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East Tennessee Technology Park Biological Monitoring and Abatement Program—2023 Fiscal Year Report



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September 2023

OAK RIDGE National Laboratory

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Environmental Sciences Division

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

BMAP	Biological Monitoring and Abatement Program
CRM	Clinch River mile
DO	dissolved oxygen
EPA	US Environmental Protection Agency
ETTP	East Tennessee Technology Park
MIK	Mitchell Branch kilometer
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCB	polychlorinated biphenyl
PCM	Poplar Creek mile
SD	Storm Drain
TDEC	Tennessee Department of Environment and Conservation
TDS	total dissolved solids
UCOR	United Cleanup Oak Ridge LLC
WRRP	Water Resources Restoration Program

1. INTRODUCTION

In FY 2023, the East Tennessee Technology Park's (ETTP's) Biological Monitoring and Abatement Program (BMAP) consisted of two tasks that reflected different but complementary approaches to evaluating the effects of ETTP effluents on the ecological integrity of waters near ETTP. These tasks included (1) fish and clams bioaccumulation monitoring and (2) fish and benthic macroinvertebrate species richness and density monitoring. The sampling and analysis requirements for the ETTP BMAP in FY 2023 are outlined in the sampling and analysis plan (UCOR 2023). Major sampling sites for the BMAP are shown in Figure 1 and Figure 2.

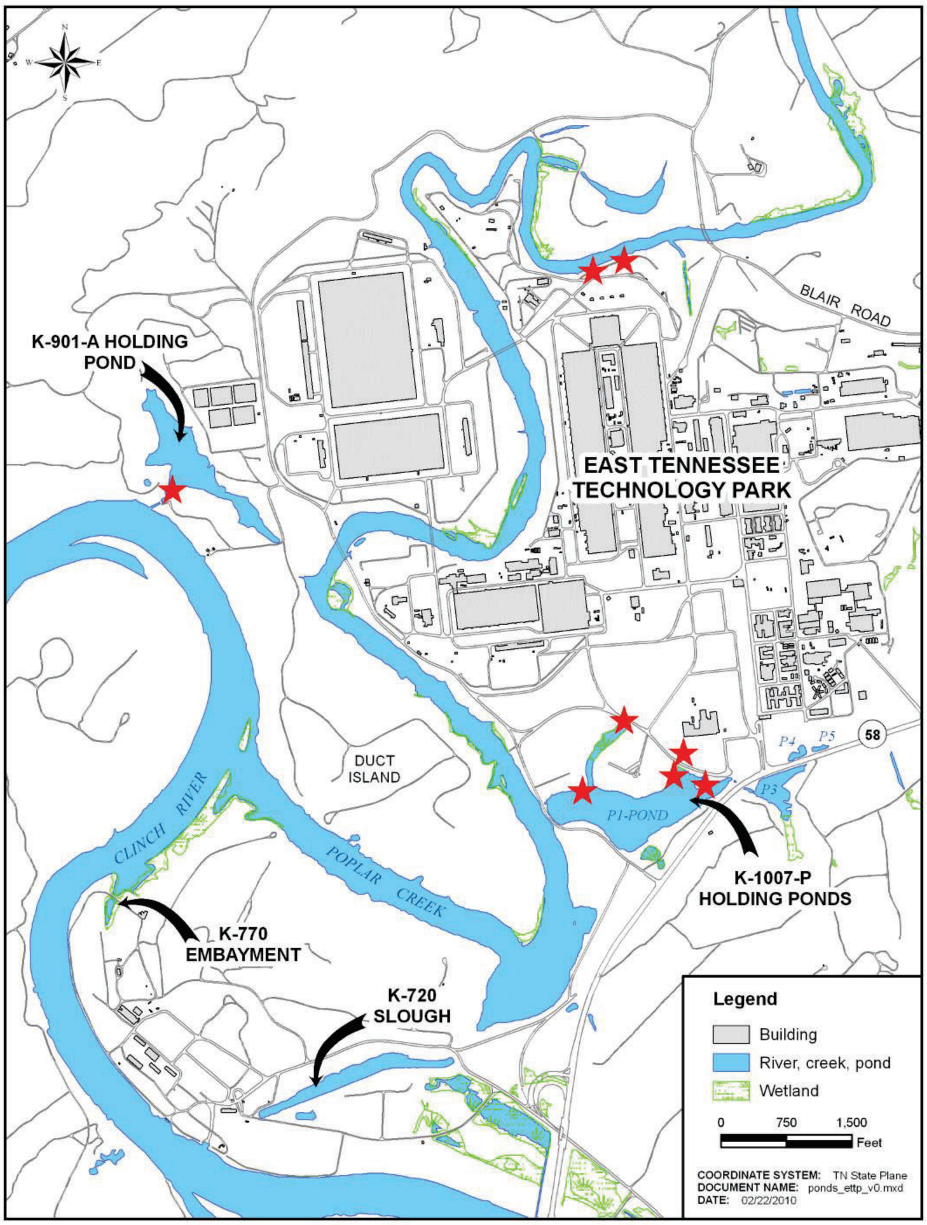

Figure 1. Map showing the major aquatic environments around the East Tennessee Technology Park. FY 2023 clam sampling locations are marked with a star (★).

