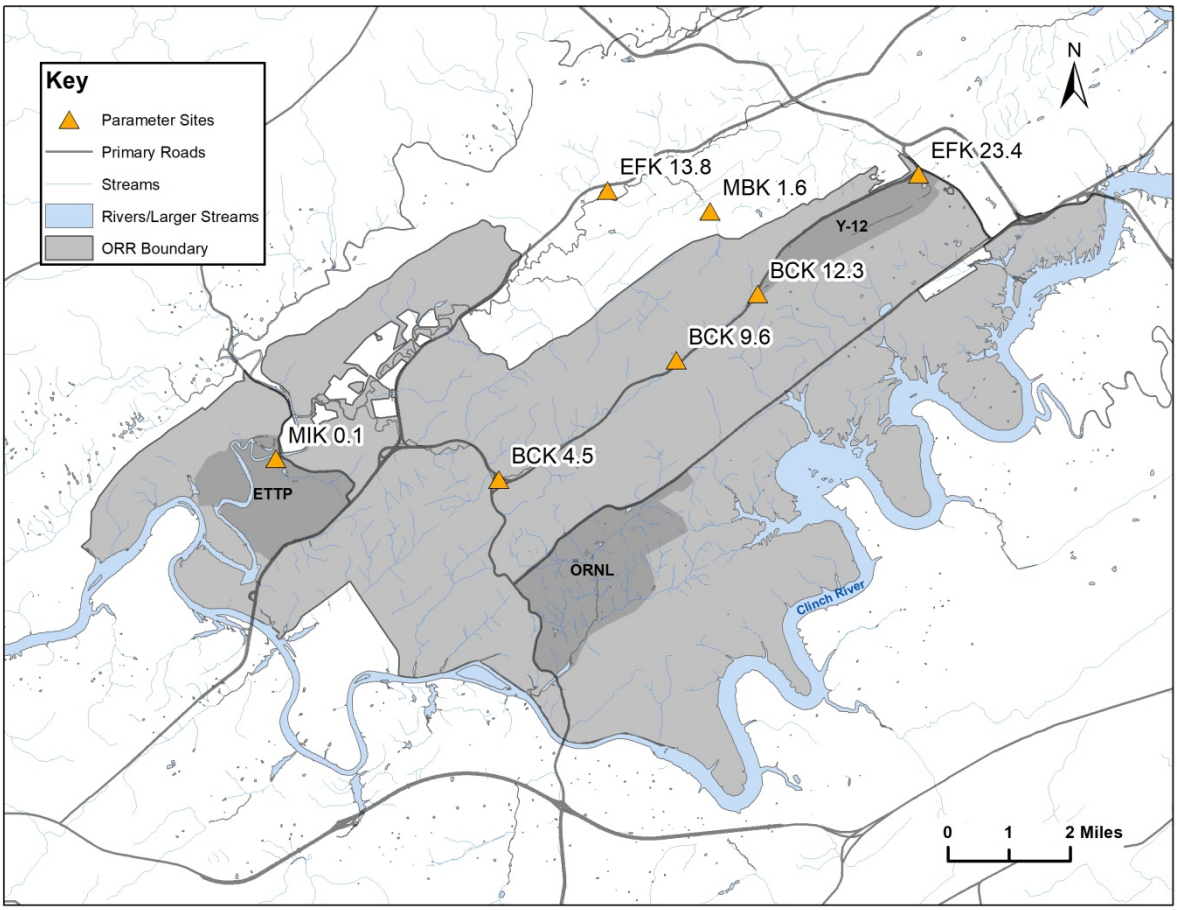

Figure 5.2.1: Map showing TDEC DoR-OR proposed surface water parameter sites

Table 5.2.1: 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

The goals of this project will be accomplished by measuring and recording physical water parameters (e.g. conductivity, dissolved oxygen, Ph, and temperature) at each site monthly. Results will be analyzed using statistical programming software to identify trends as well as any anomalous data.

5.2.5 Scope

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

5.2.6 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 against the selected ORR streams

5.2.7 Constraints

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

5.2.8 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. Parameters of 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 see if they are significantly similar in water parameters.

5.2.9 References

DOE. (1992). Federal Facility Agreement (FFA). Appendices for the Oak Ridge Reservation. Oak Ridge Site Description – UCOR, Appendix B (2017 revision). DOE/OR-1014. U. S. Department of Energy. Retrieved from http://www.ucor.com/docs/ffa/appendices/AppendixB.pdf

DOE. (2020). Environmental Monitoring Plan for the Pak Ridge Reservation, CY 2021. DOE/ORO—2228/R12. United States Department of Energy Oak Ridge Office. Retrieved from https://doeic.science.energy.gov/aser/ORR_EMP_CY2021_Final.pdfPickering, R. (1970). Composition of Water in Clinch River, Tennessee River, and White Oak Creek as Related to Disposal of Low-Level Radioactive Liquid Wastes. (Geological Survey Professional Paper No. 433–J). Retrieved from https://pubs.usgs.gov/pp/0433j/report.pdf

Turner, R. R., & Southworth, G.R. (1999). Mercury-Contaminated Industrial and Mining Sites in North America: an Overview with Selected Case Studies. In R. Ebinhaus, R. R. Turner, L. D. de Lacerda, O. Vasilev, & W. Salomons (Eds.), Environmental Science: Mercury Contaminated Sites. Springer-Verlag.

TDEC. (2011). Tennessee Department of Environment and Conservation. Division of Water Resources. Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water. Nashville, Tennessee. Retrieved from https://www.tn.gov/content/dam/tn/environment/water/policy-and-guidance/DWR-WQP-P-01-QSSOP-Chem-Bact-082918.pdf

5.3 WHITE OAK CREEK RADIONUCLIDES

5.3.1 Background

To help 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 near the ORR. The sampling locations for this project have been modified throughout the years, sometimes adding, or discontinuing sampling at particular locations. From July 2018 to June 2019, TDEC DoR-OR staff co-sampled surface water with ORNL environmental staff quarterly at CRK 32, a location along the Clinch River downstream of potential contamination from White Oak Creek (WOC). For the first two quarters, TDEC DoR-OR samples were analyzed for strontium-90 (Sr-90), which is the primary radiological contaminant of concern for WOC. In addition to Sr-90, isotopic uranium and gross alpha/beta were included in the analytical test suite for the last two quarters.

High Sr-90 concentrations were found at site CRK 33.5, which is at the confluence of WOC and the Clinch River. Sr-90 concentrations were found to be nearly seven times the EPA acceptable limit for drinking water, which is 8 pCi/L. Site CRK 32, which is just downstream of CRK 33.5, had a significantly lower concentration of Sr-90. This is likely due to dilution from the Clinch River.

The average flow rate at White Oak Dam, located before WOC reaches the Clinch River, calculated from records provided by DOE, is 24,460 L/min with a median value of 14,325 L/min. As recent flow data was not available at this site, these values were calculated from 3,571 measurements from 1993 to 2017.

The average concentration of Sr-90 over three sampling events at CRK 33.5 on the Clinch River was 36.7 pCi/L, which is well over the EPA recommended 8 pCi/L for drinking water. Assuming the median flow value from sampling is representative of WOC near the Clinch River confluence and assuming that the average concentration of Sr-90 is representative of WOC, it is estimated that over 2.82E-05 grams per year (g/yr) of Sr-90 is loaded to the Clinch River from WOC, which is 459% of the EPA recommended limit.

The purpose of this project is to continue monitoring Sr-90 and other radiological contaminant inputs to WOC, which joins the Clinch River, while levels of these contaminants remain high.

5.3.2 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, 2020). Currently, DOE collects samples quarterly at four sites along the Clinch River including at river kilometers 16, 32, 58, and 66 (Figure 5.3.1) (DOE, 2020). Of these sites, Clinch River Kilometer (CRK) 58 is near the water supply intake for Knox County, and CRK 66 is upstream of the Oak Ridge water 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 strontium-90 at three of the sites: below the confluence of White Oak Creek and the Clinch River near ORNL (CRK 32), upstream of the Oak Ridge water intake (CRK 66), and downstream of the ORR (CRK 16).

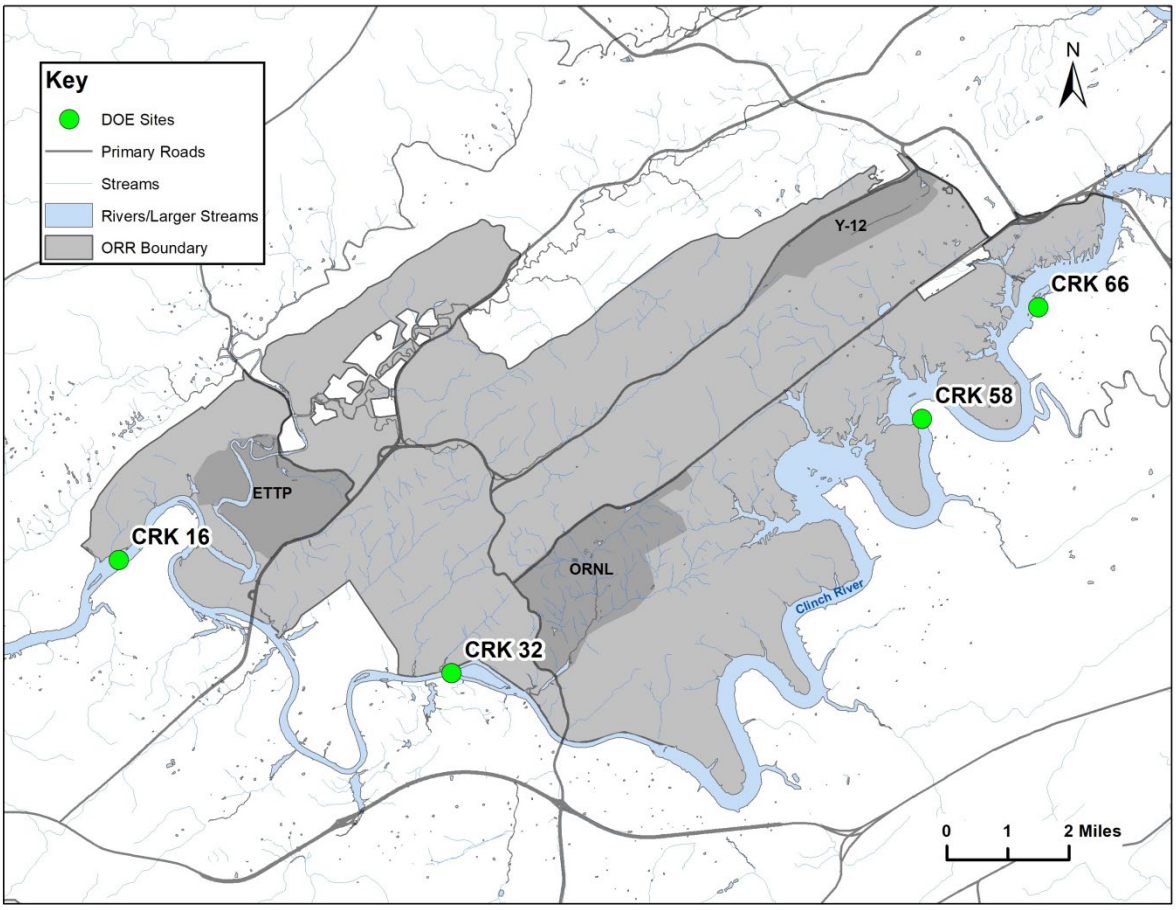

Figure 5.3.1: DOE quarterly water monitoring sample locations

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 impact (EPA, 2009).

