

**TENNESSEE DEPARTMENT
OF
ENVIRONMENT AND CONSERVATION
DIVISION OF REMEDIATION
OAK RIDGE OFFICE**

**ENVIRONMENTAL MONITORING REPORT
For Work to be Performed:
July 1, 2024, through June 30, 2025**

January 2026



Tennessee Department of
Environment and Conservation,
Authorization No. 327023

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ACRONYMS

A	ANOVA	Analysis of variance in statistics
	ARARs	Agency for Toxic Substances and Disease Registry
	As	arsenic (metal)
	ASER	<i>Annual Site Environmental Report (ASER)</i> , Calendar Year, DOE
	ATSDR	Agency for Toxic Substances and Disease Registry
	AWQC	Ambient Water Quality Criteria
B	Ba	barium (metal)
	Background site	reference site: background site located outside of a 5-mile radius of
	BC/BCK/BCV	Bear Creek/Bear Creek kilometer or station/Bear Creek Valley
	BCBGs	Bear Creek Burial Grounds
	Be-7	beryllium-7 (metal)
	Benthic Life	Organisms that live on or in the stream bed (aquatic insects,
	--	amphibians, spiders, worms, etc.)
	Bi-214	bismuth-214
	BMP	best management practice
C	CAA	Clean Air Act
	CBSQG	Consensus Based Sediment Quality Guidelines
	CC/CCK	Clear Creek/Clear Creek kilometer (background stream)
	Cd	cadmium (metal)
	CEC	Civil and Environmental Consultants
	CERCLA	<i>The Comprehensive Environmental Response, Compensation, and</i>
	--	<i>Liability Act</i> (commonly known as Superfund) enacted by Congress
	--	on December 11, 1980.
	CFR	Code of Federal Regulations
	Co-60	cobalt-60
	COCs	Contaminants of Concern
	Conc	concentration
	COND	conductivity
	Cr	Chromium (metal)
	CR/CRK	Clinch River/Clinch River kilometer
	Cs-137	cesium-137 (metal)
	CSU	Combined Standard Uncertainty
	Cu	copper (metal)
	CY	calendar year
D	D&D	Decontamination and Decommissioning

	DO	Dissolved oxygen
	DOE	US Department of Energy
	DoR	Division of Remediation
	DOR-OR	Division of Remediation – Oak Ridge
	DWR	Division of Water Resources
E	EFPC/EFK	East Fork Poplar Creek/East Fork Poplar Creek Kilometer
	EMDF	Environmental Management Disposal Facility
	EMP	Environmental Monitoring Plan
	EMR	Environmental Monitoring Report
	EMWMF	Environmental Management Waste Management Facility
	EPA	US Environmental Protection Agency
	EPT	<i>Ephemeroptera</i> (mayflies), <i>Plecoptera</i> (stoneflies), and
	--	<i>Trichoptera</i> (caddisflies)
	%EPT – Cheum	Percent EPT - Cheumatopsyche (tolerant Trichoptera)
	ESOA	Environmental Surveillance and Oversight Agreement
	ETTP	East Tennessee Technology Park (formerly K-25)
F	FCAP	Filled Coal Ash Pond
	FCK	First Creek, within ORNL campus
	FDA	Food and Drug Administration (Federal)
	FFA	Federal Facility Agreement
	FRS	Federal Regulatory Standards
	FY	Fiscal year, which for TDEC is from July 1 to June 30
G	GC/GCK	Grassy Creek, Grassy Creek kilometer
	GCN	greatest conservation need
H	HFIR	High Flux Isotope Reactor
I	IC25	Inhibition Concentration 25% reduction in survival, growth and
	--	reproduction of test organism
	ISM	Incremental Sampling Methodology
J	J	Contaminant detected below MDL, amount is estimated
K	K-25	Former site of Gaseous Diffusion Plant closed in 1987, now ETTP
	K-40	potassium-40

M	MB/MBK	Mill Branch/Mill Branch kilometer (background stream)
	MCL	Maximum Contaminant Limit see NPDWR
	MDC	Minimum Detectable Concentration
	MDL	Minimum Detection Limit
	MeHg	methylmercury
	MH	manhole 1 (MH-1), manhole 2 (MH-2) at Y-12
	MIK	Mitchell Branch/Mitchell Branch kilometer
	MSRE	Molten Salt Reactor Experiment
N	NAREL	National Air and Radiation Environmental Laboratory (EPA)
	NCBI	North Carolina Biotic Index
	NCP	National Contingency Plan
	NESHAPS	National Emissions Standards for Hazardous Air Pollutants
	NNSA	National Nuclear Safety Administration
	NOAA	National Oceanic and Atmospheric Administration
	NORM	Naturally Occurring Radioactive Materials
	NPDES	National Pollution Elimination System permit
	NRC	Nuclear Regulatory Commission
	NT	Northwest Tributary (NT-5 to NT-12), Bear Creek tributaries
	NT-5	Bear Creek Northwest Tributary Number 5 at EMWMF
	NTU	Nephelometric turbidity units, used for measurement
	NUREG	NRC Regulation
O	ORAU	Oak Ridge Associated Universities
	OREIS	Oak Ridge Environmental Information System
	ORNL	Oak Ridge National Laboratory, also known as X-10
	ORP	Oxygen Reduction Potential
	ORR	Oak Ridge Reservation
	%OC	Percent <i>Oligochaeta</i> and <i>Chironomidae</i>
P	Pb	lead, Pb-212/214
	PCCRs	phased construction completion reports
	PC/PCK/PCM	Poplar Creek/Poplar Creek kilometer/Poplar Creek mile
	PCBs	Polychlorinated Biphenyls
	PEC	Probable Effect Concentration
	PPE	Personal Protective Equipment
	PRGs	Preliminary Remediation Goals
	Pu	plutonium-238/239/240 (transuranic isotope)

Q	QA/QC QAPP	Quality Assurance/Quality Control Quality Assurance Project Plan
R	Ra RAD -- RCS RER ROD RSLs	Radium (Radium 226-228) Having to do with radiation and/or radiological materials or radionuclide activity. Roving Creel Survey Remedial Effectiveness Report Record of Decision Regional Screening Levels
S	SOP Sr-89/90 SRS SRS Station -- SU SWSA	Standard Operating Procedure strontium-89/90 Southern Research Station Sediment retention structure at the White Oak Embayment (WOE) A specific location where environmental sampling or monitoring takes place. standard units Solid Waste Storage Area
T	T&E species -- TENORM TR Tc-99 TDEC TDEC-DoR TNUTOL TN AWQC TWQC TWRA	State- or Federal-listed threatened and endangered species as protected under the Endangered Species Act of 1973. Technically Enhanced Naturally Occurring Radioactive Materials Target Risk is used for a risk-based screening technetium-99 Tennessee Department of Environment and Conservation TDEC - Division of Remediation Total Nutrient Tolerant State of Tennessee Ambient Water Quality Criteria Tennessee Water Quality Criteria Tennessee Wildlife Resources Agency
U	U U-234/235/238 UEFPC/UEFK USDI	Result is less than Method Detection Limit (MDL), undetected uranium-234/235/238 Upper East Fork Poplar Creek/Upper East Fork Creek Kilometer US Department of the Interior
V	VOCs	Volatile organic chemicals

W	WAC WOC/WC/WCK WOCAP	Waste Acceptance Criteria Whiteoak Creek/ White Oak Creek/White Oak Creek kilometer White Oak Creek Assessment Project
X	X-10	Historical name, renamed Oak Ridge National Lab (ORNL)
Y	Y-12	Y-12 National Security Complex (Building 9213, 9219, 9723-28)

UNITS OF MEASURE AND THEIR ABBREVIATIONS

°C	degrees Celsius/Centigrade
μS/cm	micro-Siemens per centimeter
mV	millivolts
DO	amount of gaseous (O ₂) dissolved in water
pH	scale of acidity from 0 to 14
pg/L	picograms per liter (1.0E-9 mg/L)
μg/L	micrograms per liter (parts per billion)
mg/L	milligrams per liter (parts per million)
ng/g	nanograms per gram (parts per billion)
μg/g	micrograms per gram (parts per million)
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
millirem	A millirem is one thousandth of a rem
rem	A rem is the unit of effective absorbed dose of ionizing radiation in human tissue, equivalent to one roentgen of X-rays
mrem	Abbreviation for millirem which is a unit of absorbed radiation dose

EXECUTIVE SUMMARY

The Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office (TDEC DoR-OR), provides the annual *Environmental Monitoring Report* (EMR), for fiscal year 2025 (FY25) with a period of performance from July 1, 2024, through June 30, 2025. This report is submitted as a comprehensive report of DoR-OR's 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 Facility Agreement* (FFA).

TDEC DoR-OR performs independent monitoring and verification sampling, as well as conducting oversight of current US Department of Energy (DOE) activities across the ORR. This independent State of Tennessee monitoring program is designed to assess current conditions for ORR related environmental media (i.e., air, surface water, soil, sediment, ground water, drinking water, and biota including food crops, fish and wildlife, and biological systems). This State-led program is also intended to provide independent assessment, where necessary, for potential emissions of any materials (i.e. hazardous, toxic, chemical, or radiological) from the ORR to its surrounding environment and to support efficient State protectiveness reviews.

This FY25 EMR presents the results of the 19 independent projects described in the FY25 *Environmental Monitoring Plan* (EMP), as well as the results of 4 additional data collection activities conducted on FFA CERCLA related projects over the FY25 period of performance. Project focus areas included: Air Monitoring, Biological Monitoring, Landfill Monitoring, Radiological Monitoring, Sediment Monitoring, Stormwater/Water Discharge Monitoring, Surface Water Monitoring, and Watershed Assessment (Holistic) Monitoring. The sections below organize the field projects by media and include more detail about individual projects. Table ES.1.1 below demonstrates the connection between TDEC's independent field projects and the FFA/ESOA responsibilities of TDEC. The **four primary goals** of the TDEC environmental monitoring program are to:

- 1) Collect data to measure potential impacts to the public/offsite risk pathways (**ESOA / FFA**)
- 2) Gather data after remedy completion to support Five Year Review and remedy effectiveness evaluations (**FFA**)
- 3) Gather data during remedy implementation to monitor potential impacts of remediation work (**FFA**)
- 4) Gather data prior to future remedy decisions to evaluate and refine baseline conditions and inform priorities (**FFA**)

Table ES.1.1: Crosswalk of TDEC Monitoring Program Goals with FFA and ESOA Goals

Environmental Monitoring Project	Grant	1) ESOA: measure potential impacts to public/offsite pathways	2) FFA: <i>after</i> <i>remedy</i> <i>completion</i> to support Five Year Reviews	3) FFA - <i>during</i> <i>remedy</i> <i>implementation</i> to monitor potential impacts	4) FFA - <i>prior to future</i> <i>remedy decisions</i> to evaluate/refine baseline conditions, inform priorities
<i>Fugitive Radiological Air Emissions</i>	FFA	●	○	●	○
<i>RadNet Precipitation</i>	ESOA	●	○	○	○
<i>Benthic Community Health</i>	FFA	○	●	●	●
<i>Roving Creel Survey</i>	ESOA	●	●	●	○
<i>Contaminant Uptake in Biota</i>	FFA	○	●	○	●
<i>Terrestrial Invertebrate Community Health</i>	FFA	○	●	○	●
<i>Radiological Uptake in Food Crops</i>	ESOA	●	○	○	○
<i>Groundwater Monitoring Offsite</i>	FFA	●	○	○	●
<i>EMDF Surface Water Sampling</i>	FFA	○	○	○	●
<i>EMWMF Landfill Monitoring</i>	FFA	○	○	●	○
<i>Haul Road Surveys</i>	FFA	●	○	●	○
<i>Ambient Gamma Radiation Monitoring</i>	ESOA	●	○	●	○
<i>Surplus Sales Verification</i>	ESOA	●	○	○	○
<i>Ambient Surface Water Parameters</i>	ESOA	●	●	●	○
<i>Ambient Surface Water Sampling</i>	ESOA	●	●	●	○
<i>White Oak Creek Radionuclides</i>	FFA	●	○	●	●
<i>CERCLA Site Investigation</i>	FFA	○	●	●	●
<i>Suspended Sediment Sampling</i>	FFA	●	○	●	●
<i>WOC Assessment Project - Phase 2a (WOCAP)</i>	FFA	●	●	●	●
<i>*Alpha-2 CLSM Spill</i>	FFA	●	○	●	●
<i>*Filled Coal Ash Pond (FCAP) Engineered Wetland</i>	FFA	●	●	○	○
<i>*1,4-Dioxane Sampling at ETTP</i>	FFA	●	○	●	●
Notes: ● = primary goal; ● = secondary goal; ○ = not directly supporting; * = sampling activities only – results provided in appendix A					

Combined, the projects associated with these goals allow TDEC, as representatives of the State's citizens and natural resources, to independently monitor the widespread contamination across the ORR to assess both changing conditions and protectiveness of implemented remedies. State monitoring during FY25 was effective in confirming DOE sampling results showing regulatory compliance for environmental media including air, precipitation, surface water, etc.

FINAL REPORT SUMMARIES FOR FY25 ARE LISTED UNDER MEDIA MONITORING TYPE AS FOLLOWS:

I. AIR MONITORING:

1. FUGITIVE RADIOLOGICAL AIR EMISSIONS

Air particulate was independently sampled at 14 ORR locations and screened for radiological emissions, which may have originated from ORR remedial actions and/or waste disposal activities. All data were evaluated for compliance within Federal Regulatory Standards. The main goal was to identify any particulate air emissions that might have had the potential to cause a member of the public to receive an effective dose greater than 10 millirem (mrem) per year. The average annual concentrations, minus background, for all sites, were below the federal standards for each isotope measured in FY25, indicating no significant impact on public health or the environment.

2. RADNET PRECIPITATION

RadNet is a national program funded by the EPA that monitors radiation air, precipitation, and drinking water across the United States. TDEC supports the precipitation monitoring portion of the program at three (3) air monitoring stations on the ORR (co-located with air monitoring stations at ORNL and Y-12), and at one (1) background reference station. For this period of performance, RadNet Precipitation results for the ORR stations were below detection limits or below the regulatory limits used for drinking water for all analyses. As such, no indication of impact on the environment or public health from ORR emissions was identified.

II. BIOLOGICAL MONITORING:

1. BENTHIC COMMUNITY HEALTH MONITORING

Aquatic macroinvertebrate species serve as both quantitative and qualitative indicators to assess biotic responses to environmental stressors (Holt, 2010). This project consisted of benthic macroinvertebrate monitoring to independently ascertain and verify DOE's findings of the current stream health of the primary ORR exit-pathway streams.

In FY25, all monitored streams and tributaries showed impairment, especially in the upper stream reaches closer to contaminant sources at the primary ORR sites, relative to reference sites. Long term monitoring of benthic macroinvertebrate communities shows that stream

health has improved since the 1980s, but streams remain impacted. Bear Creek and East Fork Poplar Creek had the lowest TMI scores of all monitored sites in FY25. TMI scores from streams and tributaries monitored at ORNL (WOC, Fifth Creek, First Creek, and Melton Branch) have remained relatively static, neither improving nor declining, over the past decade. TMI scores in Mitchell Branch at ETPP showed some improvement in TMI scores at both the reference location and the downstream sites. In addition, to support the WOCAP project in FY25, additional benthic macroinvertebrate samples were collected from WOC for radiological analysis and showed increasing trends of Sr-90 and Cs-137 tissue concentrations moving from upstream to downstream, suggesting remaining contamination in the watershed may be entering the ecological food chain.

2. ROVING CREEL SURVEY

Using public outreach surveys, TDEC documented angling efforts at four key areas where impaired ORR watersheds drain into publicly accessible waters immediately adjacent to the ORR, where recreational activity is common. Game fish tissue was also sampled from these same areas and analyzed for radionuclides, metals including mercury, and PCBs, to determine if human health risk could be elevated from recreational activities. In FY25, surveys indicated that the White Oak Lake – Clinch River confluence area was the most popular location among anglers, and the location with the next greatest angling effort recorded was the Grassy Creek – Clinch River confluence. Both locations have current or historical discharges of sediments contaminated with radiological constituents. Of the fish tissue analyzed, the only contaminant measured above regulatory thresholds was Hg and MeHg in fish sampled from the Poplar Creek and White Oak Lake confluences. Additionally, multiple recreational activities interacting with the surface water along the North Boundary Greenway were reported, including a few anglers that reported fishing in the public areas of Bear Creek and East Fork Poplar Creek. Overall, there was an increase in estimated fishing activity from FY24 to FY25. Combined, these data support continued monitoring of recreational activities in areas impacted by ORR discharges.

3. MERCURY AND CONTAMINANT UPTAKE IN BIOTA

Mercury and other legacy contaminants have the potential to bioaccumulate in biota impacted by contaminated ORR water resources (e.g., streams, stormwater, groundwater, etc.). In FY25, to better understand bioaccumulation pathways and transfer of mercury and other contaminants through food chains, this DoR-OR project sampled adult flying insects from the WOC watershed and snakes from the EFPC watershed. In WOC, gross beta activity was elevated in all insect samples collected from impacted zones. Cs-137 was observed in insect samples from the most upstream zone, and Sr-90 was measured in insects from the upper and middle zones of WOC. Detected Cs-137 and Sr-90 were measured above 1×10^{-6} risk thresholds for human fish ingestion (used as a reference threshold only). In EFPC, analyzed snakeskin samples

generally had higher levels of Hg and MeHg than compared to samples collected from reference areas. Most EFPC snakeskin samples exceeded the EPA Hg tissue criterion for fish ingestion (used as a reference threshold only). Together, these data indicate that ecological receptors are being impacted by contamination within the watershed, particularly in areas closer to known sources.

4. TERRESTRIAL INVERTEBRATE COMMUNITY HEALTH

Legacy mercury contamination is not limited to streams only; it also impacts terrestrial areas through deposition (particularly within the flood plains during storm events) or in the event of historical spills and leaks. Similar to the above benthic macroinvertebrate community health project, this project focused on assessing ecological health in impacted areas, by assessing terrestrial invertebrate communities with significant focus on ground beetles as a bioindicator species. Within the terrestrial environment of the EFPC watershed during this initial portion of the study, ground beetle species richness, diversity, and biomass indices all showed similar spatial trends, with improved metrics downstream compared to sites closer to contamination sources. Multivariate statistical analysis also identified distinct differences among ground beetle communities from impacted EFPC sites and reference sites, with this preliminary work supporting bioindicator assessment potential with the intent of expediting future eco-health evaluations within this watershed in the future.

5. RADIOLOGICAL UPTAKE IN FOOD CROPS

This project assessed possible radiological impacts of DOE ORR activities on food crops grown by local farmers and gardeners. This project intentionally mirrors a similar DOE project, by request, with DoR-OR sampling conducted independently to verify DOE sample results. During the FY25 period of performance, this DoR-OR project collected vegetables, hay, and backyard chicken egg (an alternative to milk) samples for radiological analysis within a five-mile radius of the ORR and compared results to reference samples collected from outside this radius. The TDEC DoR-OR FY25 vegetable, hay, and backyard chicken egg sampling results were similar to the corresponding DOE data from the current DOE Annual Site Environmental Report (ASER) and did not indicate impacts of radionuclide concentrations in food crops in the areas surrounding the ORR.

6. RADIOLOGICAL UPTAKE IN VEGETATION – WHITE OAK CREEK

In support of the *White Oak Creek Assessment Project* (WOCAP), this project collected a series of composite vegetation samples from the White Oak Creek floodplain to monitor for accumulation of radiological contaminants into vegetation as a pathway for ongoing impacts within the watershed associated with historical radiological contamination. In FY25, results indicated that all vegetation samples collected from historically contaminated areas of the WOC watershed had elevated levels of radiological analytes (gross alpha/beta, Sr-90, and Cs-137)

when compared to samples collected from the upstream reference area. These results suggest that impacts from radiological contamination remaining in the watershed may not be limited to only the aquatic resources or soils.

III. GROUNDWATER MONITORING:

GROUNDWATER MONITORING OFFSITE

Offsite groundwater downgradient of the ORR is monitored by both the TDEC DoR-OR and the DOE. The purpose of TDEC's DoR-OR *Offsite Groundwater Monitoring Project* is to evaluate protectiveness of human health through monitoring groundwater offsite of the ORR that citizens may potentially use for drinking water sources. In FY25, groundwater monitoring efforts were focused within the Melton Valley Offsite Subarea, downgradient of ORNL and the WOC watershed. Sampling results from both springs and private wells in these areas showed VOCs were not detected; inorganics and metals were not measured at notable levels; and alpha activity and Sr-89 were detected but at levels well below drinking water criteria, confirming similar DOE offsite samplings. Because final groundwater decisions have been deferred to later RODs, and because many plumes across the reservation have not been fully delineated laterally or vertically, creating potential for unknown migration pathways to remain, DoR-OR will continue to conduct this *Offsite Groundwater Monitoring Project* until final plume delineation and clean-up decisions have been completed.

IV. LANDFILL MONITORING

1. EMDF SURFACE WATER SAMPLING AND MONITORING

For FY25, DOR-OR continued to analyze surface water samples at the Environmental Management Disposal Facility (EMDF) site for a range of chemicals, radionuclides, and water quality parameters to provide information about the existing site conditions prior to construction and operation of the planned EMDF. The state asserts that given the presence of other significant sources of contamination upgradient in Bear Creek Valley (e.g. Bear Creek Burial Grounds), defensible pre-construction site data is important for DoR-OR to assess whether potential contamination detected in the future has been released from EMDF or could be attributable to other sources. While this sampling has been discussed within the project team, DOE is not yet collecting this information.

During FY25, seven stations were monitored by TDEC DoR-OR. All monthly water quality measurements fell within ranges consistent with background sites. Surface water grab samples were also analyzed from select locations. The only exceedances identified in FY25 in this area were arsenic and lead. This benchmark data will directly support TDEC DoR-OR's assessments and evaluations of site conditions post construction.

2. EMWMF LANDFILL MONITORING

Contaminated materials from the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) remediation activities on the ORR are approved for disposal in the Environmental Management Waste Management Facility (EMWMF), if waste meets acceptance criteria. With this project, DoR-OR independently monitors the water resources at the EMWMF, along with evaluating DOE's on-going sampling activities at the site. In FY25, surface water quality parameters were measured, and grab samples were collected for analysis from five locations representing discharges from EMWMF or representing conditions in the receiving stream, Bear Creek. Surface water quality parameters were measured within typical ranges and comparable to prior years, suggesting stability from Cells 1, 2, or 3. Turbidity measured at the V-Weir was more variable and elevated at times, likely associated with impacts within the sediment basin during heavy rainfall events. Analytical results of surface water grab samples indicated there were no exceedances of EMWMF Discharge Release Criteria constituents during FY25. TDEC's co-sampling data were consistent with DOE's data from the same locations. These State led efforts provide independent confirmation that DOE operations at the EMWMF are in accordance with ARARs defined in the ROD, and in compliance with release criteria defined in the 2017 EMWMF SAP/QAPP, to remain protective of public health and the environment.

V. RADIOLOGICAL MONITORING

1. HAUL ROAD SURVEYS

Since 2004, TDEC DoR-OR has periodically surveyed the Haul Road and all associated landfill access roads utilized by DOE to transport waste to the landfills from the site. Surveys of these ORR routes corresponded with planned and active waste hauling operations. A total of eight survey events were conducted in FY25, with one anomaly observed at the entrance of the EMDF site. Here, elevated radioactivity was observed across a wide area of the road, which was assumed to be associated with newly deposited gravel/road surface containing naturally occurring radioactive materials (NORM). No other anomalous waste items were identified. These periodic, non-exhaustive surveys are performed as an independent verification of the success of DOE's best management practices for waste management on the ORR.

2. AMBIENT GAMMA RADIATION MONITORING

The *Ambient Gamma Radiation Monitoring Project* is an ongoing TDEC project that measures emissions of ambient gamma radiation in real time, at five locations across the ORR. These monitors allow for TDEC DoR-OR assessment of conditions at locations across the reservation where gamma emissions have been known to fluctuate substantially over relatively short periods of time. The areas assessed during this period of performance included: the EMWMF, ORNL Building 3026, the Radioisotope Development Laboratory (Isotope Row), the Molten Salt Reactor Experiment (MSRE), the Spallation Neutron Source (SNS), and the Fort Loudoun Dam background location east of Lenoir City. During FY25, all monitored locations on the ORR

showed annual doses higher than the background location, though in all cases, annual dose was below the State and NRC regulatory limits. The exception to this pattern was the EMWMF site, where annual dose was calculated to be around 5% below the dose estimated at the background location. TDEC's monitoring at these locations is ongoing, and data provides independent verification of DOE's sampling and data collection at or around these sites.

3. SURPLUS SALES VERIFICATION

At the request of either Y-12 or ORNL's Excess Properties Sales Group, DoR-OR staff conducted verification surveys of auction items for radiological contamination. These supplemental scans provide an additional measure in the release process to verify no contaminated items are sold to the public. There were four survey requests during FY25. Among 20 lots of auction items, only one item was identified with elevated radiological readings that could not be linked to NORM. The elevated activity was below action levels, though Property Sales staff were notified to recheck the item. All surveyed items were within free release limits.

VI. SURFACE WATER MONITORING:

1. AMBIENT SURFACE WATER PARAMETERS

The TDEC-DoR-OR *Ambient Surface Water Parameter Project* has been operating for about 20 years measuring physical water quality parameters of three ORR exit-pathway streams (Bear Creek, East Fork Poplar Creek, Mitchell Branch) and one background stream (Mill Branch). By measuring water quality parameters (e.g. conductivity, dissolved oxygen, pH, turbidity, and temperature), a basic understanding of stream conditions over time can be gained. In FY25, all measurements were within the *State of Tennessee Water Quality Criteria* (TDEC, 2019). Looking at the temporal data (over time), statistically significant findings were identified at two locations for conductivity, where values were high but decreasing overtime at BCK 12.3, and where conductivity appears to be steadily increasing at EFK 23.4. Dissolved oxygen was significantly low at MIK 0.1 (where algae were observed covering much of the stream during the summer months), relative to other streams. Turbidity was elevated at BCK 7.6 and BCK 4.5, suspected to be associated with work at the EMDF site. These monitoring efforts provide a baseline over time from which DoR-OR may evaluate changes in water quality, both positive and negative, associated with impacts from ongoing clean-up of ORR contamination.

2. AMBIENT SURFACE WATER SAMPLING

While legacy waste across the ORR may be responsible for a larger percentage of contamination to surface water, current projects and processes at these sites also have the potential to contribute to and exacerbate overall surface water contamination. As such DoR-OR evaluates contamination in waterways, regardless of contributor (current operations or legacy impacts), to support assurance of current water quality in publicly accessible waterways, or within waterways that discharge into publicly accessible waterways. For FY25 DoR-OR focused

on continued monitoring of surface water in the Clinch River (CR) and surface water monitoring for constituents with AWQC regulatory criteria within the primary ORR exit pathway streams. DoR-OR co-sampled the Clinch River with DOE and found detectable gross alpha, gross beta, and mercury at all locations, but measurements were all below regulatory criteria. For all other streams, while many analytes with AWQC criteria were detected, the notable exceedances included: mercury and copper, which exceeded AWQC in EFPC; some VOCs which exceeded criteria at one location in EFPC and in two locations in WOC; PCB exceedances which were found within all streams on the ORR; and pesticide exceedances which were observed at multiple locations within EFPC. In all exit pathway streams sampled, regulatory exceedances were identified for both the Recreation AWQC and the Fish and Aquatic Life AWQC. Comparatively, the background stream, Clear Creek, had no AWQC exceedances identified, and only very low-level detections identified where detections occurred. This sampling helps DoR-OR identify potential current impacts of ORR activities to surface water, as well as allowing the State to monitor potential impacts associated with the key COCs identified within each administrative watershed guiding protectiveness discussions and DQO discussions in future cleanup plans.

3. WHITE OAK CREEK RADIONUCLIDES

As a Clinch River tributary, WOC became a focal ORR exit-pathway stream due to specific concerns regarding the elevated radionuclide strontium-90 (Sr-90) within the surface water. For FY25 DoR-OR has continued to evaluate impacts from ongoing radiological inputs, (specifically Sr-90), to White Oak Creek (WOC), WOC tributaries (Homogeneous Reactor Tributary-3, Melton Branch, and Fifth Creek), and any associated impacts to the Clinch River, as a complement to DOE's standard surface water monitoring in WOC. Monitoring WOC provides TDEC DoR-OR better understanding of contributions to the Clinch River from this exit pathway and allows for independent assessment of this creek and its impacts, until final clean up decisions are able to be made as planned in the future.

In FY25, water quality parameters were measured monthly, and surface water grab samples were collected on a quarterly basis. Samples were analyzed for Sr-90 and gamma isotopes. During FY25, surface water parameters were similar across WOC sites and showed expected seasonality. The primary exception to this was conductivity, where the greatest variability in conductivity and the highest measured conductivity (about 3.5x greater than the overall median) was observed at MEK 0.3. Gamma isotopes were infrequently observed, and all reported activities were well below their derived MCLs (MCLs used as a reference comparison value only due to the Clinch River designation as a drinking water source further downstream. Note: WOC is not designated as a drinking water source). Elevated Sr-90 was measured at WCK 3.9, WCK 3.4, HRT-3, MEK 0.3, WCK 2.3, and CRK 33.5, where all levels were measured greater than the EPA derived drinking water standard of 8 pCi/L (which, similar to the gamma MCL

comparison values indicated above, was used as a comparison value only). Sr- 90 activities increased from upstream to downstream, with the highest measured activity from HRT-3, and the second highest activities measures at WCK 2.3 and CRK 33.5. When comparing over time, all locations sampled showed a slight decreasing Sr-90 trend over the last 5 years.

4. CERCLA SITE INVESTIGATION

During FY25, TDEC DOR-OR performed stormwater sampling to evaluate DOE's management of stormwater run-off and erosion controls, and use of associated BMPs, at D&D sites with potential for mobilization of legacy CERCLA contaminants. DoR-OR initiated a stormwater investigation on selected D&D sites during the three states of demolition (i.e. pre-demolition, demolition, post-demolition), focusing on (1) the water quality of stormwater runoff, (2) the identification of potential pollution sources, and (3) the evaluation of the BMPs' effectiveness. Surface water samples were collected at three locations associated with planned or ongoing D&D within the ORNL campus. Samples were submitted for analysis of metals and other inorganics, radiological constituents, and organic contaminants. In addition, this project conducted pre-construction sampling of stormwater turbidity at locations upstream and downstream of the EMDF site, with a focus on determining how construction activities affect the water quality of Bear Creek. Overall, COCs were measured at low levels, and where D&D had started, no notable increases when observed during or post-demolition compared to pre-demolition conditions. At the EMDF site, surface water parameters were generally consistent both upstream and downstream of the construction site with a slight increase in pH noted at monitoring sites nearby and downstream. The primary notable finding at EMDF was a significant increase in turbidity at all sites immediately adjacent and downstream of the construction site compared to turbidity measured during FY24. This included a sustained period of turbidity measured above the EPA benchmark for turbidity in surface water (50 NTU). These changes in water quality are likely associated with construction activities at the EMDF. Use of BMPs to manage stormwater and erosion at construction and D&D sites will continue to be monitored on the ORR in the future to assure DOE's stormwater BMPs continue to be successful in preventing negative impacts to the environment.

VII. SEDIMENT MONITORING

SUSPENDED SEDIMENT SAMPLING PROJECT

The *Suspended Sediment Project* focused on monitoring migration of suspended, sediment-bound contamination as a mechanism of contamination movement around and off of the ORR. The FY25 monitoring focused on two ORR exit-pathway streams: East Fork Poplar Creek (EFPC) and Bear Creek (BC), to help identify if contamination bound to sediments suspended within the water column could have the potential to transport that contamination offsite. Composited suspended sediment samples were analyzed for radiological constituents and metals. Analytical results were compared to the *Consensus-Based Sediment Quality Guidelines (CBSQGs)* using the

Probable Effect Concentration (PEC) for metals; and the radiological activities were compared to the EPA PRGs for residential soil or to background concentrations for comparison. Sediment-bound mercury continued to exceed screening levels in EFPC. Uranium metal was elevated relative to background streams at all sites but only exceeded risk-based thresholds at EFK 23.4. Other notable findings include elevated gross alpha and gross beta activities in sediments from most sites, as compared to background stream sediments. The highest gross alpha and gross beta activities were measured from NT-5. Isotopic uranium exceeded residential soil risk thresholds in all samples analyzed from EFPC and BC. These results continue to highlight migration of sediment-bound contaminants through the ORR streams, including offsite.

VIII. HOLISTIC WATERSHED MONITORING AND ASSESSMENT

TDEC DoR-OR completes comprehensive watershed assessments periodically, to provide the citizens of the State of Tennessee with a comprehensive evaluation of the environment of the watershed at a given point in time. This project assesses the interconnectedness of all the environmental media over an entire watershed. The holistic understanding of all possible contaminants and their multiple inputs into one watershed allows for the prioritization of remediation project goals and supports planning to protect human health and the environment. Previously, DoR-OR completed holistic evaluation of the Bear Creek and East Fork Poplar Creek watersheds. FY25 holistic watershed assessment efforts were focused on the White Oak Creek watershed. While initial holistic assessment projects combined historical data reviews as well as assessment and data gap sampling, periodic updates to those initial assessments are intended to be timed with the CERCLA 5-year reviews that occur within the same watersheds and will update data sets as needed to support reviews.

WHITE OAK CREEK ASSESSMENT PROJECT (WOCAP) PHASE 2A:

White Oak Creek and its tributaries run through the main ORNL campus and through waste storage areas that have historically been impacted by radiological constituents, as well as mercury and PCBs, before emptying into the Clinch River. Although DOE restricts access to this creek, White Oak Creek is classified under TDEC Rule 0400-40-04-.09 with designated use classifications for surface waters for: Fish and Aquatic Life, Recreation, and Irrigation. Upon completion, WOCAP will serve as a comprehensive evaluation of these COCs and the ecological health of this watershed at this time and will provide data which DOR-OR or the public could use as a benchmark to gauge the effectiveness or impacts overall of ongoing and future remediation activities. To accomplish this holistic assessment, the WOCAP has been organized into several progressive phases. While a comprehensive report will be provided at the conclusion of the assessment incorporating all phases of work scope, this section of this report addresses FY25 sampling of environmental media and was supported by many of the other

projects discussed in this EMR. For this period of performance, a particular focus of WOCAP sampling and monitoring in FY25 was surface water toxicity and fish tissue sampling.

Surface water toxicity test results indicated chronic toxicity in WOC, with greater toxicity observed at upstream sites, attributed to proximity to contaminant inputs. Notably, toxicity was also documented at WCK 6.8, the reference site, in February 2025. Surface water samples from this location in March 2025, shortly after the toxicity sampling event, found elevated cyanide at this location, suggesting that though WCK 6.8 is upstream of inputs from the ORNL campus, it could be periodically impacted from inputs from other facilities in the vicinity of this site. DoR-OR also co-sampled fish tissue samples with DOE and collected two composite samples of striped shiners for analysis of radiological constituents, supporting evaluation of risk to ecological receptors. Whole body tissue sample results were compared to human health PRGs for reference only. (There are limited ecological risk thresholds available for most COCs associated with WOC, so comparison against human health fish consumption PRGs provides a rough estimate of potential risk to a receptor from consumption of fish tissue.) Both composite fish tissue samples showed bioaccumulation of multiple radiological contaminants (e.g., Cs-137, Sr-90, and isotopic uranium, among others) at levels exceeding the associated human health PRGs. These results indicate potential for the radiological contaminants in the WOC watershed to enter the ecological food chain. While interim clean ups of legacy contamination may have improved general site conditions over time, this FY25 sampling identifies the current impacts of the contamination remaining to be addressed in later CERCLA actions within the WOC watershed.

APPENDICES: CONTRACTUAL SAMPLING OUTSIDE TDEC’S FY25 SCOPE

As reflected in the Contractual Section of the FFA Budget Narrative in the FY25 Annual Grant Application, sampling and monitoring are occasionally conducted in addition to projects planned within the published EMP. This sampling is conducted in response to new information associated with ongoing cleanup activities and is used to assist in the State’s required independent oversight, or support collection of data required by the State to efficiently evaluate the or approve CERCLA decisions, in instances when DOE is unable to collect requested information. Those results are included in Appendices A-D.

DURING FY25 THIS ADDITIONAL CONTRACTUAL SAMPLING INCLUDED:

- 1) Appendix A: Beta-1 Bldg. Water Treatment System Effluent Sampling
- 2) Appendix B: Alpha-2 CLSM Release into East Fork Poplar Creek (EFPC)
- 3) Appendix C: Filled Coal Ash Pond (FCAP) Sampling
- 4) Appendix D: ETP Main Plant Area Groundwater¹,4-Dioxane Sampling

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1.0 INTRODUCTION

1.1 PURPOSE OF THE ENVIRONMENTAL MONITORING REPORT (EMR)

The Tennessee Department of Environment and Conservation, Division of Remediation, Oak Ridge Office (TDEC DoR-OR), provides the annual *Environmental Monitoring Report* (EMR) for fiscal year 2025 (FY25) with a period of performance from July 1, 2024, through June 30, 2025.

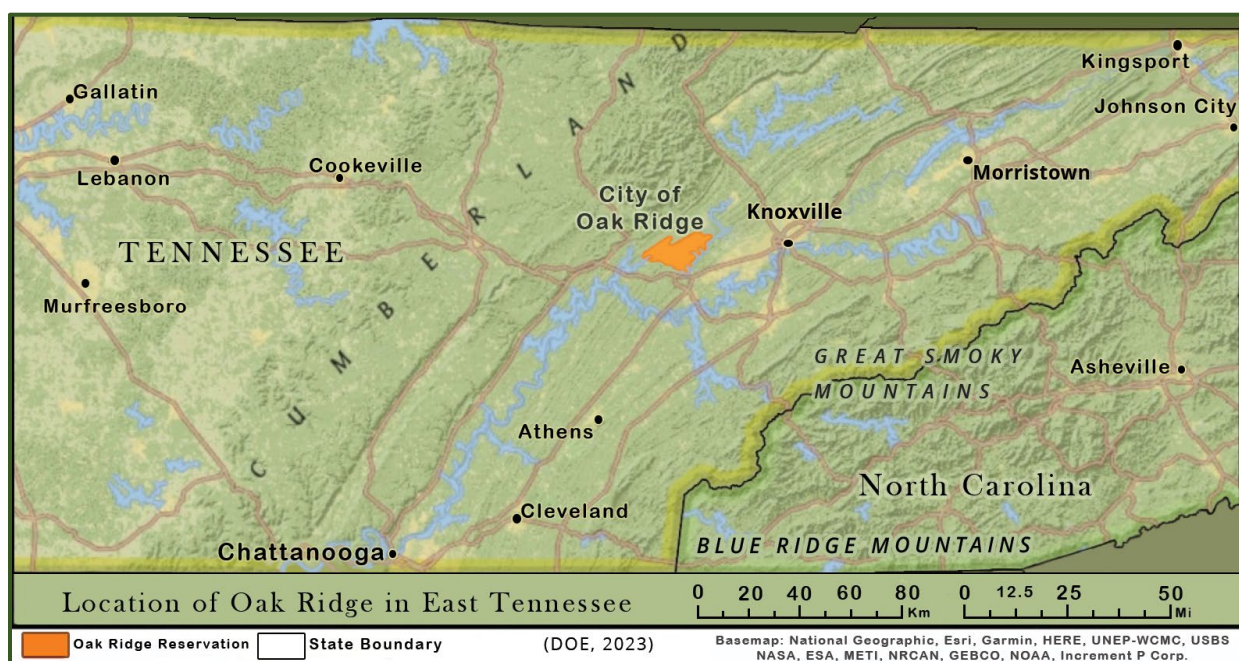


Figure 1.1.1: Location of Oak Ridge in East Tennessee

All projects defined in this EMR were found to be consistent with the National Contingency Plan (NCP) and were intentionally designed to comply with the administrative and operational requirements of the *Environmental Surveillance and Oversight Agreement* (ESOA) and, additionally, in support of the *Federal Facility Agreement* (FFA). DoR-OR monitoring of current and upcoming DOE ORR activities is outlined in the ESOA, while the monitoring of DOE's legacy contamination management is addressed in the FFA.

DoR-OR worked collaboratively co-sampling and conducted oversight of field actions with the Office of Science, National Nuclear Safety Administration (NNSA), and DOE Environmental Management and their contractors. All collected data has been made available to the public, including to DOE or EPA for triparty consideration, where appropriate. State sampling was conducted by DoR-OR to support comparison and correlation of results with DOE's monitoring programs. DoR-OR's monitoring program is intentionally designed and reviewed annually to (1) support active and ongoing environmental restoration decisions, to (2) help evaluate the performance of existing remedies, and to (3) make effective decisions going forward. These

DoR-OR monitoring projects have been key to the State's success in this role. More specifically, each environmental monitoring project scope collects data to support one or more of the following goals (Table ES.1): (1) measuring the potential impact to the public/offsite pathways, (2) evaluating conditions after remedy completion to support CERCLA Five Year Review evaluations, (3) monitoring potential impacts during remedy implementation, and (4) informing baseline conditions and clean-up priorities prior to future remedy decisions. Addressing these independent monitoring and oversight goals, in alignment with ESOA and FFA CERCLA clean-up goals, allows the State to more effectively monitor the widespread contamination across the ORR to assess both changing environmental conditions and protectiveness of implemented remedies. Project data analyses enable the State to provide decisions effectively and efficiently for the FFA CERCLA projects, as well as to verify protectiveness to Tennesseans regarding active processes conducted at the ORR under the ESOA work scopes.

Regarding the DoR-OR's primary focus on ensuring protectiveness of human health and the environment within Tennessee, all environmental monitoring was performed to meet this mission statement. All work outlined in this monitoring report was performed in accordance with the *TDEC DoR-OR Technical Standard Operating Procedures* (SOPs).

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

Table 1.1.1: Stakeholders

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

1.2 OBJECTIVE

The overarching objective of the DoR-OR, as outlined in this EMR, was to perform State-led environmental monitoring as well as to evaluate monitoring data for State oversight of current DOE activities throughout the Oak Ridge Reservation (ORR). Comparable DoR-OR monitoring results will be used to confirm yearly DOE data, as published in the ASER. This comparison will be used to gauge the performance of existing DOE remedies, and to investigate movement of legacy contamination in selected areas to evaluate the efficacy of DOE best management practices (BMPs).

The DoR-OR data was used to corroborate existing State assessment data and, if necessary, to augment DOE's separate environmental monitoring datasets. DoR-OR project teams collected

data in areas where there was a higher potential for ORR emissions of any materials (i.e. hazardous, toxic, chemical, or radiological) which could impact the surrounding biota. The environmental media and COCs to be sampled during FY25 are listed below in Table 1.2.1.

Tables 1.2.1: Types of Media Monitoring in FY25

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

1.3 THE OAK RIDGE RESERVATION (ORR)

The ORR is comprised of three major campuses:

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

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

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

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

ETTP, in contrast, has undergone a transition from a gaseous diffusion facility into an industrial technology park. Remediation activities continue and have reduced the amounts of legacy contaminants. DOE recently released portions of this area back to the local government and now private businesses operate facilities in this region of the ORR.

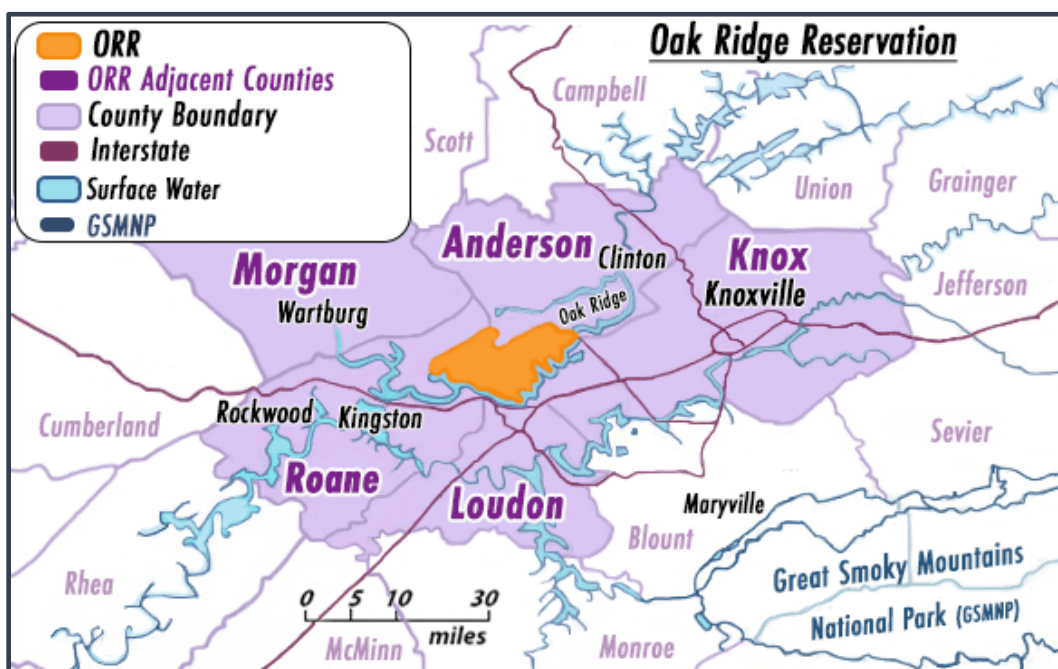


Figure 1.3.1: Location of the ORR in Relation to Surrounding Counties

1.3.1 GEOGRAPHY OF THE ORR AREA

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

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

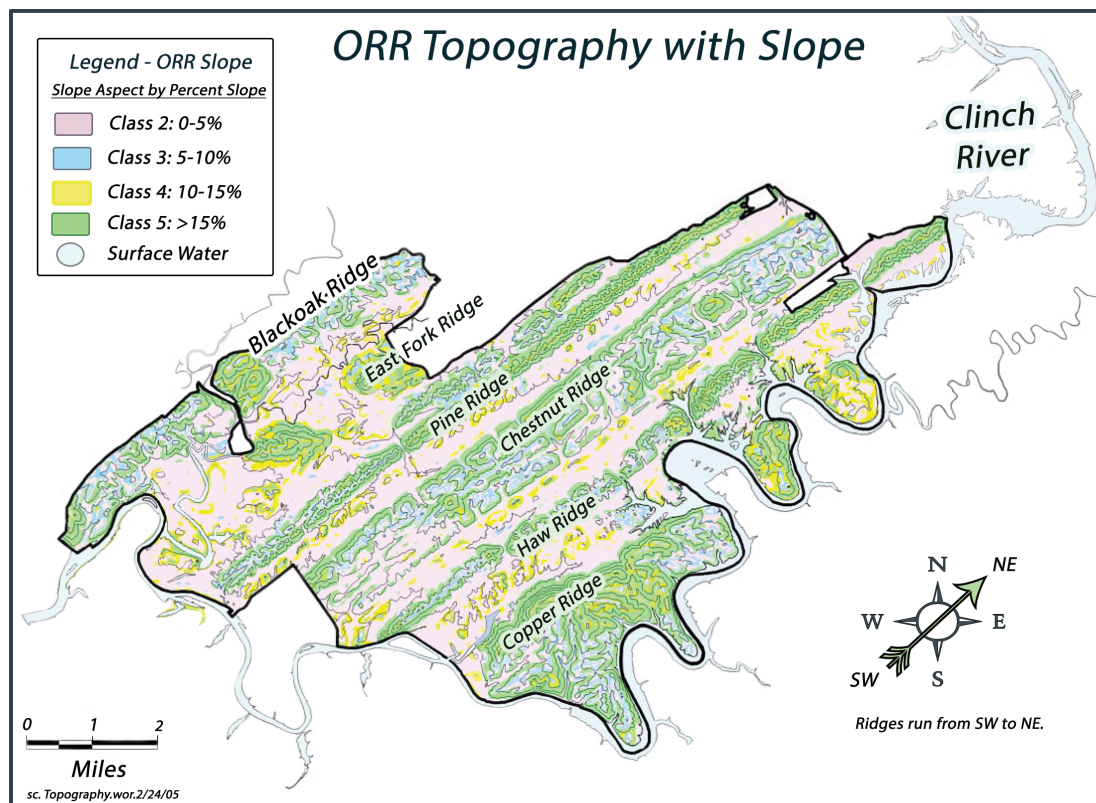


Figure 1.3.1.1: ORR Ridges (Southwest-to-Northeast Orientation)

1.3.2 CLIMATE OF THE ORR AREA

The climate of the ORR region is classified as humid and subtropical. Local climate is characterized by a wide range of seasonal temperature changes between the summer and winter months. According to DOE's CY24 Annual Site Evaluation Report (ASER), published in September 2025,

Total precipitation during 2024 as measured at meteorological tower (MT)2 [at ORNL] was 1227.9 mm (48.3 in.), which is 13 percent below the 30-year average of 1417.8 mm.

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

1.3.3 POPULATION OF THE ORR AREA

Approximately 772,000 Tennesseans reside in the counties surrounding the ORR. Knoxville, in Knox County, is the only major metropolitan area near Oak Ridge. Excluding Knoxville, land use is semi-rural and made up of residences, small farms, and pastures. Popular recreation includes fishing, hunting, boating, water skiing, and swimming.

1.4 TENNESSEE'S COMMITMENT TO TENNESSEANS

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

2.0 AIR MONITORING

2.1 FUGITIVE RADIOLOGICAL AIR EMISSIONS

2.1.1 BACKGROUND

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

For many years DoR-OR conducted three projects to monitor the air on the ORR for radiological contaminants. This project has been the longest running, with the RadNet Air project a close second, with both beginning operations in the 1990s. The third project, RadNet Precipitation, began in the 2000s and monitors radionuclides in air brought to the earth's surface by precipitation and is covered in Chapter 2.2. Both of the RadNet projects are a part of the larger RadNet program of EPA, creating a larger radiation monitoring network across the United States. In FY24, the *RadNet Air* project was phased out (with the last samples collected in June 2024) and the Fugitive Air project was increased to include samplers at the prior RadNet locations as well as at additional ORR locations.

DOE and its contractors also conduct air monitoring. They have high-volume air monitoring at two ETPP locations, at one ORNL location, and via the ORR Ambient Air Monitoring Program, which has samplers largely around the perimeter of the ORR. The results from this air sampling are used to calculate human dose exposure for vulnerable populations offsite.

2.1.2 PROBLEM STATEMENTS

Fugitive (i.e., non-point source) dispersal of contaminants can occur on the ORR. Legacy contaminants could potentially become airborne during remediation activities, disposal at the onsite hazardous and low-level radioactive waste facility, and severe weather events. Y-12 contains deteriorating older buildings with uranium contamination which must undergo remediation and can release contaminants. ORNL structures are contaminated with various fission and activation products in addition to uranium and plutonium isotopes. Some structures at ORNL were identified as the highest risk buildings on the ORR (ORAU, 2003). These buildings are physically deteriorating and contain loose contamination. The risk is exacerbated by the proximity of these structures to pedestrian and vehicular traffic, to privately funded businesses, and to other active ORNL buildings. In addition to legacy contamination concerns, releases could also be possible from current research and manufacturing projects.

2.1.3 GOALS

To verify protectiveness of human health and the environment, TDEC DoR-OR conducted independent air sampling in FY 25 and compared the results with the air sampling data published by DOE, to see if DOE had adequately monitored airborne emissions of radiological contaminants. DoR-OR's independent monitoring was compared to Federal Regulatory Standards (FRSs) and used to check that members of the public were not receiving an effective dose greater than 10 mrem per year (40 CFR 61.92 Subpart H, 2025).

2.1.4 SCOPE

During FY25, DoR-OR conducted the *Fugitive Radiological Air Emissions Monitoring* project with continuous air monitoring at each of the ORR sites plus a comparable background location (Figure 2.1.4.1). A total of fourteen air samplers were monitoring for radiological contaminants in air. For most of FY25, there were 5 samplers at ORNL, 5 samplers at Y-12, 2 samplers at ETPP, a sampler at EMWMF, and another at the background location in Lenoir City. Sampler locations were selected to maximize the likelihood of collecting representative samples from potential sources of airborne contamination.

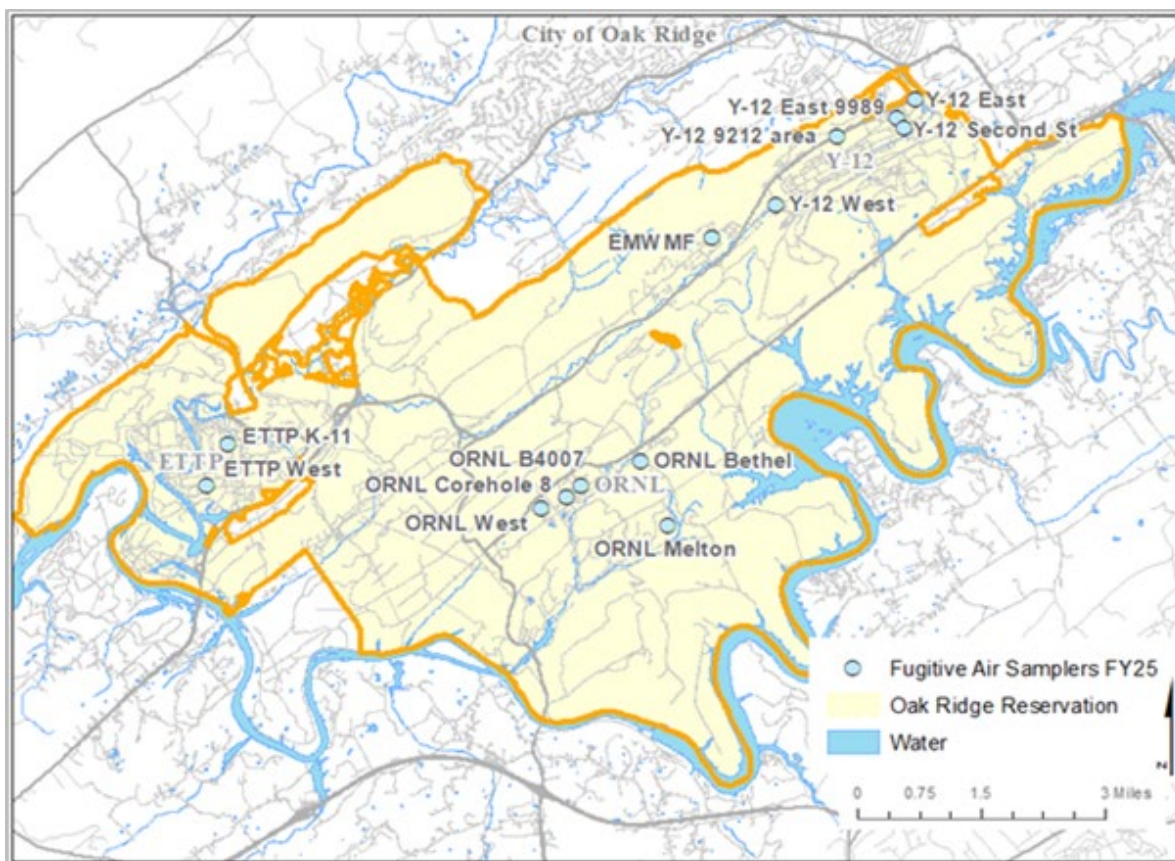


Figure 2.1.4.1: Fugitive Air Monitoring Locations

2.1.5 METHODS, MATERIALS, METRICS

The *Fugitive Air Monitoring* project operated 14 high-volume air samplers for most of FY25 to conduct continuous radiological particulate air monitoring on the ORR (Figure 2.1.4.1), with one sampler stationed in Lenoir City to collect background data for comparison. The remaining sampler units were placed at ORR locations where the potential for release of fugitive airborne emissions was higher. For example, samplers were placed near locations where contaminated soils were being excavated, contaminated structures were being demolished, and near waste disposal operations.

Each of the 14 high-volume air samplers used 8 x 10-inch glass fiber filters to collect particulates from the air. Air was drawn through each unit at a rate of approximately 35 ft³ per minute. To ensure accuracy, airflow through each air sampler was calibrated quarterly, in accordance with the air sampler guidelines (TDEC, 2024a; TDEC, 2024b; TDEC, 2024c).

Samples were collected from each air sampler weekly, with samples being composited every four weeks and analyzed for radiological contaminants by Eberline Analytical. The selection of analyses performed were based on the contaminants of concern and previous findings for the locations being monitored, with the analytes and methods listed in Table 2.1.5.1.

Table 2.1.5.1 Radiological Analytes and Methods

Analytes	Analytical Method
Gross alpha	LANL MLR-100 Modified
Gross beta	
Gamma	EPA 901.1 Modified
Isotopic uranium	EPA 908.0 Modified

To assess contaminant concentrations measured at each location, results were compared with the background data and the standards provided in the *National Emission Standards for Hazardous Air Pollutants* (NESHAPs) *National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities* (40 CFR 61 Subpart H, 2023), required by the EPA under the Clean Air Act (CAA). These standards associate radiological emissions to quantities that would not cause a member of the public to receive an effective dose equivalent greater than 10 millirem (mrem) in a year (40 CFR 61 Appx E, 2023). Associated findings are reported to DOE, its contractors, and the public in this annual monitoring report.

2.1.6 DEVIATIONS FROM THE PLAN

The original project plan was to collect and report on the full year's data. This would have included 13 four-week composite samples per station, every month through June 2025. However, one air sampler at ETPP ended up needing to be removed before the end of the fiscal

year due to a land transfer. Since this air sampling location did not have a full year's worth of data collected, the results from this station are not directly comparable to the NESHAPS standards but were compared regardless to ensure the results did not exceed the limits for the time period during which monitoring occurred.

2.1.7 RESULTS AND ANALYSIS

During FY25, fugitive radiological air samplers monitored radiological particulate emissions at 14 stations. All particulate air monitor samples were analyzed for three isotopes of uranium (U-234, U-235, U-238) as well as for gross alpha and gross beta activity. Samples from ORNL, EMWMF, and the reference location were also analyzed for gamma, due to associated radiological contaminants of concern. Only naturally occurring isotopes were detected (primarily naturally occurring daughter products of radon) and were not included in the sum of fractions calculations, so not discussed further below. The isotopic uranium results are shown in the tables below. When the sum of fractions is less than one, no regulatory limits were exceeded, as was the case at each of the air sampling locations for FY25.

ETTP

The ETTP West fugitive radiological air monitor was located at ETTP southwest of the original site of the K-25 Gaseous Diffusion Plant, at the west end of the ETTP site. A full year's worth of data was not available for the ETTP West sampling location due to the sampler being removed after the mid-April sample was collected, due to land transfer. However, eleven of the potential thirteen sample sets for the year were analyzed. The results show that no radiological limits were exceeded for the time period monitored (Table 2.1.7.1). The sum of fractions (SOF) of less than one indicates that regulatory limits were not exceeded.

Table 2.1.7.1: ETTP West Air Monitoring Average Results (pCi/m³)

ETTP West Sampling Location	U234	U235	U238	SOF
Average FY25 (July 2024 - April 2025)	0.0000128	0.0000028	0.0000076	
Average background	0.0000160	0.0000040	0.0000155	
Net Activity (Avg. minus background)	-0.0000032	-0.0000012	-0.0000079	
40CFR Part 61 Limit, Appendix E, Table 2	0.00770	0.00710	0.00830	
Fraction of Limit (Net/Limit)	0	0	0	0
<i>Levels < background can be considered ≈zero (not negative values) and don't subtract from the sum of fractions (SOF)</i>				

The K-25 K-11 area sampler at ETTP was located east of the northern portion of the K-25 building. The results show that no radiological limits were exceeded (Table 2.1.7.2). The sum of

fractions of less than one indicates that regulatory limits were not exceeded.

Table 2.1.7.2: ETPP K-25 K-11 Air Monitoring Average Results for (pCi/m³)

ETPP K-25 K-11 Sampling location	U234	U235	U238	SOF
Average FY25 (July 2024 - June 2025)	0.0000187	0.0000045	0.0000188	
Average background	0.0000160	0.0000040	0.0000155	
Net Activity (Average minus background)	0.0000028	0.0000005	0.0000033	
40CFR Part 61 Limit, Appendix E, Table 2	0.00770	0.00710	0.00830	
Fraction of Limit (Net/Limit)	0.00036	0.00007	0.00040	0.00083
<i>Levels < background can be considered ≈zero (not negative values) and don't subtract from the sum of fractions</i>				

Y-12

Table 2.1.7.3 shows the results from the samples taken at the Y-12 West area, which is at the far west end of Y-12 and is near a Y-12 mercury air sampling station. The sum of fractions of less than one indicates that regulatory limits were not exceeded.

Table 2.1.7.3: Y-12 West Air Monitoring Average Results (pCi/m³)

Y-12 West	U234	U235	U238	SOF
Average FY25 (July 2024 - June 2025)	0.0000535	0.0000066	0.0000165	
Average background	0.0000160	0.0000040	0.0000155	
Net Activity (Average minus background)	0.0000375	0.0000026	0.0000010	
40CFR Part 61 Limit, Appendix E, Table 2	0.00770	0.00710	0.00830	
Fraction of Limit (Net/Limit)	0.00487	0.00037	0.00012	0.00537
<i>Levels < background can be considered ≈zero (not negative values) and don't subtract from the sum of fractions</i>				

Results are listed in Table 2.1.7.4 for the Y-12 Building 9212 area, which is associated with nuclear weapons work. The averaged available data did not indicate any exceedances. The sum of fractions of less than one indicates that regulatory limits were not exceeded for the time monitored. This location had the highest sum of fractions of the stations monitored by DoR-OR for FY25, but it was still well below regulatory limits for the isotopes monitored.

Table 2.1.7.4: Y-12 Building 9212 Area Air Monitoring Average Results (pCi/m³)

Y-12 9212 area	U234	U235	U238	SOF
Average FY25 (July 2024 - June 2025)	0.0001450	0.0000116	0.0000214	
Average background	0.0000160	0.0000040	0.0000155	
Net Activity (Average minus background)	0.0001290	0.0000076	0.0000059	
40CFR Part 61 Limit, Appendix E, Table 2	0.00770	0.00710	0.00830	
Fraction of Limit (Net/Limit)	0.01676	0.00108	0.00071	0.01854
<i>Levels < background can be considered ≈zero (not negative values) and don't subtract from the sum of fractions</i>				

In Table 2.1.7.5, the results are shown from the Y-12 Second Street location. This area is of interest because the sampler is often downwind of the majority of the original Y-12 buildings associated with nuclear weapons work, many of which are now in disrepair and awaiting or undergoing demolition. The averaged available data did not indicate any exceedances. The sum of fractions of less than one indicates that regulatory limits were not exceeded for the time monitored.

Table 2.1.7.5: Y-12 Second Street Air Monitoring Average Results (pCi/m³)

Y-12 Second St	U234	U235	U238	SOF
Average FY25 (July 2024 - June 2025)	0.0000281	0.0000039	0.0000222	
Average background	0.0000160	0.0000040	0.0000155	
Net Activity (Average minus background)	0.0000121	-0.0000001	0.0000067	
40CFR Part 61 Limit, Appendix E, Table 2	0.00770	0.00710	0.00830	
Fraction of Limit (Net/Limit)	0.00157	0	0.00080	0.00237
<i>Levels < background can be considered ≈zero (not negative values) and don't subtract from the sum of fractions</i>				

Table 2.1.7.6 shows the results from the samples taken at the Y-12 East Building 9989 area. This area is near the northeast end of the plant and is also next to a building where Y-12 air sampling is done for mercury. The averages of the data did not indicate any exceedances for the time run. The sum of fractions of less than one indicates that regulatory limits were not exceeded for the time monitored.

Table 2.1.7.6: Y-12 East Building 9989 area Air Monitoring Average Results (pCi/m³)

Y-12 East B9989	U234	U235	U238	SOF
Average FY25 (July 2024 - June 2025)	0.0000233	0.0000044	0.0000166	
Average background	0.0000160	0.0000040	0.0000155	
Net Activity (Average minus background)	0.0000073	0.0000004	0.0000011	
40CFR Part 61 Limit, Appendix E, Table 2	0.00770	0.00710	0.00830	
Fraction of Limit (Net/Limit)	0.00094	0.00006	0.00013	0.00114
<i>Levels < background can be considered ≈zero (not negative values) and don't subtract from the sum of fractions</i>				

Table 2.1.7.7 shows the results from the samples taken at the Y-12 East sampling location. This location is at the far east end of the plant and is closest to the city of Oak Ridge. The averaged available data did not indicate any exceedances. The sum of fractions of less than one indicates that regulatory limits were not exceeded for the time monitored.

Table 2.1.7.7: Y-12 East Air Monitoring Average Results (pCi/m³)

Y-12 East	U234	U235	U238	SOF
Average FY25 (July 2024 - June 2025)	0.0000238	0.0000040	0.0000133	
Average background	0.0000160	0.0000040	0.0000155	
Net Activity (Average minus background)	0.0000078	0	-0.0000022	
40CFR Part 61 Limit, Appendix E, Table 2	0.00770	0.00710	0.00830	
Fraction of Limit (Net/Limit)	0.00101	0	0	0.00101
<i>Levels < background can be considered ≈zero (not negative values) and don't subtract from the sum of fractions</i>				

EMWMF

This station is located at the EMWMF mixed waste disposal facility in Bear Creek Valley (BCV), west of Y-12. The averaged available data and the sum of fractions of less than one indicates that regulatory limits were not exceeded (Table 2.1.7.8).

Table 2.1.7.8: EMWMF Air Monitoring Average Results (pCi/m³)

EMWMF Sampling Location	U-234	U-235	U-238	SOF
Average FY25 (July 2024 - June 2025)	0.0000441	0.0000076	0.0000206	
Average background	0.0000160	0.0000040	0.0000155	
Net Activity (Average minus background)	0.0000281	0.0000036	0.0000051	
40CFR Part 61 Limit, Appendix E, Table 2	0.00770	0.00710	0.00830	
Fraction of Limit (Net/Limit)	0.00365	0.00051	0.00062	0.00478
<i>Levels < background can be considered ≈zero (not negative values) and don't subtract from the sum of fractions</i>				

ORNL

Five air samplers were located at ORNL during FY25. The B4007 air monitor is located in the heart of ORNL and is east of the 3000 area where more of the radiological work was done historically, with some of these areas undergoing D&D or remediation in the past, present, and future. No elevated impacts were noted (Table 2.1.7.9) and the sum of fractions of less than one indicates that regulatory limits were not exceeded.

Table 2.1.7.9: ORNL B4007 Air Monitoring Average Results (pCi/m³)

ORNL B4007	U234	U235	U238	SOF
Average FY25 (July 2024 - June 2025)	0.0000147	0.0000057	0.0000101	
Average background	0.0000160	0.0000040	0.0000155	
Net Activity (Average minus background)	-0.0000013	0.0000017	-0.0000054	
40CFR Part 61 Limit, Appendix E, Table 2	0.00770	0.00710	0.00830	
Fraction of Limit (Net/Limit)	0	0.00025	0	0.00025
<i>Levels < background can be considered ≈zero (not negative values) and don't subtract from the sum of fractions</i>				

The ORNL Corehole 8 location is by the Corehole 8/Tank W-1A area and is located at the west end of the 3000 area. No elevated impacts were noted (Table 2.1.7.10) and the sum of fractions of less than one indicates that regulatory limits were not exceeded.

Table 2.1.7.10: ORNL Corehole 8 Air Monitoring Average Results (pCi/m³)

ORNL Corehole 8	U234	U235	U238	SOF
Average FY25 (July 2024 - June 2025)	0.0000112	0.0000037	0.0000096	
Average background	0.0000160	0.0000040	0.0000155	
Net Activity (Average minus background)	-0.0000048	-0.0000003	-0.0000059	
40CFR Part 61 Limit, Appendix E, Table 2	0.00770	0.00710	0.00830	
Fraction of Limit (Net/Limit)	0	0	0	0
<i>Levels < background can be considered ≈zero (not negative values) and don't subtract from the sum of fractions</i>				

The ORNL Melton Valley sampler is located in the next valley south of the main ORNL campus. It is also east of the active High Flux Isotope Reactor (HFIR) and many burial grounds and waste storage areas. No elevated impacts were noted (Table 2.1.7.11) and the sum of fractions of less than one indicates that regulatory limits were not exceeded.

Table 2.1.7.11: ORNL Melton Valley Air Monitoring Average Results (pCi/m³)

ORNL Melton Valley	U234	U235	U238	SOF
Average FY25 (July 2024 - June 2025)	0.0000156	0.0000041	0.0000121	
Average background	0.0000160	0.0000040	0.0000155	
Net Activity (Average minus background)	-0.0000004	0.0000001	-0.0000035	
40CFR Part 61 Limit, Appendix E, Table 2	0.00770	0.00710	0.00830	
Fraction of Limit (Net/Limit)	0	0.00002	0	0.00002
<i>Levels < background can be considered ≈zero (not negative values) and don't subtract from the sum of fractions</i>				

The ORNL Bethel Valley sampler is located to the northeast of the main ORNL campus, in Bethel Valley. No elevated impacts were noted (Table 2.1.7.12) and the sum of fractions of less than one indicates that regulatory limits were not exceeded.

Table 2.1.7.12: ORNL Bethel Valley Air Monitoring Average Results (pCi/m³)

ORNL Bethel Valley	U234	U235	U238	SOF
Average FY25 (July 2024 - June 2025)	0.0000172	0.0000038	0.0000116	
Average background	0.0000160	0.0000040	0.0000155	
Net Activity (Average minus background)	0.0000012	-0.0000002	-0.0000039	
40CFR Part 61 Limit, Appendix E, Table 2	0.00770	0.00710	0.00830	
Fraction of Limit (Net/Limit)	0.00016	0	0	0.00016
<i>Levels < background can be considered ≈zero (not negative values) and don't subtract from the sum of fractions</i>				

The ORNL West sampler is located west of the main ORNL campus, in Bethel Valley, and is near the ORR Ambient Air monitoring Station 3. No elevated impacts were noted (Table 2.1.7.13) and the sum of fractions of less than one indicates that regulatory limits were not exceeded.

Table 2.1.7.13: ORNL West Air Monitoring Average Results (pCi/m³)

ORNL West	U234	U235	U238	SOF
Average FY25 (July 2024 - June 2025)	0.0000168	0.0000027	0.0000120	
Average background	0.0000160	0.0000040	0.0000155	
Net Activity (Average minus background)	0.0000008	-0.0000013	-0.0000036	
40CFR Part 61 Limit, Appendix E, Table 2	0.00770	0.00710	0.00830	
Fraction of Limit (Net/Limit)	0.00011	0	0	0.00011
<i>Levels < background can be considered ≈zero (not negative values) and don't subtract from the sum of fractions</i>				

Table 2.1.7.14 shows the FY25 average gross alpha, gross beta, and isotopic uranium results for each monitoring station. While the results for each of the alpha and the beta columns were varied, these values were similar within each column, indicating they were in range of each other, including the results seen at the background location in Lenoir City. Since there are no limits specifically for total (or gross) alpha and beta levels, just specific isotopes, the fact that these values were within range of those seen at the background location indicates that they are close to background levels and thus not of concern. The results for the uranium isotopes U-234 and U-235 were more variable with the highest results seen at the sampler in the Y-12 9212 area for FY25 (Table 2.1.7.14). While the results from all individual sample sets were less than annual average limits for isotopic uranium, some locations showed more elevated levels at times throughout the year, generally leading to higher averages for FY25.

Table 2.1.7.14: Average Results at Each Air Monitoring Station (pCi/m^3)

	FY25 Averages				
	Alpha	Beta	U-234	U-235	U-238
Lenoir City (BG)	0.00199	0.0096	0.0000160	0.0000040	0.0000155
ETTP West	0.00333	0.0117	0.0000128	0.0000028	0.0000076
ETTP K-25 K-11	0.00289	0.0098	0.0000187	0.0000045	0.0000188
EMWMF (BCV)	0.00287	0.0097	0.0000441	0.0000076	0.0000206
Y-12 West	0.00398	0.0154	0.0000535	0.0000066	0.0000165
Y-12 9212 area	0.00242	0.0103	0.00001450	0.0000116	0.0000214
Y-12 Second St	0.00375	0.0151	0.0000281	0.0000039	0.0000222
Y-12 B9989	0.00233	0.0096	0.0000233	0.0000044	0.0000166
Y-12 East	0.00265	0.0098	0.0000238	0.0000040	0.0000133
ORNL B4007	0.00194	0.0086	0.0000147	0.0000057	0.0000101
ORNL Corehole 8	0.00264	0.0101	0.0000112	0.0000037	0.0000096
ORNL Melton	0.00248	0.0104	0.0000156	0.0000041	0.0000121
ORNL Bethel	0.00384	0.0132	0.0000172	0.0000038	0.0000116
ORNL West	0.00271	0.0134	0.0000168	0.0000027	0.0000120

Note: data bars can be used for a visual comparison of results for each radiological analysis.

2.1.8 CONCLUSIONS

The average annual concentrations minus background, for all sites as measured by DoR-OR, were below the federal standards for each isotope measured. Additionally, the DOE ORR Ambient Air Monitoring program indicated in the ASER that all radionuclide concentrations measured in 2023 were well below the derived concentration standards for air established by DOE as guidelines for controlling exposure to members of the public (DOE, 2024).

The DoR-OR radiological air monitoring project's shorter composite interval of every four weeks can result in a more timely observation of potential problems than the related DOE ORR Ambient Air Monitoring program, which analyzes quarterly composite samples of 13 weekly samples. Their program analyzes four composite samples per station annually, versus the 13 composites analyzed per station annually with the DoR-OR fugitive air monitoring project.

2.1.9 RECOMMENDATIONS

DoR-OR should continue routine fugitive radiological air monitoring on the ORR because this project is valuable as an independent verification of DOE's results; its sampling locations are more directly associated with active operations on the ORR; and the project analyzes samples at a greater frequency that would allow for a quicker response if elevated results were observed.

The air monitoring plan for the DOE's 2023 *Environmental Monitoring Plan* (DOE, 2022) was reviewed, and the project team suggests that DOE should provide more frequent composites

for analysis at all locations as well as high-volume site-specific monitoring by DOE contactors at Y-12 and ORNL in addition to the ongoing ORR ambient air perimeter monitoring. Currently, this DoR-OR radiological air monitoring project helps fill this monitoring gap.

2.1.10 REFERENCES

40 CFR 61, Appx E. 2023. *Title 40 of the Code of Federal Regulations, Chapter 1, Subchapter C, Part 61; National Emission Standards for Hazardous Air Pollutants (NESHAPS)*, Appendix E, Table 2: Concentration Levels for Environmental Compliance.

<https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-61/appendix-Appendix%20E%20to%20Part%2061>

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2.2 RADNET PRECIPITATION

2.2.1 BACKGROUND

The nationwide EPA RadNet Precipitation Monitoring Program measures radioactive contaminants that are removed from the atmosphere and transported to the Earth's surface by precipitation. On the ORR, the *RadNet Precipitation Monitoring Project* is an ongoing project that provides radiochemical analysis of precipitation samples taken from monitoring stations at two ORNL sites and one Y-12 site. Each year, samples are collected by TDEC DoR-OR personnel, and gamma analysis is performed on monthly composite samples by the EPA Laboratory, NAREL. Gamma analysis functions as a screening tool because few isotopes of interest are pure beta or pure gamma emitters; therefore, if a radiological release occurred on the ORR, some gamma radiation would likely be emitted either directly or from daughter products. Additional analyses are only conducted if a known radiological release occurred or if it is indicated by monthly gamma analysis results, at the discretion of EPA. The analytical results serve as an additional indicator to show when radioactive materials are present. While there are no regulatory standards that apply directly to contaminants in precipitation, this project provides data that could potentially indicate the presence of radioactive materials that may not be evident in the particulate air samples.

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

2.2.2 PROBLEM STATEMENTS

ORNL and Y-12 are ORR sites with potential for the release of airborne radioactive contaminants. Contaminants released from previous and current operations are a concern. Airborne legacy contaminants could potentially be released from the deterioration of contaminated buildings and the deactivation and decommissioning (D&D) of these facilities.

2.2.3 GOALS

The FY25 goal of the EPA RadNet Precipitation Monitoring Project was to measure radioactive contaminants that were washed out of the atmosphere and reached the Earth's surface through precipitation. DoR-OR participated in this EPA program again in FY25, collecting precipitation samples with results that were used as one indicator of the presence or absence of radiological contaminants that could potentially impact areas near the ORR.

Precipitation monitoring was used as an additional methodology to capture and measure possible radioactive contaminants in the environment. This project also compared sampling

results to a station in Nashville as it is a different sampling location in Tennessee that is not near a DOE site, as well as the EPA drinking water limits (as conservative reference values), to assure the public that human health and the environment are being protected.

2.2.4 SCOPE

In FY25, three precipitation samplers were used to monitor precipitation for radiological contamination. Each sampler was co-located with a TDEC Fugitive Radiological Air station (Chapter 2.1). One sampler was located at the east end of Y-12. At this location, the sampler would potentially indicate if any gamma radioisotopes were moving offsite and towards the City of Oak Ridge. The other two samplers were located at ORNL, with one in Bethel Valley and the other in Melton Valley, where remediation work is focused on radiologically contaminated structures and areas where radiological waste is stored. Samples from all three locations were collected weekly. Station locations are shown in Figure 2.2.4.1. The precipitation samples were composited monthly at the EPA laboratory (NAREL) and analyzed for gamma radionuclides. Additional analyses on individual samples are only conducted in the event of elevated findings in the monthly gamma analysis results or for a nuclear release.

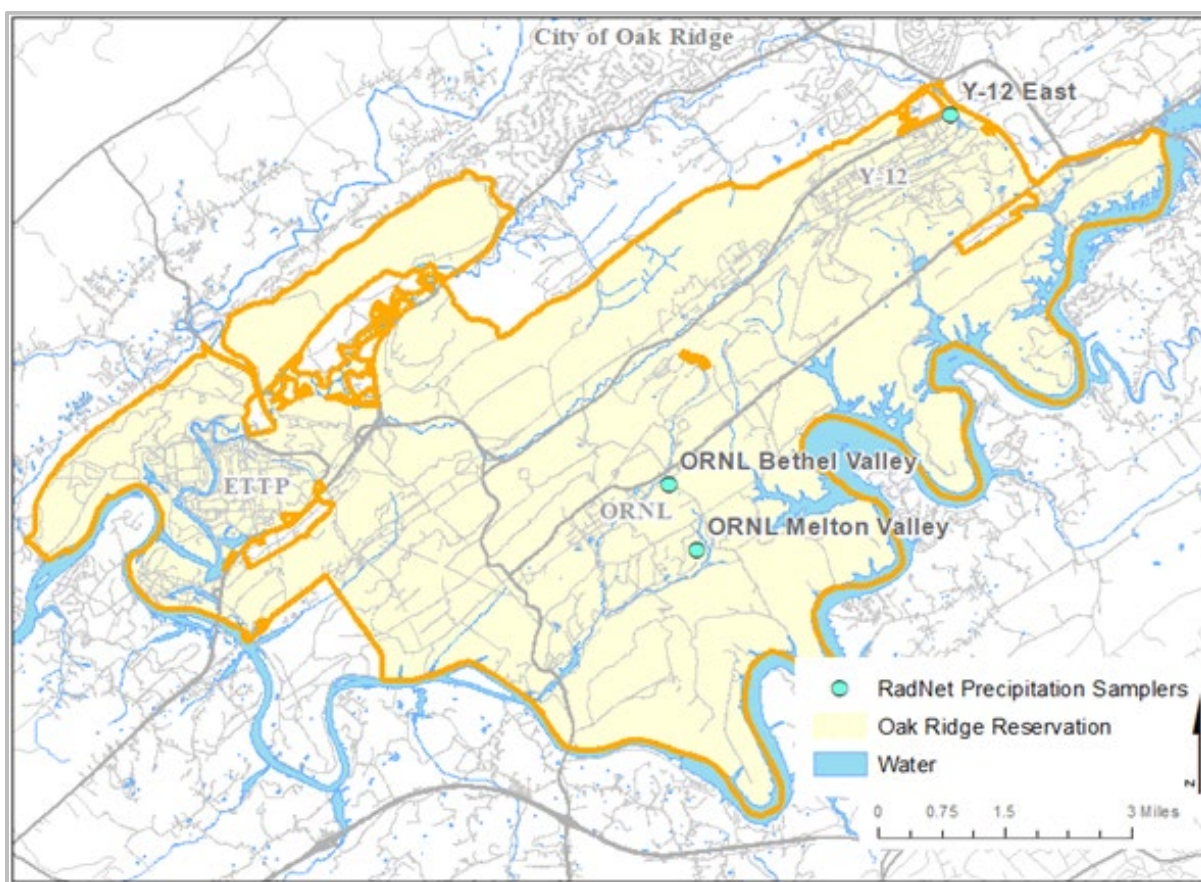


Figure 2.2.4.1: ORR RadNet Precipitation Samplers

2.2.5 METHODS, MATERIALS, METRICS

The three precipitation samplers provided by the EPA RadNet Program were used to collect samples on the ORR. Samples were measured and collected once a week.

Each RadNet Precipitation sampler collected precipitation that falls on a 0.5 square meter fiberglass collector and drained into a five-gallon plastic collection bucket. Each sample was measured in centimeters with a measuring stick, then collected from the bucket into a four-liter container. These containers were then shipped to NAREL for analysis when either (1) at least two liters of precipitation were collected or (2) at the end of the month if a sample volume of less than two liters was collected, as specified by EPA (EPA, 1988; EPA, 2017; TDEC, 2024). Once at NAREL, each station's samples are combined into one composite monthly sample. Analysis for gamma emitting radionuclides was then performed on the composite samples from each of the three stations.

Since no regulatory limits for radiological contaminants in precipitation exist, the results of the DoR-OR ORR sampling gamma analyses were compared to drinking water limits established by the EPA and were used here as conservative reference values. In general, EPA's Radionuclides Rule (EPA, 2000) for drinking water allows for gross alpha levels of up to 15 picocuries per liter (pCi/L), while beta and gamma emitters are limited to four millirem (mrem) per year and are radionuclide specific (EPA, 2015). Since the analysis for this project was for gamma radiation, that is the aspect of the radionuclide rule that was used for comparison here. Table 2.2.5.1 shows the maximum contaminant levels (MCLs) of four gamma emitters that EPA uses as drinking water limits, that had the potential to be detected by EPA's gamma analysis. Not all gamma producing isotopes have EPA drinking water limits, for example Potassium-40 and Radium-228 have none.

Results from RadNet Precipitation Monitoring stations on the ORR can also be compared to other locations in the EPA RadNet Precipitation network, such as Nashville. However, while the stations located on the ORR are in areas near nuclear sources, most of the other stations in the EPA RadNet Precipitation network are located near major population centers, not on DOE sites with major sources of radiological contaminants nearby.

The results of NAREL's analyses are available in the EPA Envirofacts RadNet searchable database, by either a [simple](#) or an [advanced](#) search (EPA, 2025). These data were used to identify anomalies in radiological contaminant levels, to appraise conditions on the ORR as compared to other locations in the RadNet database, and to determine levels of local contamination.

Table 2.2.5.1: EPA Drinking Water Limits (MCLs) for Select Isotopes

Isotope		EPA Limit (pCi/L)
Beryllium-7	Be-7	6,000
Cobalt-60	Co-60	100
Cesium-137	Cs-137	200
Iodine-131	I-131	3

Source: Beta and Photon Emitters in Drinking Water table (EPA, 2015)

2.2.6 DEVIATIONS FROM THE PLAN

The results in this report would normally cover FY25 (July 2024 through June 2025); however, the results were only available through April 2025. Since the May and June 2024 results were not available for the FY24 EMR report, those data are included here, and the monthly composite results from May 2024 through April 2025 are discussed below.

2.2.7 RESULTS AND ANALYSIS

Nationwide RadNet Precipitation sampling results are available via the [RadNet Search](#) webpage (EPA, 2025). The gamma isotopes identified from the ORR precipitation stations for May 2024 through the first four months of 2025, include beryllium-7, cesium-137, cobalt-60, potassium-40, radium-226, and radium-228. The ORR data for this timeframe were within the range of available data seen at the RadNet Precipitation station in Nashville.

Results were less than EPA MDCs (minimum detectable concentrations) for all isotopes except beryllium-7 (Be-7). As stated in the RadNet user guide, the MDCs reflect, *"...the ability of the analytical process to detect the analyte for a given sample. The MDC is the activity concentration for which the analytical process detects the radioactive material in a given sample that provides a 95% chance that the radioactive material will be detected."* (EPA, 2025)

While many of the Be-7 results were higher than MDCs at the ORR sampling locations, Be-7 was not detected during all months at any ORR location. This pattern was similar at Nashville's station. In addition, Be-7 is a naturally occurring cosmogenic radionuclide produced in the upper atmosphere and has a drinking water limit of 6,000 pCi/L. The highest ORR RadNet Be-7 result during this time period was 92 pCi/L, with an average value of 54 pCi/L, which is well below the conservative drinking water limit, and so is not of concern.

2.2.8 CONCLUSIONS

In the absence of regulatory limits for radionuclides in precipitation, EPA's drinking water limits do provide logical and scientific conservative reference values for data comparison. The highest values seen in the composited monthly precipitation samples for the three ORR stations were

well below the EPA Drinking Water MCLs. Only Be-7, had any detections above the associated MDCs, and this isotope is naturally occurring. For May 2024 through April 2025, RadNet Precipitation results for the ORR stations were below detection limits or below the regulatory limits used for drinking water for all analyses and, as such, do not indicate an impact on the environment or public health from ORR emissions.

2.2.9 RECOMMENDATIONS

Continued monitoring of the ORR precipitation for airborne radiological contamination via the ORR *RadNet Precipitation Project* is recommended by DoR-OR. Precipitation monitoring will help ensure that radiological contamination on ORR does not present risk to human health or the environment. This is especially important as the demolition of older buildings continues across the ORR. Ongoing operations also have the potential to impact precipitation contaminant levels. In the event of an emergency either on or off the ORR, this program could provide valuable data relating to the extent of radiological contamination in the air and precipitation before, during, and after an event.

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(Continues on Next Page – Unit 3.0)

3.0 BIOLOGICAL MONITORING

3.1 BENTHIC COMMUNITY HEALTH MONITORING

3.1.1 BACKGROUND

One key indicator of stream health is the biodiversity of macroinvertebrate species associated with the bottom of the stream, or within the benthic zone. The purpose of the FY25 *Benthic Community Health Monitoring Project* was to conduct macroinvertebrate sampling in the four (4) main impacted streams on the ORR. This type of sampling helps evaluate the effects of known contamination on the macroinvertebrate community.

Unimpacted reference streams were also sampled to determine the ideal composition of a healthy benthic community for the Valley and Ridge Ecoregion. The macroinvertebrate community from each impacted stream reach was compared to the communities found in an associated reference stream.

The four (4) main streams sampled are associated with the three (3) ORR campuses:

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

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

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

3.1.2 PROBLEM STATEMENTS

Past studies indicate that most of the ORR macroinvertebrate communities have been negatively impacted. ORR communities are typically less diverse, have fewer sensitive species, and lower Tennessee Macroinvertebrate Index (TMI) scores, compared to healthy communities in unimpacted reference streams (TDEC 2024, DOE 2023). Many of the impacts affecting ORR streams resulted from both historical and current DOE activities. When macroinvertebrate communities change, attempts are made to determine whether the migration of legacy waste, current operations, and/or another variable is responsible for this change. Below are specific

considerations that arise when determining what variables are responsible for the changes.

- 1) Identifying which contaminants had an impact on each sampled community. Contaminants could be from migration of legacy waste (Manhattan project), from current operational effluents and/or spills, or a combination of both.
- 2) Channelization inhibits the establishment of diverse, healthy stream bottom communities by altering the *riffle, run, pool* sequence, reducing the number of preferred habitats, and eliminating stream sinuosity (i.e. curvature). Straightening a stream eliminates its natural bends, which slows stormwater, reduces flooding, and creates in-stream areas of refuge.
- 3) Controlling for inherent, environmental variability (i.e., seasonal changes, year-to-year fluctuations in weather) as much as possible by performing long-term sampling.
- 4) Controlling for the knowledge and experience of the sampler, alleviated with ongoing long-term sampling.
- 5) Necessary sample site location changes due to habitat alterations (i.e., construction of a beaver dam), severe weather events (i.e., flash flooding), or human activities that cause a loss or alteration in habitat.

In addition, DoR-OR sampling produces semi-quantitative data and ORNL's sampling produces quantitative data. Due to this difference, DoR-OR must evaluate qualitative similarities as opposed to direct, quantitative comparisons.

3.1.3 GOALS

The goals for FY25 included the following:

- 1) Assess the benthic macroinvertebrate community health at sites along the four (4) main ORR streams.
- 2) Analyze benthic macroinvertebrate samples for contaminants of concern (COCs) at White Oak Creek (WOC) sites in support of the WOCAP project (Chapter 9.1).
- 3) Identify any changes in biodiversity that may be due to contaminant migration and/or potential releases.
- 4) Draft monitoring recommendations and contaminant impact concerns based on the analysis of macroinvertebrate communities.

3.1.4 SCOPE

Within the four (4) watersheds of the ORR, samples at fifteen (15) impacted sites and three (3)

reference sites were collected during the spring of 2024 (Table 3.1.4.1). Macroinvertebrates were collected for taxonomy following the TDEC Division of Water Resource's SOP (TDEC DWR, 2021). Additional samples were collected from WOC to be analyzed for arsenic, uranium, mercury, tritium, strontium-89, strontium-90, and isotopic gamma emitters. Quality control samples for taxonomy were collected from White Oak Creek kilometer 6.8 (WCK 6.8) and Mill Branch kilometer 1.6 (MBK 1.6).

Table 3.1.4.1: FY25 Benthic Macroinvertebrate Sampling Sites

Site Description	Name	Latitude	Longitude	Sample #
Bear Creek Kilometer 3.3	BCK 3.3	35.943535	-84.349081	1
Bear Creek Kilometer 7.6	BCK 7.6	35.951122	-84.314085	1
North Tributary 5 at Bear Creek	NT5@BCK	35.965400	-84.290400	1
Bear Creek Kilometer 12.3	BCK 12.3	35.973325	-84.277700	1
East Fork Poplar Creek Kilometer 2.2	EFK 2.2	35.951471	-84.372062	1
East Fork Poplar Creek Kilometer 6.3	EFK 6.3	35.966300	-84.351500	1
East Fork Poplar Creek Kilometer 13.8	EFK 13.8	35.992792	-84.315036	1
East Fork Poplar Creek Kilometer 23.4	EFK 23.4	35.995928	-84.240062	1
Mill Branch Kilometer 1.6	MBK 1.6	35.987846	-84.287475	2**
Mitchell Branch Kilometer 0.45	MIK 0.45	35.938088	-84.389625	1
Mitchell Branch Kilometer 1.43	MIK 1.43	35.937840	-84.377470	1
First Creek Kilometer 0.1	FCK 0.1	35.921338	-84.318546	1
Fifth Creek Kilometer 0.2	FFK 0.2	35.927370	-84.314290	1
Melton Branch Kilometer 0.3	MEK 0.3	35.911785	-84.312175	1
White Oak Creek Kilometer 2.9	WCK 2.9	35.914387	-84.316265	2*
White Oak Creek Kilometer 3.4	WCK 3.4	35.917780	-84.316120	2*
White Oak Creek Kilometer 3.9	WCK 3.9	35.924400	-84.315770	2*
White Oak Creek Kilometer 6.8	WCK 6.8	35.940482	-84.300912	3**
Total Sites 18		Total Samples 24		
Legend				
Reference Sites				
DOE Impacted Sites				
*One sample was analyzed for Cs-137 and Sr-90.				
**Additional sample was collected as quality control for species identification.				

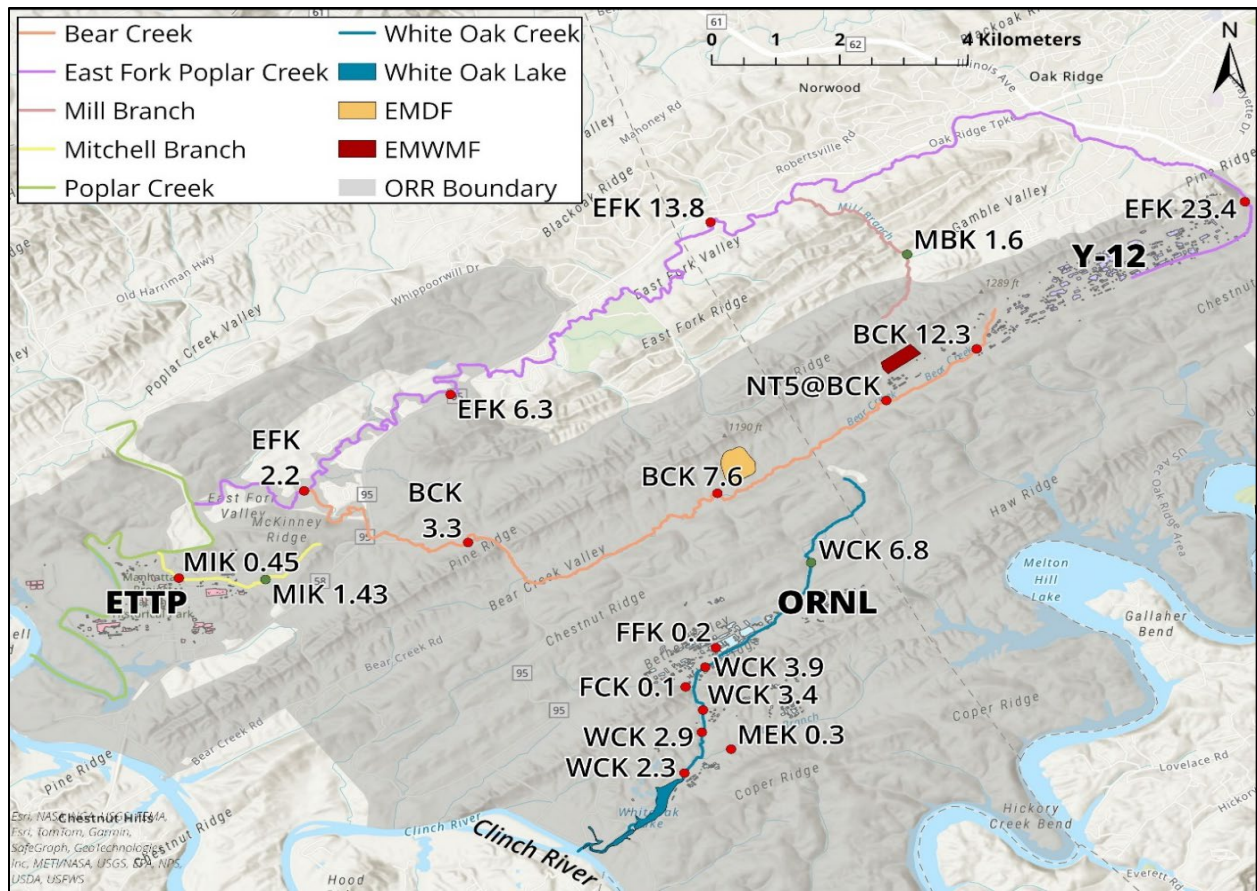


Figure 3.1.4.1: Benthic Macroinvertebrate Sampling Locations

3.1.5 METHODS, MATERIALS, METRICS

Sampling methods for calculation of biometrics followed the TDEC DWR *Standard Operating Procedure for Benthic Macroinvertebrate Sampling* (TDEC DWR, 2021).

MACROINVERTEBRATE COLLECTION FOR IDENTIFICATION

Sampling for this project requires two people at a minimum. One person, standing downstream, set a one-square-meter kick net with a 500-micron mesh across a predetermined riffle section. The other person, using their feet, disturbed approximately 1 m² Area of the streams' substrate directly upstream of that net. The organisms, sediment, and detritus flowed into the net. The net was carefully lifted out of the water and carried horizontally to the streambank. The bottom of the net was positioned in a 500-micron sieve bucket. The net was thoroughly rinsed into the sieve bucket. Organisms still clinging to the net after rinsing were collected and placed into the bucket using forceps. This process was repeated using a second riffle section upstream of the previous sample collection. The two collections were then composited, placed in a plastic container, and preserved with 95% ethanol.

PROCESSING SAMPLES FOR IDENTIFICATION

The processing of benthic samples occurred at the DoR-OR Laboratory. One sample was processed at a time. Efforts were taken to remove rocks, leaves, and other detritus from the sample. The benthic organisms and any remaining detritus were transferred into a numbered tray and evenly distributed. Four random numbers were selected using a random number generator. The corresponding numbers in the tray were then selected as subsamples. The four subsamples were processed using a binocular dissecting microscope to remove benthic macroinvertebrates from the remaining detritus. During sorting of the subsamples, macroinvertebrates were placed into a separate vial with 95% ethanol, and a running count of collected organisms was maintained. If more than 240 macroinvertebrates were counted after processing all four original subsamples, then another subsampling was performed on the macroinvertebrates counted from the original subsamples. During a second subsample, organisms and ethanol were transferred to a petri dish with a grid. Four grids were selected using a random number generator and macroinvertebrates were sorted and again counted. If the second sorting produced less than ~160 individuals, additional grid numbers were randomly selected and counted. Grid numbers were selected until the required number, between 160 and 240, of macroinvertebrates were collected. Typically, more than four grids were needed to achieve the desired number of organisms in the second subsample. Once sorting and subsampling of all samples was completed, macroinvertebrates without the potential for radiological contamination were sent to Third Rock Consultants to be identified. Macroinvertebrates with potential for radiological contamination were sent to a laboratory with the appropriate radiological license, CG Services. Macroinvertebrates were identified to genus-level when possible.

MACROINVERTEBRATE COLLECTION AND PROCESSING FOR CONTAMINANT ANALYSIS

Additional macroinvertebrate samples were collected from WOC sites using a Surber sampler. The sampler was placed in the stream at three different riffle locations within the same site. Sediment above the sampler was disturbed and macroinvertebrates and detritus flowed into the sampler. All the macroinvertebrates and detritus collected at the site were placed into a plastic bag and put in a cooler, on ice. This type of sampling was performed at all WOC and WOC tributary sites. Back at the DoR-OR laboratory, samples were frozen. Macroinvertebrates were separated from the detritus and sent to Eberline for radiological contaminants' analysis. At each WOC site there was a sample analyzed for radiological contamination. WOC tributary sites were not analyzed (see section 3.1.6).

DATA ANALYSIS

After receiving the identification results, these data were transcribed into the Division of Water Resources (DWR) macroinvertebrate template and the DoR-OR's database template. Data were sent to DWR and were also uploaded to DoR-OR's TOReis, an internal data repository. DWR

calculated various biometrics and scored them to produce final TMI scores for each site. A description of the biometrics that are calculated and expected responses to environmental stressors are listed in Table 3.1.5.1.

A numerical score was calculated for each individual biometric. Those scores were used to determine the TMI score. A TMI score of 32 to 42 meets all bio-criteria for a healthy benthic macroinvertebrate community with no impairment to the system. A TMI score below 32 falls below bio-criteria guidelines and indicates macroinvertebrate community impairment. TMI scores for impacted sites were compared to the unimpacted reference sites. Further information about sampling procedures and biometric calculations can be found in the *Quality System SOP for Macroinvertebrate Stream Surveys* published by DWR (TDEC DWR, 2021).

Table 3.1.5.1 Biometrics Used to Calculate TMI Score

<i>Description of Biometrics and Expected Responses to Stressors</i>			
Category	Biometric	Description	Response to Stress
Richness	Taxa Richness	Measures overall diversity of the macroinvertebrate assemblage	Number Decreases
	EPT Richness	Number of taxa in the orders <i>Ephemeroptera</i> , <i>Plecoptera</i> , and <i>Trichoptera</i>	Number Decreases
Composition	% EPT-Cheum	% of EPT abundance excluding <i>Cheumatopsyche</i> taxa	% Decreases
	% OC	% of <i>Oligochaetes</i> and Chironomids present	% Increases
Tolerance	North Carolina Biota Index (NCBI)	Incorporates richness and abundance with a numerical rating of tolerance	Number Increases
	% TNuTol	% of Total Nutrient Tolerant organisms, those with NCBI scores > 3.0	% Increases
Habitat	%Clingers	% of organisms with fixed retreats or attach themselves to substrate	% Decreases

3.1.6 DEVIATIONS FROM THE PLAN

There were two samples collected from FFK 0.2, FCK 0.1, and MEK 0.3. One sample was collected for identification, and one was collected for COC analysis. The sample collected for COC analysis was not processed and analyzed due to time restraints. Instead, samples were collected from the sites in spring of 2025 and sent to the lab for analysis. The lab results have not been received, as of the date of this report.

Due to a beaver dam on White Oak Creek, WCK 2.3 could not be sampled. Instead WCK 2.9, a site further upstream, was sampled.

Samples collected from WCK 6.8, WCK 3.9, WCK 3.4, and WCK 2.9 were proposed to be analyzed for arsenic, uranium, mercury, tritium, strontium-89, strontium-90, and isotopic gamma emitters. There was not enough biomass to run all the analyses, so samples were only analyzed for strontium-90 and cesium-137, the most common COCs known to be found at WOC.

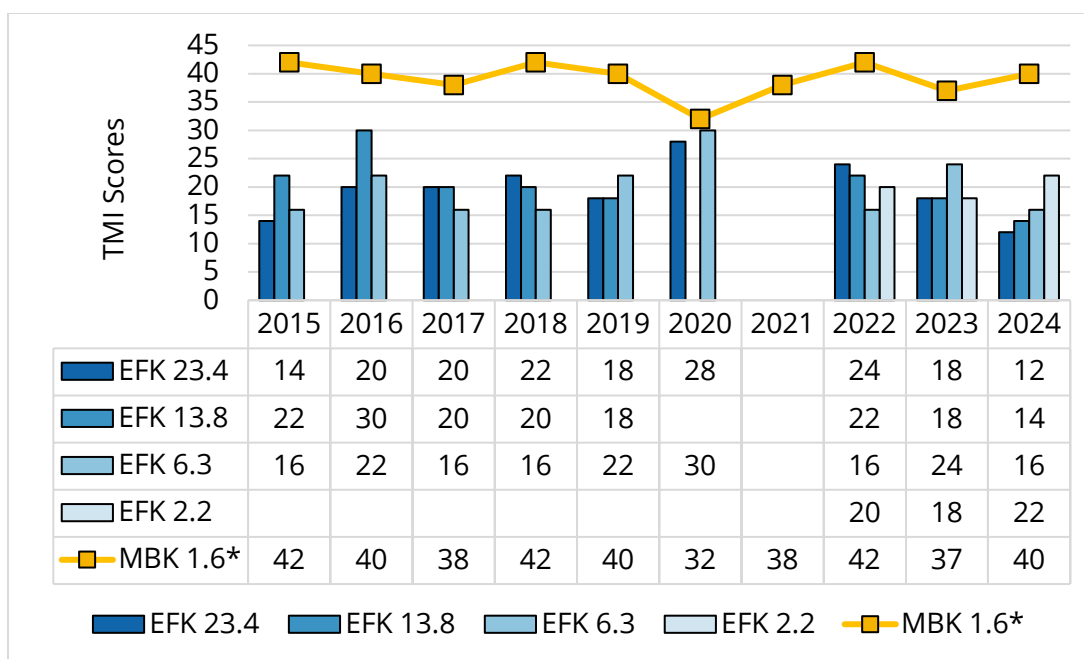
3.1.7 RESULTS AND ANALYSIS

Small year-to-year variations in TMI scores can be attributed to a multitude of factors including, but not limited to, the following:

- 1) Climate fluctuations with increased extremes in temperatures.
- 2) Dry seasons cause low water levels various times of the year.
- 3) Extreme weather events, especially heavy rains, and flooding on days prior to sampling events.