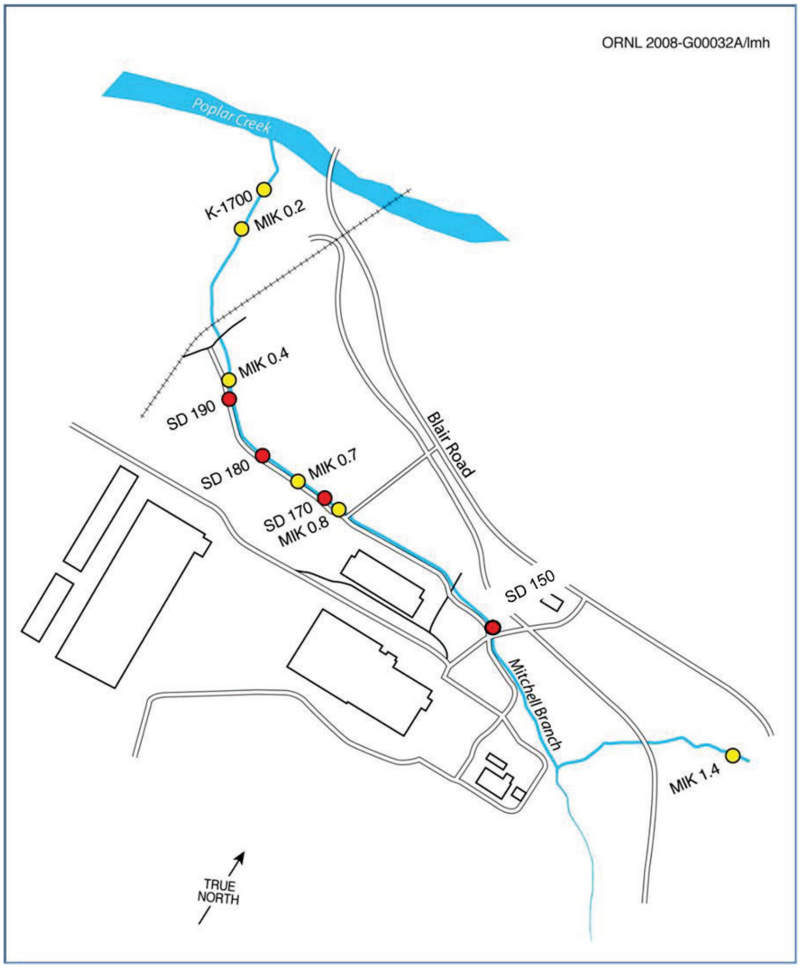

Figure 2. Map of Mitchell Branch showing the locations of routine biological monitoring sites in relation to select storm drains.
MIK = Mitchell Branch kilometer; SD = Storm Drain.

The 2023 fiscal year report for the ETTP BMAP presents the results of biological monitoring in FY 2023. A more detailed evaluation of monitoring trends will be provided in the 2023 calendar year report, due in January 2024.

2. TASK 1: BIOACCUMULATION MONITORING

Polychlorinated biphenyls (PCBs), once widely used in commercial and industrial applications, have been banned from production in the United States since the 1970s. However, PCBs persist in the environment because of their resistance to degradation and their tendency to bioaccumulate; they are still found at elevated concentrations in fish caught from ETTP waters. Additionally, in recent years, Hg has been found in ETTP storm drain waters at higher than background concentrations, and Hg concentrations in fish collected in Mitchell Branch and Poplar Creek are also elevated.

As part of the bioaccumulation monitoring task of the ETTP BMAP, contaminant concentrations in resident fish and caged clams have been evaluated to assess potential human health concerns, identify sources of contaminants to the watershed, and evaluate changes in contaminant exposure over time at ETTP. Resident fish from Mitchell Branch, the K-1007-P1 Pond, and the K-901-A Pond at ETTP have been collected annually for many years. Although the pond sites, including the K-1007-P1 Pond, K-901-A Pond, and K-720 Slough, are now monitored as part of the United Cleanup Oak Ridge LLC (UCOR) Water Resources Restoration Program (WRRP), results are included here for consistency with past years. Clams have also been used for many years in bioaccumulation monitoring at ETTP. They are collected from a reference site and placed in cages at strategic locations throughout ETTP surface waters. Because clams efficiently accumulate contaminants and remain sedentary in their cages for short exposure periods, they are used to evaluate contaminant exposure at a given site. In this way, potential contaminant sources can be identified, and site-specific changes in contaminant exposure can be evaluated.

For contaminants such as Hg and PCBs, water quality guidelines often include both aqueous and fish tissue guidelines because the greatest dose of such bioaccumulative contaminants is often through dietary, rather than aqueous, exposure. In Tennessee, assessments of watershed impairment and public fishing advisories are based on fish tissue concentrations. Currently, Tennessee's Ambient Water Quality Criteria are 51 ng/L for aqueous Hg and 0.64 ng/L for aqueous PCBs in waters designated for recreational use (Tennessee Department of Environment and Conservation 2011). The US Environmental Protection Agency's (EPA's) National Recommended Water Quality Criterion for Hg is 0.3 μg/g in fish fillets, and this value is often adopted for state guidelines for Hg in fish. In Tennessee, the fish advisory concentration is also 0.3 μg/g in fish fillets. However, guidelines for safe levels for PCBs in fish are less consistent. Using standard risk assessment assumptions, EPA recommends fish consumption limits when PCB values are between 0.05 and 0.1 μg/g, whereas the US Food and Drug Administration prohibits the sale of fish across state lines when PCB levels reach 2 μg/g (20 times higher than EPA limits). Because much depends on the assumptions used in the risk analysis, states have addressed the potential PCB risks associated with fish in very different ways.