While the current DOE project samples the Clinch River, the TDEC DoR-OR project outlined in this report will build upon DOE sampling by looking at specific points along White Oak Creek and the Clinch River. Samples will be taken at points along White Oak Creek with the intent to provide a more representative evaluation of the contaminants entering the Clinch River. Like the DOE project, all sites will be compared to MCLs defined by EPA to determine stream impacts.

5.3.3 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 (DOE, 2017).

A large portion of these people have the potential of being negatively affected by streams that drain the Oak Ridge Reservation (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 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 this exit pathway stream, White Oak Creek, as well as Clinch River monitoring by DOE, 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 to human health. Identified concerns include but are not limited to 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, we can better assess how it contributes to surface water contamination and provide insight to help protect human health and the environment, especially for the important resource of the Clinch River.

5.3.4 Goals

The goal of this ambient surface water monitoring project is to evaluate the impact of Department of Energy (DOE) Oak Ridge Operations (ORO) radioactive contamination to White Oak Creek and the Clinch River at the confluence of WOC (Figure 5.3.2). This project seeks to understand White Oak Creek's contribution of radioactive contaminants to the Clinch River. An assessment of White Oak Creek's impact on the Clinch River will be performed by comparing results to EPA defined maximum contaminant levels (EPA, 2009). In all, this project will help to define areas of concern on the ORR that may be significantly impacting the surface water resources of Tennessee citizens.

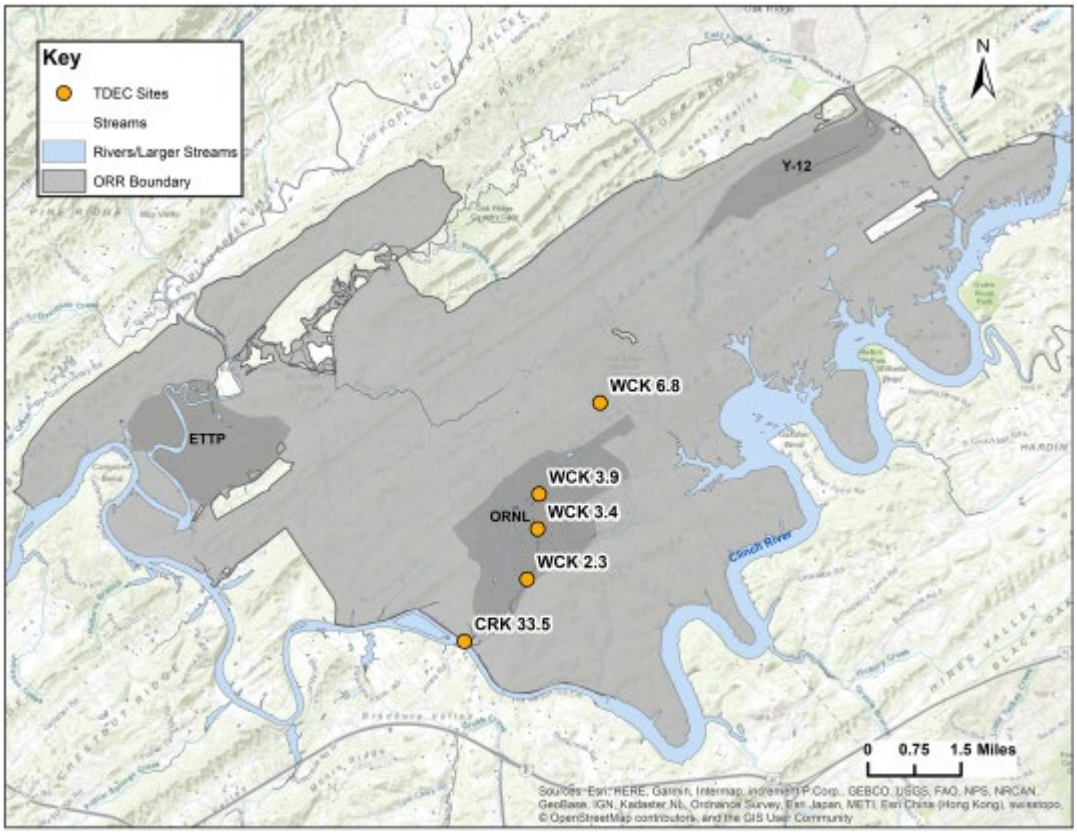

Figure 5.3.2: TDEC DoR-OR quarterly water monitoring sample locations

To accomplish this goal, the following must be completed:

1. Collect surface water samples quarterly at four sites along White Oak Creek and one at the confluence with the Clinch River and analyze for Sr-90 (Figure 5.3.2)
2. Measure physical waters parameters (e.g. conductivity, dissolved oxygen, Ph, and temperature) at each site at time of sampling
3. Evaluate resulting data and identify increasing or decreasing trends

5.3.5 Scope

The scope of this project is to sample quarterly for radiological analysis at five locations along White Oak Creek to where it flows into the Clinch River.

5.3.6 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

5.3.7 Constraints

Constraints that may impact this project include:

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

5.3.8 Methods, Materials, Metrics

Sample Collection

Surface water samples will be collected quarterly at four sites on White Oak Creek and one on the Clinch River at the confluence with WOC (Figure 5.3.2). Samples will be collected quarterly and analyzed for strontium-90, isotopic uranium, and gamma isotopes at each site (Table 5.3.1).

Table 5.3.1: Sampling locations and analysis

	DoR-OR Site	Analysis
1	WCK 6.8	Sr-90, isotopic uranium, gamma
2	WCK 3.9	Sr-90, isotopic uranium, gamma
3	WCK 3.4	Sr-90, isotopic uranium, gamma
4	WCK 2.3	Sr-90, isotopic uranium, gamma
5	CRK 33.5	Sr-90, isotopic uranium, gamma

Field Parameter Measurements

At each site, physical water parameters will be measured at the time of sampling 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 time of measurement. The water quality meter will be used according to manufacture specifications.

Data

Upon receiving sampling results, 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 EPA defined MCLs to assess impacts to human health (EPA, 2009).

EPA has established a Maximum Contaminant Level (MCL) of 4 millirems per year for beta particle and photon radioactivity from manmade radionuclides in drinking water. For Sr-90, 8 pCi/L 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 Sr-90, the sum of the annual dose from all the radionuclides cannot exceed 4 millirems per year.

5.3.9 References

DOE. (1992). Federal Facility Agreement (FFA). Appendices for the Oak Ridge Reservation. Oak Ridge Site Description – UCOR, Appendix B (2017 revision). DOE/OR-1014. U. S. Department of Energy. Retrieved from http://www.ucor.com/docs/ffa/appendices/AppendixB.pdf

DOE. (2017). Annual Site Environmental Report. DEO/ORO-2511. United States Department of Energy Oak Ridge Office. Retrieved from https://doeic.science.energy.gov/aser/aser2017/01%202017%20ASER_Ch%201%20FINAL.pdf

DOE. (2018). Remediation Effectiveness Report. DOE/OR/01-2757&D1. U.S. Department of Energy. Retrieved from https://doeic.science.energy.gov/uploads/A.0100.064.2575.pdf

DOE. (2019). Environmental Monitoring Plan for the Pak Ridge Reservation, CY 2019. DOE/ORO – 2227/R10. United States Department of Energy Oak Ridge Office. Retrieved from https://doeic.science.energy.gov/aser/ORR_EMP_CY2019_Final.pdf

EPA. (2009). National Primary Drinking Water Regulations Complete Table. EPA 816-F-09-004. US Environmental Protection Agency, Washington, DC. Retrieved from https://www.epa.gov/sites/production/files/2016-06/documents/npwdr_complete_table.pdf

Pickering, R. (1970). Composition of Water in Clinch River, Tennessee River, and White Oak Creek as Related to Disposal of Low-Level Radioactive Liquid Wastes. (Geological Survey Professional Paper No. 433–J). Retrieved from https://pubs.usgs.gov/pp/0433j/report.pdf

6.0 LANDFILL MONITORING

6.1 EMWMF

6.1.1 Background

The 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 ARARs listed in the CERCLA EMWMF Record of Decision (ROD) (DOE, 1999).

Currently, the only authorized discharge from EMWMF is 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 chromium VI (Figure 6.1.1). Depending on the chromium VI level, it is either treated onsite or if above published levels the water would be treated offsite at the Liquid and Gaseous Waste Operation (LGWO) at the Oak Ridge National Laboratory. If the levels were all below criteria 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 Surface Water Monitoring at the EMWMF Project began in 2006 and has continued until the present. TDEC DoR-OR's monitoring of groundwater and surface water assist DOE in their efforts to comply with the requirements stated in the EMWMF ROD (DOE 1999) and Tennessee General Water Quality Criteria (TDEC 2019). Each year since 2006, samples of surface water, groundwater, and sediment have been collected, analyzed, and the results published in the annual TDEC DoR-OR EMR.

6.1.2 Related DOE Projects

DOR currently monitors surface water quarterly at NT-5 and NT-3 (Bear Creek Tributaries) for potential releases from the landfill. Figure 6.1.1 shows the locations of 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 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.

6.1.3 Problem Statements

- Only low-level radioactive 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.

6.1.4 Goals

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

- This project will 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 6.1.2).
- 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.

6.1.5 Scope

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

- Measure water quality parameters in EMWMF discharges at four locations, EMWMF-2 (Underdrain) and 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 6.1.1). The measured water quality parameters are temperature, pH, specific conductivity, dissolved oxygen, and oxidation reduction potential.