EAST FORK POPLAR CREEK (EFPC)

The headwaters of EFPC originate from tributaries that flow through the main industrialized portion of Y-12. At its headwaters, EFPC receives inputs of contaminants such as mercury, uranium, volatile organic compounds (VOCs), and other metals and organics. Once offsite, EFPC receives further contaminant loading from municipal Oak Ridge as it flows downstream through urbanized and suburbanized areas. Additionally, site EFK 13.8 is located just upstream of a sewage treatment facility. Downstream portions of EFPC after site EFK 6.3 are relatively undisturbed before reaching its confluence with Poplar Creek. Construction has begun on the Triso-X facility near EFK 3.1. The construction has caused increased turbidity in EFPC at EFK 3.1 and the downstream reaches.



*2016 & 2017 MBK 1.6 samples were collected from Clear Creek kilometer 1.6. Blank spaces represent no data.

Figure 3.1.7.1 EFPC Historical and Current TMI Scores (2015-2024)

TMI scores for all EFPC sites have been below the biocriteria guideline of 32 for the past ten years (Figure 3.1.7.1). Additionally, all EFPC sites have lower TMI scores than the reference site (MBK 1.6). In 2024, EFK 2.2 had the highest TMI score of all the EFPC sites. All the other EFPC sites had similar scores to those observed in previous years. All EFPC sites scored lower than their respective 10-year averages, except EFK 2.2 (limited data). Increased sedimentation in the stream could be one reason for the lower TMI scores observed in 2024. Rain and flooding events have increased the amount of sediment in the stream, filling in interstitial spaces thus limiting macroinvertebrate habitat.

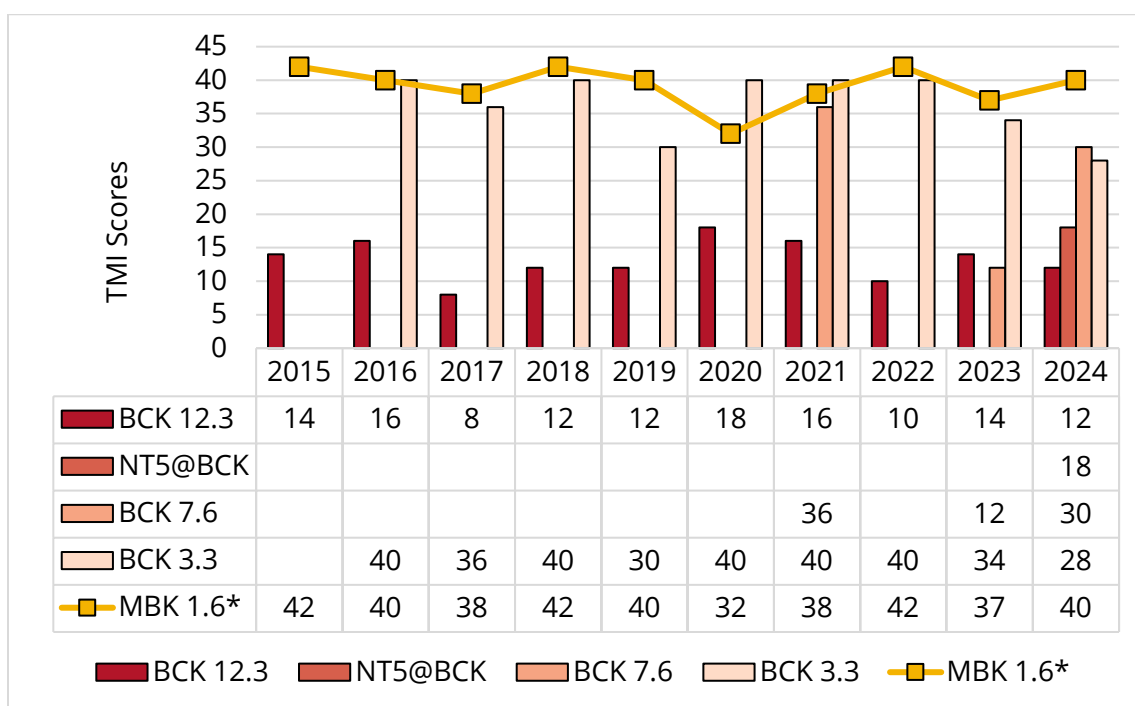
The individual calculated biometrics for each EFPC site in 2024 can be found in Table 3.1.7.1. Each of these metrics were given a score and were composited to yield the TMI score.

Table 3.1.7.1 East Fork Poplar Creek Macroinvertebrate Biometrics in 2025

Biometrics	EFK 23.4	EFK 13.8	EFK 6.3	EFK 2.2	MBK 1.6
Taxa Richness	16	19	20	29	28
EPT Richness	2	4	5	7	13
%EPT-Cheum	0.4	4	11.5	17.1	50.5
%OC	84.5	58	56.2	49	10
NCBI	7.51	5.95	5.65	5.74	2.74
%Clingers-Cheum	62.3	27.6	27.7	32.9	66.2
%TNuTol	57.5	59.6	38.3	41.4	5.7

BEAR CREEK (BC)

BC is a small to moderate-sized stream whose headwaters originate at the west end of Y-12. Historically, pollutants from industrial activities, as well as waste disposal activities at Y-12, were released into BC. Former waste disposal sites, such as the S3 ponds (at its headwaters), continue to negatively impact the water quality of the stream. Downstream from Y-12, BC continues to be impacted by inputs from legacy and active waste disposal sites, like the EMWMF Landfill and Bear Creek Burial Grounds. BC is also a stream where shallow groundwater, and surface waters mingle freely throughout its length to its confluence with EFPC. In August 2023, construction started on the Environmental Management Disposal Facility (EMDF) just upstream of BCK 7.6.



**2016 & 2017 MBK 1.6 samples were collected from Clear Creek kilometer 1.6. Blank spaces represent no data.*

Figure 3.1.7.2 Bear Creek Historical and Current TMI Scores (2015-2024)

In 2024, BCK 12.3 scored the lowest of all the Bear Creek sites (Figure 3.1.7.2). Bear Creek is very narrow at this site and has little flow most of the year. BCK 12.3 does not have good macroinvertebrate habitat available and is impacted by Y-12 activities upstream. This was the first year TDEC DoR-OR sampled the North Tributary 5 at the Bear Creek confluence (NT5@BCK). North Tributary-5 receives direct input from the EMWMF, a low-level mixed waste disposal facility (Figure 3.1.4.1). NT5@BCK has decent macroinvertebrate habitat available but receives sediment and discharges of contaminants like uranium from the EMWMF. These two factors are most likely negatively impacting the macroinvertebrate community at this site. The TMI score increased 18 points at BCK 7.6 from 2023 to 2024 for reasons unknown. All the Bear

Creek sites scored below biocriteria guidelines (TMI $\geq$ 32) and below the reference site (MBK 1.6) in 2024.

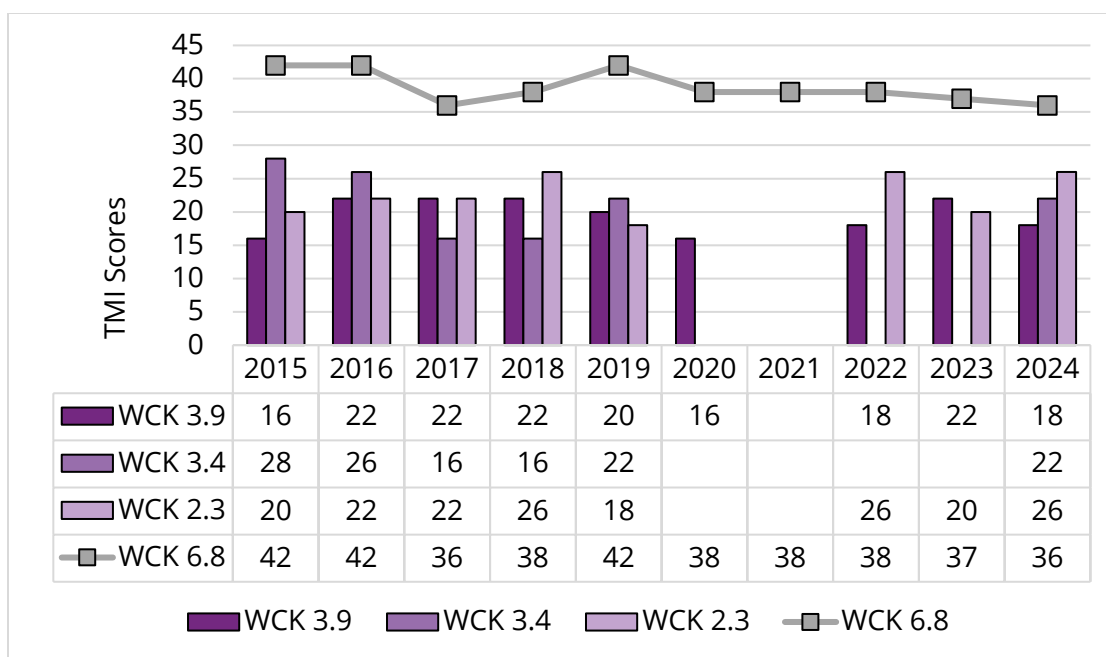
The individually calculated biometrics for each BC site in 2024 can be found in Table 3.1.7.2. Each of these metrics were given a score and were composited to yield the TMI score.

Table 3.1.7.2 Bear Creek Macroinvertebrate Biometrics 2024

Biometric	BCK 12.3	NT5@BCK	BCK 7.6	BCK 3.3	MBK 1.6
Taxa Richness	13	21	28	22	28
EPT Richness	1	5	11	7	13
%EPT-Cheum	1.3	7.8	23.2	26.2	50.5
%OC	10.2	1	12.7	9.6	10
NCBI	6.64	6.01	4.67	4.23	2.74
%Clingers-Cheum	21.7	30.2	50.3	43.3	66.2
%TNuTol	86.7	72.7	44.2	40.6	5.7

WHITE OAK CREEK (WOC)

WOC is the main drainage for the majority of ORNL's contaminated areas. The stream flows near the Spallation Neutron Source, then through the main plant area of ORNL in Bethel Valley, and finally into the Melton Valley watershed. In Melton Valley, WOC flows through Solid Waste Storage Areas (SWSAs) and then empties into White Oak Lake (WOL). Water from WOL exits the reservation through White Oak Creek Embayment (WOE) into the Clinch River. WCK 3.9 is located on the south side of ORNL and downstream of Fifth Creek. This tributary receives inputs from a large portion of ORNL's main campus. WCK 3.9 is also downstream of a radiological wastewater treatment facility. WCK 2.9 is located near the mouth of WOL and just after SWSAs. The main COCs of WOC and WOL are radionuclides such as, cesium-137 and strontium-90.



**2020 & 2021 WCK 6.8 samples were collected during the fall by ORNL following the TDEC DWR protocol. In 2024, WCK 2.9 was sampled instead of WCK 2.3. Blank spaces represent no data.*

Figure 3.1.7.3 White Oak Creek (WOC) Historical and Current TMI Scores (2015-2024)

Figure 3.1.7.3 White Oak Creek (WOC) Historical and Current TMI Scores (2015-2024)

In 2024, all WOC sites' TMI scores were similar to scores observed in previous years. Additionally, all WOC impacted sites remain well below the threshold for passing all biocriteria guidelines (TMI $\geq$ 32). The reference site, WCK 6.8, is still passing all biocriteria guidelines and provides a good comparison for impacted WOC sites.

The individual calculated biometrics for each WOC site in 2024 can be found in Table 3.1.7.3. Each of these metrics were given a score and were composited to yield the TMI score.

Table 3.1.7.3 White Oak Creek Macroinvertebrate Biometrics in 2024

Biometric	WCK 3.9	WCK 3.4	WCK 2.9	WCK 6.8
Taxa Richness	29	24	24	27
EPT Richness	4	5	6	10
%EPT-Cheum	14.2	13	31.1	49
%OC	45	27.6	21.9	8
NCBI	5.21	5.41	5.48	3.31
%Clingers-Cheum	13.8	22.9	32.2	67.7
%TNuTol	36.2	49.5	38.8	16.7

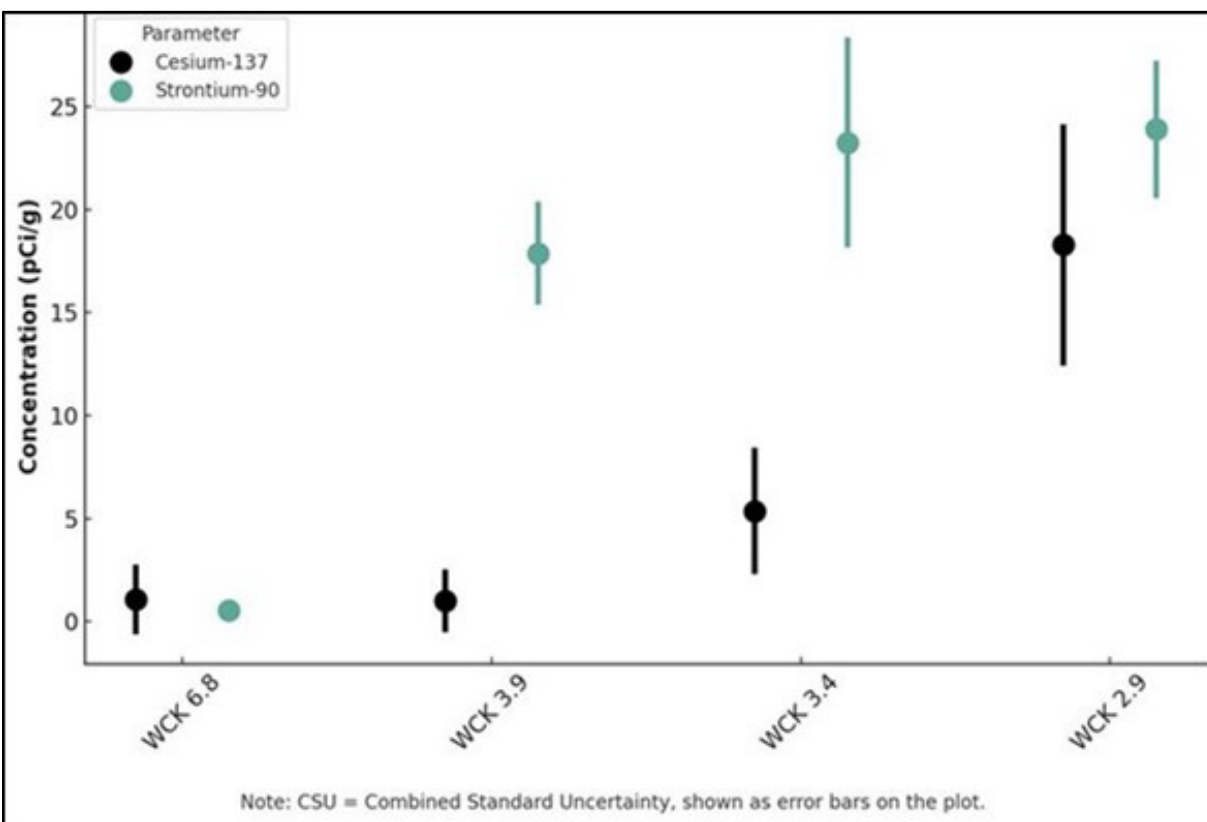


Figure 3.1.7.4: WOC Macroinvertebrates Cs-137 and Sr-90 Conc. (Spring 2024)

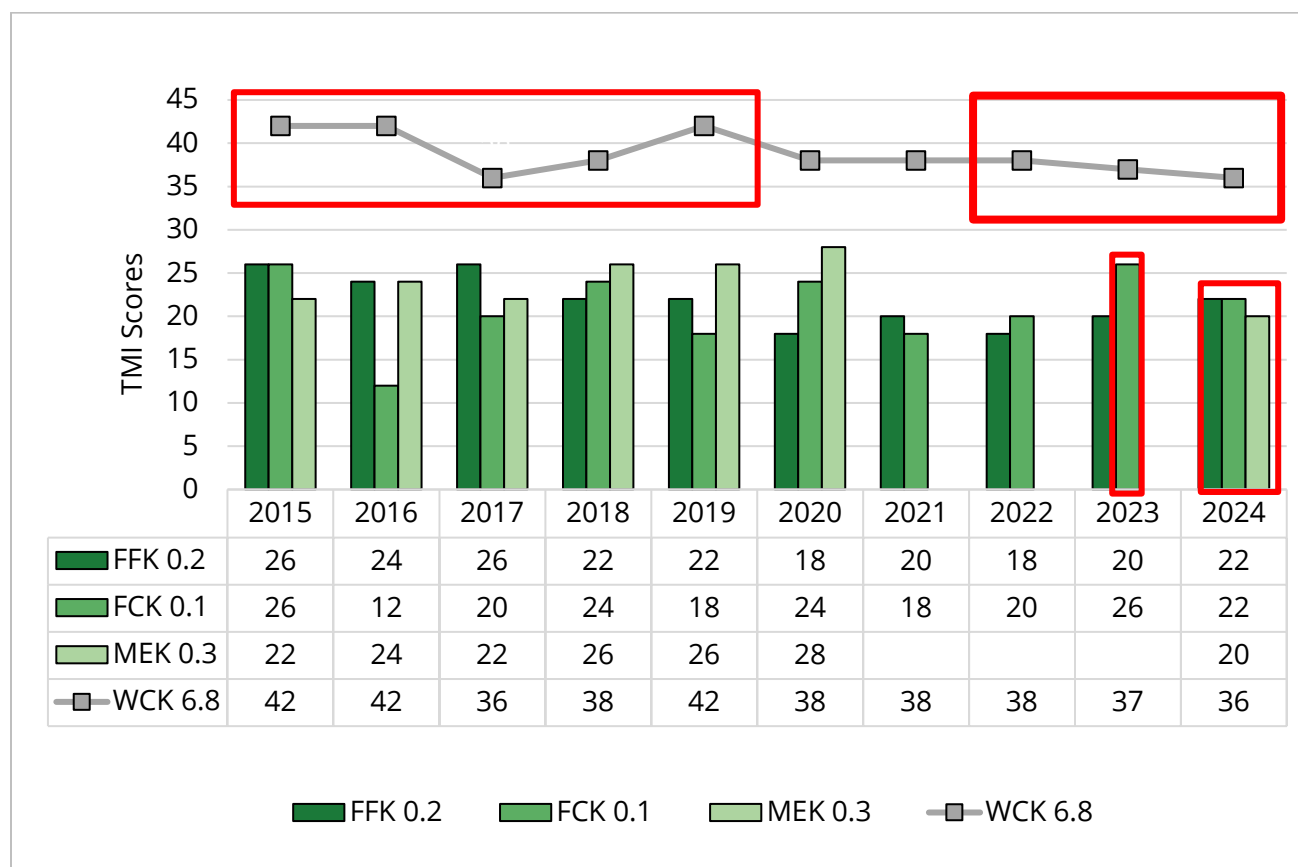
Table 3.1.7.4: WOC Macroinvertebrates Cs-137 and Sr-90 Conc.

	Site	Sr-90	Cs-137
Spring 2024	WCK 6.8	0.544 ± 0.483	1.083 ± 1.693
	WCK 3.9	17.872 ± 2.506	1.023 ± 1.523
	WCK 3.4	23.246 ± 5.095	5.371 ± 3.061
	WCK 2.9	23.888 ± 3.332	18.295 ± 5.857
*Red numbers are detections.			

Macroinvertebrate samples were collected for contaminant analysis at WOC sites. There was not enough biomass to perform all the planned analyses, but there was sufficient biomass to analyze Strontium-90 and Cesium-137 concentrations. The reference site (WCK 6.8) had non-detects for both radionuclides. Additionally, WCK 3.9 was a non-detect for Cs-137. Cs-137 concentrations were higher than the reference site at WCK 3.4 and WCK 2.9. All samples were below eco-risk levels for Sr-90 and Cs-137 in sediment and surface water (ORNL RAIS, 2025). However, there is an increasing trend in both Cs-137 and Sr-90 concentrations between upstream and downstream sites.

White Oak Creek Tributaries

In 2024, samples were collected from White Oak Creek tributaries to support the goals of the White Oak Creek Holistic Watershed Project (WOCAP, Chapter 9.1. Sites were selected just above the confluence points of Fifth Creek, First Creek, and Melton Branch with WOC. These samples help determine if any of the tributaries have an impact on those sites in WOC located just below the confluence points with the tributaries. Melton Branch has been historically contaminated with strontium-90 and tritium (Tucci, 1992). Both Fifth Creek and First Creek receive inputs from ORNL's main campus.



**Red boxes indicate samples collected by TDEC DoR-OR. Samples outside the boxes were collected in the fall by ORNL following the TDEC DWR protocol. Blank spaces represent no data.*

3.1.7.5: ORNL & TDEC – White Oak Creek TMI Scores (2015-2024)

From 2015 to 2022, Fifth Creek kilometer 0.2 (FFK 0.2) and First Creek kilometer 0.1 (FCK 0.1) samples were collected in the fall by ORNL following TDEC DWR protocol. Additionally, WCK 6.8 (2020 and 2021) and FFK 0.2 (2023) samples were also collected by ORNL in the fall, following the TDEC DWR protocol. In 2024, WOC tributary sites did not pass biocriteria guidelines ($TMI \leq 32$). Melton Branch kilometer (MEK 0.3) decreased eight points to the lowest score observed in the past 10-year span. None of the tributaries scored as high as the reference site (WCK 6.8). None of the tributary sites are passing biocriteria guidelines and all scored well-

bellow the reference site (WCK 6.8).

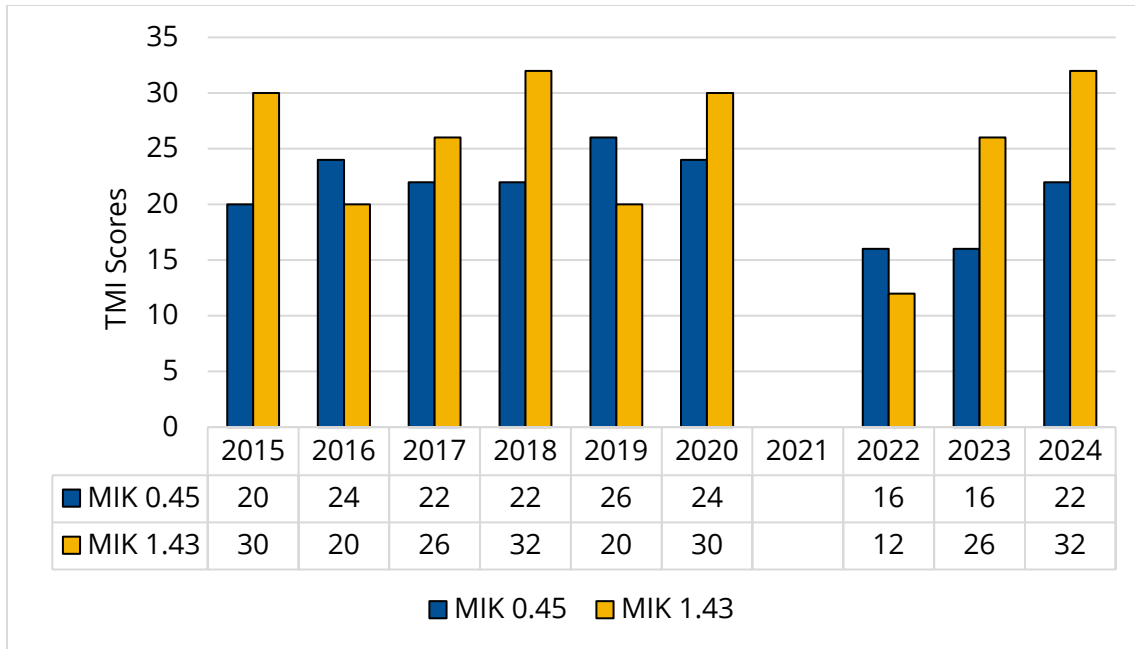
The individual calculated biometrics for each WOC tributary site and WCK 6.8 (for comparison) in 2024 can be found in Table 3.1.7.5. Each of these metrics were given a score and were composited to yield the TMI score.

Table 3.1.7.5 WOC Tributary Macroinvertebrate Biometrics

2024 Biometrics	FCK 0.1	FFK 0.2	MEK 0.3	WCK 6.8
Taxa Richness	23	29	23	27
EPT Richness	9	8	7	10
%EPT-Cheum	8.2	6.7	6.7	49
%OC	25.6	42	18.7	8
NCBI	5.32	5.05	5.4	3.31
%Clingers-Cheum	19.2	28.2	25.4	67.7
%TNuTol	59.4	34	57.5	16.7

MITCHELL BRANCH

Mitchell Branch is a small headwater tributary to Poplar Creek at ETP. The highest upstream station, which serves as the reference station (MIK 1.43), does not meet the criteria to be a reference station, according to the bioregion concept. Due to the small size of the watershed above MIK 1.43 (< two square miles). Because of the small upstream watershed and variable flow conditions depending on annual rainfall, MIK 1.43 does not always provide a clear picture of the impacted condition of the downstream station (MIK 0.45). Historically, MIK 1.43 has been relatively unimpacted by the presence of ETP. The lower station, MIK 0.45, has been impacted not only by former industrial activities at ETP and waste areas, but also channelization, with much of the channel being replaced with unnatural substrate. Over time, the substrate (stream bottom) is becoming more natural, allowing a more diverse community to inhabit those stations. Further improvements in substrate, as well as water quality improvements due to remediation activities, will allow Mitchell Branch to continue to improve.



*MIK 1.16 was sampled in 2023 instead of MIK 1.43. Blank spaces represent no data.

Figure 3.1.7.6 Mitchell Branch Historical and Current TMI Scores (2015-2024)

Figure 3.1.7.6: MIK Historical & Current TMI Scores (2015-2024)

The TMI score for MIK 1.43 has been increasing since 2022. In 2024, MIK 1.43 scored 32, passing all biocriteria guidelines, indicating the macroinvertebrate community is healthy at the site. MIK 0.45 continues to show impairment to the macroinvertebrate community, but in 2024 the TMI score increased by six points. Monitoring should continue at this site to see if the improvement continues. In 2024, soil excavation was still occurring at ETP, and some of that excavation was performed just upstream of MIK 0.45. As clean-up work ends at ETP, scores should continue to increase at MIK 0.45 as stream conditions stabilize.

The individual calculated biometrics for each MIK site in 2024 can be found in Table 3.1.7.6. Each of these metrics were given a score and were composited to yield the TMI score.

Table 3.1.7.6: MIK Macroinvertebrate Biometrics

2024 Biometrics	MIK 0.45	MIK 1.43
Taxa Richness	28	26
EPT Richness	5	10
%EPT-Cheum	10.1	49
%OC	40.4	15.7
NCBI	5.82	3.96
%Clingers-Cheum	36	34.3
%TNuTol	44.4	33.8

3.1.8 CONCLUSIONS

The health of the benthic macroinvertebrate communities in ORR streams has improved since the 1980s. The improvement has remained somewhat consistent for the past decade. In 2024, some impacted sites saw a decrease in TMI scores from previous sampling years, but a few impacted sites were comparable to previous years or improved.

EFPC sites have scored substantially lower than reference sites consistently over the years. Lower scores are potentially the result of human alterations.

- 1) Channelization at the headwaters of EFPC reduced ideal stream habitats.
- 2) Water temperatures are typically higher at EFPC sites than at reference sites.
- 3) EFPC receives substantial inputs of mercury from Y-12 facilities.

BC sites closer to Y-12 (BCK 12.3 and 7.6) have lower TMI scores than sites further away from Y-12 (BCK 3.3). Lower scores at upstream sites are potentially the result of the following:

- 1) Limited water in the stream during the dry season reduces the potential for contaminant dilution.
- 2) Higher contaminant concentrations at sites closer to Y-12 facilities.
- 3) Reduction in available habitat closer to Y-12.

In 2024, Bear Creek and East Fork Poplar Creek had the lowest TMI scores (BCK 12.3 and EFK 23.4) out of all the ORR sites sampled in 2024. BCK 3.3 fell below biocriteria guidelines for 2024, but still had the highest TMI score of all the impacted ORR sites (Figure 3.1.7.2).

The ORNL streams, White Oak Creek, Fifth Creek, First Creek, and Melton Branch have been relatively static over the past decade, with only slight variations from year-to-year. WOC and its tributary sites score well below bio-criteria guidelines and below the corresponding reference site (WCK 6.8). Since all streams only receive inputs from ORNL, it is most likely the ORNL activities have an impact on the macroinvertebrate communities, causing lower TMI scores. Strontium-90 and Cesium-137 concentrations were analyzed at WOC sites in spring of 2024. Concentrations of Cs-137 and Sr-90 were both below eco-risk screening values for sediment and surface water (ORNL RAIS, 2025). Concentrations of Cs-137 were higher than the reference site at WCK 3.4 and WCK 2.9. There are increasing trends of Sr-90 and Cs-137 concentrations moving from upstream to downstream sites, but there was only one sample analyzed for each site. More data should be collected before drawing any conclusions.

The ETPP stream, Mitchell Branch, had increases in TMI scores for the reference site (MIK 1.43) and the impacted site (MIK 0.45). One reason for the increase in TMI score at MIK 0.45 could be

due to the completion of soil excavation activities taking place near the site. An increase in sedimentation and turbidity in streams can have negative effects on macroinvertebrate communities. Since activities were completed, less sediment has been entering the stream.

3.1.9 RECOMMENDATIONS

Benthic macroinvertebrate communities should continue to be monitored yearly, generally at an upstream and downstream location for each watershed, to verify DOE's interpretation of stream health following their benthic macroinvertebrate monitoring program across the ORR. DoR-OR will compare DOE's data (collected using the TDEC semi-quantitative protocol) to DoR-OR's monitoring efforts and calculated TDEC metrics. This ongoing long-term sampling will help to adjust for differences in sampler experience and additional environmental variables (i.e., temperature increases, dry seasons, flooding events, etc.). TMI scores that are higher than previous years serve to verify that DOE remedial efforts are having a positive effect on those communities. Other areas, with lower TMI scores, are possibly more impacted and may take more time to be effectively remediated. Finally, more macroinvertebrate samples from WOC should be analyzed for Cs-137, Sr-90, and other COCs to see if there are any conclusions that can be drawn from the data.

3.1.10 REFERENCES

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3.2 ROVING CREEL SURVEY

3.2.1 BACKGROUND

The three main ORR streams, White Oak Creek (WOC), Bear Creek (BC), and East Fork Poplar Creek (EFPC) are impacted by both historical and ongoing DOE activities. These streams either directly or indirectly empty into the Clinch River (CR). Grassy Creek (GC) is a stream with headwaters in Bear Creek Valley that also empties into the Clinch River (CR). The confluence zone of GC with CR is located directly across the river from a frequently used public boat ramp. Past detections of cesium-137 (Cs-137) at the GC-CR confluence prompted the inclusion of this confluence point as another zone (Zone 4). These four areas contain contaminants of concern (COCs) that have been shown to bioaccumulate in fish tissue (Stahl et al, 2008). Since these streams discharge into publicly accessible waters (Clinch River and Poplar Creek), fish consumption is a likely pathway for human exposure to COCs. *The Roving Creel Survey* (RCS) is an ongoing project that measures angling effort on waterways just outside the ORR boundaries. Measuring angling effort provides more quantitative information on potential human exposure.

BC and EFPC originate within the confines of the Y-12. Both streams are fed by springs and numerous outfalls from the Y-12 National Security Complex. Uranium (U) in BC and mercury (Hg) in EFPC are the main COCs in these streams. Considering the risk posed by these two COCs on human and environmental health, it's important to monitor fishing and recreational activities in the lower reaches of BC and EFPC that are publicly accessible.

The North Boundary Greenway (NBG) is a popular recreation attraction for Oak Ridge citizens and parallels stretches of both BC and EFPC. Based on previously submitted surveys, fishing occurs in both BC and EFPC.

White Oak Creek (WOC) originates just north of ORNL and eventually empties into the Clinch River (CR) via White Oak Lake (WOL). Radionuclides released from ORNL to WOC are a result of leaks from ponds and waste disposal areas and include contaminants such as strontium-90 (Sr-90) and cesium-137 (Cs-137), as well as other byproducts from nuclear and industrial activities (DOE, 1988). These 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).

In 2020, Cs-137 was detected at 15 pCi/g in a sediment sample taken in the Clinch River near the mouth of Grassy Creek (OREIS, 2024). Additionally, there were multiple detections of Cs-137 in and around the K-1515 Water Treatment Plant, specifically the K-1515-F Lagoon that is next to the Clinch River (DOE, 2007). The availability of Cs-137 for biological uptake is a public health concern, as it can be transferred to humans through food webs. 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 (Rowan DJ, 1994; Sakai MT et al, 2016). The RCS project monitors angler activity where WOL discharges into the Clinch River (the WOL-CR confluence) and where Grassy Creek discharges into the Clinch River (the GC-CR confluence).

Measuring fish tissue concentrations is an important step to connecting known concentrations of COCs in fish and potential human exposure through angler surveys. In addition to surveys, FY25 included a corresponding collection of fish tissue samples from the study zones (excluding Zone 4, to be performed in FY26). These are areas with high angler activity, determined from previously collected survey data. Analysis for COCs were performed on fish species that are popular among anglers in the study areas.

3.2.2 PROBLEMS STATEMENTS

- 1) Bioaccumulation: Fish have been shown to bioaccumulate mercury and other contaminants (Murphy, 2004). If contaminated, ingestion of these fish could harm people and other piscivores.
- 2) Warning Signage: In the past, fish consumption warning signs and postings have not been visible, legible, or they have been missing entirely. Additionally, residents who have fished these waters for many years may disregard warnings.
- 3) Human Exposure: Previous surveys suggest that recreational use of the resources surrounding the ORR is common, but the extent of human engagement with these resources is not fully understood.
- 4) DOE does not monitor angling effort in areas of concern, leaving a gap in knowledge about exposure pathways after leaving the ORR.
- 5) Fish species that are caught for consumption are not typically sampled for COC analysis.

3.2.3 GOALS

The goals for this project in FY25 were as follows:

- 1) Quantify the angling effort at six key locations just outside ORR boundaries (EFPC and BC along the NBG, confluence points of EFPC-PC, PC-CR, WOL-CR, and GC-CR).
- 2) Determine if recreational fishing adjacent to the ORR is a significant pathway for human exposure to contaminants.
- 3) Provide data that is pertinent to CERCLA requirements and future ORR decisions regarding human health and environmental protection.
- 4) Document the amount of human recreational activity in the lower reaches of BC and EFPC

within the North Boundary Greenway.

- 5) Analyze the levels of specific COCs in fish tissue collected from areas with high angling activity.

3.2.4 SCOPE

Roving Creel Surveys (RCSs) were conducted along portions of the Clinch River (CR) and Poplar Creek (PC). Attempts to interview every angler observed along the entire route were made; however, angling effort was only calculated for the survey zones of interest. These survey zones are the following confluence areas; (1) WOL-CR, (2) PC-CR, (3) EFPC-PC, (4) GC-CR. Additionally, a survey box at the Gallaher boat ramp passively collected digital and paper surveys (Figure 3.2.4.1). Attempts to complete RCSs were conducted five times per quarter. Survey boxes are also stationed at different points along the NBG to passively collect digital and paper surveys from recreators using the greenway (Figure 3.2.4.1).

Fish were collected from Zones 1, 2, 3 and the reference site (Clinch River kilometer 69.8). Analysis for COCs were performed on fish species that are popular among anglers in the study areas.

(Continues on Next Page - Figure 3.2.4.1.)



3.2.5 METHODS, MATERIALS, METRICS

ANGLER SURVEYS

DoR-OR staff conducted angler interviews at and between the four study zones (Figure 3.2.4.1). Angler interviews use active, on-site methods whereby anglers are interviewed before, during, or immediately after fishing trips. Methods are outlined in the standard operating procedure, *Roving Creel Survey – Angler Interviews* (TDEC, 2024). Additionally, angler information is collected, voluntarily, via digital surveys using Survey123 and/or paper surveys posted year-round at the Gallaher Boat Ramp. The survey information collected is listed below.

OBSERVABLE DATA COLLECTED FROM ANGLERS INCLUDES:

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

ANGLER REPORTED DATA INCLUDES:

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

NBG RECREATOR SURVEYS

Recreational activities along the NBG are monitored using drop boxes with paper surveys and digital surveys accessible via QR codes posted on boxes. Surveys are available year-round to recreators posted at the three locations on Figure 3.2.4.1.

RECREATOR REPORTED DATA INCLUDES:

1. Date/Time
2. Recreation activity – hiking, biking, fishing, kayaking...etc.
3. Number of people at the party
4. County and State residence
5. Total amount of time spent recreating for that trip
6. Estimate of time spent fishing per month along the NBG (days/month)
7. Target species of fish

8. Consumption of fish harvested from areas of concern
9. Provision of fish to sensitive populations (i.e., pregnant women, nursing mothers, or children) for consumption
10. Knowledge of posted signage in these areas of concern

FISH TISSUE ANALYSIS

Fish for tissue analysis were collected via boat electro-shocker. Fish species that are commonly targeted by anglers for consumption were analyzed for COCs. Captured fish were sent to a contracted laboratory for analysis of specific COCs in each zone. A total of five fish were harvested and analyzed from each zone and the reference site (CRK 69.8). Fish tissue concentrations are compared to relevant Ambient Water Quality Criteria (AWQC) or other regulatory limits where appropriate. The various analyses performed are in Table 3.2.5.1. Not all analyses are performed in each zone, only the contaminants of concern for each zone. The reference site had all analyses performed for comparison to study zones.

Table 3.2.5.1: Fish Tissue Analyses and Methods

Analytes	Laboratory Method
Strontium (metal)	EPA 6020
Chromium	EPA 6020
Low-level mercury	EPA 1631
Methylmercury	EPA 1630
Gamma Spectroscopy	EPA 901.1 Modified
Strontium-89/90	EPA 905.0
PCBs	EPA 8082

FISHING EFFORT FOR ANGLER INTERVIEWS

Estimates of fishing efforts for a given fiscal year quarter were calculated using TWRA's method (TWRA, 1992):

$$e = c(h)$$

fishing effort = total party size (number of hours reported)

where fishing effort or total hours per interview (e) was calculated as the product of the total party size (c) and the number of hours reported (h). Each interview's total hours (e) were then added together for each quarter in each zone.

All RCSs were performed during the morning half of the day. Each survey event encompassed the same four zones. Following TWRA's methodologies to calculate full-day angler hours, it was assumed that morning and evening angler counts are roughly equal and provide an adequate approximation of fishing activity over the course of a whole day. Thus, total hours (e) were

multiplied by two to give full-day angler hours per day (f):

$$f = e(2)$$
$$\text{full day} = \text{total hours} (2)$$

To estimate the fishing effort per quarter (T), full-day angler hours (f) were divided by the number of RCSs performed during each quarter (RCS per quarter) then multiplied by the number of days in each quarter (d):

$$T = \left(\frac{f}{\text{RCS per quarter}} \right) \times d$$
$$\text{total fishing effort of the quarter} = (\text{full day in hours} / \text{RCS for the quarter}) \times \text{days in the quarter}$$

The number of days per quarter (d) are listed below. Surveys were not performed from November to February due to the cooler temperatures and decreased angler activity.

- Quarter 1 = **92** days (July – September)
- Quarter 2 = **62** days (October and March)
- Quarter 3 = **91** days (April – June)

Using the methods listed above, fishing effort was also calculated from survey responses collected digitally or via paper submission from the Gallaher Boat Ramp. Digital or paper surveys collected at the other three survey boxes on the NBG were used to calculate recreator activity.

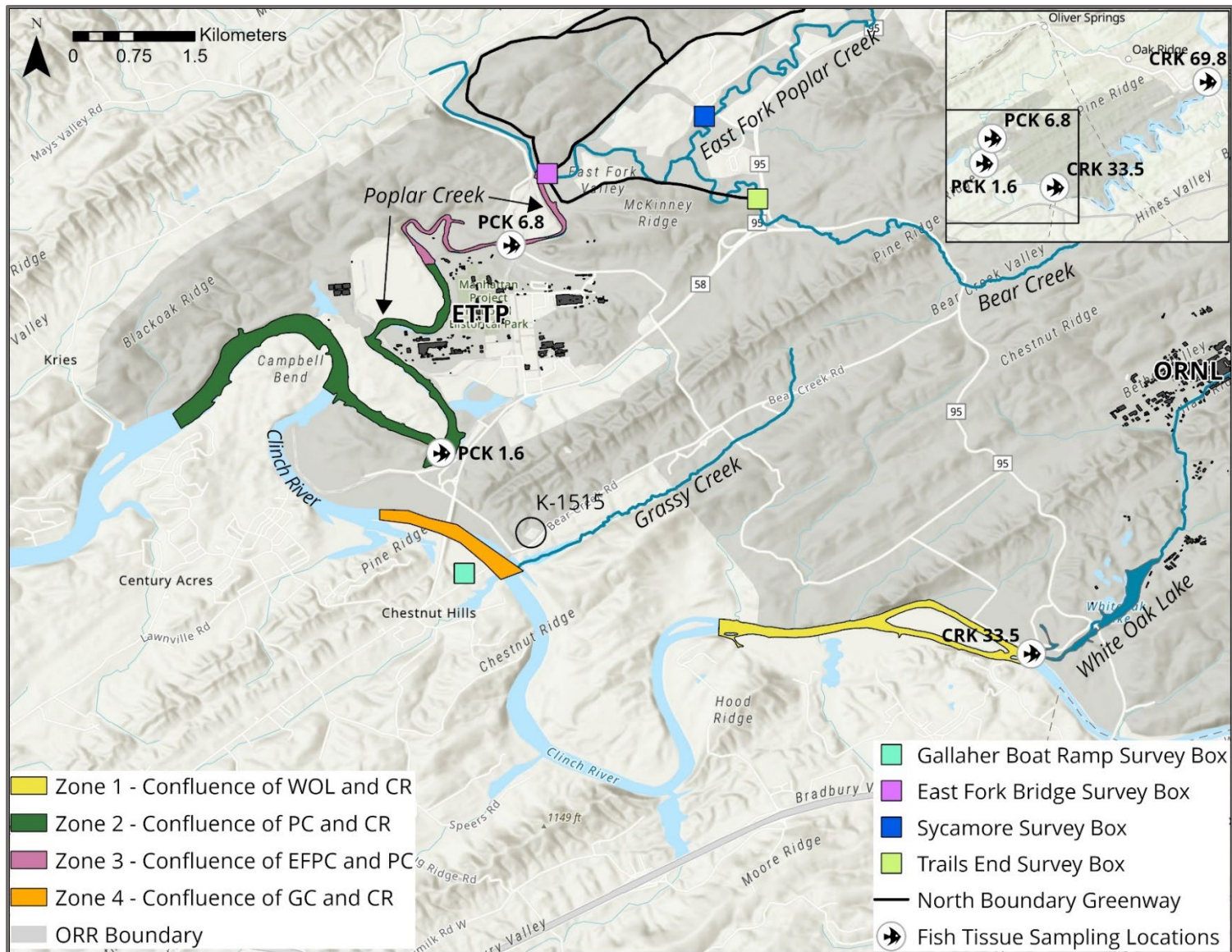
3.2.6 DEVIATIONS FROM THE PLAN

There were no deviations from the plan. All surveys were completed, and all fish were collected.

3.2.7 RESULTS AND ANALYSIS

NOTABLE ANGLER OBSERVATIONS FROM RCS RESULTS:

- 77 fishing parties were observed in FY25.
- 157 individuals were observed fishing.
- 74 individuals, or 60%, of the participants described themselves as “locals”.
- 46 individuals, or 37%, of the participants described themselves as “visiting”.
- 3% did not report locality.
- 106 individuals, or 85%, of the participants were on private fishing vessels.
- 19 individuals, or 15%, of the participants were on commercial fishing charters.
- 20 individuals, or 16%, of the participants reported “Yes” to consuming fish from the area.
 - 16 of the 20 individuals, or 80%, of the participants reported “Yes” to awareness of signage in the area warning against consumption of fish.



*Q# - # is quarter number - angling party number

Figure 3.2.7.1: Roving Creel Survey Angling Party Locations

RCS ZONE 1: WHITE OAK LAKE – CLINCH RIVER (WOL-CR) CONFLUENCE

The *Zone 1* region receives inputs from White Oak Lake and White Oak Creek, both containing discharges originating within the footprint of ORNL. The primary contaminants of concern (COC) in this area are byproducts from historical or legacy radionuclides as well as COCs from ongoing industrial activities. These radionuclides include Cs-137, Sr-90, and other fission daughter products. Due to potential release of legacy contaminants, signage is required to dissuade anglers from fishing directly in front of the White Oak Embayment (WOE). The signage on the sediment retention structure was replaced during FY25 and is no longer faded (TDEC EMR, 2024).

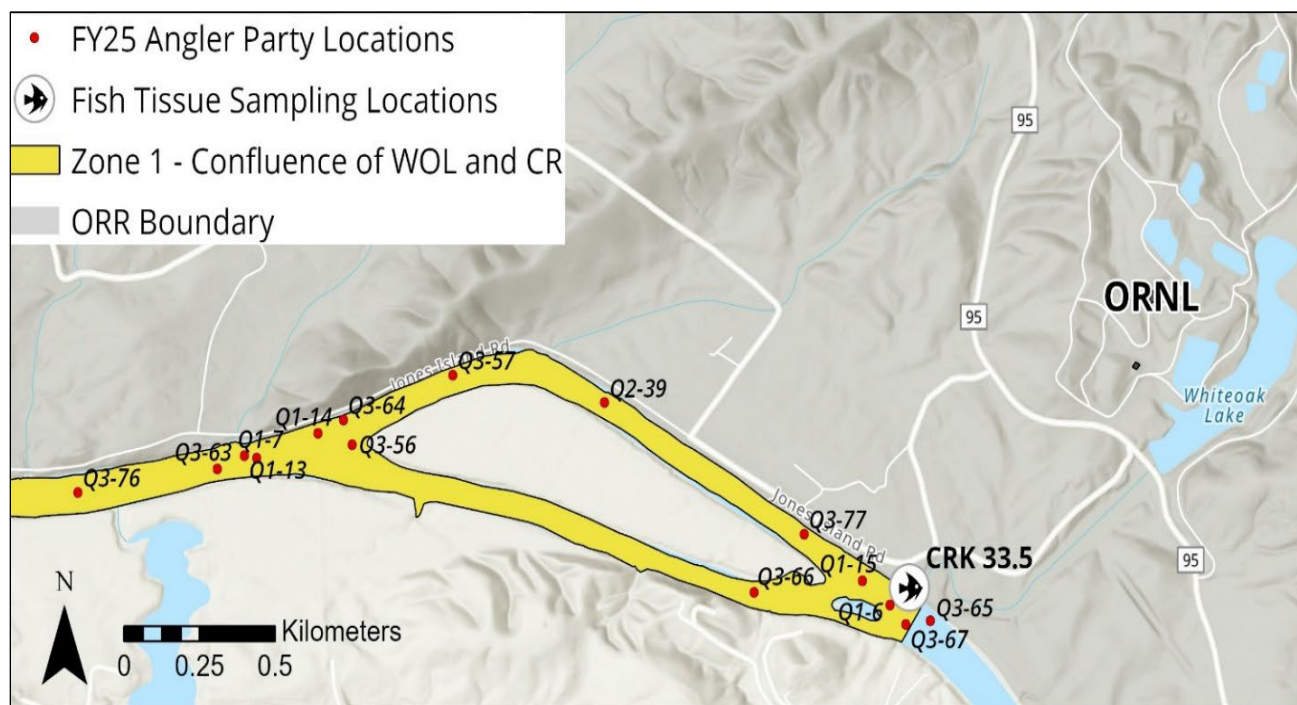


Figure 3.2.7.2: Zone 1 RCS Angling Party Locations

During FY25, fifteen angling parties were observed in *Zone 1*, only ten interviews were conducted (Figure 3.2.7.2). Anglers interviewed reported the hours they spent fishing during their trips, listed as “Reported (h)” column (Table 3.2.7.1). Anglers in *Zone 1* reported fishing between four and twelve hours on the day they were interviewed. The average time reported fishing was 6.7 hours. The median reported fishing time was 5.5 hours. The estimated fishing effort, time spent fishing, in *Zone 1* was 4460.4 hours, during FY25 (Table 3.2.7.2). In FY24, the estimated fishing effort was approximately 4080.4 hours (TDEC EMR, 2024). The total estimated fishing effort increased by 380.0 in FY25. Estimated angler effort in *Zone 1* has been increasing since FY23 (TDEC EMR, 2023).

Table 3.2.7.1: Zone 1 Summary of Angler Counts and Reported Hours

Quarter-Party	Date	Party Size (c)	Reported (h)	Total Hours (e)	Latitude	Longitude
Q1-6	7/27/2024	2	5.0	10.0	35.896214	-84.333740
Q1-7	7/27/2024	2	8.0	16.0	35.899909	-84.352606
Q1-15	8/3/2024	3	5.0	15.0	35.896827	-84.334560
Q2-39	3/30/2025	1	6.0	6.0	35.901300	-84.342235
Q3-56	5/16/2025	2	4.0	8.0	35.900552	-84.350655
Q3-57	5/16/2025	1	12.0	12.0	35.901993	-84.346755
Q3-63	5/24/2025	3	7.0	21.0	35.899635	-84.353771
Q3-64	5/24/2025	1	12.0	12.0	35.900872	-84.350022
Q3-65	5/24/2025	4	4.0	16.0	35.895808	-84.332536
Q3-76	6/21/2025	2	4.0	8.0	35.899044	-84.357918
Total		21	67.0	124.0		
<i>Notes: equation used to calculate total hours (e) is $e = c(h)$</i>						

Table 3.2.7.2: Zone 1 Summary of Angling Effort

Time Period	Hours/Day (f)	Hours/Quarter (T)
Quarter 1	82	1508.8
Quarter 2	12	148.8
Quarter 3	154	2802.8
Yearly	248	4460.4
<i>Notes: equation used is (T) total fishing effort/quarter, where (f) is the full day in hours (see equation above).</i>		

RCS ZONE 2: POPLAR CREEK – CLINCH RIVER (PC-CR) CONFLUENCE

Zone 2 includes portions of lower Poplar Creek located near the former K-25 Gaseous Diffusion Processing Building that has since been demolished. This zone also includes the confluence point of Poplar Creek with the Clinch River and downstream from the confluence around Campbell Bend. The overall site is now known as the East Tennessee Technology Park (ETTP) and has been repurposed as an industrial park. The contaminated buildings at ETTP have been removed and remediation of contaminated areas is ongoing. Roving creel surveys took place along this portion of the creek and river to monitor the ongoing impacts of historical DOE activities and the resulting legacy contaminants. The main COCs in this zone are mercury and PCBs.

During FY25, five angling parties were observed in Zone 2 (Figure 3.2.7.3). Anglers interviewed reported the hours they spent fishing during their trips, listed as “Reported (h)” column (Table 3.2.7.3). Anglers in Zone 2 reported fishing between four and six hours on the day they were interviewed. The average time reported fishing was 5.2 hours. The median reported fishing time was 6.0 hours. The estimated fishing effort, time spent fishing, in Zone 2 was 1704.8 hours, during FY25 (Table 3.2.7.4). In FY24, the fishing effort in Zone 2 was zero (TDEC EMR 2024).

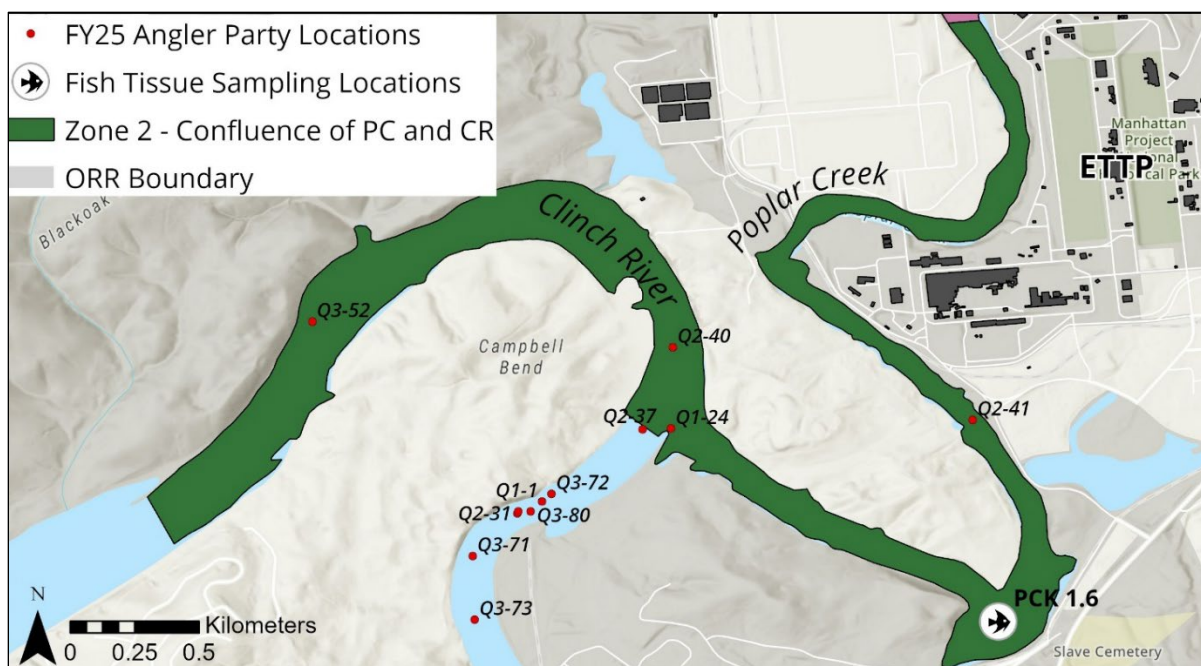


Figure 3.2.7.3: Zone 2 RCS Angling Party Locations

Table 3.2.7.3: Zone 2 Summary of Angler Counts and Reported Hours

Quarter-Party	Date	Party Size (c)	Reported (h)	Total Hours (e)	Latitude	Longitude
Q1-24	9/12/2024	1	4.0	4.0	35.9256254	-84.4100272
Q2-37	3/18/2025	4	6.0	24.0	35.9255971	-84.4110193
Q2-40	3/30/2025	3	6.0	18.0	35.9284670	-84.4099660
Q2-41	3/30/2025	3	4.0	12.0	35.9259290	-84.3994850
Q3-52	4/4/2025	1	6.0	6.0	35.9293559	-84.4225654
Total		12	26.0	64.0		

Notes: equation used to calculate total hours (e) is $e = c(h)$

Table 3.2.7.4: Zone 2 Summary of Angling Effort

Time Period	Hours/Day (f)	Hours/Quarter (T)
Quarter 1	8	147.2
Quarter 2	108	1339.2
Quarter 3	12	218.4
Yearly	128	1704.8

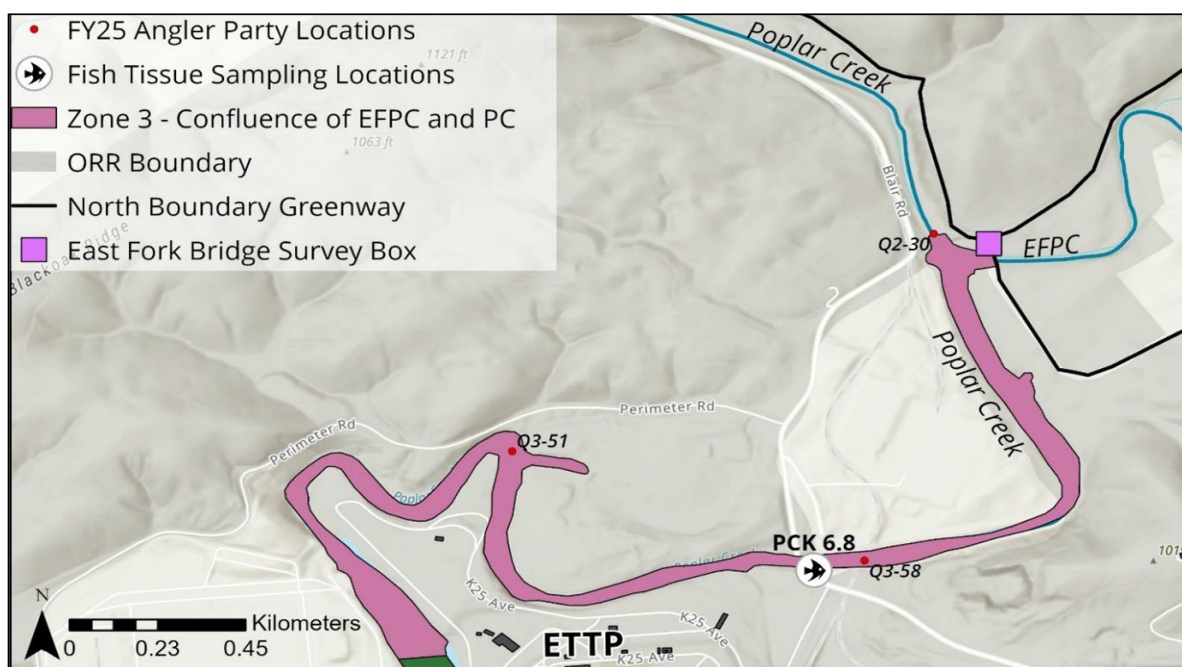
Notes: equation used is (T) total fishing effort/quarter, where (f) is the full day in hours (see equation above).

RCS ZONE 3: EAST FORK POPLAR CREEK – POPLAR CREEK (EFPC-PC) CONFLUENCE

Zone 3 includes the confluence of EFPC with PC and the downstream portion of the confluence before reaching the former K-25 footprint. The main contaminants of concern in this area are mercury (Hg) and methylmercury. Both contaminants bioaccumulate in fish tissue and are hazardous to human health.

Surveys conducted in previous fiscal years suggest that the *Zone 3* region is typically utilized by locals. These locals regard Poplar Creek as a “prime fishing spot” during the spring and fall fishing seasons, when the Clinch River shows an increase in anglers. NBG survey efforts show that *Zone 3* is typically accessed by foot from East Fork Bridge located at the EFPC-PC Confluence, or adjacent to Blair Road. There is litter scattering the banks of the area across from the East Fork bridge and a small trail leading to Poplar Creek from Blair Road. This indicates regular fishing activity in this area.

During FY25, three angling parties were observed in *Zone 3* (Figure 3.2.7.4). Anglers interviewed reported the hours they spent fishing during their trips, listed as “Reported (h)” column (Table 3.2.7.5). Anglers in *Zone 3* reported fishing either 1.0 or 4.0 hours on the day they were interviewed. The estimated fishing effort, time spent fishing, in *Zone 3* was 243.2 hours, during FY25 (Table 3.2.7.6). In FY24, the estimated fishing effort was 565.2 hours (TDEC EMR 2024). The total estimated fishing effort decreased by 322.0 hours in FY25.



*EFPC – East Fork Poplar Creek

Figure 3.2.7.4: Zone 3 RCS Angling Party Locations

Table 3.2.7.5: Zone 3 Summary of Angler Counts and Reported Hours

Quarter-Party	Date	Party Size (c)	Reported (h)	Total Hours (e)	Latitude	Longitude
Q2-30	10/13/2024	1	1.0	1.0	35.950113	-84.388076
Q3-51	4/4/2025	1	2.0	2.0	35.944824	-84.397752
Q3-58	5/16/2025	1	4.0	4.0	35.942179	-84.389669
Total		3	7	7		

Notes: equation used to calculate total hours (e) is $e = c(h)$

Table 3.2.7.6: Zone 3 Summary of Angling Effort

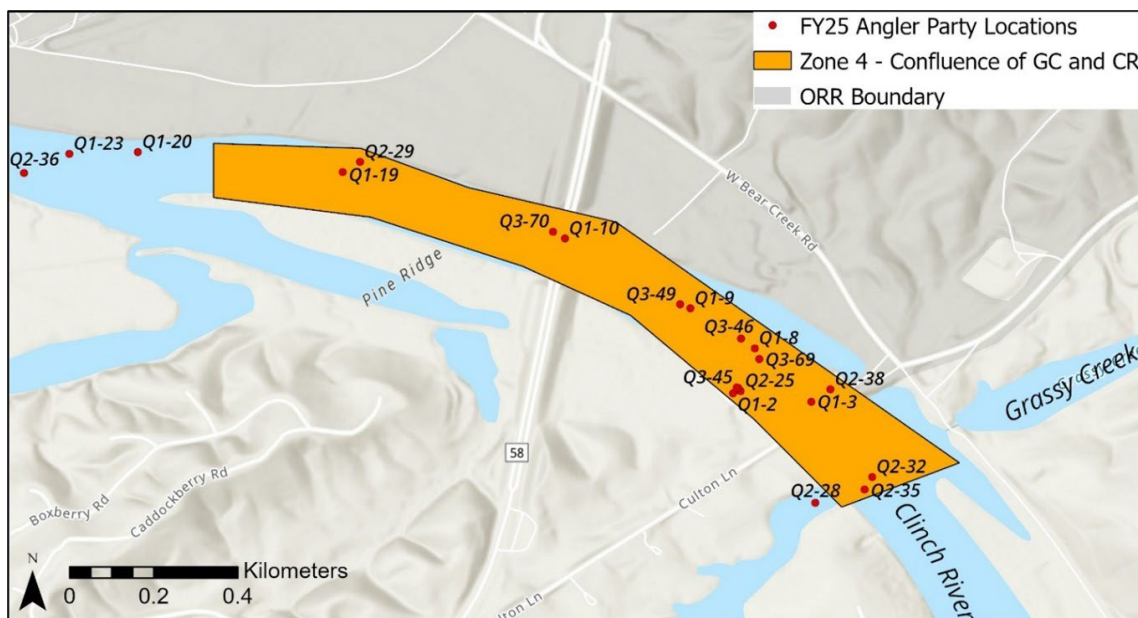
FY25	Hours/Day (f)	Hours/Quarter (T)
Quarter 1	0	0
Quarter 2	2	24.8
Quarter 3	12	218.4
Yearly	14	243.2

Notes: equation used is (T) total fishing effort/quarter, where (f) is the full day in hours (see equation above).

RCS ZONE 4: GRASSY CREEK – CLINCH RIVER (GC-CR) CONFLUENCE

During FY24, the project team decided to add an additional zone (Zone 4), at the confluence of Grassy Creek (GR) and the CR. During 2020, Cs-137 was detected at 15 pCi/g in a sediment sample from the CR near the mouth of GC, that was collected by DoR-OR and shared with DOE (OREIS, 2024). Due to this sample and a few other historical samples with detections of Cs-137 in river sediment, DoR-OR staff decided to calculate fishing effort in this zone.

During FY25, seventeen angling parties were observed in Zone 4, only eight interviews were conducted (Figure 3.2.7.5). Anglers interviewed reported the hours they spent fishing during their trips, listed as “Reported (h)” column (Table 3.2.7.7). Anglers in Zone 4 reported fishing between 1.0 and 10.0 hours on the day they were interviewed. The average time reported fishing was 6.5 hours. The median reported fishing time was 7.5 hours. The estimated fishing effort, time spent fishing, in Zone 4 was 4036.4 hours (Table 3.2.7.8). In FY24, the estimated fishing effort was 2459.2 hours (TDEC EMR 2024). The total estimated fishing effort increased by 1,577.2 hours in FY25.



*Not labelled (Q2-34)

Figure 3.2.7.5: Zone 4 RCS Angling Party Locations

Table 3.2.7.7: Zone 4 Summary of Angler Counts and Reported Hours

Quarter-Party	Date	Party Size (c)	Reported (h)	Total Hours (e)	Lat (DM)	Long (DM)
Q1-2	7/27/24	5	10.0	50.0	35.907287	-84.394284
Q2-29	10/13/24	2	7.0	14.0	35.912232	-84.402263
Q2-32	10/16/24	3	5.0	15.0	35.905502	-84.391311
Q2-34	10/16/24	1	1.0	1.0	35.907407	-84.394171
Q2-35	10/30/24	2	8.0	16.0	35.905235	-84.391468
Q3-45	4/04/25	1	5.0	5.0	35.907413	-84.394206
Q3-46	4/04/25	2	8.0	16.0	35.908458	-84.394109
Q3-70	5/24/25	1	8.0	8.0	35.910742	-84.398133
Total		17	52.0	125.0		
<i>Notes: equation used to calculate total hours (e) is $e = c(h)$</i>						

Table 3.2.7.8: Zone 4 Summary of Angling Effort

Time Period	Hours/Day (f)	Hours/Quarter (T)
Quarter 1	100	1840.0
Quarter 2	92	1140.8
Quarter 3	58	1055.6
Yearly	250	4036.4
<i>Notes: equation used is (T) total fishing effort/quarter, where (f) is the full day in hours (see equation above).</i>		

SURVEY BOX AT GALLAHER BOAT RAMP

During FY23, a survey box was placed at the Gallaher Boat Ramp to passively collect surveys from anglers (Figure 3.2.7.1). Gallaher Boat Ramp is utilized by DoR-OR to launch the boat for RCSs. Many anglers planning to fish in the defined study zones use this boat ramp to launch their own boats. Additionally, many anglers utilize the banks and boat dock at the ramp to fish.

A total of eight surveys were collected from the survey box and online submissions. Six of the eight surveys submitted reported fishing within the study zones (Table 3.2.7.9). The reported party sizes and hours are below. Angling effort was not able to be calculated using the same methods as the RCS, so only total hours (e) for each individual in a party are reported.

Table 3.2.7.9: Gallaher Survey Box Summary of Angler Counts & Hours

Survey #	Date	Party Size (c)	Reported (h)	Total Hours (e)
1	7/22/2024	1	7	7.0
2	8/6/2024	4	6	24.0
3	8/23/2024	1	3	3.0
4	12/13/2024	2	4	8.0
5	4/13/2025	2	6	12.0
6	5/4/2025	1	8	8.0
Total		11	34.0	62.0
<i>Notes: equation used to calculate total hours (e) is $e = c(h)$</i>				

NOTABLE OBSERVATIONS FROM NORTH BOUNDARY GREENWAY (NBG) SURVEYS:

- 1) 206 individuals reported recreating along the greenway.
- 2) 228.5 total hours of reported recreator use.
- 3) 10 individuals, or 5%, of the participants described themselves as “visiting”.
- 4) 196 individuals, or 95%, of the participants described themselves as “locals”.
- 5) 13 individuals were reported fishing.
 - Five of the thirteen reported “Yes” to fish consumption from the area, and “Yes” to signage awareness.
- 6) Types of reported recreation – running, hiking, swimming, kayaking, biking, walking, bird watching, and fishing.

Table 3.2.7.10: NBG Interview and Paper/Digital Survey Statistics

NBG Location	Surveys	Recreators	Total Hrs.	Hours	Days/Month	Anglers	Angling Hrs.
East Fork Bridge	72	142	157	2.3	503	11	6.5
Trails End	16	29	34	2.1	119	0	0
Sycamore	18	35	37.5	2.0	60	2	4
TOTAL	106	206	228.5	6.4	682	13	10.5

Between 7/10/2024 and 6/27/2025 surveys were collected at three survey drop boxes along the NBG (Figure 3.2.4.1). Recreators reported spending a total of 228.5 hours of activity on the greenway. The total average hours spent each day along the greenway were 6.4 hours (Table 3.2.7.10). Recreators reported spending between one and thirty (1-30) days per month along the greenway. A total of 13 anglers reported fishing along or just off the greenway (not all recreators were fishing during the visit they completed the survey). Anglers reported a total of 10.5 hours of fishing use along the greenway.

FISH TISSUE ANALYSIS

During FY25, five fish were collected from each of the three study zones and one reference site and analyzed for contaminants of concern. Certain fish species (Black Crappie, White Bass, and Large Mouth Bass) were targeted for collection. Based on previous RCS responses, these fish species are typically targeted for consumption in the study zones. The reference site in Melton Hill reservoir (CRK 68.9) was selected because it is upstream of inputs from the ORR. Fish were harvested at or near each of the fish tissue sampling locations on Figure 3.2.4.1.

Table 3.2.7.11: Fish Biometrics

Zone	Station	Date Collected	Fish ID #	Species	Length (in)	Weight (g)
1	CRK 33.5	11/5/2024	11	Largemouth Bass	17.5	1383
			12	White Bass	12	436
			13	White Bass	12	279
			14	White Bass	13	382
			15	Largemouth Bass	17	1253
2	PCK 1.6	11/4/2024	1	Black Crappie	11	343
			2	Black Crappie	9.5	248
			3	Black Crappie	12	425
			4	Black Crappie	9.5	199
			5	Black Crappie	13.5	643
3	PCK 6.8	11/4/2024	6	White Bass	10	233
			7	White Bass	14	567
			8	White Bass	14.5	678
			9	White Bass	15	703
			10	White Bass	14	625
REF	CRK 69.8	11/6/2024	16	Largemouth Bass	13	493
			17	Largemouth Bass	13	485
			18	Largemouth Bass	13.5	522
			19	Largemouth Bass	12.75	488
			20	Largemouth Bass	13	513

Fish were collected based on the sizes that would typically be harvested for consumption for each species (see Table 3.2.7.11). Each fish was filleted and analyzed separately for COCs. Fish from Clinch River kilometer (CRK) 69.8 and CRK 33.5 were analyzed for radiological contaminants in addition to metal contaminants. All radiological contaminant concentrations, including COCs Sr-90 and Cs-137, were below the minimum detectable concentrations (MDC), except for potassium-40. Potassium-40 is a naturally occurring isotope and the concentrations in the fish at CRK 33.5 (average of 15.4 pCi/g) were similar to concentrations detected at the reference site (average of 16.4 pCi/g). Fish from Poplar Creek kilometer (PCK) 1.6, PCK 6.8, and CRK 68.9 were all analyzed for chromium in addition to mercury and PCBs. There was only one detection of chromium at PCK 6.8 (0.22 mg/kg). This detection was flagged with a "J" by the laboratory, meaning it was a detection below the level of quantitation but above the detect limit.

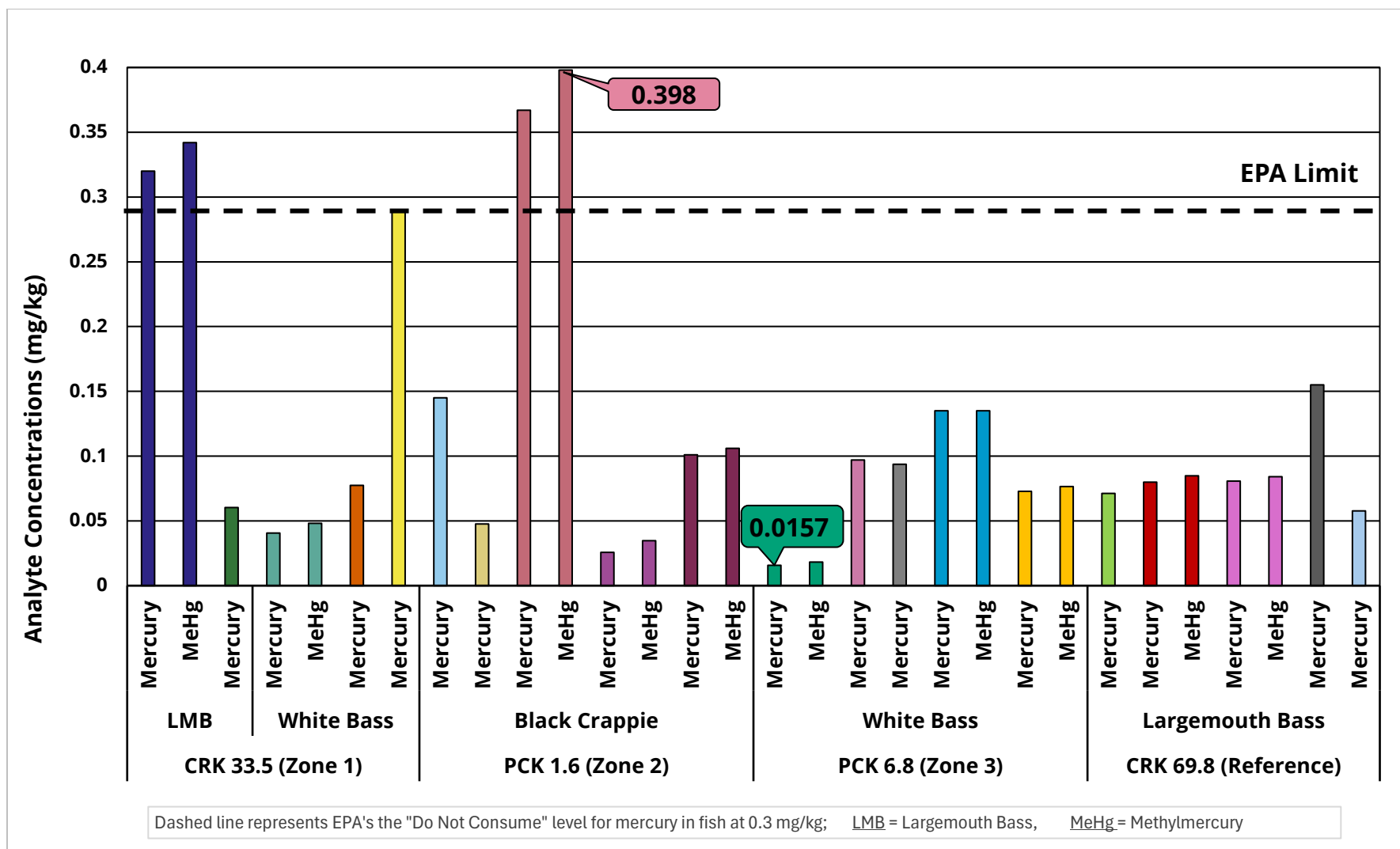
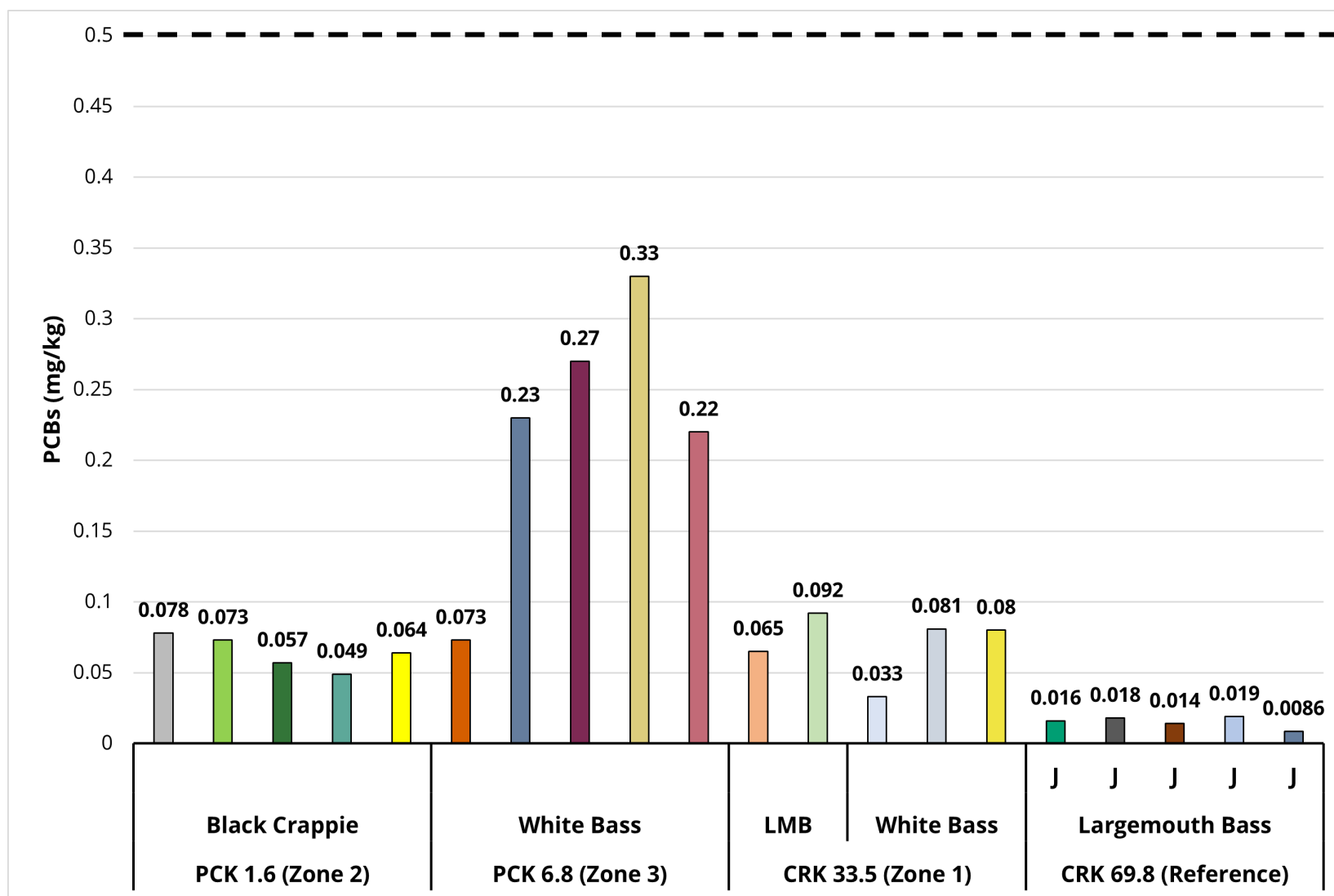


Figure 3.2.7.6: Mercury & Methylmercury Concentrations in Fish Tissue

All fish collected were analyzed for mercury, but only two to three fish from each station/zone were analyzed for methylmercury (MeHg). Most mercury in fish tissue is methylmercury, so low-level mercury analysis was performed to save laboratory costs. MeHg was analyzed on a subset of fish to ensure results were similar to low-level mercury analyses. Results for both mercury and MeHg were similar where both analyses were performed on a single fish. Mercury and MeHg concentrations with the same color and beside each other on Figure 3.2.7.6 are from the same fish. Two fish collected from *Zone 1* and one fish collected from *Zone 2* (Poplar Creek kilometer 1.6) had mercury concentrations approaching or above the EPA's limit of 0.3 mg/kg for fish tissue consumption (USEPA, 2010). All other fish were below the limit and similar to concentrations observed at the reference site.

(Continues on Next Page - Figure 3.2.7.7)

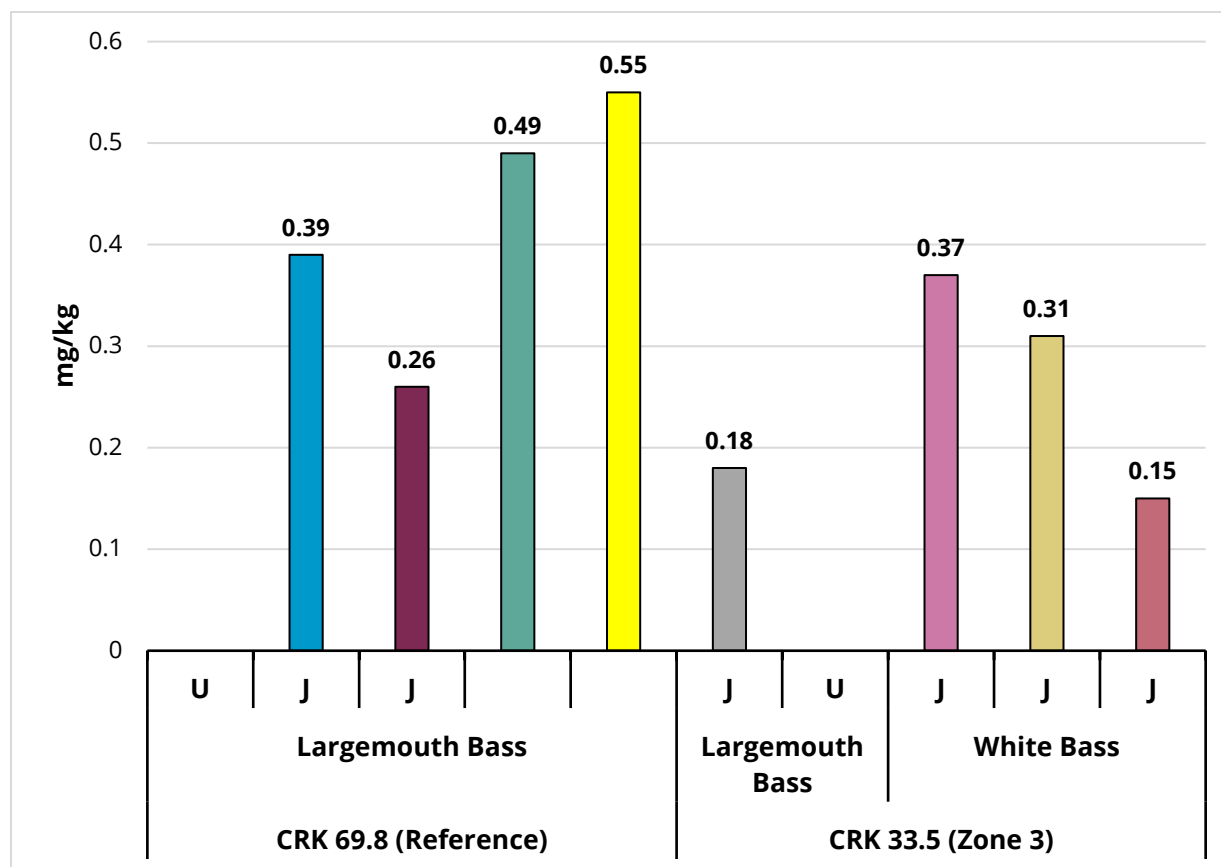


* Dashed line represents TDEC's DWR Limit to implement a precautionary advisory, LMB - Largemouth Bass

J - Estimated value above the detection limit, but below the quantitation limit

Figure 3.2.7.7: Total PCB Concentrations in Fish Tissue

Total PCB concentrations at all zones receiving inputs from the ORR have higher PCB concentrations than the reference site (located upstream of ORR inputs) (Figure 3.2.7.7). The highest concentrations were in fish collected from *Zone 3*. The fish collected from *Zone 1* and *Zone 2* had similar PCB concentrations. All PCB concentrations are below the TDEC Division of Water Resources fish consumption advisory (do not eat) of 1 mg/kg, and the precautionary advisory criteria of 0.5 mg/kg.



*U – non-detect. J – Estimated value above the detection limit, but below the quantitation limit.

Figure 3.2.7.8: Metallic Strontium Concentrations in Fish Tissue

For Sr-90, all the fish collected from *Zone 3* had concentrations similar and less than those observed at the reference site (Figure 3.2.7.8). The reference site had the highest concentration of strontium, and *Zone 3* had the lowest concentration of strontium. The EPA does not provide an advisory limit for strontium in fish tissue, but it does provide a Lifetime Health Advisory of 4 mg/L or 4 ppm in drinking water. These fish tissue values are all below 4 ppm or 4 mg/kg.

3.2.8 CONCLUSIONS

Roving Creel Surveys (RCS) in FY25 indicate that the White Oak Lake – Clinch River (WOL-CR) confluence was the most popular among anglers, with an estimated 4460.4 hours of angler

effort. The Grassy Creek – Clinch River (GC-CR) confluence had an estimated 4036.4 hours of angler effort. The East Fork Poplar Creek – Poplar Creek (EFPC-PC) confluence had an estimated 243.2 hours of angler effort (based on three interviews). The Poplar Creek – Clinch River (PC-CR) confluence had an estimated 1704.8 hours of angler effort. A total of 10,444.8 hours were spent fishing in the areas of concern. There was an increase in estimated fishing activity from FY24 (7,104.8 hours) to FY25 (10,444.8) of 3,340 hours.

While very few anglers (13 anglers) reported fishing in BC and EFPC from the NBG, there were a significant number of recreators that use the NBG for various activities (206 recreators). Activities reported include wading, swimming, and kayaking and all have the potential lead to hazard exposures (contact or ingestion) through water contact. It is important to monitor these activities as well as fishing activities in these areas due to the levels of mercury and other potential COCs in EFPC and BC.

In FY25, not as many anglers interviewed during RCSs were locals (60%) as FY24 (84%). During interviews DoR-OR staff noticed an increase in anglers that were visiting from other places. Ninety-five percent (95%) of the recreators along the NBG described themselves as locals (same as FY24). Many locals reported that they fish frequently and often angle in the areas of concern and some also reported that they consume fish caught from areas of concern. These results suggest that there is potential for human exposure to contaminants through the consumption of fish, especially amongst locals.

A total of twenty fish were harvested for laboratory analysis of contaminants of concern (COCs). Fish were selected based on previous RCS responses that indicated these species were harvested for consumption (White Bass, Black Crappie, and Largemouth Bass). The only COC that had detections above an EPA limit for consumption was mercury/methylmercury. Those fish were caught from *Zones 1* and *2*. The levels of PCBs in fish caught from all zones were higher than the reference site, but lower than TDEC DWR's level for precautionary and do not eat advisories. Strontium was detected in some fish from *Zone 1* and the reference site. Chromium was detected in one fish from PCK 6.8 but was flagged with a "J" by the lab for an estimated level of 0.22 mg/kg.

3.2.9 RECOMMENDATIONS

DoR-OR is aware that concentrations of contaminants in the water are higher than background levels at ORR watershed exit points. DoR-OR suggests that a more precise study be conducted to evaluate the potential human exposure risk of fishing in these publicly accessible waters. DOE does not have any project in place to monitor angler effort in these areas. At minimum, this *Roving Creel Survey Project* should continue.

During FY26, DoR-OR plans to collect fish to analyze tissue for contaminants in *Zone 4* to complete fish tissue sampling in all study zones. The project team recommends that this type of sampling be performed regularly to determine risk to human health through fish consumption from the study areas.

3.2.10 REFERENCES

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3.3 MERCURY AND CONTAMINANT UPTAKE IN BIOTA

3.3.1 BACKGROUND

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

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

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

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

3.3.2 PROBLEM STATEMENTS

- 1) Mobile ORR consumers, like migratory songbirds, could bioaccumulate and spread contaminants offsite.
- 2) Many adult flying insects in the ORR began life in contaminated water as nymphs. They accumulate contaminants from aquatic environments and are consumed by terrestrial

predators as adults (e.g., songbirds and bats). Sampling flying insects may reveal bioaccumulation and represent a transfer point for Hg, MeHg, and other contaminants.

- 3) Studies have demonstrated a correlation between contaminant levels in herpetological species and humans (Pelallo-Martinez et al, 2011), supporting the use of snakes to assess potential exposure risks to humans within those areas. Little to no data has been collected in the last 10–15 years on the ORR on the role(s) of snakes in mercury bioaccumulation. As an intermediate and top-level consumer, snakes have the potential to accumulate higher levels of Hg and MeHg through the consumption of exposed prey items. Additionally, with their larger home ranges, snakes have the capacity to disperse contaminants over larger distances.
- 4) DoR-OR staff have recently observed encampments of unhoused citizens along the banks of the upper reaches of East Fork Poplar Creek (EFPC), and at a new public greenway farther downstream. These sightings suggest that the human exposure risk to Hg and MeHg along EFPC may be higher than previously thought. Investigation of how much Hg and MeHg is travelling through trophic levels is relevant to assessing protectiveness in these areas for both human health and the environment.

3.3.3 GOALS

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

3.3.4 SCOPE

Biological specimens were captured from eight sites, including three impacted WOC study areas, three impacted EFPC study areas, and two reference sites (e.g., upstream WOC, Freels Bend) (Figure 3.3.5.1-3.3.5.2).

Samples were collected from all study areas over a one-year period, starting in spring 2024, until enough biomass was collected for laboratory analysis.

3.3.5 METHODS, MATERIALS, METRICS

Terrestrial biota collected to obtain biomass for contaminant analysis and associated site descriptions are listed below.

BIOTA

SONGBIRD EGGS

Songbird nest boxes were installed along WOC and at reference locations (Figure 3.3.5.1) to support FY26 sampling, following *TDEC SOP: Songbird Nest Box Construction and Deployment. DoR-OR-T-290B* (TDEC, 2023a).

ADULT INSECTS

Adult insects were collected from WOC and reference sites (Figure 3.3.5.1) between April and August 2024 following *TDEC SOP: Insect Sampling Using Light Traps. DoR-OR-T-331* (TDEC, 2023d). The SOP has been modified to include the use of Malaise and Lindgren Style funnel traps to accommodate safety concerns associated with potential radiation exposure at WOC. Insects were trapped in a combination of Lindgren Style funnel traps and Malaise traps. Traps were set and checked one week later; any insects in the traps were collected and traps reset for the following collection. Traps were sampled weekly. All insects collected from the same zone were composited into one sample. There were four total composite insect samples for WOC sent for analysis.

SNAKES

From April to October 2024, snakes were sampled along EFPC and at reference sites (Figure 3.3.5.2) following *TDEC SOP: Herpetofauna Trapping and Sampling. DoR-OR-T-312. Draft* (TDEC, 2023c). Snake boards were used to attract snakes. Snakes resting under boards were captured by hand. Trained staff recorded morphological measurements to assess snake body condition and attempted to collect blood samples from captured snakes (IACUC 2987-0623). Snakes were released unharmed at the site of capture. Due to safety concerns, venomous snakes were not sampled. Opportunistic snakeskin shed samples were also collected if available.

Site Descriptions

WHITE OAK CREEK

To ensure enough biomass was obtained without impacting local populations, WOC was divided into the following sampling zones (Figure 3.3.5.1):

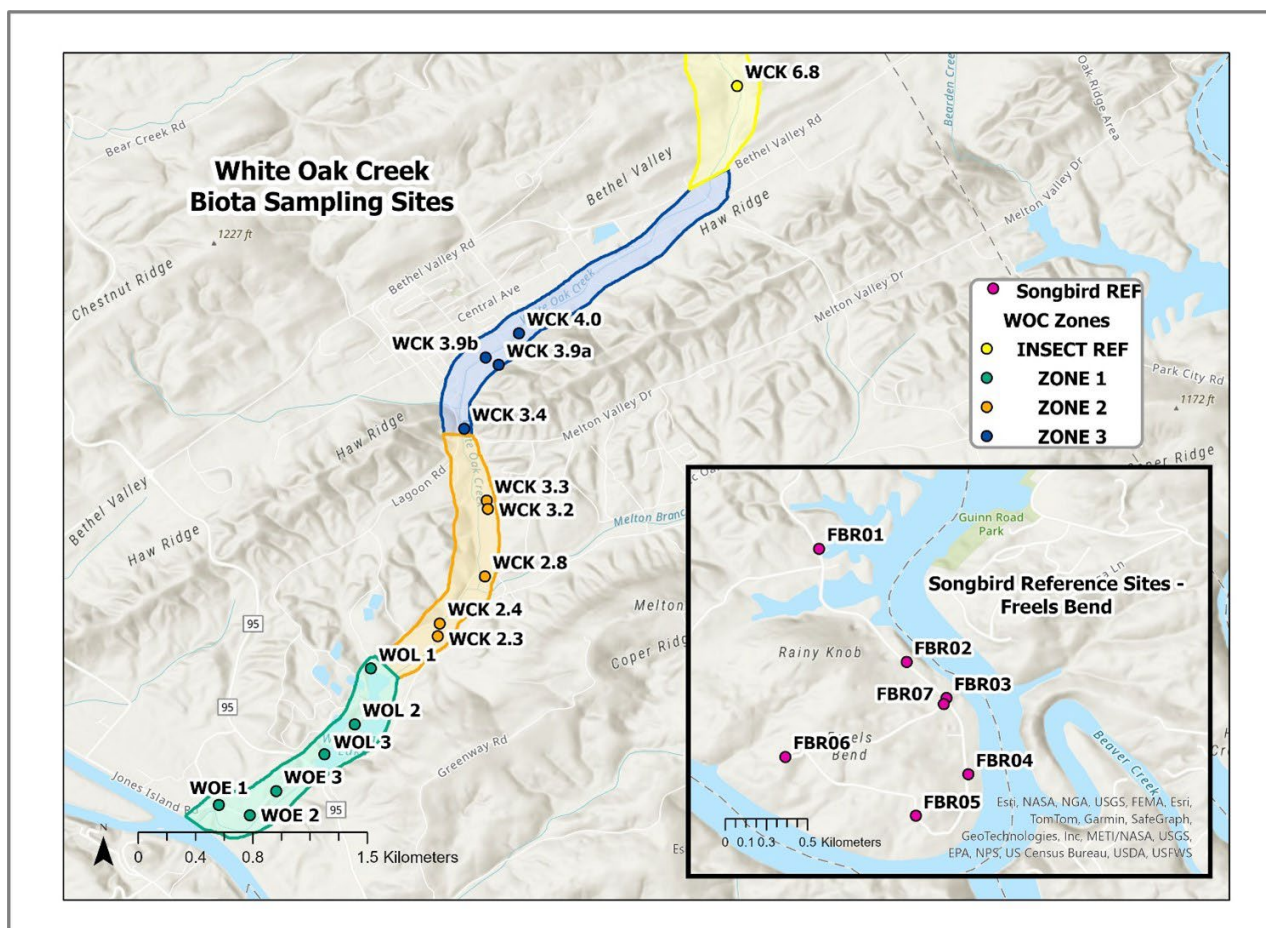


Figure 3.3.5.1: Biota White Oak Creek Sampling Sites

- 1) **WOC Zone 1:** White Oak Embayment (WOE) and White Oak Lake (WOL) comprised Zone 1 of the WOC watershed and is the most downstream reach (WCK 0.0 – WCK 1.9).
- 2) **WOC Zone 2:** Zone 2 includes the lower reaches of WOC, encompassing Melton Valley from WCK 1.9 to WCK 3.4.
- 3) **WOC Zone 3:** Zone 3 included the upper reaches of WOC that flows through Bethel Valley, from WCK 3.4 to WCK 4.2.
- 4) **WOC Zone 4:** (Insect REF) Zone 4 contained the WOC reference site, WCK 6.8. This site is located upstream of ORNL inputs into WOC. This site is not within the contaminated floodplain of WOC and has not been affected by radionuclide contaminants. WCK 6.8 was used as a reference site for insect samples. This zone is referenced by its site name (WCK 6.8) for analyses below.

- 5) **Additional Reference Locations:** were comprised of seven songbird sites within Freels Bend (not included in the above Figure 3.3.5.1). These sites are not within the floodplain of WOC and have not been affected by radionuclide or heavy metals contamination associated with ORNL and WOC. The seven reference sites were used to provide reference samples for songbird eggs.

EAST FORK POPLAR CREEK

EFPC was also divided into sampling zones to obtain adequate amounts of biomass without impacting local populations. The EFPC zones are as follows (Figure 3.3.5.2):

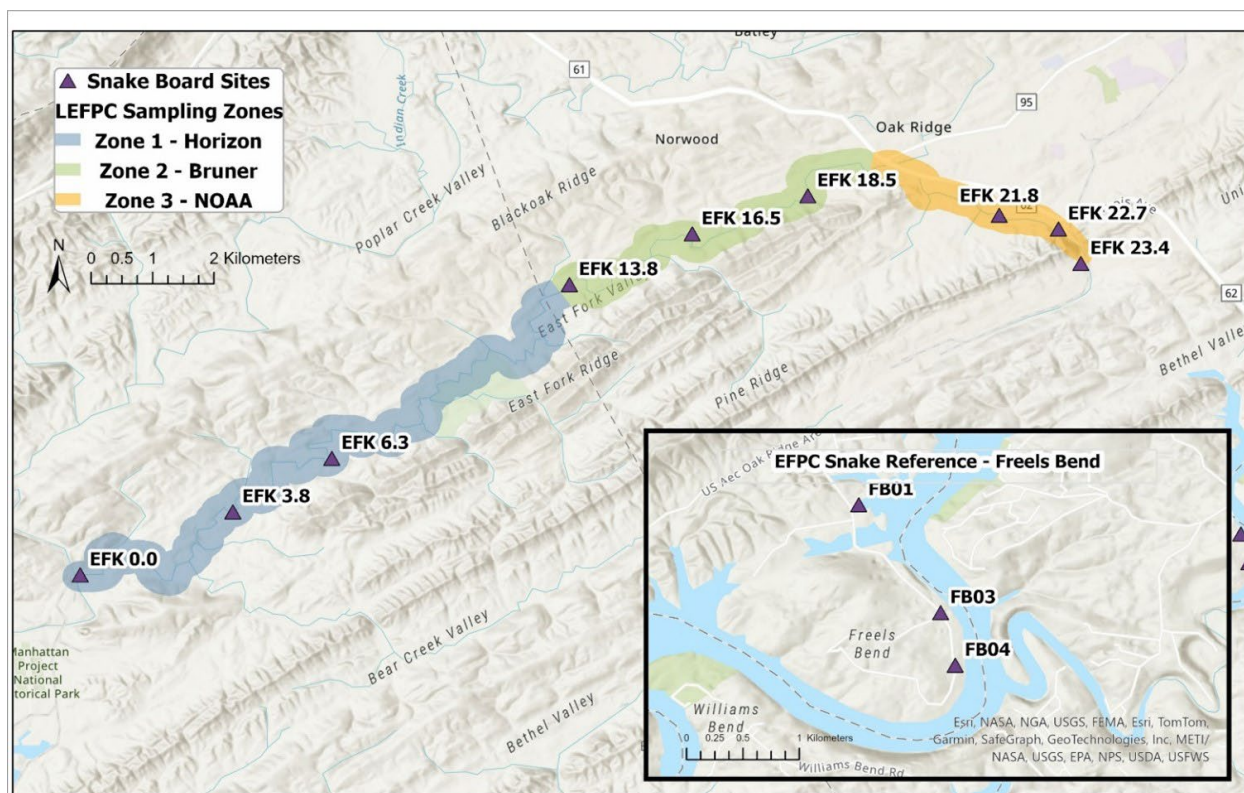


Figure 3.3.5.2: EFPC Snake Sampling Sites and Freels Bend Reference Sites

- 1) **EFPC Zone 1:** *Horizon Center reach* is the most downstream reach of EFPC consisting of EFPC kilometer EFK 0.0 to EFK 13.7.
- 2) **EFPC Zone 2:** This reach, containing the *Bruner Site*, flows through the City of Oak Ridge, following closely to the Oak Ridge Turnpike from EFK 13.8 to EFK 19.1.
- 3) **EFPC Zone 3:** The *National Oceanic and Atmospheric Administration (NOAA) Site* reach is the most upstream reach of EFPC, in the closest proximity to Y-12, and flows through the City of

Oak Ridge from EFK 19.2 to EFK 23.4.

- 4) **Reference Locations:** EFPC reference sites were comprised of three sites within Freels Bend. These sites are not within the floodplain of EFPC and have not been affected by mercury or methylmercury contamination.

Species that are State or Federally listed as greatest conservation need (GCN), threatened, endangered, or deemed in need of management will not be sampled.

BIOTA SAMPLING AND HANDLING

PROTOCOL FOR TDEC DoR-OR LAB

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

DATA ANALYSIS

- 1) Biota data results were compared to available DOE biota datasets in Oak Ridge Environmental Information System (OREIS).
- 2) The Hg, MeHg, and radiological analytical data results were normalized to account for differences in body mass, where applicable, among and between species.
- 3) Total Hg vs. MeHg graphs and figures were generated to compare among sites on the ORR and reference sites.
- 4) Results from the monitoring zones were compared with results from the reference zone(s) for each respective biota group.

3.3.6 DEVIATIONS FROM THE PLAN

SONGBIRD EGGS

Songbird nest boxes on WOC were deployed in early March 2024. Due to the timing of deployment, songbirds were not likely to locate and use the nest boxes for the spring 2024

laying season. Songbird eggs collections were delayed to spring 2025 and spring 2026 and results will be discussed in the FY26 EMR.

SNAKES

Zero samples were collected from snakes located under the boards at Freels Bend or EFPC. Two (2) skin shed samples were obtained from Walker Branch stream in ORNL and from an offsite private residence. Walker Branch is located upstream from any potential contaminant inputs from ORNL and thus can be used as a reference location. These reference samples were used to supplement the data collected in previous fiscal years.

3.3.7 RESULTS AND ANALYSIS

ADULT FLYING INSECTS

Adult flying insects were analyzed for radionuclide and tritium bioaccumulation. Cesium-137 (Cs-137) and Strontium-90 (Sr-90) were specifically analyzed, as these are two of the primary contaminants of concern (COCs) and contribute to beta emitting contamination. As there are no specified regulatory limits for radionuclides in adult flying insects, results were compared with preliminary remediation goal (PRG) values derived from the Risk Assessment Information System (RAIS). PRG values were calculated for resident contaminated fish inputs with a target risk (TR) of 1×10^{-6} . The resident fish scenario calculates contaminant levels in fish tissue at which you would see impacts to humans who ingest the fish. While people do not typically ingest flying insects as a regular part of their diet, flying insects are a link in a larger food chain that could impact fish or other higher trophic level organisms (e.g., birds, mammals). Using a resident fish comparison is very conservative and evaluates the potential impacts of adult flying insects on other organisms who may ingest them or their subsequent predators. This is done for comparison purposes only in the absence of established regulatory limits.