In Tennessee, the US Food and Drug Administration PCB limit of 2 μg/g in fish fillets was historically used for advisories, and then for many years, an approximate range of 0.8 to 1 μg/g was used, depending on the data available and factors such as the fish species and size. The remediation goal for fish fillets at the K-1007-P1 Pond is 1 μg/g, and the remediation goal for whole-body fish in this pond is 2.3 μg/g. Most recently, the water quality criterion has been used to calculate the fish tissue concentration triggering impairment and a total maximum daily load (Tennessee Department of Environment and Conservation 2007); this concentration is 0.02 μg/g in fish fillets (Tennessee Department of Environment and Conservation 2010a, b, c). All average fish fillet concentrations near ETTP well exceed the 0.02 μg/g level. Fish PCB concentrations in Poplar Creek, the Clinch River arm of Watts Bar Reservoir, and Mitchell Branch are designated as impaired by the Tennessee Department of Environment and Conservation (TDEC) in the 2012 303(d) list, a compilation of streams and reservoirs that need additional pollution controls (Tennessee Department of Environment and Conservation 2014).

This report provides tabulated bioaccumulation data from FY 2023; long-term trends in Hg and PCB concentrations in ETTP fish will be provided in the 2023 calendar year report.

2.1 FISH

In 2023, the target species for bioaccumulation monitoring in the K-1007-P1 Pond was bluegill sunfish (*Lepomis macrochirus*). After largemouth bass (*Micropterus salmoides*) and other larger and longer-lived fish species were removed from this pond in 2009, the pond was restocked with bluegill because their small size and short life spans make them less susceptible to PCB bioaccumulation. Whole-body samples (6 composites of 10 fish) and fillets from 20 individual bluegill were analyzed for PCBs to assess the ecological and human health risks associated with PCB contamination in the K-1007-P1 Pond.

In 2023, as in previous years, the target fish species for analysis of PCBs in the K-901-A Pond and K-720 Slough included gizzard shad (*Dorosoma cepedianum*) and largemouth bass, but bluegill were also collected from the K-901-A Pond for fillet and whole-body analysis for direct comparison to concentrations in the K-1007-P1 Pond. The target number of bass from each body of water (i.e., 20) could not be collected. Therefore, common carp (*Cyprinus carpio*), which are widely distributed and have been used historically in other monitoring efforts on the Oak Ridge Reservation (ORR) for contaminant analyses, were also collected to augment sample size. In total, 1 common carp (4,900 g) was collected from the K-901-A Pond. In total, 12 bass (153.3–1,810.3 g) and 8 carp (2,800–7,460 g) were collected from the K-720 Slough. Additionally, bluegill and gizzard shad were collected from off-site locations—Clinch River mile (CRM) 11 and Poplar Creek kilometer (PCM) 1—for comparison.

Table 1 lists average concentrations of total PCBs and total Hg in muscle fillets from fish collected in 2023 near ETTP and Hinds Creek, a reference stream. In 2023, mean fillet and whole-body PCB concentrations in bluegill collected from the K-1007-P1 Pond were again below the targets for this pond. Mean PCB concentrations in fillets in the K-1007-P1 Pond were 0.23 µg/g, significantly lower than concentrations seen in 2022 and below the remediation goal for this pond (1 µg/g total PCBs in fillets). Mean concentrations in whole-body bluegill were 0.99 µg/g, also lower than concentrations seen in 2021 and below the remediation target for this pond (2.3 µg/g in whole-body composites). The whole-body concentration in 2023 in the K-1007-P1 Pond (0.99 µg/g) was also lower than the 1 µg/g remediation target for fillets.

At the K-901-A Pond, it was not possible to collect the target number of any species of fish for fillets or whole-body samples. Plantings in this pond have been so successful and have covered so much of the habitat that maneuvering the sampling boat to collect fish was not possible. The plants are attaining the goals for water quality in this pond, as well; water clarity was extremely high, making sampling even more difficult. Though the target number of fish were not collected, the samples collected (12 bluegill and 1 carp) show concentrations that are significantly lower than in previous years. Mean total PCB concentrations in bluegill fillets also decreased significantly, from 0.42 µg/g in 2022 to 0.05 µg/g in 2023. Concentrations in fish fillets from the K-720 Slough in 2023 were low and similar to those seen in 2022.

The mean PCB concentrations in sunfish (0.59 µg/g) from Mitchell Branch in 2023 were lower than concentrations in 2022 (0.72 µg/g) but were comparable to concentrations seen in recent years. Mean Hg concentrations in Mitchell Branch sunfish fillets (0.37 µg/g) in 2023 were comparable to concentrations seen in the past two years, remaining above EPA’s fish-based recommended ambient water quality criterion for Hg (0.3 µg/g). Long-term trends in Mitchell Branch fish will be evaluated and discussed in the calendar year report.

Also shown for reference are PCB, Hg, and ^{137}Cs values for bass and catfish species collected in FY 2022 from off-site reservoir locations near or downstream of ETTP, listed in Table 2. These sampling and data analyses were conducted by the US Department of Energy's Oak Ridge National Laboratory (ORNL) Environmental Sciences Division in support of the UCOR WRRP. Mercury in fish data from the reservoir and other nearby sites collected in 2023 for other programs are not yet available but (as was the case last year) will be presented in the ETTP BMAP 2023 calendar year report.