  TDEC DoR-OR personnel will monitor these locations at least twice each week 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, monitoring will occur at least twice weekly at the EMWMF and will be documented.
- TDEC DoR-OR will collect confirmation samples identified in Table 6.1.1 and shown in Figure 6.1.1 on a routine basis from the selected locations 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 collected and reviewed weekly.
- Samples will be collected from EMWMF-2 once every two months.
- As it is discharged into the sediment basin, water from the contact water ponds, or the contact water tanks will be collected bi-monthly for analysis.
- EMWNT-03A/EMWNT-03B or EMWMF-6W (Cell 6 discharge) will be sampled and analyzed annually if conditions warrant and funds are available.
- Samples will be collected using criteria specified in the TDEC Quality Systems *Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water Revision 5* (TDEC 2018), and the EPA *SESD Operating Procedure for Surface Water Sampling,* SESDPROC-201-R4.
- Samples will be shipped for analysis using TDEC DoR-OR SOP No. 101, *Procedures for Shipping Samples to the State Laboratory in Nashville*, or equivalent contracted laboratories SOPs.

6.1.6 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 personnel personal protective equipment (PPE).
- Availability of equipment for conducting water parameter measurements.
- Mercury, radionuclides, and volatile organics are constituents of concern (COC).

6.1.7 Constraints

- Inclement weather may preclude conducting water parameter measurements.
- Samples will be shipped to the State of Tennessee Department of Health Environmental Laboratory (TDH) or contracted laboratories for analysis.
- Availability of equipment for water parameter measurement.
- Availability of vehicles and trained personnel.
- Availability of TDEC DoR-OR funds for analysis of collected samples.

6.1.8 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 twice a week to measure water quality parameters and observe landfill conditions (Table 6.1.1).

- Table 6.1.3 lists the analytes for this project. Collected samples will be analyzed for radionuclides (gamma radionuclides, strontium-89/90, technetium-99, tritium, transuranics and isotopic uranium), volatile organics, perfluorooctanesulfonic acid (PFOS), metals (arsenic, chromium, cobalt, copper, lead, nickel, uranium, vanadium, zinc, mercury [low-level]), and inorganics. Table 6.1.6 presents the requested analytical methods for the COCs. Locations of sampling and monitoring are shown on Figure 6.1.1 and described with the rationale for sampling in Table 6.1.1.
- Sampling at EMWMF-2 (Underdrain) will be conducted bi-monthly to complement DOE sampling.
- Sampling at one of the following, EMWMF-3 (VWEIR), EMWMF-5, EMWMF-7 or EMWMF-8 will be conducted bi-monthly to confirm DOE analyses and to coincide with a weekly “VCOMP” collection by DOE at EMWMF-3.
- Samples collected at EMWMF-5, EMWMF-7 and EMWMF-8 will be comprised of discharged water from a Contact Water pond or tank.

- Sampling of sediments at the Sediment Basin (EMWMFSB-1) will be conducted annually as conditions allow. 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 will be sampled downgradient of the waste cells at the locations currently monitored under the EMWMF surface water program (EMWNT-03A/EMWNT-03B).
- If conditions allow, additional water samples will be collected at EMWMF-1 [GW-918], and EMWMF-Cell6W.
- Observations of landfill operations and surface water parameter measurements will be made twice a week as operations warrant. Additional locations for parameter measurements are NT5@BCK and BCK11.54A at the flume (SW-003) (Figure 6.1.1)
- On a quarterly basis, DOE Project Environmental Measurement System (PEMS) sediment basin discharged water data will be downloaded and evaluated.

Laboratory analyses will be entered into a TDEC DoR-OR database for evaluation. Evaluation may include construction of tables and graphs illustrating ranges and limits of constituents over the course of the project. Included on the graphs will be pertinent water quality criteria from the EPA and TDEC (Tables 6.1.4 and 6.1.5). 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 (Table 6.1.4) will be used to compare the possible effects that discharged surface water could have on the environment.

The criteria for sediment 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 criterion is the Consensus Based Sediment Quality Criteria from the Wisconsin Department of Natural Resources which gives a threshold effects concentration (TEC) and a probable effect concentration (PEC) (MacDonald et al 2000).

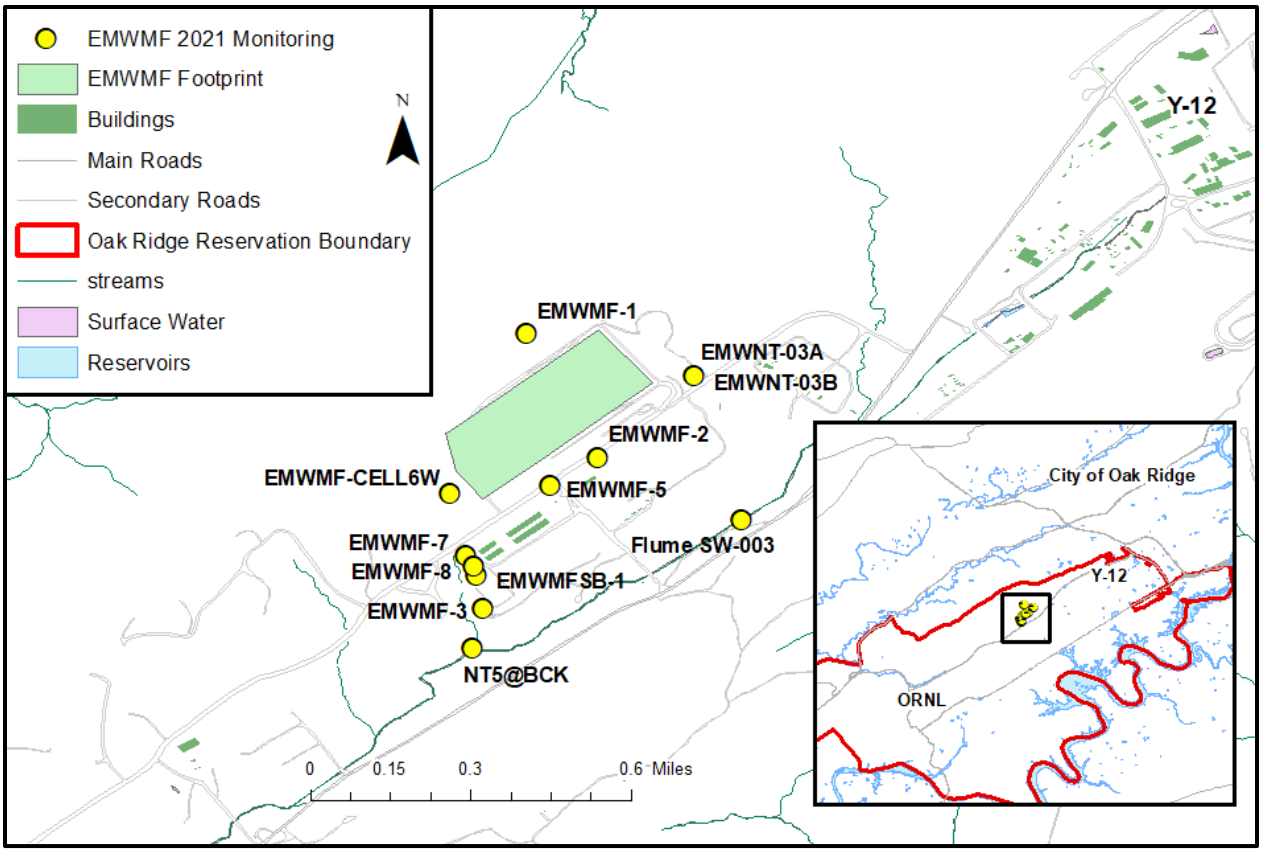

Figure 6.1.1: TDEC DoR-OR EMWMF Sampling Locations for 2022 Monitoring

Table 6.1.1: Sampling Locations and 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	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 6.1.2: ARARs for Contact Water/Surface Water from 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 6.1.3: TDEC DoR-OR EMWMF Monitoring Analyte List

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**	
Perfluorooctanesulfonic acid (PFOS)		

Table 6.1.4: EMWMF Monitoring Surface Water 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 6.1.5: EMWMF Monitoring Sediment 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

Table 6.1.6: Lab Methods and Analyses

Method Designation	Test Name	Analytes
Method 200.7	ICP-OES	Metals
Method 200.8	ICP-MS	Metals
Method 245.1	Mercury	Mercury
Method 8260B	GC/MS	Volatile Organic Compounds
Method 901.1	Gamma water	Gamma radiation
Method ENV-Rad-SOP-401-R.1.3	Gross Alpha-Beta water by LSC	Gross alpha-beta activity
Method 905.0	Sr-89-90 water	Strontium 89-90
Eichrom Method TCW02	Technetium-99 water	Technetium-99
Method 906.0	Tritium water	Tritium

6.1.9 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)

DOE 2017, Department of Energy. 2017. Sampling and Analysis Plan/Quality Assurance Project Plan for Environmental Monitoring at the Environmental Management Waste Management Facility, Oak Ridge, Tennessee, DOE/OR/01-2734&D1/R1, September 2017

DOE 2020, Department of Energy. 2020. Fiscal Year 2020 Phased Construction Completion Report for the Oak Ridge Reservation Environmental Management Waste Management Facility, Department of Energy, DOE/OR/01-2846&D1, March 2020

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

DOE Order 458.1, 2013, Department of Energy Order 458.1 Radiation Protection of the Public and the Environment, Jan. 2013, U.S. Department of Energy Office of Health, Safety and Security

MacDonald, D. D., Ingersoll, C. G., & Berger, T. A. (2000). Development and Evaluation of Consensus-based Sediment Quality Guidelines for Freshwater Ecosystems. Archives of Environmental Contamination and Toxicology, 39, 20–31.

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.

TDEC 2012, Rules of the Tennessee Department of Environment and Conservation. Chap. 0400-20-11, Licensing Requirements for Land Disposal of Radioactive Waste, 2012, Tennessee Department of Environment and Conservation. (2012).

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

Tennessee Department of Environment and Conservation, Sampling and Analysis Plan for General Environmental Monitoring of the Oak Ridge Reservation and its Environs, Division of Remediation Oak Ridge (2016)

Tennessee Department of Environment and Conservation Division of Remediation, Oak Ridge Office (DoR OR) 2019 Health and Safety Plan Including Related Policies. Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office, Oak Ridge, TN. (January 2020).

Tennessee Department of Environment and Conservation, Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water, Tennessee Department of Environment and Conservation, Division of Water Pollution Control Revision 5 (2018).

Tennessee Department of Environment and Conservation Division of Remediation, Oak Ridge Office (DoR OR). Procedures for Shipping Samples to the State Lab in Nashville. SOP No. 101

United States Environmental Protection Agency. SESD Operating Procedure for Surface Water Sampling, SESDPROC-201-R4

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

6.2 EMDF

6.2.1 Background

The Environmental Management Disposal Facility (EMDF) is proposed for the disposal of low-level radioactive waste and hazardous waste generated by remedial activities on the ORR and will be operated under the authority of CERCLA and DOE. While the EMDF facility will hold no permit from the State of Tennessee, the EMDF will be required to comply with DOE orders and substantive portions of Applicable Rules and Regulations (ARARs) listed in the upcoming CERCLA EMDF Record of Decision (ROD).