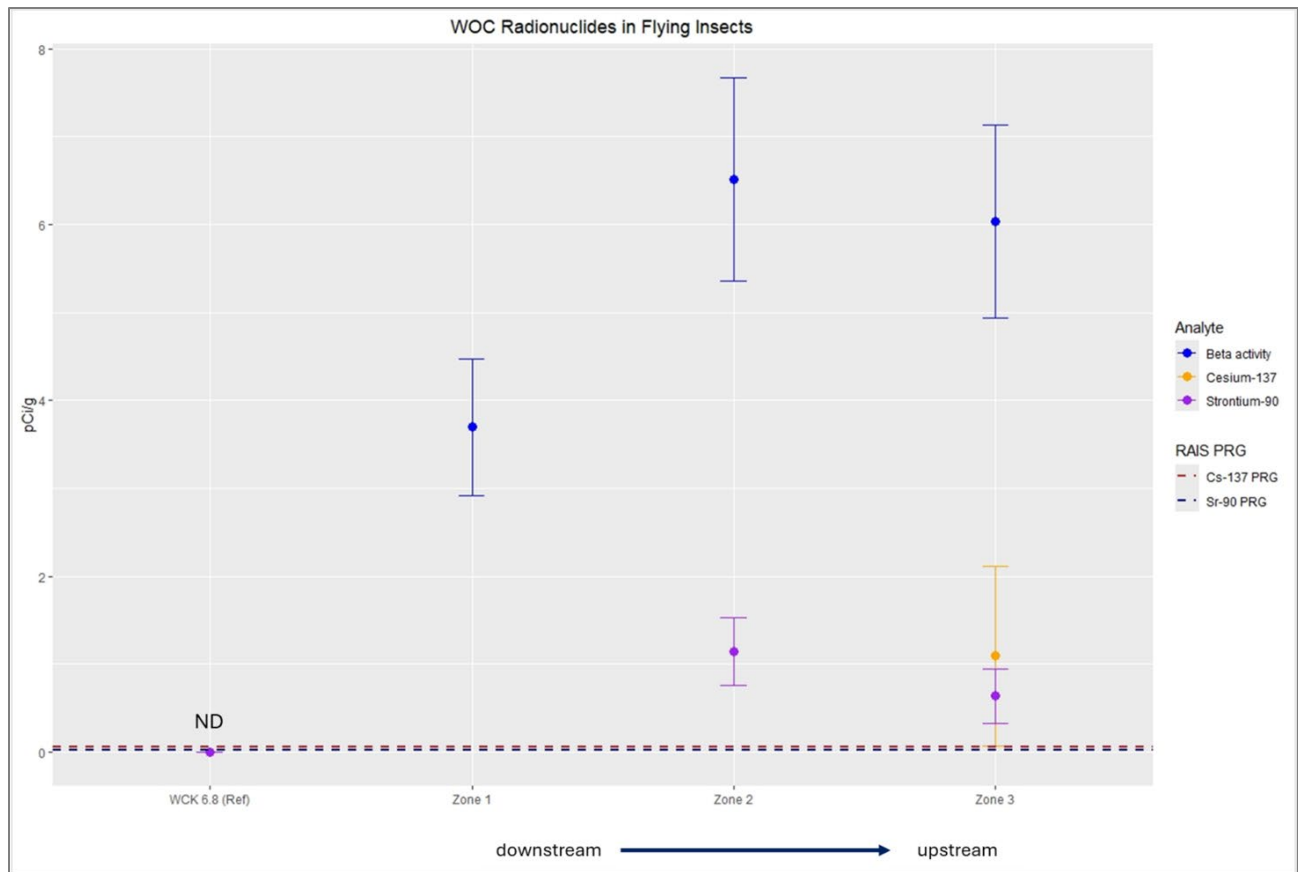


Figure 3.3.7.1: WOC Zones - Radionuclides in Flying Insect Samples

No gross alpha activity or tritium were detected in the insect samples. Gross beta radioactivity was detected in all impacted zone samples and none in the reference zone sample (Figure 3.3.7.1). Cs-137 was only detected in the uppermost zone samples (Zone 3), while Sr-90 was detected in both Zones 2 and 3. While gross beta has no specific PRG value, insects from impacted zones did have measurable beta radioactivity greater than the reference zone, which had undetected gross beta. Detectable Cs-137 and Sr-90 were all measured above PRGs for fish ingestion (RAIS 2025).

SNAKES

Snakeskin samples collected from reference sites contained less total mercury (HgT) and a lower proportion of MeHg than snake samples collected from impacted sites along EFPC (Figure 3.3.7.2). Generally, HgT and MeHg concentrations increased moving from downstream to upstream, with the exception of the redbelly snake sample collected from Zone 1. The redbelly snake sample had HgT and MeHg concentrations similar to the offsite reference site sample.

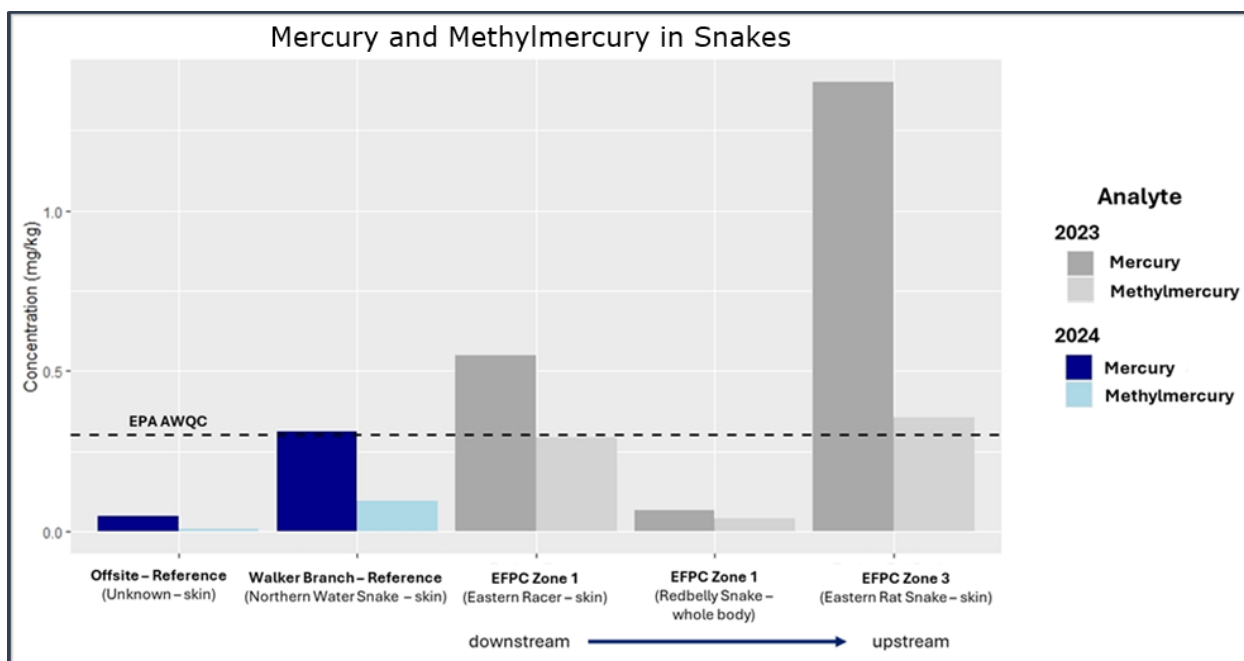


Figure 3.3.7.2: Mercury & Methylmercury in Snake Samples in 2023 (EFPC) and 2024 (REF)

3.3.8 CONCLUSIONS

ADULT FLYING INSECTS

Adult flying insects were evaluated as composited samples by zone. Some bioaccumulation of radionuclides occurred where general spatial trends can be observed. Gross beta radionuclide concentrations were generally lower in the most downstream zone (Zone 1) and increased closer to source points in the upstream zones (Zones 2 and 3). There is limited data about radionuclide bioaccumulation in receptors to inform specific regulatory limits for many radionuclide contaminants. All measured concentrations for Cs-137 and Sr-90 were above suggested PRGs for remedial action for the consumption of fish (RAIS 2025), which is used for comparison only. This suggests that adult insects did bioaccumulate radionuclides from their environment; however, the ecological impact of this uptake is unknown.

SNAKES

Snake samples were analyzed as individual samples and not composited. All sites and zones, except for Zone 1, are represented by a single sample. Interpretation of Hg bioaccumulation impacts is thus limited, but general trends can still be observed which are supported by similar trends in surrounding biota (TDEC 2025). Hg and MeHg concentrations are below EPA recommended AWQC for fish at the reference sites and increase above the AWQC as you move upstream on EFPC. Northern water snakes, eastern racers, and eastern rat snakes are of similar size and perform similar trophic functions (i.e., consumers of larger vertebrates). These species are comparable and allow for spatial trend observations.

The redbelly snake sampled from Zone 1 more closely matches Hg concentrations from the reference sites and does not follow the general trend shown in the other samples. This is likely due to ecological differences in the redbelly snake. Redbelly snakes are a smaller species than water snakes, rat snakes, and racers. Smaller individuals are more likely to bioaccumulate smaller concentrations of Hg, which is also likely attributed to their food sources having less available Hg. Additionally, the redbelly snake was analyzed as a whole-body sample; it was collected as a road mortality, whereas the other samples were skin shed samples. Hg is likely to be represented at different concentrations in different body organs. As a whole-body sample, Hg concentrations could possibly be functionally diluted within the larger tissue volume.

3.3.9 RECOMMENDATIONS

Bioaccumulation of contaminants in biota communities can have broad impacts on ecological and human health. Ongoing and future remedial actions impacting WOC necessitate the evaluation of current environmental conditions to establish a baseline for biota. With limited data about radionuclide bioaccumulation in biotic receptors to inform specific radionuclide regulatory limits, continued monitoring of adult insects may be warranted. The project team recommends monitoring radionuclide contaminants in biota on a three- or five-year basis to evaluate any consistency or fluctuations in existing concentrations.

In FY26, DoR-OR plans to continue to sample and monitor flying insect populations along White Oak Creek to broaden the contaminants analyzed to include metals and PCBs. Completion of this additional suite of analytes will provide a more complete view of the current potential risk to biota along White Oak Creek.

Similarly, DoR-OR will continue to monitor snake populations along EFPC to increase the available data. As snakes are thought to be a proxy for human health risk, increasing the data set to evaluate bioaccumulation of Hg in EFPC is ideal for monitoring human health risk to this publicly accessible stream. While the focus in EFPC is currently centered around heavy metals with more severe and acute physiological consequences (e.g., Hg and MeHg), expanding monitoring efforts to other contaminants known to be present in EFPC (e.g., radionuclides and their associated heavy metals, and PCBs) is valuable. Elevated concentrations of these contaminants warrant continued monitoring until EFPC has been fully remediated for all media types.

3.3.10 REFERENCES

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3.4 TERRESTRIAL INVERTEBRATE COMMUNITY HEALTH

3.4.1 BACKGROUND

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

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

Carabids are ideal bioindicators given their close contact with contaminants present in soils and leaf litter (Hunter et al, 1987; Pizzolotto et al, 2013; Ghannem et al, 2018). Often, contamination becomes concentrated in floodplain soils as a result of discharges into waterways and subsequent flooding events. As a result, contaminated soils and leaf litter in the riparian areas can provide a link between aquatic and terrestrial environments. Carabids are ground-dwelling arthropods throughout their life cycle. Because ground beetles spend the majority of their life stages in the soil (i.e., larval and pupa stages) or on the ground (i.e., adult stage), they have longer exposure periods to available contaminants in comparison to other flying insects that occupy spaces above the ground. The result is these beetles have a strong potential to uptake mercury and other heavy metals in their immediate environment (Ghannem et al, 2016). Also, carabids are generalist consumers that occupy multiple trophic levels and have the potential to be impacted through multiple contaminant pathways. They are additionally ideal bioindicators due to their sensitivity to environmental change. Carabids exhibit relatively rapid and measurable changes within species and community composition in response to anthropogenic impacts on local environments (Pearce and Venier, 2006; Avgin and Luff, 2010; Ghannem et al, 2018).

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

In addition to filling a data gap in terrestrial systems monitoring, this project contributes to continued monitoring of biota on EFPC. As a valuable data gap project, ground beetle community assessments will establish a more complete analysis on watershed ecological health.

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

3.4.2 PROBLEM STATEMENTS

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

3.4.3 GOALS

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

3.4.4 SCOPE

Carabid specimens were collected from three main impacted study zones along EFPC and from one reference zone in Freels Bend (Figure 3.4.4.1). Sampling took place from April – August 2024. Each zone consisted of three sample sites with three invertebrate pitfall traps per site (i.e., nine samples each per four zones). Results from each of the three impacted zones were compared to results from the reference zone. Carabid community data collected by NEON Domain 07 (NEON, Released-2024) was utilized to strengthen data collected from the Freels Bend reference zone and provide additional reference data for sites that represent similar habitat to those from the EFPC impacted zones.

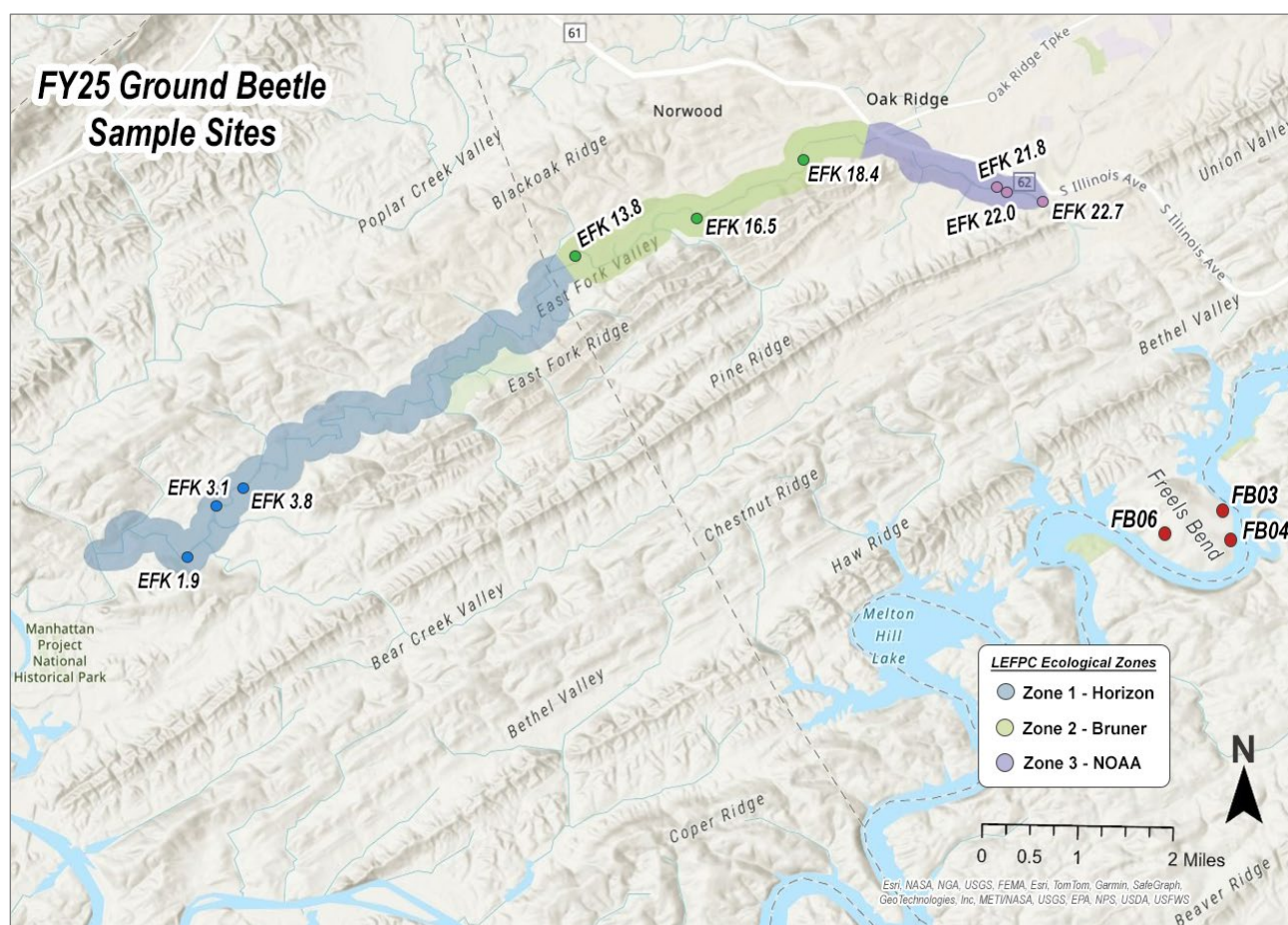


Figure 3.4.4.1: East Fork Poplar Creek Ground Beetle Sampling Sites

3.4.5 METHODS, MATERIALS, METRICS

TERRESTRIAL INVERTEBRATE FIELD SAMPLING

Insect pitfall traps were installed along EFPC and at the corresponding reference zone (Figure 3.4.4.1) following the TDEC SOP for pitfall trapping (TDEC 2023), developed from the NEON SOP for ground beetle sampling (Levan 2022). Traps contained propylene glycol, a preservative that

is non-toxic to wildlife and people. All specimens trapped in the preservative were collected in solution from each trap every two weeks. New unused propylene glycol was added during each field event to reset the pitfall traps until the removal of the traps at the end of the sampling season. The pitfall traps from all sites were left open from April through August 2024. State or federally listed species were reported to TWRA within 5 working days.

TDEC DoR-OR LABORATORY PROCESSING

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

DATA ANALYSIS

- 1) Carabid communities were assessed by various diversity metrics (e.g., richness, abundance, diversity) and impacted sites were compared to reference sites.
- 2) Mean Individual Biomass (MIB) (Jelaska et al. 2011), Shannon Diversity, and Simpson's Diversity metrics were evaluated to identify measurements that can be used to describe environmental health.
- 3) Non-metric Multidimensional Scaling (NMDS) was used to determine any relational difference between community composition of impacted sites versus reference sites. Following a NMDS, an indicator species analysis was run to determine distinct species associated with impacted versus reference sites.

3.4.6 DEVIATIONS FROM THE PLAN

There were no deviations.

3.4.7 RESULTS AND ANALYSIS

Ground beetle community data was downloaded from NEON to supplement the reference site data. Given the logistics of NEON sampling, the timing of expert taxonomy verification and upload of verified data to the NEON data portal lags behind current annual sampling. To maintain comparability between datasets, only the most current years of NEON data that include expert taxonomy verification are utilized.

SPECIES RICHNESS

Richness is the number of different species for a site. Species richness was calculated for each zone. NEON reference data was split into two different zones to account for potential variation in habitat type. Splitting the data in this way can help evaluate the effectiveness of using NEON

data to supplement TDEC reference data. More species were captured in 2024 than in 2023, but the trends were similar between years (Figure 3.4.7.1). Species richness was higher at reference zones than at impacted zones, and richness increased moving from upstream zones to downstream zones. Additionally, species richness from TDEC’s reference zone (REF 01) was similar to species richness from both NEON reference zones (REF 02 and REF 03).

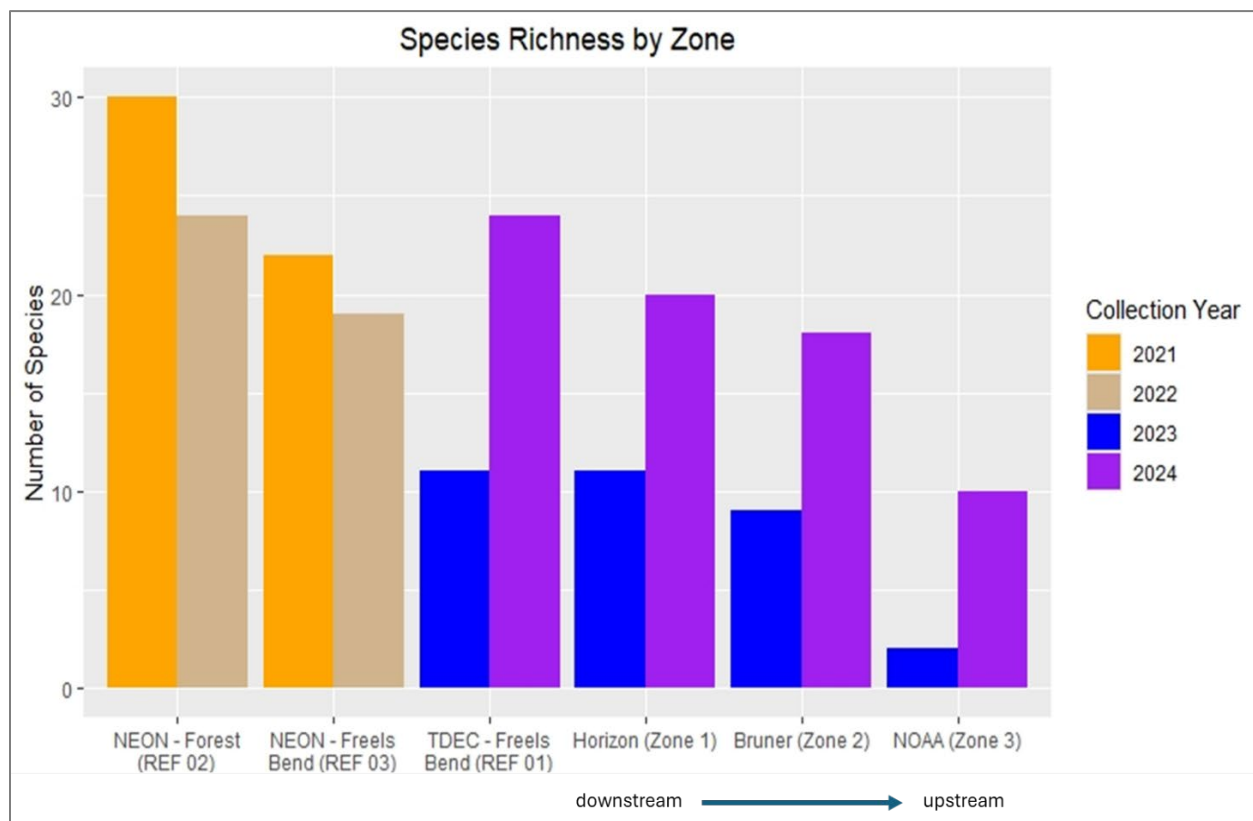


Figure 3.4.7.1: Ground Beetle Species Richness at EFPC By Zone

SPECIES DOMINANCE (SIMPSON'S D INDEX)

Species dominance describes the extent to which one or a few species numerically dominate a community. It is calculated from relative abundances (the proportion of individuals in a community belonging to each species) and is inversely related to evenness (i.e., lower dominance scores suggest a greater evenness in a community). Ground beetle communities on EFPC showed lower dominance scores at reference zones than at impacted zones (Figure 3.4.7.3). Additionally, downstream impacted zones had lower dominance scores than upstream zones.

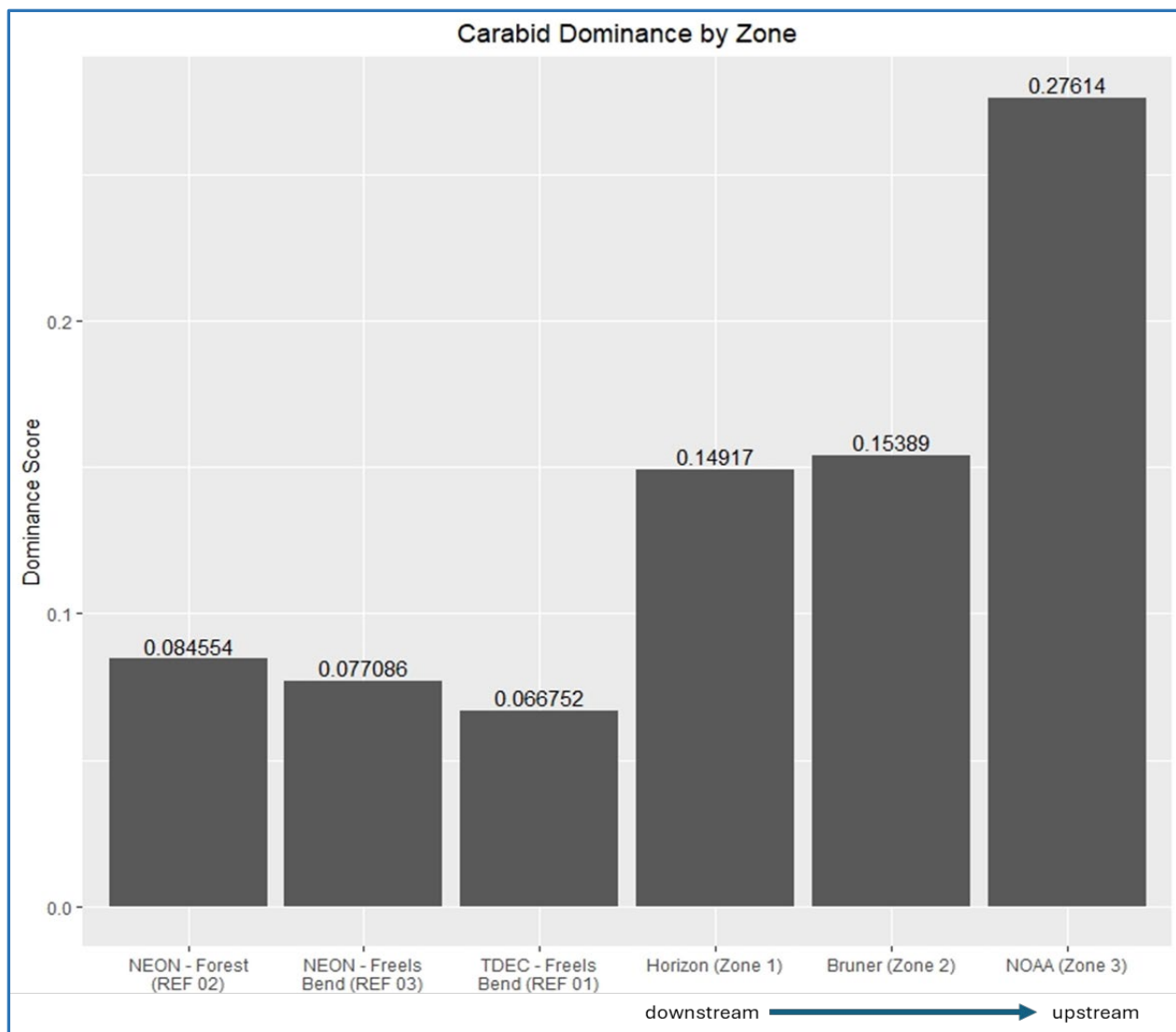


Figure 3.4.7.3: Ground Beetle Species Dominance (Evenness) at EFPC By Zone

SHANNON DIVERSITY INDEX

The *Shannon Diversity Index* is a measure of diversity that accounts for both species' richness (number of species) and evenness (density of species). Evenness is how evenly distributed individuals are across species. Higher Shannon Index scores indicate greater diversity, with a greater number of species and individuals evenly distributed across species, indicating that communities are not dominated by a few species even when richness is otherwise high. An even distribution of species (high evenness), as well as a high number of species (high richness), is an indication of population stability, with ample individuals available for mating and minimal overlap of species utilizing the same niche spaces and resources. Shannon Diversity scores at reference zones were higher than at impacted zones (Figure 3.4.7.2). TDEC reference zone (REF 01) was similar to both NEON reference zones (REF 02 and 03). Impacted Zone 1 (Horizon), the furthest zone from Y-12, had Shannon Index scores comparable with the reference zones.

Shannon index scores increased moving from upstream zones to downstream zones.

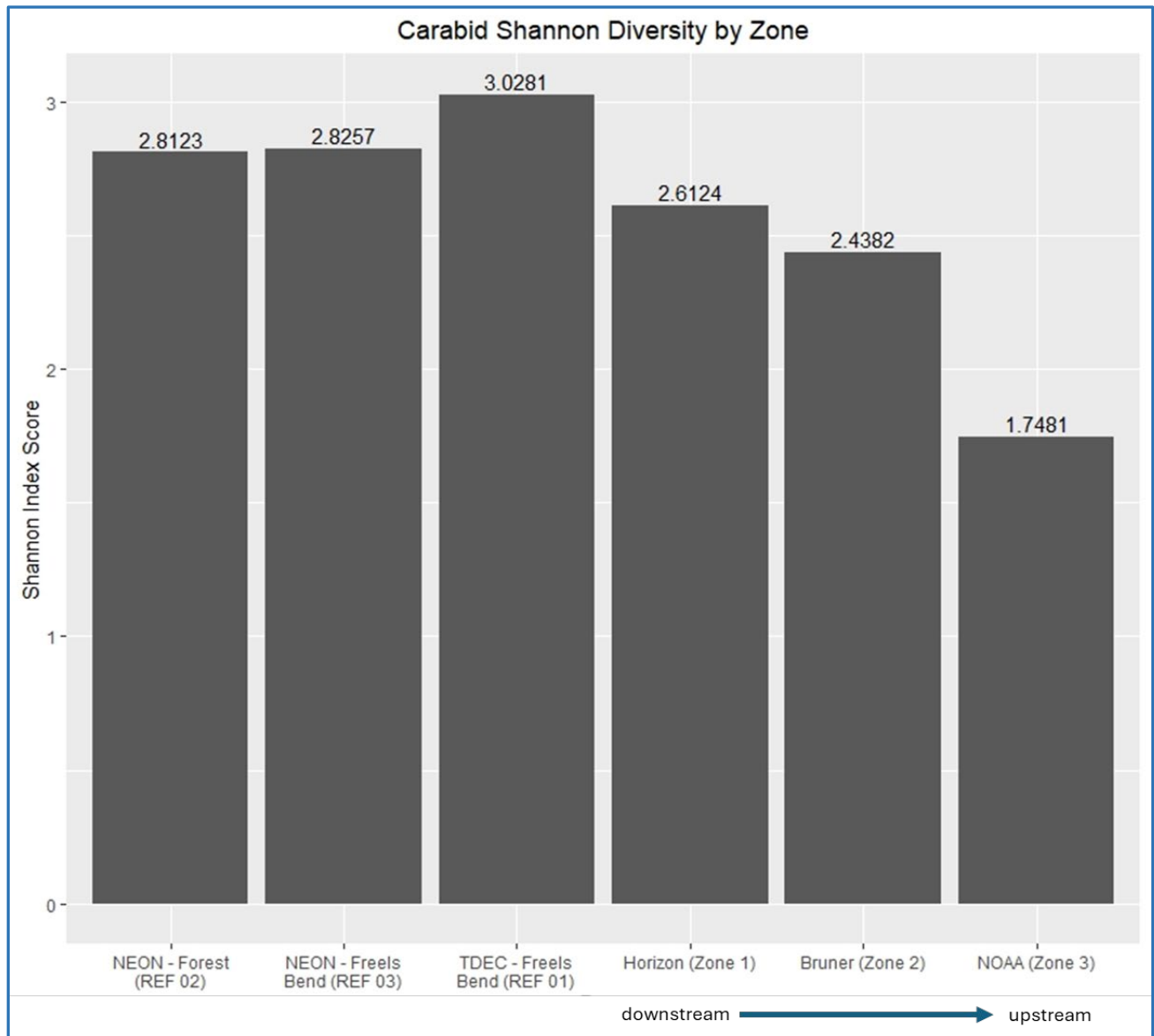


Figure 3.4.7.2: Ground Beetle Species Diversity at EFPC By Zones

MEAN INDIVIDUAL BIOMASS

Mean Individual Biomass (MIB) Index is a score based on the overall biomass of ground beetles represented in a community (Jelaska et al. 2011, Kedzior et al. 2018). MIB is calculated using the following formula:

$$\ln y = -8.92804283 + 2.5554921 \times \ln x,$$

Where:

y - biomass of carabid

x - the body length of a single individual

The MIB Index score was then calculated by summing the MIB and dividing by the abundance by zone (Kedzior et al. 2018). MIB can be used to account for individual variation within a species, as well as differences in sizes across different species. Therefore, MIB can be associated with individual changes in body condition due to impacts experienced in the environment. Higher MIB scores indicate greater biomass and are indicative of a less impacted environment. The MIB scores varied between zones and years (Figure 3.4.7.4). TDEC REF 01 had higher MIB than the corresponding NEON REF 03 zone, but less than the NEON REF 02 zone. Additionally, the most downstream impacted Zone 1 (Horizon) had higher MIB scores than the REF 01 and 03 zones. MIB scores generally decreased moving from downstream impacted zones to upstream zones.

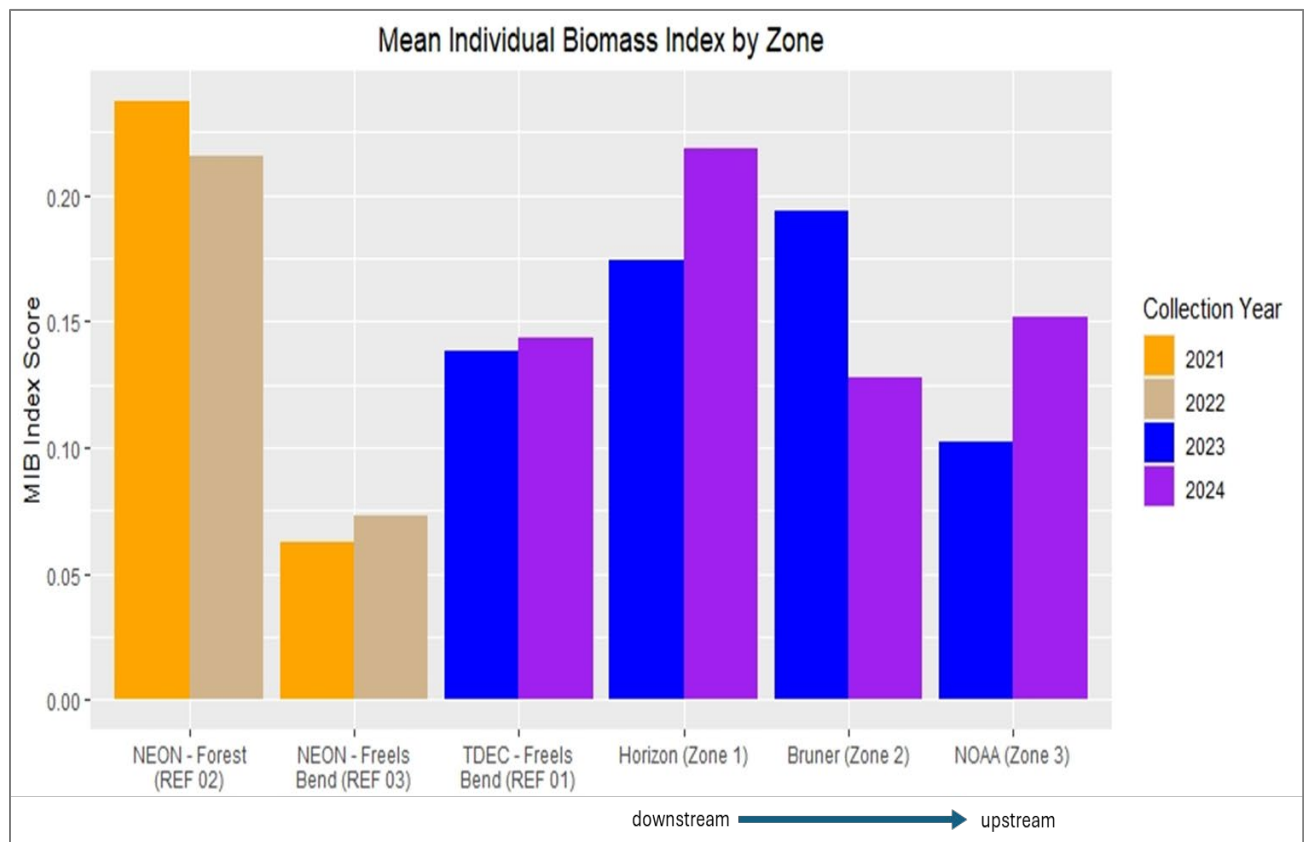


Figure 3.4.7.4: Ground Beetle Mean Individual Biomass (MIB) Index at EFPC By Zone

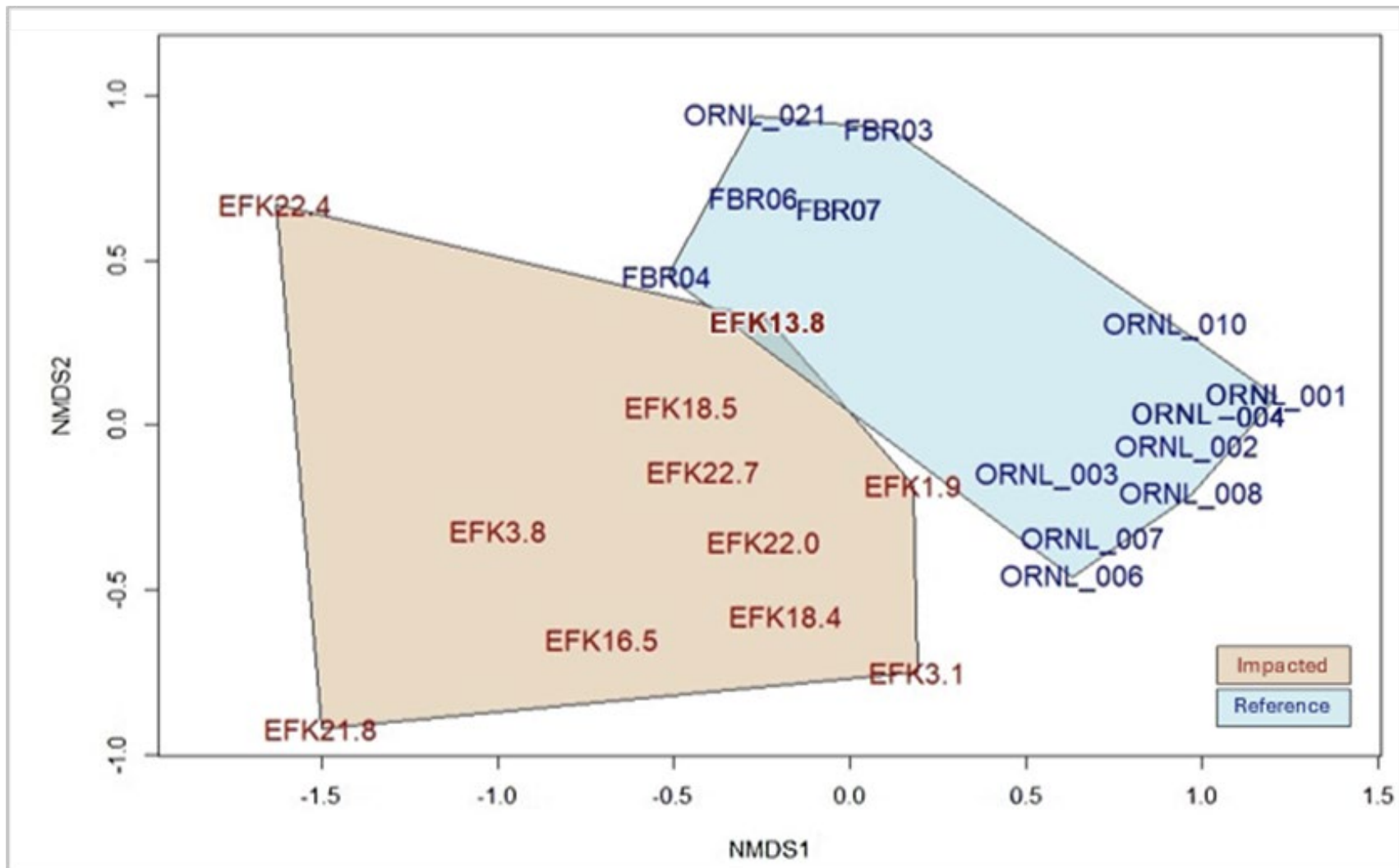
NMDS AND INDICATOR SPECIES ANALYSIS

NMDS

Non-metric multidimensional scaling (NMDS) analysis is commonly utilized in ecology to describe community composition changes. The aim of NMDS is to collapse high-dimensional multivariate data from multiple communities and sites into a fewer dimensions to make it easier to visualize and interpret the data. Interpretation of the data is simple; the closer the points (sites/communities) are on the figure, the more similar they are.

As ground beetles have limited home ranges, each site can be considered its own community. In comparing the ground beetle communities, the community composition from impacted sites was different than the community composition observed at reference sites (Figure 3.4.7.5). Within each of the reference sites there was also a noticeable gap between reference sites located in Freels Bend versus reference sites located around the ORR. This suggests there may be a functional habitat difference between Freels Bend and the other NEON reference sites.

(Continued on Next Page - Figure 3.4.7.5)



Note: *NMDS* - Non-metric multidimensional scaling

Figure 3.4.7.5: NMDS for Similarity in Sites and Ground Beetle Community Composition.

INDICATOR SPECIES ANALYSIS

Indicator Species Analysis (ISA) is used to identify species that are characteristic to specific sites or environmental conditions. The indicator value index from an ISA is comprised of two components: component A and component B. Component A (Comp A) is a *specificity predictive value* that is a sample estimate of the probability that a sampled site belongs to a target conditional group given that a certain species is found. Component B (Comp B) is a *sensitivity value* that is a sample estimate of the probability of finding a species in sites belonging to a target conditional group. For example, where Comp A = 1.000, a species is a good indicator for a group because it occurs in sites only belonging to that group. Where Comp B = 1.000, all sites belonging to a group contain a particular species. So if "Species X" has a Comp A = 1.00 and Comp B = 1.00, it is a perfect indicator species because it is found at sites that only correspond to a single group, and every site within that single group has collected "Species X." In other words, Comp A is a measure of the probability that a carabid community is located in an impaired/reference area if a particular beetle species is found, and Comp B is a measure of the probability that a particular species will be present if its community is sampled from an impaired/reference area. As an example from Table 3.4.7.1, *Sphaeroderus stenostomus* is a good indicator species for the Reference Site group type (Comp A = 1.000) because it only occurs at reference sites, but not all reference sites within the group have captured *Sphaeroderus stenostomus* (Comp B = 0.615).

After performing an ISA with R software (CRAN 2025), seven (7) unique species have been identified as possible indicator species for reference sites, and three (3) possible indicator species have been identified for impacted sites (Table 3.4.7.1). Of those ten (10) total species, the first three for reference sites (*Sphaeroderus stenostomus*, *Cyclotrachelus sigillatus*, and *Myas coracinus*) and the first species listed for impacted sites (*Chlaenius emarginatus*) were the most likely to be ideal indicator species.

Table 3.4.7.1: Indicator species - Impacted vs. Reference Sites

Site Type	Indicator Species	Comp A	Comp B
Reference	<i>Sphaeroderus stenostomus</i> **	1.000	0.615
	<i>Cyclotrachelus sigillatus</i> *	0.928	0.615
	<i>Myas coracinus</i> *	0.954	0.538
	<i>Dicaelus dilatatus</i> *	0.8088	0.615
	<i>Dicaelus politus</i> *	1.000	0.461
	<i>Dicaelus ambiguus</i> *	1.000	0.384
	<i>Pterostichus sayanus</i> *	1.000	0.384
Impacted	<i>Chlaenius emarginatus</i> *	0.917	0.727
	<i>Harpalus protractus</i> *	0.914	0.545
	<i>Pterostichus atratus</i> *	1.000	0.363
p-values: * = <0.05, ** = <0.01			

3.4.8 CONCLUSIONS

To utilize ground beetles as a bioindicator of terrestrial habitat quality, several population characteristics were evaluated as potential “markers” for environmental health. Species richness increased when moving downstream and was lower for impacted zones than for reference zones. The observed spatial pattern in species richness is consistent with reduced contaminant influence, but without additional co-measured environmental data (e.g., Hg/MeHg concentrations, habitat covariates) it is hard to attribute causation. These patterns could also reflect natural downstream biodiversity gradients.

Shannon Diversity Index scores showed similar spatial trends to species richness. The more downstream zones had greater diversity in the ground beetle communities than zones upstream and closer to Y-12. This spatial trend suggests that potential contaminant inputs from Y-12 could decrease species diversity in ground beetle communities. Conversely, dominance scores increase from downstream to upstream EFPC zones. This is expected as it suggests lower community diversity. This could potentially occur if some species are more tolerant of environmental changes than others; dominance of tolerant species would increase as environmental quality declines.

MIB Index scores displayed similar spatial trends to species diversity and richness. Decreases in MIB at more upstream zones is possibly an indicator of impacts to body condition from exposure to poor quality habitat. Upstream zones are closer to contaminant inputs from Y-12. Contaminant inputs to EFPC (predominantly mercury) could be impacting environmental health which in turn decreased community diversity and ground beetle body condition demonstrated by decreases in biomass.

Ground beetle community composition also reflected a difference between impacted and reference site, with particular indicator species associated with each site type (Table 3.4.7.1). The dataset contributing to this analysis is still relatively small, which likely impacts the indicator species analysis. For example, a species may be uniquely identified at a site because there has not been enough time allowed to capture it at other sites. Thus, it appears to be significantly associated with a particular location. Additional sampling and data will make this type of analysis more robust and informative.

3.4.9 RECOMMENDATIONS

ORR Biota receive ongoing contaminant inputs via EFPC that can transition to terrestrial ecological systems as a result of flooding, deposition, or movement of ecological receptors between habitat types. This exposure warrants additional consideration to support final clean-up decisions in the future. While the focus is currently centered around heavy metals with more severe and acute physiological consequences (e.g., Hg and MeHg), EFPC has other COCs that

have been monitored less frequently in terrestrial biota (e.g., Uranium). Thus, expanding monitoring efforts to include radionuclides and their associated heavy metals may be valuable. Moving forward, focusing monitoring efforts on bioindicator species may be a useful tool to identify heavily impacted areas and focus sampling efforts where they are likely to have the greatest impact. Additional sampling and monitoring of ground beetle communities will continue to support building a more robust data set. Elevated concentrations of contaminants in EFPC warrant continued monitoring until EFPC has been fully remediated for all media types.

3.4.10 REFERENCES

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3.4.11 SUPPLEMENT– SPECIES AND HABITAT DESCRIPTION

Table A.1: List of Captured Species with Habitat Descriptions

Species	Species/Habitat Description ¹	Sites Captured
<i>Agonoleptus thoracicus</i> ^{4,10}	Unknown feeding guild; Strongly favored by human activities and spring floods along large rivers. Grasslands, prairies, sagebrush areas, meadows, rangelands, pastures, cultivated fields (e.g., corn, wheat, clover), old fields, pastures, lawns, vacant lots, roadsides, sand pits, gravel pits, ski fields, orchards (e.g., peach), forest edges and clearings, and light woods. Open ground; dry, usually sandy soil covered with sparse vegetation.	FBR07
<i>Agonum</i> sp ^{3,4}	Insectivore; Deciduous woodland swamps, flood-plain forests, eutrophic marshes (Salix), marshy borders of slow rivers, brooks, and drainage channels. Ground shaded by trees and shrubs; soft, wet, clayish or muddy soil, rich in organic debris, covered with moderate or dense vegetation (e.g., Typha, Solanum, grass). Nocturnal; sheltering during the day under dead leaves, depressed grass, and stones (Habitat taken from <i>Agonum palustre</i>).	EFK 22.4, EFK 22.0, EFK 3.1
<i>Amara impuncticollis</i> ⁸	Herbivore, sometimes insectivore (lepidopterous caterpillars, grasshopper); grasslands, meadows, pastures, rangelands, lawns, cultivated fields, abandoned fields, gravel pits, sand pits, roadsides, forest edges and clearings, and open forests. Open ground; moderately dry, often sandy soil covered with rich discontinuous vegetation (e.g., weeds)	FBR06
<i>Amphasia interstitialis</i> ^{3,4,8}	Omnivore; Deciduous flood-plain forests. Shaded ground; wet, clayish or muddy soil, rich in organic debris. Nocturnal; sheltering during the day under dead leaves, logs, and stones.	FBR03, EFK 3.1

Species	Species/Habitat Description ¹	Sites Captured
<i>Anisodactylus</i> sp ^{4,8}	Omnivore; Cultivated fields (e.g., alfalfa, cotton, soybean), grasslands, pastures, pecan fields, orchards (e.g., peach), blowouts, upper zone of brook borders. Open ground; sandy soil covered with some vegetation. Nocturnal; sheltering during the day under dead leaves, stones, logs, and fallen tree bark (Habitat taken from <i>Anisodactylus furvus</i>).	FBR03, FBR04. FBR06, FBR07, EFK 3.8
<i>Brachinus alternans</i> ^{2,4,8}	Insectivore; River banks, swamps, low forests, salt meadows, and cultivated fields (e.g., corn). Shaded or open ground; moist, sometimes saline soil. Nocturnal; sheltering during the day under pieces of wood and logs.	FBR03, FBR04, FBR06, FBR07, EFK 13.8
<i>Calathus opaculus</i> ⁸	Insectivore; Meadows, old fields, pastures, vacant lots, cultivated fields (e.g., corn, tobacco, soybean, alfalfa), lawns, hedges, sandhills, sand pits, orchards (e.g., peach, plum), forest edges, and open forests (e.g., Quercus). Open (mostly) or shaded ground; dry, sandy soil covered with sparse or patchy low vegetation (e.g., grass, herbs).	FBR04, EFK 22.7, EFK 13.8
<i>Chlaenius aestivus</i> ⁸	Carnivores; Flood-plain forests along large rivers, small brooks, and lakes. Moist habitats, well away from open water (Lake Erie islands). Shaded ground; moist or wet, clayish, muddy or sand-mixed clay soil.	FBR03, EFK 16.5, EFK 3.8
<i>Chlaenius amoenus</i> ^{4,8}	Predatory; Deciduous forests. Moderately moist soil. Nocturnal; sheltering during the day in leaf litter.	FBR04, EFK 18.5, EFK 18.4, EFK 3.8, EFK 1.9
<i>Chlaenius emarginatus</i> ^{3,4,8}	Insectivore; Deciduous forests: along paths, roadsides, small openings, clearings, and edges. Cultivated fields (rarely; e.g., corn). Shaded ground; moderately moist, gravelly or sandy soil. Nocturnal; sheltering during the day under well-embedded stones, logs, pieces of wood, and dead leaves.	FBR03, FBR07, EFK 22.0, EFK 18.5, EFK 18.4, EFK 16.5, EFK 13.8, EFK 3.8, EFK 3.1, EFK 1.9

Species	Species/Habitat Description ¹	Sites Captured
<i>Chlaenius erythropus</i> ⁸	Insectivore; Mature flood-plain forests: along rivers. Edges of swamps, lakes, and ponds. Cultivated fields (rarely; e.g., corn). Shaded ground; wet or moist, clayish, sandy or muddy soil.	EFK 18.4
<i>Chlaenius laticollis</i> ⁸	Insectivore; Swamps, swamp-forests; borders of lakes, ponds, and rivers; cultivated fields (e.g., corn) and pastures. Shaded ground; moist or wet, muddy, clayish or sandy soil	EFK 16.5
<i>Chlaenius tricolor</i> ⁸	Insectivore; Border of large rivers, lakes, ponds, marshes, and pools; flood-plain forests. Deciduous forests: along edges, paths, and openings. Orchards (e.g., apple), pastures, and cultivated fields (e.g., tobacco, barley, asparagus, alfalfa, soybean, potato, corn, carrot, cabbage). Often at a considerable distance from water. Open or shaded ground; firm, wet or moist, gravelly, sandy or muddy soil.	EFK 16.5
<i>Cyclotrachelus fucatus</i> ^{4,11}	Unknown feeding guild; Forests (e.g., deciduous). Shaded ground; moderately moist soil. Nocturnal; sheltering during the day in leaf litter	EFK 1.9
<i>Cyclotrachelus sigillatus</i> ^{4,8}	Unknown feeding guild; Deciduous forests (mostly; e.g., Ulmus, Acer, Castanea, Fagus, Quercus, Magnolia, Carya), mixed forests (e.g., Quercus, Carya, Pinus), coniferous forests (e.g., Pinus), pastures, grasslands, low prairies, and cultivated fields (e.g., tobacco, corn). Shaded (mostly) or open ground; moderately moist soil covered with thick leaf litter or grass. Nocturnal; sheltering during the day in leaf litter (mostly), under stones, logs, pieces of wood, and other debris	FBR07, EFK 1.9

Species	Species/Habitat Description ¹	Sites Captured
<i>Cyclotrachelus sodalis</i> ^{4,6,7}	Insectivore; Cultivated fields (e.g., corn, alfalfa, sweet clover), pastures, meadows, fencerows, roadsides, and farm yards. Open ground; dry soil covered with some vegetation (e.g., grass). Nocturnal; sheltering during the day under pieces of wood.	EFK 1.9
<i>Cylindera unipunctata</i> ^{4,8,9}	Unknown feeding guild	EFK 1.9
<i>Dicaelus ambiguus</i> ^{4,8}	Unknown feeding guild; Forests (mostly; deciduous, mixed); cultivated fields (e.g., cotton). Moderately moist soil. Nocturnal; sheltering during the day under stones.	FBR03
<i>Dicaelus dilatatus</i> ⁸	Insectivore; Deciduous forests (mostly; e.g., Acer, Quercus), mixed forests (Pinus, Quercus), forest edges, open fields, grasslands, pastures, and cultivated fields (e.g., corn). Shaded (mostly) or open ground; moderately moist soil covered with thick leaf litter.	EFK 1.9
<i>Dicaelus elongatus</i> ^{4,6,7,8}	Insectivore; Deciduous forests (mostly), hillsides, swamps, and old fields. Shaded ground; moderately moist soil. Nocturnal; sheltering during the day under stones (mostly), logs, pieces of wood, and among dead leaves. Larval habitat: woods, under stones.	FBR04, FBR06, EFK 22.0, EFK 18.5
<i>Dicaelus furvus</i> ⁸	Unknown feeding guild; Deciduous forests. Flood-plain forests: along river banks. Shaded ground; moist soil.	FBR04, FBR06, EFK 18.4, EFK 3.8
<i>Dicaelus politus</i> ⁸	Insectivore; Deciduous forests (mostly; e.g., Acer, Quercus) and mixed forests (e.g., Pinus, Tsuga, Fagus, Quercus, Carya). Shaded ground; rather moist soil covered with thick leaf litter.	FBR06
<i>Dicaelus purpuratus</i> ⁸	Insectivore; Open forests. Shaded ground; rather dry soil.	FBR06

Species	Species/Habitat Description ¹	Sites Captured
<i>Galerita bicolor</i> ^{4,5,8}	Insectivore; Deciduous forests (mostly), coniferous forests (e.g., Pinus), forest clearings, and cultivated fields (e.g., peanut, alfalfa). Shaded ground; moderately moist soil. Nocturnal; sheltering during the day under the loose bark of rotten logs, in rotten tree-stumps, under logs, pieces of wood, and stones.	FBR03, FBR04, FBR06, FBR07, EFK 22.7, EFK 22.0, EFK 18.5, EFK 18.4, EFK 13.8, EFK 3.1, EFK 1.9
<i>Galerita janus</i> ^{4,5,8}	Insectivore; Deciduous forests, their clearings and edges, hedges, orchards, and adjacent cultivated fields (e.g., corn, alfalfa, wheat, soybean, tobacco), meadows, pastures, vacant lots, relict prairies, wastelands, fencerows, and gravel pits. Shaded or open ground; moderately moist soil, often covered with thick leaf litter. Nocturnal; sheltering during the day under the loose bark of logs and fallen trees, under logs, stones, pieces of wood, in leaf litter, and under other debris.	EFK 18.5
<i>Harpalus</i> sp ^{4,8}	Omnivore; Meadows, pastures, relict prairies, wastelands, cultivated fields (e.g., corn, soybean, tobacco, alfalfa), semi-open fields, fencerows, gardens, gravel pits, roadsides, forest edges, and open forests (e.g., Quercus). Open ground; rather dry, sandy or clayish soil covered with some vegetation (e.g., grass). Nocturnal; sheltering during the day under stones, dead leaves and plants, and pieces of wood (Habitat taken from <i>Harpalus erythropus</i>).	FBR03, FBR04, FBR07, EFK 22.0, EFK 21.8, EFK 18.5, EFK 18.4, EFK 16.5, EFK 13.8, EFK 3.8, EFK 3.1, EFK 1.9
<i>Myas coracinus</i> ⁸	Unknown feeding guild; Deciduous forests (e.g., Quercus). Shaded ground; loose, moderately moist soil covered with thick leaf litter, logs, pieces of wood, and stones.	EFK 3.1

Species	Species/Habitat Description ¹	Sites Captured
<i>Olisthopus parmatus</i> ^{3,4}	Insectivore; Deciduous forests (mostly; e.g., Acer, Quercus), mixed forests (often along brooks), forest clearings, roads, and edges; hedges and swampforests. Shaded ground; moderately moist, often sandy or gravelly soil covered with thick leaf litter. Nocturnal; sheltering during the day in leaf litter.	EFK 18.5, EFK 16.5, EFK 3.1
<i>Pasimachus punctulatus</i> ⁸	Insectivore; Grasslands, pastures, wastelands, and open forests (deciduous, mixed). Open ground; dry, sandy soil covered with some vegetation (e.g., grass).	EFK 1.9
<i>Pterostichus atratus</i> ⁸	Herbivore; Mostly forests (mixed or deciduous); also neighboring cultivated fields (e.g., tobacco, alfalfa). Shaded ground; moderately moist soil.	EFK 22.7, EFK 22.0, EFK 16.5, EFK 3.1
<i>Pterostichus coracinus</i> ^{4,8}	Insectivore; Mostly forests (deciduous, mixed, coniferous); forest clearings, edges and roadsides; tree plantations (e.g., Pinus) and orchards. Also wastelands, cultivated fields (e.g., wheat, tobacco, corn), and meadows. Shaded or open ground; usually moderately moist soil (wet in coastal areas) covered with thick leaf litter (in forests) or some vegetation (in open country). Nocturnal; sheltering during the day under dead leaves, stones, and in rotten logs.	EFK 1.9
<i>Pterostichus permundus</i> ^{4,8}	Open forests (deciduous, e.g., Quercus, Carya; mixed, e.g., Quercus, Pinus; sometimes coniferous, e.g., Pinus), groves, and thickets: often along ravines and streams. Cultivated fields (e.g., corn, soybean, cotton, oat, alfalfa, sweet clover), old fields, prairies, lawns, vacant lots, fencerows, and upper zone of brook banks. Shaded or open ground; moist soil consisting of sand or clay loam, covered with leaf litter (in wooded areas) or moderate to dense vegetation (in open areas). Nocturnal;	EFK 18.5

Species	Species/Habitat Description ¹	Sites Captured
	sheltering during the day under logs, pieces of wood, and stones.	
<i>Pterostichus stygicus</i> ^{3,4,8}	Insectivore; Mostly forests (deciduous, e.g., Acer, Quercus; mixed; rarely coniferous): often along streams. Also their edges, clearings, and roadsides. Adjoining hedges, cultivated fields (e.g., corn, soybean), grasslands (short-grass), relict prairies, and fencerows. Shaded (mostly) or open ground; wet or moist soil covered with thick leaf litter (in forests) or moderate to dense vegetation (in open areas). Larval habitat: under the loose bark of logs.	EFK 21.8, EFK 18.5, EFK 18.4, EFK 3.1, EFK 1.9
<i>Scarites subterraneus</i> ^{2,4,8}	Insectivore; Borders of rivers, lakes, ponds, and irrigation canals; roadsides, gardens, lawns, urban and rural parks, vacant lots, old fields, wastelands, pastures, cultivated fields (e.g., corn, soybean, peanut, alfalfa, cabbage, cotton, tobacco), field edges, seed beds, orchards (e.g., citrus, apple), forest edges, and open forests. Open ground; moderately moist, sandy, clayish or muddy, rarely gravelly soil covered with some vegetation.	FBR07, FBR06, FBR04, EFK 22.7, EFK 22.4, EFK 16.5, EFK 1.9
<i>Sphaeroderus bicarinatus</i> ⁸	Invertivore (snails); Forests (deciduous, mixed, coniferous). Shaded ground; moderately moist soil covered with thick leaf litter.	EFK 1.9
<i>Stenolophus ochropezus</i> ⁸	Herbivore; Borders of eutrophic marshes, ponds, lakes, and pools; swamps, swamp-forests, flood-plain forests, mud flats, wet meadows; borders of slow rivers, brooks, irrigation canals, and roadsides; sand pits and gravel pits with temporary water; beaver houses. Open (mostly) or shaded ground; poorly drained, soft, wet, clayish or muddy soil covered with dense vegetation (e.g., grass, Typha).	FK 16.5

Species	Species/Habitat Description ¹	Sites Captured
<i>Trichotichnus dichorus</i> ⁸	Insectivore; Deciduous forests. Shaded ground; wet or dry soil.	FBR04
<i>Trichotichnus fulgens</i> ^{4,8}	Unknown feeding guild; Open deciduous forests, pastures, cultivated fields (e.g., alfalfa), old fields, grasslands, vacant lots, and roadsides. Open or shaded ground; moderately dry, sandy or gravelly soil covered with dead leaves or grass. Mostly diurnal; active in the sunshine; sheltering on cloudy and cool days under dead leaves (mostly) and plants, stones, and other debris.	FBR03, FBR04, FBR06, FBR07
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3.5 RADIOLOGICAL UPTAKE IN FOOD CROPS

3.5.1 BACKGROUND

DOE conducts sampling of locally grown food crops, hay, and milk for many years to look for the uptake of contaminants in these products due to ORR activities. This is done to ensure that the health of residents is not being negatively impacted by consuming such products directly (vegetables, milk) or indirectly (hay as a precursor to milk for grazing animals). DOE requested that DoR-OR conduct similar sampling, which became the *Radiological Uptake in Food Crops* project, with the first samples collected in August of 2019. Each agency conducts separate sampling and radiological analysis on these locally grown products to look for any possible uptake of radiation. Sampling is done near or on the ORR and at reference locations farther from the ORR for comparison.

DOE initially conducted vegetable sampling at their perimeter monitoring stations on the ORR from 1992 to 1996. The focus then shifted to sampling at farms and gardens near the ORR. Their hay sampling later shifted from multiple locations on and near the ORR to only having one location at the far eastern edge of the ORR that is harvested for hay by an offsite operation.

Prior to 2017, cow milk was sampled from a dairy in Claxton, near the ORR, and at a few other local dairies as reference sites. There has not been any milk sampled since 2016 because the Claxton Dairy shut down and there have been no other dairy options found near the ORR by DOE staff, though they check each year (DOE, 2017; DOE, 2024). DOE's sampling plans and results for radiological uptake in vegetables, hay, milk (when available), and other media are documented in the annual DOE Environmental Monitoring Plan and ASER (DOE, 2022; DOE, 2024).

DoR-OR FY25 sampling again aimed to address monitoring gaps in vegetable and animal byproduct sampling, where DOE has not been able to complete sampling in recent years.

3.5.2 PROBLEM STATEMENTS

- ORR radiological contaminants have been released into the atmosphere, groundwater, surface water, soils, and sediment, which then has the potential to accumulate in plants and animals used as food sources.
- Contaminants could be disturbed by DOE ORR activities, become airborne, and spread outside of the ORR.
- Members of the public may have the potential to be exposed to doses of ORR radiological contaminants through the consumption of locally grown food crops and animal products.

3.5.3 GOALS

- Collect and analyze samples to determine if there was radiological contamination in food crops, hay, and animal products due to DOE activities and hence present a risk to human health through consumption.
- To check DOE's comparable sampling data to see if it showed any indications of radiological contamination off the ORR.

3.5.4 SCOPE

In FY25, this project collected and analyzed samples of hay, animal products, and food crops from within a five-mile radius of the ORR for radiological contaminants (Figure 3.5.5.1). These samples were compared to samples taken from reference locations greater than five miles from the ORR boundary.

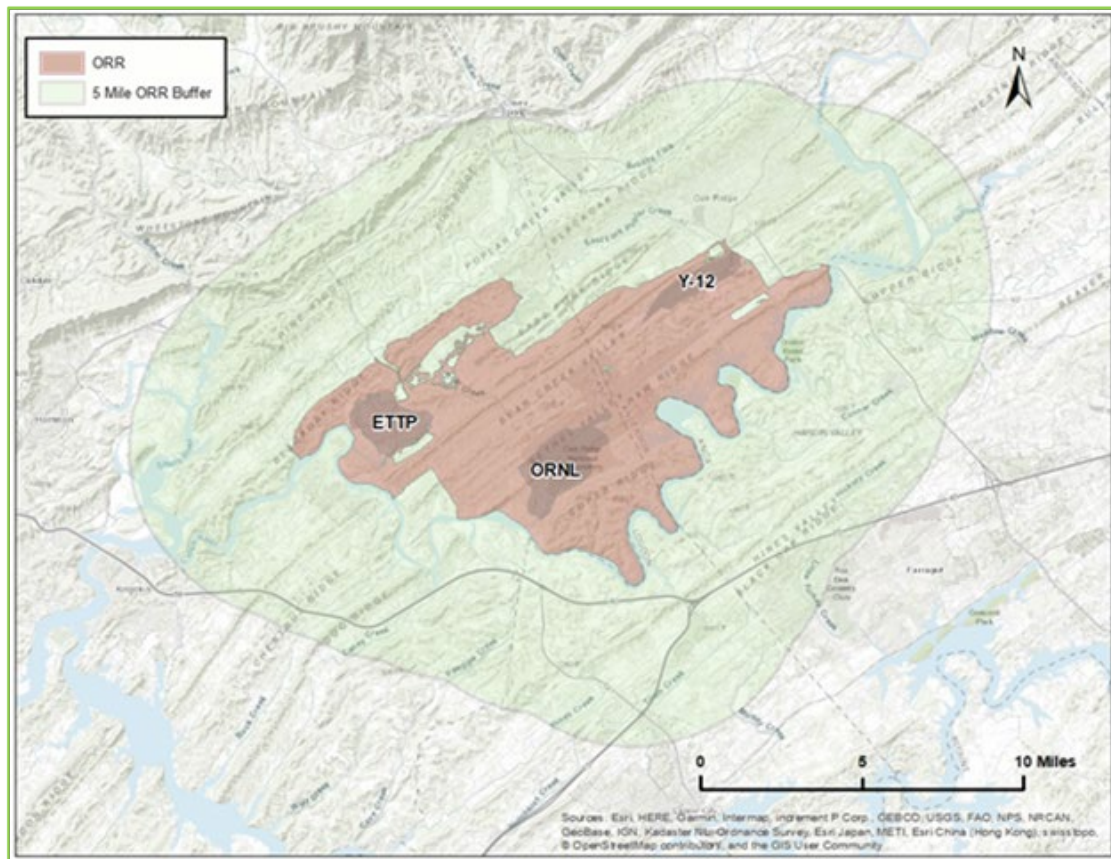


Figure 3.5.4.1: Five-Mile Radius Around ORR for Food Crops Sampling

3.5.5 METHODS, MATERIALS, METRICS

In 2024, project staff collected samples of hay, food crops (root vegetables, fruiting vegetables, leafy vegetables), and animal products (eggs) from within five miles of the ORR per the Food

Crops sampling SOP (TDEC, 2024). Samples were also collected for each food crop type, hay, and eggs, from corresponding reference locations. Sampling began in July, at the start of the State of Tennessee fiscal year, and samples were mostly collected during July and August, with three additional samples collected in November (i.e., two leafy green samples and one egg sample). The reference locations are over five miles from the ORR boundary and considered unimpacted. Vegetable and hay samples were analyzed for gross alpha, gross beta, and gamma emitting radionuclides. Egg samples were collected and analyzed for gross alpha and gross beta activity, gamma, and tritium. Additional isotopic analysis could have been requested if indicated by elevated gross alpha or gross beta results.

Radiological results were determined to be laboratory detections if the measured result exceeded the sample specific critical level (Lc) or decision level values. A detection does not automatically indicate an elevated result, just one that is detected by laboratory analysis with 95 percent certainty.

3.5.6 DEVIATIONS FROM THE PLAN

Milk samples were not readily available in 2024, for either cow or goat milk. Instead, chicken eggs were collected and analyzed as a different type of animal product. These locally consumed chicken eggs were collected from households within five miles of the ORR. Egg samples were collected and analyzed for the same isotopes as the vegetation samples, plus tritium.

3.5.7 RESULTS AND ANALYSIS

DoR-OR SAMPLING

As noted, vegetable, hay, and egg samples were collected within five miles of the ORR (Figure 3.5.4.1). Reference samples from locations greater than five miles from the ORR were used to establish background levels. Results from this project are also compared to similar sampling by DOE, as published in the ASER.

The results of the 2024 food crops sampling (FY25) are shown in Tables 3.5.7.1 (vegetables), Table 3.5.7.2 (hay), and Table 3.5.7.3 (eggs). There were 52 samples analyzed, with 45 vegetation samples (10 hay, 35 vegetable or fruit) and seven egg samples analyzed.

Those radiological results that were “detections” are shown in the tables below if the measured result exceeded the sample specific **Lc** (critical level) values. All blank cells with no data listed did not meet these criteria, indicating no radiological contaminants were detected above Lc levels. Sample sites highlighted in yellow in the tables are background or reference locations and are located at a distance greater than five miles from the boundary of the ORR.

VEGETATION: VEGETABLES AND HAY

The vegetable and hay sampling results are shown in Tables 3.5.7.1 and 3.5.7.2, respectively. For all of the types of vegetable samples analyzed (leafy greens, fruiting vegetables or fruits, and root vegetables), none had alpha activity or gamma isotopes (other than K-40 and Be-7, both naturally occurring isotopes) detected. The results for each vegetation type were compared to two times the highest reference location value for the vegetables and fruits, for each analysis type, as available.

Analyses with results greater than twice max reference value are highlighted in bold text. Most of the results were well below these values, with one exception. The plantain sample had beryllium-7 (Be-7) levels higher than twice background, but again, it is a naturally occurring isotope (Table 3.5.7.1).

Table 3.5.7.1: DoR-OR 2024 Vegetable Sampling Results (PCi/g)

Location			Alpha activity	Beta activity	gamma		
Max Veg Reference				5.80	4.85	0.00	
Max Veg Reference x 2				11.60	9.7	0.00	
vegetables & fruits	FC-13R	Reference (Clinton)	bell pepper			3.18	
	FC-13R	Reference (Clinton)	cucumber			3.35	
	FC-13R	Reference (Clinton)	tomato		5.80	2.13	
	FC-63R	Reference (Morgan Co)	zucchini squash		1.36	4.85	
	FC-23	SW of ORNL	cucumber		1.90		
	FC-23	SW of ORNL	pepper				
	FC-31	SE of ORNL	okra		2.82	2.95	
	FC-33	N of Y-12	banana pepper				
	FC-33	N of Y-12	cucumber		2.03		
	FC-33	N of Y-12	tomato				
	FC-35	NE of Oak Ridge	butternut squash		1.71	3.88	
	FC-35	NE of Oak Ridge	tomato			2.88	
	FC-35	NE of Oak Ridge	yellow squash		1.72	3.60	
	FC-55	N of Y-12	cucumber				
	FC-64	NW of Y-12	cucumber		1.91		
	FC-64	NW of Y-12	zucchini squash		2.18	4.28	
	FC-65	West of Y-12	yellow squash		2.04		
	FC-66	West of Y-12	cucumber				
	FC-69	WNW of ETPP	cucumber				
	FC-69	WNW of ETPP	tomato		1.84		
	FC-69	WNW of ETPP	zucchini squash				
root vegetables	FC-59	SE of Y-12	pear			1.21	
	FC-69	WNW of ETPP	apple			1.15	
	FC-12R	Reference (Clinton)	potato			5.37	
	FC-35	NE of Oak Ridge	beet			5.52	0.14
	FC-35	NE of Oak Ridge	onion			2.65	
leafy greens	FC-35	NE of Oak Ridge	potato		5.96	4.73	
	FC-59	SE of Y-12	chickory root			3.61	0.32
	FC-13R	Reference (Clinton)	cruciferous greens			3.39	1.09
	FC-28	SE of ORNL	mint		2.39		
	FC-33	N of Y-12	mustard greens		2.22	3.71	
	FC-34	NE of Y-12	lemon balm		4.65	7.99	2.03
	FC-59	SE of Y-12	plantain		6.08		5.21
	FC-64	NW of Y-12	mustard greens			4.45	
	FC-69	WNW of ETPP	mustard greens			4.60	

reference locations

blank cells = non-detects, only detects are shown
Data bars grouped by radiation type or isotope, to show relative amounts visually

The slightly higher gross beta levels seen in the reference tomato sample could have been due to NPK fertilizer use, though the potassium-40 (K-40) level was relatively low compared to the other levels of K-40 detected in the other vegetable samples. The slightly higher reference potato K-40 level could also have been due to NPK fertilizer use, though interestingly, it did not result in significantly higher gross beta levels (gross beta was at a non-detect level), and K-40 is also a beta emitter.

HAY

The hay sample gamma results in Table 3.5.7.2 were similar to those of the vegetable samples in the prior table, but with beryllium-7 detected for each sample. The gross beta activity levels were similar to those seen for the vegetable samples and can be used for comparison since there was no detected beta activity above Lc levels for the reference hay sample.

Table 3.5.7.2: DoR-OR 2024 Hay Sampling Results (pCi/g)

Location			Alpha activity	Beta activity	gamma		
					K-40	Be-7	Cs-137
Max Hay Reference					5.48	2.09	
Max Hay Reference x 2					10.95	4.18	
FC-9	SE of Y-12	hay			6.85	1.92	
FC-11	N of Y-12	hay			5.91	2.06	
FC-12R	Reference- Clinton	hay			5.48	2.09	
FC-16	South of ETPP	hay		2.02		4.56	
FC-23	SW of ORNL	hay			6.38	1.39	
FC-28	SE of ORNL	hay				3.14	
FC-38	N of ETPP	hay		3.96		5.98	
FC-39	NE of ETPP	hay			4.78	3.40	
FC-68	Y-12 area	hay		5.12		2.63	
FC-72	ENE of ORNL	hay			7.07	2.29	

reference locations blank cells = non-detects, only detects are shown
 Data bars grouped by radiation type or isotope, to show relative amounts visually

No additional analyses were needed for any of the vegetation samples, as indicated by no elevated gross alpha or gross beta results, at any of the home garden or hay locations in 2024. The low-level concentrations that were detected were comparable to background locations outside a 5-mile radius of potential impact from the ORR.

ANIMAL PRODUCTS:

Eggs

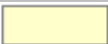
Due to prior difficulty finding cow and goat milk samples, egg samples from chickens were

collected as the sampled animal product because residents are raising and consuming this food. The egg data is shown in Table 3.5.7.3. Seven egg samples were collected from a total of seven locations, with each sample consisting of 6 eggs.

Only K-40 and Be-7 radiological detections were observed in each six-egg sample, with both isotopes occurring naturally. Four of the seven egg samples had low level K-40 detections, and one had a Be-7 detection, all at lower levels than seen in the vegetable and hay samples. All other sample results did not even meet the criteria to be considered detects.

Table 3.5.7.3 FY25 2024 Egg Results (pCi/g)

Location			Alpha activity	Beta activity	beta H-3	gamma		
						K-40	Be-7	Cs-137
Max Chicken Egg Reference						NA	NA	
Max Chicken Egg Reference x 2								
FC-59	SE of Y-12	whole eggs				1.2	0.49	
FC-63R	Reference- Morgan Co	whole eggs						
FC-66	W of Y-12	whole eggs						
FC-67	SE of ORNL	whole eggs						
FC-70	SW of ORNL	whole eggs				2.13		
FC-71	East Oak Ridge	whole eggs				1.95		
FC-73	W of ORNL	whole eggs				1.14		

 reference locations blank cells = non-detects, only detects are shown
 Data bars grouped by radiation type or isotope, to show relative amounts visually

DOE ASER COMPARISONS

The most recent DOE ORR ASER data was from 2023 in the 'ORR Environmental Monitoring Program' in section 6.6 (DOE, 2024). In 2023, DOE sampled tomatoes (5 samples), cabbage (2 samples), and hay (1 sample). In 2022, DOE sampling was limited to tomatoes (4 samples) and hay (1 sample) (DOE, 2023). DOE 2022 and 2023 detected concentrations in vegetables and hay are listed in Table 3.5.4.

VEGETABLES

The DOE vegetable results were converted to the same units (pCi/g) used for the DoR-OR data. Only data with results above detection limits were shown in the 2022 and 2023 ASER, with non-detects listed as "m". Detection limits are likely not the same between DOE and DoR-OR sampling projects as different laboratories were used.

Table 3.5.4: 2022 & 2023 DOE Vegetables and Hay Radionuclide Results

2022 Detected Concentrations (pCi/g)								
sample type	location	gross alpha	gross beta	gamma		isotopic uranium		
				K-40	Be-7	U-234	U-235	U-238
Tomatoes	North of Y-12	m	2.03	1.97	m	m	m	m
Tomatoes	East of ORNL	m	1.81	1.68	m	m	m	m
Tomatoes	West of ETPP	m	1.46	1.20	m	m	m	m
Tomatoes	Reference	m	1.81	1.55	m	m	m	m
Hay	East ORNL	m	4.65	9.92	7.02	m	m	m
m = values less than or equal to minimum detectable activity								
2023 Detected Concentrations (pCi/g)								
sample type	location	gross alpha	gross beta	gamma		isotopic uranium		
				K-40	Be-7	U-234	U-235	U-238
Tomatoes	North of Y-12	m	2.53	2.85	m	m	m	m
Tomatoes	East of ORNL	m	2.01	2.37	m	m	m	m
Tomatoes	West of ETPP	m	1.48	1.99	m	m	m	m
Tomatoes	South of ORNL	m	2.15	2.98	m	m	m	m
Tomatoes	Reference*	m	1.65	2.46	m	m	m	m
Cabbage	North of Y-12**	m	2.75	2.75	m	m	m	m
Cabbage	Reference	m	3.31	3.15	m	m	m	m
Hay	East ORNL***	m	1.93	7.44	2.34	m	m	0.009
m = values less than or equal to minimum detectable activity								
*Bismuth-214 detected in tomato sample from reference location (0.0316pCi/g)								
*Lead-214 detected in tomato sample from reference location (0.0368 pCi/g)								
**Thorium-230 detected in cabbage sample from north of Y-12 (0.0329 pCi/g)								
***Lead-210 detected in hay sample (0.710 pCi/g)								

DOE vegetable samples were analyzed for gross alpha, gross beta, gamma emitters, and uranium isotopes. The 2023 DOE vegetable gross beta and K-40 results were similar to the amounts seen by the 2023 DoR-OR sampling, with the results of most other analyses less than the minimum detectable activity.

HAY

Hay is a potential radiation exposure pathway to humans if meat, milk, or other animal products are consumed. DOE's single hay location results were similar to those listed for 2023 DoR-OR analyses (9 samples within five miles of the ORR and 1 reference location).

MILK

DOE did not collect any milk samples for analysis in 2023. The last milk analysis was performed in 2016, when a nearby dairy was still operating (DOE, 2024).

3.5.8 CONCLUSIONS

In general, for the vegetation samples (hay, vegetables) and egg samples collected in 2024, the low-level concentrations that were detected were comparable to background locations outside a five-mile radius of potential impact from the Oak Ridge Reservation boundary or were below the radiological critical levels used as detection limits. Overall, the TDEC DoR-OR FY2025 vegetable, hay, and egg sampling results did not indicate that DOE ORR activities are significantly impacting radionuclide concentrations in food crops in the areas surrounding the ORR, nor did the DOE data from the currently available ORR ASER (DOE, 2024).

3.5.9 RECOMMENDATIONS

DoR-OR recommends that additional vegetable, hay, and animal product (e.g. cow milk, goat milk, egg) sampling be conducted in order to generate a larger dataset to identify any trends in radionuclide uptake that may be present in the vicinity of the ORR and for comparison to DOE data. This is especially the case as DOE remedial activities are increasing at ORNL and Y-12, and there is greater potential for spread of contaminants near the ORR.

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3.6 RADIOLOGICAL UPTAKE IN VEGETATION – WHITE OAK CREEK

3.6.1 BACKGROUND

Throughout the ORR, there are areas with radiological contamination. Much of this existing contamination comes from past operations and buried waste. Current cleanup and other ongoing activities can contribute to the re-distribution of radiological contamination on the ORR. If surface water bodies have been impacted by radioactivity, vegetation in the immediate vicinity can uptake radionuclides, resulting in bioaccumulation of radiological contaminants. In these areas, vegetation can be sampled as a proxy of local contamination without disturbing the soils directly. Past vegetation sampling conducted by TDEC has also focused on areas likely to have radiological contamination, either from past or current DOE activities, at locations across the ORR.

White Oak Creek (WOC) is located on the ORR at Oak Ridge National Lab (ORNL). It originates in Bethel Valley and flows through a gap in Haw Ridge into Melton Valley. WOC then flows through Melton Valley and into White Oak Lake before entering the White Oak Embayment and ultimately exits the ORR and joins the Clinch River.

The primary radiological contaminants of concern (COCs) along WOC, associated with historical actions, are tritium (H-3), strontium-90 (Sr-90), cesium-137 (Cs-137), and cobalt-60 (Co-60). In FY25, this project looked at radiological uptake in vegetation along WOC and added data to the *White Oak Creek Assessment Project* (WOCAP; Chapter 9.1) which is a comprehensive evaluation of the ecological health of the WOC watershed.

At this time, DOE does not sample vegetation along WOC, or in other contaminated areas on the ORR as part of the work described in the ASER (DOE, 2023). This project filled the data gap by adding information about levels of radiological contaminant uptake by vegetation near WOC, including in more contaminated areas where sediment and soil samples have not recently been collected.

3.6.2 PROBLEM STATEMENTS

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

3.6.3 GOALS

- Obtain samples to determine the level of radiological contamination in herbaceous vegetation in three zones along radiologically contaminated WOC and at an upstream background location.
- Provide sampling data for the DoR-OR WOCAP.

3.6.4 SCOPE

Herbaceous vegetation was sampled in three zones along WOC (Figure 3.6.4.1). The three zones, starting in the lower left corner of the map, include:

- **Zone 1** - Melton Valley from Clinch River - White Oak Creek Embayment and White Oak Lake
- **Zone 2** - White Oak Creek in Melton Valley
- **Zone 3** - White Oak Creek in Bethel Valley (main plant)
- **Zone 4** - An upstream WOC site was used as a background location for comparison.

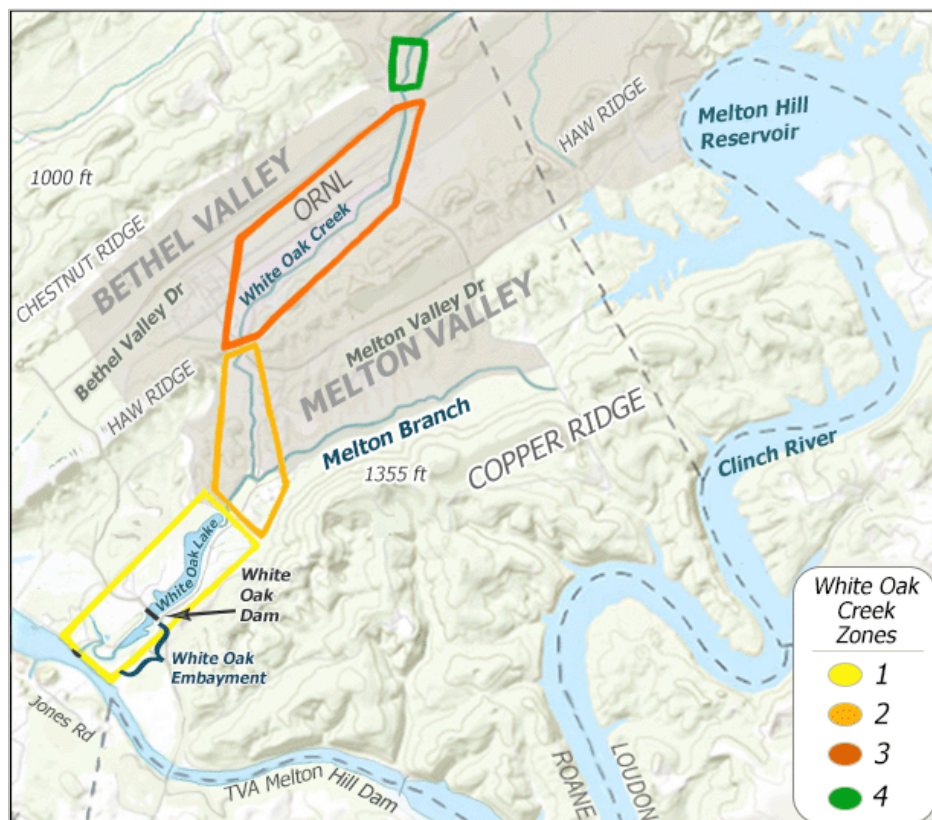


Figure 3.6.4.1: WOC Vegetation Sampling Zones

Samples were collected in July 2024, during the primary summer growing season. The vegetation samples had selected radiological analyses run. Data from this project will also be mentioned below in the watershed assessment, WOCAP (Chapter 9.1).

3.6.5 METHODS, MATERIALS, METRICS

Herbaceous (non-woody) vegetation was sampled in three impacted zones along WOC and at an upstream WOC location used as a background site. Above ground herbaceous tissue was collected to avoid soil contamination that may remain on roots. The plant types sampled were chosen based on availability and consistency across the sample zones. Grasses and cattails were the preferred target species as both do well with radiological contaminant uptake based on prior sampling, though cattails are generally available at only a few locations. Ideally, grasses would have been sampled at five locations for each of the contaminated zones along WOC had they been available at all locations. Project staff collected 18 samples, with multiple samples collected in each of the three contaminated zones along WOC, a QA/QC sample in each of the contaminated zones, and one sample at the background (upstream) location, in Zone 4 (Table 3.6.7.1). Primary samples (non-QA/QC) samples were collected at different locations in each zone where vegetation sampling sites were available. Duplicate samples were generally collected at the first location in each zone sampled with enough vegetation for two samples.

Samples were collected according to the SOP for Vegetation Sampling for Radiological Contamination (TDEC, 2024). Data from the three radiologically contaminated zones along WOC were compared to the data collected at the upstream background location. Duplicate (QA/QC) samples were used to check for consistency in lab results, though some variation was expected. Each sample consisted of approximately 500-1,000 grams of vegetation and was kept cool after collection to prevent spoilage before dropped-off at the lab. Samples were tested for radiological contaminants, with analyses run for gross alpha, gross beta, gamma isotopes, strontium 90, tritium, and isotopic uranium. Analyses were conducted by Eberline Analytical as the qualified environmental laboratory under contract. Radiological results were determined to be laboratory detections if the measured result exceeded the sample specific critical level (Lc) or decision level values. A detection does not automatically indicate an elevated result, just one that is measurable by laboratory analysis with 95 percent certainty.

3.6.6 DEVIATIONS FROM THE PLAN

While it was initially proposed that five distinct sampling locations could be sampled in each of the three contaminated zones, there were often not enough good sampling locations to do this where enough of the target or alternate species were present. When collection was not possible for mixed grasses across zones, other non-woody vegetation, such as cattails, river cane, and vine samples, was collected as available and to provide as comparable a data set as possible. Sample locations with enough of a single species or type of vegetation were even more difficult to come by than originally expected. When zones had fewer good sampling locations, two types of samples were collected at one location, such as a grasses sample and a cattail sample. Also, while it could have been ideal to only sample one vegetation type at all locations for more direct comparisons, this was also not an option. However, this was part of the contingency plan. Consequently, a large QA/QC split, or duplicate grasses sample was collected in each of the

three contaminated zones along White Oak Creek and Lake. Also, multiple vegetation types were collected along WOC, sometimes with two types collected at a single location within a zone.

3.6.7 RESULTS AND ANALYSIS

In Zone 1, a total of five samples were collected at two locations, with one cattail sample and one river cane sample collected, and the rest grasses (for more details see Table 3.6.7.1). In Zone 2, a total of six samples were collected at four locations, with one cattail sample and the remainder consisted of grasses. In Zone 3, a total of six samples were collected, with one river cane, two vines, and the rest grasses. The reference location in Zone 4 had a mixed grasses sample collected. The stations listed in Table 3.6.7.1 start with the most downstream location sample at the top (WOL Z1.1) and work their way up WOC (and down the table) to the most upstream location at WOC Z4.1, which was the background location used for comparison. Duplicate samples in the table have a 'd' after the zone and station name, such as WOC Z3.1d.

Table 3.6.7.1: July 2024 WOC Vegetation Sampling Results (pCi/g)

	Vegetation Type	Zone & Station	Gross Activity		Alpha			Beta		Gamma		
			Alpha	Beta	U-234	U-235	U-238	SR-90	H-3	K-40	Be-7	Cs-137
1	grasses	WOL Z1.1	-0.018	2.30	0.082	0.043	0.042	0.905	-23.75	2.63	1.37	0.102
2	grasses	WOL Z1.1d	0.160	4.35	0.072	0.024	0.047	0.772	0.00	4.15	0.06	0.042
3	cattails	WOL Z1.1	0.187	3.47	0.063	0.062	0.018	0.141	0.00	2.95	0.08	0.029
4	grasses	WOL Z1.2	0.181	4.82	0.092	0.038	0.060	0.082	95.88	1.28	0.02	0.031
5	river cane	WOL Z1.2	0.218	6.51	0.080	0.038	0.064	0.885	-6.18	2.65	1.87	0.125
6	grasses	WOC Z2.1	-0.013	4.25	0.074	0.075	0.068	0.806	29.80	2.97	0.45	0.122
7	grasses	WOC Z2.2	0.136	8.19	0.058	0.013	0.016	3.818	52.84	2.99	0.75	0.602
8	cattails	WOC Z2.2	0.094	5.70	0.127	0.067	0.065	1.337	55.49	1.77	0.02	0.495
9	grasses	WOC Z2.4	0.864	2.32	0.120	0.050	0.029	0.404	33.00	3.25	0.87	-0.011
10	grasses	WOC Z2.5	0.075	6.02	0.037	0.023	0.032	0.654	0.72	2.71	0.82	0.521
11	grasses	WOC Z2.5d	0.039	2.78	0.032	0.023	0.033	0.218	14.58	2.92	0.58	1.893
12	grasses	WOC Z3.1	0.071	4.99	0.047	0.037	0.031	1.688	25.68	2.78	0.73	0.521
13	grasses	WOC Z3.1d	0.068	6.41	0.122	-0.002	0.019	1.356	55.93	2.26	0.96	0.452
14	vine	WOC Z3.2	0.077	5.89	0.158	0.047	0.040	1.012	65.09	2.40	0.51	0.289
15	grasses	WOC Z3.3	0.088	2.46	0.062	0.023	0.043	0.157	-4.16	2.41	0.29	0.190
16	river cane	WOC Z3.4	0.041	1.15	0.137	0.044	0.034	0.151	-16.35	1.16	0.56	0.076
17	vine	WOC Z3.5	-0.043	4.87	0.087	0.039	0.044	0.111	3.35	2.93	0.60	0.000
18	grasses	WOC Z4.1	0.126	0.78	0.120	0.052	0.060	0.028	38.42	1.84	0.63	0.046

 non-detect via Lc
 duplicate

Color bar comparisons are applied in columns by isotopes/rad to detects

Vegetation type did not have a consistent effect on contaminant levels detected and can be considered comparable. Discrepancies between duplicate (WOL Z1.1d, WOC Z2.5d, WOC Z3.1d) and primary sample results (WOL Z1.1, WOC Z2.5, WOC Z3.1) were likely due to samples not being homogenized well enough before being split and analyzed at the laboratory.

Table 3.6.7.2: Average Values in WOC Zones 1-3 Compared to Zone 4 (pCi/g)

Zone & Station	Gross Activity		Alpha			Beta		Gamma		
	Alpha	Beta	U-234	U-235	U-238	Sr-90	H-3	K-40	Be-7	Cs-137
Zone 1	0.186	4.29	0.078	0.041	0.046	0.557		2.73	1.62	0.085
Zone 2	0.470	4.88	0.075	0.042	0.040	1.206		2.77	0.69	0.727
Zone 3	0.088	4.29	0.102	0.038	0.035	0.746		2.33	0.71	0.306
Zone 4 (Z4.1)	0.126	0.78	0.120	0.052	0.060	0.028	38.42	1.84	0.63	0.046
Only detects compared for Zones 1 - 3						non-detect via Lc				

While Table 3.6.7.2 compares the average sample values from each zone to those at the reference location, it also accentuates what was often a single high value for a zone rather than being indicative of the zone as a whole. This is especially apparent when looking at the average gross alpha, Sr-90, and Cs-137 results for Zone 2, with each being mostly the result of a single high value in that zone. It can be useful to compare the results from the two tables to see where higher averages came from.

Results Summary:

There were higher levels of the radiological analytes Sr-90, Cs-137, as well as gross alpha and gross beta activity in the vegetation from three contaminated zones along WOC than was seen in the upstream background location sample in Zone 4. With the limited sample set, there were no vegetation types that consistently had higher levels of contaminant uptake. There was also not a single zone with higher concentrations of radiological contaminants across all samples and analyte types.

Highlighted Isotope Results:

Gross Alpha:

- The highest gross alpha result was for grasses from Zone 2 at WOC Z2.4 (0.864 pCi/g), while many alpha results were non-detects (<Lc), including at the Zone 4 reference location.
- The elevated WOC Z2.4 alpha result was at a slightly upland location, so potentially this contamination was coming from an area other than WOC. Previously, transuranic waste was stored up the hill from this location. The elevated gross alpha activity did not appear to be due to the uranium isotopes measured, as those values were not elevated for the location.
- Other than the WOC Z2.4 sample, the gross alpha activity tended to be higher in Zone 1 samples, where above detection limits.

Gross Beta:

- The gross beta activities, above 5 pCi/g, were seen in six samples, with the highest value from WOC Z2.2 grasses at 8.19 pCi/g. The level of 5 pCi/g is not regulatory and is used here

for comparison to note some of the higher gross beta activities seen with the FY25 sampling.

- The WOC Z2.2 grasses sample also had the highest Sr-90 result, and Sr-90 is a beta emitter. However, the other sample collected at the WOC Z2.2 location consisted of cattails, and while it had a higher level of gross beta activity, it was more similar to the highest gross beta activities seen in Zones 1 and 3.
- Only the gross beta result from the reference location was a non-detect based on the Lc value.

Isotopic uranium (U-234, U-235, U-238):

- The isotopic uranium results were comparable to values from the upstream reference location, WOC Z4.1.
- The isotopic uranium results at WOC Z4.1 were higher than the averages seen in each of the zones further downstream (Table 3.6.7.2), though this was largely because results from Zones 1, 2, and 3 were more variable, with both lower and higher individual results.

Strontium-90 (Sr-90):

- The Sr-90 results over 1.0 pCi/g were collected from WOC Zones 2 and 3. The level of 1 pCi/g is not regulatory and is used here for comparison to note some of the higher Sr-90 activities seen with the FY25 sampling.
- The highest Sr-90 activity measured was observed in the grasses sample from WOC Z2.2 (3.818 pCi/g). However, the other sample collected at the WOC Z2.2 location consisted of cattails, and while it had a high amount of Sr-90 for zone 2, it was more similar to the highest Sr-90 values in Zone 3.
- In comparison, the sample collected from the reference location in Zone 4 had the lowest measured Sr-90 activity (0.028 pCi/g) of the 18 samples.

Tritium (H-3):

- The H-3 results were all less than the detection levels.

Potassium-40 (K-40) and beryllium-7 (Be-7):

- The K-40 and especially Be-7 results were somewhat variable but are of little concern as both are naturally occurring radionuclides.
- K-40 and Be-7 measurements in Zones 1-3 were approximately comparable to the levels seen at the Zone 4 reference location.

Cesium-137 (Cs-137):

- The Cs-137 results over 0.5 pCi/g were collected from WOC Zones 2 and 3 in grasses, with the highest result from the WOC Z2.5d (duplicate) grasses sample (1.893 pCi/g). The other WOC Z2.5 Cs-137 result (0.521 pCi/g) was more in line with other detected levels in Zone 2. The level of 0.5 pCi/g is not regulatory and is used here for comparison to note some of the higher Cs-137 activities seen with the FY25 sampling.
- The result at the reference location was a non-detect (ND) based on the Lc value, as were one or two samples from each of the zones.

3.6.8 CONCLUSIONS

The vegetation samples collected in 2024 along the WOC watershed in the three contaminated zones generally did show elevated levels of gross alpha, gross beta, Sr-90, and Cs-137, compared to the upstream reference location in Zone 4. However, results varied to some degree by zone and radiation type or isotope, without one zone showing consistently higher contamination of the vegetation collected. Grasses were often good bio-accumulators of radiological contaminants, but were not always available for sampling, and the limited other vegetation types appeared to perform comparably.

3.6.9 RECOMMENDATIONS

DoR-OR recommends continued vegetation sampling in known or potentially contaminated areas on the ORR as TDEC DoR-OR watershed assessment projects are completed.

3.6.10 REFERENCES

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4.0 GROUNDWATER MONITORING

4.1 GROUNDWATER MONITORING OFFSITE

4.1.1 BACKGROUND

Offsite groundwater downgradient of the ORR has been monitored by both the TDEC DoR-OR and the DOE for decades. Monitoring by the DoR-OR *Offsite Groundwater Monitoring Project* continues to be conducted due to the potential migration of ORR legacy contamination into the adjacent surrounding areas. During previous fiscal years, this project focused on an area where groundwater might flow from the ORR to offsite locations.

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

DOE conducts annual sampling during the wet season at 14 offsite private water wells/springs within all four subareas (Figure 4.1.2.1). The sampling includes measurement of water quality parameters and analysis for potential contaminants like volatile organic compounds (VOCs), gross alpha, gross beta, uranium-233/234, uranium-235/236, uranium-238, and selected fission products/transuranic elements. DOE documented the results of these monitoring efforts in the *Phase 2 Offsite Detection Monitoring Remedial Site Evaluation* (DOE 2022a). DOE plans to continue annual monitoring at these same 14 locations moving forward (DOE 2022a; DOE 2022b).

DoR-OR sampling is intended to supplement the DOE data and provide additional data from the wells that are not typically sampled. The overarching purpose of this DoR-OR *Offsite Groundwater Monitoring Project* is to evaluate potential impacts to human health and the environment through verification monitoring of groundwater that could be used by area residents. The sampling locations addressed in the DoR-OR offsite program rotates each fiscal year to cover different offsite areas around the ORR. Site selection is additionally guided by

ORR activities and TDEC mission support such as the current holistic watershed project. During FY25, the WOC Watershed (WOCW) was the focal watershed. The offsite subarea that is downgradient from WOCW includes the Melton Valley Offsite Subarea (MV-OS).

4.1.2 PROBLEM STATEMENTS

Delineation of the nature and extent of groundwater contamination is incomplete in most areas of the ORR (DOE 2022a). Figures 4.1.2.1 and 4.1.4.1 depict the reservation boundary and the three primary DOE facilities: ETTP, Y-12, and ORNL. Each of these facilities have numerous groundwater contaminant plumes associated with them due to past DOE mission activities. Many contaminant plumes are not well defined and require better investigation techniques to delineate their vertical and horizontal extent.

The ORR is an area with complex bedrock containing many faults and carbonates that exhibit a karst terrain with large sinkholes. Further investigation is necessary to evaluate these flow paths. It is known that groundwater can move long distances rapidly in all fractured-rock settings (Worthington 2001) and in channels and conduits. Accordingly, the monitoring of groundwater/spring water quality offsite the ORR is important. By monitoring water quality, TDEC DoR-OR can evaluate if there is no current threat to human health and the environment from potential offsite migration of DOE ORR legacy contamination.

(Continues on Next Page - Figure 4.1.2.1)

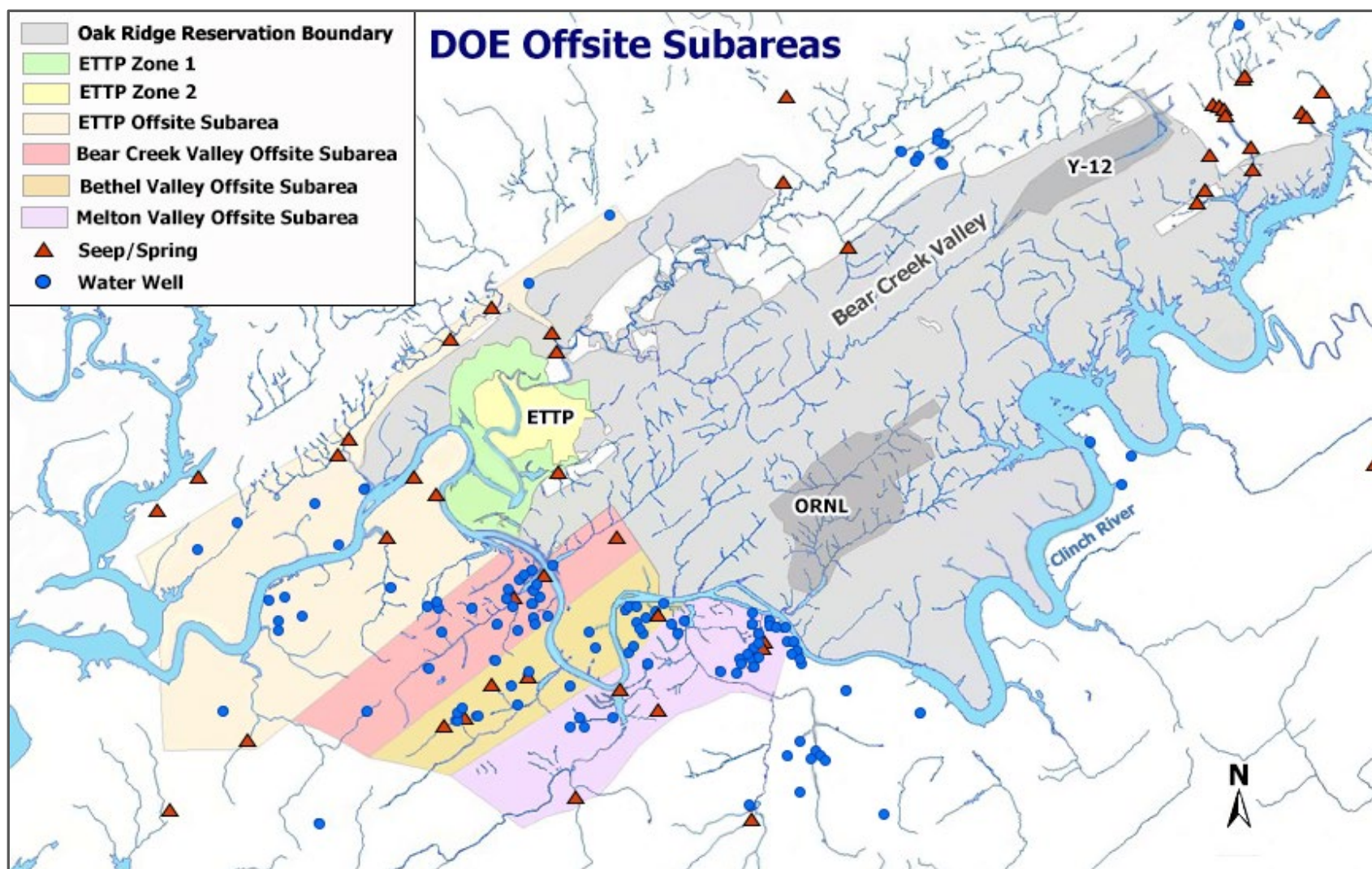


Figure 4.1.2.1: DOE Offsite Subarea Map (DOE, 2017)

4.1.3 GOALS

The primary goal of this project was to evaluate potential threats to human health and the environment through monitoring groundwater offsite of the ORR in areas that citizens may utilize for drinking water sources. This project involved collecting groundwater samples at private water wells and springs within the MV Offsite Subarea (OS) at the locations illustrated on Figures 4.1.4.1 and 4.1.4.2.