Table 1. Average concentrations (µg/g, wet weight) of total PCBs (Aroclors 1248, 1254, and 1260) and total Hg in muscle fillets from fish collected in 2023 near ETTP and Hinds Creek, a reference stream. Also listed are the ranges of values observed for PCBs and the fraction of fish whose PCB concentrations exceeded remediation targets for the K-1007-P1 Pond

Site	Species	Sample type	Sample size (n)	Total PCBs (mean ± SD)	Range of PCB values	No. > target[a] (PCBs)/n	Total Hg (mean + SD)
K-1007-P1 Pond	Bluegill	Fillet	20	0.23 ± 0.21	0.03–0.89	0/20	—
		Whole-body composite	6	0.99 ± 0.33	0.58–1.43	0/6	—
K-901-A Pond	Common carp	Fillet	1	0.54	—	0/1	—
	Bluegill	Fillet	12	0.05 ± 0.02	0.03–0.08	0/20	—
K-720 Slough	Largemouth bass	Fillet	12	0.02 ± 0.01	0.02–0.03	0/12	—
	Common carp	Fillet	8	0.09 ± 0.08	0.02–0.24	0/8	—
	Gizzard shad	Whole-body composite	6	0.12 ± 0.01	0.10–0.13	0/6	—
CRM 11.0	Bluegill	Whole-body composite	6	0.02 ± 0.002	0.02–0.03	0/6	—
	Gizzard shad	Whole-body composite	6	0.09 ± 0.02	0.05–0.13	0/6	—
PCM 1.0	Bluegill	Whole-body composite	6	0.06 ± 0.03	0.05–0.12	0/6	—
	Gizzard shad	Whole-body composite	1	0.23	—	0/1	—
Mitchell Branch	Redbreast sunfish	Fillet	5	0.59 ± 0.18	0.33–0.83	0/5	0.37 ± 0.06
Hinds Creek	Redbreast sunfish	Fillet	6	0.02 ± 0.02	0.01–0.05	0/6	0.12 ± 0.06

SD = standard deviation; CRM = Clinch River mile; PCM = Poplar Creek mile.
[a]1 µg/g total PCBs in fish fillet and 2.3 µg/g in whole-body fish.

Table 2. Mean concentrations (n = 6, µg/g ± standard error, wet weight) of total PCBs (Aroclors 1248, 1254, and 1260), Hg, and ^{137}Cs (pCi/g) in fish fillets from off-site locations in FY 2022

Site	Description	Species	Tissue	Total PCBs (µg/g)	Mercury (µg/g)	Cs-137 (pCi/g)
Clinch River						
CRM 20	Jones Island downstream of White Oak Creek	Channel catfish	Fillet	0.18 ± 0.17	0.08 ± 0.05	0.08 ± 0.03
		Largemouth bass	Fillet	NA	0.19 ± 0.13	NA
CRM 11	Brashear Island downstream of Poplar Creek	Channel catfish	Fillet	0.16 ± 0.12	0.09 ± 0.06	NA
		Largemouth bass	Fillet	NA	0.31 ± 0.14	NA
		Bluegill	Whole-body composite	0.06 ± 0.01	NA	NA
		Gizzard shad	Whole-body composite	0.12 ± 0.03	NA	NA
CRM 3	Kingston Steam Plant discharge	Striped bass	Fillet	0.22 ± 0.11	NA	NA
Poplar Creek						
PCM 1.0	Near K-1007-P1 outlet	Channel catfish	Fillet	0.22 ± 0.07	0.09 ± 0.05	NA
		Largemouth bass	Fillet	NA	0.60 ± 0.10	NA
		Bluegill	Whole-body composite	0.12 ± 0.01	NA	NA
		Gizzard shad	Whole-body composite	0.34 ± 0.06	NA	NA
Lower Watts Bar Reservoir						
TRM 530–531	Watts Bar Reservoir forebay	Channel catfish	Fillet	0.11 ± 0.06	0.12 ± 0.09	NA
		Largemouth bass	Fillet	NA	0.11 ± 0.06	NA
Reference sites (upstream of Clinch River/Poplar Creek-Lower Watts Bar Reservoir)						
CRM 23	Melton Hill Reservoir forebay	Channel catfish	Fillet	0.11 ± 0.07	0.07 ± 0.05	NA
		Largemouth bass	Fillet	NA	0.07 ± 0.04	NA
CRM 95	Norris Lake	Striped bass	Fillet	0.04 ± 0.00	NA	NA

CRM = Clinch River mile; PCM = Poplar Creek mile; TRM = Tennessee River mile; NA = not applicable.

2.2 CLAMS

Caged Asiatic clams (*Corbicula fluminea*) were placed near and within various storm drains at ETTP for a 4-week exposure period, May 11 to June 8, 2023. Table 3 lists concentrations of PCBs, total Hg, and MeHg in the caged Asiatic clams placed at ETTP sites. Two clam baskets were placed at each site with 10 clams in each basket. The soft tissues of 10 clams from each cage were homogenized, and aliquots were taken for PCB and/or Hg analysis. Because these animals are sedentary filter feeders, they accumulate contaminants that are present in the water and in suspended particles at a given site. Therefore, they are useful indicators of the bioavailable (and potentially toxic) portion of contaminants that enter the environment at a given location and provide spatial resolution of contamination on a finer scale than is possible with fish bioaccumulation studies. Caged clams have been used in this manner for more than 25 years to evaluate the importance of storm drains and other inputs of PCBs into the waterways around ETTP; for the past 11 years, they have also been used to monitor total Hg and MeHg inputs to Mitchell Branch.

As in previous years, across all sites monitored, PCB concentrations in clams were highest around Storm Drain (SD) 100 in 2023. Mean PCB concentrations in clams placed near lower SD100 have fluctuated significantly since remediation actions in 2009. SD100 was historically the most contaminated outfall in the network, but PCB concentrations had been trending downward overall since 2009 such that concentrations in clams placed in this storm drain from 2012 to 2016 were comparable to concentrations at the reference site. In 2017, however, PCB concentrations in clams placed in both upper and lower SD100 increased such that they were comparable to concentrations seen in the early 2000s, suggesting that PCB inputs to the K-1007-P1 Pond had increased. Concentrations in clams deployed at lower SD100 had been slowly decreasing from 2017 to 2022; however, in 2023, concentrations increased to 9.88 µg/g from 5.61 µg/g in 2022, which is the highest concentration measured at this location since 2007. In 2023, mean PCB concentrations in clams at upper SD100 (3.66 µg/g) were again higher than those measured in the previous year (3.08 µg/g in 2022); this is the highest concentration measured at this location since 2005. In recent years, SD190 had been among the sites with the highest PCB concentrations in caged clams, but concentrations as this location have been steadily decreasing since 2018 (0.59 µg/g in 2023).