The TDEC DoR-OR surface water monitoring along the portion of the creek in Bear Creek Valley where the potential future EMDF Project may be sighted, will begin in Fiscal Year 2021. TDEC DoR-OR's monitoring of groundwater and surface water will support the Bear Creek Valley assessment project, as well as supporting anticipated future data collection efforts at the Central Bear Creek Valley site.

6.2.2 Related DOE Projects

DOE currently monitors Bear Creek, and some Bear Creek tributaries (NT-5, NT-4, and NT-3) for potential releases from the Environmental Management Waste Management Facility (EMWMF) landfill. The water released from the EMWMF sediment basin is collected by an automatic sampler using a weekly flow-rated composite sample and then it is discharged. Annually, the results from these sampling efforts are published in the Phased Construction Completion Report (PCCR) or the *Oak Ridge Reservation Remedial Effectiveness Report*.

The analysis of the results from TDEC DoR-OR's EMDF monitoring project is intended to complement and supplement DOE's monitoring of the surface water in the environment.

6.2.3 Problem Statements

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

6.2.4 Goals

The goals of the Surface Water Monitoring at the EMDF Project follow:

- This project will provide data to identify current site conditions along Bear Creek Valley in the Central Bear Creek valley watershed area. Sampling will provide assurance through independent monitoring and coincident evaluation of DOE's data, that collected background or baseline data is appropriate for use in future stream health comparisons.
- Surface water monitoring by TDEC DoR-OR will verify that DOE has determined background water quality parameter levels in the surface water by measuring the same water quality parameters.
- Surface water monitoring will act as complementary monitoring and analysis for DOE's actions.

6.2.5 Scope

The scope of the Surface Water Monitoring at the EMDF Project includes the following:

- Staff members will measure water quality parameters in streams at six flume discharge locations: SF-1, SF-2, SF-3, SF-4, SF-5, SF-6, and spring D10W (Figure 6.2.1). Staff members will monitor these locations with the use of a YSI-Professional Plus water quality instrument or equivalent.
- Observations of site conditions and surface water parameter measurements will be made twice a week as conditions warrant.
- Collect surface water samples at the four locations semi-annually (Table 6.2.1) to complement DOE actions to characterize surface water constituent baseline.

6.2.6 Assumptions

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

6.2.7 Constraints

- Monitoring may be contingent upon availability of a DOE escort.
- Inclement weather may preclude conducting parameter measurements.

- Availability of equipment for conducting water parameter measurements.

6.2.8 Methods, Materials, Metrics

Tasks for this program include monitoring water quality parameters at seven locations, SF-1, SF-2, SF-3, SF-4, SF-5, SF-6, and spring D10W (Figure 6.2.1). TDEC DoR-OR personnel will perform basic monitoring of these locations for temperature, pH, conductivity, dissolved oxygen, and oxidation reduction potential at least twice weekly utilizing a YSI-Professional Plus water quality meter or its equivalent. Calibration and/or a confidence check of this instrument is performed prior to field use.

On a bi-weekly basis TDEC DoR-OR will visit flumes SF-1, SF-2, SF-3, SF-4, SF-5, SF-6, and spring D10W to perform general monitoring of the site. TDEC DoR-OR will monitor the streams, note discharges, water conditions, observe the condition of the banks, and note any concerns. 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.

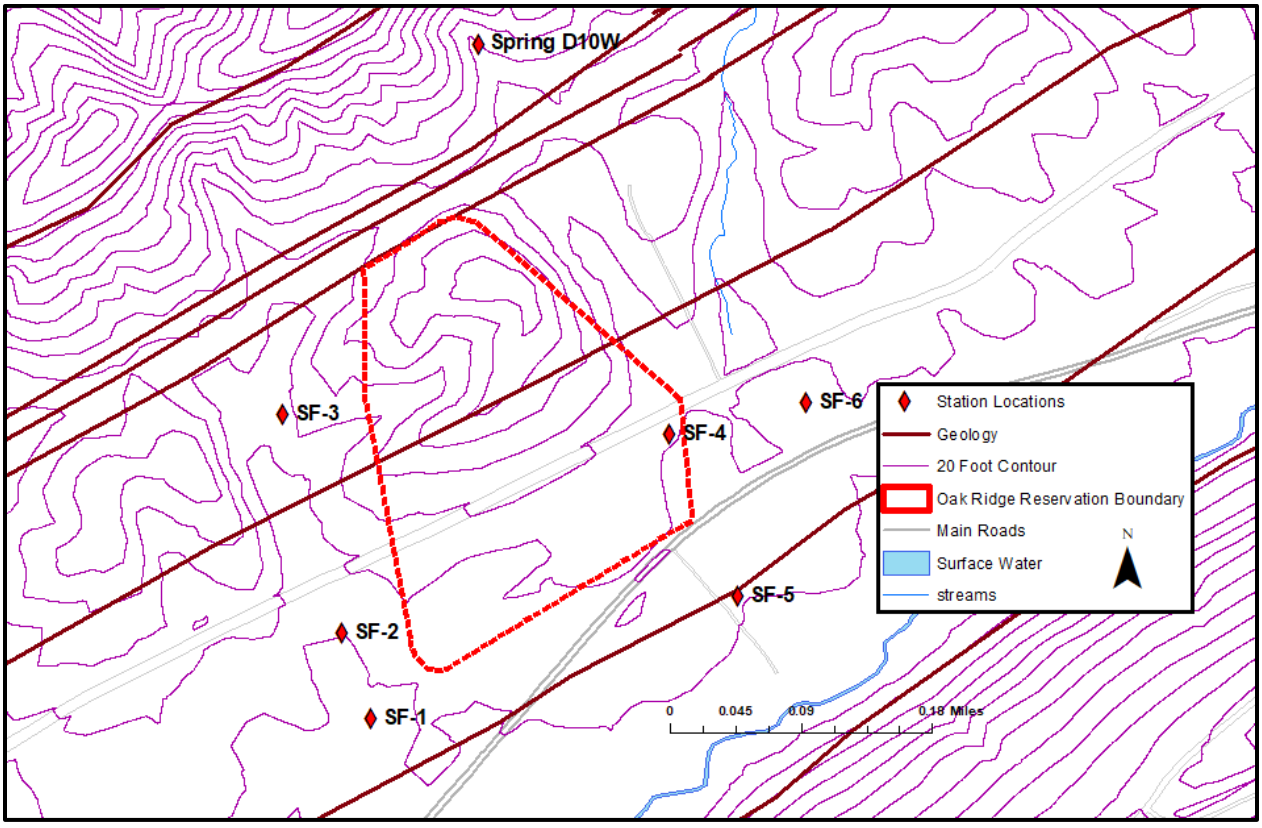

Figure 6.2.1: Sampling Locations CBCV Site 2021 Monitoring

Data collected from these key locations by TDEC DoR-OR and DOE will be entered into an Excel database for interpretation. Interpretation will include construction of tables and graphs illustrating ranges and limits of constituents and parameters over the course of the project.

Water quality parameters include temperature, pH, specific conductivity, oxygen reduction potential and dissolved oxygen. Water samples will be collected at the four stations listed in Table 6.2.1. The analytical test suite is listed in Table 6.2.2. Pertinent water quality regulatory criteria from the EPA and TDEC will be included on the graphs.

Table 6.2.1: 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 and will capture surface water and groundwater from the site
Flume 4	SF-4	Semi-Annually	Flume 4 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 6.2.2: TDEC DoR-OR EMDF Monitoring Analyte List

EMDF ANALYTE LIST	
Gamma Activity	**Sr-89,90 in water**
Technetium-99	**Tritium in water**
Transuranics	**Isotopic Uranium**
Arsenic	**Barium**
Chromium	**Cobalt**
Copper	**Lead**
Mercury	**Nickel**
Uranium	**Vanadium**
Zinc	**Volatile Organics**
PCBs	**Inorganics**
Semi-Volatiles	

6.2.9 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.

Tennessee Department of Environment and Conservation, Sampling and Analysis Plan for General Environmental Monitoring of the Oak Ridge Reservation and its Environs,

Division of Remediation Oak Ridge (2016)

Tennessee Department of Environment and Conservation Division of Remediation, Oak Ridge Office (DoR OR) 2019 Health and Safety Plan Including Related Policies. Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office, Oak Ridge, TN. January 2020.

Tennessee Department of Environment and Conservation, Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water, Tennessee Department of Environment and Conservation, Division of Water Pollution Control (2018).

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

7.0 STORM WATER / WATER DISCHARGE MONITORING

7.1 RAIN EVENT

7.1.1 Background

In general, rainwater does not exhibit static flow behavior. It accumulates, pools, and makes its way into basements, basins, and soil excavations (from decontamination and decommissioning (D&D)) and remedial action (RA) activity sites. Water that enters an abandoned building has the potential to transport contaminants beyond the confines of the building.

As of November 2017, DOE listed more than 400 sites at ETTP, more than 300 sites at ORNL, more than 100 sites at Y-12, and at least eight sites off the ORR where each site is regulated by CERCLA.

7.1.2 Related DOE Projects

DOE has a comprehensive storm water sampling program for RA and D&D sites that are briefly described in the 2019 ASER.

RA, CERCLA, and Legacy Pollutant Monitoring Storm water monitoring is conducted at outfalls that drain areas affected by RAs in order to provide a pre-RA baseline, to determine the efficacy of RAs, and to suggest areas for future RAs.

7.1.3 Problem Statements

- During and following a rain event, contamination from legacy and ongoing D&D and RAs can be disturbed and transported beyond the physical boundaries of the ORR
- Each D&D project can develop new pathways for contamination to travel offsite the ORR.

7.1.4 Goals

The goal for this project is to obtain data to determine if DOE ORR best management practices employed during remedial actions is controlling offsite releases of legacy pollution and to provide input for future cleanup decisions. Actions to achieve this goal are:

- Review and comment on documents related to D&D work.
- Use co-sampling to monitor releases into the environment.
- Observe D&D and RA sampling activities and review DOE sampling results to ensure compliance with negotiated and agreed-to-release criteria.
- Sample to create a baseline before D&D or RAs are conducted.

7.1.5 Scope

The scope of this project is to create a baseline before D&D or RAs have begun. If possible, samples will be collected over the course of a year. Sample analysis will be aligned with the constituents of concern for buildings undergoing D&D or RA.