The objectives of this project included the following:

- Attempt to obtain access and collect groundwater samples from up to 35 private water wells within the Melton Valley Offsite Subarea and surrounding area to the southeast.
- To form a rapport with private well and spring owners for continuous sampling access.
- Attempt to obtain access and collect groundwater samples from up to 5 springs within the MV Offsite Subarea (OS).
- Provide additional offsite groundwater data and compare results with DOE groundwater data, including data collected in co-sampling events.

These data will support TDEC's evaluation of future groundwater cleanup decisions and shape project prioritization discussions that support TDEC DoR-OR's mission.

4.1.4 SCOPE

The locations of sampling efforts for FY25 consisted of several selected private water wells and springs located downgradient, to the southwest and along the geologic strike, of WOC confluence with the Clinch River (WOC-CR). The WOC offsite area is downstream and downgradient of ORNL and is in Melton Valley (MV). This subarea will be referred to herein as the Melton Valley Offsite Subarea (MV-OS), whose boundary is defined by DOE (DOE/OR/01-2715&D2_R) (DOE 2017) and later documents (URS et al 2017) (Figure 4.1.4.1 and Figure 4.1.4.2). Of note, some of the proposed wells are not officially within the defined MV-OS but are immediately adjacent to the southeast (Figure 4.1.4.1). These additional wells are noted as "Additional Sites" on Figure 4.1.4.1.

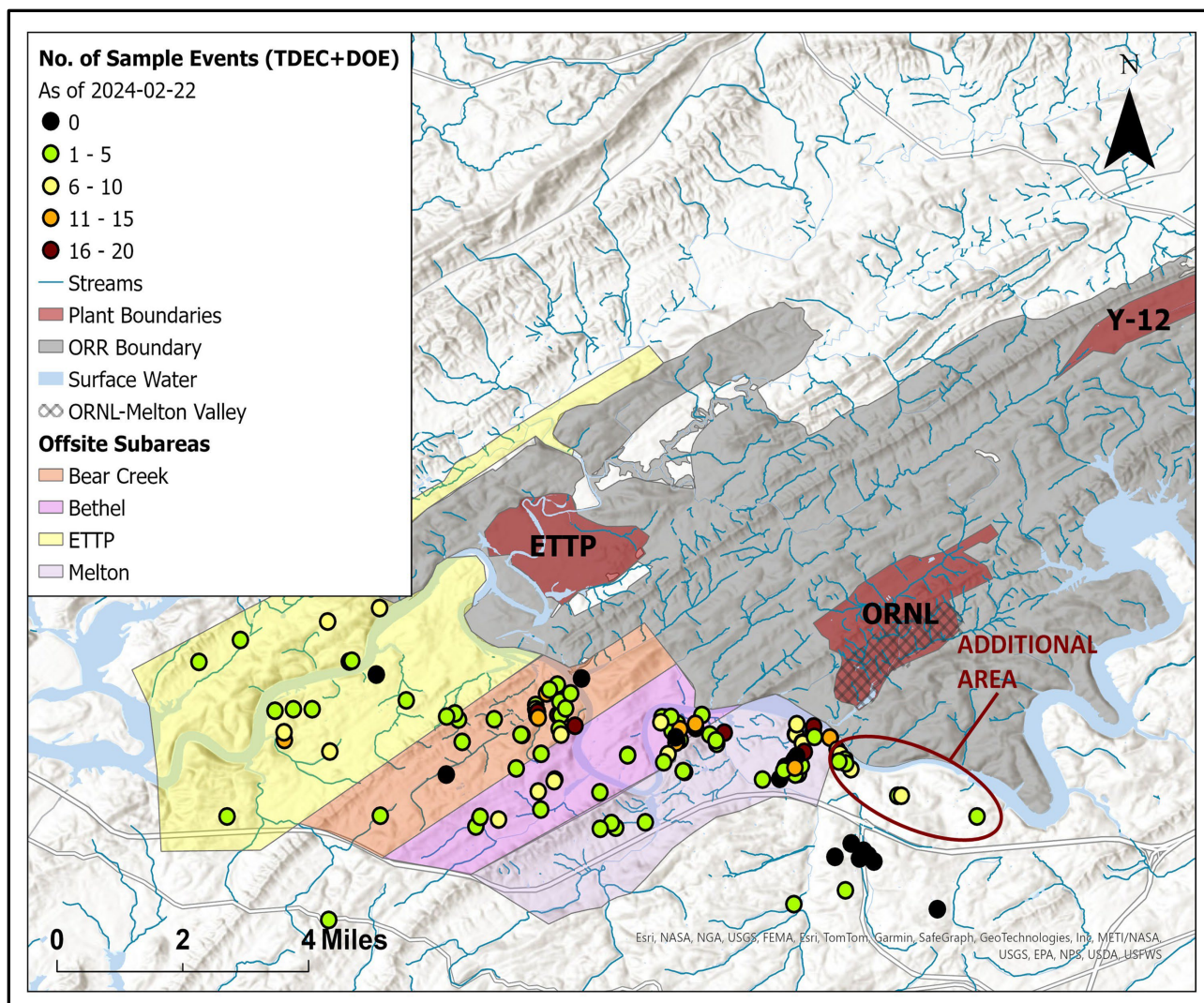


Figure 4.1.4.1: Historical Private Water Well Sites in all Offsite Subareas

The proposed sample locations included 35 offsite private water wells, 5 offsite springs, and 8 quality control samples for a total of 48 potential samples. For project planning purposes, it was assumed that not all samples would be collected due to potential site access issues. The proposed sample locations are shown on Figure 4.1.4.1 and Figure 4.1.4.2. These water samples were submitted for laboratory analysis (e.g., inorganics, volatile organic compounds (VOCs), radionuclides, and metals).

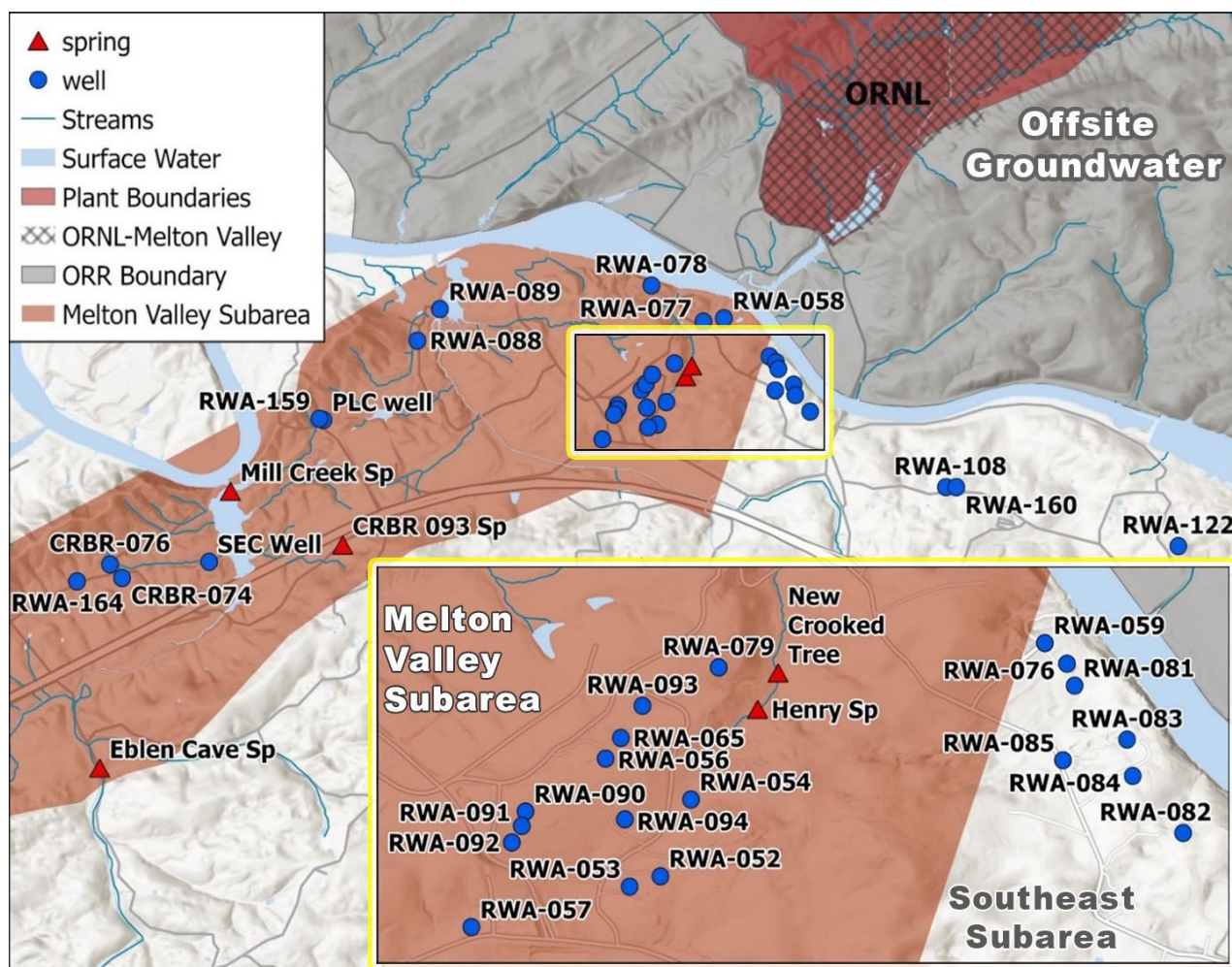


Figure 4.1.4.2: Melton Valley Offsite Subarea Sample Locations

4.1.5 METHODS, MATERIALS, METRICS

The private well water samples were collected using each well's dedicated submersible pump from an accessible tap located as close to the well as possible, ideally prior to any filtration and/or water softener systems. Once the appropriate volume of water had been purged and water quality parameters had stabilized, a groundwater sample was collected. The wells were sampled in accordance with the TDEC SOP for sampling of wells with pumps already in place (TDEC 2023a). The volume of water purged prior to sample collection was based on the frequency of use for each well. For wells that were co-sampled, samples were collected in accordance with the UCOR/TDEC/DOE Groundwater Assessment Co-sampling Protocol, which is generally consistent with the TDEC SOP.

The springs were sampled using a peristaltic pump using low flow methods in accordance with the TDEC SOP for sampling of seeps and springs (TDEC 2023b). As in the well collection protocol, once three consecutive stabilized parameter readings were obtained, a groundwater sample was collected.

The water samples collected from the private water wells and springs were analyzed for volatile organic compounds (VOCs), gross alpha/beta, inorganics, and metals. If gross alpha activity was detected in any of the groundwater samples at a concentration greater than or equal to ($\geq$) 5 picocuries per liter (pCi/L), then those groundwater sample(s) were analyzed for isotopic uranium. To ensure that water was available from each site for possible isotopic uranium analysis, a dedicated sample bottle was filled during each sampling event.

Quality control (QC) samples were collected at a frequency of 10% of samples. At least one trip blank was included in each batch of samples submitted to the laboratory.

4.1.6 DEVIATIONS FROM THE PLAN

Groundwater samples were planned to be collected from thirty-five (35) private water wells; however, due to access issues, only two (2) private water wells were sampled (RWA-079 and RWA-164). Sampling of these wells was performed as co-sampling events with the DOE.

The main reason for not sampling most of the wells was that many of the selected wells have been physically disconnected by the DOE due to water quality issues (or expected water quality issues) in the area. Some of the residential wells have had their piping connection severed between the well and the house and have been enclosed in a vault. These vaults reportedly contain the well, now equipped with a sampling pump, and a sample port. The wells that could not be sampled due to this reason included most of the wells on the proposed FY25 list. This information on the status of the wells was not readily available at the time this area was proposed. Many of the homeowners have entered a contract with DOE to have city water supplied to their homes for no charge with the contingency that the wells are not used. Based on this, many homeowners were reluctant to allow TDEC to sample and risk breaching this contract. TDEC has requested access to these wells from the DOE and is working on obtaining details on sampling pump systems, status of the wells, and permissions to sample, and a complete list of residential wells in this area that were administratively closed. Other reasons included a firm denial of access from the homeowner (hard no) and/or their pump was not working.

Groundwater samples were proposed to be collected from five (5) springs in the project area. Due to similar access issues as above, only one of the proposed springs (Eblin Cave Spring) was sampled. Fortunately, based on interviews with private well owners, two additional springs

were located in the project area that were not previously identified in the TDEC database. These springs included Coffin Spring (Coffin Spring) and Fletcher Spring (Fletcher Spring). Both springs were in isolated areas, but their locations were provided by the current landowners. The GPS location of each spring was noted and entered into the TDEC database, and each spring was sampled.

4.1.7 RESULTS AND ANALYSIS

For comparison purposes only, the resulting analytical data were evaluated and compared against numerical standards set forth by TDEC and the EPA in the following documents:

- (1) *General Water Quality Criteria Chapter 0400-40-03-.03* (TDEC 2019)
- (2) *National Priority Drinking Water Regulations* (EPA 2009)
- (3) *National Secondary Drinking Water Regulations* (EPA 2009).

A summary of the results for the private water wells and springs is presented below.

PRIVATE WATER WELLS (RWA-079, RWA164)

Based on the results of the sampling, the following were the results:

- VOCs were not detected above their respective laboratory detection limits.
- Notable levels of inorganics and metals were not reported in any of the well samples.
- Alpha activity of 3.73 pCi/L was detected in RWA-079. This is below the regulatory guideline activity of 5.0 pCi/L.
- Strontium-89 was detected at an activity of 1.1 pCi/L in RWA-164.
- Strontium-90 was not detected in any of the wells sampled.

MV OFFSITE SUBAREA SPRINGS (EBLIN CAVE SPRING, COFFIN SPRING, FLETCHER SPRING)

Based on the results of the spring sampling, the following were the results:

- VOCs were not detected above their respective laboratory detection limits.
- Notable levels of inorganics and metals were not reported in any of the spring samples.
- Alpha activity and Strontium-89/90 were not detected in any of the springs sampled.

4.1.8 CONCLUSIONS

Based on the results of the investigation, the following conclusions can be made:

- VOCs were not detected above their respective laboratory detection limits in the wells or

the springs sampled.

- Notable levels of inorganics and metals were not reported in any of the groundwater samples.
- Alpha activity and Strontium-89 were detected but were at activity levels below regulatory action levels.
- Most of the wells proposed to be sampled during FY25 were administratively closed by the DOE due to existing or potential impact.

4.1.9 RECOMMENDATIONS

DoR-OR recommends continuing monitoring of offsite groundwater. Previous FY24 monitoring plans have resulted in many wells not being sampled due to lack of access or other reasons. It is recommended that a set of offsite wells that are known to have good access be developed for all the offsite subareas and background locations. Once this set of wells is established then these wells can be sampled on a yearly basis. It is recommended that a set of wells from the MV Offsite Subarea be selected and approved by the DOE and the residents as part of this plan.

4.1.10 REFERENCES

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5.0 LANDFILL MONITORING

5.1 EMDF SURFACE WATER SAMPLING AND MONITORING

5.1.1 BACKGROUND

The Environmental Management Disposal Facility (EMDF) is proposed for the disposal of low-level radioactive waste, hazardous waste, and toxic waste generated by remediation activities on the ORR and will be operated under the authority of CERCLA and DOE directives. While the EMDF will hold no permit from the State of Tennessee, the landfill will be required to comply with DOE orders and substantive portions of *Applicable or Relevant and Appropriate Requirements* (ARARs) listed in the CERCLA EMDF Record of Decision (ROD). The EMDF site is located within the Central Bear Creek Valley (CBCV) area; specifically, it is about 1 mile to the west of the existing Environmental Management Waste Management Facility (EMWMF).

DOE currently monitors Bear Creek and some of its northern tributaries (NT-3, NT-4, and NT-5) for potential releases from the EMWMF landfill. The wastewater released from the EMWMF sediment basin is collected by an automatic sampler using a weekly flow-weighted composite sample. Annually, the results from these sampling efforts are published in the EMWMF Phased Construction Completion Report (PCCR). However, limited ongoing surface water monitoring is completed in the immediate vicinity of the EMDF site.

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

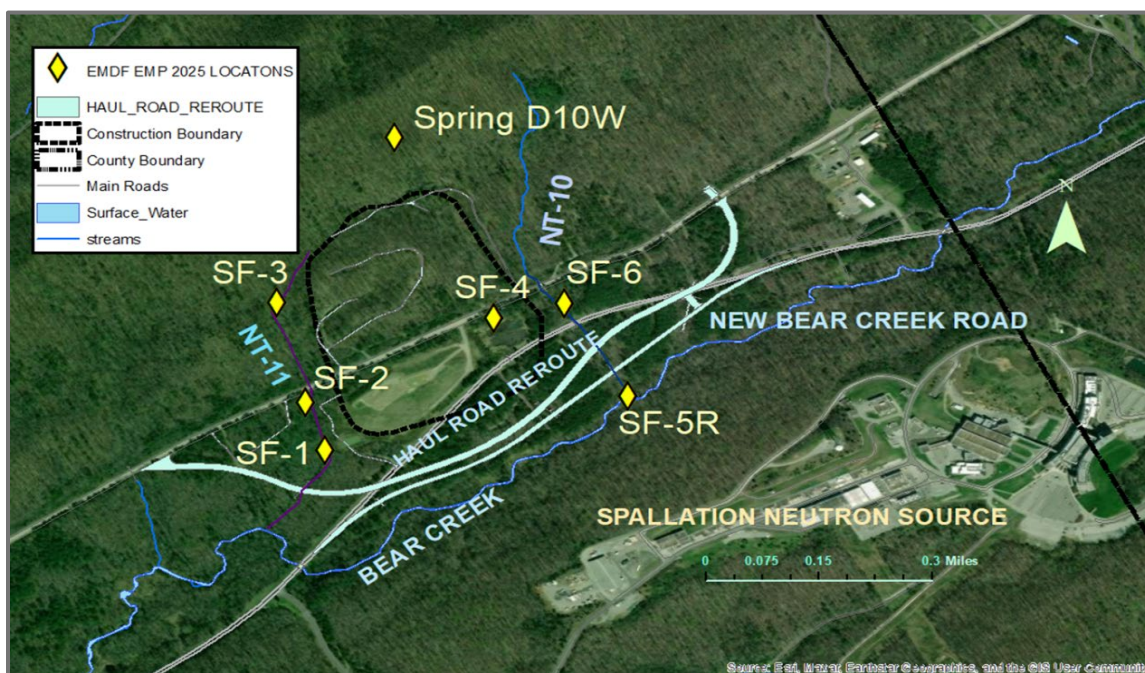


Figure 5.1.1.1: EMDF Surface Water Project Site and Monitoring Locations

5.1.2 PROBLEM STATEMENTS

- Upon completion, contaminants in the waste materials from CERCLA remediation activities will be buried in the EMDF.
- Surface water or groundwater may carry contaminants off site in concentrations or radiological activities above agreed-to limits.
- A background or baseline water quality assessment is needed, prior to waste disposal, for comparison once EMDF becomes operational.

5.1.3 GOALS

- Implemented continuous water monitoring by collecting data from the probe previously installed at SF-5R, with plans to extend monitoring to SF-1 upon the completion of construction activities in the EMDF area.
- Conducted independent monitoring of potential impacts from construction activity at the EMDF to assess compliance with ROD ARARs.
- Gathered information to support DOE in establishing spring/surface water background benchmarks using physical parameters (pH, DO, Conductivity, ORP, Turbidity), and analytical results during EMDF site preparation activities.

5.1.4 SCOPE

DoR-OR monitored surface water along the portion of Bear Creek where the EMDF landfill will be constructed. Furthermore, monitoring of surface water and one upgradient spring supported the EMDF site benchmark data, characterization in support of DOE's site characterization work, and pre-operational site conditions, as well as anticipated future data collection efforts in the CBCV.

- Within the EMDF footprint, DoR-OR staff measured water quality parameters in-stream at six flume discharge locations and one spring: SF-1, SF-2, SF-3, SF-4, SF-5R, and SF-6 and Spring D10W (Figure 5.1.1). Project staff monitored these locations using a YSI Professional Plus water quality instrument.
- General observations of site conditions, above and beyond the surface water parameter measurements were made as conditions warranted while in the field.
- The project team collected surface water samples semi-annually at four of the seven above locations to complement DOE characterizing baseline conditions following the schedule in (Table 5.1.5.1).

- DoR-OR staff deployed In-Situ continuous water monitoring equipment at two in-stream locations, SF-1 and SF-5R, to complement the monitoring process.

5.1.5 METHODS, MATERIALS, METRICS

Tasks for this project included monitoring water quality parameters at seven locations: six stream discharge flumes (SF-1, SF-2, SF-3, SF-4, SF-5, SF-6) and one spring (D10W) (Figure 5.1.1). Utilizing a YSI Professional Plus water quality meter at least once a month, project personnel measured temperature, pH, conductivity, dissolved oxygen, turbidity, and oxidation-reduction potential at these locations. Calibration and/or a confidence check of this instrument was performed prior to field use. In-Situ multi-parameter probes were used to continuously monitor the flumes at SF-1 and SF-5-R.

The EMDF project team also monitored the sampled streams, noted discharges, and water conditions, observed the condition of the banks, and noted any concerns. Any identified concerns were brought to the attention of DOE. Field notes were recorded in a dedicated field book, and events reported in a monthly internal project report.

Data collected from these key locations by DoR-OR were entered into an Excel database for evaluation. This evaluation included the construction of tables and graphs illustrating data ranges and concentration limits of constituents and parameters. Potential trends were analyzed throughout the project. For archival and future evaluation purposes, the data was entered into TDEC's TOREIS database.

Table 5.1.5.1 presents the four locations where surface water samples were collected for laboratory analysis. In addition, the sampling frequency and rationale for each station are listed. The analytical test suite is outlined in Table 5.1.5.2. Pertinent water quality regulatory criteria from the EPA and TDEC were also included in the graphs.

Table 5.1.5.1: EMDF Site Sampling Frequency/Description/Rationale

DOE Station	DoR-OR Site ID	Frequency		Site Description/Sampling Rationale
		Analytical	Parameters	
SF-1	SF-1	<i>semi-annually</i>	<i>* continuous</i>	SF-1: Most downstream NT-11 site; capture surface & groundwater
SF-5R	SF-5R	<i>Semi-annually</i>	<i>* continuous</i>	SF-5R: Captures downstream NT-10 at confluence with Bear Creek
SF-2	SF-2	<i>If needed</i>	<i>Monthly</i>	SF-2: Water from western landfill footprint, joins NT-11, then Bear Creek
SF-3	SF-3	<i>If needed</i>	<i>Monthly</i>	SF-3: Most upstream NT-11 point; captures surface water & groundwater
SF-4	SF-4	<i>If needed</i>	<i>Monthly</i>	SF-4: Site collects water at NT-11 at the midpoint of landfill
SF-6	SF-6	<i>Semi-annually</i>	<i>Monthly</i>	SF-6: An upstream site on NT-11, potentially impacted by the landfill
Spring D10W	SP D10W	<i>Semi-annually</i>	<i>Monthly, +</i>	SP D10W: Background spring
Notes: * Continuous – monthly in-situ probe downloads; + = site also sampled on a rotation, co-sample with DOE				

Table 5.1.5.2: EMDF Analyte List

EMDF ANALYTE LIST	
Radionuclides	
Gamma Activity	Plutonium-238
Gross Alpha Beta Activity	Plutonium-239/240
Americium-241	Radium-226
Carbon-14	Radium-228
Chlorine-36	Strontium-90
Cobalt-60	Technetium-99
Cesium-137	Thorium-228
Europium-154	Thorium-230
Tritium	Thorium-232
Iodine-129	Uranium-233/234
Lead-210	Uranium-235/236
Neptunium-237	Uranium-238
Metals	
Arsenic	Lead
Barium	Mercury
Cadmium	Nickel
Chromium	Uranium
Cobalt	Vanadium
Copper	Zinc
Inorganics	
Nitrite and Nitrate	
Organics	
Volatile Organics	PCBs

5.1.6 DEVIATIONS FROM THE PLAN

There were some deviations from the EMDF FY25 Environmental Monitoring Plan (EMP).

Deviations included the following:

- Monthly parameters could not be collected in August, September, and October 2024 due to no flow (dry) at several stations.
- Monthly parameters were not collected in November 2024.
- No samples collected for analysis on 12/3/2024 from Spring D10W due to absence of flow (dry).
- The flume, SF-4, was removed during EMDF construction in November 2024, and no more measurements could be obtained.

- In-Situ Continuous Multiparameter Probe, installed in July 2024 at SF-1, was moved to BCK 7.6 in September 2024.
- In-Situ Continuous Multiparameter Probe, installed at SF-5R, was moved to BCK 8.63 in September 2024 due to inconsistent flow at SF-5R.

5.1.7 RESULTS AND ANALYSIS

SURFACE WATER SAMPLING

Surface water samples were analyzed for COCs known to be present in nearby waste disposal areas.

RADIONUCLIDE ACTIVITY RESULTS

Table 5.1.7.1 shows the analytical results for radionuclides from semi-annual sampling at the EMDF. There are no EPA regulatory criteria for radionuclides for surface water quality for comparison. National Primary Drinking Water Regulations (EPA, 2021) were used for comparison for Alpha emitters, Beta and photon emitters, Radium 226/Radium 228, and Uranium metal with no exceedance of any MCLs observed in FY25.

There are no regulatory criteria for radionuclides in the Tennessee Surface Water Quality Criteria.

(Continues on Next Page – Table 5.1.7.1)

Table 5.1.7.1: FY25 EMDF Radionuclide Analytical Results

Radionuclide	SF-1				SF-5R				SF-6				Spring D10W			
	Dec-24	CSU	May-25	CSU	Dec-24	CSU	May-25	CSU	Dec-24	CSU	May-25	CSU	Dec-24	CSU	May-25	CSU
Americium-241	0.08	0.10	0.29	0.37	0.00 U	0.07	0.05 U	0.16	0.36	0.07	0.13	0.26	NS	-	0.08 U	0.20
Beryllium-7	9.43 U	35.70	-28.5 U	32.1	6.04 U	20.7	16.2 U	32.1	18.6	22.2	-22.7 U	32.7	NS	-	-19.4 U	29.2
Carbon-14	2.62	8.14	4.20	9.02	6.70	8.46	0.75	8.73	-1.68 U	8.23	0.75	8.75	NS	-	8.00	9.16
Cesium-137	3.09 U	4.58	1.80 U	2.57	3.15	2.69	3.52	2.90	2.66	2.73	3.07	2.43	NS	-	1.01 U	3.12
Cobalt-60	2.37 U	5.70	2.29 U	3.19	-0.94 U	3.72	0.91 U	3.51	-1.40 U	3.55	2.39	2.62	NS	-	-0.95 U	3.19
Gross Alpha	2.09	1.53	0.73 U	1.37	5.87	2.76	2.58	1.40	1.49 U	1.55	0.92 U	1.18	NS	-	13.8	4.70
Gross Beta	2.17 U	2.02	3.19 U	2.09	29.3	5.50	5.79 U	2.28	4.23 U	2.32	2.44 U	2.10	NS	-	16.2	4.38
Neptunium-237	0.21	0.19	0.04	0.13	0.11	0.13	-0.06 U	0.17	-0.09 U	0.07	0.07	0.20	NS	-	0.10	0.16
Plutonium-238	0.06 U	0.13	0.10 U	0.32	-0.04 U	0.10	-0.11 U	0.21	0.11 U	0.20	0.26 U	0.40	NS	-	0.40	0.45
Plutonium-239/240	0.04	0.09	0.09 U	0.31	0.04	0.10	0.18	0.27	0.11	0.20	0.09	0.23	NS	-	0.31	0.39
Potassium-40	11.4 U	41.7	19.1 U	29.4	27.3 U	31.7	19.3 U	33.2	-6.58 U	37.6	39.6	24.5	NS	-	49.4	32.7
Radium-226	0.31	0.33	0.14	0.19	0.08	0.11	0.05	0.10	0.10	0.08	0.003 U	0.05	NS	-	0.17	0.15
Radium-228	2.11	1.03	0.67 U	0.57	2.75	0.81	0.14 U	0.48	1.37	0.58	0.32 U	0.60	NS	-	0.85	0.46
Strontium-89	-0.54 U	1.79	1.51	4.95	0.13	1.77	-0.66 U	3.74	1.10	3.15	-0.29 U	4.80	NS	-	2.75	4.51
Strontium-90	-0.76 U	0.27	1.06 U	0.66	0.84 U	0.30	0.38 U	0.50	0.31 U	0.54	1.18	0.67	NS	-	0.26 U	0.57
Technetium-99	-2.98 U	3.29	-0.40 U	2.48	0.00 U	3.08	1.75	2.64	-5.27 U	4.30	-0.63 U	2.64	NS	-	-0.12 U	2.90
Tritium	333.0	284.0	790.0	453.0	205.0	206.0	677.0	437.0	81.8	273.0	350.0	438.0	NS	-	315.0	422.0
Uranium-234	0.29	0.19	0.39	0.31	0.30	0.20	0.43	0.31	0.69	0.30	2.34	3.63	NS	-	1.37	0.63
Uranium-235	0.13	0.14	0.20	0.27	0.15	0.16	0.13	0.22	0.13	0.09	1.90	4.13	NS	-	0.05	0.17
Uranium-238	0.24	0.17	0.46	0.33	0.51	0.25	0.49	0.32	0.23	0.17	27.5	4.13	NS	-	0.99	0.52
CSU = Combined Standard Uncertainty NS = Not Sampled (No Flow) U = Non-detect *Analytical Results in pCi/L Bold = detection Grey = non-detect																

METALS RESULTS

Table 5.1.7.2 lists the State of Tennessee and EPA limits for metals in surface water based on the type of water usage (e.g., recreation, fishing, consumption, etc.).

Table 5.1.7.2: Tennessee & EPA Surface Water Criteria for Metals

Surface Water Criteria Comparison							
EMDF Analyte List (µg/L)	EPA Human Life Criteria		TN Aquatic Life Criteria		TN Recreation Criteria	EPA Aquatic Life Criteria	
	Human Health	Human Health	Freshwater	Freshwater	Freshwater	Freshwater	Freshwater
	Consumption of water + organism	Consumption of organism only	CMC ¹ (acute)	CCC ² (chronic)	Consumption of organism only	CMC ¹ (acute)	CCC ² (chronic)
Arsenic	0.018	0.14	340	150	10	340	150
Barium	1000	--	--	--	--	--	--
Cadmium	--	--	1.8	0.72	--	1.8	--
Chromium III	100 (Total Cr MCL)	--	570	74	--	570	74
Cobalt	--	--	--	--	--	--	--
Copper	1,300	--	13	9	--	--	--
Lead	--	--	65	2.5	--	65	2.5
Mercury	--	--	1.4	0.77	0.051	1.4	0.77
Nickel	610	4,600	470	52	4,600	470	52
Uranium	--	--	--	--	--	--	--
Vanadium	--	--	--	--	--	--	--
Zinc	7400	26,000	120	120	26,000	120	120
CMC ¹ CMC: Criterion Maximum Concentration CCC ² CCC: Criterion Continuous Concentration MCL: maximum contaminant level							

All analyte concentrations are reported in micrograms per liter (µg/L). The metals' results are presented in Table 5.1.7.3. Only Arsenic and Lead exceeded regulatory criteria (see Table 5.1.7.2).

- Arsenic (As) concentrations ranged from 0.18 µg/L to 0.76 µg/L. All concentrations were below the acute and chronic TN Aquatic Life Criteria of 340 µg/L and 150 µg/L, respectively and TN Recreation Criteria for consumption of organism only of 10 µg/L. Arsenic levels at SF-1, SF-5R, SF-6 and Spring DW10 all exceeded the EPA Human Health Criterion for water consumption + organism, set at 0.018 µg/L and EPA Human Health Criterion for

consumption of organism only set at 0.14 µg/L. Further investigation of background arsenic levels is necessary to draw any definitive conclusions.

- Barium (Ba) concentrations range from 57.0-146.0 µg/L, and although there are no established TN Aquatic Life Criteria, TN Recreation Criteria for consumption of organism only, and EPA Aquatic Life Criteria for barium, these levels are consistent with the local geology. The barium concentrations were below the Human Life Criteria of Human Health for consumption of water + organism set by the EPA.
- Cadmium (Cd) was not detected in any of the samples.
- Chromium III (Cr^{3+}) was detected only at SF-1 in December 2024 at a concentration of 2.04 µg/L, which is below the Tennessee and EPA acute and chronic Aquatic Life Criteria levels. There are no established TN Recreation Criteria for consumption of organism only for Chromium III.
- Cobalt (Co) was detected at concentrations ranging from 0.15 µg/L to 3.09 µg/L; there are no established criteria for this metal.
- Copper (Cu) concentrations ranged from 0.50 µg/L to 2.75 µg/L, which are below the acute (13 µg/L) and chronic (9 µg/L) Tennessee Aquatic Life Criteria. There are no established TN Recreation Criteria for consumption of organism only for Copper.
- Lead (Pb) was detected at stations SF-1, SF-5R, SF-6, and Spring DW10, with concentrations ranging from 0.26 µg/L to 4.06 µg/L. These levels were below the acute criterion of 65 µg/L and the chronic criterion of 2.5 µg/L, with the exception for the lead concentration at Spring DW10 which exceeded the Tennessee Aquatic Life Criteria chronic threshold (2.5 µg/L) and the EPA Aquatic Life Criteria chronic threshold (3.2 µg/L) at 4.06 µg/L in May 2025. There are no established TN Recreation Criteria for consumption of organism only for Lead.
- Mercury (Hg) concentrations ranged from 0.0013 µg/L to 0.015 µg/L. These values were below the Tennessee and EPA acute and chronic Aquatic Life Criteria of 1.4 µg/L and 0.8 µg/L respectively. These concentrations were below the TN Recreation Criteria for consumption of organism only of 0.051 µg/L established for Mercury.
- Nickel (Ni) concentrations ranged from 0.49 µg/L to 7.01 µg/L, which were below the acute (470 µg/L) and chronic (52 µg/L) Tennessee and EPA Aquatic Life Criteria. The concentrations were below the TN Recreation Criteria for consumption of organism only of 4,600 µg/L.

- Uranium (U) concentrations ranged from 0.16 µg/L to 1.02 µg/L, there are no established TN Aquatic Life Criteria, TN Recreation Criteria for consumption of organism only, and EPA Aquatic Life Criteria for uranium.
- Vanadium (V) concentrations ranged from 0.44 µg/L to 2.85 µg/L, there are no established TN Aquatic Life Criteria, TN Recreation Criteria for consumption of organism only, and EPA Aquatic Life Criteria for vanadium.
- Zinc concentrations ranged from 6.93 µg/L to 115.0 µg/L, all of which were below the Tennessee Aquatic Life criteria and EPA Aquatic Life criteria of 120 µg/L. The concentrations were below the TN Recreation Criteria for consumption of organism-only of 26,000 µg/L.

(Continues on Next Page – Table 5.1.7.3)

Table 5.1.7.3: FY25 EMDF Metals Analysis Results

Station	Date	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Lead	Nickel	Uranium	Vanadium	Zinc	Mercury
SF-1	12/03/24	0.58 J	104	<0.12 U	2.04	2.65	2.32 J	1.53 J	3.39	0.46 J	2.14 J	115	0.0013
SF-5R	12/03/24	0.18 J	76.4	<0.12 U	<0.9 U	0.50 J	1.50 J	0.60 J	1.80 J	1.02	0.61 J	<4.0 U	0.0029
SF-6	12/03/24	0.18 J	75.0	<0.12 U	<0.9 U	0.15 J	<0.70 U	<0.50 U	0.61 J	0.33 J	<0.52 U	<4.0 U	0.0018
Sp. D10W	12/03/24	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SF-1	5/19/25	0.30 J	74.2	<0.15 U	<5.6 U	0.35 J	0.50 J	0.26 J	0.49 J	0.18 J	0.44 J	<2.2 U	0.003
SF-5R	5/19/25	0.33 J	81.6	<0.15 U	<5.6 U	0.47 J	0.88 J	0.59 J	0.77 J	0.42 J	0.70 J	6.93 J	0.012
SF-6	5/19/25	0.25 J	57.0	<0.15 U	<5.6 U	0.22 J	1.45	0.32 J	0.56 J	0.16 J	0.46 J	19.5 J	0.0035
Sp. D10W	5/19/25	0.76 J	146	<0.15 U	<5.6 U	3.09 J	2.75	4.06	7.01	0.53 J	2.85 J	7.56 J	0.015

Notes: All analyte results in (µg/L)

J = The identification of the analyte is acceptable; the reported value is an estimate

U = Not detected at the Reporting Limit (or MDL where applicable)

MDL = Method Detection Limit

NS=Not Sampled (No Flow)

Bold = detection; Grey = non-detect

ORGANIC AND OTHER INORGANIC RESULTS

- VOCs and PCBs were not detected above their respective laboratory detection limits at any station for TN Recreation Criteria for consumption of organism only.
- Low levels of Nitrate-Nitrite were observed at concentrations below regulatory MCLs at SF-1, SF-5R, and SF-6.

WATER QUALITY PARAMETERS

Table 5.1.7.4 shows the monthly results for the seven stations monitored during FY25. Water quality parameters measured included temperature (°C), pH (standard units), conductivity (µS/cm), dissolved oxygen (mg/L), oxidation-reduction potential (mV), and turbidity (NTU). Some stations were not visited due to accessibility issues. Some stations often had no discharge after periods of dry weather, with little-to-no flow observed at SF-2, SF-4, SF-6, and Spring D10W until rainfall occurred. Water quality parameters could not be measured at stations without flow.

(Continues on Next Page - Table 5.1.7.4)

Table 5.1.7.4: FY25 EMDF Monthly Water Quality Parameter Measurements

Station	WQ	2024						2025					
		July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
SF-1	Temp.	21.3	19.0	19.3	12.1	DNV	4.9	4.1	8.5	8.0	14.5	17.6	18.6
	pH	7.69	7.8	7.82	7.84	DNV	NM	7.46	7.41	7.95	7.59	7.53	7.86
	SPC	294.5	331.8	382.4	320.0	DNV	322.7	244.1	204.4	215.8	101.7	202.6	274.2
	DO	7.06	7.98	6.91	8.88	DNV	11.26	12.50	11.81	11.57	9.83	8.40	8.32
	ORP	137.2	81.8	128.9	320.0	DNV	132.1	77.3	140.1	102.1	142.1	93.2	75.5
	Turbidity	156.9	32.6	9.1	8.9	DNV	3.76	7.25	16.98	9.41	30.21	15.18	20.15
SF-2	Temp.	22.0	19.8	20.2	Dry	DNV	DNV	3.0	8.1	7.5	14.6	18.2	19.2
	pH	7.72	7.58	7.83	Dry	DNV	DNV	7.18	7.20	7.72	7.39	7.65	7.57
	SPC	215.9	265.7	351.6	Dry	DNV	DNV	214.1	179.8	194.3	89.2	177.0	236.8
	DO	7.64	8.24	7.99	Dry	DNV	DNV	12.55	11.57	11.11	9.85	8.65	8.32
	ORP	103.7	102.6	72.5	Dry	DNV	DNV	55.5	78.1	53.3	68.1	41.3	33.2
	Turbidity	144.1	79.2	18.4	Dry	DNV	DNV	7.65	20.21	17.95	26.41	22.3	29.39
SF-3	Temp.	23.7	21.7	21.8	12.3	DNV	DNV	4.0	8.9	8.2	14.6	18.4	21.6
	pH	7.39	7.27	7.4	7.7	DNV	DNV	7.17	6.94	7.67	7.17	7.64	7.36
	SPC	128.4	131.6	123.8	189.6	DNV	DNV	158.0	132.8	137.5	63.1	167.6	167.4
	DO	7.21	7.6	7.36	8.98	DNV	DNV	12.17	11.51	11.32	9.70	8.52	7.37
	ORP	64.1	73.7	160.6	189.6	DNV	DNV	71.8	135.6	55.3	100.0	-8.9	-17.1
	Turbidity	47.4	143.8	110.5	8.98	DNV	DNV	9.31	49.13	25.76	19.15	25.28	8.45
SF-4	Temp.	23.4	Dry	Dry	Dry	DNV	DNV	DNV	DNV	DNV	DNV	DNV	DNV
	pH	7.27	Dry	Dry	Dry	DNV	DNV	DNV	DNV	DNV	DNV	DNV	DNV
	SPC	330.9	Dry	Dry	Dry	DNV	DNV	DNV	DNV	DNV	DNV	DNV	DNV
	DO	3.35	Dry	Dry	Dry	DNV	DNV	DNV	DNV	DNV	DNV	DNV	DNV
	ORP	114.4	Dry	Dry	Dry	DNV	DNV	DNV	DNV	DNV	DNV	DNV	DNV
	Turbidity	418.3	Dry	Dry	Dry	DNV	DNV	DNV	DNV	DNV	DNV	DNV	DNV
SF-5R	Temp.	22.3	19.5	Dry	12.1	DNV	7.8	Dry	9.4	8.5	15.2	18.8	17.0
	pH	7.53	7.47	Dry	7.59	DNV	NM	Dry	8.05	8.19	7.88	7.91	8.23
	SPC	538	480.9	Dry	518.0	DNV	404.5	Dry	226.3	207.9	129.0	220.2	45.74
	DO	6.98	5.97	Dry	6.04	DNV	9.2	Dry	11.55	11.68	9.71	9.02	9.06
	ORP	181	94.1	Dry	518.0	DNV	141.2	Dry	147.9	150.0	131.9	83.9	147.7
	Turbidity	37.5	170.9	Dry	6.04	DNV	14.25	Dry	21.6	16.53	31.55	31.63	4.42
SF-6	Temp.	23.5	Dry	Dry	Dry	DNV	6.1	2.3	9.1	7.3	14.6	17.4	19.7
	pH	7.39	Dry	Dry	Dry	DNV	NM	7.20	6.45	7.99	7.84	7.18	6.86
	SPC	875	Dry	Dry	Dry	DNV	255.9	131.9	185.2	136.4	70.2	121.0	288.1
	DO	6.05	Dry	Dry	Dry	DNV	10.78	12.52	10.34	10.60	9.41	8.02	6.95
	ORP	122.4	Dry	Dry	Dry	DNV	149.4	184.1	190.8	33.0	124.3	202.1	211.0
	Turbidity	37.5	Dry	Dry	Dry	DNV	44.23	13.55	27.78	10.35	28.01	15.61	56.02
Spring D10W	Temp.	22.2	20.3	Dry	Dry	DNV	Dry	4.4	8.9	7.5	14.0	18.7	19.4
	pH	7.56	7.6	Dry	Dry	DNV	Dry	7.67	6.95	7.89	7.52	7.01	7.47
	SPC	122.3	125.5	Dry	Dry	DNV	Dry	95.9	70.4	84.0	35.6	492.2	100.6
	DO	7.29	8.01	Dry	Dry	DNV	Dry	9.75	11.03	10.16	9.74	8.70	8.40
	ORP	109.3	56.3	Dry	Dry	DNV	Dry	176.7	234.6	54.9	67.3	158.1	82.6
	Turbidity	45.7	7.4	Dry	Dry	DNV	Dry	7.32	17.75	24.35	24.53	200.0	24.35
Temperature - °C pH - Std. Units Conductivity - μSiemen/cm Dissolved Oxygen (DO) - mg/L Turbidity - NTU Oxidation-Reduction Potential (ORP) - mV DNV = Did not visit; SPC = Specific Conductivity; SF = stream discharge flume; NM = Not Measured; Dry=No flow													

5.1.8 CONCLUSIONS

DoR-OR's monthly monitoring of water quality parameters and analytical water sampling show that most water quality parameters and analytes fall within ranges consistent with background. Metals analyses and radiological laboratory results indicate low concentrations and activities. No exceedances of any criteria were observed during FY25 with the exceptions of Arsenic (As) concentrations at SF-1, SF-5R, SF-6 and Spring DW10 and Lead (Pb) concentration at Spring DW10. This project provided data to identify current water quality conditions in the CBCV EMDF area. TDEC's sampling provided independent monitoring of baseline data for use in future stream evaluations.

5.1.9 RECOMMENDATIONS

TDEC recommends continued surface water monitoring of the EMDF water along the portion of Bear Creek where the planned EMDF landfill will be constructed. Furthermore, the DoR-OR team recommends continued monitoring of surface water and one upgradient spring to support continued development of the EMDF baseline to support future water quality evaluations, as well as supplement anticipated future data collection efforts in the CBCV.

Additionally, DoR-OR recommends semi-annual sampling and spot sampling based on field observations to perform continuity checks, as well as monthly monitoring of water quality parameters in the interim until DOE initiates their own pre-operational baseline sampling. Regular sampling should be conducted at streams and the spring feeding the Bear Creek tributaries, focusing on radionuclides, metals, PCBs, PFAS, and volatile organic compounds, which are contaminants known to be in nearby disposal areas.

5.1.10 REFERENCES

EPA: Risk Assessment, Regional Screens Levels (RSLs), "Regional Screening levels for Chemical Contaminants at Superfund Sites". 2020. Washington (DC): US Environmental Protection Agency; [assessed 2023 Feb]. <https://www.epa.gov/risk/regional-screening-levels-rsls>.

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5.2 EMWMF LANDFILL MONITORING

5.2.1 BACKGROUND

The Environmental Management Waste Management Facility (EMWMF) is located in Bear Creek Valley west of the Y-12 National Security Complex (Y-12) (Figure 5.2.1.1). EMWMF is a landfill operated by DOE under the *Comprehensive Environmental Response, Cleanup and Liability Act* (CERCLA) and was constructed for the disposal of low-level radioactive and hazardous wastes generated by remedial activities on the Oak Ridge Reservation (ORR). The EMWMF is comprised of six disposal areas, or cells, that have a total capacity of approximately 2.3 million cubic yards (DOE, 2017).

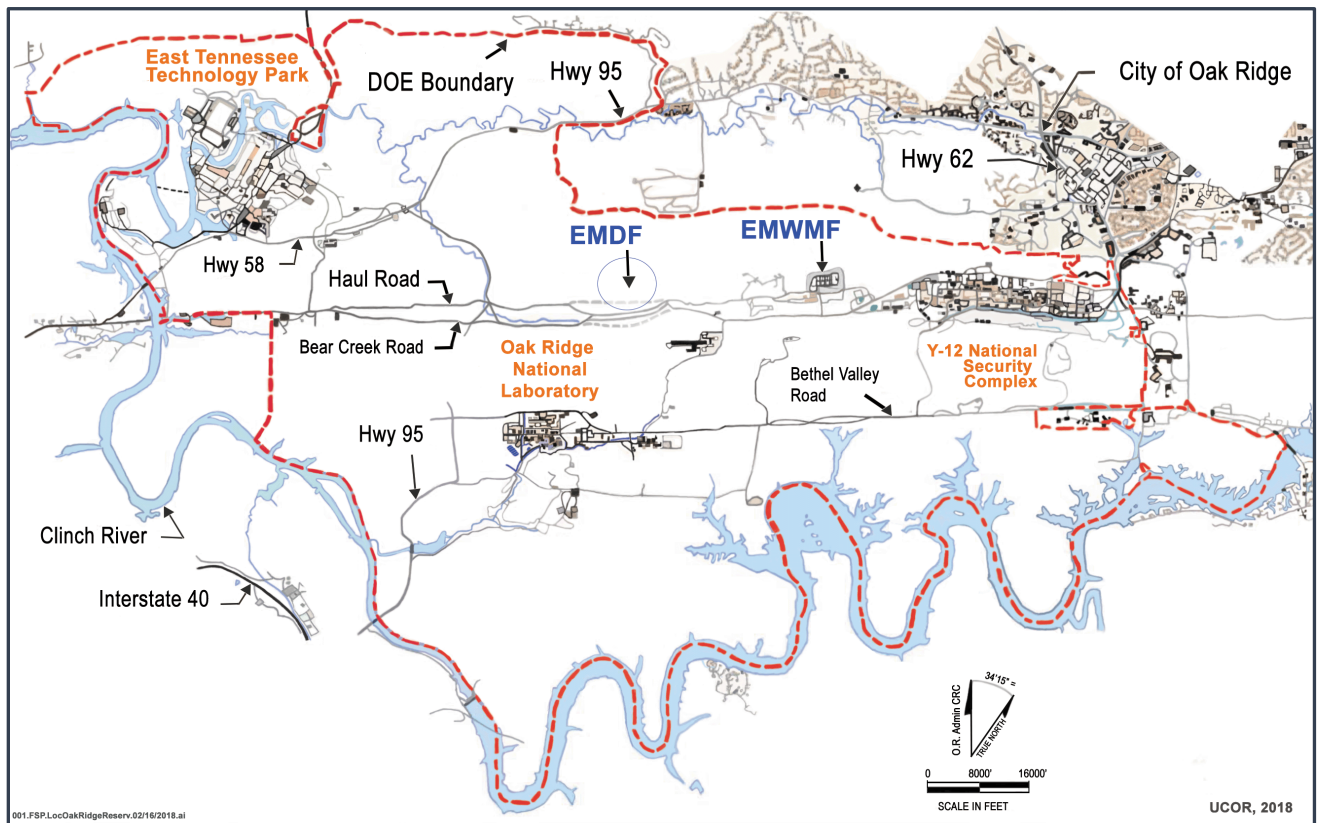


Figure 5.2.1.1: Location of EMWMF (DOE, 2025)

Materials that are shipped to the EMWMF include soil, sediment, building demolition debris, personal protective equipment, and scrap equipment. Currently, only low-level radioactive solid waste is approved for disposal in the EMWMF. Disposal requirements for this type of waste are recorded in the EMWMF ROD (DOE, 1999) and WAC plan (DOE, 2001). These requirements are interpreted in *TDEC 0400-20-11-.16(2) (Licensing Requirements for Land Disposal of Radioactive Waste, "Performance Objectives")*, with radiological concentrations below limits imposed by Waste Acceptance Criteria (WAC) and agreed upon by the FFA tri-parties (DOE, EPA, and TDEC) (TDEC, 2012; DOE, 2020).

The potentially contaminated stormwater (contact water) is the only authorized discharge allowed from EMWMF following established release criteria. The *Clean Water Act* (CWA) discharge limits for radiological and chemical constituents are currently in development. Contact water collects in the disposal cells, just above the leachate collection system and is routinely pumped from the disposal cells to holding ponds and tanks (i.e. contact water ponds and tanks) (Figure 5.2.1.2). Water is then sampled and analyzed for contaminants of concern (COCs). If contaminant levels exceed release criteria limits, the contact water is treated offsite at the Liquid Gaseous Waste Operation (LGWO).



Figure 5.2.1.2: Aerial Photo of the EMWMF (DOE, 2025)

Whenever contact water concentrations are below the release criteria, the water is discharged into the stormwater sedimentation basin, which discharges into NT-5, a tributary of Bear Creek. Contact water monitoring was conducted to evaluate compliance with the dose limits required by EMWMF ARARs 10 CFR 20.1301(a) (*Standards for Protection Against Radiation, "Dose Limits for Individual Members of the Public"*), 10 CFR 20.1301(a) (As Low As Reasonably Achievable, ALARA), and TDEC 0400-20-11-.16(2) (formerly TDEC 1200-2-11-.16(2)) to verify performance objectives for the disposal of radioactive waste. Additionally, monitoring was performed to

assess compliance with *TDEC 0400-40-03-.03(3)* (formerly *TDEC 1200-04-03-.03(3)*) under the General Water Quality Criteria, "Criteria for Water Users," as specified in the SAP/QAPP (DOE, 2017).

TDEC DoR-OR began surface water monitoring at the EMWMF in 2006 which has continued through FY25. Each year, samples were collected, analyzed, and results published in the DoR-OR *Environmental Monitoring Report* (EMR). This monitoring provides independent regulatory oversight and verification of DOE's monitoring data.

5.2.2 PROBLEM STATEMENTS

In Spring and Fall 2018, chromium VI (Cr^{6+}) levels in contact water exceeded the release criteria of 16 $\mu\text{g/L}$ (DOE, 2022). Additionally, DOE environmental monitoring reports have identified groundwater concentrations of U-233/234, U-238, barium, boron, calcium, magnesium, molybdenum, strontium, and Cl-36 exceeding threshold values (DOE, 2022).

These contaminants in the waste materials from CERCLA remediation activities are buried in the EMWMF and could potentially leach out of the landfill, enter the surrounding environment, and migrate offsite via surface water and/or groundwater at concentrations exceeding agreed-upon limits.

5.2.3 GOALS

OVERALL, THE EMWMF MONITORING PROJECT:

- 1) Monitored discharges from the landfill into the Bear Creek Watershed.
- 2) Conducted independent monitoring to verify DOE monitoring data.
- 3) Provided oversight to ensure that operational requirements and remedial action objectives were met for the EMWMF.

SPECIFIC FY25 MONITORING GOALS:

- 1) Performed high-frequency and routine independent monitoring.
- 2) Augmented DOE's surface water data and filled potential gaps in DOE's monitoring.
- 3) During this year of the project, staff calculated the approximate amount of discharged water volume from the contact water ponds/tanks. The project manager maintained an accurate record of discharged volumes for an evaluation of contaminant loading.

5.2.4 SCOPE

In FY25, DoR-OR's EMWMF surface water monitoring project consisted of three components:

MONTHLY DISCHARGE WATER QUALITY PARAMETERS: EMWMF-3, EMWMF-2, SW-003, NT5@BCK

In FY25, the project team measured water quality parameters monthly at four locations: EMWMF-2 (underdrain), EMWMF-3 (sediment basin V-weir discharge), SW-003 (upstream of EMWMF at BCK 11.54), and NT5@BCK (confluence of NT-5 and Bear Creek) (Figure 5.2.4.1 & Table 5.2.4.1).

CONTINUOUS IN-SITU ® MONITORING: EMWMF-2, EMWMF-3

In-Situ® multiparameter probes were installed at site EMWMF-2 and EMWMF-3. These probes collected water quality parameters on an hourly basis. Water quality parameter data were downloaded by DoR-OR personnel monthly.

SEMI-ANNUAL & ANNUAL SURFACE WATER SAMPLING & ANALYSIS: EMWMF-2, EMWMF-3, NT5@BCK, POND 4

From July 2024 through June 2025, surface water samples were collected semi-annually at sites EMWMF-2 and EMWMF-3, and annually at sites NT5@BCK and Contact Water Pond 4. Detailed COCs are listed in Table 5.2.6.3. The summary of the monitoring and sampling for FY25 is listed in Table 5.2.4.1.

Sites EMWMF-2 and EMWMF-3 are primary discharge points of the EMWMF, while sites SW-003 and NT5@BCK are located along Bear Creek, upstream and downstream of the EMWMF, respectively.

(Continues on Next Page - Table 5.2.4.1)

Table 5.2.4.1: EMWMF Monitoring and Sampling Sites

DOE Station ID	DoR-OR Sample ID	Frequency			Site Description
		Water Quality Parameter	In-Situ® Continuous Parameter	Surface Water Sampling	
EMW-VWEIR	EMWMF-3	Monthly	Continuous	Semi-annually	<i>EMWMF effluent discharge. Provides potential contaminant levels being discharged from the sediment basin.</i>
EMW-VWUNDRDRAIN	EMWMF-2	Monthly	Continuous	Semi-annually	<i>NT-4 discharge below the landfill. The underdrain was installed below Cell 3, The underdrain beneath Cell 3 is expected to serve as the earliest detection point for potential leaks from Cells 1–3 (DOE, 2022).</i>
BCK 11.54A	SW-003	Monthly	<i>None</i>	<i>None*</i>	<i>Upstream of EMWMF at BCK 11.54 location to be used as a water quality reference.</i>
BCK 10.60	NT5@BCK	Monthly	<i>None</i>	Annually	<i>Downstream surface water location along western landfill footprint; confluence of NT-5 and Bear Creek.</i>
Ponds/Tanks	Pond 4	<i>None</i>	<i>None</i>	Annually	<i>Provides confirmation of contaminant levels being discharged to the sediment basin</i>
* Surface Water samples were collected at SW-003 on November 13, 2024. It is included in the section of project deviation.					

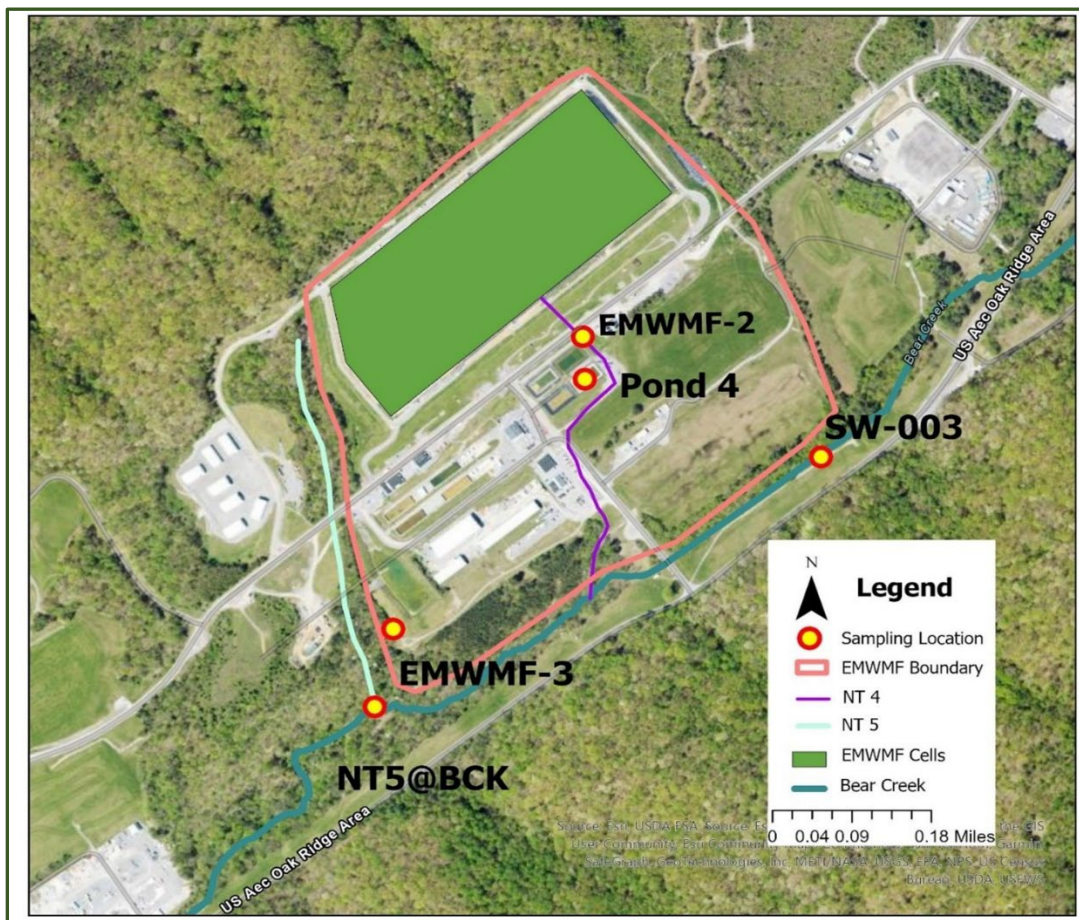


Figure 5.2.4.1: EMWMF Sample Sites

5.2.5 METHODS, MATERIALS, METRICS

MONTHLY WATER QUALITY PARAMETERS

The six water quality parameters measured in this first portion of the project include temperature, pH, specific conductivity, dissolved oxygen, turbidity and oxidation-reduction potential. DoR-OR personnel monitor parameters monthly in the field with two instruments (1) a YSI-Professional Plus and (2) a HF Scientific Micro-TPW Handheld Turbidimeter. Field measurements were collected following the *DoR-OR T-703 Field Use for Water Quality Parameters Instrument* (TDEC, 2023a) and *DoR-OR T-153 Water Quality Field Instrument Calibration and Maintenance* (TDEC, 2023b).

CONTINUOUS IN-SITU® MONITORING

Continuous water quality data at EMWMF-2 and EMWMF-3 were automatically collected on hourly intervals by installed In-situ® multiparameter probes. The water quality parameters included the same six parameters as noted (Table 5.2.5.1). Data was downloaded monthly onsite using the VuSitu® app.

Table 5.2.5.1: EMWMF - Water Quality Parameters

Field Measurement	Instrument	Parameters	Units
Monthly Water Quality Parameters	YSI-Professional Plus® water quality instrument	1. pH	1. STD Units
	HF Scientific MicroTPW Handheld Turbidimeter	2. Temperature	2. °C
In-situ® Continuous Monitoring	In-Situ® Multiparameter Probes	3. Specific conductivity	3. µS/cm
		4. Dissolved oxygen	4. mg/L
	VuSitu® App	5. Oxidation-reduction potential	5. mV
		6. Turbidity	6. NTU

SEMI-ANNUAL AND ANNUAL SURFACE WATER SAMPLING

DoR-OR collected surface water grab samples at site EMWMF-2 and EMWMF-3 *semi-annually*, and at the Contact Water Pond 4 and NT5@BCK site *annually*. Collected samples were analyzed for radionuclides, metals, inorganics, and organics (Table 5.2.5.2). Water samples were collected following *DoR-OR T-704 Collection of Surface Water Samples* (TDEC 2023c). Surface water analytical results were compared to applicable EPA and TDEC criteria.

Table 5.2.5.2: EMWMF Analytes and Contaminants of Concern (COCs)

Parameter Type	Analytes	Lab Analysis Method
Radionuclides	Gross Alpha/Beta	EPA 900.0
	* Gamma	EPA 901.1
	** Transuranics	DOE HASL 300
	Carbon-14	EPA EERF
	*** Isotopic Uranium	DPE HASL 300
	Strontium-89/90 (Sr-89/90)	EPA 905.0
	Radium-226/228 (Ra-226/228)	EPA 904.0
	Technetium-99 (Tc-99) / Tritium (H-3)	EPA 906.0
Metals	Arsenic	Method 6020
	Barium	
	Cadmium	
	Chromium (Total)	
	Cobalt	
	Copper	
	Lead	
	Nickel	
	Uranium	
	Vanadium	
	Zinc	
	Low-Level Mercury (LLHg)	EPA 1631
Organics	Low-level PCBs	EPA 1668
Inorganics	TSS	2540d
	TDS	2540c
Notes: * Gamma: Cs-137, Co-60, Pb isotopes, Np-237, Am-241, and others ** Transuranics: Pu isotopes, Am-241, Np-237, and others *** Isotopic Uranium: U-234, U-235, U-238		

5.2.6 DEVIATIONS FROM PLAN

MONTHLY WATER QUALITY PARAMETERS

- Water quality parameters were not collected at SW-003 and NT5@BCK in July 2024.

CONTINUOUS IN-SITU® MONITORING

- There are data gaps for EMWMF-2 and EMWMF-3 between July 10 and August 27, 2024, caused by firmware equipment issues.

SEMI-ANNUAL AND ANNUAL SURFACE WATER SAMPLING

- In November 2024, an additional water sample was collected from site SW-003 to provide supplemental water quality background data for EMWMF discharge.
- No per-and polyfluoroalkyl substances (PFAS) analysis was conducted per DOE request.

5.2.7 RESULTS AND ANALYSIS

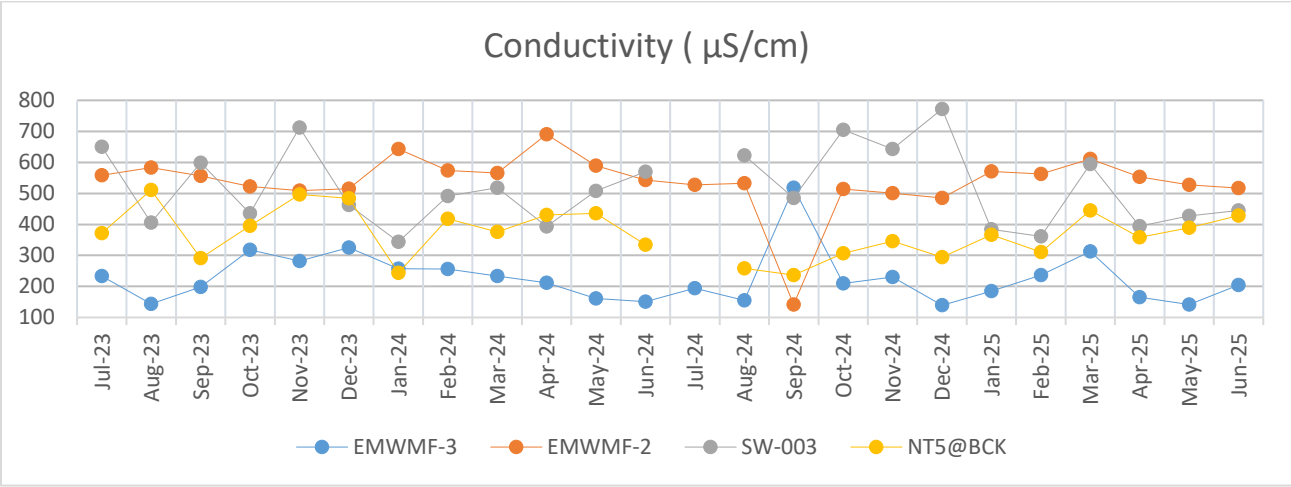
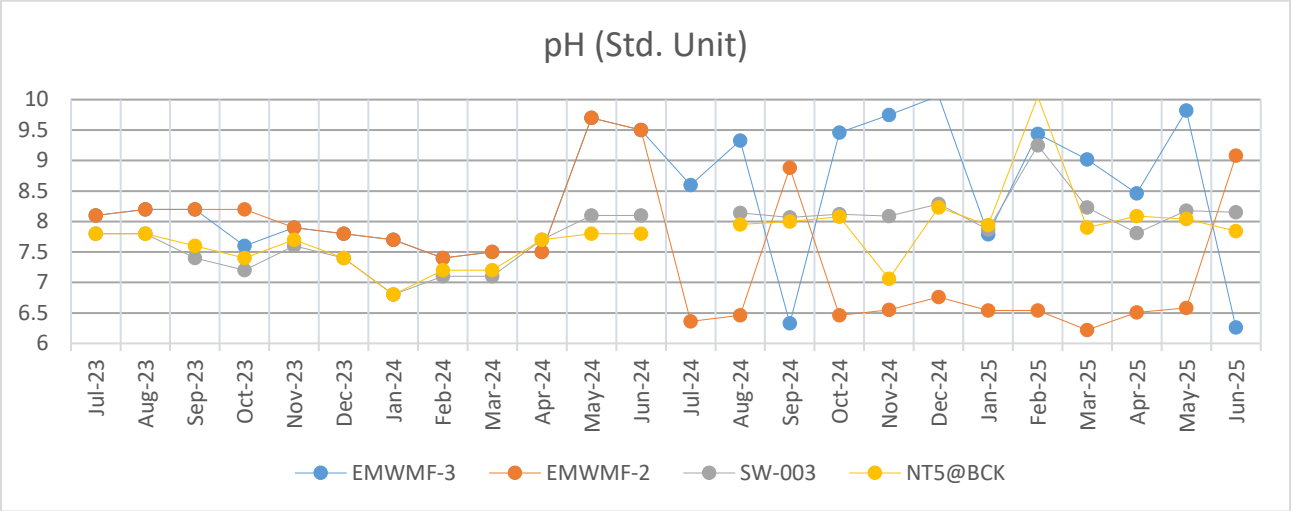
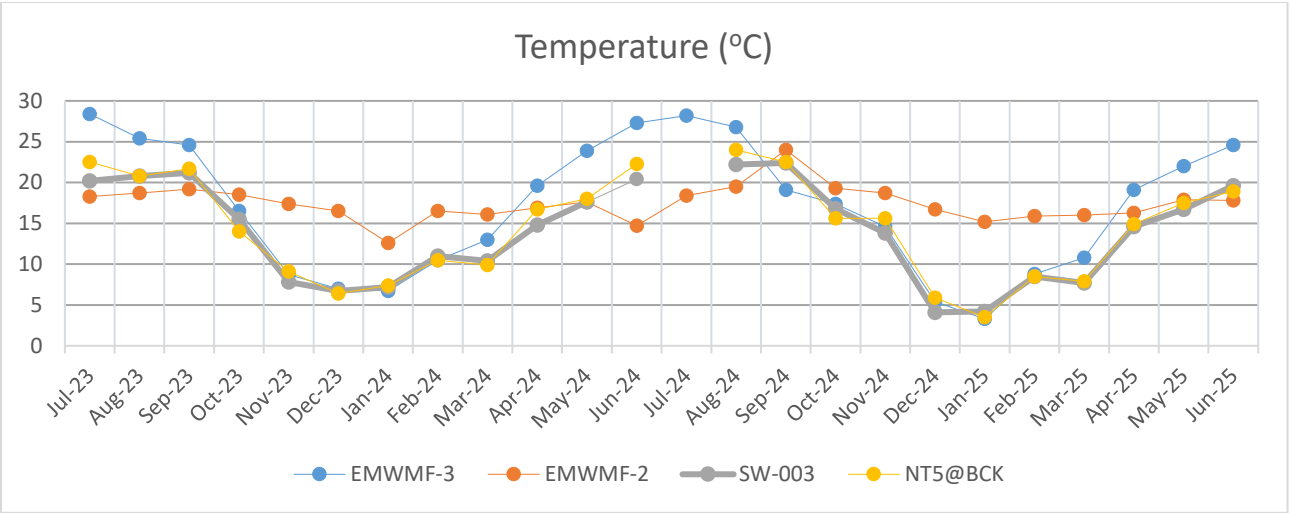
MONTHLY WATER QUALITY PARAMETERS

In FY25, water quality data from the four sampling locations are listed below in Table 5.2.7.1.

(Continues on Next Page - Table 5.2.7.1)

Table 5.2.7.1: FY25 EMWMF - Water Quality Parameters Monthly

FY25 EMWMF - Water Quality Parameters Monthly Averages														
Site	Parameter	July 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	Apr 2025	May 2025	Jun 2025	Annual Average
EMWMF-3	Temperature	28.2	26.8	19.1	17.4	14.6	5.4	3.3	8.8	10.8	19.1	22.0	24.6	16.7
	pH	8.6	9.3	6.3	9.5	9.8	10.1	7.8	9.4	9.0	8.5	9.8	6.3	8.7
	Conductivity	194.7	154.7	518	209.2	229.9	139.1	185	236.4	312.8	165	141.3	204.1	224.2
	DO	6.8	7.5	3.0	9.9	9.8	9.7	13.4	11.0	11.2	8.3	9.2	9.6	9.1
	ORP	87.0	32.7	153.7	80.5	77.4	100.1	207.2	186.8	115.6	112.6	103.4	203.9	121.7
	Turbidity	1.7	1.1	1.6	1.2	1.4	4.4	13.8	15.4	3.5	7.1	2.4	1.0	4.5
EMWMF-2	Temperature	18.4	19.5	24	19.3	18.7	16.7	15.2	15.9	16.0	16.3	17.9	17.8	18.0
	pH	6.4	6.5	8.9	6.5	6.6	6.8	6.6	6.6	6.2	6.5	6.6	9.1	6.9
	Conductivity	527	533	141.7	514	501	485	571	563	611	553	527	517	503.7
	DO	2.6	3.9	7.4	6.7	5.5	7.9	8.3	6.1	6.5	4.9	4.7	5.2	5.8
	ORP	131.9	71.1	58.5	157.2	160.5	120.5	231.3	230.7	201.5	124.9	128.1	189.2	150.5
	Turbidity	20.3	12.5	16.5	1.2	0.8	1.8	1.9	6.2	0.5	3.4	2.5	0.01	5.6
SW-003	Temperature	-	22.2	22.4	16.8	13.8	4.1	4.2	8.5	7.7	14.6	16.7	19.6	13.7
	pH	-	8.1	8.1	8.1	8.1	8.3	7.9	9.3	8.2	7.8	8.2	8.2	8.2
	Conductivity	-	622	485	705	643	772	384	362	595	395	427	445	530.4
	DO	-	8.2	8.5	9.4	9.0	12.3	12.3	10.8	11.0	9.4	8.6	8.4	9.8
	ORP	-	108.2	84.5	123.2	118.2	147.7	232.2	207.6	108.7	134.1	143.7	140.6	140.8
	Turbidity	-	1.8	3.2	5.0	2.3	1.7	11.5	54.9	5.4	19.5	13.6	8.5	11.6
NT5@BCK	Temperature	-	24	22.5	15.6	15.6	5.9	3.5	8.5	7.9	14.9	17.5	18.9	14.1
	pH	-	8.0	8.0	8.1	7.1	8.2	7.9	10.1	7.9	8.1	8.0	7.8	8.1
	Conductivity	-	259	237	306	346	294	366	310	445	358	390	428	340
	DO	-	7.3	7.5	9.0	8.6	11.8	12.5	11.0	10.8	9.6	8.4	8.7	9.6
	ORP	-	85.4	100.6	119.9	123.3	120	185.1	213.0	46.4	127.7	137.8	80.0	121.8
	Turbidity	-	3.3	4.8	5.0	3.6	3.4	9.0	89.5	6.7	19.9	12.8	13.5	15.6
Temperature: °C; Conductivity: $\mu S/cm$; Oxygen Reduction Potential (ORP): <i>mV</i> ; pH: <i>std. units</i> ; Dissolved Oxygen (DO): <i>mg/L</i> ; Turbidity: <i>NTU</i> * No data collected during this event.														



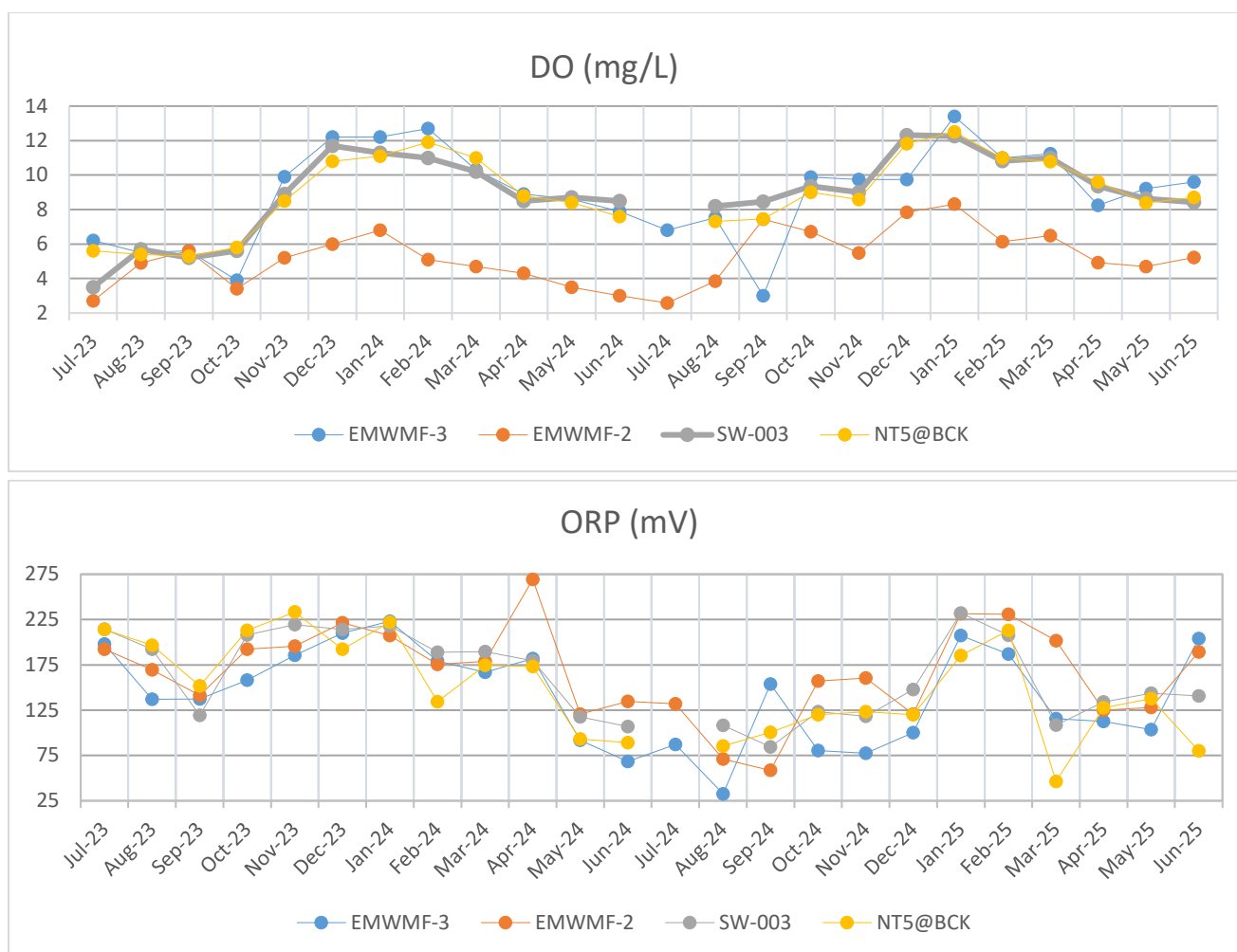


Figure 5.2.7.1: Means for Five Parameters from July 2023 to May 2025

TEMPERATURE

The water temperature showed a clear seasonal trend over all sites. EMWMF-2 temperature was more consistent compared with the other three sites. The lowest temperature at EMWMF-2 was 15.2 °C in January, whereas EMWMF-3, SW-003, and NT5@BCK recorded much lower temperatures of 3.3 °C, 4.2 °C, and 3.5 °C during the same sampling event, respectively.

pH

The mean pH of EMWMF-3, EMWMF-2, SW-003 and NT5@BCK during FY25 was 8.7, 6.9, 8.2, and 8.1, respectively. The highest pH value observed was 10.06 detected at EMWMF-3 in December 2024, while the lowest was 6.2 at EMWMF-2.

CONDUCTIVITY

From July 2024 to June 2025, mean conductivity ranged from 224 to 530 $\mu\text{S}/\text{cm}$ across all sites. SW-003 had the highest mean annual conductivity and the maximum observed value of 772

µS/cm in December 2024. In contrast, the lowest conductivity value (139 µS/cm) was recorded at EMWMF-3 during the same sampling event. Similar conductivity seasonal trends were observed at EMWMF-3, EMWMF-2, and NT5@BCK.

DISSOLVED OXYGEN

All sites displayed a similar seasonal trend in DO. Peak DO concentrations occurred in January 2025. The highest concentration was 13.4 mg/L at EMWMF-3, and the lowest was 2.6 mg/L at EMWMF-2. EMWMF-2 consistently showed a lower annual mean of DO concentrations compared with the other three sites.

OXIDATION-REDUCTION POTENTIAL

ORP followed similar seasonal trends across the four sites. Mean annual ORP values ranged from 121.7 to 150.5 mV. The highest ORP was observed at SW-003 in January 2025, while the lowest value (32.7 mV) was detected at EMWMF-3 in August 2024. ORP was generally highest in winter and lowest in summer. Annual mean ORP values at EMWMF-2 and SW-003 were higher than those at EMWMF-3 and NT5@BCK.

TURBIDITY

Annual mean turbidity ranged from 4.5 NTU at EMWMF-3 to 15.6 NTU at NT5@BCK. The highest individual turbidity value (89.5 NTU) was recorded at NT5@BCK, elevating the annual mean at that site. SW-003 recorded the second highest individual turbidity of 54.9 NTU in February 2025. Annual mean turbidity values were similar at EMWMF-3 (4.5 NTU) and EMWMF-2 (5.6 NTU).

FY24 AND FY25 FIELD PARAMETER COMPARISON

The FY25 field parameter data were evaluated alongside the monthly data collected in FY24 with same field protocols (Figure 5.2.7.2). Temperature, DO, and ORP showed similar seasonal fluctuations across all four sites in both fiscal years. pH measurements at EMWMF-2 and EMWMF-3 showed greater variability in FY25 compared to FY24, with the annual mean pH at EMWMF-3 elevated relative to the prior year. Conductivity monthly averages remained relatively stable across all four sites during both fiscal years.

CONTINUOUS IN-SITU® MONITORING

On October 19, 2023, DoR-OR personnel installed multiparameter probes at sites EMWMF-2 and EMWMF-3 to collect continuous water quality data. These probes measured pH, temperature, conductivity, DO, ORP, and turbidity on an hourly basis. The dataset was summarized using the 25th percentile (Q1), median (Q2), 75th percentile (Q3), monthly averages, and observed minimum and maximum values (Table 5.2.7.2). Boxplots (Figures 5.2.7.1 and 5.2.7.2) illustrate the monthly distributions and seasonal trends observed from September 2024 through June 2025.

EMWMF-2

At EMWMF-2, which represents the NT-4 discharge downstream of the landfill and is influenced by the underdrain installed below Cell 3, pH, temperature, and ORP displayed more frequent outliers in October and November 2024, although most values remained within the ranges of pH 5.15–7.98, temperature 15.98–24.4 °C, and ORP 151.64–439.58 mV. From December 2024 through June 2025, these parameters were generally distributed between the first and third quartiles, suggesting stable seasonal conditions across winter, spring, and summer. Turbidity at EMWMF-2 was comparatively low in fall and winter 2024 but increased during spring and summer 2025, with monthly means ranging from 1.69 to 43.9 NTU and occasional outliers as high as 916 NTU.

EMWMF-3

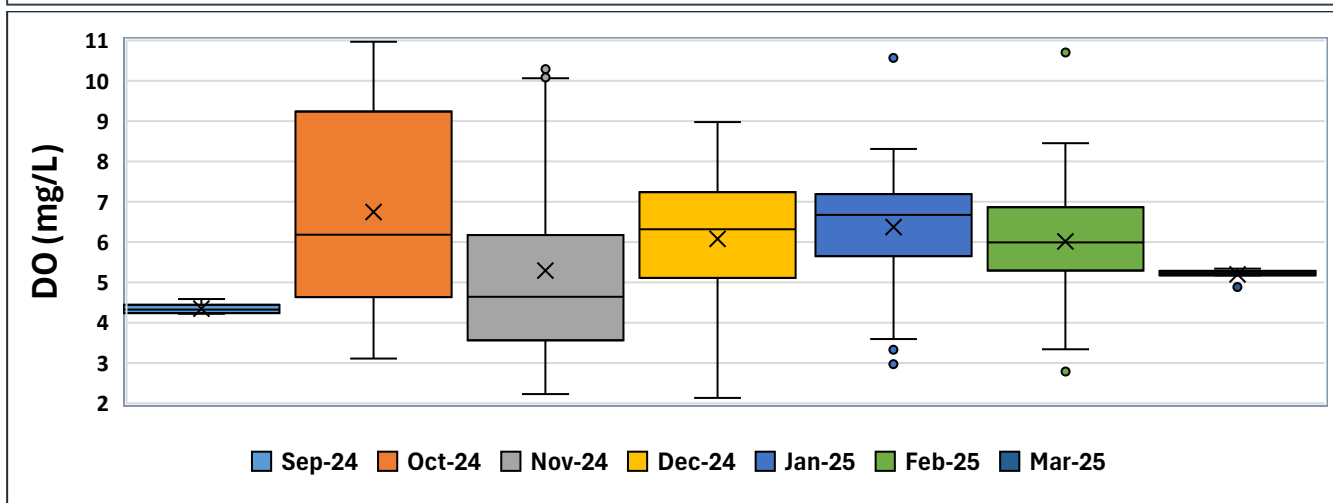
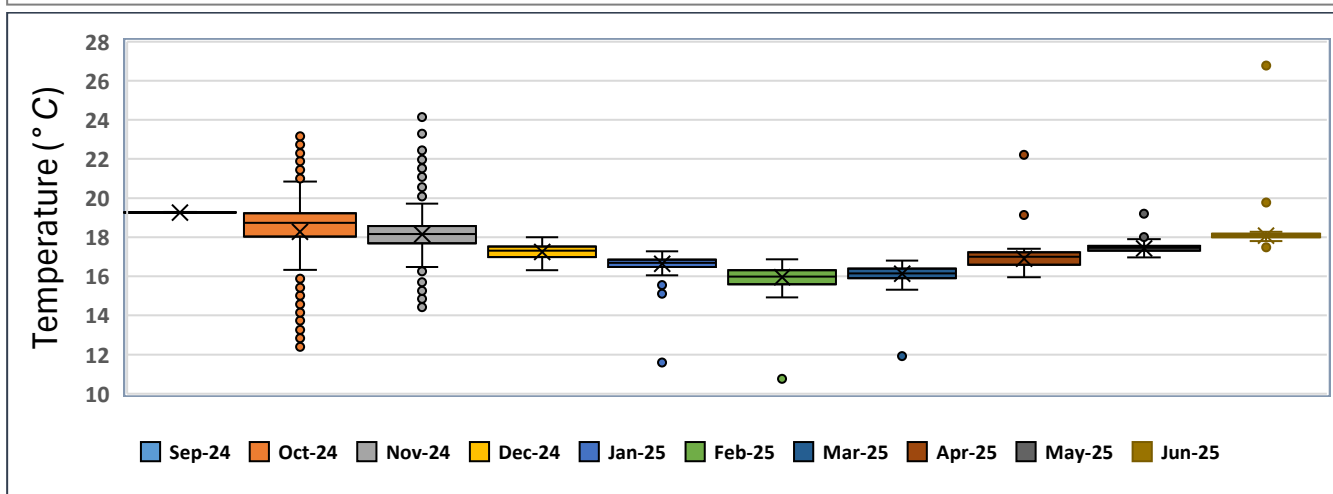
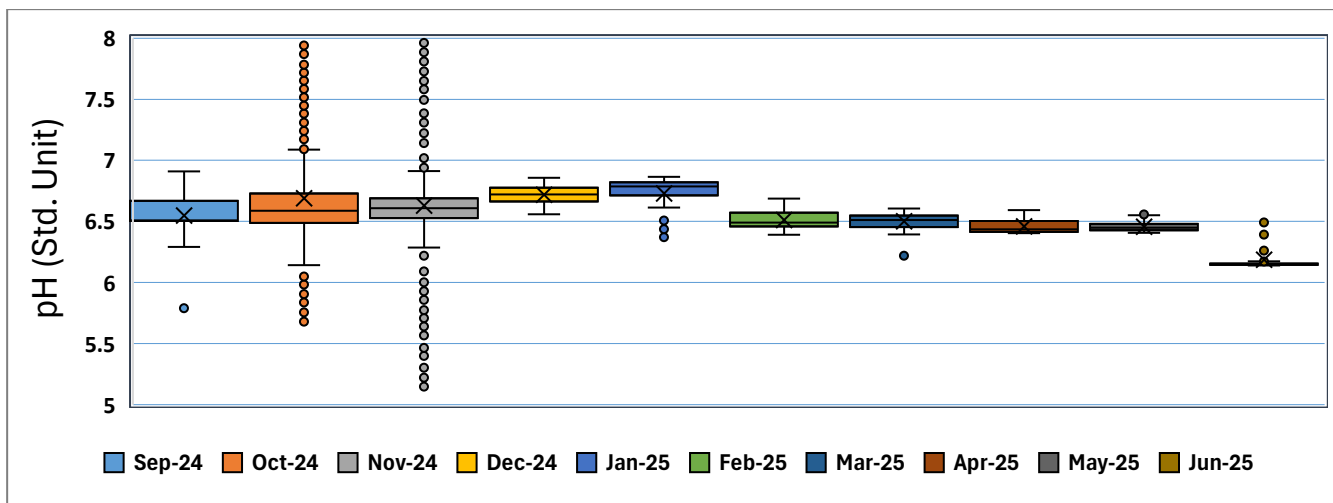
At EMWMF-3, seasonal patterns of temperature and dissolved oxygen aligned with water quality measurements collected using the YSI-Professional Plus® instrument in FY25. pH and ORP were relatively stable during fall and winter 2024 but showed greater variability in spring and summer 2025. According to Table 5.2.7.2, most pH values at this site exceeded the EMWMF discharge criterion of 6–9 standard units. Turbidity at EMWMF-3 was more variable between February and June 2025, with monthly means ranging from 50.79 to 1,472.24 NTU. The maximum turbidity recorded was 4,000 NTU, which corresponded to the upper detection limit of the probe's calibration range.

(Continues on Next Page - Table 5.2.7.2.)

Table 5.2.7.2: FY25 EMWMF Continuous In-Situ® Water Quality Parameters

Site	Calculation	2024				2025					
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
pH											
EMWMF-2	25%Q	6.50	6.49	6.53	6.66	6.72	6.46	6.45	6.42	6.43	6.14
	Median	6.51	6.59	6.61	6.72	6.79	6.54	6.51	6.44	6.45	6.15
	75%Q	6.65	6.73	6.69	6.78	6.82	6.57	6.55	6.50	6.48	6.16
	Maximum	6.91	7.94	7.98	6.86	6.87	6.69	6.61	6.59	6.59	6.52
	Mean	6.55	6.69	6.63	6.72	6.73	6.51	6.50	6.46	6.46	6.19
	Minimum	5.79	5.68	5.15	6.56	6.37	6.39	6.22	6.40	6.41	6.14
EMWMF-3	25%Q	-	-	9.45	9.42	9.30	8.75	9.10	9.41	9.41	7.74
	Median	-	-	9.82	9.87	9.46	9.14	9.38	9.56	9.37	8.33
	75%Q	-	-	10.16	10.29	9.67	9.50	9.76	9.72	9.65	8.80
	Maximum	-	-	10.39	10.62	9.91	9.79	10.11	10.07	9.95	9.93
	Mean	-	-	9.75	9.82	9.45	9.07	9.33	9.52	9.52	8.29
	Minimum	-	-	8.55	8.60	7.69	7.96	7.82	9.52	9.52	8.29
DO											
EMWMF-2	25%Q	4.25	4.64	3.57	5.11	5.68	5.30	5.18	-	-	-
	Median	4.32	6.18	4.64	6.31	6.67	5.99	5.23	-	-	-
	75%Q	4.44	9.23	6.17	7.23	7.18	6.86	5.28	-	-	-
	Maximum	4.59	10.97	10.39	8.98	10.56	10.70	5.34	-	-	-
	Mean	4.35	6.75	5.29	6.07	6.37	6.01	5.19	-	-	-
	Minimum	4.22	3.11	2.23	2.13	2.97	2.79	4.88	-	-	-
EMWMF-3	25%Q	-	-	9.69	12.15	13.28	12.14	10.47	9.45	8.35	6.03
	Median	-	-	10.68	13.07	14.14	12.82	11.35	10.17	9.00	6.82
	75%Q	-	-	11.95	13.79	14.47	14.07	12.57	10.85	9.64	7.67
	Maximum	-	-	12.96	16.20	16.11	15.87	14.82	12.82	10.98	10.00
	Mean	-	-	10.72	12.94	13.94	13.15	11.56	10.16	8.97	6.91
	Minimum	-	-	8.02	9.75	10.56	11.00	8.76	4.93	5.82	4.88
Temperature											
EMWMF-2	25%Q	19.26	18.04	16.94	16.98	16.48	15.60	15.90	16.59	17.31	18.00
	Median	19.26	18.73	18.16	17.31	16.70	15.98	16.15	16.99	17.47	18.11
	75%Q	19.27	19.22	18.57	17.51	16.85	16.31	16.40	17.22	17.56	18.18
	Maximum	19.29	23.16	24.40	17.99	17.27	16.88	16.81	22.21	19.38	26.78
	Mean	19.26	18.28	17.28	17.25	16.64	15.96	16.13	16.91	17.42	18.09
	Minimum	19.26	18.73	18.16	17.31	16.70	15.98	16.15	16.99	17.47	18.11
EMWMF-3	25%Q	-	-	11.10	5.89	3.86	7.36	11.99	18.32	21.40	27.60
	Median	-	-	13.93	7.38	5.87	9.20	14.78	20.82	22.78	29.43
	75%Q	-	-	17.12	9.43	7.15	12.07	16.62	22.70	24.46	31.59
	Maximum	-	-	22.92	12.75	13.08	16.42	20.58	28.08	27.38	36.27
	Mean	-	-	14.20	7.58	5.78	9.45	14.39	20.55	22.86	29.43
	Minimum	-	-	6.55	2.82	2.24	3.02	8.34	13.82	17.94	21.80

Site	Calculation	2024				2025					
		Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Conductivity											
EMWMF-2	25%Q	541.98	502.63	478.66	482.10	539.81	570.87	554.60	546.83	548.23	517.84
	Median	543.49	510.45	482.39	498.73	547.13	581.37	561.49	549.15	560.53	519.30
EMWMF-2 (cont.)	75%Q	544.13	518.49	488.41	540.55	558.45	590.10	569.58	554.21	573.10	520.24
	Maximum	546.18	539.16	501.00	582.38	584.61	627.64	639.48	633.68	601.96	594.29
	Mean	543.10	511.94	482.63	513.24	548.51	579.18	567.18	551.01	562.88	526.07
	Minimum	539.61	498.35	457.66	458.73	501.50	501.42	406.07	533.67	441.74	504.03
EMWMF-3	25%Q	-	-	136.70	128.59	171.29	180.96	158.43	152.84	145.57	224.17
	Median	-	-	139.15	136.53	255.29	188.08	178.88	166.99	170.12	235.23
	75%Q	-	-	226.41	163.00	263.49	205.48	313.62	217.54	198.61	248.75
	Maximum	-	-	247.22	242.32	267.32	346.94	347.58	553.00	245.51	271.10
	Mean	-	-	168.36	150.46	226.61	199.26	226.72	183.62	173.90	236.52
	Minimum	-	-	118.24	109.04	103.79	134.88	1.36	128.30	125.58	196.39
ORP											
EMWMF-2	25%Q	327.89	272.70	339.38	338.15	346.78	377.99	376.02	374.19	378.65	327.89
	Median	329.66	283.65	345.53	342.66	354.80	391.50	389.40	383.04	400.71	329.66
	75%Q	333.16	296.83	350.49	347.80	357.09	399.95	397.45	390.60	410.13	333.16
	Maximum	338.29	399.80	439.58	356.28	366.43	410.72	414.34	397.00	419.83	338.29
	Mean	328.13	276.74	336.21	342.46	345.63	388.27	385.57	380.81	393.15	328.13
	Minimum	293.71	151.64	207.73	320.65	179.08	348.63	312.09	263.09	212.29	293.71
EMWMF-3	25%Q	-	-	138.92	129.56	171.86	208.20	162.01	142.87	143.44	226.93
	Median	-	-	161.87	142.45	184.31	233.68	207.02	164.14	174.39	290.36
	75%Q	-	-	206.25	168.99	194.78	258.40	242.43	185.53	238.08	359.83
	Maximum	-	-	326.44	241.11	258.67	307.21	327.81	296.38	388.18	395.15
	Mean	-	-	177.42	151.43	185.23	234.23	205.00	167.61	196.64	289.84
	Minimum	-	-	107.79	107.79	140.91	175.11	104.63	108.73	115.86	147.86
Turbidity											
EMWMF-2	25%Q	-	2.51	3.43	2.94	11.02	2.65	0.24	0.42	1.13	0.48
	Median	-	2.77	15.48	8.18	19.55	5.58	0.33	0.70	9.07	0.51
	75%Q	-	4.11	31.76	78.54	37.17	18.05	0.59	1.44	20.81	0.87
	Maximum	-	5.26	47.74	187.77	105.28	438.89	296.96	65.52	916.00	387.80
	Mean	-	3.24	18.67	43.90	25.80	24.89	9.26	1.69	17.98	4.12
	Minimum	-	1.56	0.59	0.18	0.34	0.16	0.11	0.03	0.54	0.40
EMWMF-3	25%Q	-	-	357.87	515.97	146.81	170.25	32.79	19.70	733.70	29.34
	Median	-	-	457.7	533.7	330.5	284.9	74.5	24.7	1134.6	40.5
	75%Q	-	-	535.7	536.8	400.1	458.0	300.0	62.3	2032.8	53.0
	Maximum	-	-	541.5	544.1	>4000	>4000	>4000	>4000	>4000	>4000
	Mean	-	-	412.92	507.50	284.77	383.56	339.18	112.49	1472.24	50.79
	Minimum	-	-	0.66	108.88	1.24	43.86	11.86	10.37	124.39	3.02
Temperature: °C; Conductivity: µS/cm Oxygen Reduction Potential (ORP): mV pH: std. units Dissolved Oxygen (DO): mg/L Turbidity: NTU= no data collected during this event.											