Mean total PCB concentrations in clams placed at the K1007-P1 Pond weir had been steadily declining since 2017 but began increasing slightly in 2022. In 2023, mean PCB concentrations at the K1007-P1 Pond weir increased slightly to 0.78 µg/g (compared with 0.46 µg/g in 2022). Further analysis of temporal trends in clam PCB concentrations in the K-1007-P1 Pond will be presented in the upcoming remediation effectiveness report.

Additional sites investigated in 2023 included SD150, SD230, and one location between SD230 and the outflow of Mitchell Branch (approximately Poplar Creek mile [PCM] 4.2; Figure 1). Average total PCB concentrations in clams placed in SD150 were higher than concentrations seen in upper Mitchell Branch (0.21 µg/g). Average total PCB concentrations were elevated at the SD230 location (0.66 µg/g), and these concentrations are not likely attributable to inputs from Mitchell Branch or other upstream PCB sources in Poplar Creek, because the clams placed at PCM 4.2 just upstream from SD230 were relatively low (0.07 µg/g).

Mercury concentrations in clams at the Mitchell Branch sites were only slightly elevated with respect to the reference site; the highest concentrations were at SD180 (average of 0.145 µg/g), higher than what was measured in 2022 (0.126 µg/g). Mercury concentrations in clams generally decreased with distance from SD180. Again in 2023, Hg concentrations in both the K-1007-P1 and K-901-A Ponds were comparable to reference site concentrations. Unlike in fish tissue, MeHg generally made up a small proportion of the total Hg found in soft tissues of clams. A more in-depth analysis of temporal trends in aqueous and biota Hg concentrations will be presented in the 2023 calendar year report.

Table 3. Concentrations (µg/g; wet weight) of PCBs (shown as Aroclors 1248, 1254, and 1260 and total Aroclors) and total Hg and MeHg in caged Asiatic clams placed at ETTP sites for 4 weeks, May to June 2023

Site	Sample identification		Aroclor 1248	Aroclor 1254	Aroclor 1260	Total Aroclors	Total Hg	MeHg
Reference site								
Sewee Creek	21917	A	ND	0.0091	ND	0.0091	0.050	0.009
		B	ND	0.009	ND	0.009	0.029	0.011
Mitchell Branch								
MIK 0.2	21925	A	ND	0.361	0.0643	0.4253	0.068	0.048
		B	ND	0.413	0.0722	0.4852	0.048	0.038
MIK 0.3	21926	A	ND	0.723	0.101	0.824	0.15	0.098
		B	ND	0.835	0.109	0.944	0.077	0.079
MIK 0.4 (below SD190)	21929	A	ND	0.377	0.0637	0.4407	0.078	0.023
		B	ND	0.458	0.0864	0.5444	0.064	0.031
SD190	21930	A	ND	0.478	0.0964	0.5744	0.056	0.008
		B	ND	0.503	0.108	0.611	0.066	0.010
SD180	21932	A	ND	0.0841	ND	0.0841	0.130	0.010
		B	ND	0.0878	ND	0.0878	0.160	0.013
MIK 0.7 (below SD170)	21931	A	ND	0.0336	ND	0.0336	0.042	0.014
		B	ND	0.0397	ND	0.0397	0.02	0.012
SD170	21933	A	ND	0.0412	ND	0.0412	0.041	0.010
		B	ND	0.0467	ND	0.0467	0.020	0.010
MIK 0.8	21934	A	ND	0.037	ND	0.037	0.03	0.016
		B	ND	0.036	ND	0.036	0.040	0.015
K-1007-P1 Pond								
SD490	21922	A	0.0132	0.0819	0.0269	0.122	—	—
		B	ND	0.0578	0.0179	0.0757	—	—
SD100 (upper)	21920	A	2.61	1.05	ND	3.66	—	—
		B	2.6	1.05	ND	3.65	—	—
SD100 (lower)	21921	A	6.49	3.49	0.406	10.386	—	—
		B	5.91	3.09	0.364	9.364	—	—

Table 3. Concentrations (µg/g; wet weight) of PCBs (shown as Aroclors 1248, 1254, and 1260 and total Aroclors) and total Hg and MeHg in caged Asiatic clams placed at ETTP sites for four weeks, May to June 2022 (continued)

Site	Sample identification		Aroclor 1248	Aroclor 1254	Aroclor 1260	Total Aroclors	Total Hg	MeHg
SD120	21919	A	0.123	0.275	0.0348	0.4328	—	—
		B	0.0975	0.194	0.0239	0.3154	—	—
K-1007-P1 Pond	21923	A	0.375	0.351	0.0451	0.7711	0.019	0.007
		B	0.387	0.359	0.0458	0.7918	0.009	0.008
K-901-A Pond								
K-901-A outfall	21924	A	ND	0.0157	0.009	0.0247	0.039	0.010
		B	ND	0.0208	0.0101	0.0309	0.019	0.010
Additional locations								
SD150	21935	A	ND	0.199	ND	0.199	0.034	0.015
		B	ND	0.214	ND	0.214	0.009	0.019
PCM 4.2	21928	A	ND	0.0532	0.0166	0.0698	0.130	0.043
		B	ND	0.0592	0.018	0.0772	0.29	0.03
SD230	21927	A	ND	0.631	ND	0.631	0.068	0.029
		B	ND	0.697	ND	0.697	0.100	0.048

Note: A dash (—) denotes sites where Hg and MeHg were not measured.
ND = not detected; MIK = Mitchell Branch kilometer; PCM = Poplar Creek mile; SD = Storm Drain.