7.1.6 Assumptions

- Legacy contaminants are transported offsite or into receiving bodies of water during or following a rain event.
- Staff will be available for field work on short notice to perform observation when notification is given by DOE.
- During D&D and RA, not all contaminants of concern (COC) are kept within the facility or transported offsite for final disposal.
- During D&D and RA, COC's that have entered containment areas, sumps, and storm drains may not be detected by the sampling performed under parameters set forth by the National Pollutant Discharge Elimination System (NPDES) Permit.

7.1.7 Constraints

- Availability of DOE staff or contractors to accompany and facilitate entry into work areas.
- Availability of TDEC DoR-OR personnel to assist with sampling.
- Availability of a suitable vehicle to transport equipment and personnel to sampling sites.
- Lack of or late notification by DOE concerning water discharges or sampling events.
- Difficulty in making arrangements with security to access locked areas in time to take samples while storm conditions are occurring.

7.1.8 Methods, Materials, Metrics

Submitted results will be compared to NPDES permit discharge limits, DOE, EPA and TDEC agreed-upon-limits or water quality standards for the receiving body of water.

If a sampled area is comprised of long-term outfall sample points, trends in concentrations will be reviewed for future sampling or observations. The outfalls selected as sampling locations are based on current DOE D&D activities.

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, DWR-WQP-P-Q1-QSSOPCHEM-BACT-082918. Samples will be collected at the same point and time as the DOE contractor's samples are being taken.

Analytes will be determined for each sampling site based on COCs as listed in the Contamination Migration Plan or DOE's SWPPP (Storm Water Pollution Prevention Plan).

If sampling is being conducted to create a baseline, a sample should be taken monthly for a year. If a year timeframe is not available, an attempt will be made to sample twelve times in the timeframe available.

7.1.9 References

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

DOE. (2017) Oak Ridge Reservation, Annual Site Environmental Report. DOE/ORO-2511

7.2 ACCUMULATED WATER DISCHARGES

7.2.1 Background

In general, rainwater and groundwater do not exhibit static flow behavior. Water from ORR excavations, Deactivation and Decommissioning (D&D) and Remedial Action (RA) operations can accumulate in pools and then flow into basements, sediment and/or stormwater basins, and subsequently permeate into soils. For example, based on past DOE D&D activities, DOE's contractors estimate volumes of water accumulated at ETTP remedial action sites range from 200 gallons to 1.5 million gallons (UCOR URS / CH2M 2018a).

It is possible accumulated water may contain at least one contaminant that needs to be treated before it is discharged into the environment.

As of November 2017, DOE listed more than 400 sites at ETTP, more than 300 sites at ORNL, more than 100 sites at Y-12, and at least eight sites off the ORR where each site is regulated by CERCLA.

Since June 2017, the following projects have been ongoing at the three major operating sites on the ORR:

1. an estimated 12,500 cubic yards of contaminated soil removal at ETTP
2. a soils excavation project estimated to be greater than 80,000 cubic yards at Y-12
3. a soil excavation project estimated to be greater than 100,000 cubic yards at ORNL

These remedial action soil excavation activities present many opportunities for rainwater and/or groundwater to accumulate and mix with hazardous and/or radioactive legacy waste.

Additionally, the ORR receives on average 54 inches of precipitation per year; an extended period of rain in February 2020 resulted in greater than ten inches of precipitation on the ORR in less than two weeks. Together, the numerous ongoing ORR CERCLA remedial actions and considerable regional precipitation warrants independent oversight of DOE sampling and treatment operations at ORR excavation sites where additional wastes have possibly been generated by the accumulation and infiltration of water.

7.2.2 Related DOE Projects

The ORR has National Pollution Discharge Elimination System (NPDES) permits that require specific monitoring programs. As part of the Storm Water Pollution Prevention (SWPP) program, DOE has implemented monitoring outside of the NPDES that assists in controlling legacy pollutant releases.

7.2.3 Problem Statements

The TDEC DoR-OR Accumulated Water Project focuses on the following problems:

- Water can accumulate in D&D or RA areas by entry into basins, sumps, and basements or during soil remediation activities
- Accumulated water may become contaminated and dispersed into the environment
- D&D projects can release diverse contaminants that can enter the various ORR exit water pathways

7.2.4 Goals

The goals of this project are:

- Obtain and review pertinent sampling data to evaluate DOE's treatment system and use that data to provide input for future cleanup decisions
- Review and comment on DOE documents related to D&D work
- Collect co-samples at treatment systems to monitor sampling results
- Observe D&D and RAs to ensure compliance with TDEC, EPA, and DOE negotiated and agreed-to-discharge criteria
- Review DOE sampling results to ensure compliance with negotiated and agreed to release criteria
- Observe sampling events to ensure compliance with standard operating procedures

7.2.5 Scope

- Sites with D&D and/or RA operations will be monitored, including but not limited to, the Y-12 Outfall-200 Mercury Treatment Facility headworks construction and the ORNL Molten Salt Reactor Experiment basement groundwater sump and its free-released water
- Sampling events will be observed to ensure that proper sampling methods are used. If a contractor's standard operating procedures (SOPs) are released to this office, sampling processes will be compared to those SOPs. Otherwise, observations will be compared to industry or EPA standards
- At various sampling sites, TDEC DoR-OR will collect co-samples with DOE contractors to confirm that relevant treatment and discharge criteria are met

7.2.6 Assumptions

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

- Samples taken during treatment activities will ensure release criteria are being met
- Co-sampling will be accomplished to confirm DOE sampling results
- DOE sampling operations will be observed to ensure compliance with site-specific performance documents (Storm Water Pollution Prevention Plan (SWPPP), Comprehensive Monitoring Plan (CMP), Standard Operating Procedures (SOP), etc.)
- Possible new or ongoing releases to the environment, which are not currently monitored by DOE, may warrant TDEC DoR-OR sampling and monitoring of these release areas

7.2.7 Constraints

- Availability of TDEC DoR-OR personnel to assist with sampling
- Availability of a suitable vehicle to transport equipment and personnel to sampling sites
- Lack of or late notification by DOE concerning water discharges or sampling events

7.2.8 Methods, Materials, Metrics

- 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, DWR-WQPP-01- QSSOP-Chem-Bact-082918
- Samples will be collected at the same location and time as the DOE contractor's samples are being taken

- Submitted results will be compared to NPDES permit discharge limits, DOE, EPA and TDEC agreed-upon-limits, or water quality standards for the receiving body of water
- If the sampled area is a long-term project, trends in concentrations will be reviewed for future sampling or observations
- Analytes chosen for each treatment system will be based on COCs listed in the applicable ROD, CMP, or the SWPP. The available data will be compared to NPDES discharge limits and EPA CWA standards
- Sampling observation criteria will be based on submitted sampler's SOP

7.2.9 References

UCOR URS / CH2M 2018 presentation

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

8.0 SEDIMENT MONITORING

8.1 TRAPPED SEDIMENT (BEAR CREEK VALLEY)

8.1.1 Background

Since 2015, a sediment trap project has been implemented each year by the Tennessee Department of Environment and Conservation (TDEC), Department of Remediation (DoR) Oak Ridge Office (OR). The project began with the monitoring of sediment quality at six locations on or near the Oak Ridge Reservation (ORR). This project has evolved over the years, resulting in changes in locations and frequencies of sampling. This program monitors for suspended sediment contaminants transported in waterways that have been impacted by past and present activities on the ORR. This method of sampling sediment can provide samples from streams that lack sediment deposition areas suitable for traditional sampling, such as the upper reaches of East Fork Poplar Creek located within the Y-12 Plant.

Contaminated sediments can directly impact benthic life and pose detrimental indirect effects on other organisms, including humans, through bioaccumulation and subsequent transfer through the food web. Sediment-associated contaminants are accepted as an important ongoing environmental problem that impacts the uses of many water bodies. In order to assess the degree of contamination at the benthic level, attributable to the activities of the DOE, TDEC DoR-OR collects sediment samples for chemical analysis from tributaries that enter the Clinch River and drain the ORR.

8.1.2 Related DOE Projects

DOE does not currently sample suspended sediments with a sediment trap device.

8.1.3 Problem Statements

Sediment is an integral component of stream ecosystems, serving as a sink for many contaminants. The sediment traps that are used for this project collect suspended sediment particles from the stream. The information gathered from the chemical analysis of these sediments reveals what is being transported downstream in the water column. The sediment traps are a means of detecting changes in sediment associated contaminants.

Work done with the sediment traps is crucial in that this type of sampling is not conducted by DOE. In recent years, sediment traps have been placed at three major locations in the Bear Creek valley. These locations, which include NT-5 (EMWMF Bear Creek tributary), BCK 7.6 (Bear Creek kilometer 7.6), and BCK 3.3 (Bear Creek kilometer 3.3), will continue to be used for this project. The sediment trap at NT-5 serves a similar purpose for detecting abnormal contaminant releases from EMWMF.

The sediment traps at BCK 7.6 and BCK 3.3 will provide important baseline data for assessing the condition of Bear Creek sediments leaving the Bear Creek watershed. Mill Branch will provide background reference data to compare to the results from the sediment traps on Bear Creek.

8.1.4 Goals

The goal of the project is to detect releases of contaminants in suspended sediments from the DOE facilities at the western end of Y-12. The data obtained from the sediment traps will be used to assess the extent of sediment transported contamination in Bear Creek to provide a baseline of data to compare to future data.

8.1.5 Scope

This project will provide independent data to assist in the evaluation of streams that drain the ORR. The trapped sediment project will sample suspended sediment and analyze for various metals and radiological parameters.

8.1.6 Assumptions

- Sediment traps continue to function as designed.
- Maintenance is performed weekly.
- Flooding does not damage the traps or installations.
- Funding is available for chemical analysis of samples.

8.1.7 Constraints

- Exceptionally high flows during flooding events may damage the sediment trap installations and result in loss of sediment traps.
- Sustained low flows may result in insufficient yield of sediment for analysis.

8.1.8 Methods, Materials, Metrics

In order to monitor for changes in contaminant flow through sediment transport, passive sediment samplers (traps) are deployed. Mill Branch is a tributary of EFPC that is used as a background stream. Samples will be retrieved from the sediment traps twice during the year. The first set of samples collected in December 2021 will be analyzed for radiological parameters and metals, while the second set of samples collected in June 2022 will be analyzed for organics.

Sediment samples will be analyzed for metals (arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium, uranium, and zinc) and radiological parameters (gross α/β, gamma, Sr-89,90, isotopic U).

The metals data will be compared to the Consensus-Based Sediment Quality Guidelines (CBSQGs) (MacDonald et al. 2000). Radiological data will be compared to data from background locations.

Since DOE does not conduct this type of sampling, there is not another relevant dataset for data comparison.