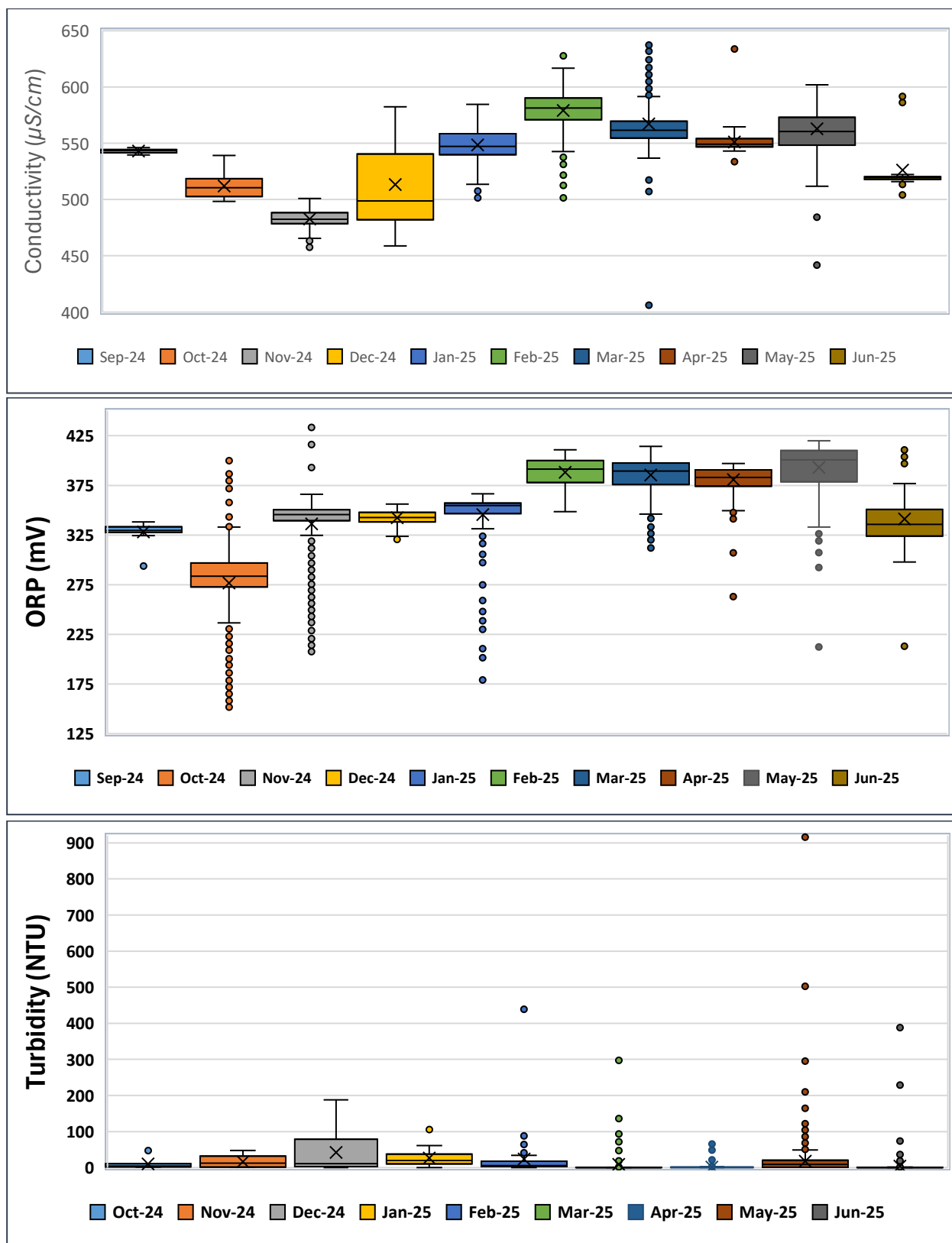
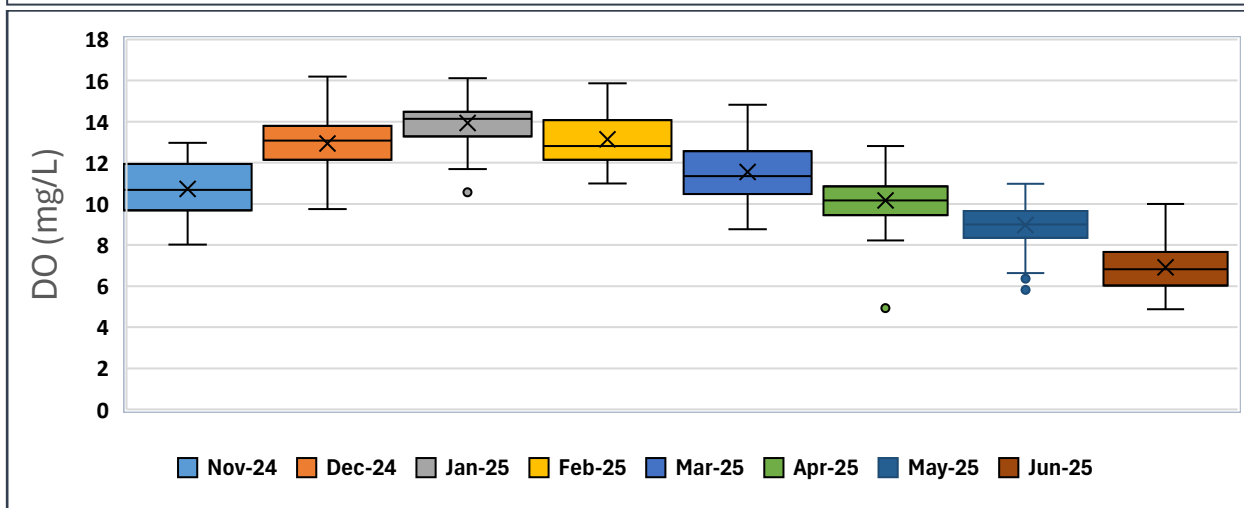
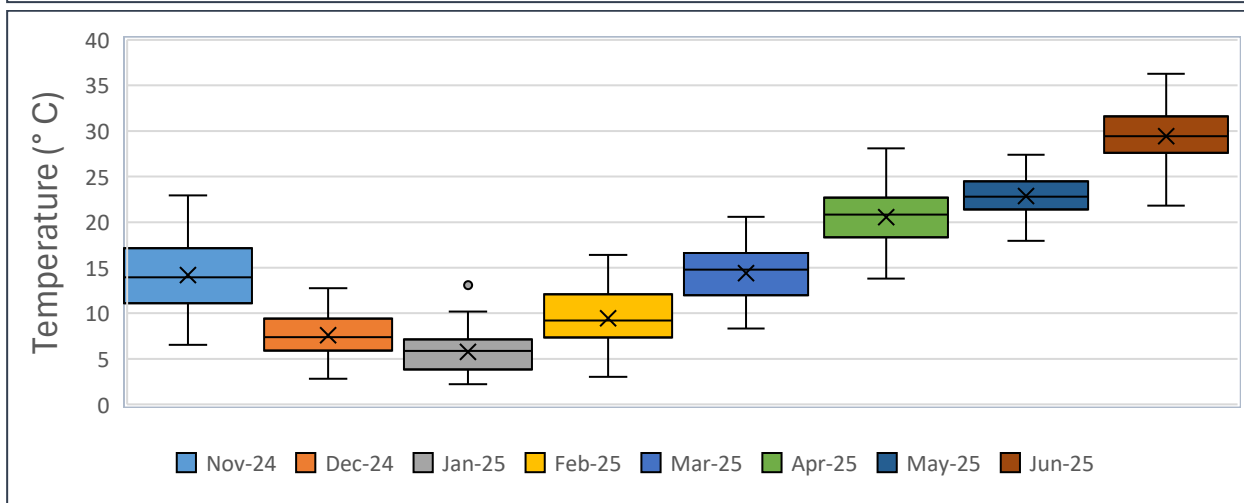
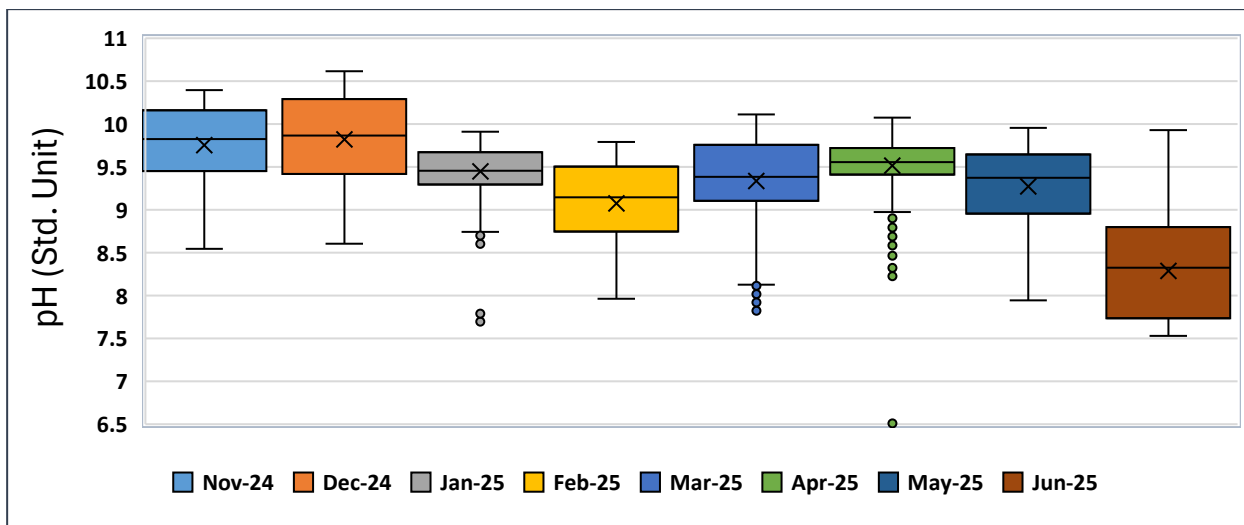


Figure 5.2.7.2: In-Situ® Continuous Water Quality Parameters at EMWMF-2



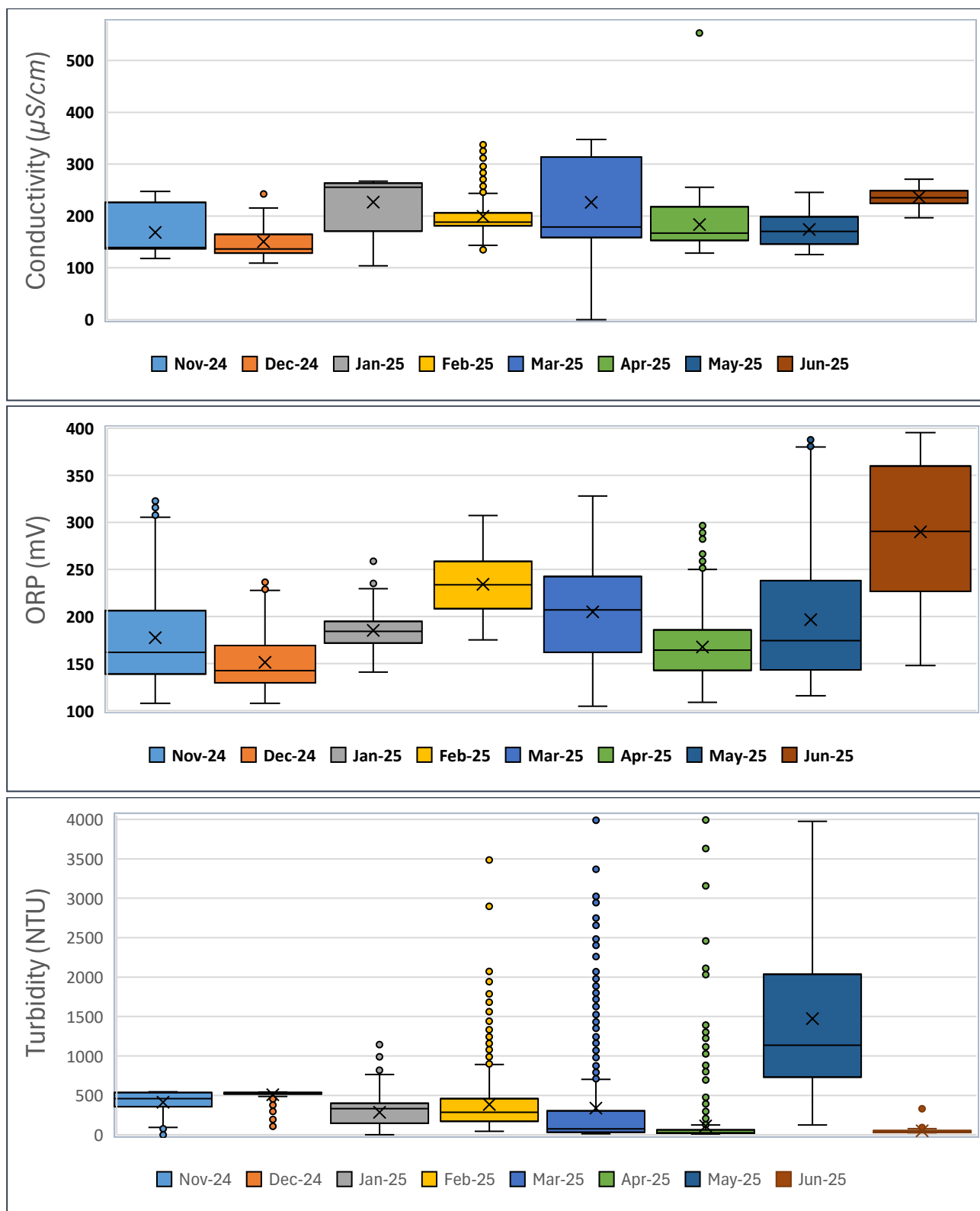


Figure 5.2.7.3: In-Situ® Continuous Water Quality Parameters at EMWMF-3

ANALYTICAL SURFACE WATER GRAB SAMPLES

Between July 2024 and June 2025, three surface water sampling events were conducted at EMWMF. Grab samples were collected on November 13, 2024, from EMWMF-2, EMWMF-3, SW-003, and NT5@BCK; on June 2, 2025, from EMWMF-2 and EMWMF-3; and on June 5, 2025, contact water was co-sampled with DOE from Pond 4. All samples were analyzed for radiological, organic, inorganic, and metal constituents (Tables 5.2.7.3 and 5.2.7.4).

Concentrations of radiological parameters were compared with EPA Maximum Contaminant Levels (MCLs) for drinking water (EPA, 2020), EPA Preliminary Remediation Goals (PRGs) for radionuclides at Superfund sites (EPA, 2023), and EMWMF Release Criteria (DOE, 2017). All radionuclides were below EMWMF Release Criteria. Radionuclides exceeding EPA MCL and TDEC Drinking Water Supply Rule were gross alpha and gross beta detected at Pond 4 on June 5, 2024. Across EMWMF-2, EMWMF-3, and Pond 4, radionuclide concentrations were above EPA PRGs for Residential Tap Water.

Radiological results indicated that gross alpha, radium-226, radium-228, technetium-99, tritium, uranium-234, and uranium-238 were detected at all sites. Pond 4 exhibited the highest concentrations of gross alpha, gross beta, cobalt-60, strontium-90, technetium-99, tritium, uranium-234, and uranium-235. The highest concentration of potassium-40 and uranium-238 were detected at site SW-003. Beryllium-7 and plutonium-238 were not detected at any location.

Metals and total suspended solids (TSS) were compared to five benchmarks: Tennessee Aquatic Life Fresh Water Criterion Maximum Concentration (CMC) and Criterion Continuous Concentration (CCC), Tennessee AWQC Recreation Organisms Only Criteria, Tennessee Community/Non-Community Water Systems MCLs, and EMWMF Discharge Release Criteria. At EMWMF-2, most metals were observed at higher concentrations in June 2025 compared to November 2024. Chromium, lead, and mercury reached peak concentrations at Pond 4. Mercury and uranium were consistently detected at all sites, while vanadium was not detected at any location. All metals were below benchmark criteria except lead, which was detected at Pond 4 on June 5, 2025, at 3.42 µg/L, exceeding the Tennessee Aquatic Life Fresh Water CCC of 2.5 µg/L.

Total dissolved solids (TDS) were highest at NT5@BCK, while the maximum TSS of 51.6 mg/L occurred at EMWMF-2 in November 2024, approximately ten times higher than at SW-003 during the same event, but still below the EMWMF Discharge Release Criteria. Polychlorinated biphenyls (PCBs) were not detected at any site. The Tennessee AWQC for PCBs is 0.014 µg/L, which is below the analytical method detection limit and not suitable for direct comparison.

Table 5.2.7.3: FY25 EMWMF Radionuclides Results

Sampling Frequency	Semi-Annual				Annual			EPA Drinking Water MCL	EPA PRGs for Residential Tap Water	EMWMF Discharge Release Criteria
Site	EMWMF-2		EMWMF-3		SW-003	NT5@BCK	Pond 4			
Sampling Date	11/13/24	6/2/25	11/13/24	6/2/25	11/13/24	11/13/24	6/5/25			
	Results (pCi/L)							(pCi/L)		
Gross alpha	0.0815 U	4.17	3.24	2.50 U	9.79	2.89	20.0	15	-	-
Americium-241	0.0181 U	0.203	0.0643	0.0441 U	0.14	0.289	0.0572 U	-	0.0158	-
Beryllium-7	6.06 U	-26.9 U	16.4 U	9.07 U	-21.1 U	-20.7 U	-6.19 U	-	137	-
Gross beta	0.519	5.09	15.3	1.92 U	28.3	7.33 U	95.5	50*	-	-
Cesium-137	-1.19 U	4.82	0.514 U	0.511 U	3.3 U	5.33	0.753 U	200	0.38	-
Cobalt-60	0.372 U	0.940 U	-0.451 U	0.869 U	-3.65 U	1.33 U	3.11	-	0.528	-
Neptunium-237	0.0811	-0.102 U	0.0583	0.170	0.174	0.802	0.0455 U	-	0.018	-
Plutonium-238	-0.0574 U	0.298 U	0.0744 U	-0.0255 U	0.0587 U	-0.00702 U	0.0261 U	-	0.00352	-
Plutonium-239/240	-0.0359 U	0.297	0.0907	0.548	0.0293	0 U	0.144	-	0.0133	-
Potassium-40	38.1	37.8	44.8	19.1 U	62.8	4.18 U	47.9	-	0.127	--
Radium-226	0.0877	0.116	0.0531	0.196	0.0722	0.113	0.113	5 (pCi/L) Combined	0.00383	--
Radium-228	2.14	0.352	0.972	0.250	1.61	2.19	0.177		0.00714	--
Strontium-89	-0.135 U	-0.727 U	1.76	-0.564 U	2.22	2.36	1.85	20	0.268	--
Strontium-90	0.529	0.253	0.68	0.331	-0.239 U	-0.242 U	0.813	8	0.0637	960
Technetium-99	-0.933 U	2.15	32.4	17.9	70	18.2	98.4	-	0.0241	96,000
Tritium	160	159	420	92.3	220	162	553	-	-	1,920,000
Uranium-234	0.738	1.06	6.19	3.57	12.2	3.58	19.5	-	0.00356	480
Uranium-235	0.516	0.0875	0.292	0.589	1.32	-0.0372 U	1.98	-	0.0154	480
Uranium-238	0.319	0.566	2.9	2.01	17.9	1.84	8.06	-	0.00356	480
U: Non-detect * referenced from TDEC Drinking Water Supply Rule 0400-45-01-.11.4.(b) Bold: Exceeded EPA Drinking Water MCL, .and TDEC Drinking water Supply Rule										

Table 5.2.7.4: FY25 EMWMF Metals and Inorganics Results

Table 5.2.7.4: FY25 EMWMF Metals and Inorganics Results

Sampling Frequency	Semi-Annual				Annual			TN Fish and Aquatic Life		AWQC Recreation Use Organisms Only	TN Community/ Non-Community Water Systems MCL	EMWMF Discharge Release Criteria
Site	EMWMF-2		EMWMF-3		SW-003	NT5@ BCK	Pond 4	CMC ₁	CCC ²			
Sampling Date	11/13/24	06/02/25	11/13/24	06/02/25	11/13/24	11/13/24	06/05/25					
Metals (ug/L)												
Arsenic	0.12 U	0.225 J	1.3 J	0.794 J	0.561 J	0.309 J	7.83 U	340	150	10.0	10	340
Chromium	0.9 U	5.6 U	0.9 U	5.6 U	0.9 U	0.9 U	4.66 B J	570	74	--	100	513
Cobalt	0.1 U	0.145 J	0.214 J	0.131 U	0.129 J	0.1 U	1.41 U	--	--	--	--	--
Copper	0.7 U	5.01	0.7 U	0.896 J	0.7 U	0.757 J	4.14 J	13	9.0	--	--	12
Lead	0.5 U	0.594 J	0.5 U	0.212 U	0.5 U	0.5 U	3.42 J	65	2.5	--	--	56
Mercury	0.00031 J	0.003	0.00099	0.0032	0.0025	0.001	0.0099	1.4	0.77	0.051	2	1.4
Nickel	0.5 U	0.178 J	0.554 J	0.165 U	0.5 U	0.62 J	1.96 U	470	52	4600	100	420
Uranium	0.258 J	0.403 J	6.84	5.14	3.55	49.8	30.6	--	--	--	--	--
Vanadium	0.52 U	0.408 U	0.52 U	0.408 U	0.52 U	0.52 U	5.64 U	--	--	--	--	--
Zinc	4 U	4.13 J	4 U	5.34 J	4 U	4 U	4.67 U	120	120	26000	--	
Inorganics (mg/L)												
Residue, Filterable (TDS)	285	339	142	124	203	382	297	--	--	--	--	--
Residue, Non-filterable (TSS)	0.283 U	51.6	0.8 J	2.1 J	4.9	1.6 J	1.8 J	--	--	--	--	110
CMC ¹ CMC: Criterion Maximum Concentration; CCC ² CCC: Criterion Continuous Concentration; Bold : Exceeded TN Fish and Aquatic Life CCC.												
U: Non-detect; J: Estimated between method detection limit (MDL) and method quantitation limit (MQL); B: Same analyte is found in the associated blank.												

DOE – EMWMF MONITORING

The DOE conducts regular monitoring of water samples from various sources at EMWMF, including wells, pipes, streams, ponds, tanks, and air. DOE's sampling schedule includes monthly, quarterly, annual, and biennial intervals. This report focuses on data from three primary discharge points: EMWMF-2 (designated as EMW-VWUNDRDRAIN for groundwater), EMWMF-3 (designated as EMW-VWEIR for surface water) and Pond 4 (designated as EMW-POND4 for surface water). Radionuclide levels measured in TDEC DoR-OR grab samples from EMWMF-2, EMWMF-3 and Pond 4 align closely with those recorded by DOE at these same locations (Table 5.2.7.5). The DOE project team has shared radionuclide data, which is also available on the Oak Ridge Environmental Information System (OREIS) database. All radionuclides concentration monitored at EMWMF-2 and EMWMF-3 by DoR-OR and DOE in FY 25 were below the DOE EMWMF Release Criteria.

Metals detected in DoR-OR grab samples from EMWMF-2, EMWMF-3, and Pond 4 were generally consistent with DOE's results, with concentrations within expected ranges and below Fish and Aquatic Life and Recreation Criteria, and EMWMF Discharge Release Criteria.

(Continued on Next Page - Table 5.2.7.5)

Table 5.2.7.5: DoR-OR & DOE EMWMF Surface Water Radionuclides Comparison at Pond 4, EMWMF-2 and EMWMF-3

Site	Pond 4		EMWMF-2									
Agency	DOR-OR	DOE	DOR-OR						DOE			
Sampling Date	07.29.23	06.05.24	07.15.24	07.15.24 Dup	07.16.24	08.12.24	09.17.24	09.17.24 Dup	11.13.24	06.02.25		
Gross alpha		20			2.36	2.36	-1.18 U		0.0815 U	4.17		
Gross beta		95.5			2.33 U	2.33 U			0.519	5.09		
Ne-237		0.0455 U							0.0811	-0.102 U		
Pu-238		0.0261 U							-0.0574 U	0.298 U		
K-40		47.9							38.1	37.8		
Sr-90		0.813	1.51	1.58			0.39 U	0.224 U	0.529	0.253		
Tc-99	44.6	98.4	0.672 U	0.671 U			1.06 U	0.29 U	-0.933 U	2.15		
Tritium	2020	553	333	663			258	191	160	159		
U-233/234	3.71	19.5	0.435 J	0.736			0.44	0.65	0.738	1.06		
U-235/236	0.393 U	1.98	0.0819U	0.143 U			0 U	0.197 J	0.516	0.0875		
U-238	1.74	5.06	0.308 J	0.38J			0.195 J	0.183	0.319	0.566		

Site	EMWMF-3													
Agency	DOR-OR										DOE			
Sampling Date	07.02.24	07.16.24	07.18.24	07.23.24	07.30.24	08.06.24	08.12.24	08.13.24	08.20.24	08.27.24	09.10.24	11.13.24	06.02.25	
Gross alpha			1.06U						3.3			3.24	2.50 U	
Gross beta												15.3	1.92 U	
Ne-237	0.078 U	0.0761 U	0.0267 U	0.129 U	0.053 U	0.029 U	0.391 J	0.0287 U		0.0526 U	0.0384 U	0.0583 U	0.170	
Pu-238	0.0517 U	0.575 U	0.298 U	-0.0243 U	0.0868 U	-0.0374 U	-0.057 U	-0.00832 U		0.00244 U	0.00948 U	0.0744 U	-0.0255	
K-40	22.3	16.2	42.3 U	26. 6U	4.29 U	19.3	53.5 U	53.6 U	-37 U	7.44 U	34.1 U	44.8	19.1 U	
Sr-90	0.406 U	1.99	1.13	0.64 J	0.293 U	0.719 U	0.464 U	0.663 U	0.43	0.734 J	0.432 U	0.0744 U	0.331	
Tc-99												32.4	17.9	
Tritium												420	92.3	
U-233/234												6.19	3.57	
U-235/236	0.336 U	0.457 U	0.682	0.518 J	0.427J	0.136 U	0.406 J	0.293 U	0.22	-0.0339 U		0.292	0.586	
U-238												2.9	2.01	

U= Non-detect; **J**= Estimated between method detection limit (MDL) and method quantitation limit (MQL), Light blue color = No data collected during this event

CONTACT WATER PONDS AND TANKS DISCHARGE SUMMARY

Throughout FY25, DoR-OR received weekly updates from the DOE EMWMF Project Team regarding water management at the EMWMF. These "Water Management Snapshots" provided essential data on the volumes within the Contact Water Ponds (CWP), Contact Water Tanks (CWT), and Leachate Tanks, including:

- 1) Approximate volume in each pond/tank
- 2) Normal maximum capacity
- 3) Total available volume
- 4) Remaining available capacity in gallons & percent full
- 5) Hexavalent chromium (Cr⁺⁶) concentrations
- 6) Additional operational comments

DoR-OR reviewed this information each year to monitor DOE's water management practices at EMWMF. Table 5.2.7.6 summarizes the total volumes of contact water discharged from the ponds and tanks to the sediment basin for environmental release each quarter. Across all quarters, EMWMF discharged 7,974,000 gallons from ponds and 580,600 gallons from tanks, totaling 8,554,600 gallons of contact water for FY25.

Table 5.2.7.6: EMWMF FY25 Contact Water Discharged Volumes

FY25 Quarter	Pond Subtotal	Tank Subtotal	Total
First	1,614,000	70,500	1,684,500
Second	758,000	94,000	852,000
Third	2,670,000	296,100	2,966,100
Fourth	2,932,000	120,000	3,052,000
FY25 Total	7,974,000	580,600	8,554,600

5.2.8 CONCLUSIONS

Surface water monitoring results from FY25 indicate the following:

- Seasonal fluctuations in surface water parameters were generally similar across most sites compared to FY24 during the monthly monitoring surveys.
- At EMWMF-2, most water quality parameters measured by the In-Situ® sonde were within normal ranges, suggesting no evidence of leakage from Cells 1, 2, or 3.
- Turbidity levels at EMWMF-3 were generally higher and more variable, with values exceeding 4,000 NTU during multiple months. These elevated turbidity levels may be associated with sediment transport from the sediment basin during heavy rainfall events.

- Lead concentrations exceeded the reference values from the TN Fish and Aquatic Life Fresh Water CCC of 2.5 ug/L from the sample collected at Contact Water Pond 4 on June 5, 2025. Other metals were below all five criteria, and no exceedances were observed at the EMWMF-3 (V-Weir).
- All detected radionuclides across EMWMF-2, EMWMF-3 and Pond 4 were above the EPA PRGs for Residential Tap Water except Beryllium-7.
- Gross alpha and gross beta at Pond 4 were above EPA drinking water MCL and TDEC Drinking Water Supply Rule, respectively. However, no radionuclides concentration exceeded EMWMF Discharge Release Criteria.
- Radionuclide concentrations in DoR-OR grab samples from EMWMF-2, EMWMF-3, and Contact Water Pond 4 were consistent with DOE results at the same locations. All of the detected radionuclides by DOE were below the EMWMF Discharge Release Criteria.
- Contact water discharge volumes in FY25 were relatively lower than in FY24 and FY23, this most likely reflects reduced precipitation during FY25.

5.2.9 RECOMMENDATIONS

- Continue water quality monitoring at EMWMF to track trends associated with waste disposal and seasonal variation.
- Increase periodic grab sampling at key sites (e.g., EMWMF-3) to verify DOE monitoring results.
- Expand analytical parameters to include additional organic contaminants (e.g., PFAS and pesticides).

5.2.10 REFERENCES

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(Continues on Next Page – Unit 6)

6.0 RADIOLOGICAL MONITORING

6.1 HAUL ROAD SURVEYS

6.1.1 BACKGROUND

On Friday, May 14, 2004, contaminated waste was lost from a DOE contractor's dump truck on a state highway in Tennessee. DOE conducted a *Type B Accident Investigation* to determine preventative measures. This investigation resulted in an agreement with the State of Tennessee Department of Environment and Conservation (TDEC) to construct a separate transportation route for these dump trucks. The Haul Road was constructed and is reserved solely for trucks transporting CERCLA low-level radioactive and hazardous waste.

On the ORR, remedial action wastes are transported to the EMWMF if the following criteria are met:

- 1) Waste meets the definition for low-level radioactive waste, as defined in *TDEC 0400-02-1.03 (21)*.
- 2) Radiological concentrations must be below limits set forth by the Waste Acceptance Criteria (WAC).
- 3) Waste lots are approved by the FFA tri-parties.

DOE is accountable for compliance with waste acceptance criteria (WAC) and has delegated responsibility for WAC attainment decisions to its prime contractor. This contractor oversees waste characterization and compares these determinations against WAC to make final decisions for disposal in the EMWMF.

TDEC and EPA oversee and periodically audit associated activities related to this work. TDEC, for example, reviews approvals authorizing waste for disposal.

The *Haul Road Survey Project* was created to augment and verify DOE waste transport safety protocols. TDEC DoR-OR staff performed surveys of the Haul Road and of all associated transportation routes over which remedial action waste traveled to the EMWMF in FY25.

6.1.2 PROBLEM STATEMENTS

In FY25, remedial activities and construction continued to increase on the ORR, especially on the Y-12 and ORNL campuses. This increase in waste production also raised the probability of a dump truck losing contaminated waste items on transportation routes.

6.1.3 GOALS

The primary goal of the project was to conduct independent oversight of the Haul Road to

identify potentially contaminated items resulting from the transportation of radioactive and hazardous waste from the ORR clean up locations to the EMWMF.

In particular, the objectives included the following:

- 1) Assessing the radiological conditions of the Haul Road and objects that may have fallen from trucks.
- 2) Verifying, through monitoring and oversight, that DOE and their contractors continue waste transportation in a manner that limits potential environmental impacts to the Haul Road and the surrounding areas.

6.1.4 SCOPE

The scope of this Haul Road project included routine radiation walk-over surveys of nine (9) segments of the Haul Road, Reeves Road, and associated access roads used for transportation of CERCLA waste to the EMWMF. Each monitoring event consisted of surveying one to two road segments, with each segment approximately 1 mile in length.

Table 6.1.4.2: Haul Road Survey Locations and Dates Performed (FY25)

Section	Description	Date Performed
Section 1	K-25 to Zirconium Road	09 Sept 2024
Section 2	Zirconium Road to Firing Range Cut Off	31 Oct 2024
Section 3	Firing Range Cut Off to Heavy Equipment Staging Area	15 Jan 2025
Section 4	Heavy Equipment Staging Area to Hwy. 95	16 Jan 2025
Section 5	Hwy. 95 to Reeves Road	17 Apr 2025
Section 6	Reeves Road to EMWMF West Gate	23 Apr 2025
Section 7	EMWMF East Gate to Y-12	*
Section 8	Reeves Road on Y-12 Side	18 Jun 2025
Section 9	Reeves Road on ORNL Side	23 Jun 2025
<i>Note: * Section 7 was not surveyed as this section was not utilized by DOE during FY25.</i>		

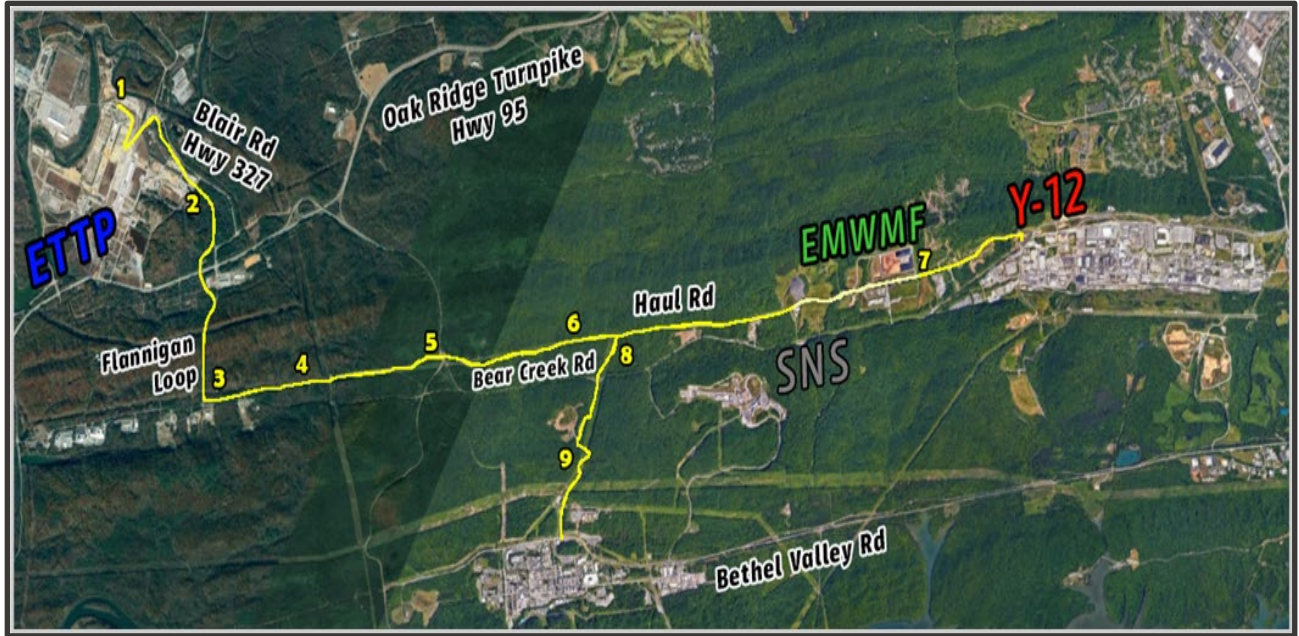


Figure 6.1.4.1: Haul Road Monitoring Sections

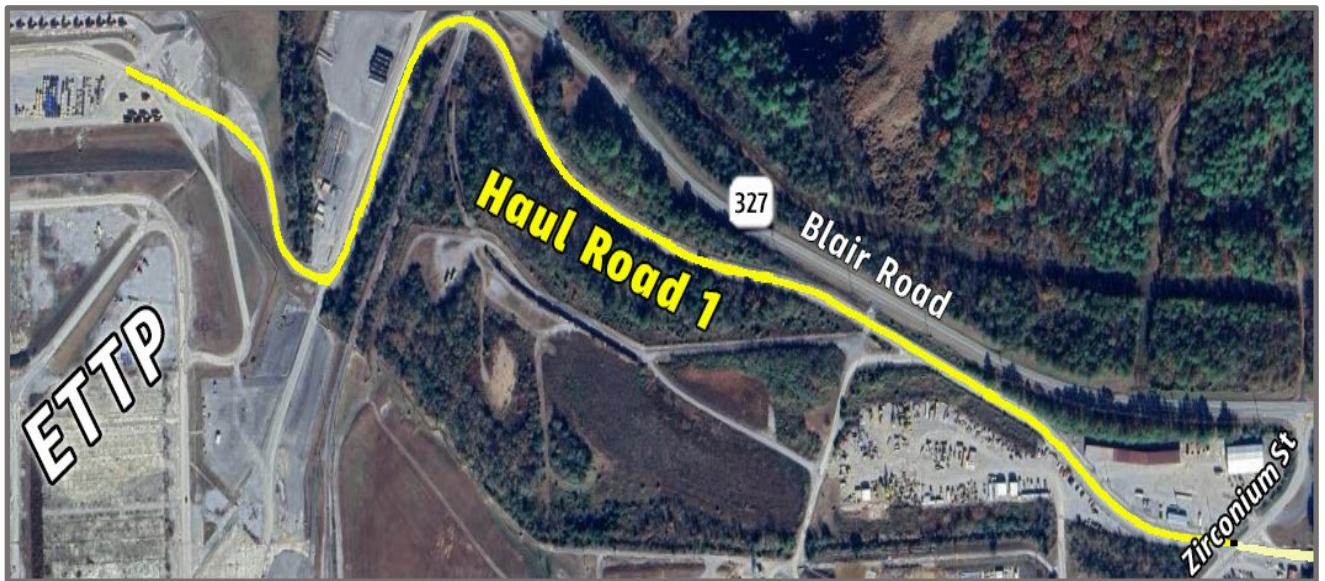


Figure 6.1.4.2: Haul Road Section 1



Figure 6.1.4.3: Haul Road Section 2



Figure 6.1.4.4: Haul Road Sections 3 & 4

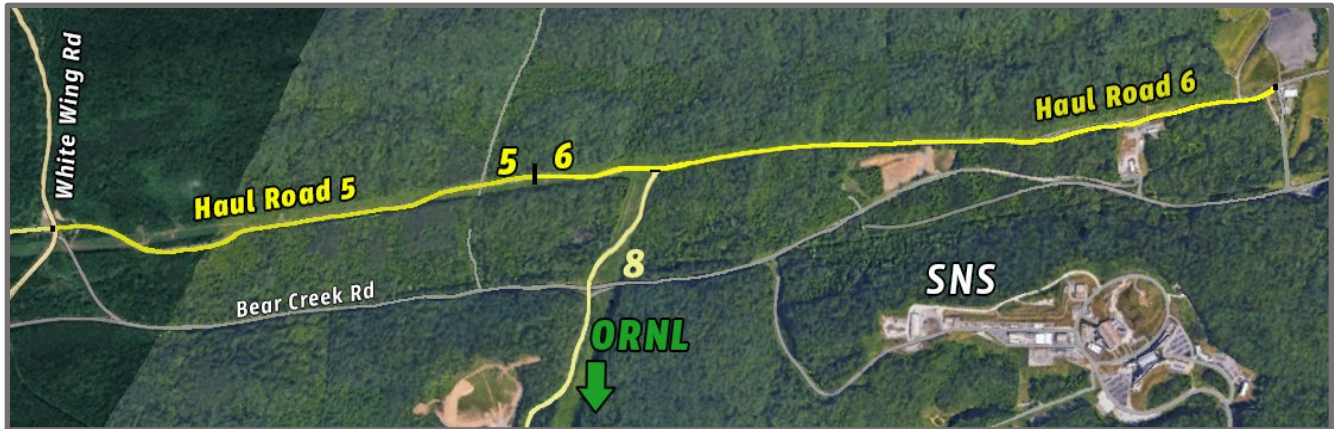


Figure 6.1.4.5: Haul Road Sections 5 & 6



Figure 6.1.4.6: Haul Road Section 7



Figure 6.1.4.7: Haul Road Sections 8 & 9

6.1.5 METHODS, MATERIALS, METRICS

The nine miles of the Haul Road were surveyed in one-mile segments, typically consisting of one to two miles per survey event in accordance with SOP T-560. The Reeves Road Access to Haul Road connects ORNL with the main stem of the Haul Road (Sections 8 and 9).

For safety reasons, DoR-OR staff coordinated with Haul Road site personnel prior to all surveys, either UCOR or DOE. UCOR, as DOE's main contractor, was primarily responsible for providing briefings to our surveyors on road conditions and on any known situation that could present a safety hazard. Alternatively, when UCOR was not available, survey staff called the designated DOE site safety office. On occasions when excessive traffic presented a safety concern, the survey was postponed to a later date. In these instances, alternate entrances were sometimes used to survey the road with DOE approval, but the basic requirements remained the same.

When DoR-OR staff members arrived at the segment of the road to be surveyed, the vehicle was parked completely off the road and as far away from vehicular traffic as possible. No fewer than two staff performed each of the surveys. During some survey events, both staff surveyed using meters while walking in a serpentine pattern along opposite sides of the road. During other surveys, one person walked in a serpentine pattern across the entire road accompanied by an approved safety buddy.

A Ludlum Model 2221 Scaler Ratemeter with a Model 44-10 2"x2" Sodium-Iodine Gamma Scintillator probe was used in accordance with SOP T-525 and T-540. The surveyor held the probe approximately six inches above the ground's surface. The road segment was scanned for radioactive contaminants as the walkover proceeded.

Another detection meter, a Ludlum 2224 Scaler with a Model 43-93 Alpha/Beta dual detector, was also used and operated in accordance with SOP T-525 and T-532 to investigate potential surface contamination and to scan any anomalous items found along the road that may be associated with waste shipments. Any areas or items with elevated contamination levels were noted for further investigation.

Elevated contamination levels are defined below:

- 1) 200 dpm/100 cm² removable beta
- 2) 1,000 dpm/100 cm² total beta
- 3) 20 dpm/100 cm² removable alpha, and/or
- 4) 100 dpm/100 cm² total alpha

Any found material that was potentially contaminated from and lost during waste transportation was marked with contractor's ribbon and returned to the side of the road. A description of each item and its location were logged and reported to DOE for evaluation and

disposition. These items potentially contained non-radiological hazardous constituents as well. A survey form was completed for each walkover and was retained by DoR-OR. When survey staff conducted subsequent inspections, they performed a follow-up inspection of items found and reported during previous weeks. Items that remained on the road were included in subsequent reports until the item was removed by DOE or until DOE confirmed that the item(s) were free of radioactive and hazardous constituents.

Nine (9) individual surveys were completed over a 12-month period. Surveys were always scheduled around any waste hauling activity on the waste transit routes.

Table 6.1.5.3: Haul Road Survey Coordination

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

6.1.6 DEVIATIONS FROM THE PLAN

Section 7, EMWMF West Gate to Y-12, was not surveyed because it was not used for hauling waste in FY25. This section of the road was blocked with concrete barricades. Surveys will resume when waste hauling activities begin using this road again.

6.1.7 RESULTS AND ANALYSIS

During FY25, the project teams performed eight (8) survey events and only one (1) anomaly was observed along waste transit routes. On April 23, 2025, while surveying Section 6 of the Haul Road (i.e. road segment from EMWMF to Reeves Road), the section of the Haul Road at the entrance of the EMDF uniformly increased from approximately 6,000 cpm to 12,000 cpm. No discreet locations of elevated activity were identified, but rather an increase over wide areas of the road (Figure 6.1.7.1).

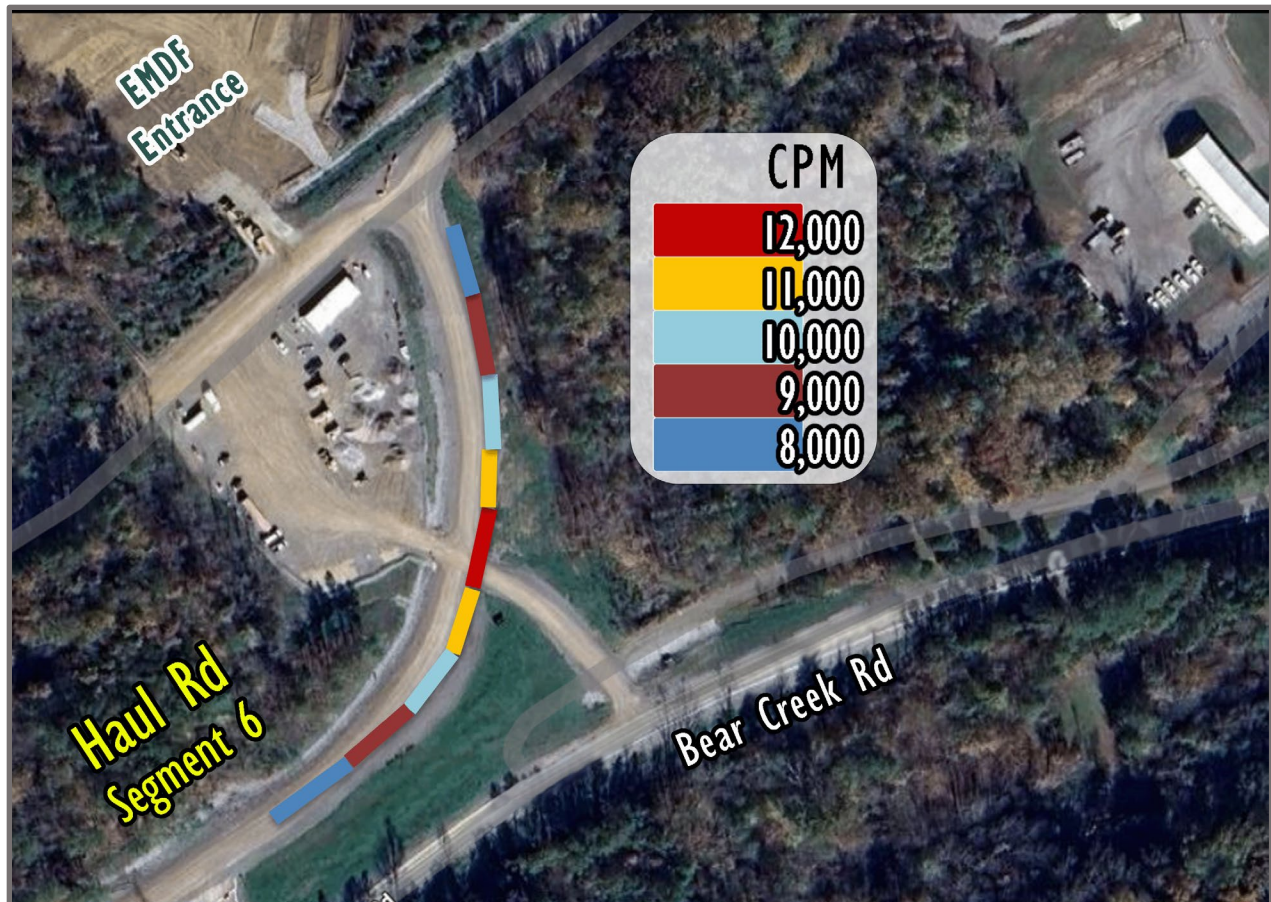


Figure 6.1.7.1: Elevated Activity on Section 6

6.1.8 CONCLUSIONS

The periodic surveys of the transit roads to EMWMF indicated that during FY25, there were no observations of lost waste items associated with the transportation of waste to the EMWMF. The identification of increased activity around the entrance of the EMDF facility may be the result of newly deposited gravel/road surface used in the construction of this section of the Haul Road. The increase in activity was consistent and evenly spread through the area as opposed to discreet locations. Gravel contains naturally occurring radioactive materials (NORM), as do all rocks and soils. The primary naturally occurring radioactive elements found in gravel are traces of uranium, thorium and potassium-40, as well as their decay products. The specific level of radioactivity in a given sample of gravel depends on the source rock.

6.1.9 RECOMMENDATIONS

DOE has scheduled to increase the amount of construction, decommissioning, demolition, and other remedial actions on the ORR campuses in the coming years. The waste produced from all these activities will be transported on the Haul Road to EMWMF, to the EMDF (see Chapter 5.1), as well as to the railyard at ETP and/or the *EnergySolutions* facility on Bear Creek Road.

Based on the increase in remedial activities and the FY25 findings, the DoR-OR recommends the continuation of the Haul Road Survey Project to verify DOE waste transportation and disposal protocols remain sufficiently protective. The accidental release of anomalous items from dump trucks could occur and has the potential to increase over the next few years. This waste transit system should be monitored routinely to protect human health and the environment.

6.1.10 REFERENCES

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6.2 AMBIENT GAMMA RADIATION MONITORING

6.2.1 BACKGROUND

During early operations, leaks and spills were common at industrial facilities within the three ORR campuses (Y-12, ORNL, ETTP). Contaminants, including radioactive materials, often in the form of gaseous, liquid, and solid effluents, were released from operations, sometimes with little to no treatment (ORAU, 2003).

Recently, DOE has increased its ORR remedial activities, with the goal of removing contamination from the environment and making space available for reuse. For example, certain sites at ORNL and Y-12 are currently undergoing deactivation and decommissioning (D&D) then demolition. These activities could cause legacy radionuclides to become airborne and spread outward. Due to these concerns, TDEC DoR-OR conducts continuous gamma air monitoring within the proximity of D&D structures to verify and help ensure best management practices (BMPs) are protective of human health and the environment.

6.2.2 PROBLEM STATEMENTS

- 1) Facilities on the ORR have the potential to emit variable amounts of gamma radiation. The TDEC DoR-OR *Ambient Gamma Radiation Monitoring Project* focuses on measuring radiological exposure rates at ORR sites where gamma radiation is expected to fluctuate. D&D and demolition activities would most likely increase this variability.
- 2) Constant, ongoing monitoring in areas of variable emissions helps evaluate overall impacts in these areas.

6.2.3 GOALS

- 1) The *Ambient Gamma Radiation Monitoring Project* provided a framework for TDEC to independently monitor gamma emissions near specific ORR areas with the potential for gamma exposure.
- 2) The gamma sensors continuously track gamma emissions over time at specific areas of concern within the ORR.
- 3) Data was collected in a manner that allowed for correlation with the existing radiological standards, which includes a limit of two millirem (mrem) per hour, and a dose limit of 100 mrem (0.001 Sv) per year (TN Rules 0400-20-05-.60 & USNRC 10 CFR 835.208).
- 4) This project allowed for the evaluation of protectiveness of radiological controls in select publicly accessible areas around the ORR.

6.2.4 SCOPE

The project team collected data from five GammaTRACER® Stations. The stations were located at the following areas:

- 1) **FORT LOUDOUN DAM (BACKGROUND):** This station was used to record naturally occurring gamma data, to be used as background dose rates during data evaluations.
- 2) **EMWMF:** Located in Bear Creek Valley, this site is the landfill used for disposal of low-level radiological waste.
- 3) **ORNL BUILDING 3026:** This building is centrally located on ORNL's main campus and is in proximity to pedestrian and vehicular traffic. Its location was used to monitor for potential radiological releases during the demolition of high-risk facilities in the proximity of this site.
- 4) **MSRE (MOLTEN SALT REACTOR EXPERIMENT):** Located at ORNL, MSRE has been shut down but is actively monitored and maintained because of radiological waste remaining in place. MSRE has seen fluctuating dose rates in the past, and sampling allowed for temporal comparisons of prior data sets.
- 5) **SNS (SPALLATION NEUTRON SOURCE):** A facility located on ORNL that produces neutrons with an accelerator-based system.

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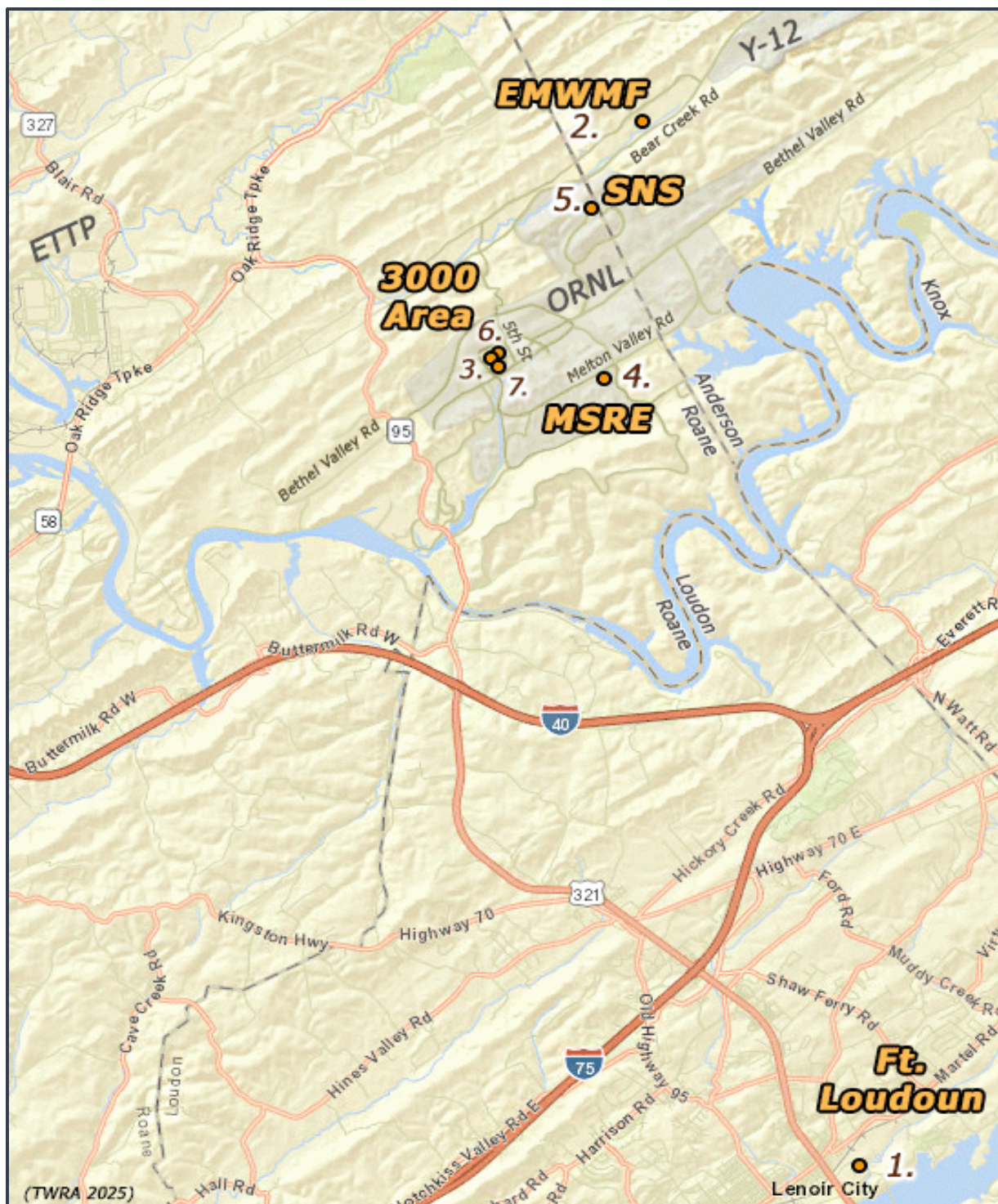


Figure 6.2.4.1: DoR-OR GammaTRACER® Stations

Ambient gamma monitoring was conducted at four ORR stations and one background location (Figure 6.2.4.1). These stations were placed near areas where D&D, remediation, waste disposal, or active operations were the most likely to occur and contribute dose to the

environment or to human receptors.

6.2.5 METHODS, MATERIALS, METRICS

The gamma exposure rate detectors have been deployed since 1996. Each of these GammaTRACER® units contain two Geiger-Mueller tubes for gamma detection, a microprocessor-controlled data logger to store exposure rates, and lithium batteries, all sealed in a weather resistant case to protect internal components. The detectors were set to record at 5-minute intervals, with an automatic shift to 1-minute intervals above a set threshold of radiological activity. Data was downloaded at least once per month following established DoR-OR protocols (TDEC, 2023).

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

In addition, the gamma dose exposure rates were compared to the State of Tennessee and NRC limit of 2 mrem per hour. This comparison determined the maximum dose exposure to an unrestricted, or publicly accessible, area. The results were compared to the State and DOE primary dose limits for protecting members public to verify that a dose of 100 mrem (0.001 Sv) in a year (i.e. consecutive 12-month period) was not exceeded at the monitored locations.

6.2.6 DEVIATIONS FROM THE PLAN

On September 10th, 2024, it was discovered that the datalogging feature on the GammaTRACER® at the SNS site was not functioning as designed. As a result, the GammaTRACER® at SNS was removed from the field for further testing. The malfunction in this GammaTRACER® was not resolved, and the SNS location was not monitored after September 10th, 2024.

6.2.7 RESULTS AND ANALYSIS

Each GammaTRACER® collects data continuously, 24-hours per day and 365 days per year, which equates to 8,766 hours. For TDEC's review, the following parameters are assumed. An average worker would only spend up to 2,000 hours per year (i.e. 40 hours per week for 50 weeks a year) on the ORR. Per NUREG-1556, using an occupancy factor of 1/20, it is conservatively assumed that a member of the public would only spend up to 100 hours per year on the ORR. To calculate the estimated annual exposure to members of the public, the annual exposure, based on the daily average, is divided by 8,766 hours. The resulting number is

the average hourly dose, which is then multiplied by 100 hours to calculate the annual dose that a member of the public could receive from each of the monitored sites on the ORR. Figures 6.2.7.1- 6.2.7.6 show daily average dose rates, which have been provided in $\mu\text{rem/hr}$. A rem is equivalent to 1,000,000 μrem . Table 6.2.7.1 lists monthly estimated accumulated dose and is provided in mrem. A rem is equivalent to 1,000 mrem.

Table 6.2.7.4: FY25 Estimated Dose

	<i>Ft. Loudoun</i>	<i>ORNL 3000 Area</i>	<i>ORNL MSRE</i>	<i>SNS *</i>	<i>EMWMF</i>
Jul-24	0.325 mrem	0.506 mrem	0.432 mrem	0.270 mrem	0.324 mrem
Aug-24	0.326 mrem	0.498 mrem	0.429 mrem	4.796 mrem	0.324 mrem
Sep-24	0.320 mrem	0.485 mrem	0.419 mrem	5.927 mrem	0.325 mrem
Oct-24	0.332 mrem	0.480 mrem	0.415 mrem	0.000	0.328 mrem
Nov-24	0.329 mrem	0.461 mrem	0.401 mrem	0.000	0.319 mrem
Dec-24	0.339 mrem	0.451 mrem	0.407 mrem	0.000	0.295 mrem
Jan-25	0.326 mrem	0.431 mrem	0.403 mrem	0.000	0.264 mrem
Feb-25	0.295 mrem	0.408 mrem	0.361 mrem	0.000	0.253 mrem
Mar-25	0.327 mrem	0.471 mrem	0.404 mrem	0.000	0.297 mrem
Apr-25	0.309 mrem	0.486 mrem	0.392 mrem	0.000	0.298 mrem
May-25	0.322 mrem	0.526 mrem	0.397 mrem	0.000	0.332 mrem
Jun-25	0.304 mrem	0.496 mrem	0.383 mrem	0.000	0.304 mrem
Estimated ** Annual Dose	3.854 mrem	5.699 mrem	4.842 mrem	10.993 mrem	3.662 mrem
Note: Calculations based on NUREG-1556. <i>*SNS: data recorded was for 5 days in July, 21 days in August, and 10 days in September.</i> <i>This absence of data in July-September was due to the SNS's GammaTRACER® unit malfunction</i> <i>** The State and DOE both have primary dose limits of 100 mrem in any consecutive 12-month period.</i>					

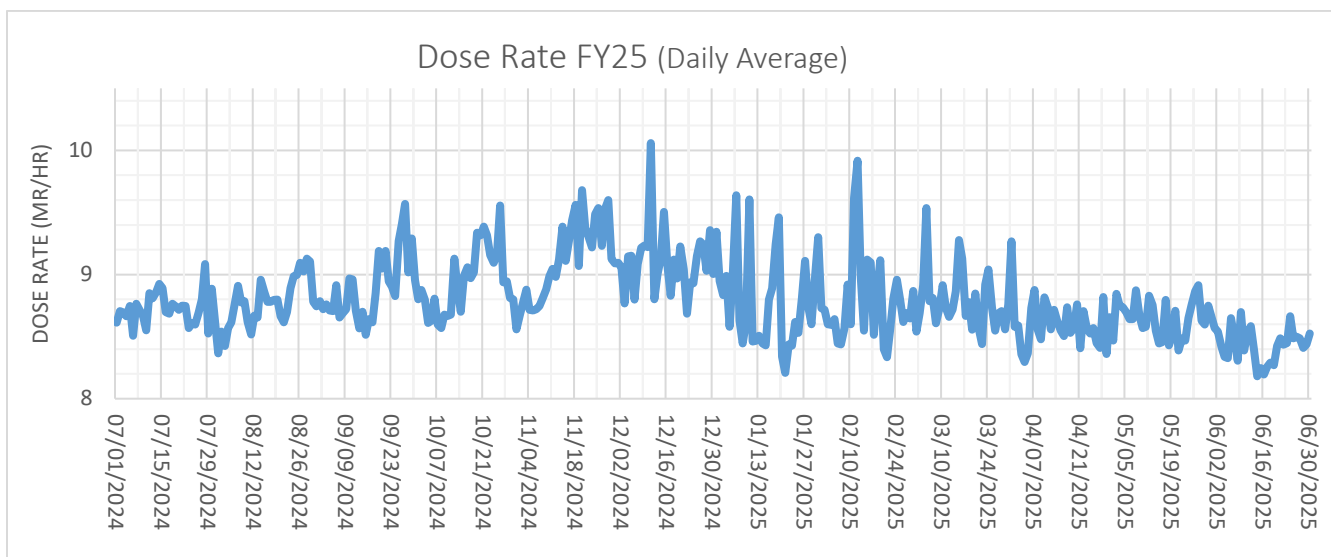


Figure 6.2.7.8: Ft. Loudoun (Background Location)

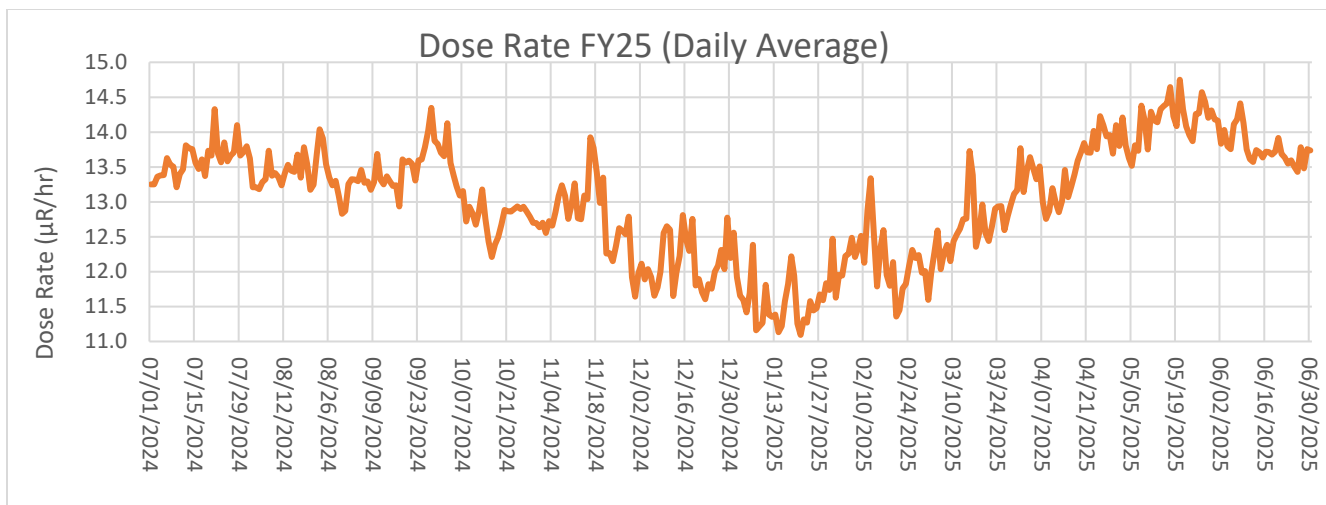


Figure 6.2.7.3: ORNL 3000 Area

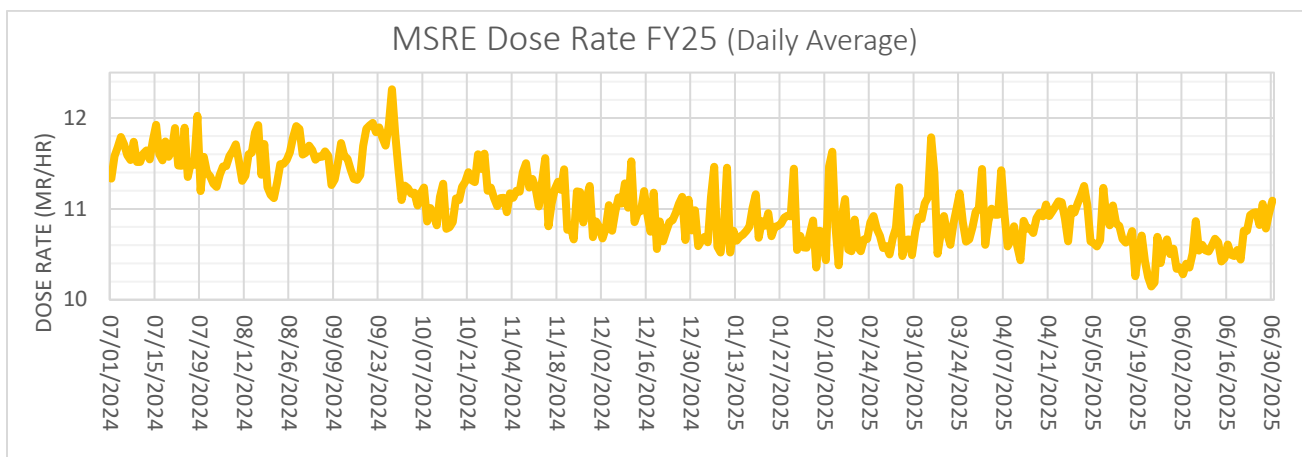


Figure 6.2.7.4: ORNL MSRE

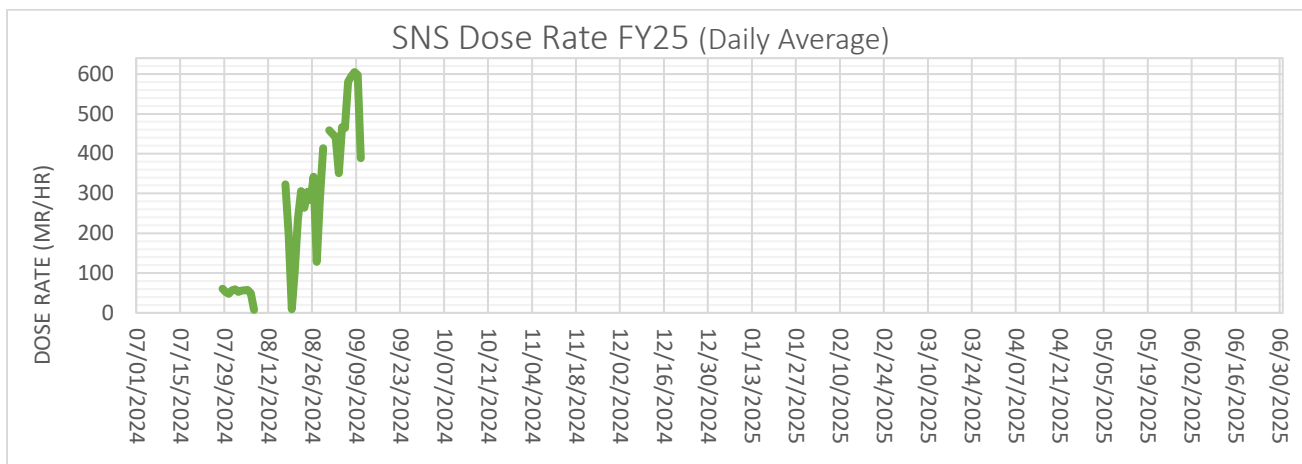


Figure 6.2.7.5: ORNL SNS

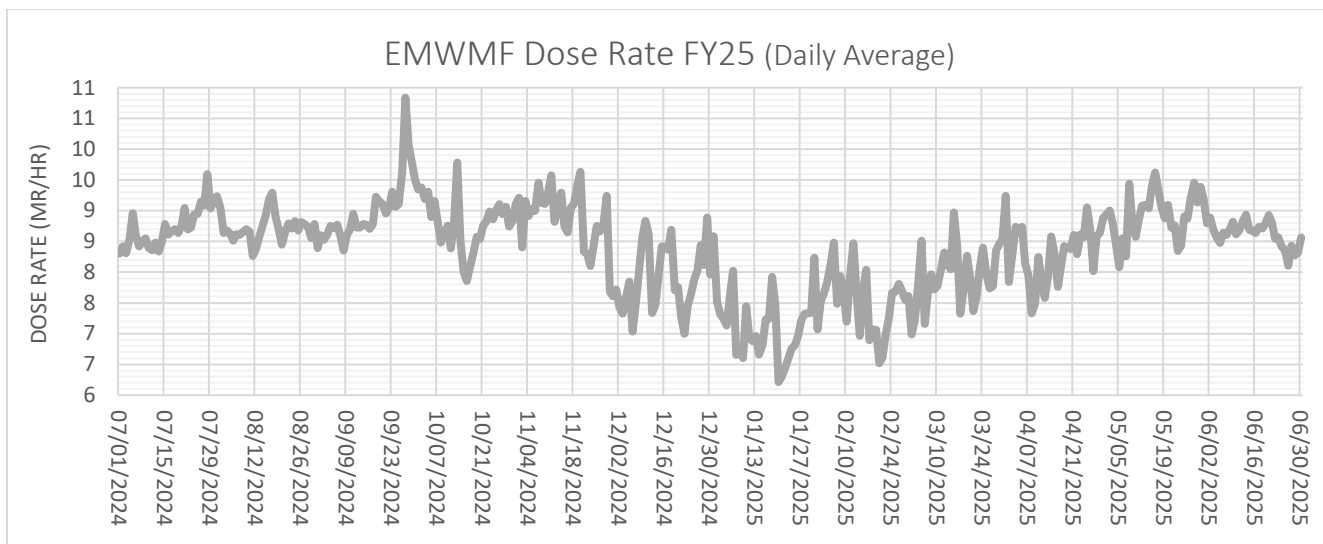


Figure 6.2.7.6: EMWMF

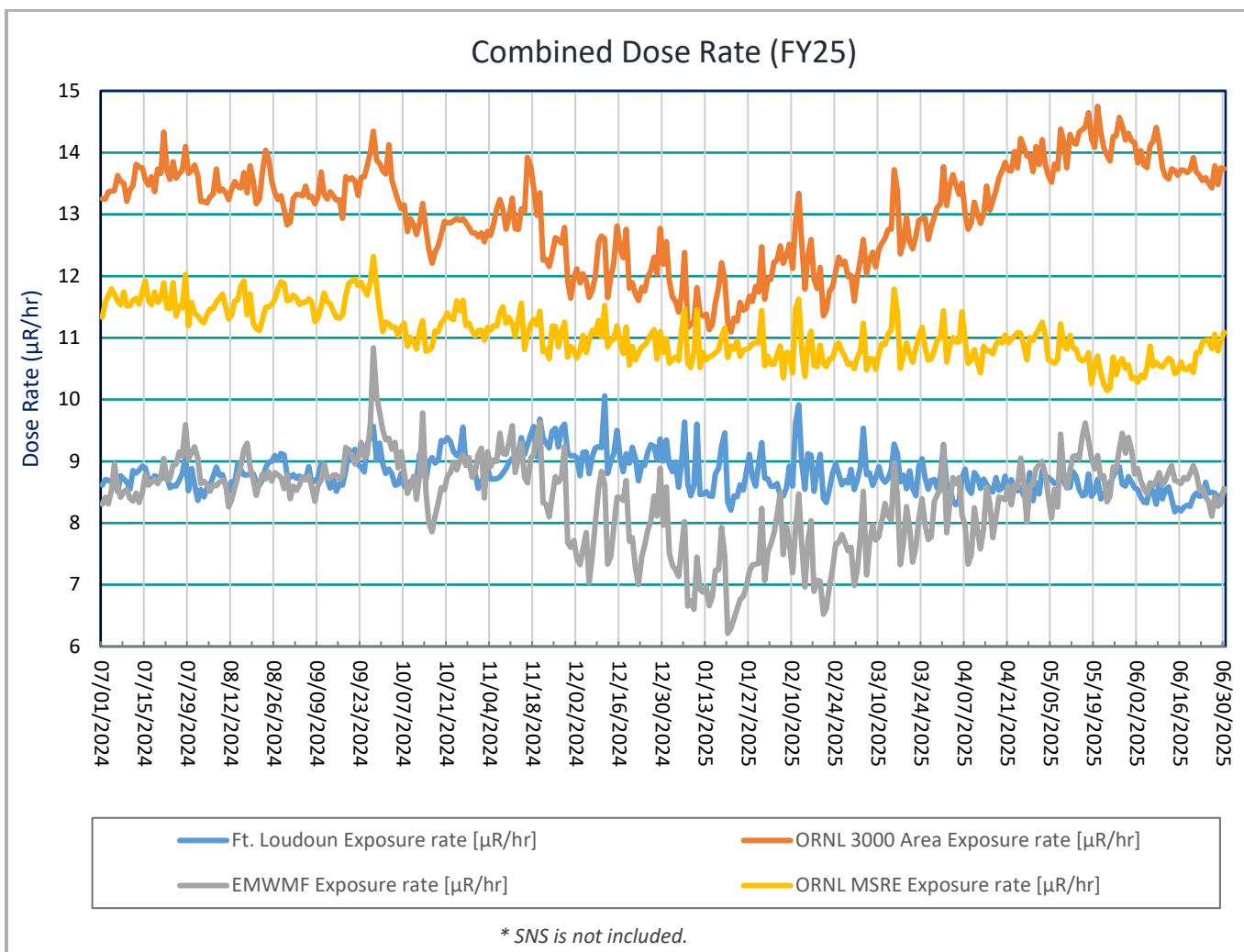


Figure 6.2.7.6: Combined Dose Rate FY25 (Daily Average)

6.2.8 CONCLUSIONS

The estimated FY25 annual dose at Ft. Loudoun (background location) was 3.854 mrem. This was calculated assuming that a member of the public would spend a maximum of 100 hours at this location in a one-year period. All monitored locations on the ORR showed annual doses higher than the background location, though in all cases, annual dose was below the State of TN and NRC regulatory limits. The only exception to this pattern was at the EMWMF site, where annual dose was calculated to be 5% below the estimated background dose. The locations at ORNL 3000 Area and ORNL MSRE were 48% and 26% above the estimated background dose, respectively.

The GammaTRACER® equipment deployed at the SNS site was mounted on the side of the exhaust stack, approximately 25 feet above ground level, which is not representative of dose that a member of the public may receive at ground level. The SNS GammaTRACER® equipment failed during the 1st quarter of FY25. The detector was operable for approximately 36 days during the 1st quarter, representing an operating time of 9.9% of FY25. The estimated dose from this location was 27.594 mrem during the 1st quarter.

6.2.9 RECOMMENDATIONS

Three additional GammaTRACER® units were purchased in April 2025, one detector will replace the inoperable unit at SNS and the two remaining new detectors will be installed at new locations. The location at the SNS stack, approximately 25 feet above the ground level, is not representative of where a member of the public would be located. The replacement GammaTRACER® unit for the SNS site will be placed in a more representative location where a member of the public is most likely to be present. The *Ambient Gamma Radiation Monitoring* activities should continue to document the dose rates and estimated dose emitted from the various locations on the ORR.

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6.3 SURPLUS SALES VERIFICATION

6.3.1 BACKGROUND

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

DOE Radiation Control Personnel (RCPs) are tasked with the initial survey of all items. The goal is to find any equipment with elevated radiation levels or removable contamination.

Radiological detection meters are used for these thorough scans by RCPs. DOE seeks to prevent the spread of contaminants from surplus equipment to members public.

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

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

6.3.2 PROBLEM STATEMENTS

- 1) Associated contaminated items: When incidental radiological contamination is present, the source is most likely related to activities in the area where the material was being used. Any material or equipment from that same area should be located and scanned to ensure that no contaminated equipment is accidentally sold.
- 2) Radon: Items with surface activity may not ultimately prove to possess any radiological contaminants of concern. Sometimes elevated levels are attributed to naturally occurring radon and its daughter isotopes. These isotopes are considered Naturally Occurring Radioactive Material (NORM), or Technically Enhanced Naturally Occurring Radioactive Materials (TENORM).

6.3.3 GOALS

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

6.3.4 SCOPE

Upon request, DoR-OR staff performed four pre-auction verification surveys, as requested by DOE staff, during FY25. The dates of these surveys were:

- 1) 08/29/2024: Lots BSA 162-166
- 2) 11/07/2024: Lots BSA 167-171
- 3) 03/03/2025: Lots BSA 172-176
- 4) 06/11/2025: Lots BSA 177-181

6.3.5 METHODS, MATERIALS, METRICS

DoR-OR radiological contamination survey meters were calibrated and source-checked before staff left for the auction site in accordance with TDEC DoR-OR SOPs T-525, T-530, and T-532. Scans were biased toward well-used items rather than items that looked new. Areas on well-used items that were damaged, unclean, or stained were targeted by scans. Well-maintained or new items were selectively scanned or omitted based on their prior usage and former location. Not all items nor all surfaces of scanned items could be surveyed for potential radiological contamination. When radiological activity (alpha or beta/gamma) measured significantly above ambient background, that item was then brought to the attention of the Property Excessing Team.

DOR-OR staff actively tried to locate any contaminated items, to notify DOE staff to determine if any contaminated items met DOE release criteria. Table 6.3.5.1 summarizes the release criteria generally used by DOE and DoR-OR. Items with radiological contamination could then be cleared, cleaned, or removed from auction if not able to meet unrestricted release criteria set forth by TDEC Division of Radiological Health (DRH). The final determination on releasing an item is made by DOE.

DOE and its contractors followed procedures for unrestricted release of material and equipment using process knowledge; therefore, the purpose of DoR-OR's efforts was to verify that procedures were followed and provide built-in redundancy to catch potential errors.

Table 6.3.5.1: 10 CFR 835, Appendix D — Surface Contamination Values

Surface Contamination Values ¹ in dpm/100 cm ²		
Radionuclide	Removable ² 4	Total (Fixed + Removable) ^{2 3}
U-nat, U-235, U-238, and associated decay products	⁷ 1,000	⁷ 5,000
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	20	500
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	200	1,000
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above ⁵	1,000	5,000
Tritium and STCs ⁶	10,000	See Footnote 6

6.3.6 DEVIATION FROM THE PLAN

There were no deviations from the plan. The survey events were conducted according to standard procedures.

6.3.7 RESULTS AND ANALYSIS

Project staff responded to four (4) *Surplus Sales Verification* survey requests in FY25. During these visits, twenty (20) lots of items (Lot BSA 162 through Lot BSA 181) were surveyed. During these visits to the Property Excessing Facility, located at 115 Union Valley Road, four items were identified with activities above the ambient background. Three of these items included CRT-type television monitors (one was an oscilloscope screen). The elevated readings were likely the result of NORM or TENORM activity. Another item included the top window of a device noted labeled “HIPPA Main Chamber”. The elevated results were below any action levels, though Property Sales were notified of the need to re-check the items. The DoR-OR survey results were shared with Property Sales in a report sent via e-mail and each trip report was completed and uploaded to DoRway.

6.3.8 CONCLUSIONS

All the Surplus Lots previously scanned by RCTs were independently screened by the DoR-OR *Surplus Sales Verification* project team. DOE was notified regarding all items that exceeded background readings. The DoR-OR team identified some items with elevated readings and provided a useful service by conducting these additional, final screenings of equipment and materials.

6.3.9 RECOMMENDATION

DoR-OR staff recommends that the *Surplus Sales Verification Project* be continued because this service is useful to DOE and provides an extra layer of protection to the public. Additional

scans provided a way for DOE to have independent confirmation of their own scans.

6.3.10 REFERENCES

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7.0 SURFACE WATER MONITORING

7.1 AMBIENT SURFACE WATER PARAMETERS

7.1.1 BACKGROUND

Legacy waste across the ORR is responsible for a large portion of the contamination that is present in surface water and accumulates via releases of hazardous wastes (e.g. metals, organics, and radioactive materials). Current projects and processes at these sites also have the potential to significantly contribute to surface water contamination (DOE, 1992; DOE, 2021; Pickering et al, 1970; Turner et al, 1999). DOE performs environmental surveillance around the ORR facility boundaries to comply with their internal requirements to protect the public and the environment from undue risks associated with DOE activities (DOE, 2022). As part of the *Environmental Surveillance Oversight Agreement* between DOE and the State of Tennessee, TDEC performs additional monitoring in and around the ORR.

The TDEC-DoR *Ambient Surface Water Parameter Project* was first implemented in 2005 to supplement DOE's monitoring efforts by helping to measure general physical water quality parameters of several streams that exit the ORR and flow into public waters. By measuring water quality parameters (e.g. conductivity, dissolved oxygen, pH, turbidity, and temperature), a general understanding of stream health and trends can be gained. This project has been ongoing for nearly 20 years and provides a benchmark from which to determine significant changes in water quality that may be impacted by DOE activities.

For FY25 (July 2024-June 2025), DoR-OR continued this project and measured stream water quality parameters monthly to establish and build upon a database of physical stream parameters on three (3) ORR exit-pathway streams (Bear Creek, East Fork Poplar Creek, and Mitchell Branch) and one (1) background stream (Mill Branch).

7.1.2 PROBLEMS STATEMENTS

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

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

- Approximately 100 metric tons of **Mercury (Hg)** were released from Y-12 into East Fork Poplar Creek (EFPC) from 1950 to 1963. Mercury exited Y-12 via spills, leakage from subsurface drains, purposed discharge of wastewater, and leaching from contaminated building foundations and soils (Turner and Southworth, 1999).
- Other **metals** (e.g. cadmium, chromium, lead, nickel, silver, and zirconium) are present in

elevated concentrations in exit pathway streams (DOE, 1992).

- **Uranium** contaminated nitric acid wastes and other liquid wastes (roughly 7.5 million L/yr) were disposed of in the S3 ponds from 1951 to 1984 near the headwaters of Bear Creek (Moss et al, 1999).
- Solid and liquid wastes, including approximately 18 million kg of **uranium metal** and 1 million L of **waste oils and chlorinated solvents**, were disposed of in the unlined Bear Creek Burial Grounds (BCBG) between 1955 and 1989. BCBG is adjacent to Bear Creek (Moss et al, 1999).
- The ORR has a history of undesired releases of contaminants such as **chlorine** and **mercury** from activities on the ORR.
 - In November 1986 and July 1987, fish kills related to chlorine and mercury extended over a period of 2 to 3 weeks killing 1148 and 747 fish, respectively (ORNL, Etnier et al, 1994).
 - On June 8, 2013, a high-volume release of chlorinated water from a line break occurred leading to a fish kill where 8,318 dead fish were counted (DOE, 2013).
 - A large fish kill occurred during June through August of 2018 due to releases of mercury to East Fork Poplar Creek from demolition activities at Y-12 (DOE, 2020).
 - Additionally, fish kills from chlorine leaks or releases occurred on January 10, 2021, March 9, 2021, and March 15, 2021, where 2186 dead fish, 376, and 1346 dead fish were identified respectively (ORNL, 2021).

DOE's surface water monitoring program puts a lot of focus on the Clinch River (DOE, 2022). Meanwhile, the other exit pathway streams are sampled less frequently as part of CERCLA actions or for NPDES permits, and often these sampling events are not as routinely scheduled, and DOE staff may not measure water quality parameters. Therefore, a data gap exists for a higher frequency of qualitative water quality monitoring for ORR exit-pathway streams.

7.1.3 GOALS

The goal of DoR-OR's *Ambient Surface Water Parameters Project* is to measure surface water quality parameters in EFPC, Bear Creek (BC), and Mitchell Branch (MI) within the ORR. These monitoring results can assist in the evaluation of site activities and can also be used to supplement DOE's surface water monitoring program.

In addition to achieving parameter monitoring goals, this project also recorded ambient

conditions that can be used as a benchmark of *expected* conditions for each stream reach. These annual data can then be used in the event of an unintentional release to determine impacts to surface water.

Another long-term project goal is to conduct frequent monitoring of ORR streams. Water quality parameters will be taken in conjunction with other surface water projects (e.g. *Ambient Surface Water Sampling, current holistic watershed project*). All stream data will be compiled in the stream database which will provide adequate data for analyzing statistical trends on ORR streams.

7.1.4 SCOPE

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

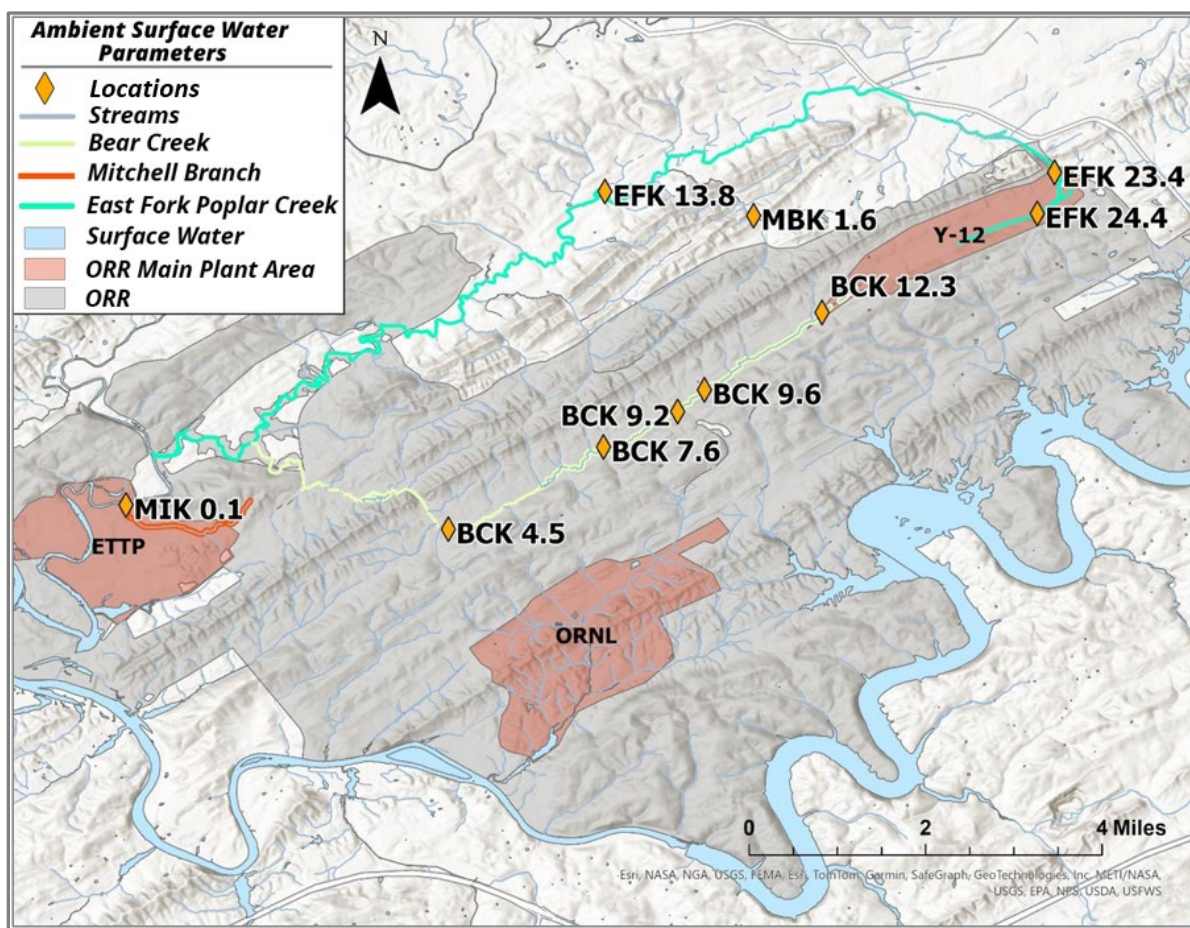


Figure 7.1.4.1: Surface Water Parameter Sites

7.1.5 METHODS, MATERIALS, METRICS

Field Parameter Measurements

At each site, five physical water parameters were measured and recorded. All but one of these parameters were measured using a YSI Pro-DSS meter. The fifth parameter, turbidity, was measured using a HF Scientific Micro-TPW Handheld Turbidimeter. In total, conductivity ($\mu\text{S}/\text{cm}$), dissolved oxygen (mg/L), pH, turbidity (NTU), and temperature ($^{\circ}\text{C}$) were recorded along with the time of measurement. All measurements were taken in accordance with internal SOP *DoR-OR T-703 Field Use for Water Quality Parameters Instrument* (TDEC, 2023).

Data Evaluation

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

The selected ORR streams were compared to the Mill Branch (MB) background stream. Statistical approaches, such as an analysis of variance (ANOVA), were used to determine if corresponding water quality measurements were statistically similar to previous years. Lastly, data were compared to Tennessee's general water quality criteria (TDEC, 2019).

7.1.6 DEVIATIONS FROM THE PLAN

There were two major deviations during this project year. The first deviation is that one turbidity measurement was missed during October 2024 at all stream sites due to a turbidity sensor malfunction. Once a new turbidity sensor was procured, turbidity measurements were continued for all subsequent events.

Another deviation from the project plan occurred due to lack of stream flow. Location BCK 9.6 was dry in July, September, November, and December of 2024, making measurements impossible. Otherwise, all other monitoring was able to be performed as planned.

7.1.7 RESULTS AND ANALYSIS

Field parameters were collected monthly during FY25 from ten (10) monitoring locations (Figure 7.1.7.1). These data generally seemed to follow similar patterns over time for each respective parameter. However, a few monitoring locations had slight deviations for certain parameters. These significant differences among streams will be analyzed and discussed below.

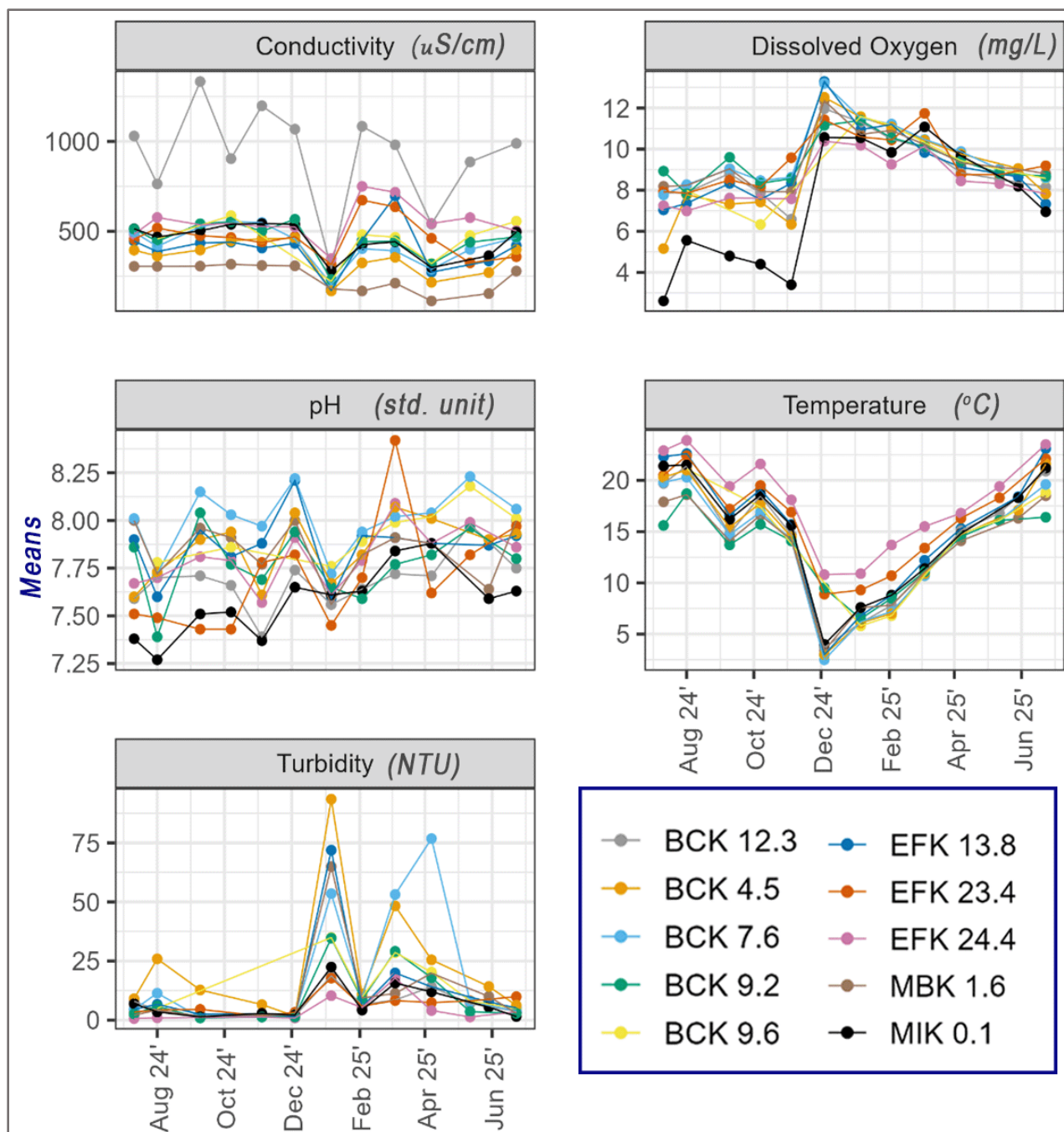


Figure 7.1.7.1: FY25 Field Parameter Results

Parameter Means Comparisons

FY25 data was averaged at each site for each of the five physical parameters. An ANOVA Test was completed for each parameter in order to find if there were any statistically significant parameter differences among the sample sites. If the ANOVA found statistically significantly different *means* among the sites, a Tukey Test was used to determine which sites were different.

CONDUCTIVITY

One of the field parameters with significant differences among streams was conductivity. Mean conductivity values from measurements collected July 2024 to June 2025 ranged from 922.52 to 246.67 $\mu\text{S}/\text{cm}$ among all of the monitoring sites. Bear Creek sites BCK 12.3 and BCK 9.2 had the higher mean conductivity values of 922.52 and 455.66 $\mu\text{S}/\text{cm}$, respectively. Further downstream, BCK 4.5 had a lower mean value of 354.57 $\mu\text{S}/\text{cm}$. On EFPC, EFK 24.4 yielded an average of 552.43 $\mu\text{S}/\text{cm}$, which was the second highest of all streams measured. EFK 24.4 had an uncharacteristic spike in February and March 2025, which influenced this higher average. EFK 23.4, near the eastern border of the Y-12 NSC, had a mean conductivity of 465.89 $\mu\text{S}/\text{cm}$. Downstream of EFK 23.4, Site EFK 13.8 had a lower mean value of 407.93 $\mu\text{S}/\text{cm}$. The Mitchell Branch site MIK 0.1 at ETPP had a mean conductivity value of 450.92 $\mu\text{S}/\text{cm}$. Lastly, Mill Branch (MBK 1.6), an ecological reference site, had the lowest conductivity among all streams measured with a mean value of 246.47 $\mu\text{S}/\text{cm}$.

An *analysis of variance* (ANOVA) was performed to determine if mean conductivity differed significantly among streams. Results from the ANOVA indicated statistically significant differences with $p < 0.05$. A post hoc Tukey Test was performed to distinguish which monitoring sites were significantly different in conductivity. Results indicated that Bear Creek site BCK 12.3 is statistically significantly higher in conductivity than all other monitored sites with $p < 0.05$ (see Table 7.1.7.1). Similarly, the ecological reference site, Mill Branch (MBK 1.6), was found to be statistically significantly lower in conductivity than all other monitored sites with $p < 0.05$, except for BCK 4.5 and EFK 13.8. These findings are consistent with historical comparisons of these streams.

Table 7.1.7.1: Conductivity – Average Means

Site	Mean Conductivity ($\mu\text{S}/\text{cm}$)
BCK 12.3 *	922.52
EFK 24.4 †	552.43
EFK 23.4 † ‡	465.89
BCK 9.2 † ‡	455.66
MIK 0.1 † ‡	450.92
BCK 9.6 † ‡	445.94
BCK 7.6 † ‡	429.04
EFK 13.8 † ‡ §	407.93
BCK 4.5 † ‡ §	354.57
MBK 1.6 §	246.45
<i>*, †, ‡, and § represent statistically similar groupings defined by Tukey Comparison of Means test with $p < 0.05$. If a site does not share a group with another site, then they are considered statistically different.</i> <i>Mean values used in an ANOVA Test – statistically different means.</i> <i>Tukey Test: Red text: statistically significantly higher value than other sites.</i> <i>Blue text: statistically significantly lower value than other sites.</i>	

DISSOLVED OXYGEN (DO)

DO values were also measured and evaluated. Mean values of DO concentrations ranged from 9.67 to 7.3 mg/L. Bear Creek, site BCK 7.6, had the highest dissolved oxygen concentration among all sites. The ETPP Mitchell Branch site, MIK 0.1, had the lowest mean concentration of DO. In general, streams were quite similar in DO concentrations.

An ANOVA was performed to determine if any significant differences exist among streams for DO concentrations. Results from the ANOVA indicated no statistically significant differences in DO among sites. Mean DO concentrations for each site are shown below (Table 7.1.7.2).

Table 7.1.7.2: Dissolved Oxygen – Average Means

Site	Mean Dissolved Oxygen (mg/L)
BCK 7.6	9.67
BCK 9.2	9.45
EFK 23.4	9.41
MBK 1.6	9.39
BCK 9.6	9.30
EFK 13.8	9.08
BCK 12.3	9.03
BCK 4.5	8.86
EFK 24.4	8.47
MIK 0.1	7.30
<i>Means data were used in ANOVA test with $p < 0.05$. No statically significant differences in sites.</i>	

pH

Mean pH values ranged from 8.01 to 7.57 among all sites. BC site BCK 7.6 had the highest average pH readings. Mitchell Branch site MIK 0.1, while similar to other streams, was lower with an average pH of 7.57. An ANOVA was performed to determine if any significant differences exist among streams for pH value. Results from the ANOVA indicated statistically significant differences with $p < 0.05$. A post hoc Tukey Test was performed to distinguish which monitoring sites were significantly different. While all sites were relatively similar, BCK 7.6 significantly differed from MIK 0.1. Average pH values are shown in Table 7.1.7.3 below.

Table 7.1.7.3: pH – Average Means

<i>Site</i>	<i>Mean pH (Std. Unit)</i>
BCK 7.6 *	8.01
BCK 9.6 * †	7.94
EFK 13.8 * †	7.87
BCK 4.5 * †	7.85
MBK 1.6 * †	7.85
EFK 24.4 * † §	7.81
BCK 9.2 † §	7.77
EFK 23.4 † §	7.70
BCK 12.3 † §	7.68
MIK 0.1 §	7.57
<i>* , †, and § represent statistically similar groupings defined with ANOVA Test, $p < 0.05$. If a site does not share a group with another site, then they are considered statistically different.</i> <i>Mean values used in an ANOVA Test – statistically different.</i> <i>Tukey Test: Red text: statistically significantly higher value than other sites.</i> <i>Blue test: statistically significantly lower value than other sites.</i>	

TEMPERATURE

Temperature data were evaluated for all sites measured in FY24. Mean water temperatures ranged from 18.04 to 13.35 degrees Celsius with EFPC being the warmest and Mill Branch being the coolest among all sites. With large variation due to seasonality, a ANOVA indicated no statistically significant differences in water temperature among sites (see Table 7.1.7.4).

Table 7.1.7.4: Temperatures – Mean Averages

<i>Site</i>	<i>Mean Temperature (°C)</i>
EFK 24.4	18.04
EFK 23.4	16.29
EFK 13.8	15.33
MIK 0.1	14.95
BCK 12.3	14.21
BCK 4.5	14.12
BCK 9.6	13.94
BCK 7.6	13.58
BCK 9.2	13.37
MBK 1.6	13.35
<i>Means were used in ANOVA test with $p < 0.05$.</i> <i>No statically significant differences in sites.</i>	

TURBIDITY

Turbidity was measured at each stream location. Averages ranged from 23.18 to 4.31 NTU. Of all stream locations, BCK 4.5 and BCK 7.6 yielded the highest average turbidity. While the average turbidity was above 20 NTU at these locations, individual measurements jumped up to over 90 and 70 NTU at BCK 4.5 and BCK 7.6, respectively. EFK 24.4 yielded the lowest average turbidity among all locations measured. Due to large variation in turbidity data, the ANOVA did not indicate any statistical differences in mean turbidity.

Table 7.1.7.5: Turbidity – Average Means

<i>Site</i>	<i>Mean Turbidity (NTU)</i>
BCK 4.5	23.18
BCK 7.6	20.55
BCK 9.6	15.95
EFK 13.8	12.96
MBK 1.6	11.90
BCK 9.2	9.93
MIK 0.1	7.12
BCK 12.3	6.83
EFK 23.4	6.81
EFK 24.4	4.31
<i>Measurements had large variations at each site and potentially skewed the average Means values. The ANOVA Test could not find any statistically significant differences in Means of sites.</i>	

Trend Analysis (2005-2025)

The above-mentioned FY25 field parameter data were also analyzed in conjunction with data collected annually from 2005 to 2025 (Figure 7.1.7.2).

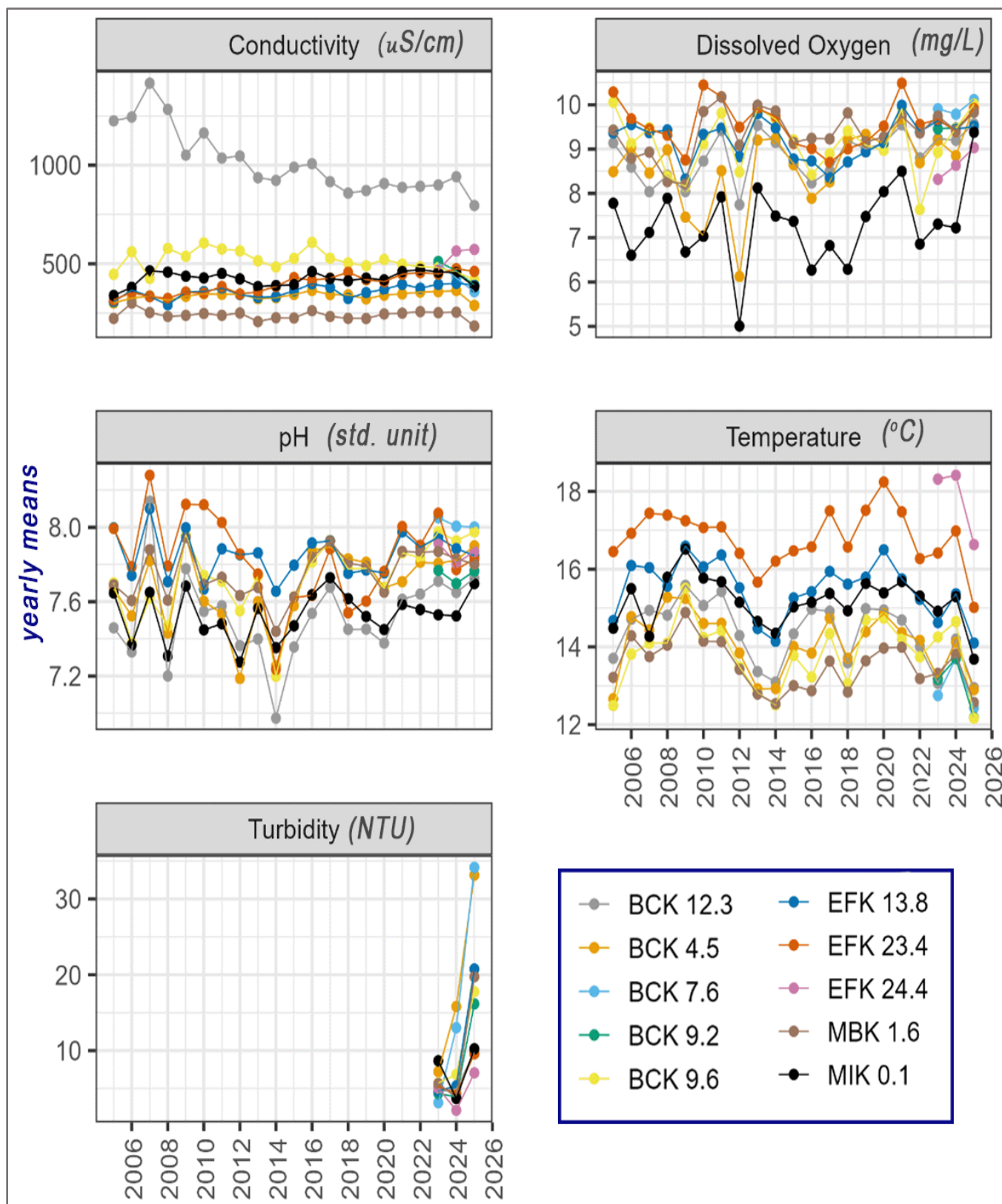


Figure 7.1.7.2: Mean Annual Parameter Values from 2005 to 2025

Data were evaluated for significant increasing or decreasing trends with data for each parameter averaged by year since 2005. Significant linear trends with $p < 0.05$ were found for conductivity at two different stations. A statistically significant negative correlation was found between mean annual conductivity and time for BCK 12.3 with $p < 0.05$. This correlation was found through linear regression, with mean annual conductivity as the dependent variable and time as the independent variable. The coefficient of determination (R^2) was 0.73, indicating a good fit. This indicates that there is a trend of decreasing conductivity with time for site BCK 12.3. The slope of the regression line illustrates that this decrease is occurring at roughly 22 $\mu\text{S}/\text{cm}$ annually. Similarly, a statistically significant positive correlation was found with mean annual conductivity and time for EFK 23.4 with $p < 0.05$. The coefficient of determination (R^2) was 0.87, which indicates the regression fits the data well. This trend illustrates that conductivity has increased with time since 2005 for EFK 23.4. The slope of the regression line shows that this increase is occurring at roughly 7.6 $\mu\text{S}/\text{cm}$ annually (Figure 7.1.7.3).

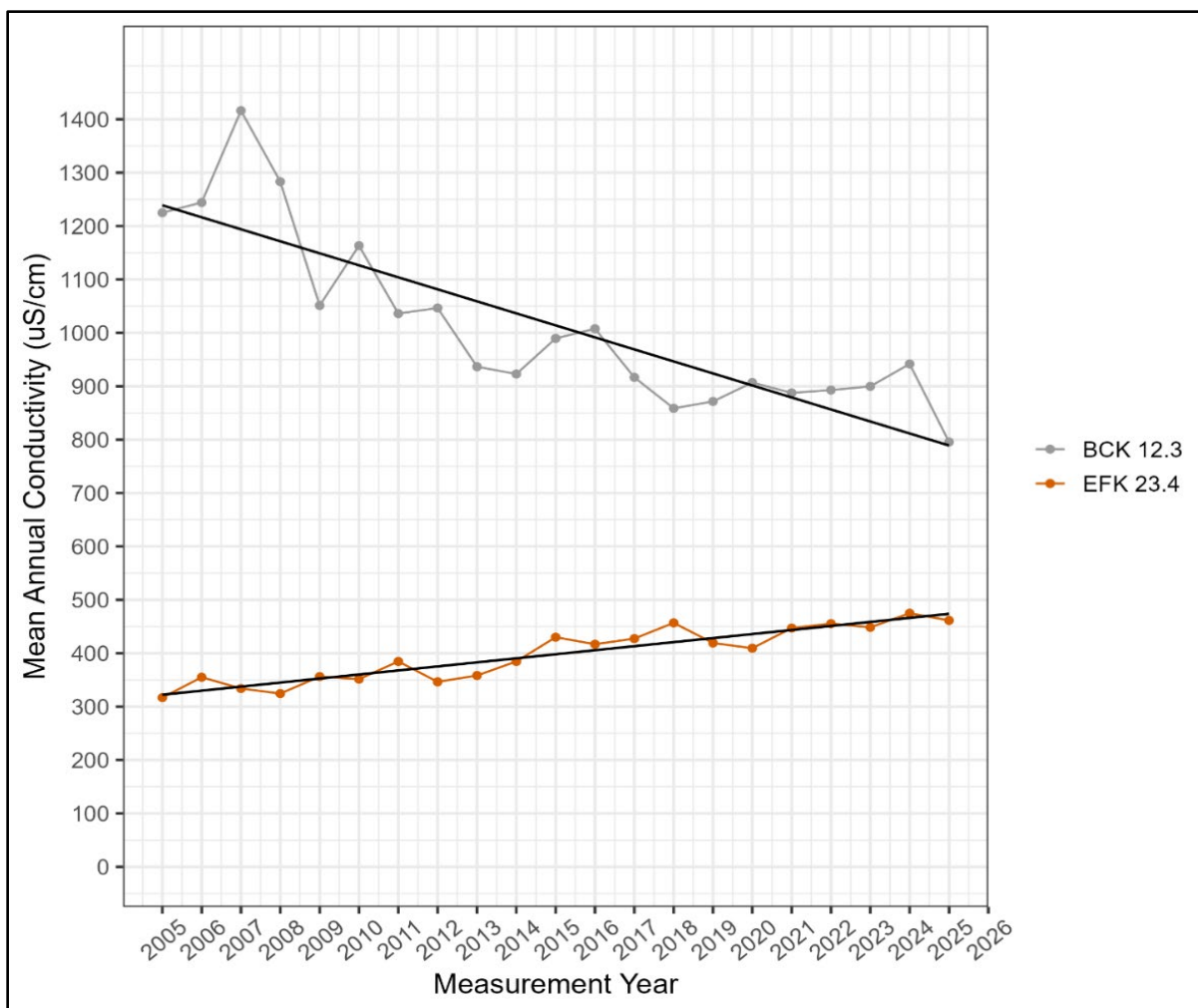


Figure 7.1.7.3: Linear Regression - Mean Annual Conductivity Over Time on Bear Creek (BCK 12.3) and East Fork Poplar Creek (EFK 23.4)

7.1.8 CONCLUSIONS

Parameter Means' Comparison

Field parameters including conductivity, dissolved oxygen, pH, temperature, and turbidity were collected monthly from the ten (10) monitoring locations. These data serve to populate a database and benchmark for surface water conditions for many streams in the ORR as well as help to assess impact of remediation efforts and identify accidental releases. Of these measurements, all readings were within the *State of Tennessee Water Quality Criteria* (TDEC, 2019).