3. TASK 2: INSTREAM MONITORING OF BIOLOGICAL COMMUNITIES

The major objectives of the instream community monitoring task are to help assess the ecological condition of Mitchell Branch; assist in the assessment and documentation of the effectiveness of new pollution abatement facilities; assist in the detection of new perturbations, should they occur; and follow long-term trends that may be associated with and/or affected by abatement activities. To meet these objectives, sampling of fish and invertebrate communities in Mitchell Branch has been conducted annually since 1986. Sampling for fish communities has been conducted in the K-1007-P1 Pond for the UCOR WRRP since 2009, and results are presented here.

3.1 BENTHIC MACROINVERTEBRATES (SUBTASK 2A)

This summary includes the results of habitat assessments and water quality measurements collected in August 2023 following TDEC protocols (Tennessee Department of Environment and Conservation 2011) from four sites in Mitchell Branch—Mitchell Branch kilometers (MIKs) 0.4, 0.7, 0.8, and 1.4. Of these sites, MIK 1.4 serves as the reference site. Results from quantitative samples collected with ORNL BMAP protocols in April 2023 and semi-quantitative samples collected following TDEC protocols in August 2023 are pending and will be presented in the 2023 calendar year report.

As in 2022, habitat assessments completed in 2023 concurrently with the collection of invertebrate samples following TDEC protocols rated habitat as scoring above the Ecoregion 67f habitat goal at all Mitchell Branch sites (Table 4). Habitat scores improved at all sites compared with 2017 and 2018, when habitat was rated as falling below the habitat goal at all sites. In general, improvements from the previous years were primarily seen in a decrease in embeddedness and sediment deposition. However, poor substrate quality (i.e., dominance of gravel instead of cobble and excessive sediment deposition) and unstable, highly erodible banks continue to be an issue at multiple sites.

Table 4. Habitat assessment results for benthic macroinvertebrate community sampling sites in Mitchell Branch, August 17, 2023. Results are based on TDEC standard protocols for stream habitat assessments[a]

Habitat parameter	Parameter scores			
	MIK 0.4	**MIK 0.7**	**MIK 0.8**	**MIK 1.4**
1. Epifaunal substrate/available cover	11	17	17	11
2. Embeddedness	12	16	14	10
3. Velocity/depth regime	13	11	14	13
4. Sediment deposition	10	15	15	8
5. Channel flow	20	20	20	20
6. Channel alteration	15	15	15	20
7. Frequency of reoxygenation zones	13	14	18	13
8. Bank stability				
Left	6	8	8	8
Right	9	8	8	6
9. Vegetative protection				
Left	6	4	6	8
Right	8	6	6	8
10. Riparian vegetative zone width				
Left	1	3	3	10
Right	10	8	4	10
Total habitat assessment score compared with Ecoregion 67f goal[b]	**134**	**145**	**148**	**145**

MIK = Mitchell Branch kilometer.
[a] (Tennessee Department of Environment and Conservation 2011).
[b]Green shading indicates a habitat assessment score that falls above the habitat goal for Ecoregion 67f (a score of ≥123 for a drainage area of ≤2.5 mi^2 or a score of ≥128 for a drainage area of >2.5 mi^2).

Stream discharge in August 2023 was slightly elevated at all sites, reflecting increased rainfall in late summer 2023. Table 5 lists results for water quality and physical characteristic measurements at Mitchell Branch sites. Measurements of pH in 2023 indicate circumneutral conditions (i.e., near a neutral pH of 7.0) at all sites, which is typical of waterbodies on the ORR. Similar to previous years, temperature displayed relatively little variation among sites for both sampling periods (typically <3°C difference among sites), with August values averaging approximately 10°C higher than April values. Conductivity values were typical of those measured in Mitchell Branch in recent years, with conductivity at MIK 1.4 lower than at the other three sites (Table). As is typical, lower discharges in August 2023 compared with April 2023 led to higher conductivity values. The conductivity of water in small, unimpacted streams on the ORR is typically below 225 µS/cm; higher values are normally found in late summer and early fall during low-flow conditions, when the proportion of stream flow from deep groundwater increases. The conductivity of water in small streams that receive significant inputs of water from urban runoff, industrial effluent discharges, and cooling tower discharges typically exceeds 300 µS/cm, especially during periods of low precipitation. Dissolved oxygen (DO) concentrations in April 2023 indicated well oxygenated waters with a range of 9.31 to 11.09 mg/L, while DO conditions in August 2023 were lower, ranging from 7.64 to 8.95 mg/L across sites (Table 5). Total dissolved solids (TDS) were higher at the downstream sites (MIKs 0.4, 0.7, and 0.8) than at the upstream site (MIK 1.4); turbidity was low, although it was higher than typical values seen in August because of recent rainfall (Table 5). Canopy cover was high at all sites in August 2023, ranging from 85% at MIK 0.8 to 99% at MIK 1.4 (Table 5).