Method Summary

The standard operating procedure used for this project is the TDEC DoR-OR Standard Operating Procedure for Sediment Sampling (TDEC DoR-OR 2019). Suspended sediment samples may be collected by using fixed sediment collection devices (traps). Sediment traps are installed in a stream bed in a position where considerable water flows through the body of the trap. Suitable sites are limited in a stream and careful consideration must be given to selecting installation locations for the sediment traps. The sediment traps must be placed in stream locations with sufficient flow and adequate depth to completely immerse the sediment traps.

Following a collection period of a minimum of four months, the collected sediment is emptied from a sediment trap and is transferred to a clean bucket where the sediment is allowed to settle on ice for 24 to 48 hours. After the sediment is allowed to settle, the supernatant water is carefully drawn off the sample with a peristaltic pump. Sediment samples are spooned from the bucket into sample containers.

Table 8.1.1: Sediment Sampling Stations

Site Description	Name	Latitude	Longitude
Bear Creek kilometer 3.3	BCK 3.3	35.94354	-84.34911
Bear Creek kilometer 7.6	BCK 7.6	35.95094	-84.31455
North Tributary 5 of Bear Creek	NT-5	35.96633	-84.29031
Mill Branch kilometer 1.6	MBK 1.6	35.98560	-84.28722

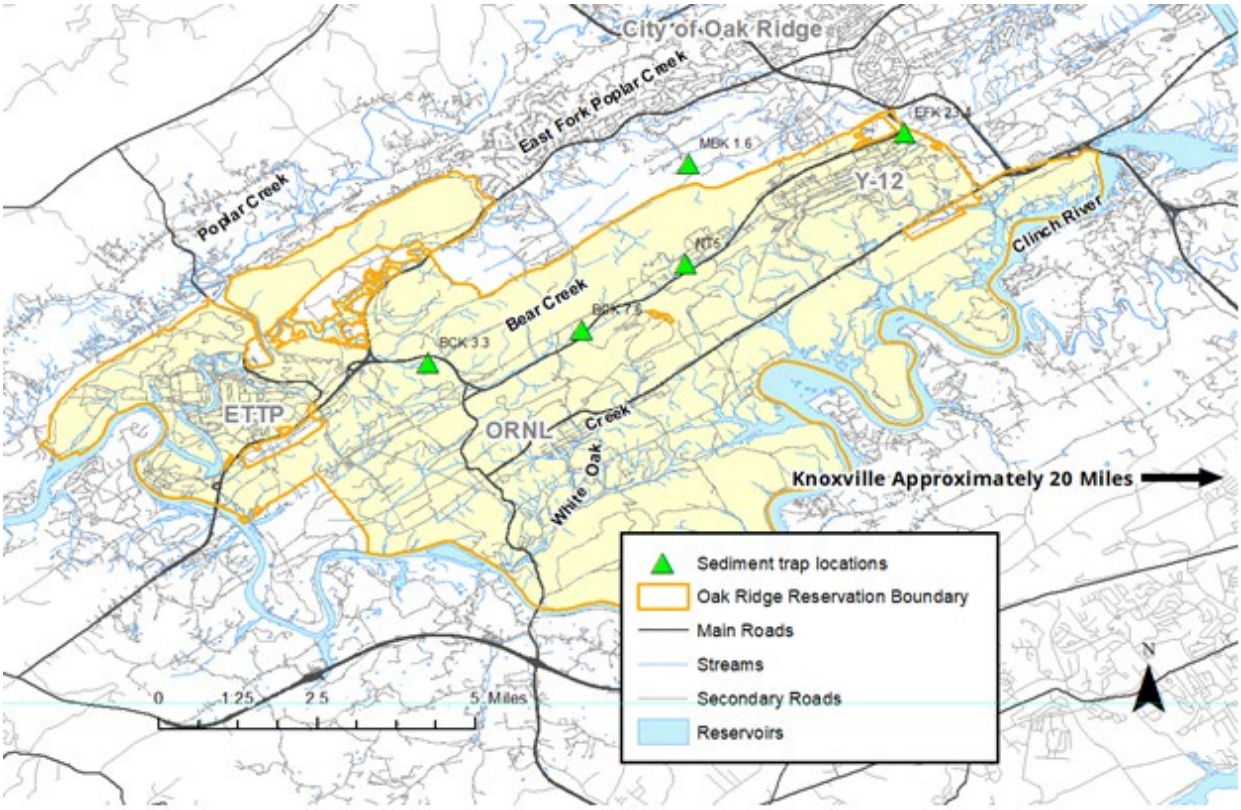

Figure 8.1.1: Map of Sediment Trap Sampling Stations

8.1.9 References

MacDonald, D. D., Ingersoll, C. G., & Berger, T. A. (2000). Development and Evaluation of Consensus-based Sediment Quality Guidelines for Freshwater Ecosystems. Archives of Environmental Contamination and Toxicology, 39, 20–31.

TDEC DoR-OR. (2019). Quality System Standard Operating Procedure for Sediment Sampling (T-600). Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office, Oak Ridge, Tennessee.

8.2 TRAPPED SEDIMENT (EAST FORK POPLAR CREEK)

8.2.1 Background

Since 2015, a sediment trap project has been implemented each year by the Tennessee Department of Environment and Conservation (TDEC), Department of Remediation (DoR) Oak Ridge Office (OR). The project began with the monitoring of sediment quality at six locations on or near the Oak Ridge Reservation (ORR). This project has evolved over the years, resulting in changes in locations and frequencies of sampling. This program monitors for suspended sediment contaminants transported in waterways that have been impacted by past and present activities on the ORR.

This method of sampling sediment can provide samples from streams that lack sediment deposition areas suitable for traditional sampling, such as the upper reaches of East Fork Poplar Creek located within the Y-12 Plant.

Contaminated sediments can directly impact benthic life and pose detrimental indirect effects on other organisms, including humans, through bioaccumulation and subsequent transfer through the food web. Sediment-associated contaminants are accepted as an important ongoing environmental problem that impacts the uses of many water bodies. In order to assess the degree of contamination at the benthic level, attributable to the activities of the DOE, TDEC DoR-OR collects sediment samples for chemical analysis from tributaries that enter the Clinch River and drain the ORR.

8.2.2 Related DOE Projects

DOE does not currently sample suspended sediments with a sediment trap device.

8.2.3 Problem Statements

Sediment is an integral component of stream ecosystems, serving as a sink for many contaminants. The sediment traps that are used for this project collect suspended sediment particles from the stream. The information gathered from the chemical analysis of these sediments reveals what is being transported downstream in the water column. The sediment traps are a means of detecting changes in sediment associated contaminants.

Work done with the sediment traps is crucial in that this type of sampling is not conducted by DOE. Contaminant releases from Y-12 or the EMWMF can potentially be detected by the sediment traps. With the remediation work ongoing at Y-12, it is important to have the sediment trap at East Fork Poplar Creek kilometer 23.4 (EFK 23.4) act as a sentinel to detect releases that are not normal. Mill Branch (MBK 1.6) will provide background reference data to compare to the results from the sediment trap on East Fork Poplar Creek.

8.2.4 Goals

The goal of the project is to detect releases of contaminants in suspended sediments from the DOE facilities at Y-12. The data obtained from the sediment traps will be used to assess the extent of sediment transported contamination in East Fork Poplar Creek and to provide a baseline of data to compare to future data.

8.2.5 Scope

This project will provide independent data to assist in the evaluation of East Fork Poplar Creek. This sediment project will sample suspended sediment and analyze for various metals, organics, and radiological parameters at EFK 23.4.

8.2.6 Assumptions

- Sediment traps continue to function as designed.
- Maintenance is performed weekly.
- Flooding does not damage the traps or installations.
- Funding is available for chemical analysis of samples.

8.2.7 Constraints

- Exceptionally high flows during flooding events may damage the sediment trap installations and result in loss of sediment traps.
- Sustained low flows may result in insufficient yield of sediment for analysis.

8.2.8 Methods, Materials, Metrics

In order to monitor for changes in contaminant flow through sediment transport, passive sediment samplers (traps) are deployed. Sampling is proposed for East Fork Poplar Creek (EFPC) at stream kilometer 23.4 (EFK 23.4). A sediment trap will be deployed there in July 2021. Mill Branch is a tributary of EFPC that is used as a background stream; this reference stream is also sampled in the Bear Creek sediment project. Samples will be retrieved from the sediment trap at EFK 23.4 twice during fiscal year 2022 (December 2021 and June 2022).

Sediment samples will be analyzed for metals (arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium, uranium, and zinc), organics (semivolatiles, pesticides, and PCBs), and radiological parameters (gross α/β, gamma, Sr-89,90, isotopic U). Since the sample volume is limited, the first sediment sample (December 2021) will be analyzed for metals and radiological parameters, while the second sample (June 2022) will be analyzed for organics. The metals data will be compared to the Consensus-Based Sediment Quality Guidelines (CBSQGs) (MacDonald et al. 2000). Radiological data will be compared to data from background locations. Since DOE does not conduct this type of sampling, there is not another relevant dataset for data comparison.

Method Summary

The standard operating procedure used for this project is the TDEC DoR-OR Standard Operating Procedure for Sediment Sampling (TDEC DoR-OR 2019). Suspended sediment samples may be collected by using fixed sediment collection devices (traps). Sediment traps are installed in a stream bed in a position where considerable water flows through the body of the trap. Suitable sites are limited in a stream and careful consideration must be given to selecting installation locations for the sediment traps. Deployment depth must be sufficient to completely immerse the sediment traps.

Following a collection period of a minimum of four months, the collected sediment is emptied from a sediment trap and is transferred to a clean bucket where the sediment is allowed to settle on ice for 24 to 48 hours. After the sediment is allowed to settle, the supernatant water is carefully drawn off the sample with a peristaltic pump. Sediment samples are spooned from the bucket into sample containers.