CONDUCTIVITY

While there is no existing *State of Tennessee Water Quality Criteria* for conductivity, Bear Creek site BCK 12.3 was found to be statistically significantly higher than all other streams. Despite having higher conductivity at this location, historical data (2005-2025) indicate that BCK 12.3 has a decreasing trend in conductivity. This trend is declining at an estimated average rate of 22 $\mu\text{S}/\text{cm}$ annually. One explanation for this elevated conductivity may be related to the proximity of this site to the capped S-3 ponds and the Y-12 West End Water Treatment Facility on the Y-12 NSC. The S-3 ponds have been known to have an ongoing release of contaminants to groundwater which ultimately influences Bear Creek concentrations and conductivity. This area is known for containing high concentrations of metals and nitrates (DOE, 2001). High levels of nitrate can increase conductivity by adding more dissolved ions to the water (Mamun, 2025). The decrease in conductivity at BCK 12.3 since 2005 may be the result of attenuation of these contaminant sources.

On the other hand, East Fork Poplar Creek, site EFK 23.4, has shown a steadily increasing trend of conductivity through time, albeit a small increase. This trend has been increasing at an average rate of roughly 7.57 $\mu\text{S}/\text{cm}$ annually. The reason for this increase has not yet been determined.

Alternatively, Mill Branch (MBK 1.6), which is an ecological reference site, was statistically significantly lower in conductivity than all ORR streams measured, except for location BCK 4.5 and EFK 13.8. This lower conductivity is likely attributed to the lack of solute and contaminant loading in this background stream that is otherwise seen in many of the ORR exit-pathway streams.

DISSOLVED OXYGEN (DO)

Mitchell Branch (MIK 0.1) was found to have lower dissolved oxygen levels relative to other streams measured around the ORR. These dissolved oxygen levels were especially low during the summer months when the weather is generally hotter. For a typical stream, an increase in water temperature results in a decrease in dissolved oxygen concentrations. These higher

water temperatures could perhaps explain this decreased oxygen concentration. One explanation for low DO at MIK 0.1 may be the growth of oxygen demanding plants that may be more likely to thrive in warmer weather. Algae were identified covering much of the stream in the summer months.

TURBIDITY

Turbidity was much higher at BCK 7.6 and BCK 4.5 than in other streams. The maximum turbidity, exceeding 90 NTU, was detected at BCK 4.5 in January 2025. This elevated turbidity may be associated with debris and soil transported by runoff from the EMDF worksite, leading to increased turbidity levels at BCK 7.6 which persist downstream to BCK 4.5 during heavy rain events. This monitoring effort was able to help identify this issue which helped promote better management practices, like runoff and sedimentation controls, by DOE and its contractors.

7.1.9 RECOMMENDATIONS

As legacy DOE ORR pollution has negatively impacted East Fork Poplar Creek, Bear Creek, and Mitchell Branch, DoR-OR recommends continued physical parameter monitoring at the ten monitoring stations in order to identify, categorize, and interpret changing trends such as the upward trend of conductivity in EFK 23.4 and the downward trend of conductivity at BCK 12.3.

In addition, continued monitoring can help to identify rapid changes such as high turbidity identified at BCK 7.6. This is especially important with upcoming construction projects and demolition of buildings at Y-12 and other ORR facilities that may influence ORR exit-pathway water quality.

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(Continues on Next Page – Chapter 7.2)

7.2 AMBIENT SURFACE WATER SAMPLING

7.2.1 BACKGROUND

Activities at the three ORR sites have resulted in the discharge of hazardous substances (e.g., metals, organics, and radioactive materials) causing contamination of waterbodies on the ORR and in the surrounding areas (DOE, 1992; DOE, 2023; 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.

TDEC evaluates current contamination impacts from the ORR under the *Environmental Surveillance Oversight Agreement* (ESOA). This DOE-TDEC interagency collaboration permits DoR-OR to conduct additional monitoring to assess impacts to human health and the environment and to fill potential data gaps not covered by DOE's current programs. The DoR-OR *Ambient Surface Water Sampling Project* has been implemented each year since 1993. Sampling locations often change from year to year, where necessary, to provide additional information of DOE activities. The FY25 surface water monitoring project focused on ambient water quality in exit-pathway streams of the ORR.

DOE also has a surface water monitoring program that largely focuses on monitoring of the Clinch River (CR). The DOE program samples the Clinch River quarterly with a goal of assessing impacts of past and current DOE operations on the quality of surface water (DOE, 2023). DOE also monitors several locations, with varying frequency, that are connected to CERCLA investigations or actions. Most site related surface water sampling efforts focus on major contamination from legacy waste, but do not focus on TN AWQCs or contamination from current projects, which is the focus of this project.

7.2.2 PROBLEMS STATEMENTS

The ORR is located within the Clinch River watershed. Therefore, all ORR contamination introduced to smaller exit-pathway streams eventually flows into the CR, which is an important drinking water source. As discussed above, the Clinch River and its tributaries on the ORR are subject to legacy contaminants and current operational contaminant releases. Identified concerns related to these contaminants include, but are not limited to, the following:

- Approximately 100 metric tons of **Mercury (Hg)** were released from Y-12 into East Fork Poplar Creek (EFPC) from 1950 to 1963. Mercury exited Y-12 via spills, leakage from subsurface drains, purposed discharge of wastewater, and leaching from contaminated building foundations and soils (Turner and Southworth, 1999).
- Other **metals** (e.g. cadmium, chromium, lead, nickel, silver, and zirconium) are present in

elevated concentrations in exit pathway streams that flow into the CR (DOE, 1992).

- **Uranium (U)** contaminated nitric acid wastes and other liquid wastes (roughly 7.5 million L/yr) were disposed of in the S3 ponds from 1951 to 1984 near the headwaters of Bear Creek (Moss et al. 1999).
- Solid and liquid wastes, including approximately 18 million kg of **uranium metal** and 1 million L of **waste oils** and **chlorinated solvents**, were disposed of in the unlined Bear Creek Burial Grounds (BCBG) between 1955 and 1989. BCBG is adjacent to Bear Creek (Moss et al. 1999). This has resulted in ongoing uranium loading to Bear Creek at levels upwards of 90 kg/year or more (DOE, 2024).
- The ORR has had several instances of undesired releases of contaminants such as **chlorine**, **strontium-90**, and **mercury** from activities on the ORR.
 - In November 1986 and July 1987, fish kills related to chlorine and mercury extended over a period of 2 to 3 weeks killing 1148 and 747 fish, respectively (ORNL, Etnier D, et al., 1994).
 - On June 8, 2013, a high-volume release of chlorinated water from a line break occurred leading to a fish kill where 8,318 dead fish were counted (DOE, 2013).
 - In 2015, a ruptured pipe at the Process Waste Treatment Complex at ORNL released high concentrations of strontium-90 directly to soils and the groundwater, ultimately flowing to White Oak Creek and to the CR (DOE, 2018). In addition, general releases of strontium-90 from Outfall 304 have been ongoing at average levels of 1,825 pCi/L directly to White Oak Creek (DOE, 2021). This strontium, in addition to other unknown sources, is a potential concern for water quality of the CR.
 - A large fish kill occurred during June through August of 2018 due to releases of mercury to East Fork Poplar Creek from demolition activities at Y-12 (DOE, 2020).
 - Additionally, fish kills from chlorine leaks or releases occurred on January 10, 2021, March 9, 2021, and March 15, 2021, where 2186 dead fish, 376, and 1346 dead fish were identified, respectively (ORNL, 2021). These chlorine releases enhanced the dissolution and mobility of mercury within the stream which enables toxic levels to occur.

The TDEC Division of Water Resources (DWR) performs assessments of streams across Tennessee to determine stream impairment as required by Section 303(d) of the Clean Water Act. DWR identifies a stream as impaired when TN AWQCs “are violated with enough frequency and magnitude that the public’s uses are no longer maintained” (TDEC, 2022). All

ORR streams are listed in TN Rule 0400-40-04-.04 for water use classifications of fish and aquatic life, recreation, livestock watering and wildlife, and irrigation (TDEC, 2019b). However, DWR does not perform assessments within the ORR. While the ORR has evidence of contamination, as listed above, a broader sampling scope has not been performed to allow a thorough assessment of stream impairment against all TN AWQCs.

7.2.3 GOALS

The goals for this project were to:

- Provide oversight and verification of DOE's environmental sampling program on the Clinch River by collecting comparable Clinch River water quality data.
- Perform surface water monitoring (for AWQC analytes) of several ORR streams.

7.2.4 SCOPE

Sampling was conducted at several monitoring locations on the Clinch River, Bear Creek, East Fork Poplar Creek, Mitchell Branch, and White Oak Creek. Samples and measurements were also taken from Clear Creek, which is a reference stream outside of the ORR (see Figure 7.2.4.1).

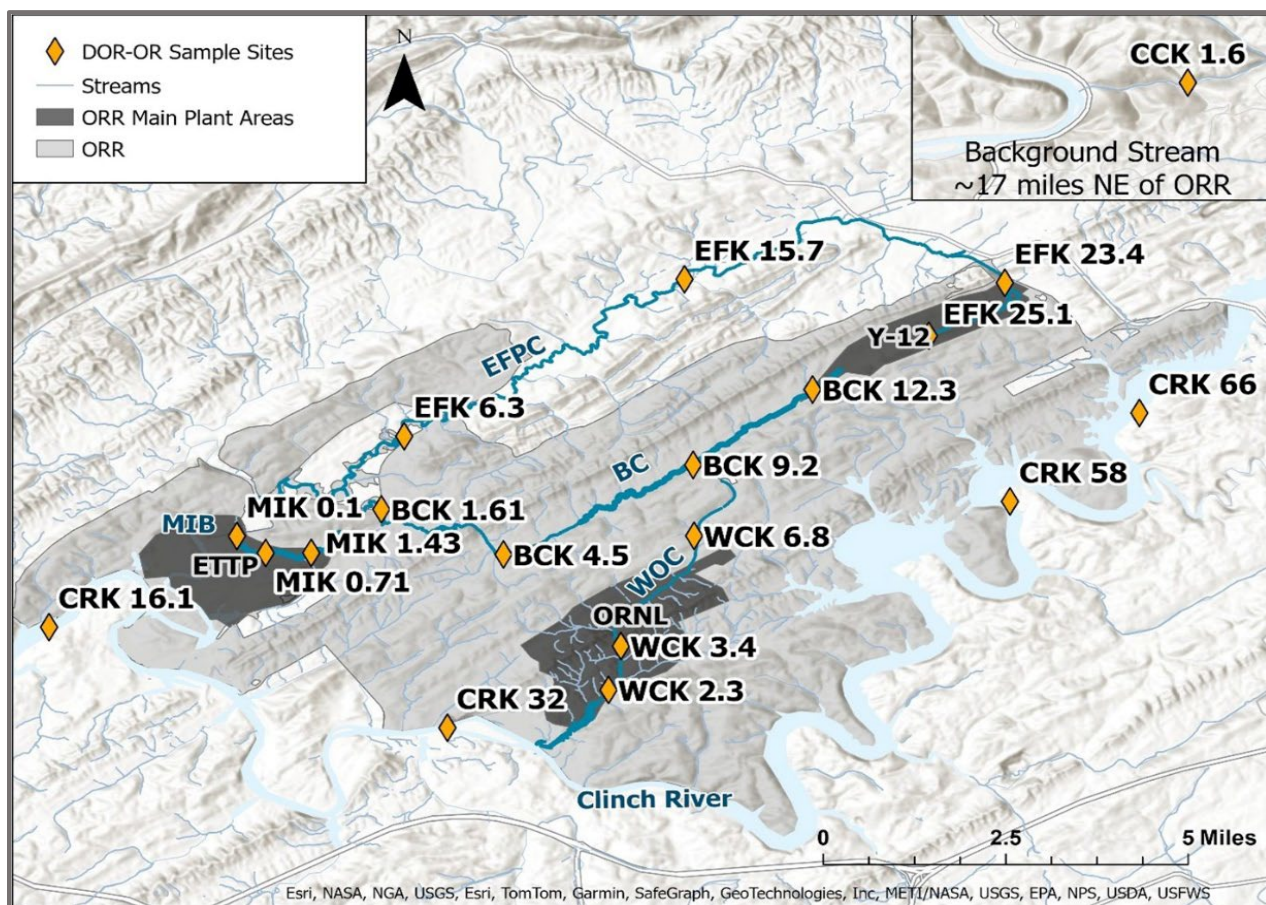


Figure 7.2.4.1: FY25 ORR Surface Water Sampling Sites

Samples were collected twice at all locations with one sampling event occurring in the drier months (July – November) and one event occurring in the wetter months (December – June). The only exception is the Clinch River, which was sampled at one of the four locations each quarter (see Table 7.2.4.1).

Table 7.2.4.1: FY25 Sample Sites and Frequency

<i>River</i>	<i>Site</i>	<i>Description</i>	<i>Parameters</i>	<i># Sampling Events*</i>
Clinch River (CR)	CRK 66	Melton Hill Reservoir near Oak Ridge water intake	Gross Alpha/Beta, Mercury	1
	CRK 58	Near water supply intake for Knox Co.	Gross Alpha/Beta, Mercury	1
	CRK 32	Downstream of ORNL WOC inputs	Gross Alpha/Beta, Mercury, Strontium-90	1
	CRK 16.1	Downstream of ETPP and all DOE ORR inputs	Gross Alpha/Beta, Mercury	1
Bear Creek (BC)	BCK 12.3	Upper headwaters within Y-12	TN AWQCs*	2
	BCK 9.2	Middle stream near BCBG	TN AWQCs*	2
	BCK 4.5	Middle/Lower section near highway 95	TN AWQCs*	2
	BCK 1.61	Lower section near Trail's End greenway	TN AWQCs*	2
Clear Creek (CC)	CCK 1.6	Background stream near Norris, TN	TN AWQCs*	2
East Fork Poplar Creek (EFPC)	EFK 25.1	Upper headwaters within Y-12	TN AWQCs*	2
	EFK 23.4	Upper section at DOE integration point near Y-12 east entrance	TN AWQCs*	2
	EFK 15.7	Middle section in residential/business Oak Ridge	TN AWQCs*	2
	EFK 6.3	Lower section near Horizon Center	TN AWQCs*	2
Mitchell Branch (MIB)	MIK 1.43	Upper headwaters within ETPP	TN AWQCs*	2
	MIK 0.71	Middle section within ETPP near the CWTS	TN AWQCs*	2
	MIK 0.1	Lower mouth at K-1700 Weir near Poplar Creek confluence	TN AWQCs*	2
White Oak Creek (WOC)	WCK 6.8	Upper headwaters in ORNL	TN AWQCs*	2
	WCK 3.4	Middle section in ORNL near 7500 Bridge	TN AWQCs*	2
	WCK 2.3	Lower section in ORNL near White Oak Lake	TN AWQCs*	2
Note: *AWQCs from TN Rule 0400-40-03 for Recreation and Fish and Aquatic Life				

7.2.5 METHODS, MATERIALS, METRICS

Sample Collection

Grab samples were collected both during the fall and spring months from the top few inches of the stream at each sampling location. Analytes included TN AWQCs listed in *TN rule 0400-40-03* for both recreation and fish and aquatic life (TDEC, 2019a). Table 7.2.4.1 shows sample

frequency, and 7.2.5.1 below shows a list of analytes and respective analytical methods used for analysis. Quality assurance/quality control (QA/QC) samples were collected for every 10th sample of any given analyte. Surface water sampling protocols followed internal standard operating procedures (SOPs) including *DoR-OR T-704 Collection of Surface Water Samples* (TDEC, 2023c).

Field Parameter Measurements

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

Data Evaluation

Data were screened using TDEC AWQCs as listed in *TN 0400-40-03(4)(j)* for protection of recreation and *TN 0400-40-03 (3)(g)* for protection of fish and aquatic life to determine if there is a potential impact to human health and the environment (TDEC, 2019a). Those parameters that have AWQCs are listed below (see Table 7.2.5.1). Comparisons to these AWQCs are shown in the Results and Analysis section below.

Table 7.2.5.1: Analytical Methods and Ambient Water Quality Criteria

<i>Metals ($\mu\text{g}/\text{L}$)</i>				
Analyte	Method	FAL-Max	FAL-Cont.	Rec-Org
Chromium, hexavalent	3500Cr B-2011	16	11	-
Antimony	EPA 200.8	-	-	640
Arsenic	EPA 200.8	340	150	10
Cadmium	EPA 200.8	1.8	0.72	-
Chromium	EPA 200.8	570	74	-
Copper	EPA 200.8	13	9	-
Lead	EPA 200.8	65	2.5	-
Nickel	EPA 200.8	470	52	4600
Selenium	EPA 200.8	20	3.1	4200
Silver	EPA 200.8	3.2	-	-
Thallium	EPA 200.8	-	-	0.47
Zinc	EPA 200.8	120	120	2600
Mercury	EPA-1631	1.4	0.77	0.051

<i>Inorganics (µg/L)</i>				
Analyte	Method	FAL-Max	FAL-Cont.	Rec-Org
Dissolved Solids (TDS)	2540 C-2011	-	-	-
Hardness	EPA 130.1	-	-	-

<i>Radiochemical (µg/L)</i>				
Analyte	Method	FAL-Max	FAL-Cont.	Rec-Org
Alpha activity	EPA 900.0	-	-	-
Beta activity	EPA 900.0	-	-	-
Strontium-90	EPA 905.0	-	-	-

<i>Organics (µg/L)</i>				
Analyte	Method	FAL-Max	FAL-Cont.	Rec-Org
Cyanide	4500CN E-2016	22	5.2	140
4,4-DDD	EPA 8081B	-	-	0.0031
4,4-DDE	EPA 8081B	-	-	0.0022
4,4-DDT	EPA 8081B	1.1	0.001	0.0022
Aldrin	EPA 8081B	3	-	0.0005
alpha-BHC	EPA 8081B	-	-	0.049
beta-BHC	EPA 8081B	-	-	0.17
Chlordane	EPA 8081B	2.4	0.0043	0.0081
Dieldrin	EPA 8081B	0.24	0.056	0.00054
Endosulfan I	EPA 8081B	0.22	0.056	89
Endosulfan II	EPA 8081B	0.22	0.056	89
Endosulfan sulfate	EPA 8081B	-	-	89
Endrin	EPA 8081B	0.086	0.036	0.06
Endrin aldehyde	EPA 8081B	-	-	0.3
Heptachlor	EPA 8081B	0.52	0.0038	0.00079
Heptachlor epoxide	EPA 8081B	0.52	0.0038	0.00039
Hexachlorobenzene	EPA 8081B	-	-	0.0029
Hexachlorocyclohexane (HCH)	EPA 8081B	-	-	0.414
Lindane	EPA 8081B	0.95	-	1.8
Methoxychlor	EPA 8081B	-	0.03/0.001	-
Toxaphene	EPA 8081B	0.73	0.0002	0.0028
Azinphos-methyl	EPA 8141B	-	0.01	-
Diazinon	EPA 8141B	0.17	0.17	-
Diazinon	EPA 8141B	0.17	0.17	-
Ethion	EPA 8141B	0.083	0.041	-

Organics (µg/L) – Continued 2				
Analyte	Method	FAL-Max	FAL-Cont.	Rec-Org
Malathion	EPA 8141B	-	0.01	-
Parathion	EPA 8141B	0.065	0.013	-
1,1,2,2-Tetrachloroethane	EPA 8260 VOC	-	-	40
1,1,2-Trichloroethane	EPA 8260 VOC	-	-	160
1,1-Dichloroethene	EPA 8260 VOC	-	-	7100
1,2,4-Trichlorobenzene	EPA 8260 VOC	-	-	70
1,2-Dichlorobenzene	EPA 8260 VOC	-	-	1300
1,2-Dichloroethane	EPA 8260 VOC	-	-	370
1,2-Dichloropropane	EPA 8260 VOC	-	-	150
1,3-Dichlorobenzene	EPA 8260 VOC	-	-	960
1,4-Dichlorobenzene	EPA 8260 VOC	-	-	190
Acrolein	EPA 8260 VOC	3	3	9
Acrylonitrile	EPA 8260 VOC	-	-	2.5
Benzene	EPA 8260 VOC	-	-	510
Bromodichloromethane	EPA 8260 VOC	-	-	170
Bromoform	EPA 8260 VOC	-	-	1400
Bromomethane	EPA 8260 VOC	-	-	1500
Carbon tetrachloride	EPA 8260 VOC	-	-	16
Chlorobenzene	EPA 8260 VOC	-	-	1600
Chloroform	EPA 8260 VOC	-	-	4700
Dibromochloromethane	EPA 8260 VOC	-	-	130
Ethylbenzene	EPA 8260 VOC	-	-	2100
Methylene chloride	EPA 8260 VOC	-	-	5900
Tetrachloroethene	EPA 8260 VOC	-	-	33
Toluene	EPA 8260 VOC	-	-	15000
trans-1,2-Dichloroethene	EPA 8260 VOC	-	-	10000
Trichloroethene	EPA 8260 VOC	-	-	300
Vinyl chloride	EPA 8260 VOC	-	-	24
1,2,4,5-Tetrachlorobenzene	EPA 8270 SVOC	-	-	1.1
1,2-Diphenylhydrazine	EPA 8270 SVOC	-	-	2
2,4,5-Trichlorophenol	EPA 8270 SVOC	-	-	3600
2,4,6-Trichlorophenol	EPA 8270 SVOC	-	-	24
2,4-Dichlorophenol	EPA 8270 SVOC	-	-	290

Organics (µg/L) – Continued 3				
Analyte	Method	FAL-Max	FAL-Cont.	Rec-Org
2,4-Dimethylphenol	EPA 8270 SVOC	-	-	850
2,4-Dinitrotoluene	EPA 8270 SVOC	-	-	34
2-Chloronaphthalene	EPA 8270 SVOC	-	-	1600
2-Chlorophenol	EPA 8270 SVOC	-	-	150
3,3-Dichlorobenzidine	EPA 8270 SVOC	-	-	0.28
4,6-Dinitro-2-methylphenol	EPA 8270 SVOC	-	-	280
Acenaphthene	EPA 8270 SVOC	-	-	990
Anthracene	EPA 8270 SVOC	-	-	40000
Benzidine	EPA 8270 SVOC	-	-	0.002
Benzo(a)pyrene	EPA 8270 SVOC	-	-	0.18
Benzo(b)fluoranthene	EPA 8270 SVOC	-	-	0.18
Benzo(k)fluoranthene	EPA 8270 SVOC	-	-	0.18
Bis(2-chloroethyl)ether	EPA 8270 SVOC	-	-	5.3
Bis(2-chloroisopropyl) ether	EPA 8270 SVOC	-	-	65000
Bis(2-ethylhexyl)phthalate	EPA 8270 SVOC	-	-	22
Butyl benzyl phthalate	EPA 8270 SVOC	-	-	1900
Chrysene	EPA 8270 SVOC	-	-	0.18
Dibenz(a,h)anthracene	EPA 8270 SVOC	-	-	0.18
Diethyl phthalate	EPA 8270 SVOC	-	-	44000
Dimethyl phthalate	EPA 8270 SVOC	-	-	1100000
Di-n-butyl phthalate	EPA 8270 SVOC	-	-	4500
Fluoranthene	EPA 8270 SVOC	-	-	140
Fluorene	EPA 8270 SVOC	-	-	5300
Hexachlorobenzene	EPA 8270 SVOC	-	-	0.0029
Hexachlorobutadiene	EPA 8270 SVOC	-	-	180
Hexachlorocyclopentadiene	EPA 8270 SVOC	-	-	1100
Hexachloroethane	EPA 8270 SVOC	-	-	33
Indeno(1,2,3-cd)pyrene	EPA 8270 SVOC	-	-	0.18
Isophorone	EPA 8270 SVOC	-	-	9600
Nitrobenzene	EPA 8270 SVOC	-	-	690
N-Nitrosodiethylamine	EPA 8270 SVOC	-	-	2.4
n-Nitrosodimethylamine	EPA 8270 SVOC	-	-	30
N-Nitroso-di-n-butylamine	EPA 8270 SVOC	-	-	2.2
n-Nitrosodi-n-propylamine	EPA 8270 SVOC	-	-	5.1

Organics (µg/L) – Continued 4				
Analyte	Method	FAL-Max	FAL-Cont.	Rec-Org
n-Nitrosodiphenylamine	EPA 8270 SVOC	-	-	60
N-Nitrosopyrrolidine	EPA 8270 SVOC	-	-	340
Parathion	EPA 8270 SVOC	0.065	0.013	-
Pentachlorobenzene	EPA 8270 SVOC	-	-	1.5
Pentachlorophenol	EPA 8270 SVOC	19	15	30
Phenol	EPA 8270 SVOC	-	-	860000
Pyrene	EPA 8270 SVOC	-	-	4000
PCB-Total	EPA-1668A	-	0.014	0.00064
2,3,7,8-Tetrachlorodibenzo-p-dioxin	SW846-8290A	-	-	1E-06
<i>Note: FAL-Max = Fish and Aquatic Maximum; Rec-Org = Recreational Organisms Only AWQC</i> <i>FAL-Cont. = Fish and Aquatic Continuous (see TDEC, 2019a)</i>				

7.2.6 DEVIATIONS FROM THE PLAN

Total chlorine samples were discontinued after the first round of sampling as it was difficult for laboratories to meet the very short holding time for the analysis. Similarly, the method for hexavalent chromium was changed to one that allowed longer holding times for the second round of sampling. The first round of hexavalent chromium samples was not analyzed within holding time and were discarded from the results.

7.2.7 RESULTS AND ANALYSIS

Clinch River (CR) Sampling

Several CR locations were sampled throughout FY25. Radiological results were very low at all locations. The highest alpha activity was identified at CRK 32 (1.00 pCi/L) and the highest beta activity also at CRK 32 (4.88 pCi/L) which is near the CR and WOC confluence. Mercury was detected at all locations but was very low in concentrations, well below AWQCs. Results are shown in table 7.2.7.1 below.

Table 7.2.7.1: CR Sample Results

River	Location	pCi/L			µg/L
		Alpha activity	Beta activity	Strontium-90	Mercury
Clinch River (CR)	CRK 66	0.32	2.36	-	0.0010
	CRK 58	0.97	1.14	-	0.0015
	CRK 32	1.00	4.88	0.28	0.0003
	CRK 16.1	0.61	0.17	-	0.0059

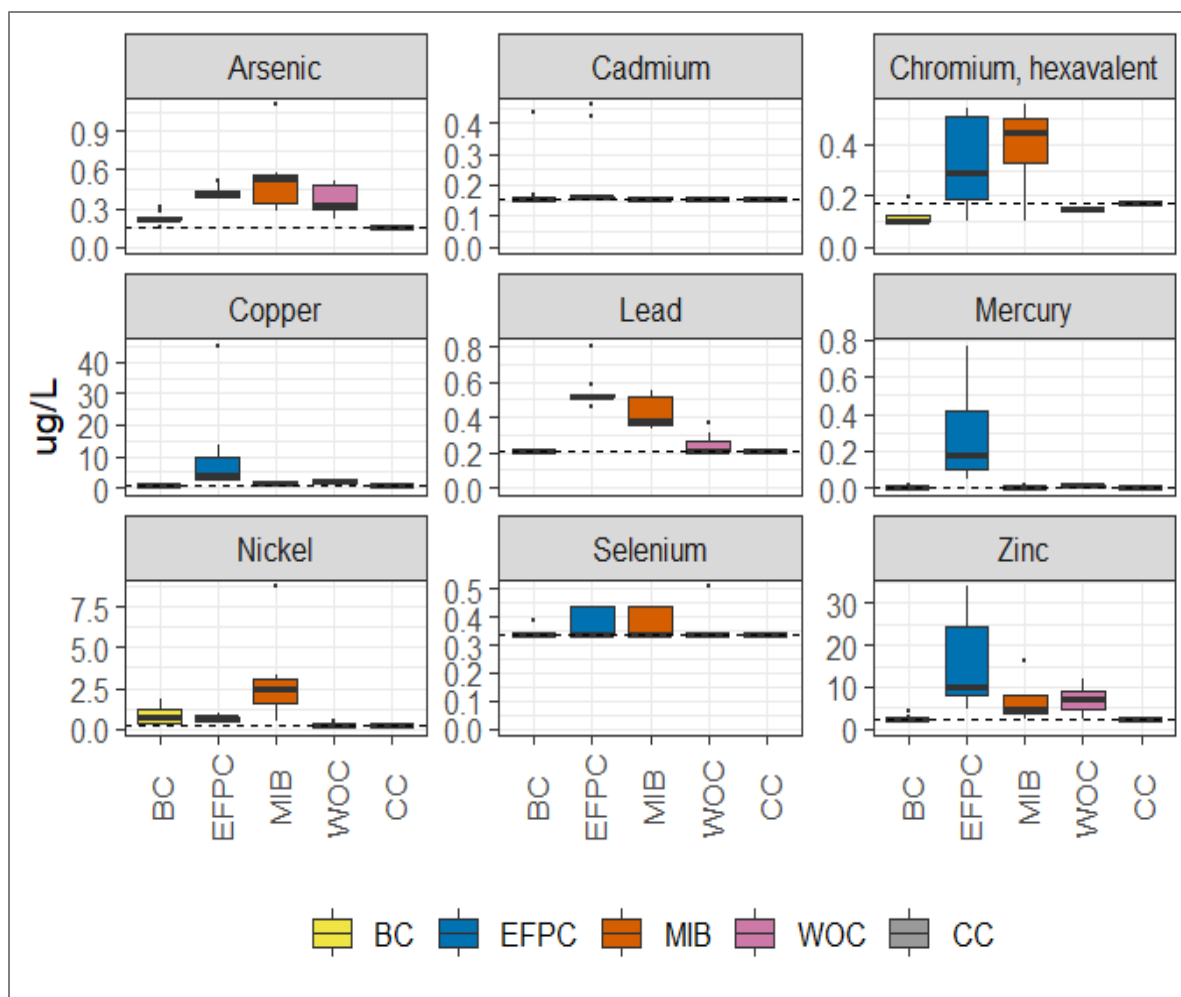
Ambient Water Quality Criteria (AWQC) Sampling

METALS

Each stream was sampled for a suite of AWQC metals. Of the analyzed metals, no detections occurred for antimony, chromium, silver, or thallium in any of the collected samples. Other metals such as arsenic, copper, lead, mercury, nickel, and zinc were more commonly detected. Cadmium, chromium (VI), and selenium were also detected, but were not prevalent across all streams. Copper and mercury were the only metals to exceed AWQCs. These exceedances occurred solely in EFPC. See detections of metals in Table 7.2.7.2 below. AWQC exceedances are bolded Table 7.2.7.2 and Figure 7.2.7.1.

Table 7.2.7.2: Detected Metals vs Total Number Sampled

Stream	Location	Antimony	Arsenic	Cadmium	Chromium (Total)	Chromium (VI)	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
BC	BCK 12.3	-	2/2	2/2	-	-	2/2	-	1/2	2/2	-	-	-	1/2
	BCK 9.2	-	2/2	-	-	1/1	2/2	-	2/2	2/2	-	-	-	1/2
	BCK 4.5	-	2/2	-	-	1/1	2/2	-	2/2	1/2	-	-	-	1/2
	BCK 1.61	-	2/2	-	-	-	2/2	-	2/2	1/2	1/2	-	-	-
EFPC	EFK 25.1	-	3/3	2/3	-	2/2	3/3[†]	2/3	3/3[†]	2/3	-	-	-	3/3
	EFK 23.4	-	2/2	-	-	1/1	2/2[†]	1/2	2/2[†]	1/2	-	-	-	1/2
	EFK 15.7	-	2/2	-	-	1/1	2/2	1/2	2/2[†]	1/2	-	-	-	1/2
	EFK 6.3	-	2/2	-	-	-	2/2	1/2	2/2[†]	2/2	-	-	-	2/2
MIB	MIK 1.43	-	2/2	-	-	-	2/2	1/2	2/2	1/2	-	-	-	-
	MIK 0.71	-	2/2	-	-	1/1	2/2	2/2	2/2	2/2	-	-	-	2/2
	MIK 0.1	-	3/3	-	-	2/2	3/3	2/3	3/3	3/3	-	-	-	2/3
WOC	WCK 6.8	-	1/2	-	-	-	1/2	-	2/2	-	-	-	-	1/2
	WCK 3.4	-	1/2	-	-	-	1/2	1/2	2/2	1/2	-	-	-	1/2
	WCK 2.3	-	1/3	-	-	-	1/3	1/3	3/3	1/3	-	-	-	1/3
CC	CCK 1.6	-	-	-	-	1/1	2/2	-	2/2	-	-	-	-	-
Note:	# detected/total samples; '-' indicates no detections of the analyte for any sampling event *exceeded Fish and Aquatic Life - Continuous TN AWQC † exceeded Fish and Aquatic Life- Maximum TN AWQC ‡ exceeded Recreation TN AWQC													



Note: black dashed line represents median concentrations at the CC background location

Figure 7.2.7.1: Boxplots - Analyte Concentration Distributions per Stream.

Arsenic was detected at all stream locations except for the background stream CC. While not exceeding AWQCs, arsenic levels were highest in Mitchell Branch (MIB), with an average concentration of $0.527 \mu\text{g/L}$ across all MIB sample locations. The maximum concentration in MIB was $1.11 \mu\text{g/L}$ at MIK 0.71, which is much lower than the recreation AWQC of $10 \mu\text{g/L}$. EFPC had the next highest concentrations with an average of $0.425 \mu\text{g/L}$ followed by WOC ($0.369 \mu\text{g/L}$), and BC ($0.224 \mu\text{g/L}$). All ORR streams sampled had higher median concentrations compared to the background CC stream (see Figure 7.2.7.1).

Cadmium concentrations were not identified at most stream locations sampled. However, a few higher concentration occurrences were detected at BCK 12.3 ($0.435 \mu\text{g/L}$) and EFK 25.1 ($0.459 \mu\text{g/L}$). These two locations, while being elevated relative to the other stream sites, are still well below the TN Fish and Aquatic Life (FAL) AWQC of $0.72 \mu\text{g/L}$. Nearly all streams had similar median concentrations to that of the background stream (see Figure 7.2.7.1).

Hexavalent chromium, or chromium (VI), was most commonly detected in MIB, EFPC, and BC. Average concentrations were 0.387 µg/L, 0.326 µg/L, and 0.124 µg/L, respectively. The highest concentration detected among all streams was 0.557 µg/L at MIK 0.1 followed by 0.546 µg/L at EFK 25.1. All detections were below the 11 µg/L FAL AWQC. Despite no detections of total chromium, hexavalent chromium was detected due to a lower laboratory method detection limit. BC and WOC were at or below background levels while EFPC and MIB were generally higher than background (see Figure 7.2.7.1).

Copper concentrations were highest at EFPC, with an average concentration of 10.17 µg/L across all EFPC sites. The maximum concentration of all streams occurred at EFK 25.1 which was 45.2 µg/L. EFK 23.4 also yielded an elevated result of 13.4 µg/L. All other streams had much lower concentrations with WOC having the next highest average of 1.8 µg/L followed by MIB (1.4 µg/L), BC (0.77 µg/L), and CC (0.64 µg/L). EFPC locations EFK 25.1 and EFK 23.4 yielded results higher than both the FAL maximum and FAL continuous AWQCs. All other streams were at or near background levels (see Figure 7.2.7.1).

Lead concentrations were highest in EFPC, with an average concentration of 0.55 µg/L. EFK 25.1 yielded the highest lead concentration of 0.59 µg/L. MIB yielded the next highest average of 0.43 µg/L followed by WOC (0.25 µg/L). There were no detections of lead in BC or CC. No lead concentrations were higher than TN AWQCs. EFPC and MIB were generally higher than background while BC and WOC were at or near background levels (see Figure 7.2.7.1).

Mercury concentrations were highest in EFPC exceeding the recreation AWQC of 0.051 µg/L at all locations. The stream had an average concentration of 0.25 µg/L across all sampled sections. The highest concentration was at EFK 25.1, with a concentration of 0.77 µg/L. EFK 25.1 also exceeded the FAL continuous AWQC. All other EFPC locations were also elevated with EFK 23.4 at (0.18 µg/L), EFK 15.7 (0.13 µg/L), and EFK 6.3 at 0.24 µg/L. Other streams had lower average concentrations relative to EFPC, with WOC (0.007 µg/L), BC (0.005 µg/L), MIB (0.004 µg/L), and CC at 0.0006 µg/L (see Figure 7.2.7.1).

All sampled concentrations of **nickel** were well below all TN AWQCs. MIB yielded the highest average of 3 µg/L followed by BC (0.8 µg/L), EFPC (0.7 µg/L), and WOC (0.22 µg/L). CC did not have any detections of nickel (see Figure 7.2.7.1).

Zinc was detected in all of the sampled streams. While concentrations were below all TN AWQCs, EFPC yielded the highest average concentrations (15 µg/L) with the highest concentration of 33 µg/L at EFK 25.1. WOC followed EFPC with an average concentration of 7 µg/L. This was followed by MIB (6.6 µg/L) and BC (2.5 µg/L). CC did not have any detections of

zinc (see Figure 7.2.7.1).

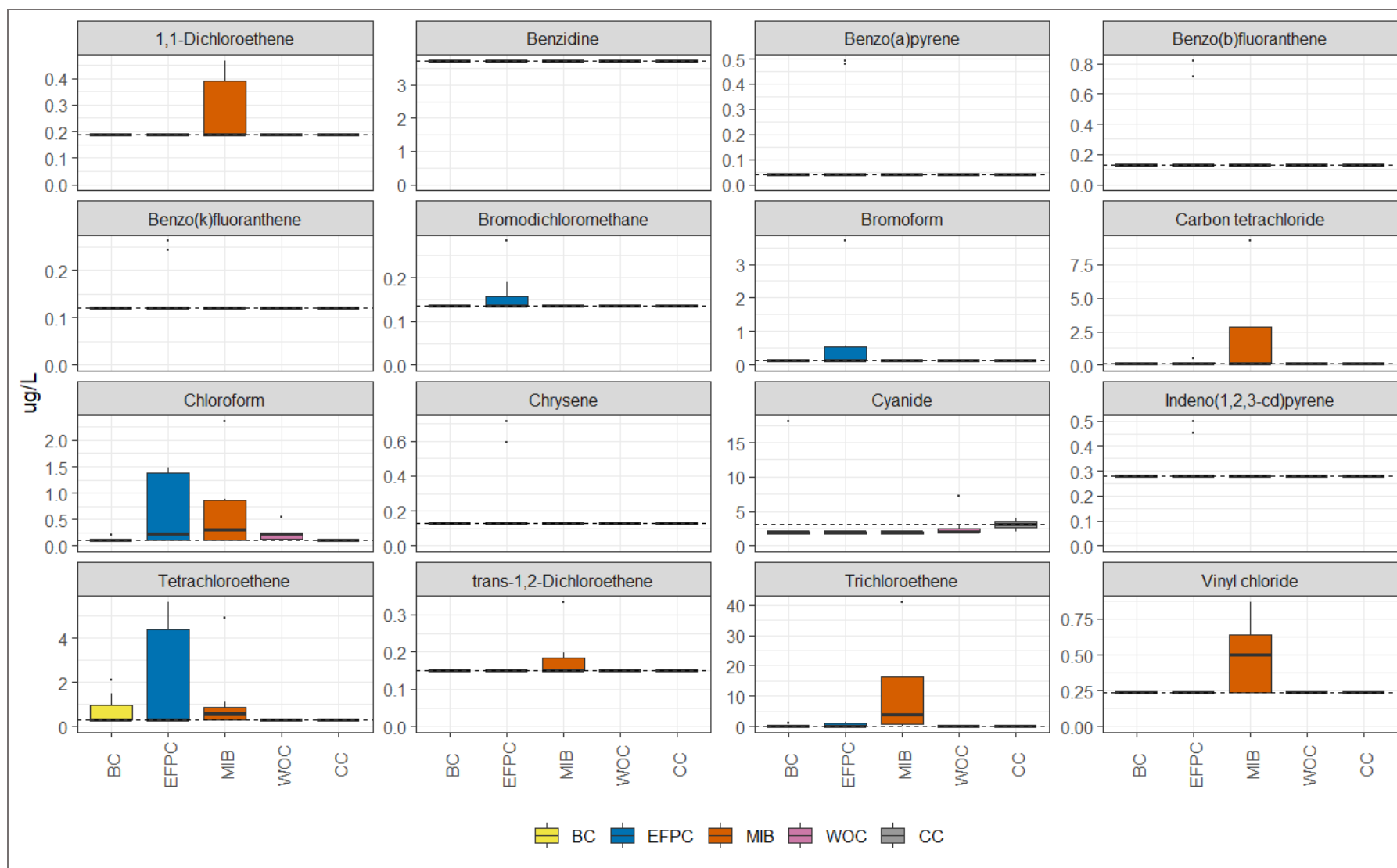
VOLATILES (VOCs) AND SEMI-VOLATILES (SVOCs)

All stream locations were sampled and analyzed using method 8260 and 8270. These methods compared against hundreds of volatile and semi-volatile compounds. Due to the numerous analytes evaluated via these methods, those analytes that were not detected at any sampling event are excluded from the table and figures below. Please refer to table 7.2.5.1 to identify the full list of analytes with AWQCs for methods 8260 and 8270. Table 7.2.7.3 shows all locations where a detection occurred for a given VOC/SVOC and is bolded where AWQC exceedances occurred (see Table 7.2.7.3).

(Continued on Next Page - Table 7.2.7.3.)

Table 7.2.7.3: Detected VOCs/SVOCs vs Total Number Sampled

Stream	Location	1,1-Dichloroethene	1,1,2-Trichloroethane	1,4-Dichlorobenzene	2-Chloronaphthalene	4,6-Dinitro-2-methylphenol	Acenaphthene	Anthracene	Benidine	Benzol(a)pyrene	Benzol(b)fluoranthene	Benzok(j)fluoranthene	Bromodichloromethane	Bromoform	Butylbenzylphthalate	Carbon tetrachloride	Chloroform	Chrysene	Cyanide	Dibenz(a,h)anthracene	Dibromochloromethane	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Phenol	Pyrene	Tetrachloroethene	trans-1,2-Dichloroethene	Trichloroethene	Vinyl chloride		
BC	BCK 12.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2/2	-	-	-			
	BCK 9.2	-	-	-	-	-	-	-	-	-	-	-	-	-	1/2	-	-	-	-	-	-	-	-	-	-	1/2	-	1/2	-			
	BCK 4.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
	BCK 1.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
EFPC	EFK 25.1	-	-	-	-	2/3	2/3	-	2/3 [†]	2/3 [†]	2/3 [†]	3/3	3/3	-	1/3	3/3	2/3 [†]	-	1/3	1/3	3/3	2/3	2/3 [†]	-	3/3	3/3	-	3/3	-			
	EFK 23.4	-	-	-	-	-	-	-	-	-	-	1/2	-	2/2	2/2	-	-	-	-	-	-	-	-	-	-	1/2	-	-	-			
	EFK 15.7	-	-	-	-	-	-	-	-	-	-	-	-	-	1/2	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
	EFK 6.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
MIB	MIK 1.43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
	MIK 0.71	-	-	-	-	-	-	-	-	-	-	-	-	-	1/2	-	-	-	-	-	-	-	-	-	-	2/2	-	2/2	1/2			
	MIK 0.1	3/3	-	-	-	-	-	-	-	-	-	-	-	3/3	3/3	-	1/3	-	-	-	-	-	-	-	-	2/3	3/3	3/3	3/3			
WOC	WCK 6.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1/2 [*]	-	-	-	-	-	-	-	-	-	-	-	-			
	WCK 3.4	-	-	1/2	1/2	-	-	-	-	-	1/2	-	-	1/2	-	1/2	-	-	-	-	-	-	-	1/2	1/2	-	-	-	-			
	WCK 2.3	1/3	1/3	-	-	1/3	-	1/3 [†]	-	-	-	-	-	-	1/3	-	1/3	-	-	-	-	-	-	-	-	-	-	-	-			
CC	CCK 1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1/2	-	-	-	-	-	-	-	-	-	-	-	-			
Note:	# detected/total samples; '-' indicates no detections of the analyte for any sampling event *exceeded Fish and Aquatic Life - Continuous TN AWQC † exceeded Fish and Aquatic Life- Maximum TN AWQC ‡ exceeded Recreation TN AWQC																															



Note: black dashed line represents median concentrations at the CC background location

Figure 7.2.7.2: Boxplots of VOC/SVOC Concentration Distributions By Stream.

The majority of VOC and SVOC detections occurred in the upper sections of EFPC, middle and lower sections of MIB, and in the middle and lower sections of WOC. Upper BC also had a few detections, but for a limited number of analytes. Many of the detections are isolated to individual stations and may not persist throughout the entire stream.

In EFPC, recreation AWQC exceedances occurred for benzo(a)pyrene (0.494 µg/L), benzo(b)fluoranthene (0.822 µg/L), benzo(k)fluoranthene (0.262 µg/L), chrysene (0.711 µg/L), and indeno(1,2,3-cd)pyrene (0.497 µg/L) (see Table 7.2.5.1). All of these AWQC exceedances occurred at EFK 25.1 but did not persist at downstream locations. Other VOC/SVOC analytes were detected but were below AWQCs. See table 7.2.7.3 for these other detected analytes. In WOC, AWQC exceedances occurred for benzidine (3.74 µg/L) and cyanide (7.25 µg/L) at WCK 2.3 and WCK 6.8, respectively (see Table 7.2.5.1). Middle and lower WOC had several other VOC/SVOC detections that were below AWQCs (see Table 7.2.7.3).

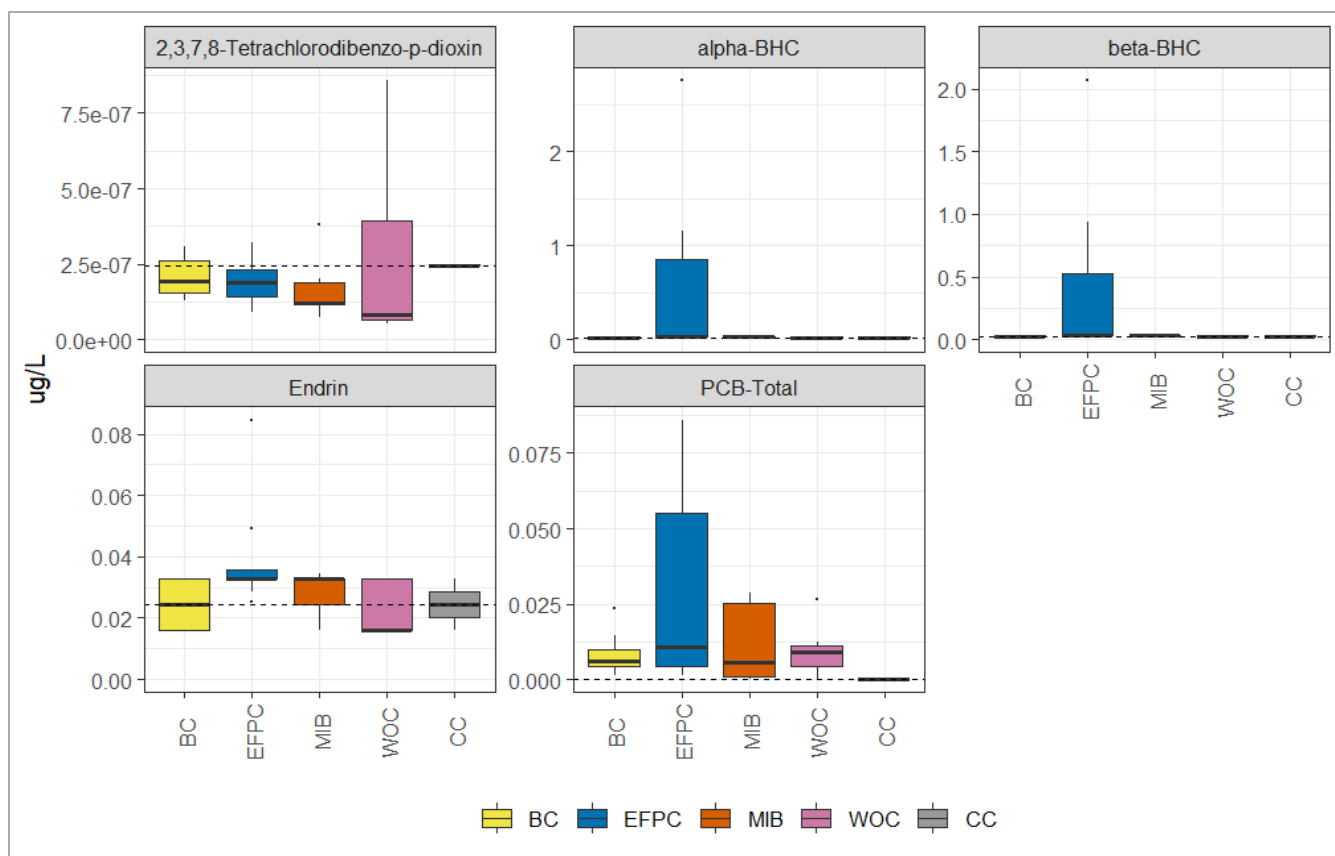
MIB yielded no detections for any VOC/SVOC in the upper section of the stream. Several detections of PCE, TCE, and other daughter products were identified, albeit below AWQCs. BC only had a few detections of PCE, TCE, and chloroform in the upper section of the stream. No detections were above AWQCs.

DIOXINS, PESTICIDES, AND PCBs

Streams were also sampled for dioxins, pesticides, and PCBs. Some pesticides may be listed in the previous section as there is some overlap of SVOC pesticides analyzed via method 8270. This section focuses on pesticides sampled via EPA method 8181 and EPA 8141B. All detected analytes are identified in Table 7.2.7.4 below. Due to the large number of analytes run by these methods, only those contaminants that were detected are shown in the table and figures below.

Table 7.2.7.4: Detected Dioxins, Pesticides, and PCBs vs Total Number Sampled

Stream	Location	2,3,7,8-Tetrachlorodibenzo-p-dioxin	alpha-BHC	beta-BHC	Endrin	PCB-Total
BC	BCK 12.3	-	-	-	-	2/2 ^{†‡}
	BCK 9.2	-	-	-	-	2/2 ^{†‡}
	BCK 4.5	1/2	-	-	-	2/2 ^{†‡}
	BCK 1.61	1/2	-	-	-	2/2 ^{†‡}
EFPC	EFK 25.1	-	1/3 [†]	1/3 [†]	1/3 ^{†‡}	3/3 ^{†‡}
	EFK 23.4	-	1/2 [†]	1/2 [†]	1/2	2/2 ^{†‡}
	EFK 15.7	-	1/2 [†]	1/2 [†]	1/2	2/2 ^{†‡}
	EFK 6.3	-	1/2 [†]	-	1/2 [*]	2/2 [†]
MIB	MIK 1.43	-	-	-	1/2	2/2
	MIK 0.71	-	-	-	-	2/2 ^{†‡}
	MIK 0.1	-	-	-	-	3/3 ^{†‡}
WOC	WCK 6.8	-	-	-	-	2/2
	WCK 3.4	-	-	-	-	2/2 ^{†‡}
	WCK 2.3	-	-	-	-	3/3 ^{†‡}
CC	CCK 1.6	1/2	-	-	-	2/2
Note:	# detected/total samples					
	'-' indicates no detections of the analyte for any sampling event					
	*exceeded Fish and Aquatic Life - Continuous TN AWQC					
	† exceeded Fish and Aquatic Life- Maximum TN AWQC					
	‡ exceeded Recreation TN AWQC					



Note: black dashed line represents median concentrations at the CC background location

Figure 7.2.7.3: Dioxins, Pesticides, & PCB Concentration Distributions by Stream.

Dioxins were only detected in lower BC and in CC. The maximum result was $0.00000029 \mu\text{g/L}$ in lower BC and $0.00000025 \mu\text{g/L}$ in CC. These values are orders of magnitude lower than the TN AWQC. The background stream actually had a higher median concentration compared to ORR streams (see Figure 7.2.7.3).

Pesticides alpha-BHC, beta-BHC, and Endrin were identified in EFPC. While the frequency of detections was low, a few samples identified concentrations above the recreational AWQCs of $0.049 \mu\text{g/L}$ (alpha-BHC), $0.17 \mu\text{g/L}$ (beta-BHC), and $0.06 \mu\text{g/L}$ (Endrin). Upper EFPC yielded the highest concentrations, including alpha-BHC ($2.76 \mu\text{g/L}$), beta-BHC ($2.07 \mu\text{g/L}$), and endrin ($0.085 \mu\text{g/L}$). Other streams did not have frequent or high detections of pesticides (see Figure 7.2.7.3). No pesticides were identified via the EPA 8141B method at any stream.

PCBs were prevalent at all ORR sampled locations. EFPC had the highest average concentration of $0.027 \mu\text{g/L}$ total PCBs followed by MIB ($0.012 \mu\text{g/L}$), WOC ($0.0095 \mu\text{g/L}$), BC ($0.0084 \mu\text{g/L}$), and CC ($0.00016 \mu\text{g/L}$). The highest concentration occurred at EFK 25.1 with a result of $0.086 \mu\text{g/L}$. All streams except for the background stream CC exceeded recreation AWQCs ($0.00064 \mu\text{g/L}$) and all were well above the background levels of CC (see Figure 7.2.7.3). Additionally, EFK 25.1 also

exceeded the FAL continuous AWQC (0.014 µg/L).

7.2.8 CONCLUSIONS

Clinch River

The CR samples were collected to compare to DOE's sampling results published in their *Annual Site Evaluation Report*. All concentrations at each location were low and were below all screening criteria. These findings are consistent with DOE's reported concentrations at these sites (DOE, 2023).

Bear Creek

BC was found to be above the PCB recreation AWQC (0.00064 µg/L) and FAL-continuous AWQC (0.014 µg/L) at every sampling location in all reaches of the stream (see Figure 7.2.8.1). No other AWQC exceedances were identified during the FY25 sampling events. Notable detections, albeit below AWQCs, also occurred for tetrachloroethene (2.1 µg/L) at BCK 12.3 and (1.5 µg/L) at BCK 9.2. Similarly, trichloroethene was detected at BCK 9.2 with a concentration of 1.09 µg/L. These detections are quite high for surface water relative to the groundwater MCL of 5 µg/L (EPA, 2024). These high surface water concentrations are likely indicative of a nearby or upstream VOC groundwater source.

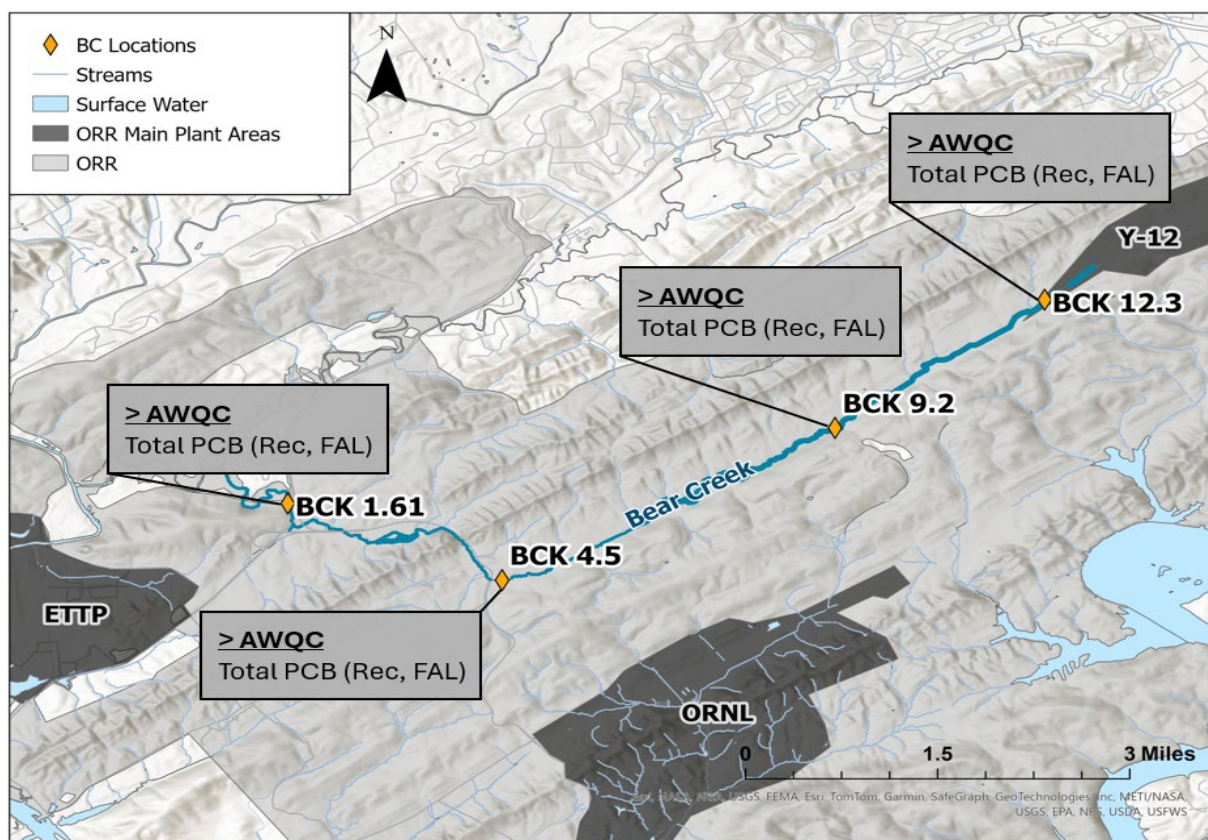


Figure 7.2.8.1: AWQC Exceedance Locations for Bear Creek Sample Sites

East Fork Poplar Creek

EFPC had the most AWQC exceedances of the streams sampled for this project. The majority of exceedances occurred near the EFPC headwaters and decreased downstream. However, mercury, alpha-BHC, and PCBs persisted and exceeded AWQC levels in all stream sections. These three contaminants had highest concentrations near Y-12 that later decreased downstream, but still at concentrations above AWQCs. EFK 25.1 contained metals, VOC/SVOCs, and pesticides above AWQC values. Mercury is a known contaminant of the Y-12 site and had the highest concentration at EFK 25.1. The VOCs that were detected at this location make up a suite of poly-aromatic-hydrocarbons (PAHs) that may be biproducts of industrial processes or even may be associated with creosote pits which were sometimes used at Y-12 to treat wood. Pesticides and PCBs may also be tied with Y-12 industrial processes. At the integration point of Y-12 (EFK 23.4), the VOCs were no longer present in surface water. However, the metals, pesticides, and PCBs were still above AWQCs. In middle-EFPC, EFK 15.7 had AWQC exceedances of mercury, pesticides, and PCBs, but had no detections of copper that was prevalent near Y-12. At EFK 6.3, the same contaminants persist above AWQCs, with Endrin being identified as well. It is possible that Endrin, which is a pesticide that was banned in the US in 1991, relates to old farming practices that may have been used in this more agricultural or rural land of lower EFPC. Notable detections, although below AWQCs, also occurred for tetrachloroethene (PCE) and trichloroethene (TCE) at EFK 25.1. EFK 25.1 had 5.61 µg/L PCE and 1.62 µg/L TCE in surface water which may be indicative of a groundwater plume adjacent to the stream.

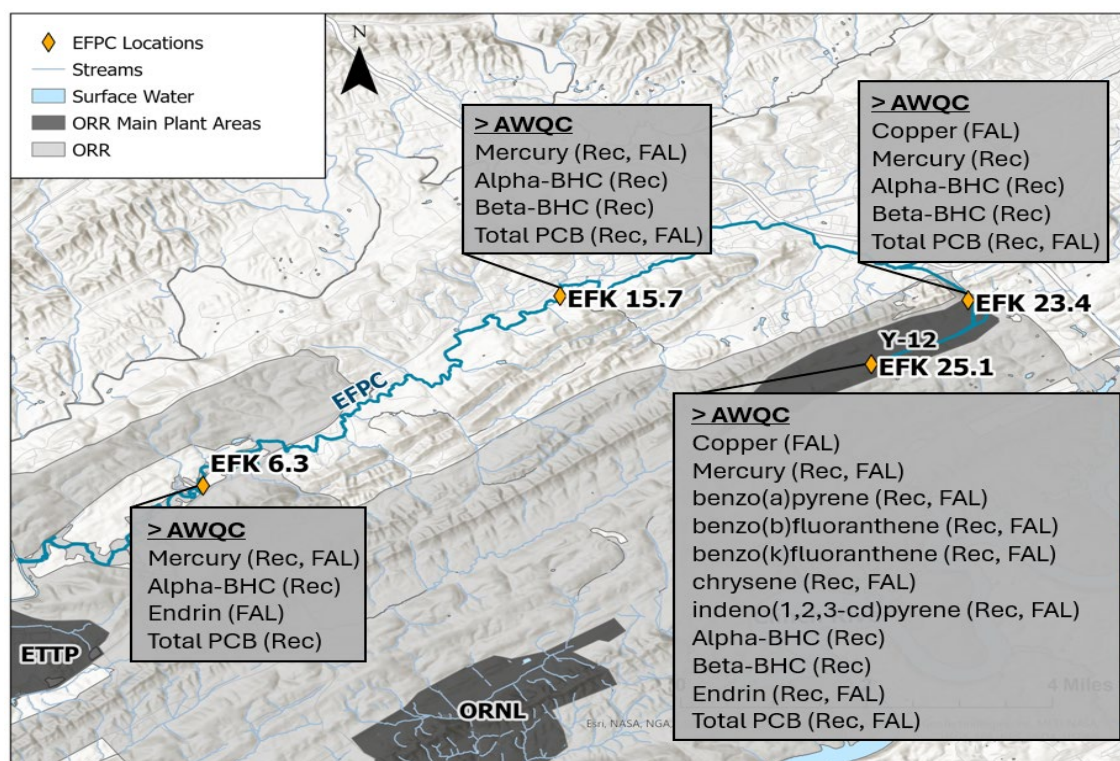


Figure 7.2.8.2: AWQC exceedance locations for East Fork Poplar Creek sample sites

Mitchell Branch

Mitchell Branch only had AWQC exceedances of PCBs in the middle and lower sections of the creek. Upper MIB was the only location of all streams sample to not have an exceedance of PCBs. The upper section of MIB actually had very few detections of contaminants. PCBs were identified above AWQCs where MIB runs through the ETPP main plant area. These contaminants are likely tied to an ETPP industrial process.

The middle and lower sections of MIB also had several notable detections that were below AWQCs. These include a sample containing 40.8 µg/L TCE at MIK 0.1 and a result of 4.93 µg/L PCE at MIK 0.71. Carbon tetrachloride was also identified at 9.24 µg/L at MIK 0.1. These concentrations of VOCs track with the known large groundwater plumes of various VOC compounds along Mitchell Branch. These contaminants are leaching into the MIB and causing surface water concentrations to be elevated. While these concentrations are lower than AWQCs, they are elevated relative to groundwater MCLs.

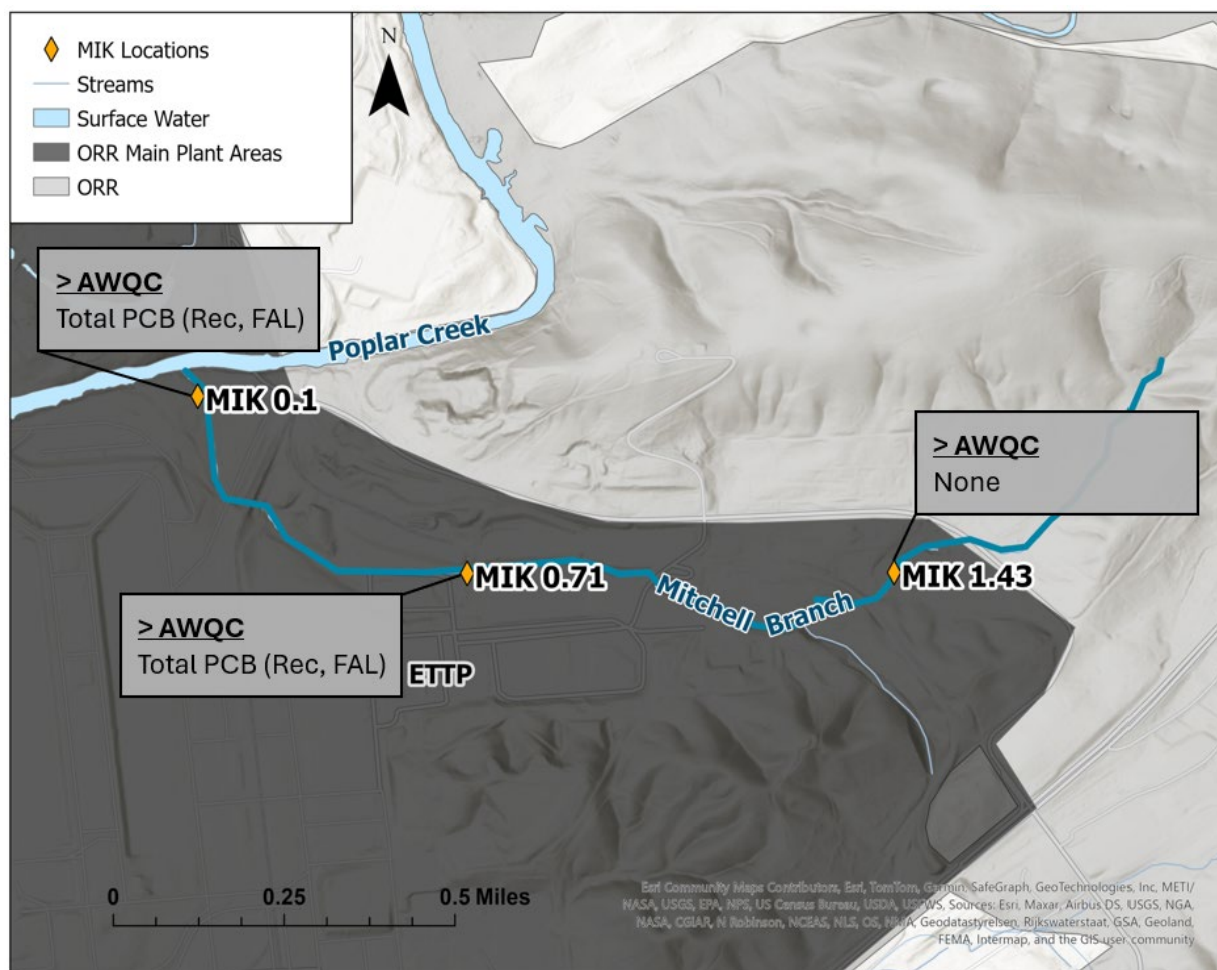


Figure 7.2.8.3: AWQC Exceedance Locations for Mitchell Branch Sample Sites

White Oak Creek

WOC had most of the AWQC exceedances occur in the middle to lower section of the stream. The headwaters of the creek, WCK 6.8, had little to no detection of contaminants. However, one sample detected elevated cyanide levels above AWQCs. In the lower section of the stream, which is downstream of ORNL inputs, PCBs were detected above AWQCs. Benzidine was also detected at WCK 2.3 above AWQCs. It is possible that these contaminants are used or were used in industrial processes at ORNL.

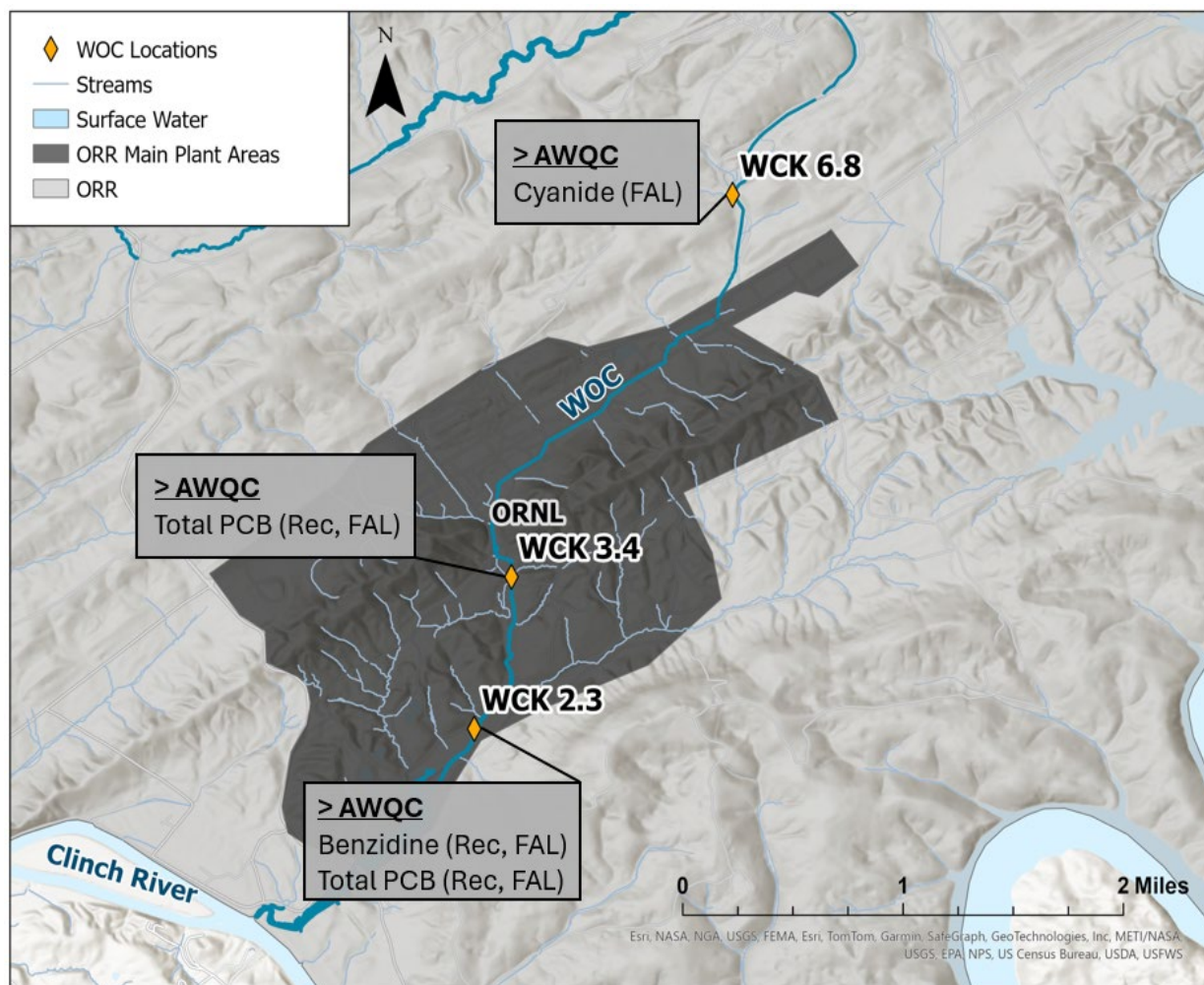


Figure 7.2.8.4: AWQC Exceedance Locations for White Oak Creek Sample Sites

Clear Creek

Clear Creek, which is the background comparison stream, had no AWQC exceedances. This stream was lower in concentration for nearly every analyte analyzed.

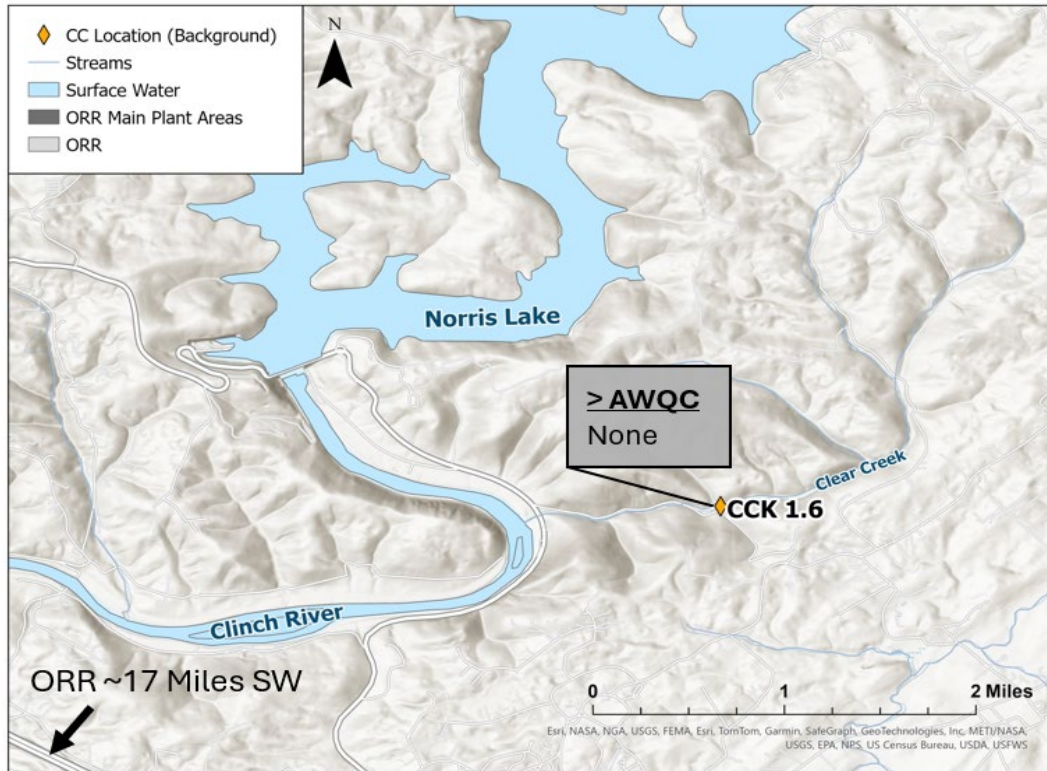


Figure 7.2.8.5: AWQC Exceedance Locations for Clear Creek Sample Sites

7.2.9 RECOMMENDATIONS

TDEC recommends that the analytes that exceeded AWQCs continue to be sampled and investigated to evaluate if there is seasonality or certain conditions that tend to express higher concentrations. As these results are from only a few sample points, additional sampling will help the project team to understand the frequency and magnitude of contamination. This may help to evaluate if additional sample points or more frequent sampling is warranted.

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7.3 WHITE OAK CREEK RADIONUCLIDES

7.3.1 BACKGROUND

White Oak Creek (WOC) was monitored periodically under the TDEC DoR-OR *Ambient Surface Water Sampling Project* since 1993 (Chapter 7.2); however, since 2020, DoR-OR has focused on this stream under a separate project. As a Clinch River tributary, WOC became a focal ORR exit-pathway stream due to specific concerns regarding the elevated radionuclide strontium-90 (Sr-90). Sr-90 was first detected at a Clinch River (CR) sampling station (CRK 33.5) in 2017. CRK 33.5 is located at the WOC-CR confluence, immediately downstream of the WOC Embayment (WOE) sediment retention structure (SRS) (Figure 7.3.2.1). Because this radionuclide entered the Clinch River via WOC, DoR-OR has prioritized monitoring surface water quality of WOC and its tributaries. These results also supplement DOE's ongoing investigations of Sr-90 migration and CR monitoring.

The ORR exit-pathway streams, such as WOC, and the CR have historically been, and are currently, subject to contaminants' releases from activities at Y-12, ORNL, and ETP. Monitoring WOC and its tributaries provides a better understanding of its contributions to CR surface water contamination and may provide insights into helping protect human health and the environment.

DOE has implemented a surface water monitoring program for several years that consists of monitoring surface water at a few locations along the Clinch River (DOE, 2022a). The purpose of DOE's surface water monitoring project is to assess impacts of site operations, both past and present, on surface water bodies. While the current DOE projects only sample the CR, and one location along WOC, this DoR-OR project will complement DOE's sampling by monitoring specific points along WOC and its tributaries. The intent is to provide a more representative evaluation of the contaminants entering WOC, and ultimately the CR.

7.3.2 PROBLEM STATEMENTS

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

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

- ORNL has released low-level radioactive liquid wastes to the Clinch River via White Oak Creek since 1943. (Pickering, 1970).
- Approximately 665 curies of cesium-137 (Cs-137) were released to the CR from WOC between 1954 and 1959 (DOE, 1992).

- Groundwater containing elevated levels of strontium-90 has historically been collected from the solid waste storage areas in Melton Valley and transferred to the Process Waste Treatment Complex (PWTC) in Bethel Valley for treatment. The PWTC did not entirely remove strontium-90 from the waste stream and ultimately discharged treated wastewater containing elevated levels of strontium-90 into WOC at Outfall X12. (Figure 7.3.2.1) (DOE, 2022c). The PWTC is currently not in operation and scheduled for demolition. Much of the water treatment has been shifted over to the newer Liquid-Gaseous Waste Operation (LGWO) (Building 3608). Treated water from the LGWO is also discharged into WOC at Outfall X12.
- Historic and ongoing discharges of strontium-90 and cesium-137 into White Oak Creek are impacting surface water quality. Known sources include, but are not limited to, impacted floodplain soils from the former Surface Impoundment Operable Unit (SIOW) area (Figure 7.3.2.1) and baseflow groundwater seepage into White Oak Creek (DOE, 2022).
- TDEC's Roving Creel Study (Chapter 3.2) has determined that the Clinch River near the White Oak Creek and Clinch River confluence is used for recreational fishing.
- Evaluating potential strontium-90 surface water impacts to Fifth Creek if the sump pump at Building 3042 is turned off. It is theorized that continuous operation of the sump has created a groundwater capture zone, that when the pump is turned off, the natural groundwater flow may direct contaminants toward 5th Creek. Sampling along 5th Creek (DOE station name = "5TH CR" aka "FFK 0.2") has been conducted since at least 1987, with semi-annual sampling currently being conducted (DOE, 2022b).
- Anomalous conductivity readings have been observed in Melton Branch, specifically at MEK 0.3. The increased readings appear to be associated with decreased concentrations of Sr-90. As this area of Melton Branch has documented seepage and underflow into the creek, this area is identified as an area needing further evaluation.

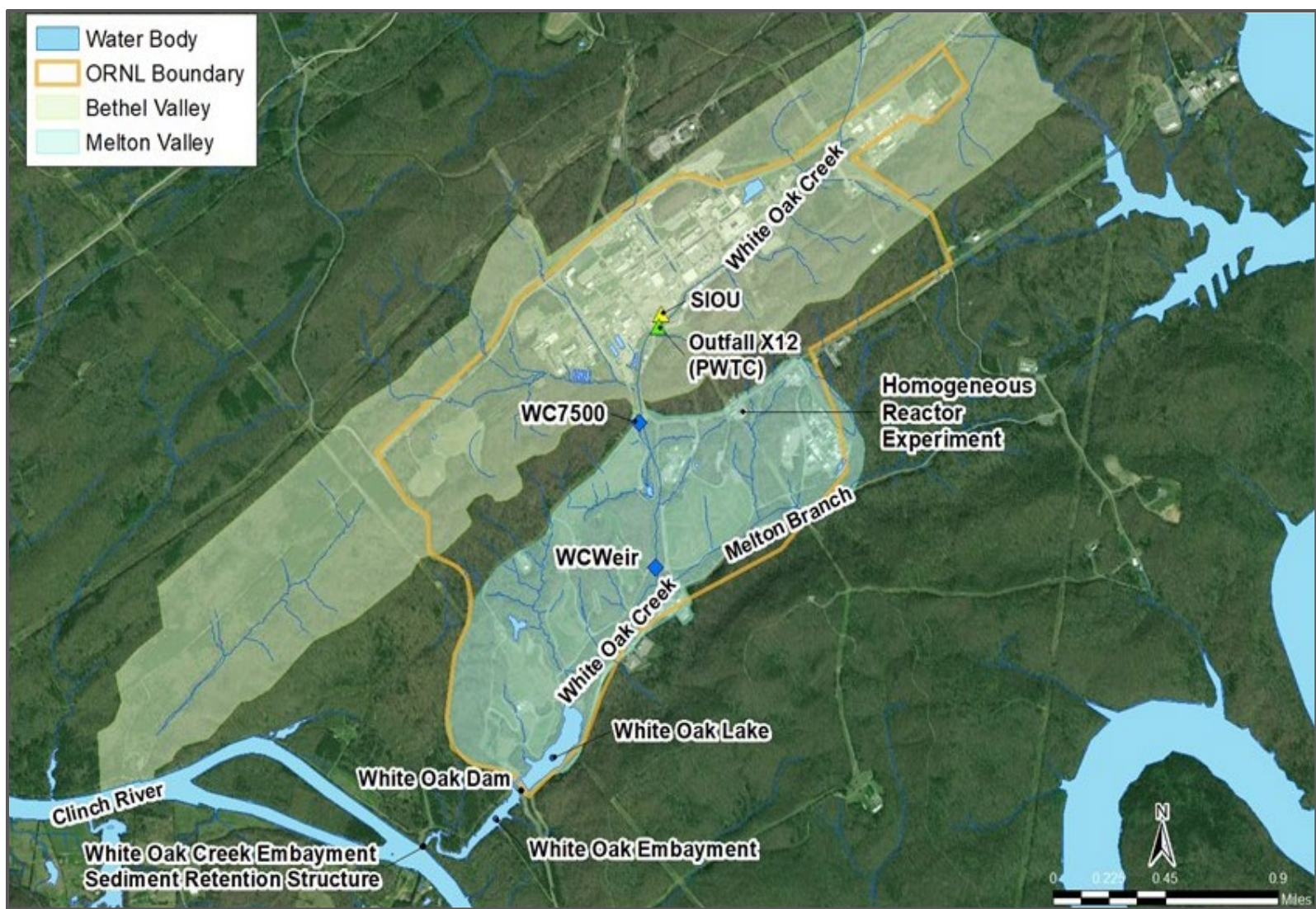


Figure 7.3.2.1: White Oak Creek Map and Pertinent Features

7.3.3 GOALS

The goal of the *White Oak Creek Radionuclides Monitoring Project* is to evaluate the impacts of DOE ORR contamination to WOC, its tributaries, and the mainstem CR at the WOC confluence. This project involved collecting surface water samples at the locations illustrated on Figure 7.3.4.1.

7.3.4 SCOPE

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

The surface water collection sites include four WOC monitoring locations (WCK 6.8, WCK 3.9, WCK 3.4, WCK 2.3), one Clinch River (CR) monitoring location (CRK 33.5) at the confluence (WOC-CR), and the remaining three monitoring locations (FFK 0.2, HRT-3, MEK 0.3) are on tributaries of WOC. FFK 0.2 is located on Fifth Creek which is a tributary into WOC. HRT-3 is located on a tributary of Melton Branch, which is a tributary into WOC. Surface water monitoring locations are shown on Figure 7.3.4.1.

(Continues on Next Page – Figure 7.3.4.1)

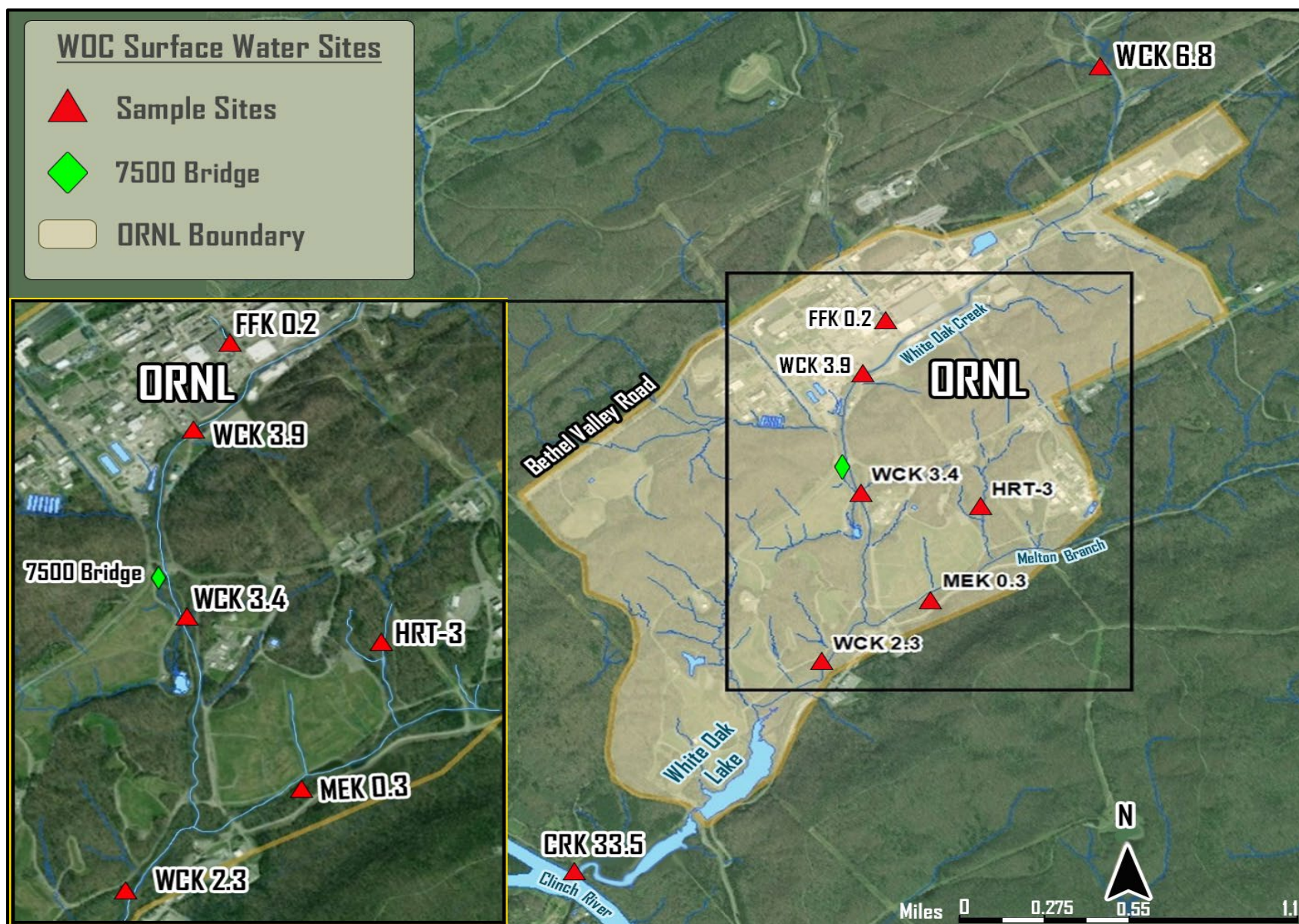


Figure 7.3.4.1: DoR-OR White Oak Creek (WOC) Surface Water Sampling Locations

7.3.5 METHODS, MATERIALS, METRICS

Streamflow

Although streamflow was not directly measured in the field, DoR-OR downloaded available streamflow records for WOC from the Oak Ridge Environmental Information System (OREIS) to evaluate the hydrologic regime of WOC. The project team identified two DOE maintained weirs (Figure 7.3.7.1), WC7500 and WCWeir, that had daily streamflow measurements for the period of record between 2009 and 2024 (ending September 30, 2024).

Field Water Quality Parameter Measurements

At each site, water quality parameters were measured in the field at the time of sampling using a properly calibrated multi-parameter water quality meter. The following water quality parameters were measured: pH, temperature, specific conductivity, oxidation reduction potential (ORP), dissolved oxygen, and turbidity.

Surface Water Analytical Sampling

Surface water samples were collected quarterly at eight (8) monitoring sites (WCK 6.8, WCK 3.9, WCK 3.4, WCK 2.3, CRK 33.5, FFK 0.2, HRT-3, and MEK 0.3) illustrated on Figure 7.3.4.1. Samples were submitted for laboratory analysis of Sr-90, and gamma radionuclides. Sampling protocols followed the TDEC-DoR-OR *Standard Operating Procedures – Collection of Surface Water Samples, Dor-OR T-704* (TDEC, 2023).

7.3.6 DEVIATIONS FROM THE PLAN

During the fiscal year (FY25), there were no deviations from the proposed plan.

7.3.7 RESULTS AND ANALYSIS

Streamflow

The average annual flow was 5.9 cubic feet per second (cfs) at WC7500 and 15.1 cfs at WCWeir. Figure 7.3.7.1 presents daily streamflow data for the period from June 1, 2019, to September 30, 2024. The streamflow data available in OREIS did not coincide with the entire FY25 period. However, the data overlaps with historic TDEC DoR-OR's WOC surface water sampling efforts. As evident in this figure, streamflow is highly variable, likely because of precipitation events.

Additionally, the streamflow data presented in Figure 7.3.7.1 suggests WOC is a gaining stream, evident by the increase in measured streamflow moving downstream from the weir at the 7500 Bridge (WC7500) to the WCWeir. Increases in streamflow moving downstream are likely a result of various contributions such as smaller tributaries/drainages, outfalls, baseflow groundwater seepage, and/or other influx.

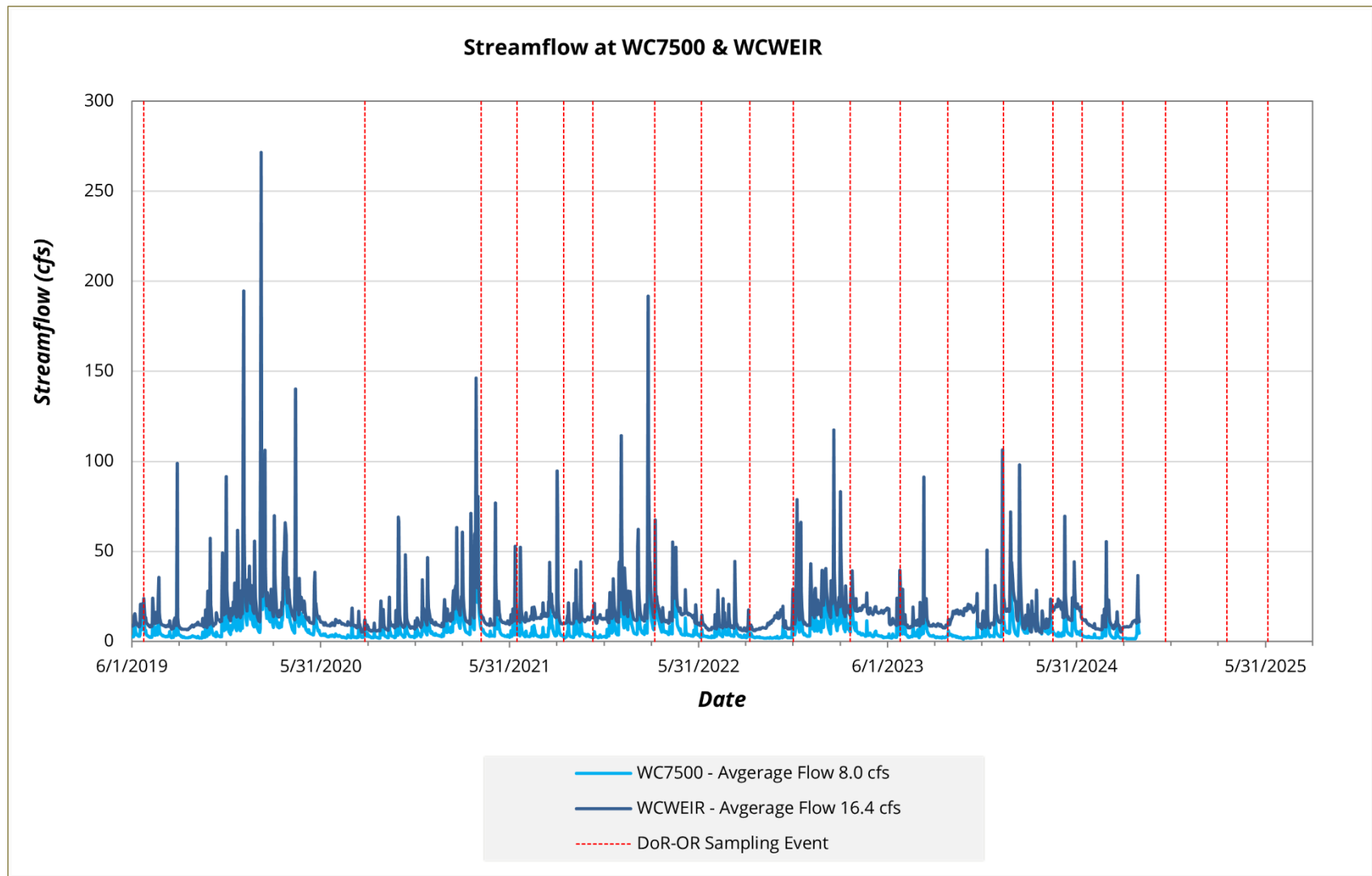


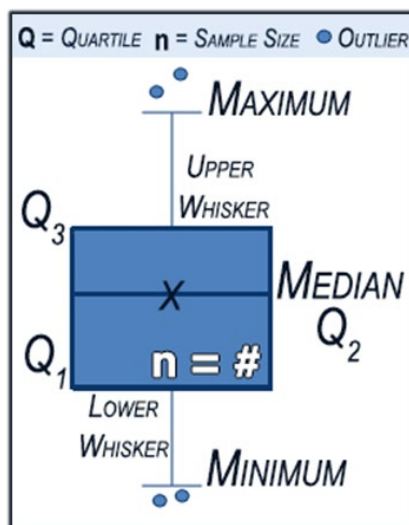
Figure 7.3.7.1: WC7500 Weir & WCWeir Streamflow (2019-2025)

Although not part of the scope for this investigation, it has been important to evaluate the stream flow during the ongoing TDEC sampling periods for future calculation of contaminant flux. Streamflow for the WOC has been compiled during this and previous years sampling events to eventually be used in a mass flux calculation into the CR.

During field measurement and sampling events, it was noted that the weir located at HRT-3 was severely washed-out during Hurricane Helene in September of 2024. The DOE was informed of this during an ORNL Team meeting in 2025. The exact magnitude of flow at this site has not been measured by the DOE since that time.

Field Water Quality Parameters

Water quality parameters of pH, temperature, and specific conductivity were measured in the field during sample collection. During FY25, field parameters were measured monthly versus quarterly producing a larger data set than previous years. A summary of the measured water quality parameters during the FY25 sampling events is provided below and the variability of these field parameters across the five surface water sampling locations are visually displayed using box plots. A box plot is generated using five numbers which include the minimum, 25th percentile (Q_1), median, 75th percentile quartile (Q_3), and maximum. During generation of these plots, outliers are visually illustrated but are not included when calculating the five numbers.



As shown above in the generic box plot, the top and bottom horizontal lines are the maximum and minimum values, the top and bottom of the box are the lower (Q_1) and upper quartiles (Q_3), the horizontal line in the box is the median (Q_2), the "X" marker displays the mean value, and the dots represent outlier values. For FY25 box plots the sample size (n) at each sampling location is 12.

pH

The pH is a measure of the hydrogen ion concentration and is measured on a logarithmic scale between 0 and 14, with pH 7 being neutral. Values measured over the twelve months ranged from 7.11 (CRK 33.5) to 8.25 (WCK 3.9). As illustrated in Figure 7.3.7.2, the median pH values across the seven sample locations are very similar. The highest variability in pH was observed at FFK 0.2 and MEK 0.3.

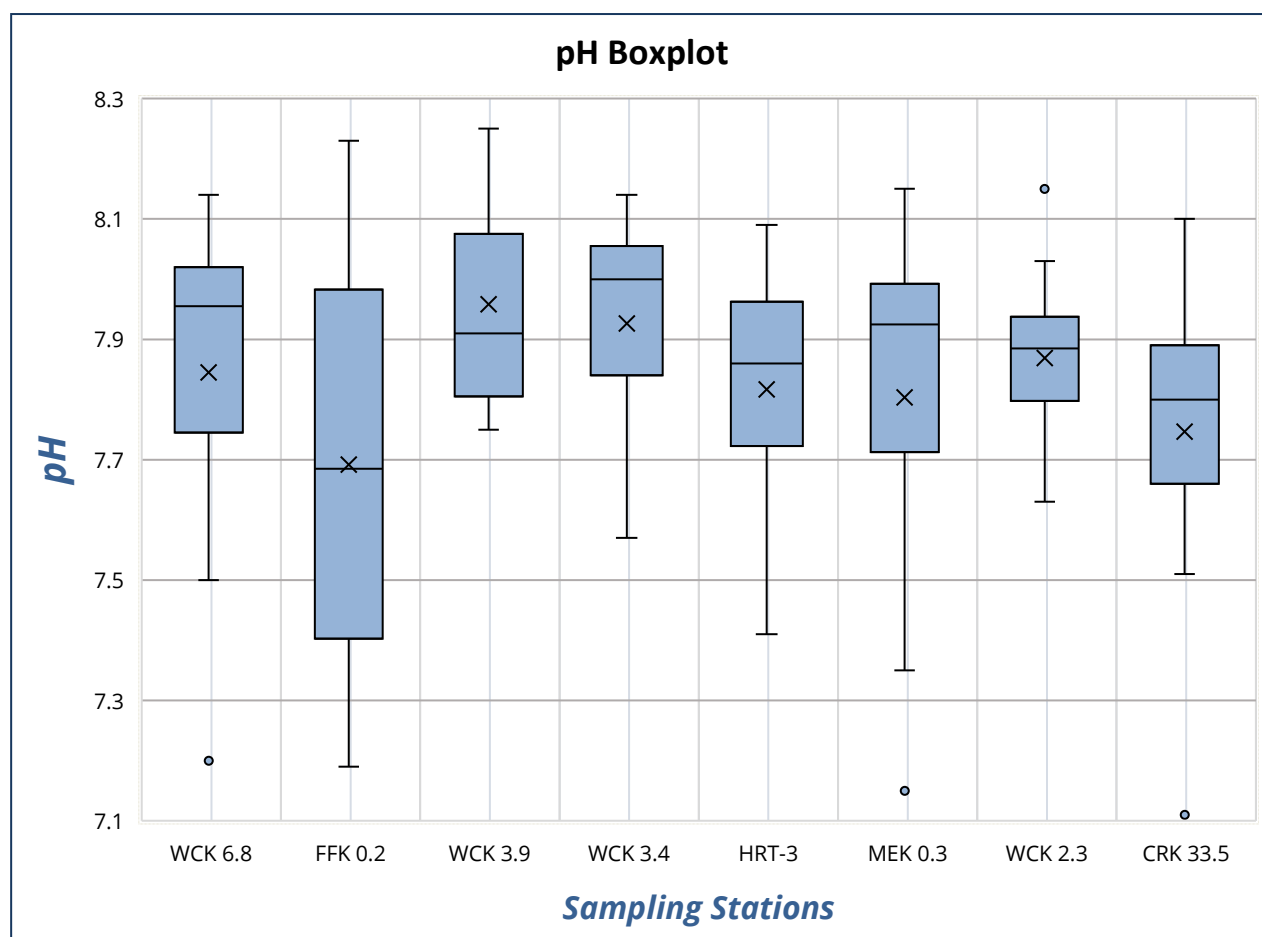


Figure 7.3.7.2: pH Boxplot from WCK 6.8 Downstream to CRK 33.5

TEMPERATURE

Surface water temperatures ranged from 0.9 degrees Celsius (°C) to 24.5 °C, both at MEK 0.3. In general, as shown on Figure 7.3.7.3, the median temperature among the seven sample stations is similar. Minimums were observed during the cold month of January and maximums during the hot months of July and August. Location MEK 0.3 showed the highest variability in temperature throughout the year.