Table 5. Mitchell Branch results for water quality and physical characteristic measurements, April 25 and August 17, 2023

Site	Geographic coordinates[a]	Drainage area (mi^2)	Date	DO (mg/L)	Temperature (°C)	pH	Conductivity (µS/cm)	Specific conductance (µS/cm)	TDS[b] (mg/L)	Turbidity[b] (FNU)	Canopy cover (%)[c]	Discharge[d]	
												(ft^3/s)	(L/s)
MIK 0.4	35.939158 N 84.389955 W	0.60	04/25/23	9.34	11.0	7.81	299	408	—	—	—	—	—
			08/17/23	7.97	19.8	7.75	417	463	301	2.00	96.6	0.519	14.70
MIK 0.7	35.93786 N 84.38792 W	0.52	04/25/23	9.50	10.9	7.75	261	357	—	—	—	—	—
			08/17/23	7.66	20.2	7.59	387	426	278	2.58	93.2	2.603	73.69
MIK 0.8	35.93786 N 84.38682 W	0.49	04/25/23	9.31	10.4	7.72	216	299	—	—	—	—	—
			08/17/23	7.64	19.8	7.54	301	334	217	4.71	84.5	0.304	8.60
MIK 1.4	35.9379 N 84.37662 W	0.12	04/25/23	11.09	9.6	8.06	126	176	—	—	—	—	—
			08/17/23	8.95	19.0	7.61	144	163	106	6.73	98.6	0.085	2.41

MIK = Mitchel Branch kilometer; DO = dissolved oxygen; TDS = total dissolved solids; FNU = Formazin Nephelometric Unit.
[a]Coordinates in decimal-degrees, North American Datum 27.
[b]TDS and turbidity measured with a YSI ProDSS multiparameter meter; not measured during April sampling.
[c]Canopy cover measured with a spherical densitometer; not measured during April sampling.
[d]Discharge measured with a Hach FH950 portable flow meter; not measured during April sampling.

3.2 FISH COMMUNITY (SUBTASK 2B)

Fish population and community studies are used to evaluate the biotic integrity of Mitchell Branch annually in comparison with local reference streams. The fish community was sampled quantitatively at two sites in Mitchell Branch (MIKs 0.4 and 0.7) and at local reference streams. The objective of the stream fish sampling at MIK 0.7 was to monitor the influence of SD170 and upstream outfalls on the stream. Sampling at MIK 0.4 was designed to monitor conditions downstream of SD190, SD170, and SD180. The fish community in the K-1007-P1 Pond was also evaluated as part of the UCOR WRRP, and the results are presented here.

3.2.1 Mitchell Branch Fish Communities

The fish community was sampled at sites in Mitchell Branch and three reference streams (Mill Branch, Ish Creek, and Scarboro Creek) in April and May 2023. Data from all sites were processed following the quality assurance and analysis procedures consistent with task protocols.

Fish communities at MIKs 0.4 and 0.7 experienced some changes in values from 2022 to 2023. Table lists fish community metrics at Mitchell Branch sites and reference sites. The number of species at both monitoring locations in Mitchell Branch decreased slightly in 2023 when compared with 2022. The fluctuation in species richness at these sites is not unexpected and could relate to changes in habitat, sampling efficiency, or specific species ecology, which may limit diversity and density values. As in previous years, the fish communities in Mitchell Branch in 2023 were dominated by several tolerant species, including striped shiner (*Luxilus chrysocephalus*) and western blacknose dace (*Rhinichthys obtusus*), that can feed on a variety of food types. These species are considered generalists and often occur in high numbers in streams with limited complexity of habitat or prey. Largescale stonerollers (*Campostoma oligolepis*) continued to be the most abundant species at both sites and have a biomass two or three times that of any other species observed at these sites. Large numbers of this species are sometimes associated with stream systems receiving higher organic or nutrient loading and/or insufficient riparian cover, resulting in dense growth of periphyton, which is the primary food source for largescale stonerollers. The fish communities within Mitchell Branch include sporadic occurrences of sunfish and intolerant species such as banded sculpin (*Cottus carolinae*); however, these species are represented by very few individuals and constitute only a fraction of the community as a whole.

Overall, the composition of the Mitchell Branch fish communities is typical of small, highly stressed streams. The fish communities in Mitchell Branch, compared with the reference streams, still lack the presence of multiple resident sensitive species. If the recovery process continues, sensitive or specialized species (e.g., darters) would be expected to establish continuing populations in Mitchell Branch, and the density of tolerant species such as stonerollers would decline; more stability in biomass measures would also be expected. The proximity of Mitchell Branch to a system as large and diverse as Poplar Creek should provide an avenue for a variety of species to populate the resident fish community, and despite the potential barriers (e.g., weirs, culverts), other species do sporadically occur within the sites, indicating that the barriers have at least limited passibility.

Table 6. Fish community metrics at Mitchell Branch sites (MIKs) and reference sites in Mill Branch (Mill Branch kilometer [MBK]), Ish Creek (Ish Creek kilometer [ISK]), and Scarboro Creek (Scarboro Creek kilometer [SCK]) for April 2023. Values shown include fish species richness (number of species by site totaled at the bottom of the table), density (individuals/m^2 by species and site), and biomass (g fish/m^2 by species, in parentheses). Sensitive fish species are highlighted in gray