Table 8.2.1: Sediment Sampling Stations

Site Description	Name	Latitude	Longitude
E. Fork Poplar Ck. Km 23.4	EFK 23.4	35.99596	-84.24004

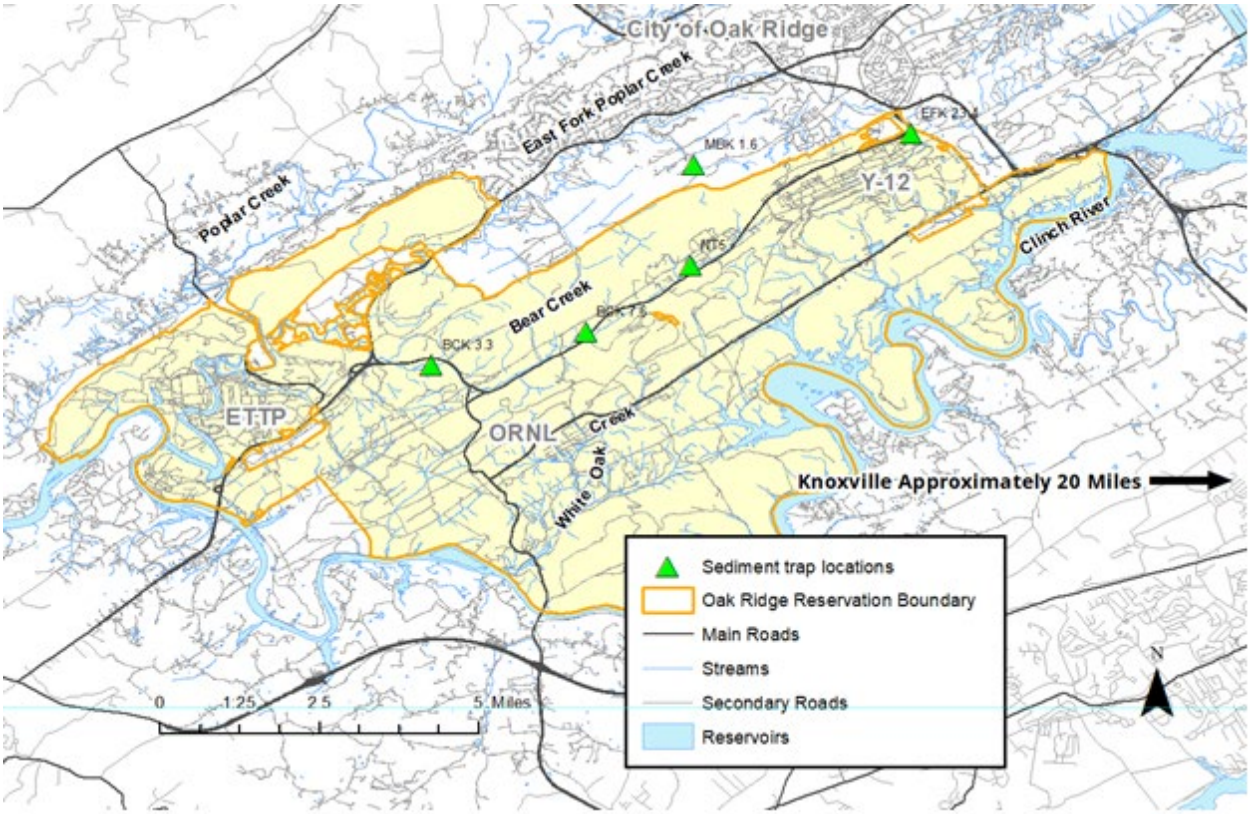

Figure 8.2.1: Map of Sediment Trap Sampling Stations

8.2.9 References

MacDonald, D. D., Ingersoll, C. G., & Berger, T. A. (2000). Development and Evaluation of Consensus-based Sediment Quality Guidelines for Freshwater Ecosystems. Archives of Environmental Contamination and Toxicology, 39, 20–31.

TDEC DoR-OR. (2019). Quality System Standard Operating Procedure for Sediment Sampling (T-600). Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office, Oak Ridge, Tennessee.

9.0 GROUNDWATER MONITORING

9.1 OFFSITE (BEAR CREEK VALLEY, ETTP, AND THE TUSKEGEE NEIGHBORHOOD)

9.1.1 Background

On the ORR, in Bear Creek Valley and ETTP (Former K-25 Gaseous Diffusion Plant Facility) there is documented groundwater contamination. This contamination is related to various releases from legacy operations from operational facilities, burial grounds, historical disposal, waste storage, and accidental releases from various facilities following decades of operations on the Oak Ridge Reservation. This contamination has affected groundwater to considerable depth along these pathways.

9.1.2 Related DOE Projects

DOE and its contractor (RSI) also collect samples from many offsite residential well locations through the offsite groundwater program.

9.1.3 Problem Statements

- Bedrock on and surrounding the ORR consists of either carbonate rocks or a combination of carbonate rocks and fractured clastic rocks. Groundwater can move long distances rapidly in all fractured-rock settings (Worthington, 2004; Worthington et al., 2016), as well as in channels and conduits.
- While rivers and creeks are defined as watershed boundaries for surface water, the rivers and creeks of the Valley and Ridge are not barriers to groundwater flow (Davies et al., 2012). Residential wells in the extended portions of BCV and other valleys that may be connected to subsurface groundwater, should be included for sampling under this program.

9.1.4 Goals

- This project will assist with FFA site-wide groundwater decisions for the BCV, by evaluating additional potential exit pathways.
- This project will support the holistic assessment of offsite groundwater in BCV and ETTP (including assessment this FY in the Tuskegee neighborhood).
- The goal of this project is to identify any contaminants detected in groundwater samples. This assessment will support a better understanding of the nature and extent of potential groundwater impacts around ETTP, BCV, and Tuskegee.

9.1.5 Scope

The project scope for FY22 is limited to the sampling of groundwater from the residential wells listed in the areas/valleys/ridges at locations identified here.

Figure 9.1.1 below shows the proposed sampling locations. Table 9.1.1 lists the locations.

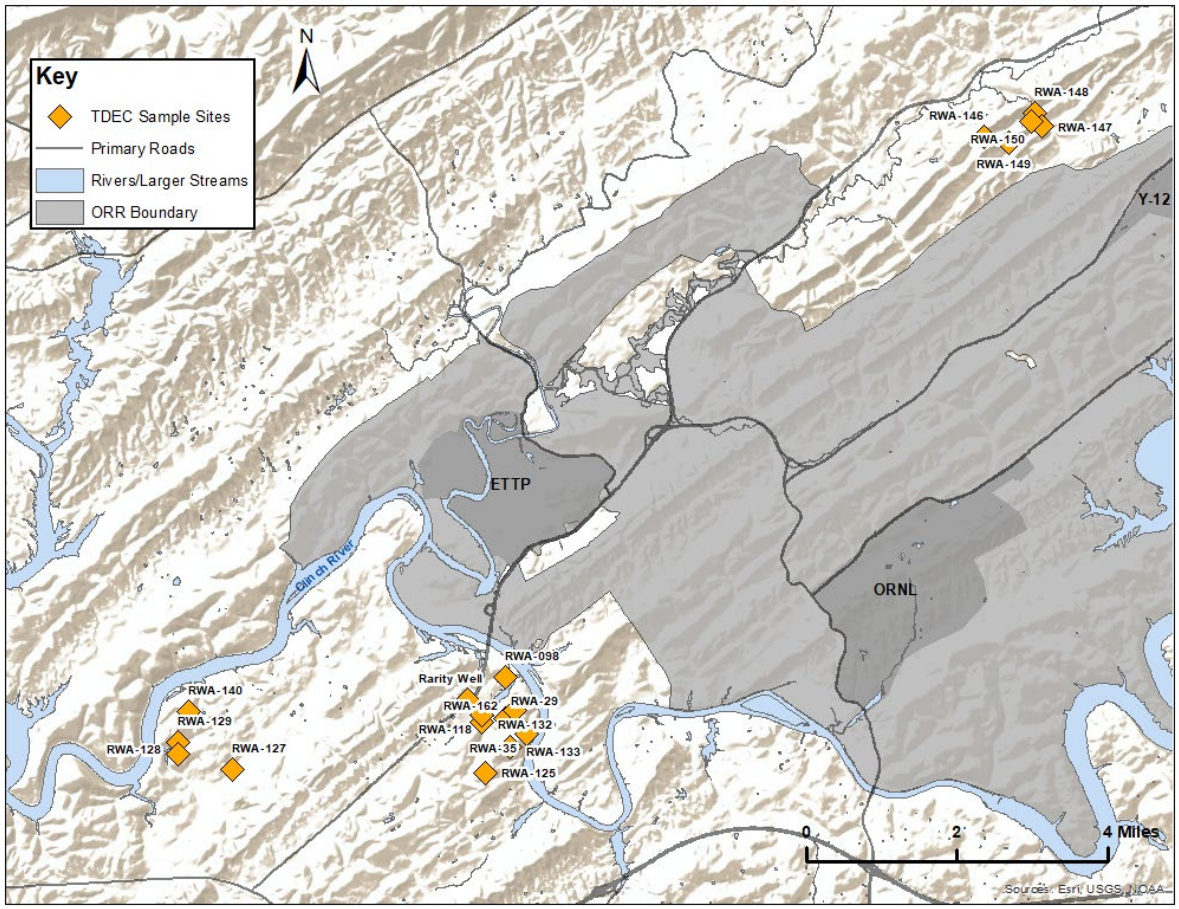

Figure 9.1.1: TDEC DoR-OR proposed residential well sampling locations

Table 9.1.1: Reference Numbers, Well Type, and Valley/Ridge Locations

RWA-29	Residential Well	BCV/Chestnut Ridge
RWA-132	Residential Well	BCV/Chestnut Ridge
RWA-133	Residential Well	BCV/Chestnut Ridge
RWA-162	Residential Well	BCV/Chestnut Ridge
RWA-35	Residential Well	BCV/Chestnut Ridge
RWA-125	Residential Well	BCV/Chestnut Ridge
Rarity Ridge Subdivision	Well (to supply a decorative spring)	BCV
RWA-098	Residential Well	BCV
RWA-118	Residential Well	BCV
RWA-140	Residential Well	ETTP
RWA-127	Residential Well	ETTP
RWA-128	Residential Well	ETTP
RWA-129	Residential Well	ETTP
RWA-148	Residential Well	Tuskegee/East Fork Ridge
RWA-149	Residential Well	Tuskegee/East Fork Ridge
RWA-146	Residential Well	Tuskegee/East Fork Ridge
RWA-147	Residential Well	Tuskegee/East Fork Ridge
RWA-150	Residential Well	Tuskegee/East Fork Ridge

9.1.6 Assumptions

- The wells being sampled can provide representative information required for the correct interpretation of the monitoring results.
- Parameters in the analytical list will be adequate to describe any potential contamination that might be present.

9.1.7 Constraints

- Well access in residential homes require the owner's permission and support of the project.
- Funding and manpower to complete the tasks
- The project is limited to the infrequent sampling of wells in a karst or fractured rock setting providing a snapshot only of the groundwater environment. Ideally, for a longer-term monitoring project / assessment, groundwater in such wells would be sampled much more frequently to show variability of water quality through time.

9.1.8 Methods, Materials, Metrics

Groundwater samples will be collected from residential wells using the current TDEC DoR-OR SOP T-300 (TDEC 2015).

At each sample location, the water quality parameters listed in Table 9.1.2 will be measured. In addition, the collected samples will be submitted for laboratory analysis where the analytical test suite is listed in Table 9.1.3.