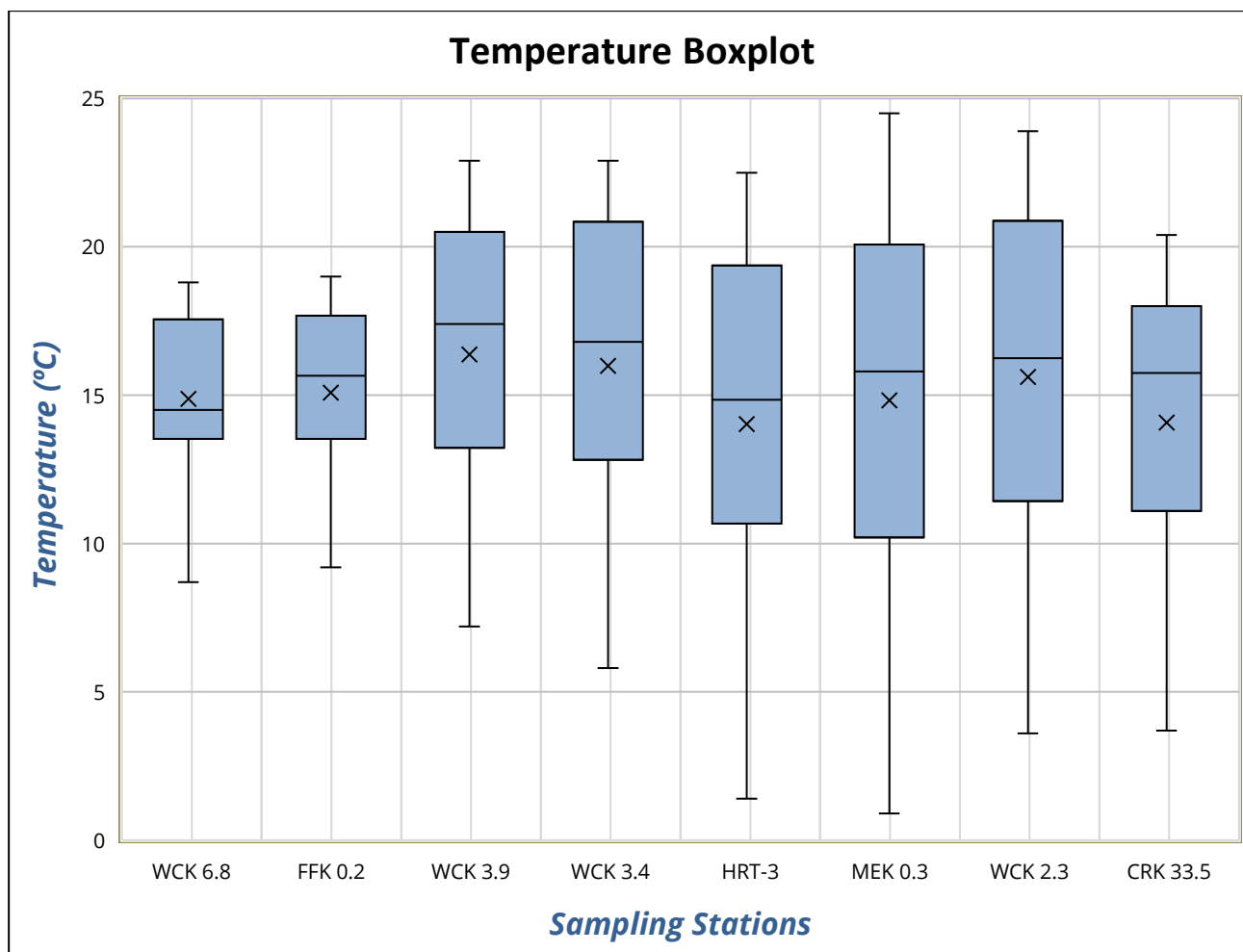


Figure 7.3.7.3: Temperature Boxplot from WCK 6.8 Downstream to CRK 33.5

SPECIFIC CONDUCTIVITY

Specific conductivity is an indirect measurement of the concentration of dissolved ions in solution. Higher specific conductivity values can indicate more dissolved minerals or salts in the water. Specific conductivity values ranged from 232.3 micro siemens per centimeter ($\mu\text{S}/\text{cm}$) at CRK 33.5 to 1,591 $\mu\text{S}/\text{cm}$ at MEK 0.3. As illustrated in Figure 7.3.7.4, the median specific conductivity values at WCK 6.8, FFK 0.2, WCK 3.9, WCK 3.4, WCK 2.3, and CRK 33.5 were generally similar to each other ranging from approximately 300.9 $\mu\text{S}/\text{cm}$ and 466.6 $\mu\text{S}/\text{cm}$.

Between locations WCK 6.8 and WCK 3.4, there is a general increasing trend in specific conductivity. HRT-3 has conductivities similar to the background sample (WCK 6.8) and the Clinch River location (CRK 33.5) with the smallest degree of variation throughout the year. The median specific conductivity for MEK 0.3 was 391.9 $\mu\text{S}/\text{cm}$ which was within the range of the median conductivities of the other sample locations. MEK 0.3 also demonstrated the highest variation in specific conductivity having a minimum of 272.7 $\mu\text{S}/\text{cm}$ and a maximum of 1,591

μS/cm.

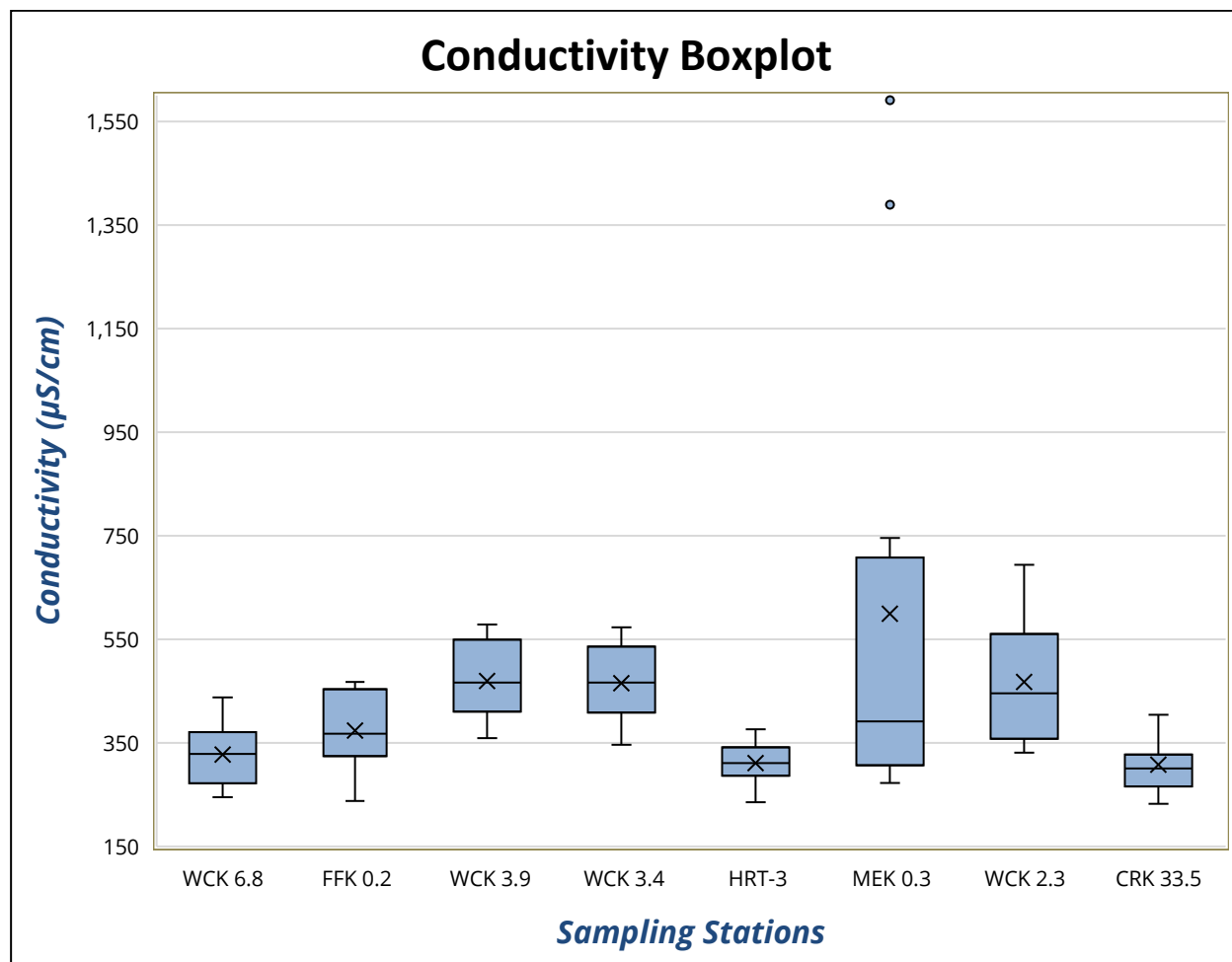


Figure 7.3.7.4: Specific Conductivity from WCK 6.8 Downstream to CRK 33.5

Surface Water Analytical Results

The analytical results are summarized in Table 7.3.7.1. Analytical testing of surface water at WCK 6.8, FFK 0.2, WCK 3.9, WCK 3.4, HRT-3, MEK 0.3, WCK 2.3, and CRK 33.5 indicated the following results:

- Select gamma isotopes (beryllium-7, cesium-137, cobalt-60, europium-154, plutonium-238, plutonium-239/240, and potassium-40) were infrequently observed. All reported activities were well below their derived MCLs or there is no derived MCL.
- Elevated Sr-90 activities were observed at WCK 3.9, WCK 3.4, HRT-3, MEK 0.3, WCK 2.3, and CRK 33.5. All surface water samples collected at these six locations had Sr-90 measured at levels greater than the EPA derived drinking water standard of 8 pCi/L.
- Sr-90 activities were the highest in samples collected from HRT-3. The second highest

concentrations were present in samples collected from WCK 2.3 and CRK 33.5, which are downstream from HRT-3. It should be noted that the closest downstream location, MEK 0.3, had one of the lowest activities. MEK 0.3 is located downstream from the HRT-3 tributary confluence and upstream from the confluence of MB and WOC.

- Sr-90 activities increased from upstream (WCK 6.8) to downstream (WCK 2.3) locations along WOC. The CR sample station (CRK 33.5) exhibited a slight decrease in Sr-90 compared to WCK 2.3, likely due to dilution since this sample was collected within the CR immediately downstream of the WOC Embayment (WOE) sediment retention structure (SRS).
- During this and previous FY sampling events, elevated levels of radiological contaminants were not detected in surface water at WCK 6.8, the location considered a background location upstream of ORNL.
- As illustrated in Figure 7.3.7.5, elevated activities of Sr-90 were observed in surface water samples collected at FFK 0.2, WCK 3.9, WCK 3.4, HRT-3, WCK 2.3, MEK 0.3, and CRK 33.5. Activities at these locations exceeded the derived EPA drinking water standard of 8 pCi/L during the second quarterly sampling event. It should also be noted that the highest Sr-90 activities were reported during the second quarterly event. At locations WCK 3.9, WCK 3.4, HRT-3, WCK 2.3, MEK 0.3, and CRK 33.5, activities exceeded the standard during the third quarter sampling event. Sample location HRT-3 was the only exceedance during the first quarterly event. Locations, WCK 3.4 and WCK 2.3, were the only exceedances during the fourth quarterly event.

Table 7.3.7.1 Summary Table of the Quarterly Surface Water Analytical Results

Sample Location	Sample Date	Beryllium-7	Cesium-137	Cobalt-60	Europium-154	LeadND214	Plutonium-238	Plutonium-239/240	Potassium-40	StrontiumND89	Strontium-90	Uranium-234	Uranium-235	Uranium-238
Derived Standard ^{1,2}		NE	200	100	60	NE	NE	NE	NE	20	8	30	NE	30
Activities														
WCK 6.8	8/29/2024*	ND	ND							-0.15±0.7	-0.45±0.3			
	11/20/2024	ND	ND						29.5±28	-1.53±1.9	0.97±0.37			
	3/18/2025*	ND	4.56±2.6						36.9±43	-0.43±5.9	0.73±1.3			
	6/16/2025	ND	ND						30.6±30.2	ND	1.73±0.64			
FFK 0.2	8/29/2024	ND	2.20±4.8							0.139±0.96	2.69±0.38			
	11/20/2025	ND	1.60±4.7						57.4±51	-0.877±3.5	9.22±0.70			
	3/18/2025	ND	4.05±3.4						41.4±49	1.66±7.5	3.55±1.4			
	6/16/2025	ND	2.59±2.6						20.7±25	1.03±6.2	7.94±0.88			
WCK 3.3	8/29/2024	ND	6.43±4.0							0.498±0.90	2.02±0.36			
	11/20/2024	ND	ND						ND	-2.86±3.9	12.2±0.78			
	3/18/2025	ND	5.71±2.9						34.6±33	-5.06±8.9	10.6±1.8			
	6/16/2025	ND	3.40±3.4						ND	ND	7.85±0.86			
WCK 3.4	8/29/2024	ND	-0.530±3.3							0.827±0.90	1.42±0.37			
	11/20/2024	ND	5.20±2.9						24.1±31	1.86±4.0	17.4±0.77			
	3/18/2024	ND	1.96±3.5						39.4±24	6.50±7.9	11.9±1.5			
	6/16/2025	ND	ND						ND	ND	9.32±0.87			
HRTND3	8/29/2024	ND	ND							ND	17.4±0.76			
	11/20/2024	ND	5.27±5.2						ND	ND	136±2.1			
	3/18/2025	ND	5.80±3.1						26.1±27	ND	86.3±3.8			
	6/16/2025		ND						ND	ND	3.81±1.1			
MEK 0.3	8/29/2024	ND	ND							ND	1.08±0.28			
	11/20/2024	ND	ND						ND	ND	16.6±0.77			
	3/18/2025	ND	ND						30.4±28	4.17±8.6	13.2±1.7			
	6/16/2025*	ND	ND						38.7±38	ND	4.0±0.63			
WCK 2.3	8/29/2024	ND	5.62±3.2							ND	2.19±0.34			
	11/20/2024*	35±29.3	5.68±6.8						40.0±38	ND	47.7±1.3			
	3/18/2025	ND	3.23±2.8						28.9±32	ND	43.0±2.6			
	6/16/2025	ND	4.00±3.5						31.6±28	0.35±7.89	15.3±1.1			
CRK 33.5	8/29/2024	ND	ND							ND	3.10±0.37			
	11/20/2024*	ND	2.80±3.2						19.5±24	ND	34.6±1.1			
	3/18/2025	ND	7.26±3.1						ND	8.05±10	21.1±1.9			
	6/16/2025	ND	ND						53.5±65	ND	5.29±0.68			

Notes: **Bolded** values > MCL; **ND** = Laboratory indicates not detected

Blank = Not reported but historically detected; NE = No drinking water standard established
All activities in pCi/L (picocurie per liter)

CSU = 1-sigma combined standard uncertainty reported as ± with analytical result.

1 = Derived standards of beta and photon emitters in drinking water taken from NBS Handbook 69.

2 = EPA derived isotopic uranium standards for uranium mill tailing sites: uranium-234 and -238 combined
All activities rounded to 3 significant figures unless lab reported less.

* Duplicate collected -highest activity shown in table

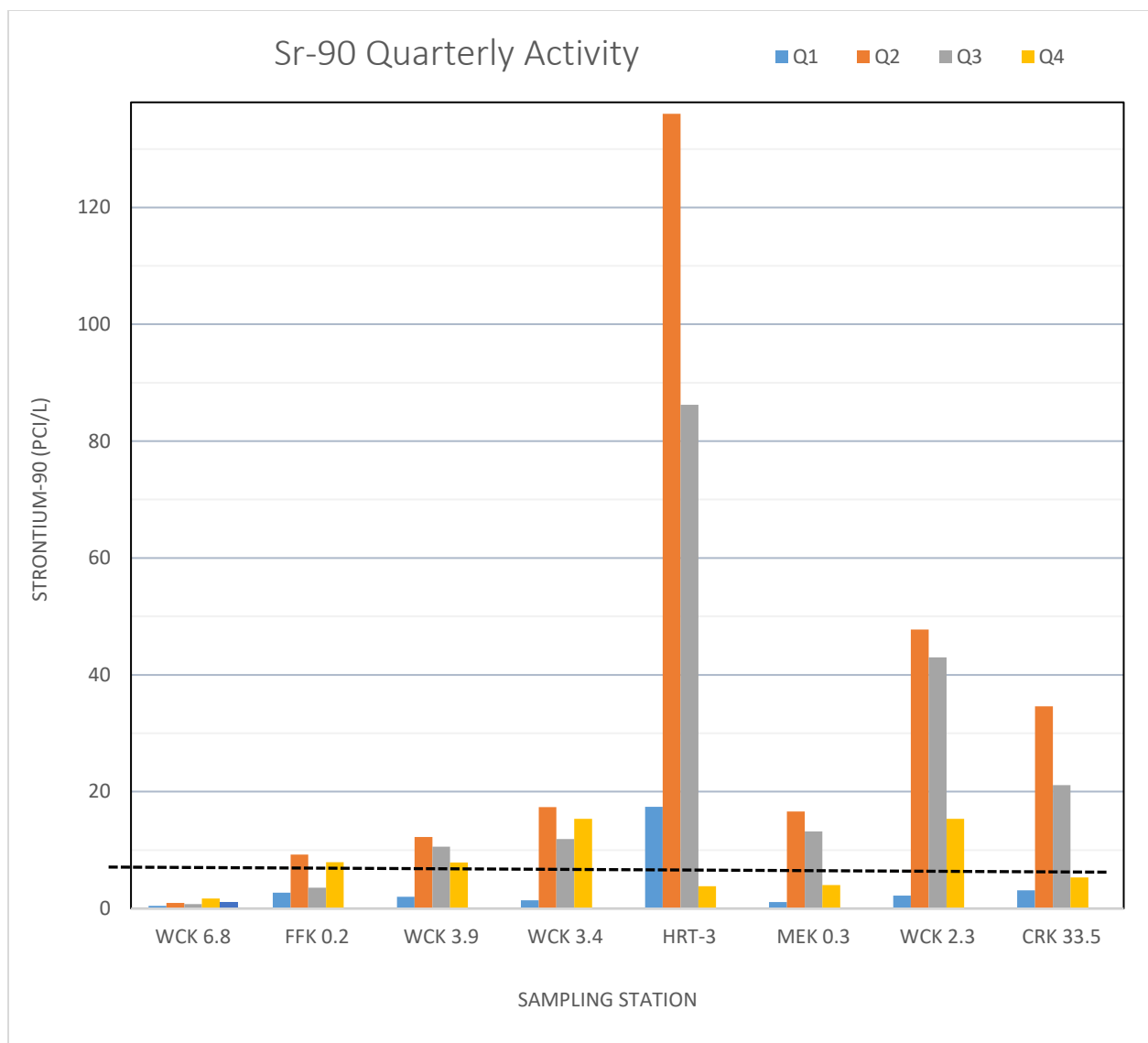


Figure 7.3.7.5: Strontium-90 Quarterly Activity from WCK 6.8 Downstream to CRK 33.5

The Sr-90 activities ranged from -0.136 pCi/L at WCK 6.8 to 136 pCi/L measured at HRT-3, a tributary of Melton Branch which originates near the Homogeneous Reactor Experiment (HRE) site in Melton Valley. The highest mean Sr-90 activities were measured from samples collected from HRT-3 (51.8 pCi/L). The mean Sr-90 activities downstream of the confluence of HRT-3 were higher at WCK 2.3 (25.6 pCi/L), and CRK 33.5 (13.2 pCi/L), compared to WCK 6.8 (0.591 pCi/L). Mean activities at MEK 0.3, despite being the closest downstream sample location to HRT-3, were much lower (4.00 pCi/L). A box plot illustrating Sr-90 data collected during FY25 is provided as Figure 7.3.7.6. The trend between sampling stations was consistent with the quarterly data collected during FY24.

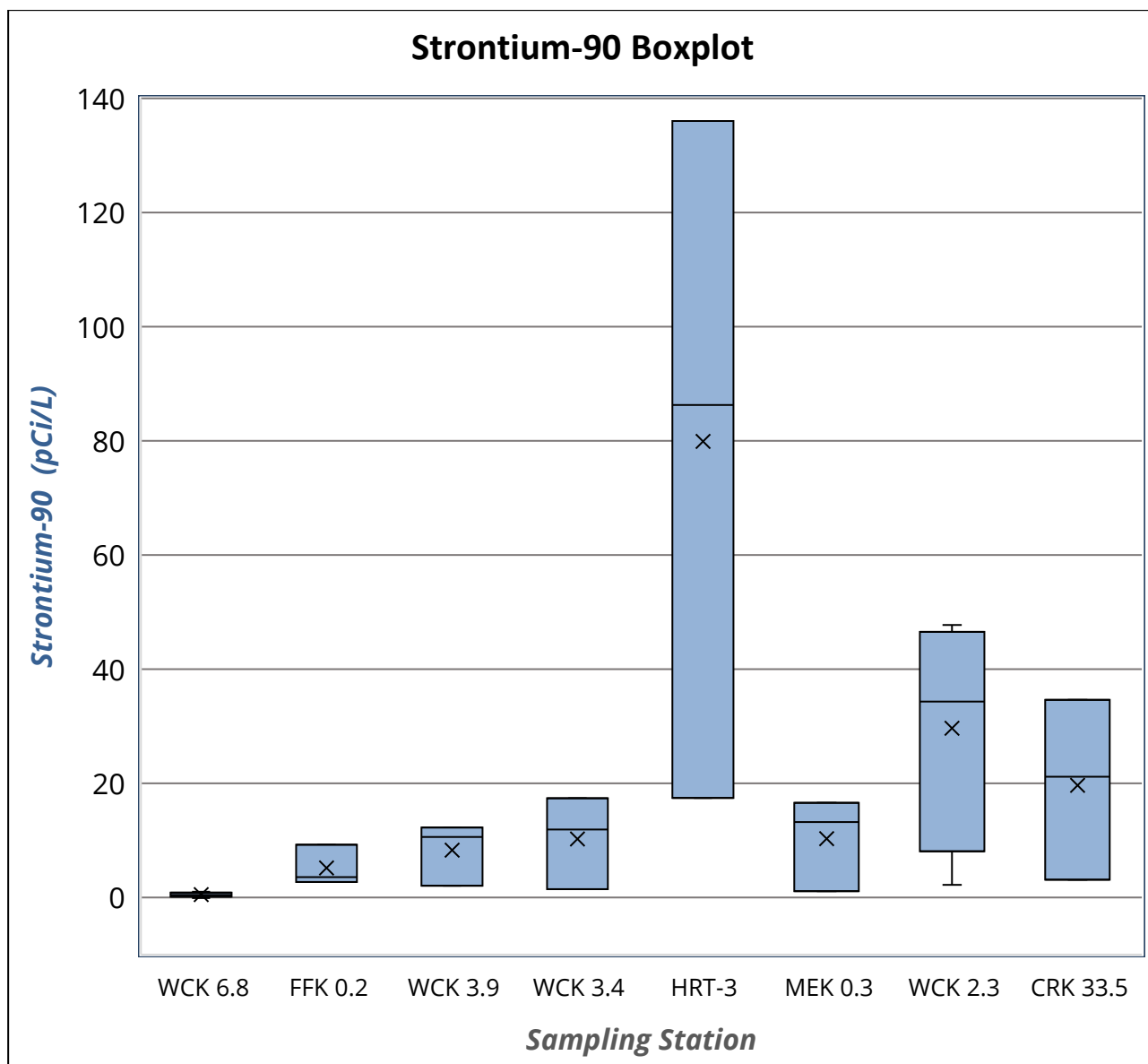


Figure 7.3.7.6: Sr-90 Box Plot from WCK 6.8 Downstream to CRK 33.5 (2019-2024)

TREND ANALYSIS

A sampling timeline illustrating Sr-90 activities measured between June 2019 and June 2025 at the seven sampling stations is provided as Figure 7.3.7.7. A trend analysis was performed to determine if Sr-90 activities are increasing or decreasing over time.

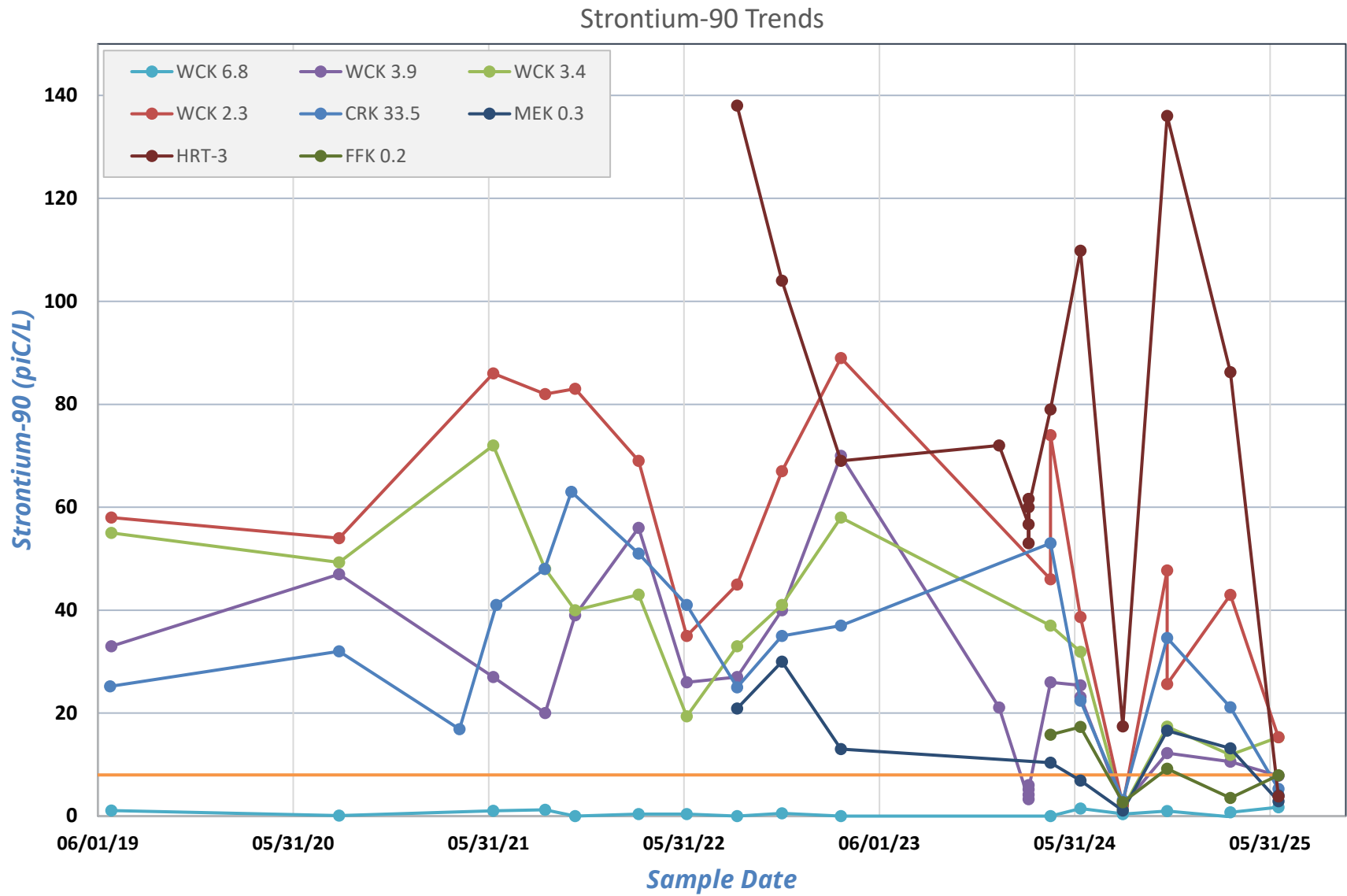


Figure 7.3.7.7: Strontium-90 Trends (2019-2025)

The above graph was analyzed for linear trends by evaluating a trendline for each sample location data. The trendline was calculated using Excel Linear Trend Line (Least Squares Linear Regression). All locations show a general decreasing trend (negative slope value).

7.3.8 CONCLUSIONS

In conclusion, analytical testing of surface water at WCK 6.8, FFK 0.2, WCK 3.9, WCK 3.4, HRT-3, MEK 0.3, WCK 2.3, and CRK 33.5 during FY25 revealed the following:

- Sr-90 activities were the highest in surface water samples collected from HRT-3.
- The second highest concentrations were present in samples collected from WCK 2.3 and CRK 33.5, which are downstream from HRT-3.
- It should be noted that the closest downstream location, MEK 0.3, which is located downstream of HRT-3 on MB, had one of the lowest activities except for the background location WCK 6.8. This anomalous “skip” may be related to the anomalously high conductivity readings and range that are also associated with this location. This “skip” and anomalous conductivity on MB have been noted for the last two fiscal years. This anomalous low may be for some other reason not yet evaluated, such as flow conditions, dilution effects, or natural geochemistry. Further data needs to be evaluated.
- Contributions of Sr-90 from the past and current activities have impacted WOC at activity levels above the derived MCL. Sr-90 levels are also above the derived MCL within the CR at the point of discharge from WOC (CRK 33.5).

7.3.9 RECOMMENDATIONS

As mentioned in the Problem Statement, due to the potential for turning off the sump pump during D&D of Building 3042 located in Bethel Valley and for general monitoring of the WOC, DoR-OR recommends continuing monitoring WOC and Melton Branch and its tributaries (specifically FFK 0.2) for radiological contaminants of concern.

Because of the ongoing discharge of radioisotopes (specifically Sr-90) into the CR, future projects should seek to gauge the discharge at the CRK 33.5 location and/or develop a hydrologic budget of the WOC and its tributaries to estimate an average flow rate into the CR. This would aid in calculations of the actual mass of radioisotopes into the CR from WOC and help understand the overall flow of the WOC and its tributaries. It is recommended to utilize historic and ongoing flow measurements from other areas such as HRT-3 and Melton Branch Weir (MBWEIR aka X-14), and White Oak Dam locations.

It is recommended that the weir located at HRT-3 be repaired and measurements resume.

Based on anomalous Sr90 activity and specific conductivity measurements between HRT-3 and MEK-0.3 (mentioned above), evaluation of these parameters in this area of the creek and in other nearby tributaries is warranted.

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7.4 CERCLA SITE INVESTIGATION

7.4.1 BACKGROUND

ORR stormwater runoff has the potential to transport various contaminants into waterways, including sediments, nutrients, organic and inorganic chemicals, metals, and bacteria. This unmitigated runoff continues to cause water quality issues and environmental degradation (Marsalek, 2002). Elimination, or at least a reduction, of these negative impacts on surface water and groundwater requires delineation of sufficient best management practices (BMPs). BMPs should be implemented prior to and throughout building demolition and all related remediation activities on the ORR.

During FY25, DoR-OR conducted stormwater investigations that were designed to monitor impacts from contaminated building D&D and remediation and included: (1) the quantification of the water quality of stormwater runoff, (2) the identification of potential pollution sources, and (3) the evaluation of the effectiveness of relevant BMPs. The stormwater sampling was conducted during all three (3) stages of demolition, which are the pre-demolition, demolition, and post-demolition period.

In particular, history and contaminants associated with these focal sites included:

ORNL

In FY25, the stormwater assessment was performed at three D&D sites at ORNL: (1) Building 2523 and 2523A (Bldg. 2523 Complex), (2) Bldg. 3005, (3) Bldg. 3003 (Figure 7.4.1.1).

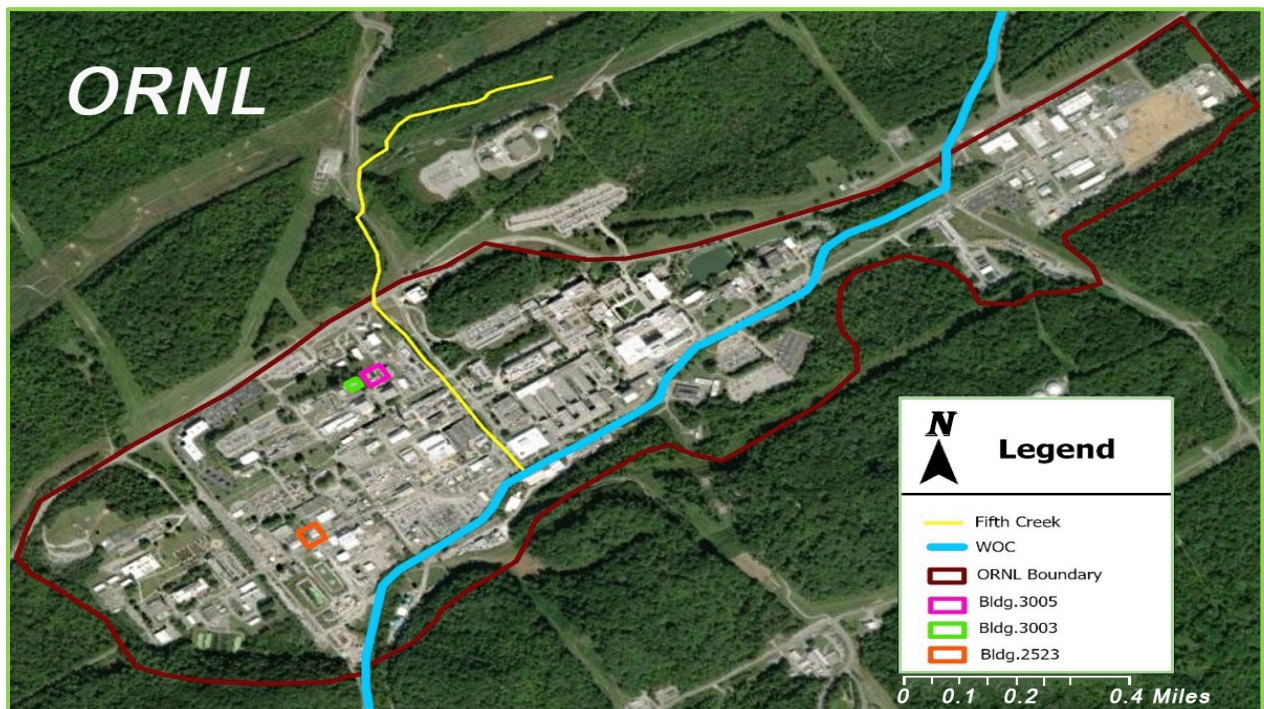


Figure 7.4.1.1: FY25 ORNL D&D Sites

(1) Bldg. 2523 Complex

Bldg. 2523 is located in the southern portion of ORNL at the junction of White Oak Avenue and First Street (Figure 7.4.1.2). The nearest surface water conveyances to Bldg. 2523 are First Creek to the west and White Oak Creek (WOC) to the south.

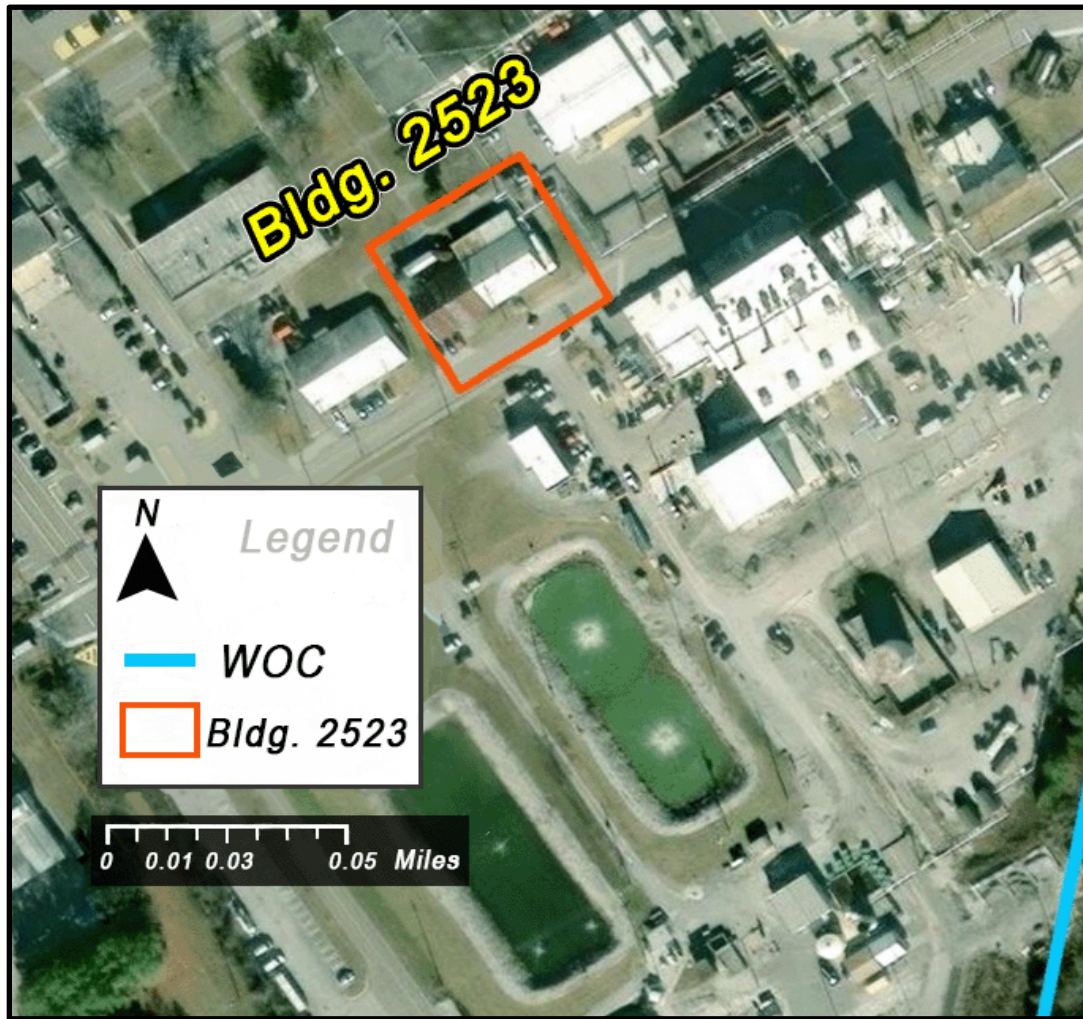


Figure 7.4.1.2: ORNL Bldg. 2523

Bldg. 2523 was built in 1955 and served as the ORNL decontamination laundry facility. Annex 2523A is a small, add-on trailer on the north side of Bldg. 2523. Bldg. 2523 is considered low-level radiological facilities. The potential Contaminants of concern (COCs) for Bldg. 2523 include radiological contaminants (U-isotopes, gross alpha/beta), metals (beryllium, lead, cadmium, copper, zinc, low-level mercury), suspended solids, and PCBs. Annex 2523A is an uncontaminated trailer and served as a general storage area (DOE, 2023). Since 2523 includes 2523A as a support facility, the facilities will be referred to as Bldg. 2523 Complex for simplicity in this report.

The demolition activities, involving miscellaneous structures around Bldg. 2523, started October 2024. Sampling activities during FY25 focused on collecting demolition period stormwater data.

(2) Bldg. 3005

Bldg. 3005, also referred to as the Low Intensity Test Reactor (LITR), was located at the north boundary of ORNL (Figure 7.4.1.3). The nearest surface water conveyance is Fifth Creek which is located approximately 250 ft east of Bldg. 3005. Fifth Creek flows southward and eventually discharge into WOC.

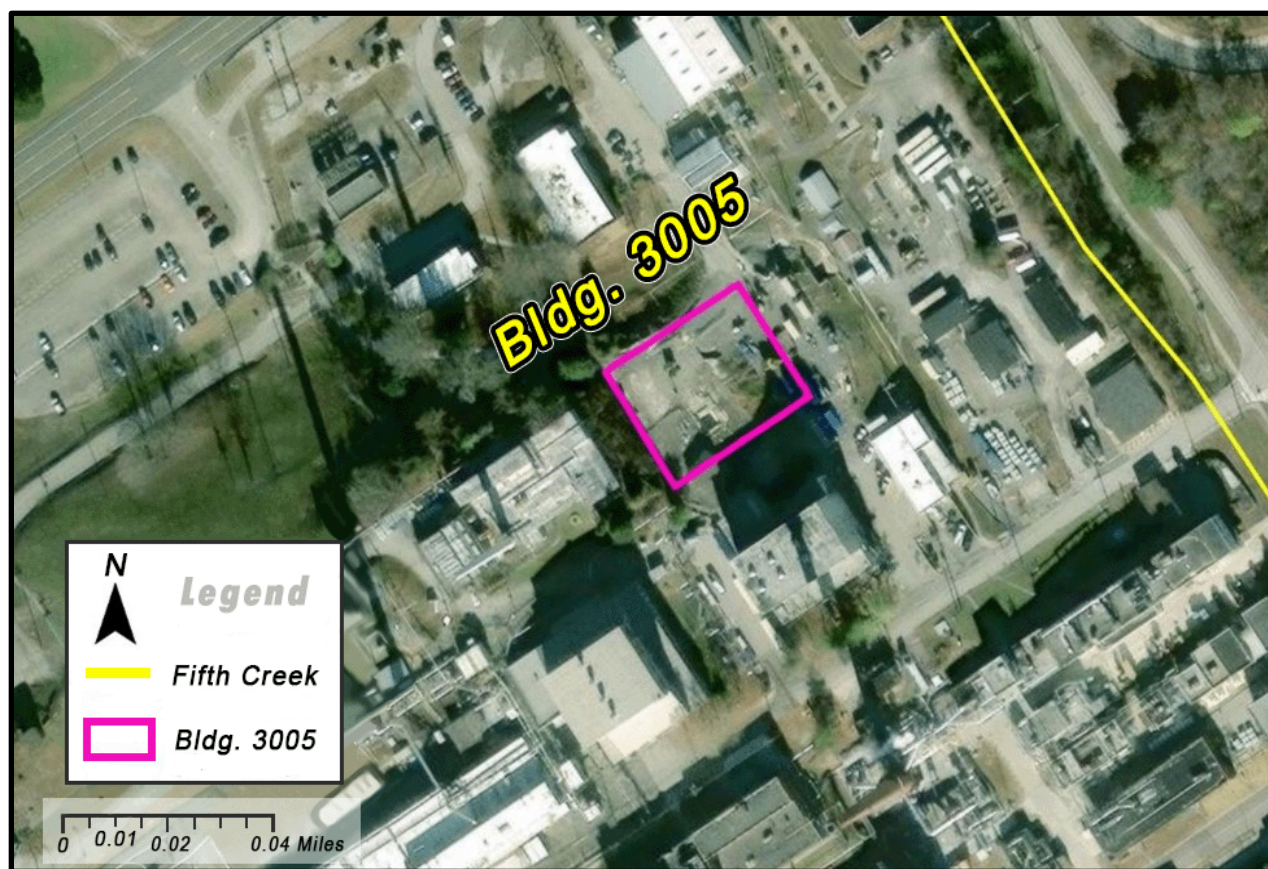


Figure 7.4.1.3: ORNL Bldg. 3005

Bldg. 3005 was a three-story, 6400-sq ft metal and concrete building. It was a water-moderated and water-cooled reactor that used enriched uranium as fuel and beryllium as a reflector. Demolition and waste disposal activities at Bldg. 3005 addressed under the scope of the Phased Construction Completion Report (PCCR) were performed in accordance with the 3005 *Demolition RDR/RAWP* (DOE 2021a) and *Waste Handling Plan for the Demolition of Building 3005, the Low-Intensity Test Reactor, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE 2021b).

The primary COCs at Bldg. 3005 and the nearby North Auxiliary Building are uranium, transuranic isotopes, fissile materials, and beryllium (UCOR, 2023).

The demolition of Bldg. 3005 began in March 2023 and completed in April 2024. Sampling activities at this site during FY25 focused on collecting stormwater data during the post-demolition period.

(3) Bldg. 3003

Bldg. 3003 is located at the north end of ORNL main campus area (Figure 7.4.1.4). Bldg. 3003 is part of the Oak Ridge Graphite Reactor (OGR) Support Facilities. The nearest surface water conveyance is Fifth Creek, which is located approximately 500 feet east of Bldg. 3003. Fifth Creek flows southward and eventually discharge to WOC.



Figure 7.4.1.4: ORNL Bldg. 3003

Bldg. 3003, also referred to as the Graphite Reactor Fan house, was part of the Oak Ridge Graphite Reactor (OGR) Support Facilities. Cooled air from the graphite reactor was filtered and drawn through underground ducts into 3003 and then released through the Graphite Reactor stack (DOE, 2022).

The potential COCs for this site include radiological contaminants (U-isotopes, gross alpha/beta, gamma), metals (beryllium, lead, cadmium, copper, zinc, low-level mercury), suspended solids, and polychlorinated biphenyls (PCBs).

The Demolition of Bldg. 3003 started in September 2025 and was completed in November 2025. Sampling activities at this site during FY25 focused on collecting stormwater data to establish pre-demolition baseline conditions.

EMDF

EMDF is the landfill planned for the disposal of low-level radioactive waste and hazardous waste generated by future remediation activities on the ORR; it is operated under the authority of CERCLA and DOE. The EMDF site is located in Central Bear Creek Valley (CBCV) within an upland area located between north-south trending valleys of North Tributary (NT)-10 and NT-11 (Figure 7.4.1.5). Surface water drainages near the site include NT-9, NT-10, and NT-11. Water flow in these drainage channels flows from Pine Ridge to Bear Creek. The drainage includes precipitation, surface runoff, and groundwater that discharges via springs and seeps (DOE, 2024).

Bear Creek was monitored by DoR-OR at its confluences with CBCV tributaries to evaluate the effectiveness of the BMPs. The major COCs of EMDF construction were sediments, dust, and debris which can be monitored by measuring turbidity in Bear Creek.

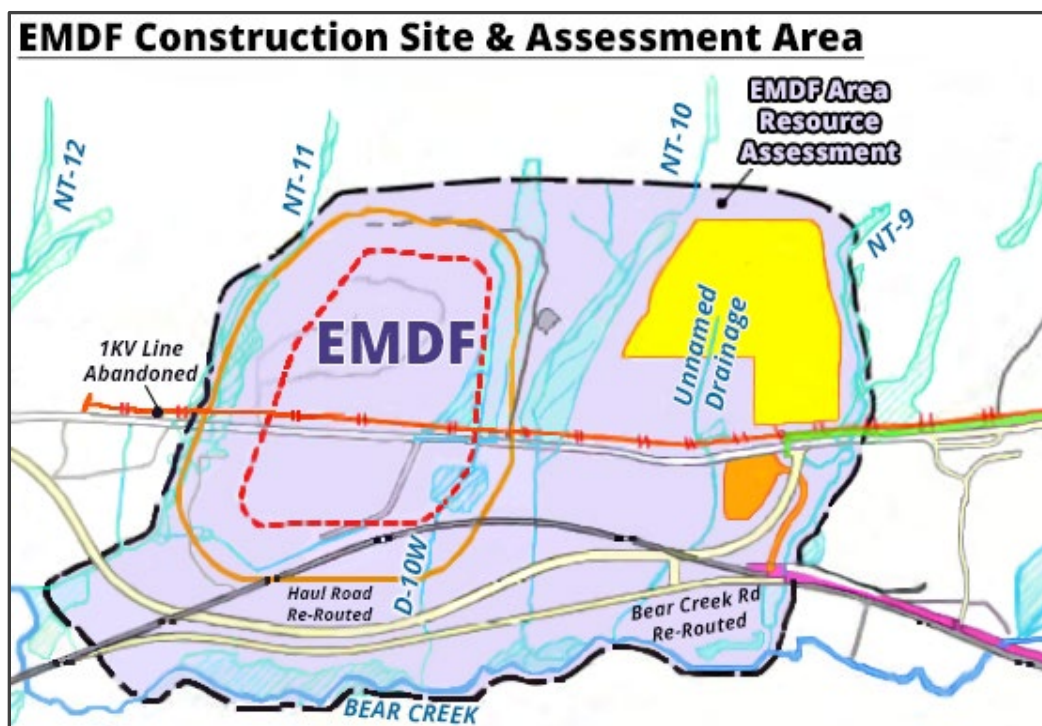


Figure 7.4.1.5: EMDF Construction Site in Central Bear Creek Valley (DOE, 2022)

In addition to D&D impacts, construction activities can introduce sediments, debris, and other chemicals by disturbing the land. These potentially mobilized contaminants are transported by stormwater directly into nearby surface water. In FY25, turbidity levels, along with other water quality parameters, were monitored in Bear Creek which receives stormwater from the Environmental Management Disposal Facility (EMDF) construction site.

7.4.2 PROBLEM STATEMENTS

For D&D activities, Bldg. 2523 Complex is located near White Oak Creek while Bldg. 3003 and Bldg. 3005 are near the Fifth Creek. Given the historical use of these facilities, the debris and waste generated by D&D activities may contain radioactive and hazardous materials. These contaminants could be carried by stormwater into the surrounding environment and water resources, posing environmental risks and health concerns.

For EMDF, water turbidity and any contaminants released or mobilized by construction activities could negatively impact water quality in Bear Creek.

7.4.3 GOALS

The planned objectives of this project included:

- Conducting stormwater assessments of various remediation projects across the reservation and evaluated COC levels discharged from D&D sites.
- Establishing stormwater water quality conditions before D&D was initiated (pre-demolition).
- Assessing the effectiveness of the BMPs selected and implemented at demolition sites.
- Comparing stormwater data collected during and post-demolition to pre-demolition conditions.
- Co-sampling with DOE where possible and comparing DoR-OR stormwater monitoring data to sampling data collected by DOE.

7.4.4 SCOPE

The scope of this project for FY25 included collecting stormwater samples at three ORNL D&D sites (Bldg. 2523, 3003, and 3005). Additionally, turbidity and water quality data were measured at the EMDF landfill construction site.

ORNL D&D Sites

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

EMDF Construction Site

For the EMDF site, the turbidity and water quality parameter data were measured from NT-9 to NT-12 along Bear Creek.

Specific sampling locations for each site are shown in Figures 7.4.4.1, 7.4.4.2, 7.4.4.3, and 7.4.4.4.

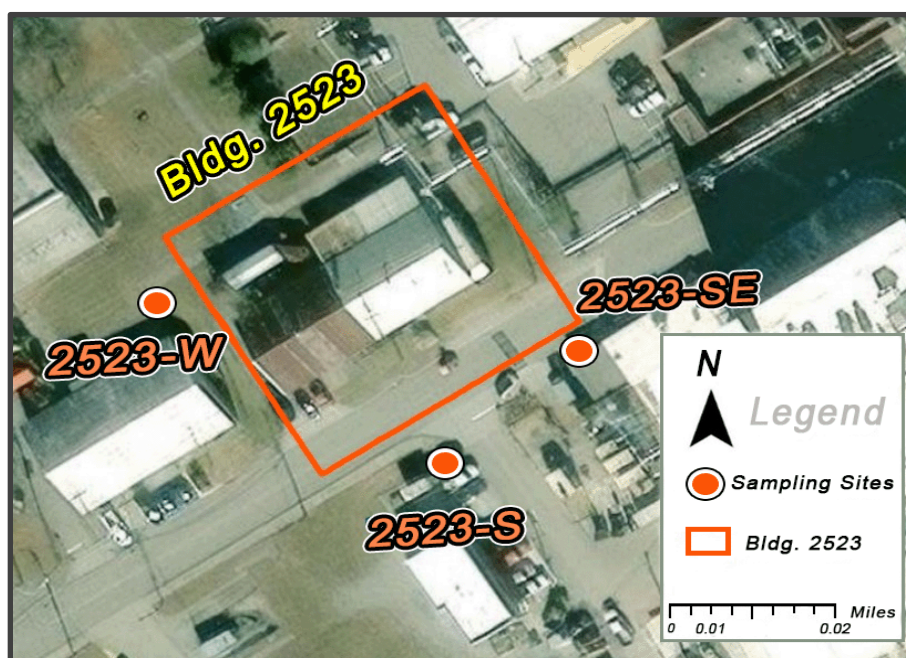


Figure 7.4.4.1: ORNL Building 2523 Complex Sampling Sites

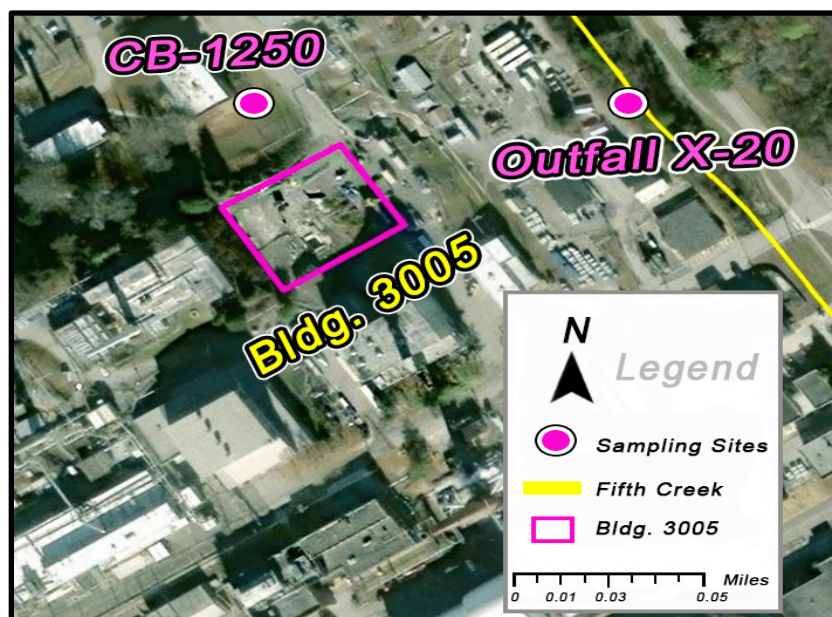


Figure 7.4.4.2: ORNL Bldg.3005 Sampling Sites

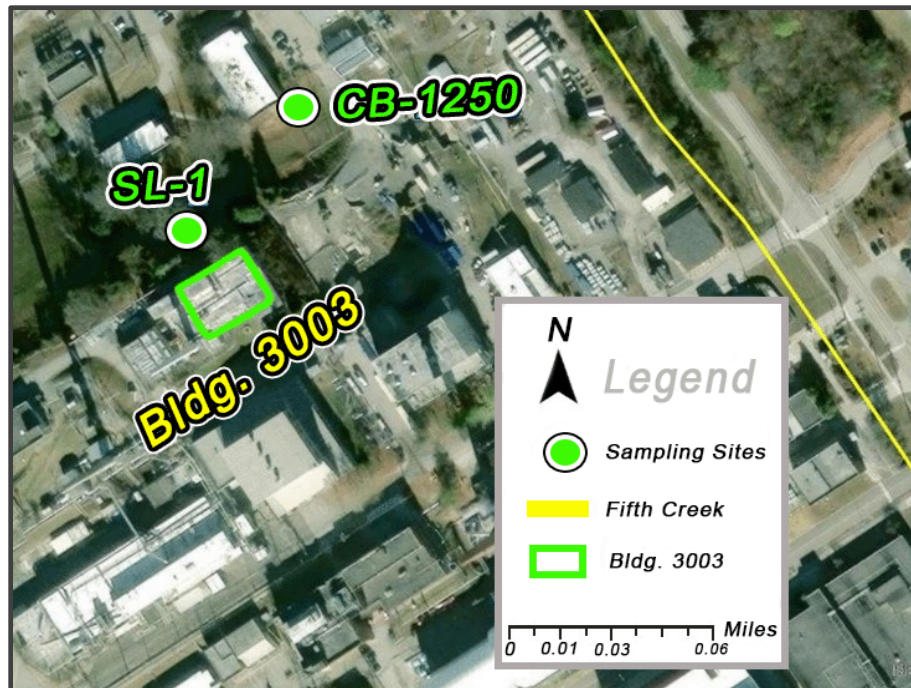


Figure 7.4.4.3: ORNL Bldg,3003 Sampling Sites

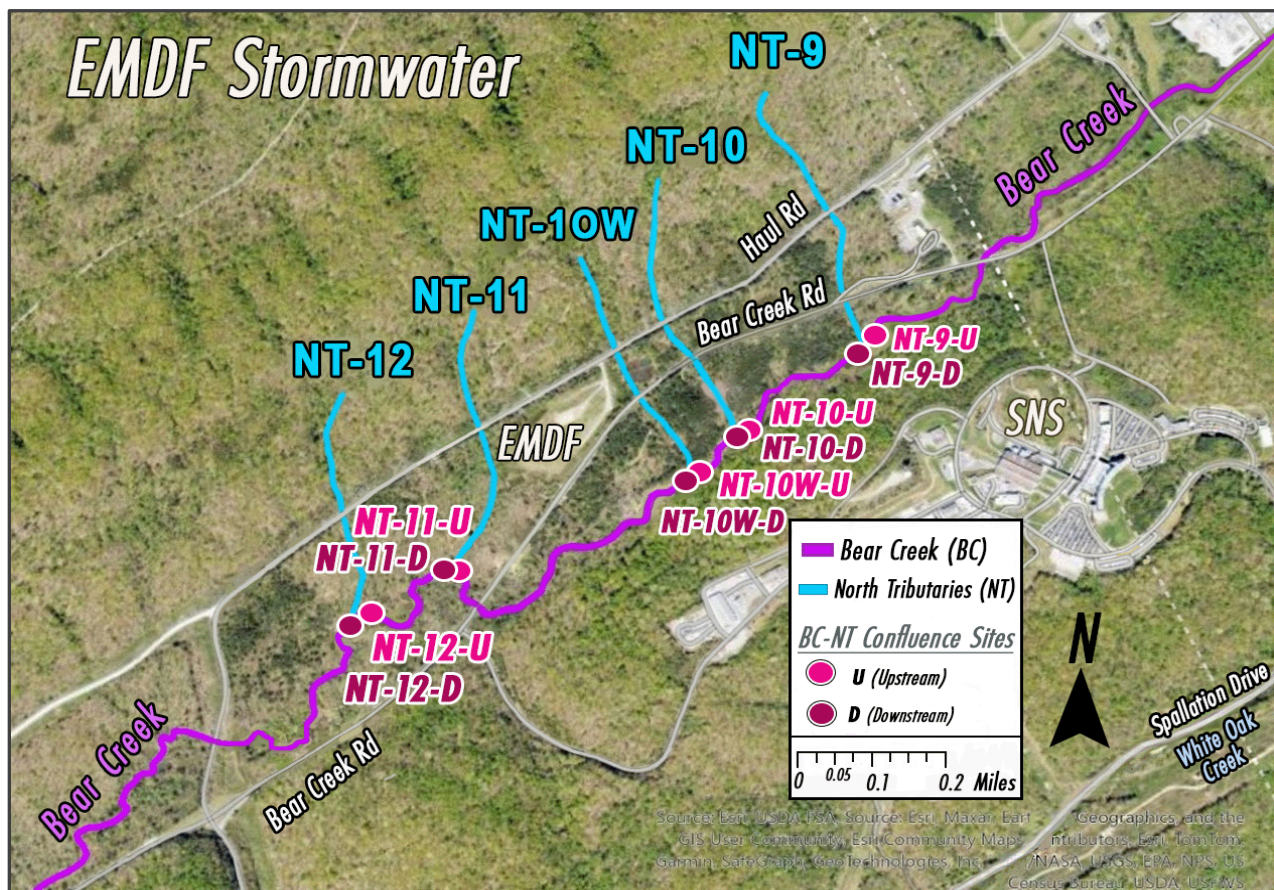


Figure 7.4.4.4: EMDF Parameter Survey Sites NT-9 U to NT-12 D

7.4.5 METHODS, MATERIALS, METRICS

D&D Site Stormwater Investigation

Sampling protocols, site selection, sampling intervals, and sample sizes followed the *DoR-OR T-710 SOP Stormwater Sampling* (TDEC, 2023a) and *UCOR Pre-Demolition and Demolition Activities Program Stormwater Management Plan* (UCOR, 2022). QA/QC measures, safety protocols, and data analyses followed the procedures outlined in the site-specific monitoring reports (DOE, 2023d; (TDEC, 2022).

These analytes, analytical methods, and field measurements are listed in Table 7.4.5.1. The stormwater sampling interval, sites, and COCs are listed in Tables 7.4.5.2 and 7.4.5.3, respectively. Water quality measurements were collected following the *DoR-OR T-703 SOP Field Use for Water Quality Parameters Instrument* (TDEC, 2023b) and *DoR-OR T-153 SOP Water Quality Field Instrument Calibration and Maintenance* (TDEC, 2023c). Stormwater and surface water grab samples were collected following the *DoR-OR T-704 SOP Collection of Surface Water Samples* (TDEC, 2023d).

Table 7.4.5.1: COCs Analytes and Lab Methods

Parameter Type	Analytes	Analytical Method
Radionuclides	Gross alpha	Method 900.0
	Gross beta	
	Gamma	Method 901.1
	Isotopic uranium (Iso-U)	Method 908
Organics	PCBs	Method 8082
Metals	Beryllium	Method 6020
	Cadmium	
	Copper	
	Lead	
	Zinc	
	Low-level mercury (LL Hg)	Method-1631
Inorganics	Total Suspended Solids	SM-2540-D

Table 7.4.5.2: FY25 ORNL D&D Stormwater Sampling Events, Sites, and COCs

Building #	Sample Events/ Demolition Stage			Sample Sites	COCs			
	Pre-demo	Demo	Post-demo		Radiological	Metals	Organics	Inorganic
Bldg.2523	07/24/24	11/01/24		2523-S 2523-SE 2523-W	Iso-U Gross Alpha Gross Beta	Beryllium Cadmium Copper Lead Zinc LL Hg	PCBs	Total Suspended Solids
Bldg.3005			11/14/24	CB-1250 OF X-20				
Bldg.3003	02/06/25			CB-1250 SL-1	Iso-U Gross Alpha Gross Beta Gamma			
Notes: OF: Outfall, CB: Catch Basin, SL: Sampling Location, LL Hg: low-level mercury, Iso-U: Uranium Isotopes								

EMDF Turbidity Survey

Eight (8) EMDF turbidity survey events were conducted in FY25. The survey dates, field water quality parameters, and associated field meter are listed in Table 7.4.5.3. Field measurements were conducted following the *DoR-OR SOP T-703 Field Use for Water Quality Parameters Instrument* and *DoR-OR SOP T-153 Water Quality Field Instrument Calibration and Maintenance*.

Some states require turbidity downstream of construction activities not to exceed 5 NTU over background measurements when the background is 50 NTU or less. Increases in turbidity cannot exceed 10% when the background turbidity is greater than 50 NTU (EPA, 2022a), (WSDOT, 2018). The EPA has set a turbidity benchmark of 50 NTU for nearby streams affected by construction activities (EPA, 2022b). This report uses the 50 NTU EPA turbidity benchmark for comparison since the State of Tennessee does not have aquatic life turbidity criteria in freshwater.

Table 7.4.5.3: EMDF Water Quality Parameters Summary

Water Quality Meter		Parameters
1. YSI Pro DSS		<i>pH</i>
		<i>Temperature</i>
		<i>Specific conductivity</i>
		<i>Dissolved Oxygen (DO)</i>
		<i>Oxidation-reduction potential (ORP)</i>
2. HF Sci Micro TPW Turbidimeter		<i>Turbidity</i>
Streams	Dates	Measurement Location
Bear Creek		NT-9 U
		NT-9 D
	07/22/24	NT-10 U
	07/29/24	NT-10 D
	09/26/24	NT-10W-U
	11/14/24	NT-10W-D
	12/18/24	NT-11 U
	02/12/25	NT-11 D
	04/07/25	NT-12 U
	05/29/25	NT-12 D
<i>Notes: U: Upstream; D: downstream; NT: North Tributary of Bear Creek</i>		

7.4.6 DEVIATIONS FROM THE PLAN

Due to changes in DOE schedules and scope (i.e. milestones), DoR-OR maintains flexibility to support DOE operations and monitoring of potential associated environmental impacts.

- ORNL Stormwater Sites:
 - Sampling plan for Bldg. 3002 and Bldg. 3544 at ORNL were postponed to FY27 due to changes in the DOE demolition plan.
 - Bldg. 3005 post-demolition sampling was *added* into FY25 EMR due to the changes in the demolition schedule.
- Y-12 Stormwater Sites:
 - Alpha-2 Stormwater sampling at Y-12 in February 2025 was not conducted due to insufficient runoff flow.
 - The stormwater sampling plan for the Beta-1 facility at Y-12 was postponed to FY26 due to the change in the demolition schedule.
- EMDF Sampling Sites:
 - Water parameters at BCK NT-12 U and NT-12 D were not collected in FY25 due to site safety concerns and ongoing construction and operation of the Groundwater Field Demo at the EMDF site.

7.4.7 RESULTS AND ANALYSIS

CERCLA D&D SITES STORMWATER INVESTIGATION

BLDG. 2523

Two stormwater sampling events were conducted at Bldg. 2523 on July 24, 2024, and November 1, 2024. Results for the July 24, 2024, sampling event were combined with sampling conducted in FY24 to establish a pre-demolition baseline for comparison with data to be collected during and after demolition. Water samples were analyzed for metals, radiological contaminants, TSS, and PCBs. Results are presented in Tables 7.4.7.1 and 7.4.7.2. PCBs were undetected at both sites. No water samples were collected at site 2523-S on November 1, 2024, due to insufficient runoff flow.

Table 7.4.7.1: Bldg. 2523 Stormwater - Metals and TSS Results

Site	Date	Fiscal Year	Demolition Stage	TSS	Beryllium	Cadmium	Copper	Lead	Zinc	LL Hg
				(mg/L)	(µg/L)					
2523-S	7/24/24	FY25	Pre-Demo	44	0.19 U	0.15 U	27.5	2.95	96.5	0.012
2523-SE	11/01/24	FY25	Demolition	8	0.2 U	0.149	3.02 J	0.843 J	118	0.0033
	7/24/24	FY25	Pre-Demo	11.2	0.19 U	0.15 U	1.91 J	0.849 U	12.3 J	0.0015
	6/5/24	FY24	Pre-Demo	9.07	0.308 J	0.932 J	72.4	8.97	770	0.0099
2523-W	11/01/24	FY25	Demolition	22.3	0.2 U	0.12 U	0.7 U	0.5 U	25.5	0.00084
	7/24/24	FY25	Pre-Demo	5.2	0.19 U	0.15 U	5.24	2.6	332	0.0024
	6/05/24	FY24	Pre-Demo	37.6	0.190 U	0.308 J	5.35	5.71	413 O1	0.0068
U: Non-detect; J: Estimated between method detection limit (MDL) and method quantitation limit (MQL) O1: Analyte failed the method required serial dilution test and/or subsequent post-spike criteria, matrix interference LL Hg: low-level mercury										

Table 7.4.7.2: Bldg. 2523 Stormwater – Radiological Results

Site	Date	Fiscal Year	Demolition Stage	Gross alpha	Gross beta	U-234	U-235	U-238
				(pCi/L)				
2523-S	7/24/2024	FY25	Pre-Demo	2.98 U	5.42 U	0.385	0.0983	0.168
2523-SE	11/1/2024	FY25	Demolition	1.18 U	4.2	0.404	0.114	0.141
	7/24/2024	FY25	Pre-Demo	7.76	3.55 U	0.642	0.0906	-0.0322 U
	6/5/2024	FY24	Pre-Demo	1.59	5.39	0.229 J	0.0253 U	0.344
2523-W	11/1/2024	FY25	Demolition	8.09 U	12.3	0.499	0.303	0.119
	7/24/2024	FY25	Pre-Demo	0.457 U	5.59 U	0.387	0.218	0.0442
	6/5/2024	FY24	Pre-Demo	0.785 J	3.1	0.143 J	-0.0179 U	0.0318 U
U: Non-detect; J: Estimated between method detection limit (MDL) and method quantitation limit (MQL)								

When comparing combined stormwater samples collected during both FY24 and FY25, concentration of metals, TSS, and radionuclides during the demolition period were generally lower than those measured during the pre-demolition period at the same sampling sites.

DOE conducted co-sampling with DoR-OR during each sampling event, focusing exclusively on radionuclides. Co-sampling laboratory results were not received at the time of this report. Therefore, data comparisons will be incorporated into the FY26 EMR report.

Bldg. 3005

In FY25, there was one stormwater sampling event conducted at site CB-1250 and Outfall X-20 (OF X-20) on November 14, 2024. Cadmium, copper, lead, and zinc were detected at higher concentrations at CB-1250 as compared to OF X-20. Conversely, beryllium was not detected at any of these sites.

The highest TSS concentration observed during FY25 and FY23 was 426 mg/L, measured at CB-1250 on November 14, 2025. Copper concentrations during the post-demolition period were elevated compared with both pre-demolition and demolition periods. PCBs were not detected in any samples from either FY25 or FY23.

Table 7.4.7.3: Bldg. 3005 Stormwater - Metals and TSS Results

Site	Date	Fiscal Year	Demolition Stage	TSS	Beryllium	Cadmium	Copper	Lead	Zinc	LL Hg
				(mg/L)	(µg/L)					
CB-1250	11/14/24	FY25	Post-Demo	426	0.2 U	0.13 J	5.08	5.64	140	0.0062
	5/8/23	FY23	Demolition	350	0.121J	0.35 U	3.95	7.35	56.7	0.0146
	3/12/23	FY23	Pre-Demo	10 U	0.123 U	0.095 U	2.28	0.288 U	317 D	0.00185 U
OF X-20	11/14/24	FY25	Post-Demo	55.7	0.2 U	0.12 U	2.36 J	1.87 J	23.6 J	0.0077
	5/8/23	FY23	Demolition	8	0.102 U	0.35 U	0.927 J	0.378 J	14	0.00328
	3/12/23	FY23	Pre-Demo	10 U	0.123 U	0.095 U	0.677 J	0.354 J	6.39	0.00288 J
SP-3010-SE	5/8/23	FY23	Demolition	NA	NA	NA	NA	NA	NA	NA
	3/12/23	FY23	Pre-Demo	10 U	0.123 U	0.202 J	1.61	25.6	55.1	0.00361 J

U: Non-detect; **J:** Estimated between method detection limit (MDL) and method quantitation limit (MQL); **NA:** data not available
O1: Analyte failed the method required serial dilution test and/or subsequent post-spike criteria, matrix interference; **LL Hg:** low-level mercury

For radionuclides, gross alpha was not detected at any Bldg. 3005 sites in FY25. Gross beta concentration at Outfall X-20 during post demolition period was higher than those measured during the pre-demo and demolition stage. The highest concentrations of U-234, U-235, and U-238 were observed at Outfall X-20 during the demolition period. However, no notable increases in radionuclides concentrations were observed during the demolition period compared with the pre- and post-demolition periods.

Table 7.4.7.4: Bldg. 3005 Stormwater - Radiological Results

Site	Date	Fiscal Year	Demolition Stage	Gross alpha	Gross beta	U-234	U-235	U-238
				(pCi/L)				
CB-1250	11/14/2024	FY25	Post-Demo	1.18 U	4.2	0.404	0.114	0.141
	5/8/2023	FY23	Demolition	1.58	1.81	0.236	0.118	0.348
	3/12/2023	FY23	Pre-Demo	0.42	2.3	0.222	0.029	0.093
OF X-20	11/14/2024	FY25	Post-Demo	8.09 U	12.3	0.499	0.303	0.119
	5/8/2023	FY23	Demolition	0.211	2.64	1.65	0.116	1.19
	3/12/2023	FY23	Pre-Demo	0.98	-0.9	0.185	0.042	0.146
SP-3010-SE	5/8/2023	FY23	Demolition	3.2	7.27	0.96	0.0986	0.662
	3/12/2023	FY23	Pre-Demo	0.5	-0.2	0.094	0.026	0.051
U: Non-detect; J: Estimated between method detection limit (MDL) and method quantitation limit (MQL)								

BLDG. 3003

On February 6, 2025, stormwater samples were collected from CB-1250 and SL-1. Results from this event establish a pre-demolition data point for comparison with data to be collected during and after demolition. Samples were analyzed for metals, radiological contaminants, TSS, and PCBs, with results summarized in Tables 7.4.7.5 and 7.4.7.6. PCBs were not detected at either site.

Table 7.4.7.5: Bldg. 3003 Stormwater - Metals and TSS Results

Sampling Sites	Date	Fiscal Year	Demolition Stage	TSS	Beryllium	Cadmium	Copper	Lead	Zinc	LL Hg
				(mg/L)	(µg/L)					
CB-1250	2/06/25	FY25	Pre-Demo	5.9	0.2 U	0.12 U	2.84 J	0.5 U	49	0.0013
SL-1				473	0.208 J	0.184	6.49 J	7.65	87	0.009
U: Non-detect; J: Estimated between method detection limit (MDL) and method quantitation limit (MQL); LL Hg: low-level mercury 01: Analyte failed the method required serial dilution test and/or subsequent post-spike criteria, matrix interference										

Table 7.4.7.6: Bldg. 3003 Stormwater - Radiological Results

Sampling Sites	Date	Fiscal Year	Demolition Stage	Gross alpha	Gross beta	Be-7	Cs-137	K-40	U-234	U-235	U-238
				(pCi/L)							
CB-1250	02/06/25	FY25	Pre-Demo	1.96 U	2.76 U	-3.78 U	0.368 U	24.7	2.03	0.339	1.92
SL-1				12	15.7	11.3 U	0.0565 U	18.4 U	2.58	0.312	1.75
U: Non-detect											

These results serve as the pre-demolition point of comparison for Bldg. 3003, which is scheduled for demolition in September 2025. Data collected during and after demolition will be compared against these data and reported in the FY26 EMR.

DOE has conducted regular stormwater monitoring at CB-1250 (3010-SP) since 2022 using an ISCO composite sampler, with results available in the Oak Ridge Environmental Information System (OREIS) database. Tables 7.4.7.7 and 7.4.7.8 compare DoR-OR and DOE sampling results at CB-1250. Metals detected in DoR-OR grab samples were generally consistent with DOE's findings. Overall, DOE sampling results for both metals and radiological contaminants have tended to be higher than DoR-OR results across all three sampling periods (pre-demolition, demolition, and post-demolition).

Table 7.4.7.7: CB-1250: DOE and DoR-OR Stormwater TSS and Metals Results

Site	Stage of Demolition	Sample	TSS	Beryllium	Cadmium	Copper	Lead	Zinc	LL Hg
		Date	(mg/L)	(µg/L)					
CB-1250	Post-Demo	2/06/25	5.9	0.2 U	0.12 U	2.84 J	0.5 U	49	0.0013
		12/31/24	1210	0.407 J	0.508	12.4	19.5	202	0.0717
		11/21/23	113	0.2 U	0.058 J	1.27	2.29	17.5	0.00263
		11/14/24	426	0.2 U	0.13 J	5.08	5.64	140	0.0062
		11/14/24	336	0.305 J	0.171	5.56	6.92	42.9	0.00876
	Demolition	8/03/23	27.3	0.2 U	0.123	1.45	1.4 J	10.5	0.00265
		6/19/23	648	0.236 J	0.685	15.4	34.4	407	0.0327
		5/08/23	350	0.121J	0.35 U	3.95	7.35	56.7	0.0146
	Pre-Demo	3/12/23	10 U	0.123 U	0.095 U	2.28	0.288 U	317 D	0.00185 U
		1/26/23	405	0.208 J	0.71	11.7	32.9	222	0.0305
		1/17/23	10 U	0.123 U	0.095 U	1.44	0.288 U	31.9	0.00276
		12/07/22	314	0.2 U	0.691	10.2	20.7	209	0.0237
		3/08/22	187	0.2 U	0.84	25.6	16.1	293	0.0316
		2/03/22	40	0.2 U	0.275	9.49	6.08	95	0.009
U: Non-detect; J: Estimated between method detection limit (MDL) and method quantitation limit (MQL; D: Dilution required									
Data collected by DOE					Data collected by DoR-OR				

Radiological contaminants detected in DoR-OR grab samples from CB-1250 were generally consistent with DOE's findings. Gross alpha concentration did not exceed the EPA Drinking Water MCL. Most U-234, U-235, and U-238 results reported by DOE during the pre-demolition period were not detected.

Table 7.4.7.8. CB-1250: DOE and DoR-OR Stormwater Radiological Results

Site	Demolition Stage	Date	Gross alpha	Gross beta	U-234	U-235	U-238
			(pCi/L)				
CB-1250	Post-Demo	2/6/25	1.96 U	2.76 U	2.03	0.339	1.92
		12/31/24	12.7	32.8	0.273 U	0.0898 U	0.359
		11/14/24	1.18 U	4.2	0.404	0.114	0.141
		11/14/24	4.82	12.1	1.04	0.0847 U	1.12
		11/21/23	0.744 U	0.411 U	1.22	0.0486 U	1.11
	Demolition	8/3/23	0.278 U	1.69 U	0.57	-0.0085 U	0.513
		6/19/23	13	26.5	0.474	0.0707 U	0.425
		5/8/23	1.58	1.81	0.236	0.118	0.348
	Pre-Demo	3/12/23	0.42	2.3	0.222	0.029	0.093
		1/26/23	9.27	14.1	1.37	0.115 U	1.53
		1/17/23	1.1	2.2	0.66	0.088	0.56
		12/7/22	6.26	7.61	0.196 U	0 U	0.286 U
		3/8/22	2.64 U	7.7	0.116 U	0.0357 U	0.14 U
		2/3/22	2.21 U	3.76 U	-0.007 U	0.0494 U	0.123 U
U: Non-detect							
Data collected by DOE				Data collected by DoR-OR			

EMDF Turbidity Survey

To measure EMDF landfill construction impacts on Bear Creek, turbidity was measured along Bear Creek between NT-9 U to NT-12 D (Table 7.4.7.9). The variability of turbidity across the eight sites is demonstrated in Figure 7.4.7.1 and Figure 7.4.7.2.

TURBIDITY

Results are compared to EPA's turbidity benchmark of 50 NTU, since there is no State of Tennessee numeric AWQC for turbidity.

Table 7.4.7.9: EMDF Turbidity

Sample Site	Turbidity (NTU)							
	07/22/24	07/29/24	09/26/24	11/14/24	12/18/24	02/12/25	04/07/25	05/29/25
NT-9 U	6.26	15.04	3.01	99.03	10.88	46.34	18.13	11.65
NT-9 D	5.18	15.4	3.48	89.44	13.16	46.23	20.08	47.75
NT-10 U	10.71	16.16	3.23	96.21	9.95	46.4	19.64	12.01
NT-10 D	659.2	71.19	57.05	99.7	212.2	110.6	21.11	12.04
NT-10W-U	56.96	18.73	40.73	106.5	347.3	44.09	24.66	22.16
NT-10W-D	55.19	37.25	34.05	107.8	308.7	59.76	23.8	19.43
NT-11 U	-	-	9.32	131.9	11.82	49.37	56.04	13.44
NT-11 D	-	-	173.4	128.6	157.4	57.01	76.81	12.26
* no data collected at this site								

Turbidity in the stream can be impacted by multiple factors such as precipitation duration, intensity, number of dry days, change of land use, as well as land disturbance. This report uses line charts (Figure 7.4.7.1) and a box plot (Figure 7.4.7.2) to visually illustrate the turbidity levels monitored at Bear Creek. Line charts connect data points to show changes after precipitation events, while box plots show the distribution of numeric data values, especially when comparing them between each site.

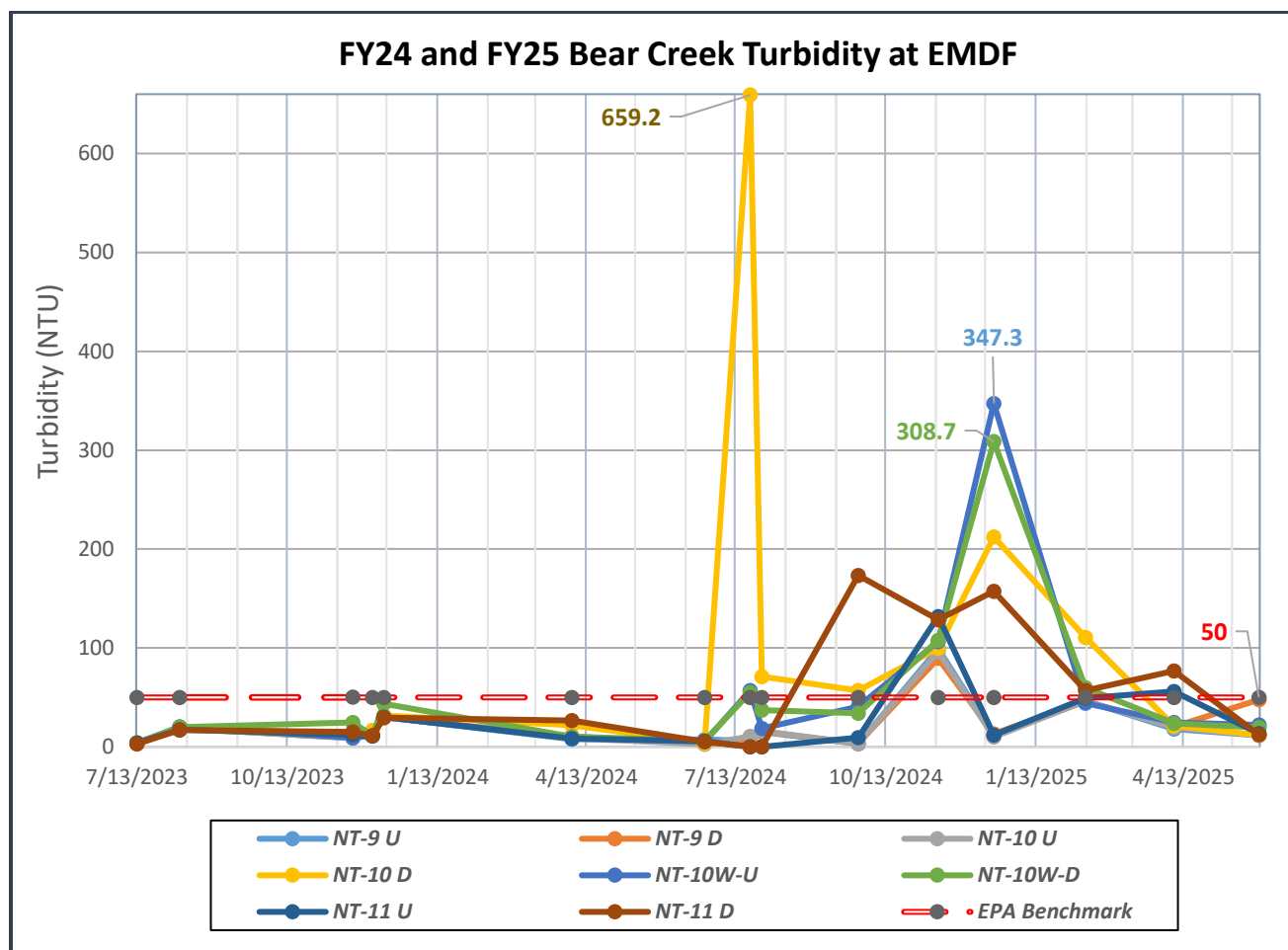


Figure 7.4.7.1: FY25 Bear Creek Turbidity at EMDF

As shown in Figure 7.4.7.1, the highest turbidity (659.20 NTU) was detected at NT-10 D on July 22, 2024, followed with 347.3 NTU at NT-10W-U and 308.7 NTU at NT-10W-D, both measured on December 18, 2024, which are located downstream of EMDF. The boxplot (Figure 7.4.7.2) indicates that site NT-10 D has the highest mean turbidity values (noted by the "x" in the boxplot) compared with all other sites.

For the upstream EMDF sites, NT-9 U, NT-9 D, and NT-10 U, the peak turbidity was detected on November 14, 2024, while the lowest turbidity level was detected on September 26, 2024. The mean and medium turbidity values across NT-9 U to NT-10-U were very similar.

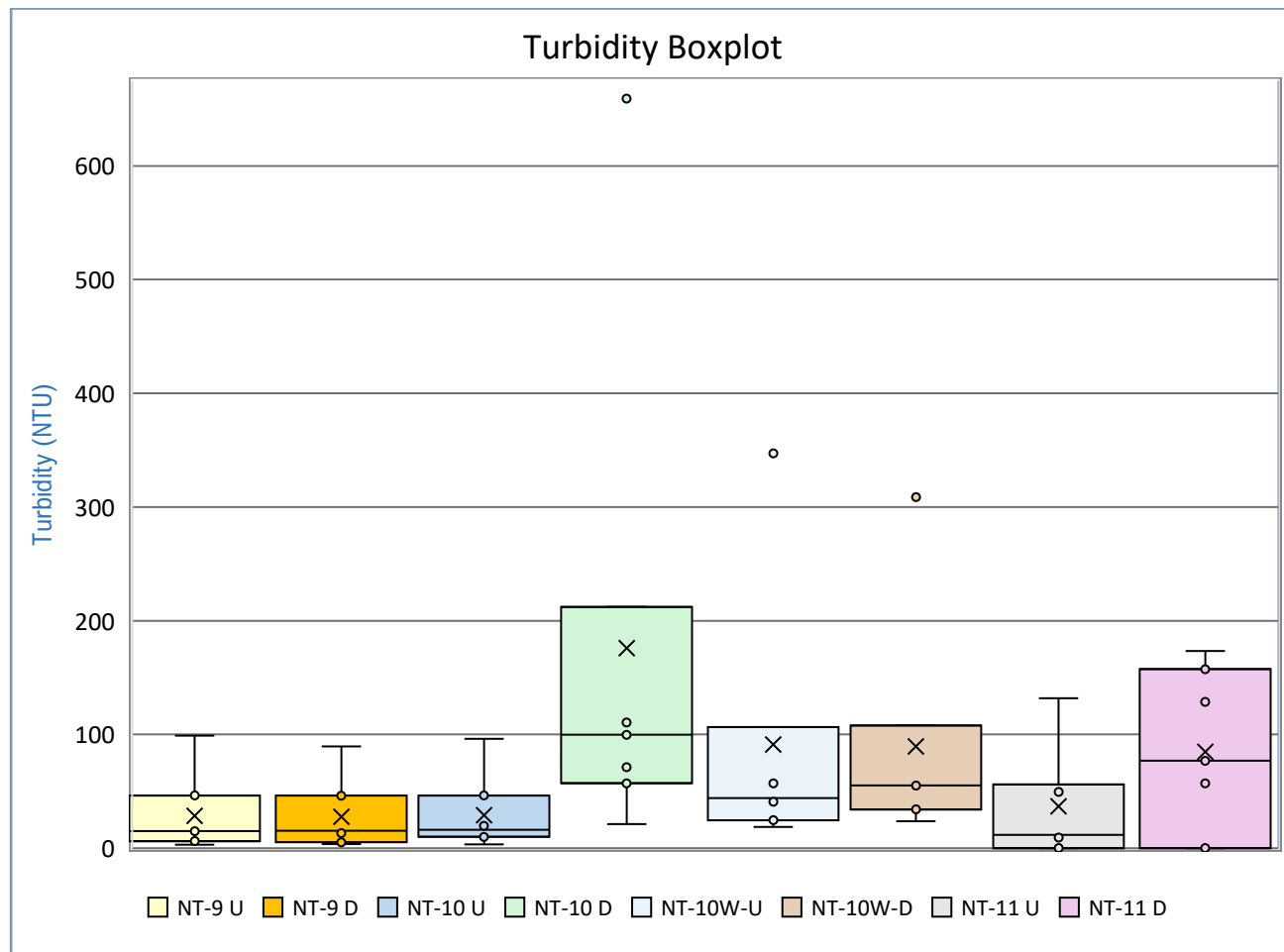


Figure 7.4.7.2: EMDF Turbidity

In FY24, turbidity levels were relatively low and stable most of the year (<50 NTU). The maximum turbidity detected was 43.62 NTU monitored at NT-10W-D in December 2023. Since EMDF construction activity started in FY25, sites NT-10D, NT-10W-D, and NT-11D, which all received surface runoff from the EMDF construction site, started showing significant elevated turbidity levels. Turbidity increases appeared at monitoring locations upstream of EMDF (NT-9U, NT-9D and NT-10U) simultaneously in FY25.

Additional water quality parameters, including pH, specific conductivity, DO, temperature, and ORP, were monitored along Bear Creek in addition to turbidity. The water quality parameter data collected along Bear Creek from July 2024 to June 2025 are listed in Table 7.4.7.10.

Table 7.4.7.10: EMDF Water Quality Parameters (WQP)

Site	WQP	Monitoring Date							
		07/22/24	07/29/24	09/26/24	11/14/24	12/18/24	02/12/25	04/07/25	05/29/25
NT-9 U	pH (Std. Unit)	7.62	7.71	7.78	7.5	7.59	-	7.84	7.5
NT-9 D		7.62	7.68	7.85	7.5	7.57	-	7.84	7.51
NT-10 U		7.94	7.82	7.97	7.68	7.83	-	7.99	7.7
NT-10 D		7.95	7.72	7.83	7.68	7.85	-	7.82	7.71
NT-10W-U		8.02	7.86	8.06	7.73	7.9	-	7.97	7.86
NT-10W-D		8.05	7.84	8.09	7.71	7.87	-	7.96	7.81
NT-11 U		-	-	7.89	7.77	7.96	-	8.05	7.95
NT-11 D		-	-	7.81	7.76	7.92	-	8.04	7.93
NT-9 U	Conductivity (uS/cm)	483.5	373.2	513	323.5	354.5	291.4	319.5	373.7
NT-9 D		483.3	371.7	514	323.8	408.1	279.4	319.5	373.5
NT-10 U		472.3	375	506	314.3	401.4	277.4	305.8	360.4
NT-10 D		467.2	340	526	313.5	321.7	216	134.2	360.6
NT-10W-U		444.4	372.9	439.6	314.1	350	256	292.2	349.2
NT-10W-D		452.2	349.5	484.4	309.2	344.1	251.8	293.2	348.1
NT-11 U		-	-	463.2	293.2	394.9	261.8	289	348.6
NT-11 D		-	-	382.8	297.9	378.5	253.9	288.7	298.2
NT-9 U	DO (mg/L)	8.64	8.08	8.53	9.19	9.49	10.9	9.53	8.78
NT-9 D		8.67	8.09	8.47	9.16	9.49	10.84	9.59	8.79
NT-10 U		8.73	8.2	8.24	9.19	9.56	10.91	9.91	9.03
NT-10 D		8.65	7.81	8.16	9.21	9.58	10.86	9.48	9.05
NT-10W-U		8.69	8.19	8.51	9.24	9.58	10.87	9.87	9.09
NT-10W-D		8.69	8.13	8.47	9.22	9.57	10.9	9.84	9.09
NT-11 U		-	-	7.84	9.28	9.73	10.99	9.86	9.27
NT-11 D		-	-	7.9	9.16	9.67	10.93	9.88	9.23
NT-9 U	Temperature (°C)	18.2	21.7	17.2	13.9	12.9	8.5	14.5	16.6
NT-9 D		18.3	21.7	17.3	13.9	12.9	8.5	14.5	16.6
NT-10 U		19.5	21.8	18.5	13.9	12.9	9.0	14.6	16.7
NT-10 D		19.7	23.5	19.7	14	12.6	9.0	15.1	16.7
NT-10W-U		20.3	22	18.9	13.9	12.7	9.0	14.7	16.9
NT-10W-D		20.4	22.3	18.9	14	12.7	8.9	14.8	17
NT-11 U		-	-	20	13.8	12.8	9.0	14.8	17.2
NT-11 D		-	-	20.5	13.9	12.7	8.9	14.8	17.4
NT-9 U	ORP (mV)	228.6	209.9	234.4	224.5	255.1	211	123.4	170.5
NT-9 D		172.2	224	227.2	211.6	27.6	213.5	122.4	173
NT-10 U		177.4	200.4	215.9	182.6	225.3	216.7	170.1	209.7
NT-10 D		127.6	164.9	228.9	217.1	222	217.5	101.9	208.3
NT-10W-U		197.8	155.4	202	180.1	219	223.4	126.8	154.3
NT-10W-D		153.4	168	175.3	221.3	213.6	222.9	124.6	145.2
NT-11 U		-	-	193.3	184.2	196	216	131.9	164.5
NT-11 D		-	-	197.2	178.2	193.5	217.8	145.1	163.7

pH

In streams, pH is a measure of the activity of the hydrogen ion (H⁺). U.S. EPA water quality criteria for pH in freshwater suggest a range of 6.5 to 9.0 (EPA, 2024). The measured pH values in Bear Creek ranged from 7.5 (NT-9 U and NT-9 D) to 8.09 (NT-10W-D). As illustrated in Figure 7.4.7.3, the lowest and highest mean pH value was measured in NT-9 U&D, and NT-11-U, respectively. pH values from across all eight sites are relatively stable in FY25.

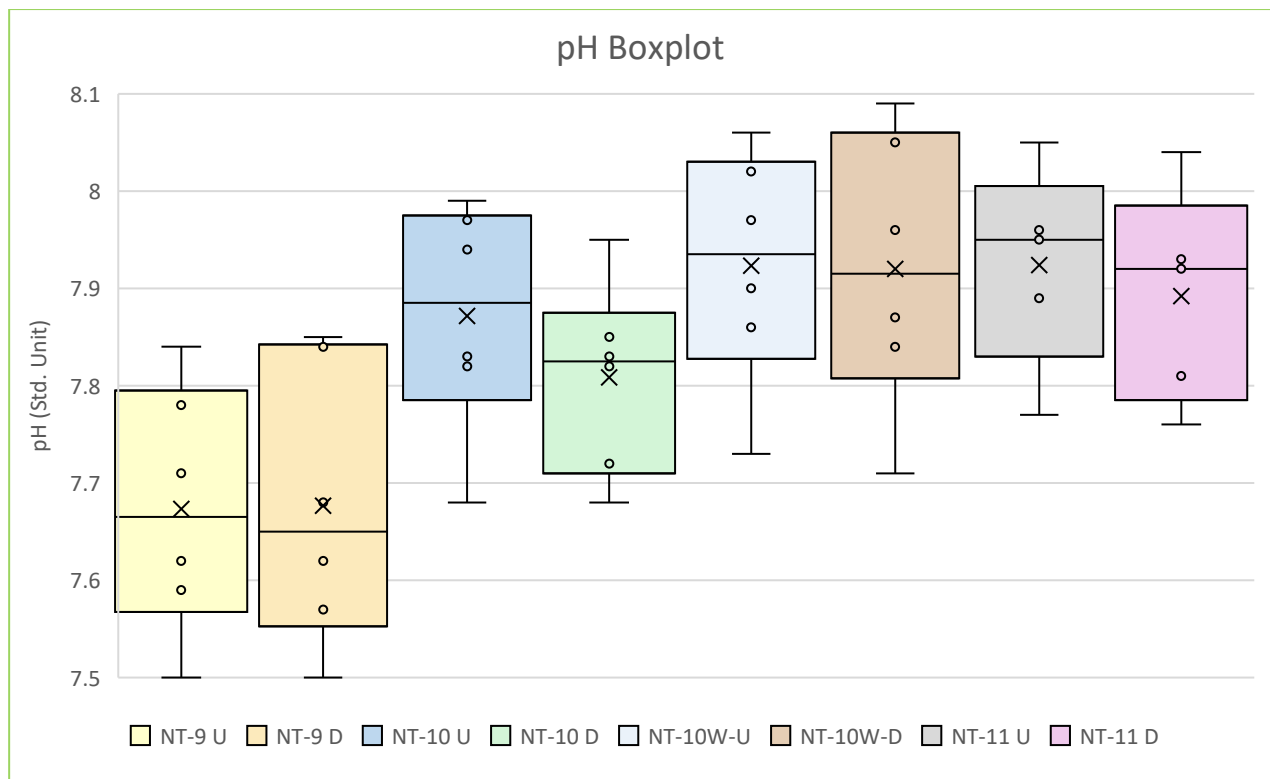


Figure 7.4.7.3: Bear Creek pH at EMDF

TEMPERATURE

Similarly to pH seasonal trends, temperature across each site did not show great fluctuation. The highest and lowest average water temperature was measured at site NT-11 D and site NT-9 U, respectively.

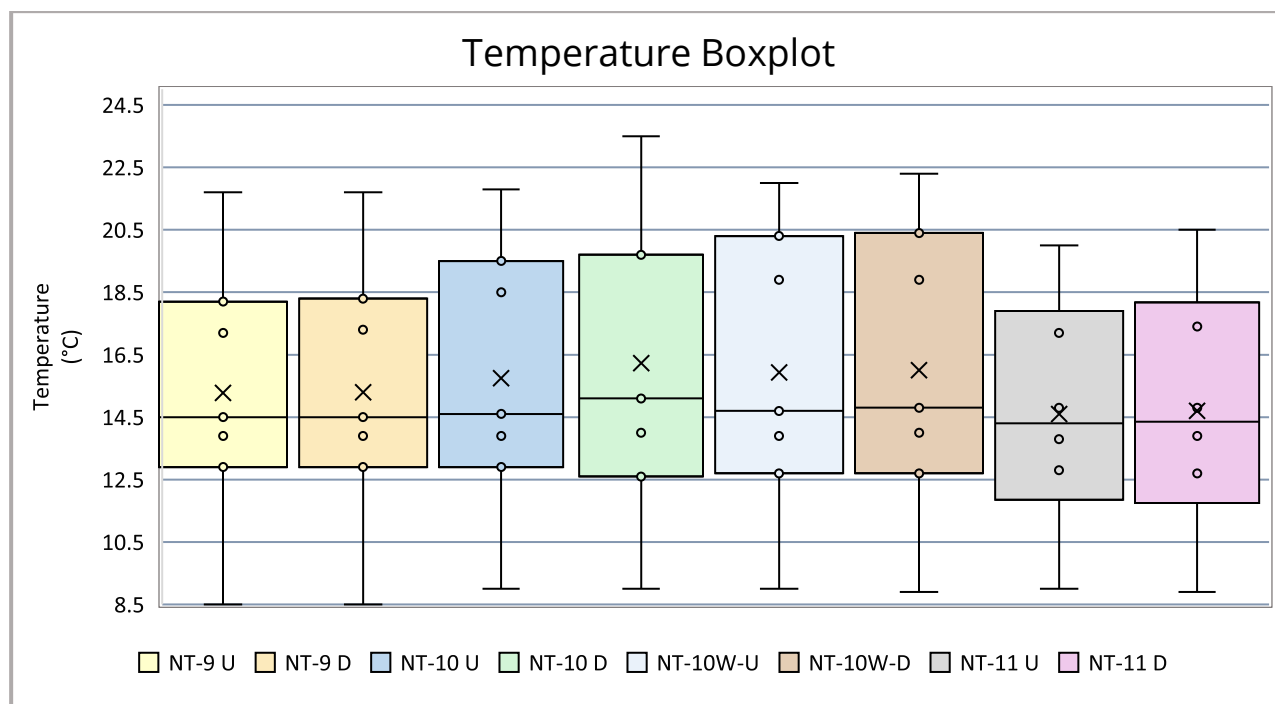


Figure 7.4.7.4: Bear Creek Temperature at EMDF

CONDUCTIVITY

The highest conductivity among all the monitoring sites was measured at site NT-10D with a value of 526 $\mu\text{S}/\text{cm}$ on September 26, 2024 (Figure 7.4.7.5). The lowest conductivity was measured from the same site, with a value of 134.2 on April 7, 2025.

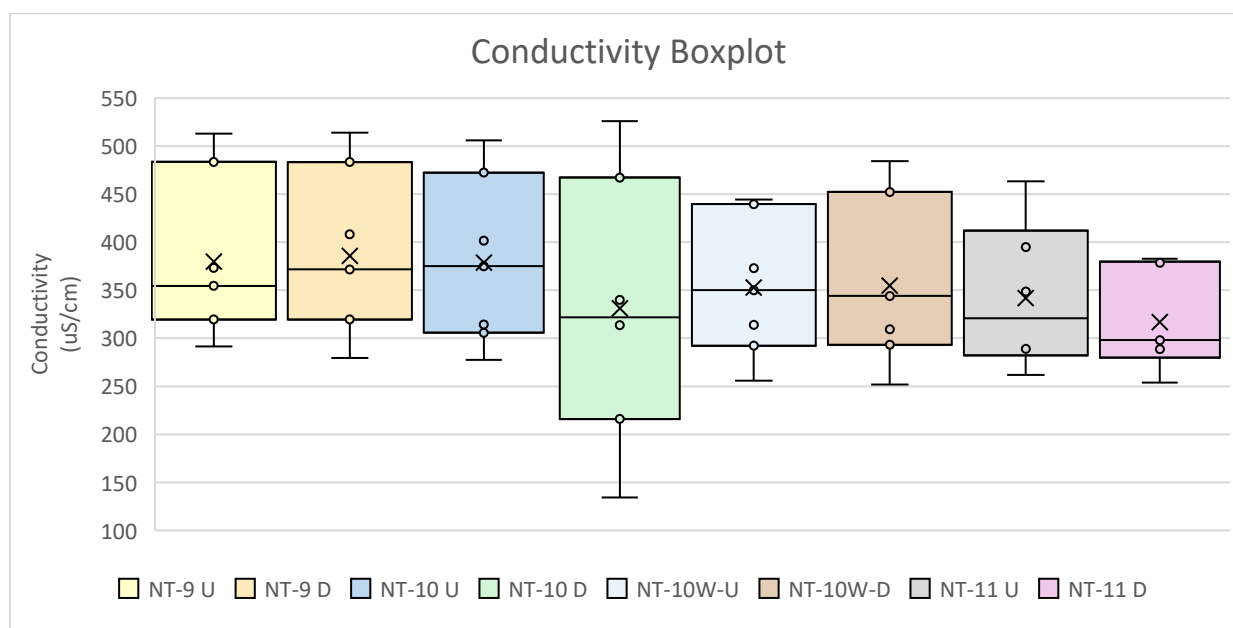
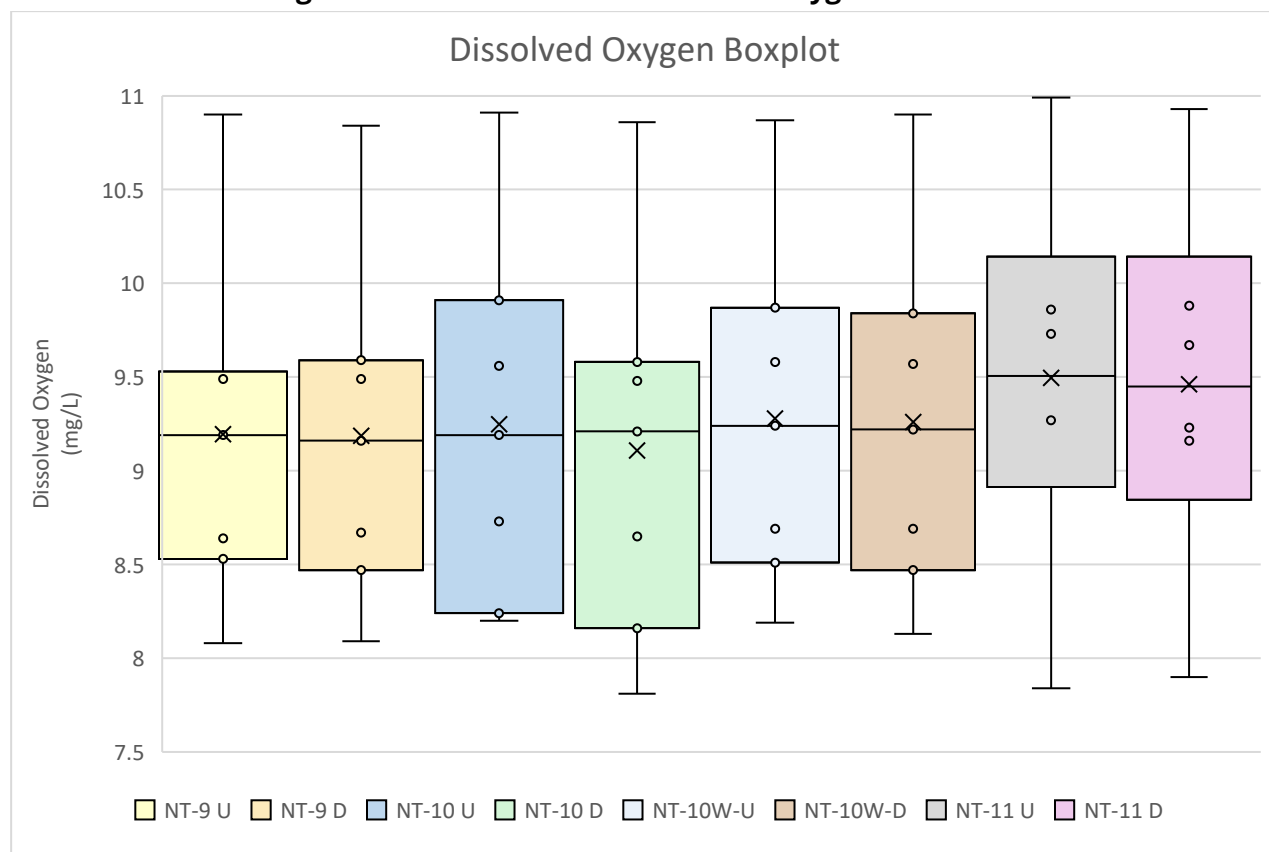


Figure 7.4.7.5: Bear Creek Conductivity at EMDF

DISSOLVED OXYGEN

DO concentration was higher in winter and lower in summer across all sites. Values of DO range from 7.81 to 10.99 mg/L (Figure 7.4.7.6). Site NT-11U had the highest mean oxygen concentration, while NT-10D was measured with the lowest mean concentration of DO over all sites.