Species	**MIK 0.4**	**MIK 0.7**	**MBK 1.6**	**ISK 1.0**	**SCK 2.2**
Largescale stoneroller	1.63	3.29	0.02	0.12	0.16
Campostoma oligolepis	(4.48)	(11.98)	(0.22)	(0.36)	(0.75)
Striped shiner	1.27	0.30	0.04	0.28	—
Luxilus chrysocephalus	(3.19)	(1.37)	(0.17)	(1.64)	
Tennessee dace	—	—	<0.01	—	—
Chrosomus tennesseensis			(0.01)		
Western blacknose dace	0.43	0.85	0.18	0.15	1.13
Rhinichthys obtusus	(0.79)	(1.85)	(0.29)	(0.44)	(2.50)
Creek chub	0.44	0.17	0.06	0.14	—
Semotilus atromaculatus	(1.68)	(0.61)	(0.41)	(0.78)	
Yellow bullhead	—	0.02	—	0.02	—
Ameiurus natalis		(0.33)		(0.19)	
Banded sculpin	—	—	—	0.04	0.62
Cottus carolinae				(0.44)	(2.31)
Redbreast sunfish	—	—	0.01	0.05	-
Lepomis auritus			(0.29)	(0.36)	
Green sunfish	0.03	0.15	<0.01	0.02	0.01
Lepomis cyanellus	(0.18)	(2.37)	(0.21)	(0.19)	(0.08)
Bluegill	—	—	0.06	<0.01	0.01
Lepomis macrochirus			(0.73)	(0.04)	(0.06)
Stripetail darter	—	—	0.06	—	—
Etheostoma kennicotti			(0.08)		
Snubnose darter	—	—	—	0.01	—
Etheostoma simoterum				(0.03)	
Total					
Species richness	5	6	9	10	5
Density	3.81	4.77	0.42	0.84	1.93
Biomass	10.32	18.51	2.40	4.47	5.70

3.2.2 K-1007-P1 Pond Fish Communities

The fish communities in K-1007-P1 Pond are also assessed annually for composition and stability. Table lists actual electrofishing catches per minute during fish community surveys in February 2023. This sampling is conducted to evaluate the effectiveness of remediation efforts implemented beginning in 2009. These remedial actions included soil sediment grading, planting native aquatic vegetation to stabilize sediment, and removing potentially contaminated fish from the pond. After a piscicide (rotenone) was used to remove fish from the pond, uncontaminated native fish were stocked in the pond with the goal of establishing a sunfish-dominated population. Sunfish have a shorter life span than many other species of fish, especially higher–trophic level fish, and they have a prey source that is generally varied but consistently lower on the aquatic food chain than species such as largemouth bass, thus reducing the likelihood that contaminants could biomagnify within the system.

Table 7. Actual electrofishing catches per minute during fish community surveys in the K-1007-P1 Pond in 2007 and 2023

Species	May 2007[a]	February 2023
Spotted gar *Lepisosteus oculatus*	0.01	—
Gizzard shad *Dorosoma cepedianum*	1.30	0.10
Common carp *Cyprinus carpio*	0.03	—
Smallmouth buffalo *Ictiobus bubalus*	0.02	—
Spotted sucker *Minytrema melanops*	—	0.03
Yellow bullhead *Ameiurus natalis*	0.01	0.01
Western mosquitofish *Gambusia affinis*	—	0.13
Green sunfish *Lepomis cyanellus*	0.01	—
Warmouth *Lepomis gulosus*	0.01	0.69
Bluegill *L. machrochirus*	0.49	5.84
Redear sunfish *Lepomis microlophus*	—	0.43
Largemouth bass *Micropterus salmoides*	0.16	0.17
White crappie *Pomoxis annularis*	0.08	—
Black crappie *Pomoxis nigromaculatus*	—	0.12
Total species	**10**	**9**

[a]These data were collected before remediation work and rotenone application.

Fish removal actions have been conducted annually in the K-1007-P1 Pond since the rotenone application in June 2009. Fish removals after May 2010 were primarily necessitated by damage to the outfall weir grate, which allowed numerous fish from Poplar Creek to bypass the grate during a high-flow event and gain access to the K-1007-P1 Pond in early spring 2010. Other high-water events since then have also potentially allowed fish to enter the K-1007-P1 Pond. Substantial numbers of gizzard shad, threadfin shad (*Dorosoma petenense*), largemouth bass, common carp, and smallmouth buffalo (*Ictiobus bubalus*) were removed from the K-1007-P1 Pond from May 2010 to February 2022. These species are considered undesirable in the pond because of their role in the bioaccumulation of contaminants (food chain dynamics) and/or the resuspension of potentially contaminated sediments. Fish removal efforts in FY 2023 were conducted during annual population surveys. Table 8 lists the types and numbers of nuisance fish removed from the K-1007-P1 Pond in 2023.

Table 8. Numbers of nuisance fish removed from the K-1007-P1 Pond in 2023

Species	February 2023
Gizzard shad *Dorosoma cepedianum*	18
Spotted sucker *Minytrema melanops*	6
Yellow bullhead *Ameiurus natalis*	1
Largemouth bass *Micropterus salmoides*	30
Black crappie *Pomoxis nigromaculatus*	21
Total	**76**

The K-1007-P1 Pond fish community in 2023 continues to be dominated by sunfish. There are still signs of fluctuation between sampling years among some species such as shad, but the desired sunfish species have remained consistent for several years and remain much higher than values before remedial activities. Overall, sunfish comprised ~93% of the total estimated fish population in 2023. Gizzard shad feed primarily on phytoplankton and zooplankton as adults, preferring large areas of open (pelagic) water to feed. This habitat is very limited annually in the K-1007-P1 Pond because of the substantial growth of American lotus (*Nelumbo lutea*) and other aquatic vegetation, which currently cover most of the pond during the late growing season. The plant growth continues to serve its primary purpose of sediment stabilization and essentially eliminates any exposed sediments that might be resuspended by fish such as shad or carp, especially in the eastern and central portions of the pond.

The fish removal efforts have also affected the population of undesirable fish species, including largemouth bass, in the pond. Bass are predominantly piscivorous as adults, and juveniles share a varied diet of zooplankton and insects with sunfish species. By removing the larger size class of bass and reducing the number of bass in the zero- to one-year class each year, competition among the younger size class with existing sunfish populations is expected to reduce the bass population in the pond.

4. REFERENCES

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