Table 9.1.2: Field Water Quality Indicator Parameters

Measurement (units)	Normal Range	Acceptable Variability[1]
Temperature (°C)	10 to 18	± 10%
pH (SU)	4.6 to 8.5	± 0.1
Specific Conductivity	10 to 8,000	± 5%
Turbidity (NTU)	variable	± 10%
ORP[Eh](mV)	variable	± 10 mv

[1] **Acceptable variability over four consecutive readings.**

°C -Degrees Celsius
µS/cm -MicroSiemens per centimeter
mV -Millivolt
NTU -Nephelometric turbidity unit
SU -Standard Units
ORP -Oxidation Reduction Potential
Eh -Reduction Potential

Table 9.1.3: Laboratory/Analytical Parameters

VOC's		
EPA 8260b list – low level detection[1]		
Metals		
aluminum	copper	selenium
antimony	iron	silver
arsenic	lithium	sodium
barium	lead	strontium
beryllium	magnesium	thallium
boron	manganese	uranium
cadmium	mercury	vanadium
calcium	nickel	zinc
chromium	potassium	total hardness
Inorganics		
bicarbonate	total dissolved solids	nitrate and nitrite
chloride	sulfate	ammonia
fluoride	°	°
Radionuclides		
gross alpha	tritium	radium 226
gross beta	gamma scan[2]	radium 228
Strontium 89,90	technetium 99	isotopic uranium
transuranic radionuclides	°	°
Stable Isotopes		
N-15, O-18, 2-H		

[1]EPA-8260b – volatile organic compound analyses list

[2] gamma list includes: Ra-226, Pb-210, Pb-212, Pb-214, Tl-206, Th-208, Bi-212, Bi-214, K-40

After the analytical data have been received and checked for completeness, they will be evaluated and interpreted. Geochemical parameters will be compared with existing data and against MCLs. Geochemical fingerprinting may be made using plots of the six Principal Chemical Components using the method devised by Schöeller (1962) so that they can be compared with both onsite and offsite patterns. Plots of uranium-series disequilibrium (that can be used as a natural and anthropogenic tracer), and stable isotopes may also be done (depending on data) that will potentially allow for further evaluation of the offsite data, and may be used to assess possible sources, pathways, and mixings.

9.1.9 References

ASTM, 1996, Standard Guide for the Design of Ground Water Monitoring Systems in Karst and Fractured Rock Aquifers, ASTM D5717-96, (inactive, but currently being revised), American Society for Testing and Materials, Philadelphia, Pennsylvania.

Brassington, R., Field Hydrogeology, Geological Society of London, Professional Handbook Series, 175 p. (see p. 115-116)

Davies, G.J., Worthington, C.E., and Sebastian, J.E., 2012, Deep circulation of meteoric water in East Tennessee: Is this a 50 M.Y. old groundwater system that is still active? Geological Society of America, Abstracts with Programs, Vol. 44, No. 7, p. 298

Schöeller, H., 1962, les Eaux souterraines, Hydrologie dymnamique et chimique, rescherche, éxploitation, evaluation des resources, Masson et Cie niort, impr. Soulisse et Cassegrain

TDEC, 2015, TDEC DoR-OR Standard Operating Procedure T-300 Groundwater Sampling for Residential Wells.

USEPA, 1997, Guidelines for Wellhead and Springhead Protection Area Delineation in Carbonate Rocks, EPA 904-B-97-003, 28 p.+ Appendices and maps.

Worthington, S.R.H., Davies, G.J., and Alexander, E.C., jr., 2016, Enhanced bedrock permeability by weathering, Earth-Science Reviews 160, p. 188-202.

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

10.0 WATERSHED ASSESSMENTS (HOLISTIC) MONITORING

10.1 BEAR CREEK VALLEY ASSESSMENT

10.1.1 Background

This project follows up on Phase 2 of the Bear Creek Assessment Project (BCAP). Phase 3 will take the data obtained from the Phase 2 sampling projects and interpret the results in graphs, charts, and tables that enhance understanding of the findings. The Phase 3 report will explain new data revelations and relationships with older data obtained in the Phase 1 investigation.

A comprehensive evaluation of the Bear Creek Valley's environmental health will be made available, and a baseline of data established for future assessment needs.

10.1.2 Related DOE Projects

Although DOE conducts environmental sampling of surface water, toxicity, fish, and benthic macroinvertebrates, it has not been determined if they sample sediment, soils, vegetation, or biota (bird eggs, adult insects, spiders, and crayfish) in the Bear Creek Watershed. G.R. Southworth and others conducted an ecological study of Bear Creek that included surface water, sediments, fishes, benthic macroinvertebrates, and toxicity monitoring. The report, *Biological Effects of Contaminants and Remedial Actions in Bear Creek*, was published in January of 1992.

10.1.3 Problem Statements

- DOE has not conducted a comprehensive assessment of BCK 3.3 or areas downstream on Bear Creek.
- The areas downstream of the DOE restricted area may not be perceived as safe for recreation.
- TDEC DoR-OR does not have a comprehensive environmental baseline assessment of the Bear Creek Valley.

10.1.4 Goals

- To provide an intensive evaluation of Bear Creek in order to provide a baseline for future reference including for assessments that may be required following the construction of the proposed EMDF landfill.
- To assure that the sections of Bear Creek accessible to the public do not pose a health threat to those using the area for recreation.

10.1.5 Scope

The scope of this project is limited to the environmental assessment of Bear Creek through sampling and analysis of surface water, surface water toxicity, sediment, soil, benthic macroinvertebrate communities, fish tissue, vegetation, and other biota tissue (bird eggs, crayfish, adult insects, and spiders). The stream reach being assessed is from Bear Creek km 3.3 (BCK 3.3) to Bear Creek km 12.3 (BCK 12.3), see Figure 10.1.1 and Table 10.1.1.

Figure 10.1.1: Bear Creek Assessment Map

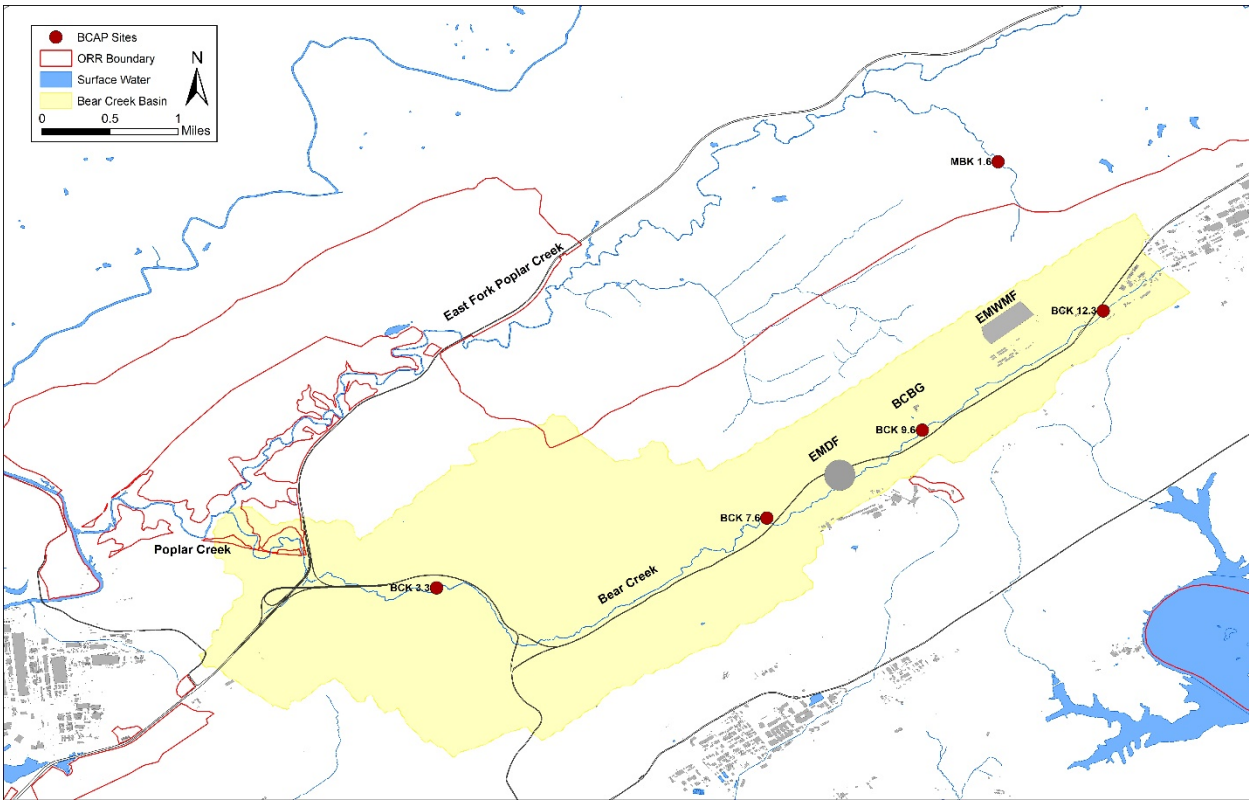

Table 10.1.1: Bear Creek Assessment Locations

Site Description	Name	Latitude	Longitude
Bear Creek kilometer 3.3	BCK 3.3	35.94354	-84.34911
Bear Creek kilometer 7.6	BCK 7.6	35.95096	-84.31395
Bear Creek kilometer 9.6	BCK 9.6	35.96032	-84.29741
Bear Creek kilometer 12.3	BCK 12.3	35.973	-84.27814
Mill Branch Mile 1.0	MBK 1.6	35.98886	-84.28935

10.1.6 Assumptions

- Staff is available to conduct data interpretation and report writing.
- All Phase 2 field work is completed by June 30, 2021.
- All Phase 2 analytical data is received by August 30, 2021.

10.1.7 Constraints

Sufficiency of time allotted to the completion of the Phase 3 report.

10.1.8 Methods, Materials, Metrics

The following list comprises the BCAP Phase 3 tasks and projected due dates.

- Jun 30, 2021 – All EMP project files due: EMP, charter, budget request (approved), planning forecast with manpower needs and sampling schedule
- Jun 30, 2021 – Project schedule due: includes work estimates
- Jul 1, 2021 – Project schedule including reporting deliverables.
- Jul 15, 2021 – Final planning outline and schedule
- Feb 28, 2022 – Phase 3 draft report due
- Mar 31, 2022 – Phase 3 draft report editing begins
- June 30, 2022 – Phase 3 final report due

10.1.9 References

Southworth, G.R., J.M. Loar, M.G. Ryon, J.G. Smith, A.J. Stewart, and J.A. Burris. Oak Ridge National Laboratory, Environmental Sciences Division. *Biological Effects of Contaminants and Remedial Actions in Bear Creek*. Oak Ridge, TN. 1992.