Figure 7.4.7.6: Bear Creek Dissolved Oxygen at EMDF



ORP

The highest ORP value was measured 255.1 mV at NT-9 U on December 18, 2024, while the lowest value was 101.9 at NT-10D on April 7, 2025. In FY25, the mean ORP value was between 178.0 to 207.2 mV.

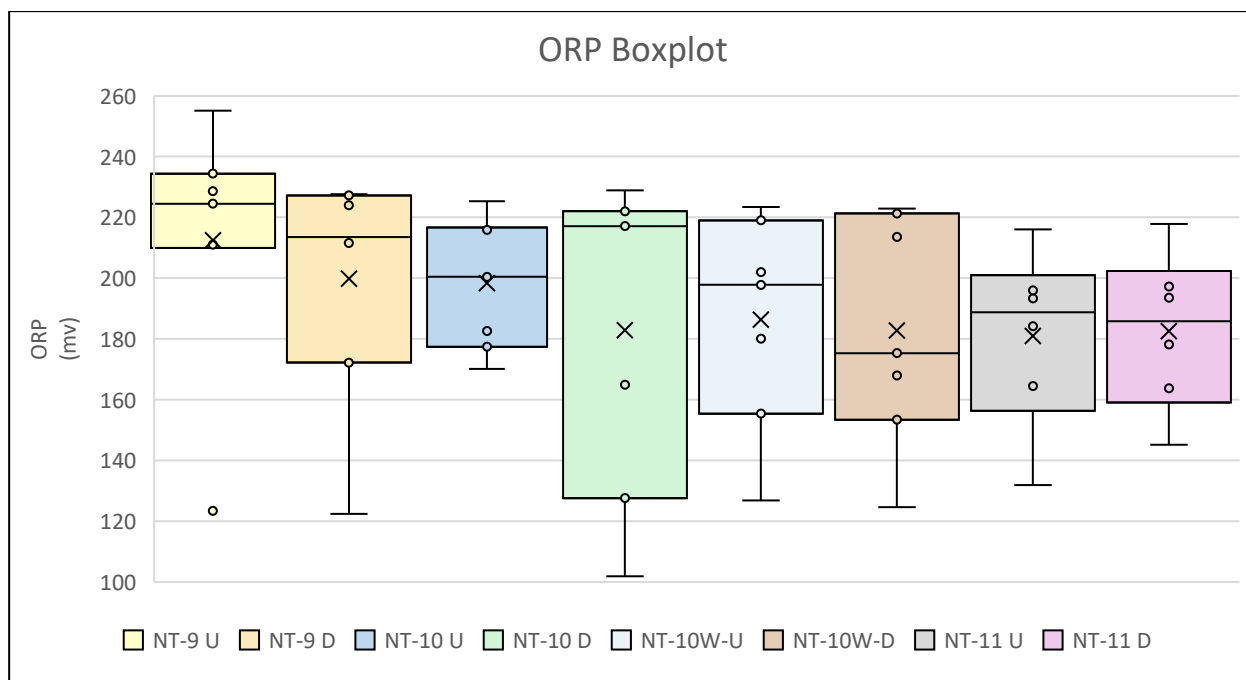


Figure 7.4.7.7: Bear Creek ORP at EMDF

7.4.8 CONCLUSION

In FY25, DoR-OR collected stormwater samples from three D&D sites at ORNL: Bldg. 2523, Bldg. 3005, and Bldg. 3003. This assessment evaluated stormwater COCs across different demolition stages at Bldg. 2523 and Bldg. 3005 and supported establishment of baseline conditions at Bldg. 3003 prior to demolition. The report also compared metals and radionuclide concentrations measured by DoR-OR and DOE at the same sites. No significant increases in COCs concentrations were observed during demolition compared with pre-demolition or post-demolition monitoring at the same locations.

Based on EMDF turbidity survey data, all FY25 turbidity measurements from Bear Creek were more elevated than those recorded in FY24, likely due to construction activities at the EMDF.

7.4.9 RECOMMENDATION

As D&D activities progress and transition to new locations within ORNL, there exists the potential for adverse impacts on the surrounding surface waters from contaminated stormwater runoff. Thus, DoR-OR strongly recommends the continued stormwater monitoring oversight of remediation and construction activities at ORNL. There are valid concerns related to contaminant mobility that may arise during these ongoing activities.

7.4.10 REFERENCES

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8.0 SEDIMENT SAMPLING

8.1 SUSPENDED SEDIMENT SAMPLING PROJECT

8.1.1 BACKGROUND

Stream-bottom (benthic) communities reside in stream sediment and can be negatively impacted by contamination present in the sediment surrounding them (De Lange *et al.*, 2004). Contaminated sediments can inversely impact benthic organisms and can also indirectly impact terrestrial biota, including humans. These detrimental effects stem from bioaccumulation and subsequent transfer of contaminants through the food web (EPA, 1994).

Contaminated sediments have been detected at various stream sites across the ORR. The contaminants present at these sites can be attributed to past and current DOE operations (EPA, 2017). Large quantities (11 million kilograms) of elemental mercury were used at the Y-12 plant from 1950 to 1963 for a lithium isotope separation process. Loss of mercury to the air, soil and to EFPC are estimated to be 3% of the mercury used at the site. Mercury continues to be released to the creek from contaminated soil and groundwater sources at Y-12 (Brooks and Southworth 2011). Uranium is a dense, silver-white, radioactive metal in its pure state. It is found in the environment in rocks, soil, water, and air in very small amounts. Uranium became more prevalent in the environment with the development of nuclear energy applications, such as nuclear power plants and weaponry.

Unintentional releases from historical ORR activities resulted in the release of contaminants including uranium and mercury to the environment. Contaminated sediments are an important, ongoing environmental problem that impacts the uses of many ORR streams. To assess the degree of sediment-bound contamination in the ORR streams that could enter the food chain at the benthic level, TDEC DoR-OR collected sediment samples for chemical and radiological analysis from streams that ultimately drain into the Clinch River.

In FY25, this project monitored suspended stream sediment contaminants transported in impacted waterways (Bear Creek and East Fork Poplar Creek) and an unimpacted reference site (Mill Branch). The sediment traps used for this project collect suspended sediment particles from each stream at multiple sites. This project is unique because it captures mobile stream sediment instead of sediment that has simply settled at the stream's bottom. The information gathered from the chemical and radiological analysis of these sediments helps reveal contaminants being transported downstream and then offsite. The sediment traps are an additional means for detecting any changes in sediment-associated contamination.

8.1.2 PROBLEM STATEMENTS

Sediment is an integral component of stream ecosystems but often serves as a sink for many

contaminants (Mulligan *et al.*, 2009). The following statements list the main issues that are addressed by this project:

- 1) Contaminated stream sediments are highly mobile and could potentially be transported offsite.
- 2) Contaminated stream sediments have negative impacts on aquatic and terrestrial organisms through bioaccumulation.
- 3) Mercury contaminated soils surrounding East Fork Poplar Creek (EFPC) are being washed into the stream during rain and flooding events.
- 4) DOE's monitoring relies on grab samples, which reflect localized, settled sediment. This project addresses that data gap by capturing suspended sediments continually over six months to better evaluate contaminant mobility and potential offsite transport.

8.1.3 GOALS

The goals of this project are as follows:

- 1) Detect contaminants in suspended stream sediment at sites along Bear Creek (BC) and East Fork Poplar Creek (EFPC).
- 2) Use the collected data to assess the extent of sediment transported contamination in these two streams.
- 3) Provide a benchmark of contamination in BC and EFPC stream sediment to support future CERCLA decisions and assess remedial effectiveness of past decisions.
- 4) Assess the potential impacts of contaminated stream sediment in BC and EFPC on benthic communities.

8.1.4 SCOPE

During FY25, suspended sediment traps were monitored at five impacted ORR sites and one reference site. The number of sampling sites per stream were: two sites in EFPC, two sites in BC, one site in North Tributary 5 (NT5), and one site in the reference stream, Mill Branch (Table 8.1.4.1 and Figure 8.1.4.1). There is a second trap at EFK 23.4 to provide a field-duplicate sample to verify field sampling techniques that are replicable. The NT5 trap monitors contaminated sediment originating from the Environmental Management Waste Management Facility (EMWMF) which accepts low-level mixed waste. The furthest downstream site (EFK 2.2) is located below the confluence of BC with EFPC and provides data on combined stream sediment from both streams. The other EFPC and BC sites are used to monitor the movement of sediment-bound contamination leaving Y-12 and potential sediment deposition in floodplain soils downstream.

Table 8.1.4.1: Suspended Sediment Trap Locations

Site Name	Site Description	Latitude	Longitude
EFK 23.4	East Fork Poplar Creek kilometer 23.4	35.99596	-84.24004
EFK 23.4 Dup	East Fork Poplar Creek kilometer 23.4 (Field Duplicate)	35.99596	-84.24004
EFK 2.2	East Fork Poplar Creek kilometer 2.2	35.95169	-84.3716
NT5	North Tributary 5 of Bear Creek	35.966026	-84.290237
BCK 7.6	Bear Creek kilometer 7.6	35.95096	-84.31395
BCK 3.3	Bear Creek kilometer 3.3	35.943538	-84.349114
MBK 1.6	Mill Branch kilometer 1.6 (Reference)	35.98886	-84.28935

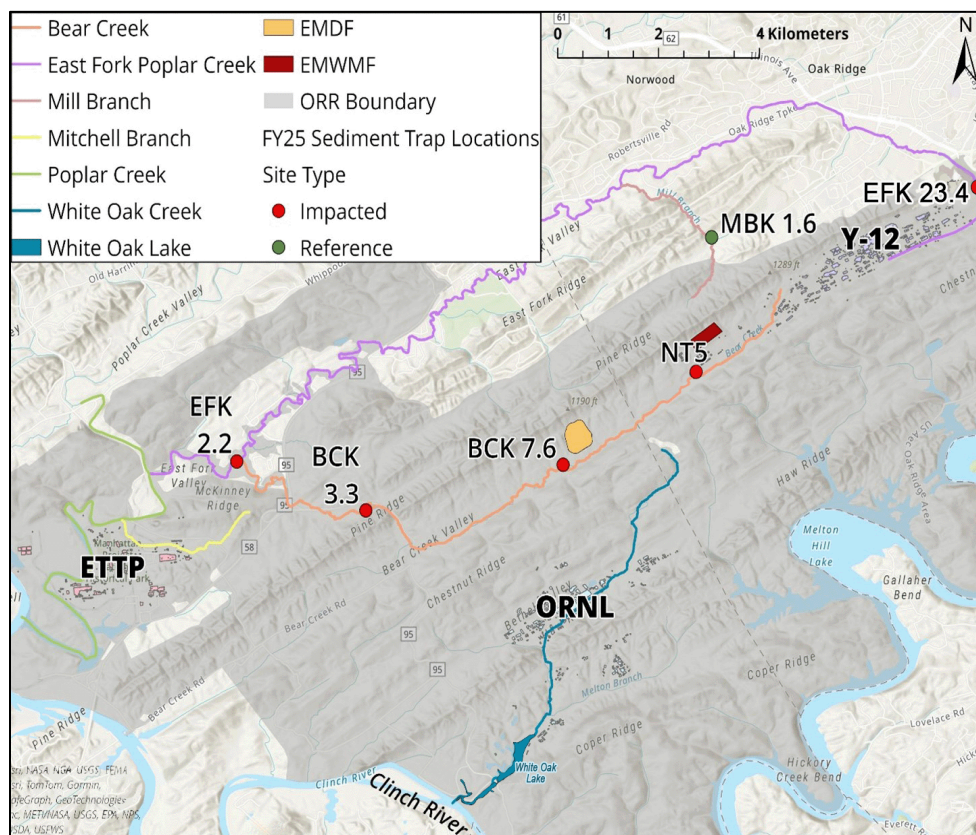


Figure 8.1.4.1: Suspended Sediment Sampling Locations

8.1.5 METHODS, MATERIALS, METRICS

Passive sediment traps were used to monitor changes in sediment contamination levels that flow through EFPC and BC. Sediment samples were collected from each sediment trap twice during FY25, once in November 2024 and once during May 2025. Each sample was submitted for analysis based on certain contaminants of concern (COCs). The written procedure used for this project is *DoR-OR-T-600 Standard Operating Procedure for Sediment Sampling* (TDEC DoR-OR, 2023).

Sediment traps are placed on the stream bed and held down with sandbags. The traps are oriented so that considerable water flows through them. Modeled after Phillips *et al.* (2000), these passive samplers provide a longer-term measure of contaminant transport, capturing trends that grab samples might miss. Following a collection period of a minimum of six months, the sediment and water are emptied from a sediment trap and transferred to a clean bucket designated for each individual site. The bucket is then surrounded by ice for 48 to 72 hours to allow the sediment to settle at the bottom of the bucket. After the sediment settles, the water on top of the sediment is carefully drawn off each sample with a peristaltic pump and clean tubing. Sediment samples are transferred into sample containers using a clean spoon and sent to the appropriate analytical laboratory for analysis.

Sediment samples were analyzed for metals (cadmium, lead, and mercury) and radiological activity (gross alpha/beta, gamma, isotopic uranium, total uranium).

The *Development and Evaluation of Consensus-Based Sediment Quality Guidelines (CBSQGs) for Freshwater Ecosystems* lists consensus-based Probable Effect Concentrations (PECs) that are used for comparison to the metals data (MacDonald et al. 2000). The PECs are concentrations above which harmful effects on sediment-dwelling organisms are likely to be observed frequently (MacDonald et al. 2000). The CBSQGs do not consider the potential for bioaccumulation in aquatic organisms nor the associated hazards to the species that consume aquatic organisms (i.e., wildlife and humans) (MacDonald et al. 2000).

In the case that PECs were not available, EPA Regional Screening Levels (RSLs) or Preliminary Remediation Goals (PRGs) for Radionuclides at Superfund Sites were utilized (EPA 2023, EPA 2024). RSLs and PRGs are risk-based screening levels that correspond to fixed levels of risk to the specified receptor from contamination in soil, air, and water. RSLs and PRGs are not cleanup standards, but are used to identify areas, contaminants, and conditions that require attention at a site (EPA 2025). For selection of the screening criteria, a residential scenario was utilized with a Target Risk of 10^{-5} and Target Hazard Quotient of 1.0.

In addition, sample results were compared to data from MBK 1.6, the background site. The following graphs and associated charts follow the sediment data through the past five years.

8.1.6 DEVIATIONS FROM THE PLAN

Sediment samples were collected in November 2024 instead of October 2024 and May 2025 instead of April 2025.

8.1.7 RESULTS AND ANALYSIS

Blanks in the following charts (Figure 8.1.7.1 - 8.1.7.9), signify the parameter was not analyzed in

that year.

METALS

CADMIUM

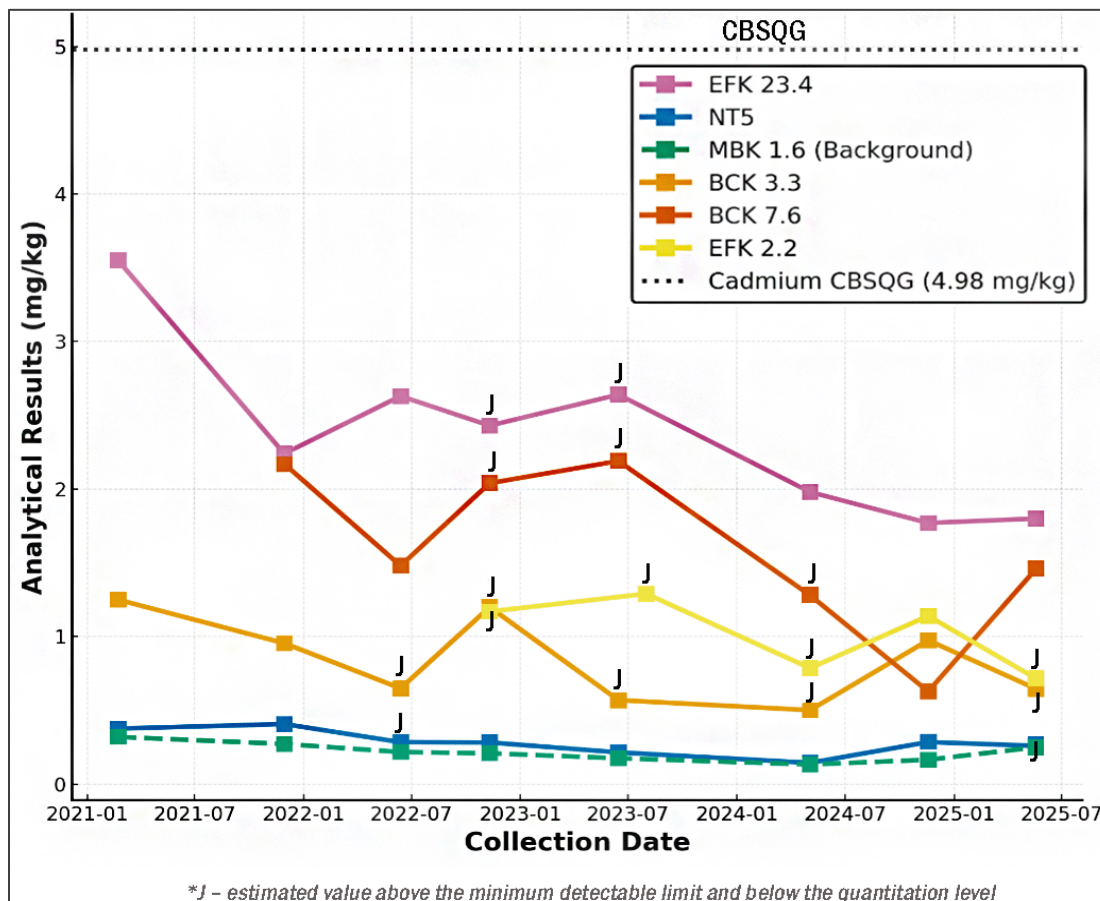


Figure 8.1.7.1: Suspended Sediment – Cadmium (2021 – 2025)

Cadmium concentrations from suspended sediment samples collected from 2021 through 2025 were below the CBSQG's PEC of 4.98 mg/kg. In FY25, all samples were below the screening criteria. Suspended sediment from all locations (except NT5) was above the background concentrations of the MBK 1.6 samples. EFK 23.4 had the greatest quantity of cadmium in suspended sediment samples. There was an increase in cadmium concentrations at BCK 7.6 during spring of 2025. The NT-5 cadmium concentrations only slightly exceeded background. Overall, cadmium concentrations tend to decrease in downstream sampling locations (EFK 2.2, BCK 3.3) as compared to upstream sampling locations (EFK 23.4, BCK 7.6).

MERCURY

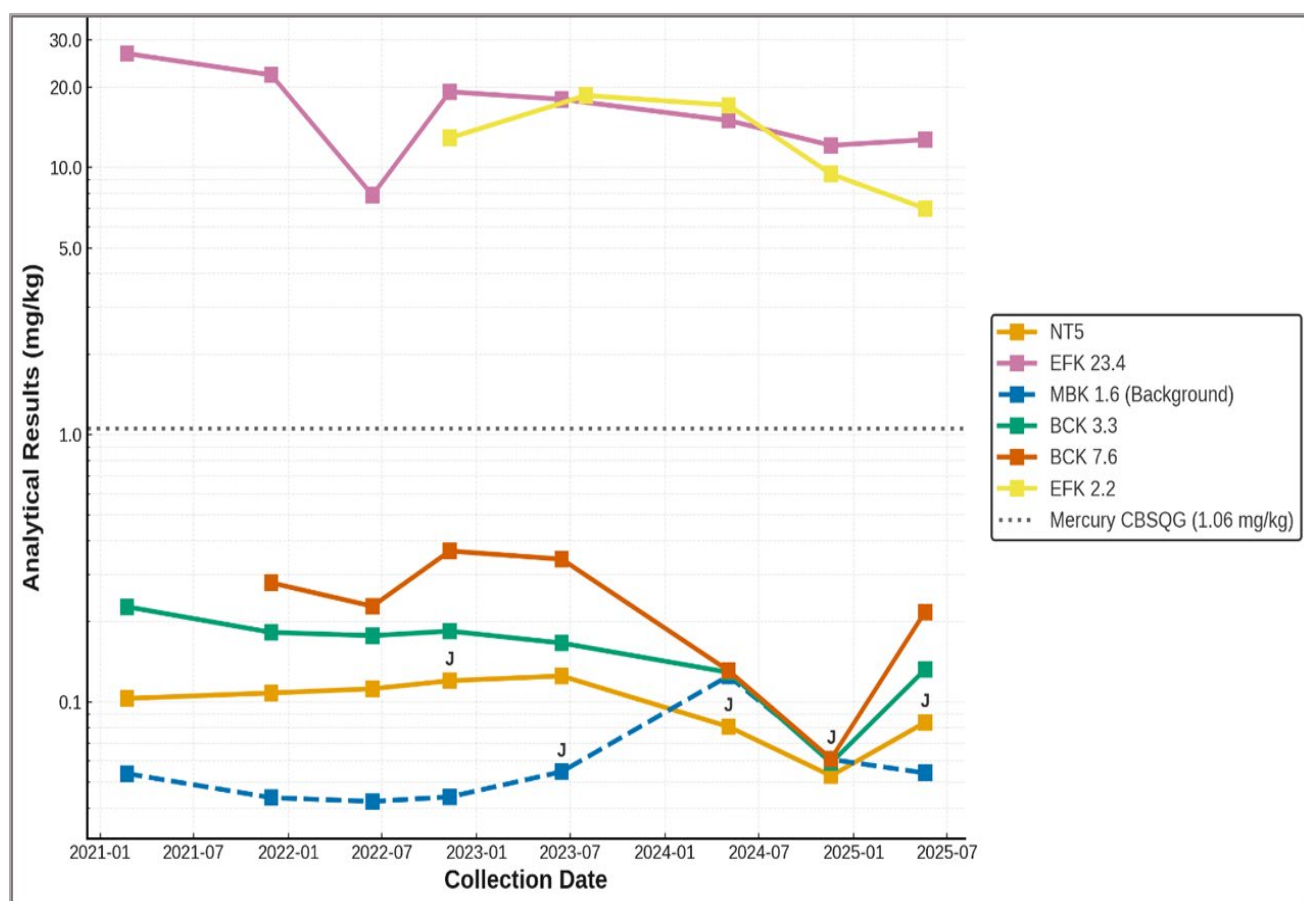


Figure 8.1.7.2: Suspended Sediment – Mercury (2021-2025)

Between 2021 and 2025, mercury concentrations from samples collected in Bear Creek (BCK 7.6, BCK 3.3, and NT-5) were below the CBSQG's PEC (1.06 mg/kg) and were similar to concentrations observed in the background sample (MBK 1.6). However, samples collected from EFPC (EFK 23.4 and EFK 2.2) had mercury concentrations that significantly exceeded the CBSQG. Mercury concentrations have decreased in the last three suspended sediment samples collected at EFK 2.2. More samples will need to be collected to validate this trend.

URANIUM

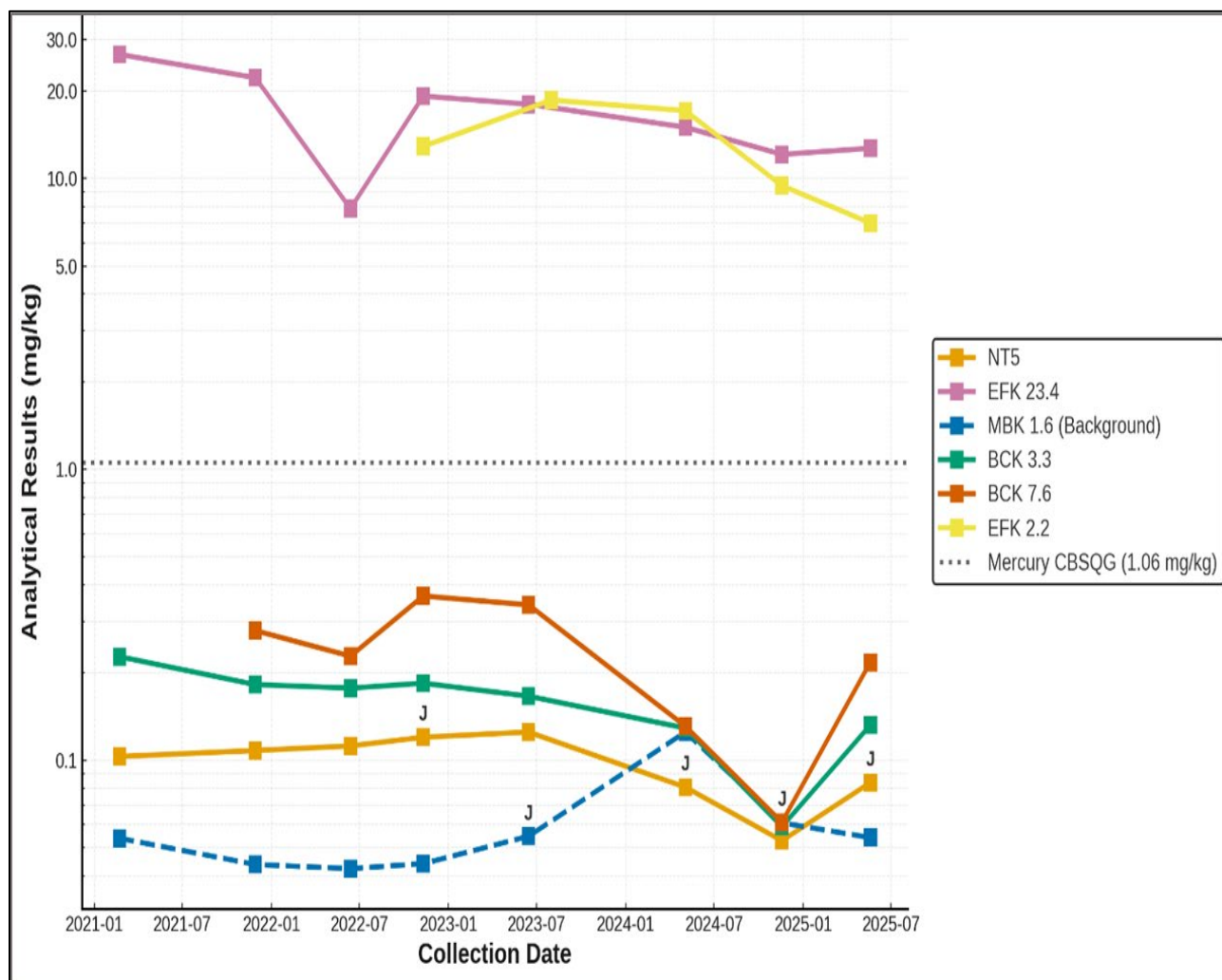


Figure 8.1.7.3: Suspended Sediment – Uranium Metal (2021 – 2025)

The highest concentrations of uranium in FY25 were in the samples from EFK 23.4. Uranium quantities from EFK 23.4 exceeded the EPA RSL of 15.6 mg/kg in the samples collected during FY25. Uranium in all samples collected since 2021 exceeds the background concentrations in the samples collected from MBK 1.6. Overall, uranium concentrations decrease in downstream sampling locations (EFK 2.2, BCK 3.3) as compared to upstream sampling locations (EFK 23.4, BCK 7.6), except for the one BCK 7.6 sample collected in November 2024.

LEAD

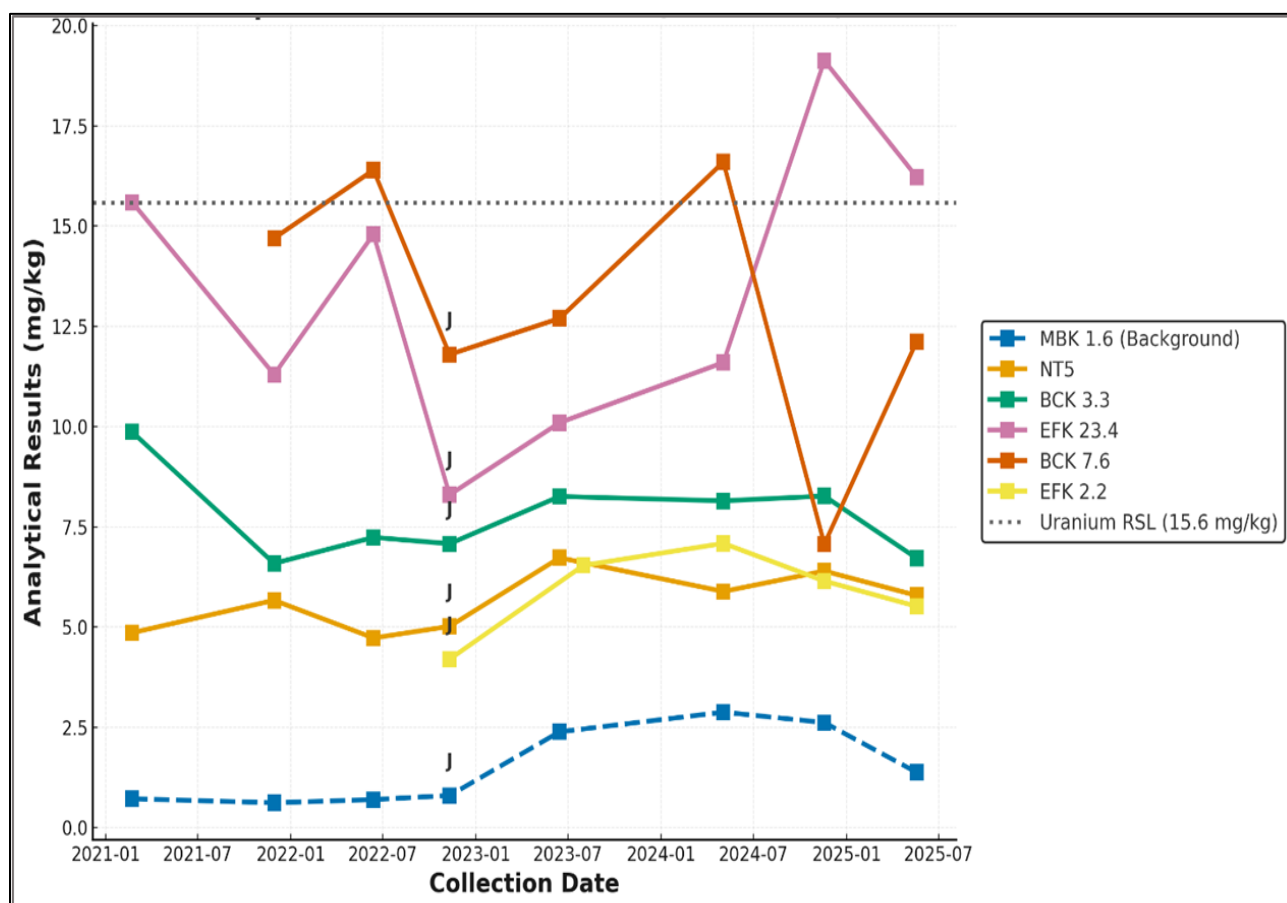


Figure 8.1.7.4: Suspended Sediment – Lead (2021 – 2025)

Lead concentrations in all samples collected from 2021 through 2025 were below the CBSQG's PEC (128 mg/kg). However, most concentrations from all samples exceed background concentrations in samples from MBK 1.6. In general, lead concentrations were higher in samples collected from EFPC (EFK 23.4 and EFK 2.2). The BCK 7.6 sample collected in May 2025, had the highest observed lead concentrations for this site.

RADIOLOGICAL

GROSS ALPHA

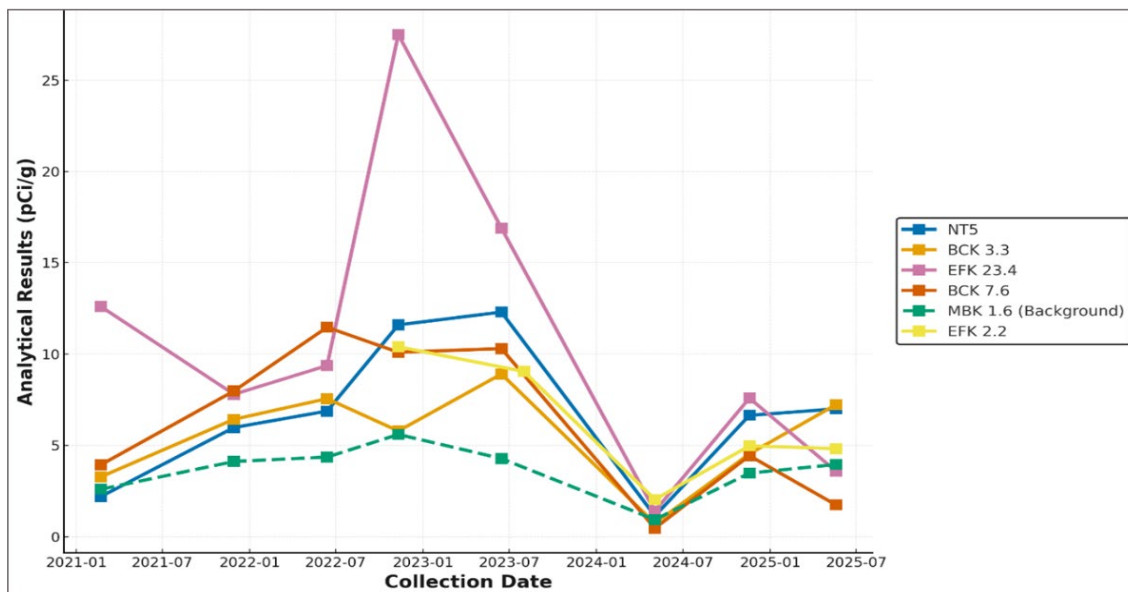


Figure 8.1.7.5: Suspended Sediment – Gross Alpha (2021 – 2025)

Generally, gross alpha activity in all suspended sediment samples collected was greater than background activity. However, in 2025 activity for EFK 23.4 and BCK 7.6 was lower than the background activity. In FY25, the highest gross alpha activities were in samples collected from BCK 3.3 and NT5.

GROSS BETA

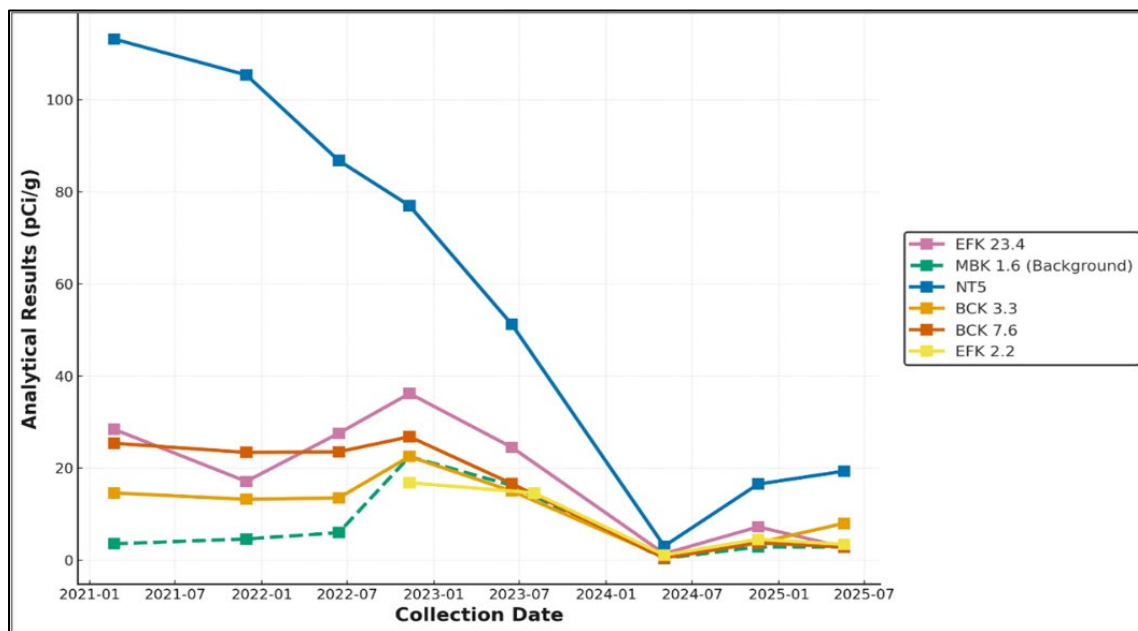


Figure 8.1.7.6: Suspended Sediment – Gross Beta (2021 – 2025)

From 2021 to 2023, gross beta activities were the highest in samples collected from NT-5. Activity had been decreasing since 2021, but for the past two sampling events activity has increased. Downstream sampling locations, BCK 3.3 and EFK 2.2, have been below or near to background activity.

ISOTOPIC URANIUM (U-234, U-235, U238)

U-234

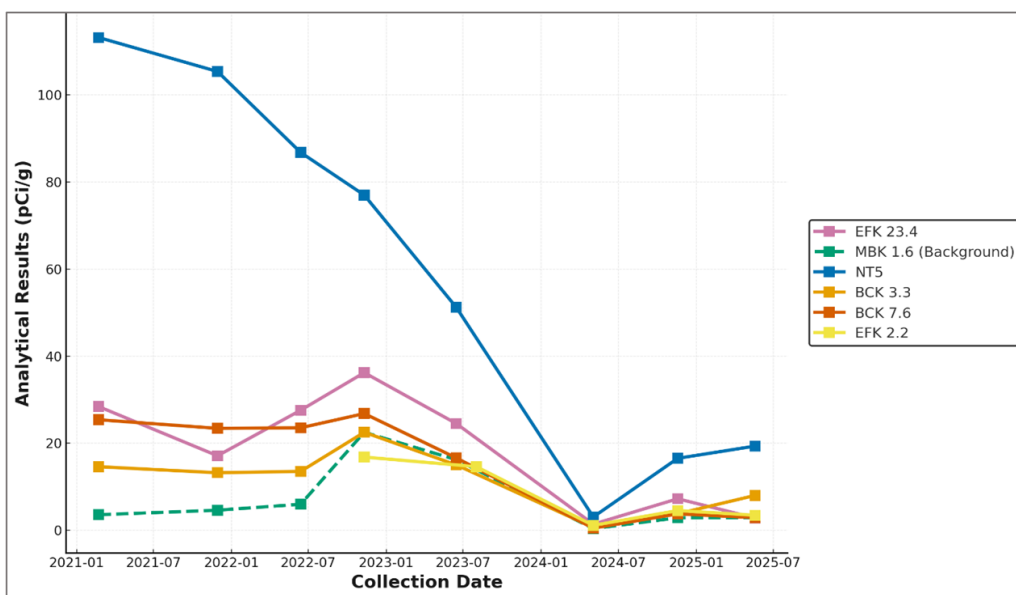


Figure 8.1.7.7: Suspended Sediment - Uranium-234 (2021 - 2025)

U-235

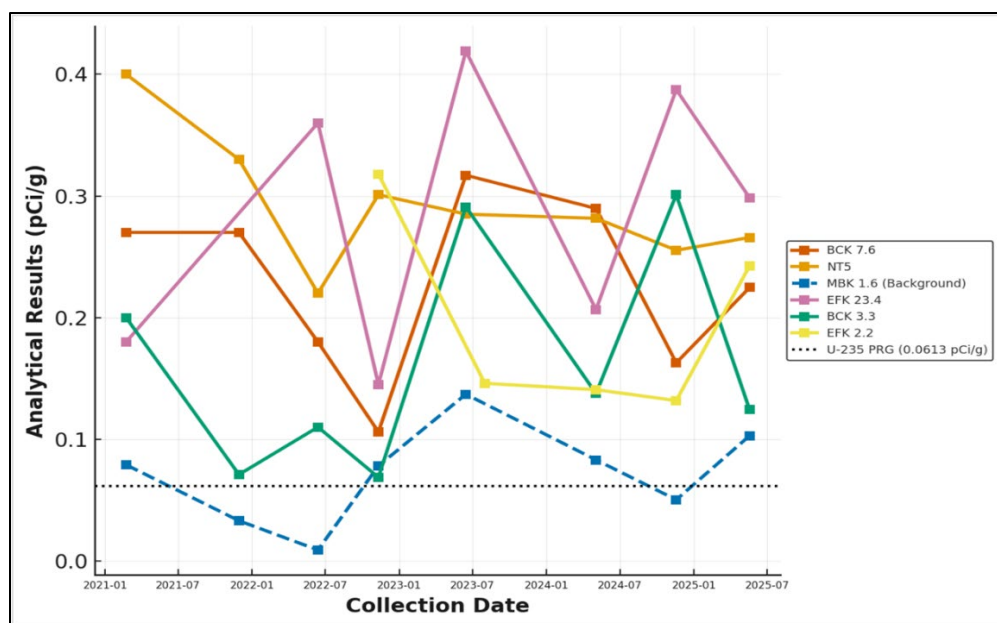


Figure 8.1.7.8: Suspended Sediment - Uranium-235 (2021 - 2025)

U-238

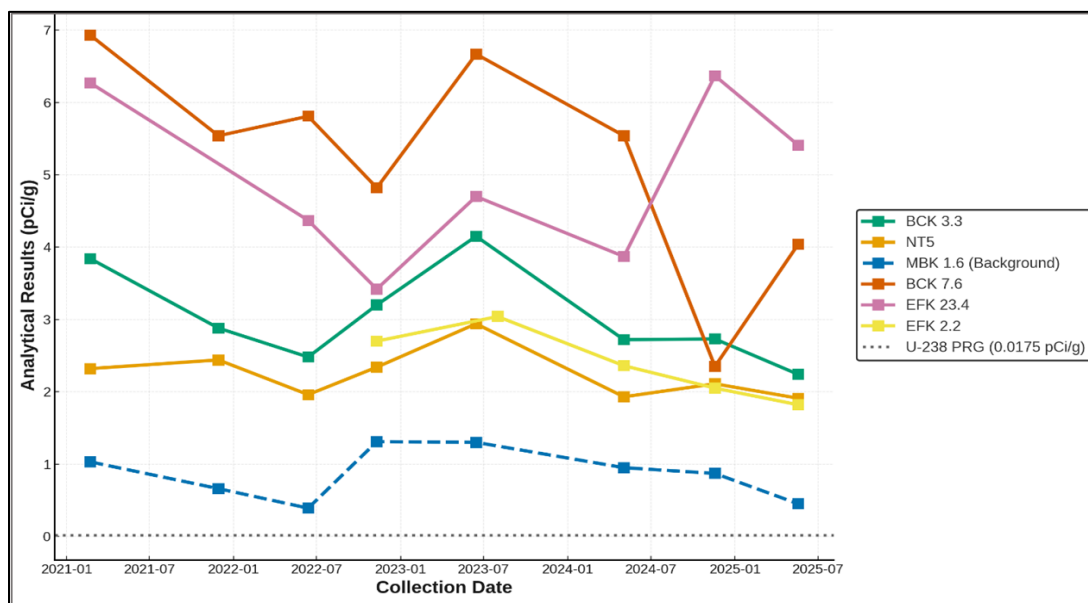


Figure 8.1.7.9: Suspended Sediment – Uranium-238 (2021 – 2025)

Isotopic uranium data is available at all sampling locations from 2021 through 2025, with the exception of EFK 2.2. Isotopic uranium results are available from EFK 2.2 beginning in the fall of 2022. Overall, all samples collected since 2021 exceed the respective EPA PRG's for U-234 (0.03 pCi/g), U-235 (0.06 pCi/g), and U-238 (0.018 pCi/g). In all but two cases, the background samples from MBK 1.6 also exceeded the screening criteria. U-234 activity had the highest levels at NT-5 followed by the upstream locations (EFK 23.4 and BCK 7.6). U-238 activity was the highest at the upstream locations (EFK23.4 and BCK 7.6), while EFK 2.2 had the lowest activity of all sampling sites aside from the background location. No data trends are apparent from the U-235 quantifications.

8.1.8 CONCLUSIONS

Suspended sediment samples collected from within Bear Creek and EFPC from 2021 through 2025 were evaluated. Analytical results were compared to screening levels and background concentrations over the five-year period to identify data trends. Suspended sediment samples collected since 2021 show cadmium and lead were below harmful levels but above natural background concentrations. On the other hand, mercury remains a major concern in EFPC, and uranium exceeded screening criteria in multiple sites.

Concentrations of mercury from sediment samples collected within EFPC (EFK 23.4 and EFK 2.2) have consistently exceeded the CBSQG, while samples collected from within Bear Creek (BCK 7.6, NT-5, and BCK 3.3) have been near background concentrations. Uranium concentrations have been below the CBSQG, except for two samples collected from BCK 7.6 and two samples

collected from EFK 23.4. Cadmium and lead for all samples were below the CBSQG for each contaminant. EFK 23.4 had the highest concentrations of both cadmium and lead.

Gross alpha and gross beta activities exceeded background concentrations throughout the study period, with some exceptions at downstream sampling locations. In 2025, the highest gross alpha activities were in samples collected from BCK 3.3 and NT5. The highest gross beta activity was in samples collected from NT-5; concentrations in NT-5 appeared to be decreasing since 2021 but have increased with the past two sampling events. Isotopic uranium exceeded the respective screening levels in all samples analyzed and could potentially account for the exceedances in gross alpha and gross beta.

8.1.9 RECOMMENDATIONS

Sediment traps capture suspended sediments that are being carried by the stream. Analysis of the sediments collected in this manner shows changes in direct response to environmental contaminant discharges or environmental clean-up activities in the period that the trap was deployed. Sediment traps provide an intermediary form of information between sediment grab sampling and surface water sampling. It is the purpose of this project to stay abreast of the quality of sediment being transported in the ORR exit pathway streams. The TDEC DoR-OR trapped sediment project is needed to provide this information. In the coming years, it is anticipated there will be many *decontamination and decommissioning* (D&D) projects as well as construction projects in the upper EFPC watershed. In the years ahead, to provide critical information about both East Fork Poplar Creek and Bear Creek, suspended sediment sampling is recommended for continuation twice per year. This sampling is an integral part of stream monitoring on the ORR and fills a gap in DOE's data. These results will continue to inform DOE and State monitoring efforts and can help guide cleanup in ORR streams.

8.1.10 REFERENCES

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9.0 HOLISTIC WATERSHED MONITORING AND ASSESSMENT

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

9.1.1 BACKGROUND

White Oak Creek (WOC) is located in the south-central part of the ORR. There are a series of northeast-southwest trending ridges with interceding valleys (Bethel and Melton Valleys for WOC, see Introduction), which alter weather patterns and stream flow. The stream originates on the slope of Chestnut Ridge near the ORNL Spallation Neutron Source (SNS) facility and flows into Bethel Valley and through the ORNL main campus. From there it travels through the gap in Haw Ridge and enters Melton Valley, passing along several solid waste storage areas. Further downstream, WOC proceeds through Melton Valley before emptying into the Clinch River (i.e. CRK 33.5, CRM 20.8). The WOC watershed drainage area is 6.45 square miles (Figure 9.1.4.1) (USGS, 2024).

The *White Oak Creek Assessment Project* (WOCAP) is intended to establish a current benchmark of environmental conditions in this watershed. DOE's *White Oak Creek Remedial Investigation Report: Melton Valley Area* describes an assessment of the Melton Valley segment of the WOC watershed (DOE, 1996). Although comprehensive, this assessment is outdated, and a new holistic assessment is warranted to support TDEC evaluations moving forward. The environmental data generated from various environmental media will help to establish benchmarks that can be used to evaluate future impacts and support decisions for final Bethel Valley and Melton Valley RODs.

There are multiple data gaps that this WOCAP addressed. WOC data in the Oak Ridge Environmental Information System (OREIS) is limited for impacts to some ecological resources. More specifically, monitoring data is considerably scarce for the following:

- 1) Whole Effluent Toxicity (WET) testing
- 2) Radiological uptake in WOC vegetation
- 3) Bioaccumulation of known contaminants in terrestrial organisms

Contaminants of concern (COCs) within WOC include but are not limited to: tritium (H-3), strontium-90 (Sr-90), cesium-137 (Cs-137), cobalt-60 (Co-60), mercury (Hg), and PCBs. The WOCAP involves a comprehensive evaluation of the ecological health of this entire watershed and will focus on the primary COCs associated with each valley and its associated tributaries. To accomplish this holistic assessment, the WOCAP has been organized into several progressive phases.

- 1) **Phase 1** (FY24) involved researching and compiling existing data.
 - a. Data acquisition, review, summarization, and interpretation of historical data for the

WOC Watershed.

- b. Examination and compilation of available types of environmental data including: (1) surface water, (2) groundwater, (3) sediment, (4) soils, (5) toxicity/biomonitoring, (6) fish tissue, (7) benthic macroinvertebrates, (8) terrestrial biota.
- 2) **Phase 2** (FY25 and FY26) includes new sampling and subsequent analysis of monitoring data collected in Phase 1.
- a. In **Phase 2a (FY25)**, new sampling and analysis projects included (1) surface water, (2) toxicity/biomonitoring, (3) fish tissue, (4) benthic macroinvertebrate community health, (5) benthic macroinvertebrate chemical analysis, (6) terrestrial biota (flying insects), and (7) vegetation.
 - b. Phase 2b (FY26) will include continued sampling in WOC and the remaining sampling that could not be completed during Phase 2a: (1) surface water, (2) benthic macroinvertebrate community health, (3) benthic macroinvertebrate chemical analysis, (4) terrestrial biota (songbird eggs and flying insects), and (5) gamma walk-over surveys as a preliminary soils analysis.
- 3) **Phase 3** (FY27) will use the analytical data obtained from Phases 1 and 2 to produce a comprehensive report. If data gaps are present after Phase 2, there will be further sampling and analysis.
- 4) **Phase 4** (FY27 and FY28) will address any areas requiring additional field sampling for a more comprehensive analysis and interpretation of all watershed data.

9.1.2 PROBLEM STATEMENTS

Melton Valley is a major waste storage area on the ORR, storing hazardous and radioactive waste in several Solid Waste Storage Areas (SWSAs) and burial grounds. Contaminant releases from Melton Valley become mobilized via surface water, which flows into WOC and ultimately empties into the Clinch River (DOE, 2023). Some notable contaminants of concern (COCs) included H-3, Sr-90, Cs-137, and Co-60. In the early years of ORNL operations, these COCs were discharged to nearby streams. Industrial waste disposal areas also contributed to the contamination of the watershed through leaks, spills, and subsurface leaching (DOE, 1995).

As a result, WOC floodplain soils and sediments have extensive deposits of Cesium-137 (Cs-137). Cs-137 is of particular concern because of its high potential for mobility with sediment to downstream areas of WOC which empties into the Clinch River (DOE, 2023).

These COCs also resulted in elevated gamma radiation activity along WOC from ORNL to the

WOC Embayment (WOE) at the Clinch River confluence (WOC-CR). In previous years, Melton Branch, a tributary of WOC, had lower levels of gamma radiation in the reach that spans from the High Flux Isotope Reactor (HFIR) to the confluence with White Oak Creek (MB-WOC).

9.1.3 GOALS

The goals of this **Phase 2a** project included the following:

- To conduct a comprehensive evaluation of WOC to provide a current benchmark to help inform future remedial decisions.
- To assess the impacts that historical and ongoing contamination of WOC may be having on the health of the environment (ecological receptors, including wildlife, within the watershed). Data from this assessment can also be used to assess ongoing human health risk.
- To provide a benchmark to gauge the effectiveness of future remediation activities in the WOC watershed.
- To report to the public the current status of the WOC watershed.

9.1.4 SCOPE – PHASE 2

WOC sample sites are represented on Figure 9.1.4.1 and cover the length of WOC from the headwaters to the confluence with the Clinch River, as well as major tributaries of WOC. Except for the toxicity and fish surveys, all **Phase 2a** sampling occurred as components of separate monitoring projects. Monitoring data used to support this holistic watershed assessment were collected and provided by the following projects: *Benthic Community Health* (community metrics and chemical analysis), *White Oak Creek Radionuclides* surface water sampling, *Contaminant Uptake in Biota* (songbird eggs and flying insects), and the *Roving Creel Survey* (fish).

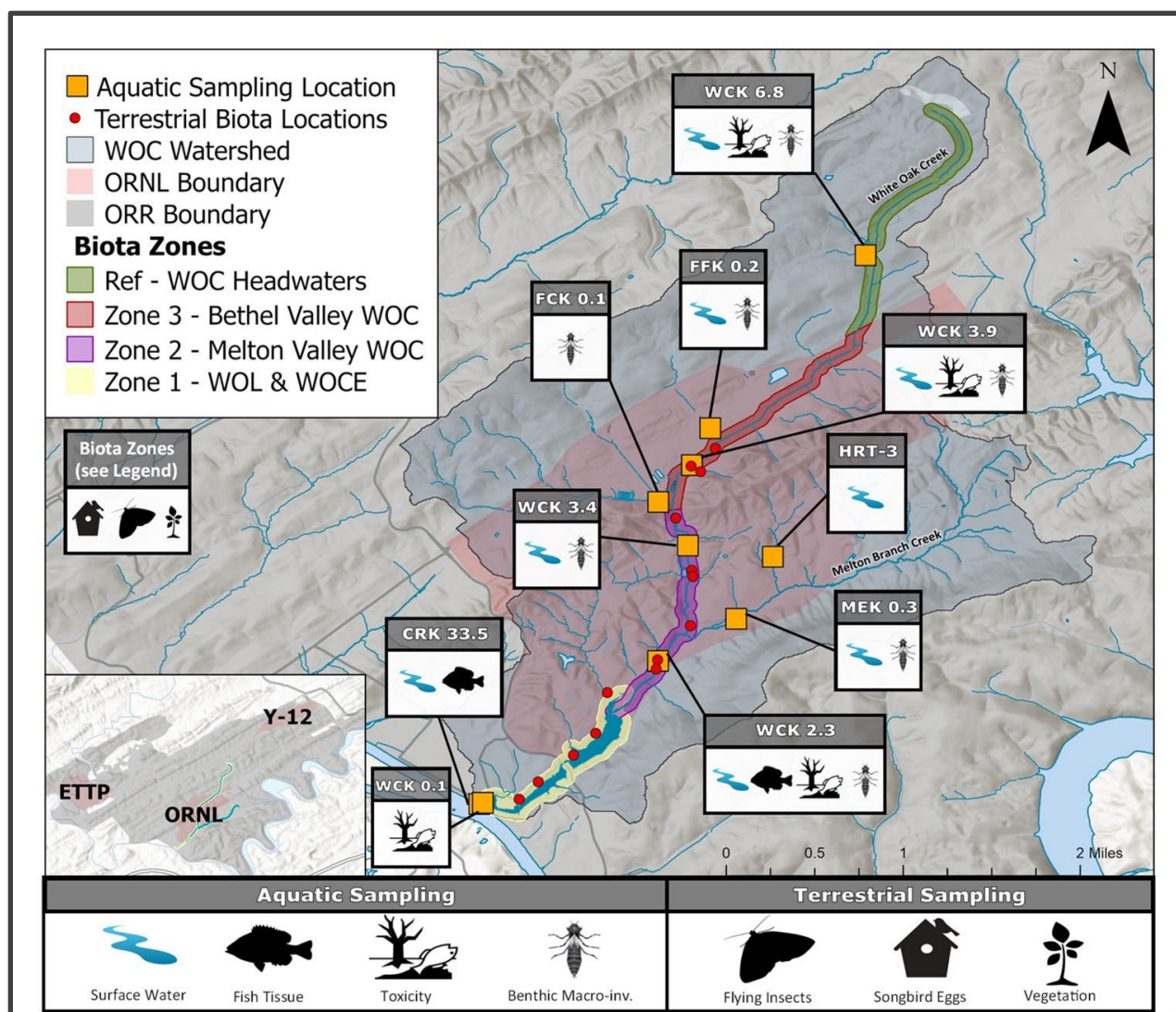


Figure 9.1.4.1: Phase 2 Sampling Sites

9.1.5 METHODS, MATERIALS, METRICS

Surface water samples were collected quarterly at multiple sites along WOC, its tributaries, and the confluence with the Clinch River. The most upstream site on WOC (WCK 6.8) was used as the reference stream site. Surface water samples from WOC were analyzed for Sr-90 and gamma radionuclides. For information about the WOC surface water sampling project, refer to the *White Oak Creek Radionuclides Surface Water* EMP in this document (Chapter 7.3).

Benthic macroinvertebrates were sampled in the spring of 2025 at seven (7) locations in the WOC watershed (Figure 9.1.4.1). For additional information, refer to the Benthic Macroinvertebrate sampling project section of this EMP document (Chapter 3.1). Samples collected from these sites assessed benthic community health, and a subset will be analyzed for Cs-137 and Sr-90.

Biota samples were collected within four specified biota zones in the WOCW (Figure 9.1.4.1) during the spring and summer of 2024 and in spring 2025 (flying insects). These zones are WOC Headwaters (reference), Bethel Valley WOC (Zone 3), Melton Valley WOC (Zone 2), and White Oak Lake (WOL) & White Oak Creek Embayment (WOE) (Zone 1). Flying insects collected in spring 2024 were sampled and analyzed for gross alpha/gross beta, gamma radionuclides, Sr-90, and tritium. For additional information, refer to the Contaminant Uptake in Biota section of this EMR (Chapter 3.3).

Table 9.1.6.1: Complete WOCAP Field Sampling and Analytes Plan

Media	<i>Surface Water</i>	<i>Toxicity & biomonitoring</i>	<i>Fish (DoR-OR)</i>	<i>Benthic Macroinvertebrates</i>	<i>Flying Insects</i>	<i>Songbird Eggs</i>	<i>Vegetation</i>	<i>Gamma Walk-Over</i>
<i>arsenic (As)</i>		X	X	X	X	X		
<i>mercury (Hg)</i>			X	X	X	X		
<i>low-level mercury (LLHg)</i>		X						
<i>methyl mercury (MeHg)</i>			X		X	X		
<i>cadmium (Cd)</i>			X					
<i>selenium (Se)</i>								
<i>uranium (U)</i>		X	X	X	X	X		
<i>polychlorinated biphenyls (PCBs)</i>			X		X	X		
<i>dioxins/furans</i>			X			X		
<i>strontium-89/90 (Sr-89/90)</i>	X	X	X	X	X	X	X	
<i>technetium-99 (Tc-99)</i>			X					
<i>alpha and beta activity</i>			X		X	X	X	
<i>gamma radionuclide activity</i>	X	X	X	X	X	X	X	X
<i>tritium (H-3)</i>		X		X	X	X	X	X
<i>isotopic uranium</i>		X	X		X	X	X	
<i>isotopic plutonium</i>			X					
<i>carbon-14 (C-14)</i>			X					
<i>polonium-210 (Po-210)</i>			X					
<i>biodiversity</i>				X				

Note: green indicates sampling that occurred for this FY25 report. Non-green sampling efforts planned for FY26. Empty boxes indicate no planned sampling.

9.1.6 DEVIATIONS FROM THE PLAN

Toxicity

An initial sampling event was attempted in September 2024. Heavy rain associated with Hurricane Helene created uncharacteristically high flow conditions in WOC. Since these were atypical conditions for the time of year, the sampling event was rescheduled for November 2024. However, surface water samples were collected for the first sampling day prior to the decision to reschedule. These samples were analyzed for potential COCs but not used for toxicity analysis. The data from the one sampling day in September are included in the results for surface water.

Fish Tissue

Fish were co-sampled with ORNL. Two (2) striped shiner samples were collected. Limitations in biomass for each sample allowed for only radionuclide analysis.

Gamma Walk-over

Gamma walk-over surveys will be conducted as part of the Phase 2b sampling, currently planned for the fall/winter 2025. These data are not discussed in this report. Identified areas of the WOC floodplain will be scanned for gamma radiation and isotopes identified in the soils. Gamma walk-over surveys will identify localized contamination in floodplain soils that are likely derived from stream sediments and likely to impact terrestrial ecological systems. Once hotspots have been identified, consideration will be given to the collection of soil samples for further analysis.

Other Supporting Projects

Discussions of deviations associated with other monitoring efforts supporting this holistic watershed assessment can be reviewed in the chapters reporting on those monitoring projects.

9.1.7 RESULTS AND ANALYSIS

Phase 2 sampling for the WOCAP will be completed across two Fiscal sampling years (FY25 – FY26). The sections below describe the results from the FY25 sampling year.

Toxicity & Biomonitoring

Surface water samples were collected for analysis of toxicity for *Ceriodaphnia dubia* (water flea) and *Pimephales promelas* (fathead minnow). Three (3) impacted sites were sampled as well as one reference site (WCK 6.8). The analysis for surface water samples included mercury, arsenic, uranium, gross alpha/beta, and radionuclides. PFAS and low-level PCBs were also evaluated for one sampling event. To determine whether surface water or effluent was causing acute or chronic toxicity, two statistical values are evaluated: IC25 and LC50. The Inhibition Concentration 25 (IC25) is a measure of chronic toxicity that causes a 25% reduction in a

biological function (often reproduction or growth). The Lethal Concentration 50 (LC50) is a measure of acute toxicity that results in the mortality of 50% of the test organisms.

The results values for IC25 and LC50 analyses are reported as percentages (%), indicating the relative concentration of collected surface water sample that will impact the test population at either 25% inhibition (IC25) or 50% mortality (LC50). For example, an IC25 result of 50% indicates that a 50% solution of collected surface water and control water will result in a growth inhibition of 25% of the test population, and thus ultimately indicates a **chronic toxic effect** of the collected surface water sample. An IC25 result of 100% indicates no chronic toxic effect of the collected surface water because a population in a water environment containing 100% of collected surface water does not have a 25% inhibition of growth.

The LC50 for minnows and water fleas indicated there were no acute toxic effects from the collected surface water samples.

Collected surface water samples did show some chronic toxic effects (IC25 below 100%) for both minnows and water fleas for some of the sampling events. Water fleas experienced chronic toxic effects for three of the four sampling events, but not at all sites (Figure 9.1.7.1.1). All toxic effects for water fleas impacted reproduction. IC25 values below 100% were observed for the July 2024 field event at WCK 2.3 and WCK 6.8, for the November 2024 sampling event at WCK 0.1, and for the February 2025 sampling event at WCK 6.8. The toxic effects for the July event were slight with IC25 values reported at 88.5% and 76.9% for WCK 2.3 and WCK 6.8, respectively. The toxic effects for the November and February field events were more severe. IC25 values were reported at 5.55% for WCK 0.1 in November and 3.31% for WCK 6.8 in February.

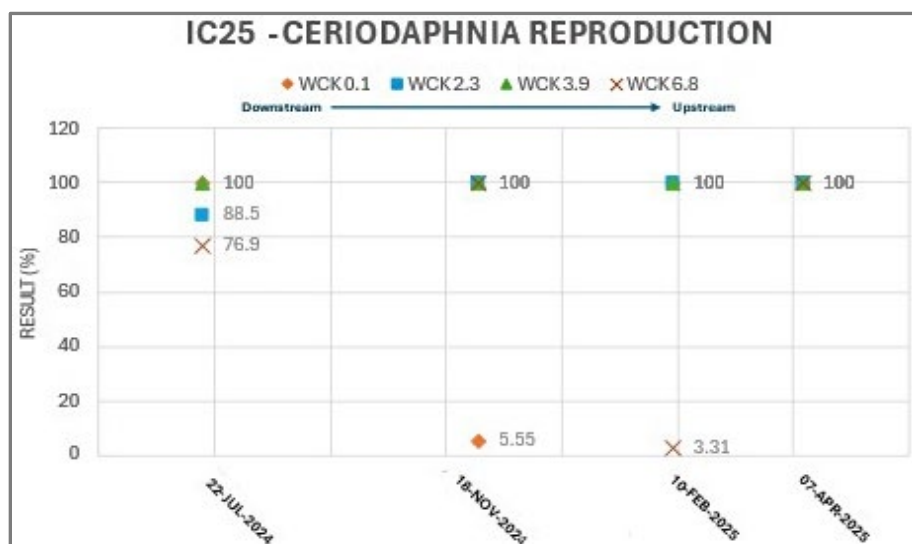


Figure 9.1.7.1: *Ceriodaphnia dubia* (water flea) IC25 for Reproduction

As shown in the plot below, minnows experienced chronic toxic effects for both survival and growth during two of the four sampling events, but not at all sites (Figure 9.1.7.2). IC25 values below 100% were observed for the November 2024 field event at WCK 2.3 and WCK 3.9; and for the April 2025 sampling event at WCK 0.1, WCK 2.3, and WCK 6.8. The toxic effects for the November event were driven by survival, though lesser impacts to growth were also observed, and were reported with IC25 values at 81.9% and 50% for WCK 2.3 and WCK 3.9, respectively. The toxic effects for the April field event were driven by growth, with some smaller impacts to survival as well, and were observed with more variability among effected sites. IC25 values were reported at 77.7% for WCK 0.1, 18% for WCK 2.3, and 39.1% for WCK 6.8.

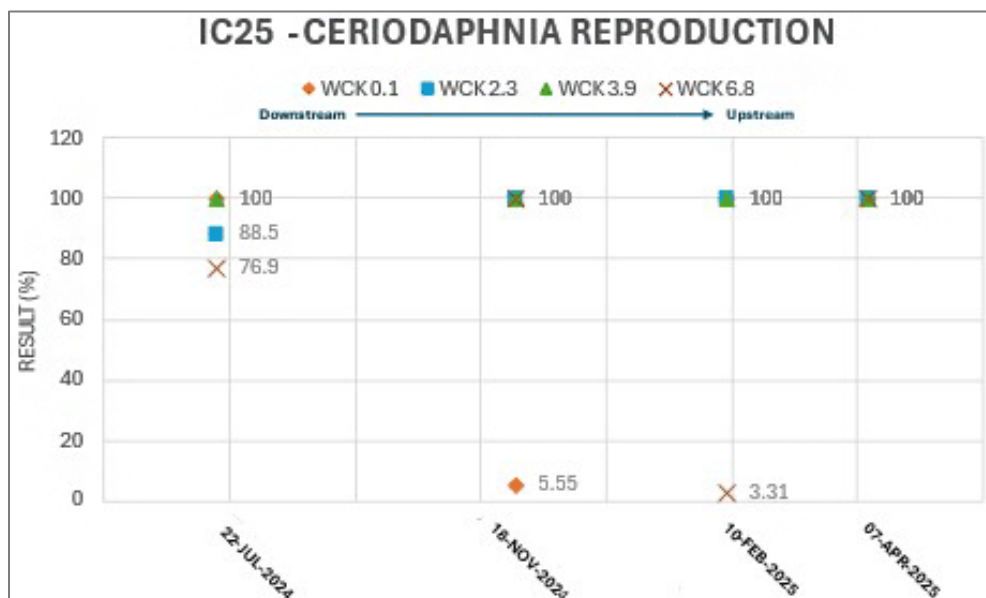
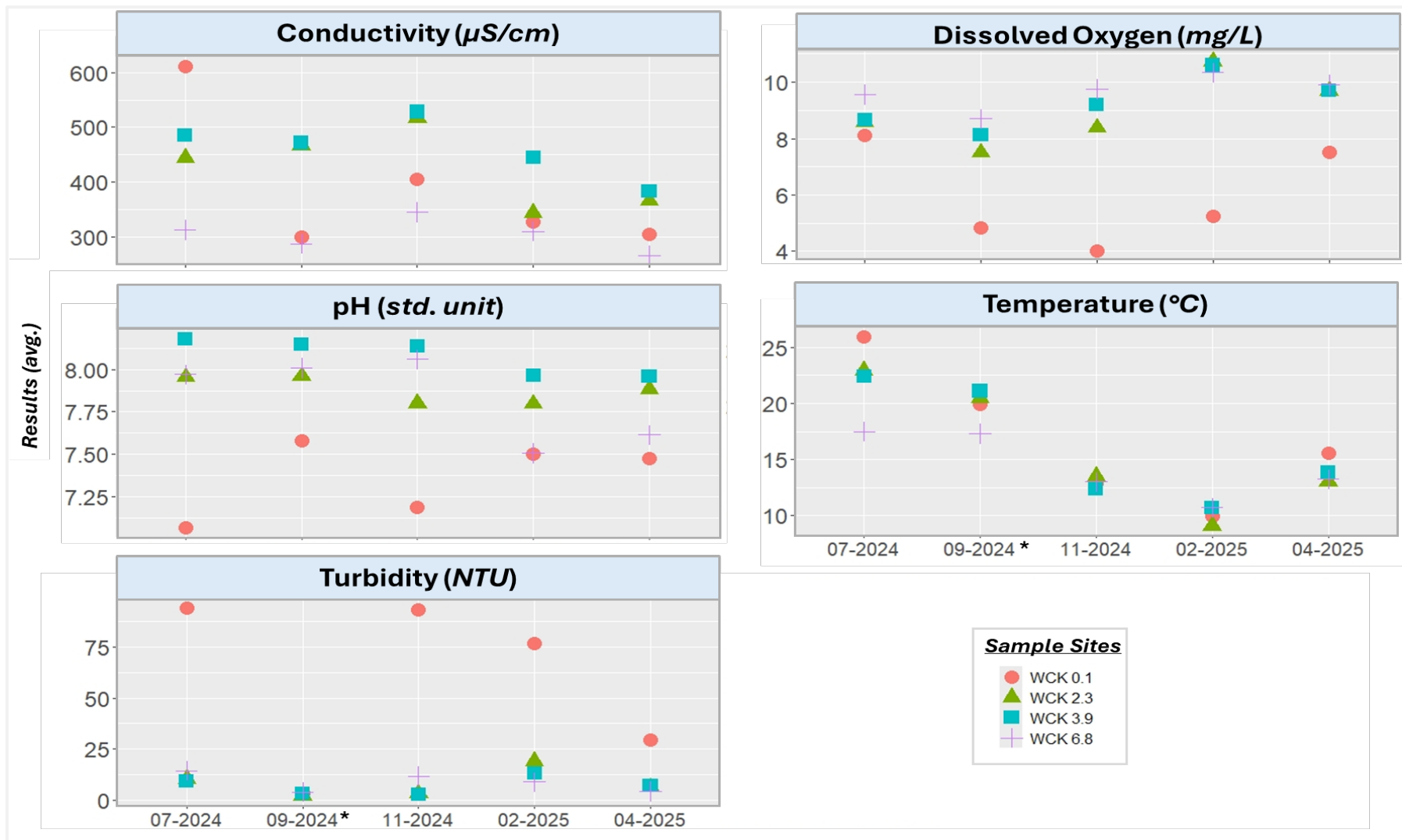


Figure 9.1.7.2: Fathead Minnow IC25 Survival and Growth.

SURFACE WATER PARAMETERS

Surface water parameters were monitored in conjunction with surface water sampling for toxicity. Parameter measurements were recorded for each sampling day during the sampling event (3 days) and averaged for the sampling event. The mean values are represented in Figure 9.1.7.1.3. The one exception was for the September 2024 sampling event; due to high rain events and elevated water levels in WOC, the sampling event was rescheduled to November. However, one surface water sample and associated parameters was collected at each field site. The September parameter measurements are represented in the below figure but represent a single measurement and not a mean.



Note: Results were averaged over the three sampling days for each site. WCK 6.8 is a reference site.

* - indicates a single sample collected after Hurricane Helene

Figure 9.1.7.3: Surface Water Parameters at WCK Toxicity Sample Sites.

CONDUCTIVITY

Specific conductivity is an indirect measurement of the concentration of dissolved ions in solution. Higher specific conductivity values can indicate more dissolved minerals, salts, or even contaminants in the water. Conductivity ranged from 234.4 $\mu\text{S}/\text{cm}$ to 615 $\mu\text{S}/\text{cm}$ across all sites. Impacted sites had higher conductivity than the reference site (WCK 6.8). Except for the July 2024 sampling event, conductivity from impacted sites increased from downstream to upstream, with WCK 6.8 having the lowest conductivity. The highest mean conductivity at WCK 3.9 was 528.3 $\mu\text{S}/\text{cm}$ in November 2024. WCK 0.1 had a mean conductivity of 610.5 $\mu\text{S}/\text{cm}$ in July 2024. Generally, conductivity measured higher in the fall (dry season) and lower in the spring (wet season).

DISSOLVED OXYGEN

Dissolved oxygen concentrations were lowest for WCK 0.1 and were generally highest at the reference site (WCK 6.8). February 2025 was an exception where dissolved oxygen concentration was highest at WCK 2.3. Dissolved oxygen measurements increased from downstream to upstream. Concentrations were also higher in the wet season (winter and spring) and lower in the dry season (summer and fall).

pH

pH value trends were similar to dissolved oxygen. Measurements were lowest at WCK 0.1 and highest at WCK 3.9. pH increased from downstream to upstream, generally, but all pH measurements ranged from 7.00 to 8.25. pH did not display any obvious seasonal or temporal trends.

TEMPERATURE

Temperature stayed relatively consistent across sites, showing no obvious spatial trend. In July and September 2024, WCK 6.8 was cooler than the impacted sites. However, temperature did display the expected temporal trends, warming from spring to summer and cooling through fall and winter.

TURBIDITY

The spatial trend for turbidity is largely obvious. WCK 0.1 had much higher turbidity than upstream sites. Generally, WCK 2.3, WCK 3.9, and WCK 6.8 did not vary in turbidity measurements, and all were relatively low. WCK 0.1 was the only site to display a potential temporal trend, with the higher turbidity in the surface waters measured for the summer and fall events and decreasing from the fall 2024 to spring 2025 sampling event.

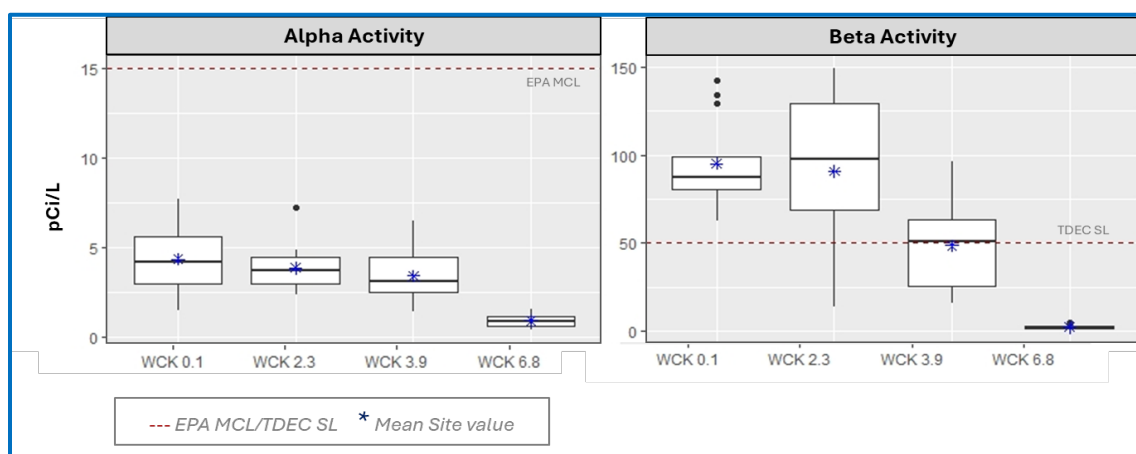
SURFACE WATER SAMPLES

In addition to parameter measurements, surface water samples were collected and analyzed

for a suite of potential contaminants.

Radionuclides

Gross alpha and gross beta emissions were measured for each collected sample (Figure 9.1.7.1.4). For both gross alpha and gross beta radiation, sites downstream on average had higher concentrations than sites upstream and averaged much higher than the reference site concentrations (WCK 6.8). While gross alpha measurements did not exceed the EPA MCL (EPA 2024) for alpha particle activity at any site, the impacted sites still measured at least 2x higher than the reference site. Similarly for gross beta activity, measurements at the impacted sites were recorded significantly higher than for the reference site. TDEC utilizes a 50 pCi/L screening level for gross beta in public water systems, above which additional sampling and analysis should occur (TDEC 2019b). This value will be used for comparison purposes as WOC empties into the Clinch River, which is a source for public drinking water. Concentrations for gross beta activity were much higher than gross alpha.



Notes: EPA MCL – EPA maximum concentration level, TDEC SL – TDEC Screening Level.

Figure 9.1.7.4: Surface Water - Gross Alpha/Beta Activity at Toxicity Sites (EPA 2024).

Of the several potential contaminants tested, only lead-210 (Pb-210), mercury (Hg), Perfluorooctanesulfonic acid (PFOS), strontium-90 (Sr-90), and tritium had some elevated results (Figure 9.1.7.5). Regulatory criteria vary by analyte and are thus listed and represented in the figure below (EPA 2024, RAIS 2025b, TDEC 2019). Except for PFOS, these analytes were measured multiple times for each site. PFOS was only measured for the November 2024 sampling event. Sample results are represented across all sampling events for each site. Pb-210 and Sr-90 consistently had values above regulatory criterion at multiple sites. While Hg, tritium, and PFOS generally had result values below the regulatory criteria across sites, there were some results above those criteria. Hg, Sr-90, and PFOS generally had higher concentrations downstream than upstream. While Pb-210 and tritium did not exhibit a clear spatial trend.

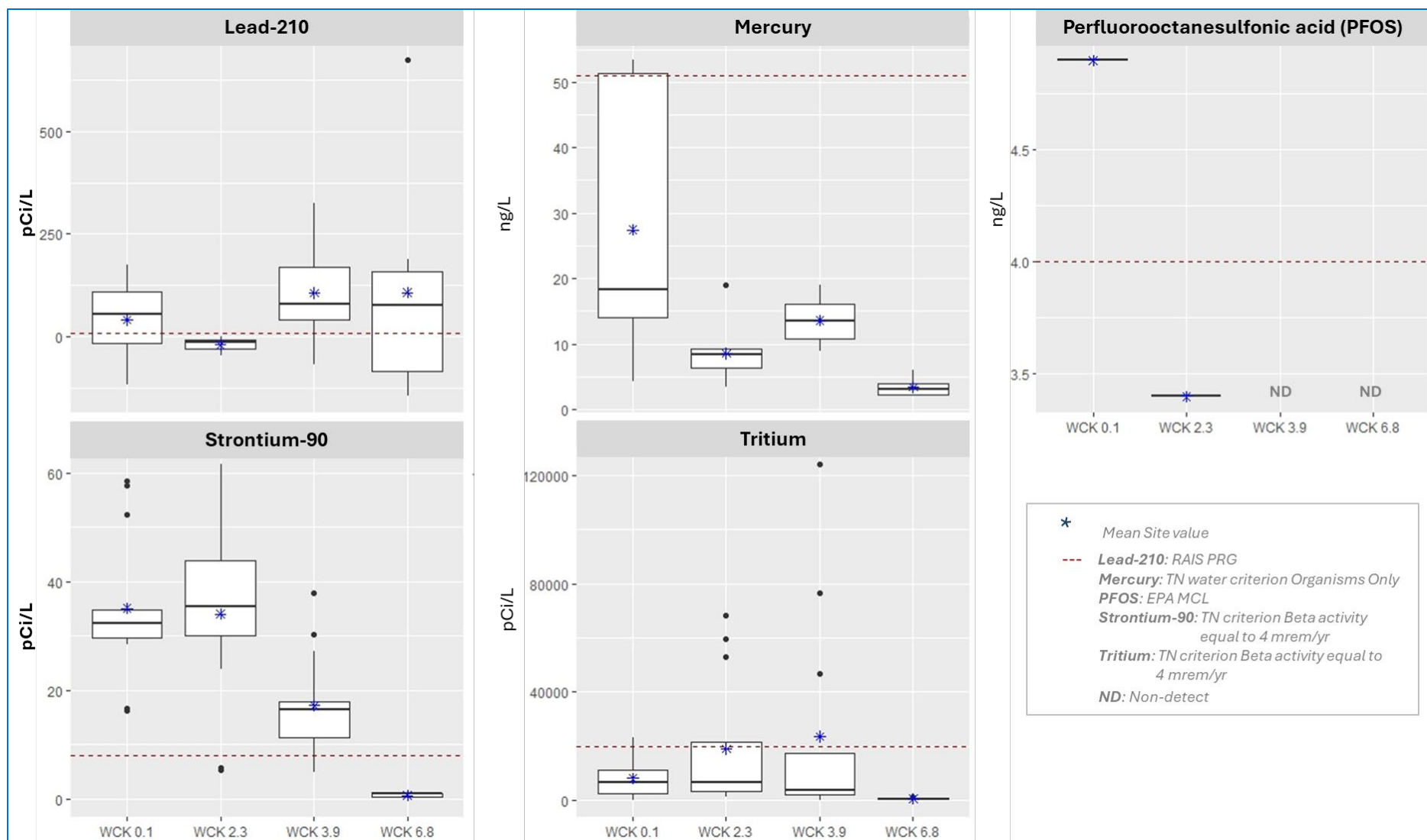


Figure 9.1.7.5: Radionuclide and chemical analytes in surface water collected for WCK toxicity sampling

Fish Tissue

Two (2) striped shiner fish samples were collected from WCK 2.7 and submitted for contaminant analysis. The two fish samples represented different size classes with Sample 1 representing larger fish, and Sample 2 represented smaller fish (Table 9.1.7.2.1). Each sample was composed of five (5) individuals which were composited and homogenized.

Table 9.1.7.1: WCK 2.7 - Metadata for Fish Tissue (Striped Shiner)

Sample ID	Number of Individuals	Average Length (cm)	Average Weight (g)
1	5	11.6	15.9
2	5	10.1	10.5

Each fish sample was analyzed for a suite of radionuclide contaminants. The results are represented in Table 9.1.7.2.2. Table 9.1.7.2.2 evaluates the analyzed results against PRGs generated from the ingestion of fish with a human health risk of 1×10^{-6} (RAIS 2025a). Several radionuclides were measured at concentrations higher than the PRGs.

(Continues on Next Page – Table 9.1.7.2)

Table 9.1.7.2: WCK 2.7 - Analytical Results for Fish Tissue

Analyte	Sample 1		Sample 2	
	Results $\pm$ CSU	MDC	Results $\pm$ CSU	MDC
Bismuth-212	----		0.519 $\pm$ 1.73	1.927
Carbon-14	1.34 $\pm$ 1.63	2.72	1.26 $\pm$ 1.36	2.25
Cesium-134	----		0.055 $\pm$ 0.158	0.166
Cesium-137	0.521 $\pm$ 0.158	0.139	0.637 $\pm$ 0.137	0.081
Gross Beta	8.73 $\pm$ 2.42	2.85	6.49 $\pm$ 1.73	1.96
Lead-212	0.061 $\pm$ 0.207	0.26	0.049 $\pm$ 0.208	0.26
Plutonium-239	0.008 $\pm$ 0.009	0.013	0.006 $\pm$ 0.005	0.003
Plutonium-240	0.008 $\pm$ 0.009	0.013	0.006 $\pm$ 0.005	0.003
Polonium-210	5.02 $\pm$ 1.15	0.288	0.045 $\pm$ 0.154	0.311
Potassium-40	3.12 $\pm$ 1.931	2.109	2.904 $\pm$ 1.607	1.823
Radium-226	0.078 $\pm$ 2.439	3.222	----	
Radium-228	----		0.095 $\pm$ 0.483	0.594
Strontium-89	0.96 $\pm$ 0.305	0.099	0.146 $\pm$ 0.22	0.139
Strontium-90	4.36 $\pm$ 0.817	0.0642	1.51 $\pm$ 0.293	0.0775
Technetium-99	0.205 $\pm$ 1.9	3.25	----	
Thorium-234	----		0.146 $\pm$ 3.825	5.101
Uranium-234	0.007 $\pm$ 0.012	0.024	---	
Uranium-235*	----		0.008 $\pm$ 0.014	0.011
Uranium-235**	----		0.372 $\pm$ 0.571	0.682
Uranium-235	0.004 $\pm$ 0.016	0.012	----	
Uranium-238*	----		0.011 $\pm$ 0.012	0.015
Uranium-238	0.001 $\pm$ 0.012	0.009	----	
Notes: measurements made in pCi/g wet weight ---- = no analysis of analyte requested * Analytical Method HSL-300 for Isotopic Uranium: ** Analytical Method EPA901.1 Gamma Spectrometry YELLOW analytes = results exceed Preliminary Remediation Goal (PRG) calculated for ingestion of fish with a risk of 1 ± 10^4				

Other WOCAP Projects' Results

BENTHIC MACROINVERTEBRATES (SEE CH. 3.1)

Results of the WOC benthic macroinvertebrate monitoring, calculated Tennessee Macroinvertebrate Index (TMI) scores, and associated biometrics are reported and discussed in the *Benthic Macroinvertebrate Community Health Project* section of this report.

BIOTA (SEE CH. 3.3)

Results of biomonitoring efforts to understand bioaccumulation of contaminants impacting the WOC watershed and impacts to terrestrial and riparian ecological receptors can be reviewed in the *Contaminant Uptake in Biota Project*, discussed in Ch. 3.3 of this report.

RAD UPTAKE IN VEGETATION (SEE CH. 3.6)

Radionuclide bioaccumulation in terrestrial vegetation was monitored in the WOC watershed. Results are reported in the *Rad Uptake in Vegetation Project* of this report.

SURFACE WATER SAMPLING (SEE CH. 7.3)

Surface water sampling was conducted to characterize stream conditions and assess contaminant presence throughout the WOC watershed. Results of these sampling efforts are reported in the *White Oak Creek Surface Water Project* section of this report.

9.1.8 CONCLUSIONS

Conclusions for results covered in other projects can be viewed within the specific project sections.

Toxicity and Biomonitoring

Toxicity in the surface waters in WOC was attributed exclusively to chronic toxic effects (IC25) and impacted minnow survival and growth more than water flea reproduction. Upstream sites showed higher levels of impact than downstream sites with some exceptions. The site level difference could be attributed to proximity to contaminant inputs (sites more upstream are closer to contaminant inputs) or to general stream characteristics. WCK 0.1 is located at the confluence of WOC and the Clinch River (CR). This location is characterized by deeper, slower moving waters which are likely to dilute contaminants than sites with lower volumes of water.

Interestingly, the reference site (WCK 6.8) was the only site in February 2025 that had an IC25 below 100% for both *Ceriodaphnia* and fathead minnows, and the IC25 value for *Ceriodaphnia* was very low at 3.31%. This result suggested that even a low concentration of a contaminant in the water at the reference site had an impact on water flea reproduction during that time. Surface water samples collected from WCK 6.8 for the Ambient Surface Water project (Section 7.2 in this report) returned elevated cyanide concentrations in March 2025. It is possible these elevated cyanide conditions were also present during February and could have impacted toxicity during this time. WCK 6.8 is used as a reference site because it is located upstream of inputs from the ORNL campus. However, it is located downstream of the Spallation Neutron Source (SNS) at ORNL. It is possible that WOC received inputs further upstream from WCK 6.8

that could have temporarily impacted toxicity levels in the creek. Determination of the source of contaminants (like cyanide) and determination of the precise cause of toxicity change would warrant further investigation.

Surface water parameters and contaminants were also analyzed. While most contaminants were measured at low levels below regulatory criteria, there were some that were measured at higher concentrations that could impact water quality parameters and/or toxicity. Turbidity was higher at WCK 0.1, which could have greater potential for contaminants to bind and settle into sediments. Additionally, conductivity was higher at sites further upstream and closer to contaminants, suggesting a potential for increased ion activity at these sites.

Fish Tissue

While there are no specific regulatory limits for radionuclide contaminants in fish defined in the current CERCLA RODs, Preliminary Remediation Goals (PRGs) can be used for comparison. These PRGs are generated based off a human health risk associated with consumption of fish, whereas the striped shiners were analyzed as a whole-body sample which is typically used for ecological risk. However, the PRGs are still valuable as a comparison for general ingestion. Striped shiners represent forage fish that are lower in the food chain. As such, they are more likely to bioaccumulate potential contaminants from their food sources or incidental ingestion of sediments. The striped shiner samples showed bioaccumulation of radionuclides with several samples at concentrations higher than the PRGs. Bioaccumulation of radionuclide contaminants at these lower trophic levels have the potential to pass contaminants to organisms higher in the food chain or to people through the ingestion of predatory fish species (e.g., bass).

9.1.9 RECOMMENDATIONS

Based on the holistic data compilation above plus the upcoming remedial actions at ORNL, there is potential for the release of legacy contaminants from WOC and COC infiltration into WOC that could migrate through the watershed. Future flooding events at remedial and construction sites might deposit new contaminated layers of sediment on top of soils. This deposition could potentially increase COCs in soils. Newly contaminated floodplain soils could result in elevated human risk and ecological impacts. Considering the bioaccumulation of contaminants within biota communities and potential toxicity impacts, holistic environmental sampling is recommended periodically to monitor the WOC watershed until future remedial actions for all media are established.

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APPENDICES: CONTRACTUAL SAMPLING OUTSIDE TDEC'S FY25 SCOPE

Sampling and monitoring efforts are sometimes conducted outside the scope of the EMR, with the support of TDEC's contractor, in response to new information, to assist in the State's required independent oversight, or to evaluate the effectiveness of completed remedies. During FY25 this work included effluent sampling at the Beta-1 water treatment system and Alpha-2 water quality sampling at Y-12, vegetation and environmental media sampling at the Filled Coal Ash Pond in Chestnut Ridge, and 1,4-dioxane sampling at ETPP.

(Continues on Next page – Appendix A)

APPENDIX A: BETA-1 BLDG. WATER TREATMENT SYSTEM EFFLUENT SAMPLING

A.1 BACKGROUND

Beta-1 is a large former uranium enrichment facility at the Y-12 National Security Site. Over time, groundwater has seeped into the basement resulting in complete flooding of contaminated water in the basement. In preparation for the demolition of Beta-1, this water must be removed. A mobile treatment system was installed to treat and discharge this water to Upper East Fork Poplar Creek. Due to persistent water infiltration and schedule constraints, a second (auxiliary) mobile treatment system was installed to operate synonymously with the original. The sample was taken from the auxiliary mobile treatment unit on the east side of the Beta-1 facility (noted as the red dot below).

A.2 SCOPE

TDEC collected a sample from the auxiliary mobile treatment system to analyze treatment efficiency for PCBs. The state conducted this sampling to verify compliance with water quality standards as the DOE's selected PCB sampling methodology is not sufficiently sensitive to verify compliance of PCBs.



Figure A.2.1: Beta-1 Outfall (OF) into Upper East Fork Poplar Creek

A.3 SAMPLING SUMMARY

TDEC sampled the treated wastewater effluent on June 24, 2025. The sample was tested by Eurofins using EPA Method 1668A as this method has a MDL less than the state's PCB water quality standard of 0.00064 µg/L.

A.4 RESULTS

Total PCB concentration in the effluent was 0.0005 µg/L (6/24/2025), which is below the state's water quality standard.

APPENDIX B: ALPHA-2 CLSM RELEASE INTO EAST FORK POPLAR CREEK (EFPC)

B.1 BACKGROUND

On October 1, 2024, DoR-OR was informed of an incident involving controlled low-strength material (CLSM) entering the East Fork Poplar Creek (EFPC) through a pipeline connected to Alpha-2. UCOR inserted CLSM into the basement of the Alpha-2 building as part of its demolition when the material reached the creek, causing discoloration and an observed fish kill.

That same day, DoR-OR conducted a site visit to the CLSM spill site at EFPC near Alpha-2. CLSM was observed at the bedrock of the stream near Outfall 48, where the water level was significantly lower than usual. A thick layer of CLSM was present within the UEFPC channel. Rocks downstream were covered with a gray “dusting,” and other visual impacts were noticeable. No CLSM was observed upstream of Outfall 48. Additionally, Outfalls 14, 16, and Station 17 appeared to have higher turbidity than usual based on visual observations.

B.2 SCOPE

To assess the impact of the CLSM spill on water quality in EFPC, TDEC sampled the stream on October 1, 2024, the same day as the CLSM spill. Water quality measurements were taken at four locations downstream of the CLSM spill: Outfall 48-D, Outfall 41-B, Outfall 16, and Station 17 (Fig. B.1). In addition, a surface water grab sample was collected at Outfall 48-D, immediately adjacent to the spill, during the site visit.



Figure B.2.1: Location of Surface Water Sampling & Water Quality Parameter Survey

B.3 SAMPLING SUMMARY

Measured water quality parameters included temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), and conductivity. The surface water grab sample was analyzed for mercury, chloride, and sodium. Laboratory analysis was conducted by PACE, with mercury analyzed using Method 7470A, chloride using Method 9056A, and sodium using Method 6010B.

B.4 RESULTS

Mercury, the primary CERCLA contaminant of concern, was measured below the TN Aquatic Life Fresh Water Criterion Maximum Concentration (CMC) and Criterion Continuous Concentration (CCC). Chloride and sodium, components of CLSM, are not included in either the CCC or the CMC regulatory limit list.

Table B.4.1: Surface Water Chemistry Results at Outfall 48-D

Site	Analytes	Results	Unit
Outfall 48-D	Chloride	34.8	mg/L
	Mercury	0.109 J	ug/L
	Sodium	24.8	mg/L
J: Estimated between method detection limit (MDL) and method quantitation limit (MQL)			

Table B.4.2: EFPC Water Quality Parameters

Site	Temperature (°C)	DO (mg/L)	ORP (mv)	pH (STD Unit)	Conductivity (µS/cm)
Outfall 48-D	23.6	7.16	161.1	8.11	636
Outfall 41-B	23.8	7.22	112.5	8.72	532
Outfall 16	23.7	7.3	152.4	9	505
Station 17	22.5	8.69	184.8	8.54	455

APPENDIX C – FILLED COAL ASH POND (FCAP) SAMPLING

C.1 BACKGROUND

The Filled Coal Ash Pond (FCAP) on Chestnut Ridge was a settling basin for coal ash generated at the Y-12 Steam Plant; it was capped and remediated under CERCLA to prevent coal combustion residuals and associated contaminants from continuing to discharge into Rogers Quarry and to protect human health and the environment. A primary component of selected CERCLA remedy was an engineered wetland. The FCAP wetland is used as a passive treatment system to treat leachate from the coal ash retention pond through a subsurface drainage system. This wetland, located at the base of the dam that was constructed to create the pond, discharges to Upper McCoy Branch and Rogers Quarry.

The *2016 Five-Year Review* identified reduced arsenic uptake through the wetland system due to channelization around the edges of the wetland and invasive plants displacing the cattails which are utilized for the uptake of arsenic and other metals. Work was concluded in 2019 to restore the flow in the wetland and the cattail community.

C.2 SCOPE

TDEC contracted CEC to conduct additional sampling of the FCAP engineered wetland treatment system following a focused sampling effort, led by TDEC in FY24 and reported in the FY24 TDEC Environmental Monitoring Report, that produced results suggestive of seasonal differences in treatment system efficacy. To further understand the potential for seasonal changes in effectiveness, a second sampling effort was completed.

C.3 SAMPLING SUMMARY

Sampling was conducted in 2024 by CEC at the FCAP wetland treatment system. Additional sampling was needed to allow for comparison to previous sampling conducted by TDEC to determine if seasonal die off of cattails is increasing overall COC loading to the wetland. One sample each of vegetation, sediment, and surface water was collected in October. Samples were analyzed for Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Fluoride, Lead, Lithium, Mercury, Molybdenum, Selenium, Thallium, Radium-228, and Radium-226. The tables below present the results from the sampling event.

C.4 RESULTS

METALS

Table C.4.1: Metal Analysis Results for FCAP Samples

Metals	Water (mg/l)	Sediment (mg/kg)	Vegetation (mg/kg)
	10/14/2024	10/14/2024	10/14/2024
Antimony	U	U	U
Arsenic	0.0244	76.5	41.2
Barium	0.073	52	71.8
Beryllium	0.000221 J	0.569	0.997
Cadmium	U	0.190 J	U
Chromium	U	10	23
Cobalt	0.00556	15.1	32.9
Fluoride	U	U	U
Lead	0.00425	11.7	27.8
Lithium	0.0426	11.4	26.1
Mercury	U	0.0808	U
Molybdenum	0.000625 J	2.2	5.18
Selenium	0.000563 J	3.5	8.62
Thallium	U	U	U
<i>U: Not detected at the Reporting Limit (or Method Detection Limit where applicable)</i>			
<i>J: The identification of the analyte is acceptable; the reported value is an estimate.</i>			

RADIONUCLIDES

Table C.4.2: Radionuclide Analysis Results for FCAP Samples

	Water (pCi/l)	Sediment (pCi/g)	Vegetation (pCi/g)
	10/14/2024	10/14/2024	10/14/2024
Actinium-228 (Ra-228)	-	0.643 J	0.0250 U
Bismuth-214 (Bi-214)	-	1.11	0.0302 U
Radium-228	0.0515 U	-	-
Radium-226	0.0777 U	-	-
<i>U: Not detected at the Reporting Limit (or Method Detection Limit where applicable)</i>			
<i>J: The identification of the analyte is acceptable; the reported value is an estimate.</i>			

APPENDIX D – ETPP MAIN PLANT AREA GROUNDWATER 1,4-DIOXANE SAMPLING

D.1 BACKGROUND

EPA METHOD 8270 SIM

Prior to development of the Remedial Investigation Work Plan (RIWP) for the ETPP Main Plant Area Final GW ROD, DOE proposed and performed in FY25, pre-RIWP groundwater sampling of approximately 110 monitoring wells at ETPP. The purpose of that sampling was to obtain current groundwater data from the existing monitoring wells in the area. As part of that DOE led analytical testing, DOE analyzed the samples for VOCs using EPA Method 8260B, which included 1,4-dioxane. TDEC requested that DOE consider the use of low level 1-4 dioxane sampling methodology. TDEC selected several wells based on screen intervals, location of past operations, and inferred plume locations. DOE was unable to accommodate that request. As such, TDEC requested to co-sample the selected wells, with the intent of evaluating 1-4 dioxane concentrations at those locations using the more sensitive EPA 8270 SIM method. The final list of wells that TDEC co-sampled with the DOE is included in the table below.

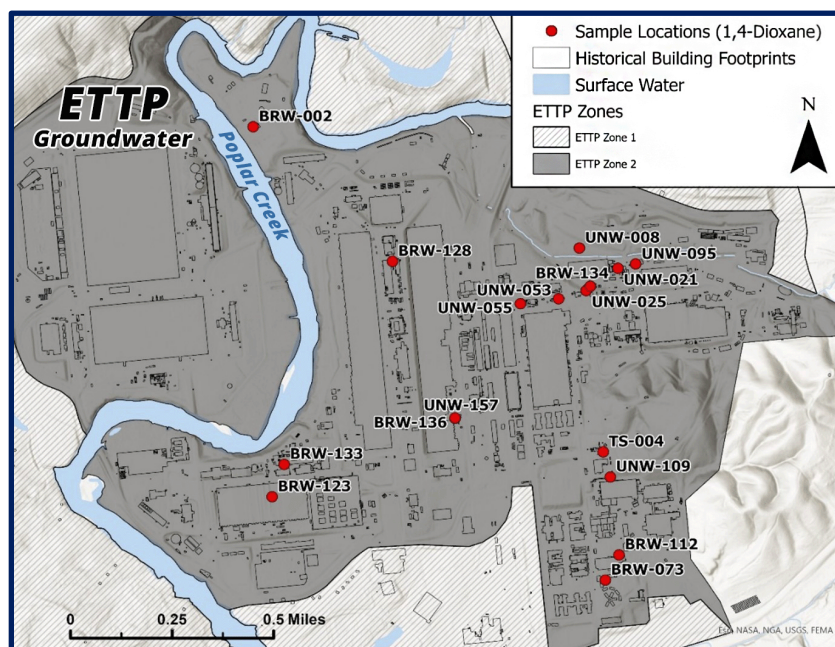


Figure D.1.1: ETPP Zone 1 Main Plant Groundwater Sampling

D.2 SCOPE

The scope of investigation was to collect water samples at eighteen (18) selected locations. The DOE conducted the purging and sampling of each well in accordance with their standard operating procedures (DOE PROC-ES-2101). Once each of the wells were purged, TDEC co-sampled one bottle of water for analysis of 1,4-dioxane using EPA Method 8270 SIM M Isotope Dilution.

D.3 SAMPLING SUMMARY

Between December 4 and December 18, 2024, TDEC co-sampled 18 groundwater wells with the DOE.

D.4 RESULTS

1,4-Dioxane was detected at concentrations ranging from non-detect to 32.4 µg/L. 1,4-Dioxane results from TDEC's co-samples are summarized in the table below.

Table D.4.1: ETPP Groundwater Sampling Results for 1,4-Dioxane

ETPP Split Sampling Results Summary for 1,4-Dioxane			
Well Number	Sample Date	* (µg/L)	Qualifier
BRW-002	12.09.2024	< 0.30	
BRW-073	12.13.2024	< 0.30	
BRW-112	12.10.2024	1.84	
BRW-123	12.16.2024	15.0	B
BRW-123	12.16.2024	2.48	Q
BRW-128	12.09.2024	0.93	
BRW-133	12.10.2024	1.25	
BRW-134	12.13.2024	2.83	
BRW-136	12.10.2024	0.33	J
DPT-K1070-4	12.15.2024	32.4	
TS-004	12.16.2024	17.5	B
TS-004	12.16.2024	7.34	Q
UNW-008	12.18.2024	1.78	B
UNW-008	12.18.2024	< 0.315	Q
UNW-021	12.04.2024	< 0.309	
UNW-025	12.04.2024	8.28	
UNW-053	12.18.2024	3.60	B
UNW-053	12.18.2024	< 0.30	Q U
UNW-055	12.04.2024	<0.309	
UNW-095	12.16.2024	4.86	B
UNW-095	12.16.2024	0.89	Q
UNW-109	12.18.2024	0.95	B
UNW-109	12.18.2024	< 0.30	Qu
UNW-157	12.13.2024	0.34	J
* Lab reported data in mg/L, converted to µg/L for this table. B = Analyte detected in method blank; Q = analyzed past hold time; J = estimated value			

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