Prepared for:

Kentucky Utilities Company

Prepared By:
Ramboll US Consulting, Inc.

Date:
November 2022

Agreed Order No.:
DOW - 17001

Project Number:
1690006320-001

HERRINGTON LAKE 2022 SUPPLEMENTAL PERFORMANCE MONITORING REPORT

CORRECTION ACTION PLAN (CAP), E.W. BROWN STATION, MERCER COUNTY, KENTUCKY

DOCUMENT DEVELOPMENT AND APPROVAL

Title and Approval Sheet

Action By	Signature	Date
Prepared by: Alex Smith, Ramboll		November 10, 2022
Prepared/Reviewed/Approved by: Mary Sorensen, Ramboll		November 16, 2022

CONTENTS

TABLES

FIGURES

APPENDICES

ACRONYMS AND ABBREVIATIONS

#	Number
%	Percent
ASI	Aqua Survey Inc.
BCA	benthic community assessment
Cabinet	Kentucky Energy and Environment Cabinet
CAP	corrective action plan
CCR	coal combustion residual
COPCs	constituents of potential concern
EPT	Ephemeroptera, Plecoptera, Trichoptera
ERA	ecological risk assessment
GIS	geographic information system
HBI	Hilsenhoff Biotic Index
HD samplers	Hester Dendy artificial substrate samplers
HHRA	human health risk assessment
HI	Hardin Inlet
HQ	HQ Inlet
IRM	interim remedial measure
ISARA	Investigation, Source Assessment, and Risk Assessment
KAR	Kentucky Administrative Record
KDOW	Kentucky Division of Water
KPDES	Kentucky Pollutant Discharge Elimination System
KU	Kentucky Utilities Company
KMBI	Kentucky Macroinvertebrate Bioassessment Index
KY mHBI	Kentucky modified HBI
LCI	Lower Curds Inlet
LHL	Lower Herrington Lake
µg/L	microgram per liter
MCI	Middle Curds Inlet
mg/kg	milligram per kilogram
mg/L	milligram per liter
MHL	Middle Herrington Lake
Plant	E.W. Brown Generating Station
RAO	remedial action objective
RSL	regional screening level
SDI	Shannon Diversity Index
SOP	standard operating procedure
SPM	Supplemental Performance Monitoring
SRAA	Supplemental Remedial Alternatives Assessment
UCI	Upper Curds Inlet
US	United States
USEPA	United States Environmental Protection Agency
WQS	Surface Water Standards –Here refers to Kentucky Administrative Regulation [KAR] 224.10:031
YOY	young-of-the-year

1. INTRODUCTION

This Supplemental Performance Monitoring (SPM) Report is provided to the Kentucky Energy and Environment Cabinet (Cabinet) in partial fulfillment of the Corrective Action Plan (CAP) for E.W. Brown Generating Station, Herrington Lake (Ramboll 2017a) per the Agreed Order (No. DOW - 17001), on behalf of Kentucky Utilities (KU). The E.W. Brown Station (i.e., the Plant) and adjacent Herrington Lake are in Mercer County, approximately 3.8 miles northeast of the city of Burgin, along the northwestern shore of Herrington Lake (Figure 1-1A).

The 2022 supplemental performance monitoring (hereafter referred to as the 2022 monitoring) described herein was performed in accordance with the E.W. Brown Supplemental Remedial Alternatives Assessment Report (SRAA, Ramboll 2021). The SRAA Report identified the following Remedial Action Objectives (RAOs) for Herrington Lake, which served as the basis of the performance monitoring approach outlined in the SRAA Report:

- RAO 1: Sustain the applicable standards for protection of aquatic life in Curds Inlet and Herrington Lake for selenium.
- RAO 2: Reduce selenium concentrations in young-of-the-year (YOY) fish in Curds Inlet compared to the 2018 YOY selenium tissue concentrations.
- RAO 3: Demonstrate an acceptable level of diversity and abundance of the sediment-dwelling invertebrate community in Curds Inlet or reduce concentrations of selenium in sediment and arsenic and iron in sediment pore water to achieve acceptable levels of diversity and abundance.

The purpose of this report is to document the 2022 monitoring approach and results, with consideration of the performance criteria for each RAO, as outlined in the SRAA Report. The 2022 monitoring augments information provided in the Investigation, Source Assessment, and Risk Assessment (ISARA) Report and the Coal Pile Addendum to the ISARA Report (Ramboll 2019, 2020). The ISARA Report and Coal Pile Addendum provided extensive information about the characterization of potential coal combustion residual (CCR) constituents in Herrington Lake, detailed the sources of possible CCR-related constituents in the lake, and evaluated the human health and the environmental risks associated with possible CCR-related constituents that were detected. The ISARA field investigations and subsequent human health and ecological risk assessments presented in the ISARA Report were conducted in 2017 and 2018. KU has completed numerous interim remedial measures (IRMs) dating back to 2014 to lessen the potential for any ongoing CCR-related impacts to the lake. Some of those IRMs were completed after the 2017 and 2018 sampling that served as the basis of the human health risk assessment (HHRA) and the ecological risk assessment (ERA) provided in the ISARA Report and Coal Pile Addendum. Therefore, this 2022 monitoring provides an understanding of conditions in Herrington Lake following implementation of those IRMs. The remainder of this section provides background information and a summary of key findings from the HHRA and ERA that served as the basis for the 2022 supplemental performance monitoring.

1.1. Plant Operations

The E.W. Brown Station has generated CCR since the late 1950s. Historically, CCR consisted primarily of bottom ash and fly ash generated from coal combustion. Beginning in 2009, gypsum began to be produced from scrubbers installed to remove sulfur dioxide from the plant’s air emissions. Historically, ash from all coal combustion units (1, 2, and 3) was sluiced to the Main Pond until 2008 and thereafter to the Auxiliary Ash Pond (Aux Pond). Currently, only Unit 3 remains in operation. The Main Ash Pond, located directly south of the Generating Station, was created by placement of an embankment across a valley that drained into Curds Inlet. As the Main Ash Pond was filled with ash sluiced from the boilers, it was expanded multiple times, to a surface area of approximately 114 acres. In 2008, the pond was taken out of service, and sluice waters were redirected to the Aux Pond. Much of the Main Ash Pond was covered with soil in 2011. Construction of a special waste landfill over the top of the Main Ash Pond was permitted in 2014 and completed in 2016. The landfill is currently receiving plant-generated CCRs including bottom ash, fly ash, and gypsum. The constructed landfill also serves as a remedial cap for the Main Ash Pond. The layout of the E.W. Brown Station, including the Main Ash Pond and Aux Pond relative to Herrington Lake, is illustrated in Figure 1-1B.

Water that accumulated in the Main Ash Pond from sluicing operations and precipitation was decanted and formerly discharged to Curds Inlet at a discharge point referred to as Outfall BRN001 located at the head of the inlet (Figure 1-1B). Beginning in the mid-1970s, this discharge was authorized and regulated under a Kentucky Pollution Discharge Elimination System (KPDES) permit issued by the Kentucky Division of Water (KDOW). The KPDES permit for the E.W. Brown Station was most recently renewed in November 2019 (Permit Number KY0002020) (KPDES 2019a,b; KU 2021a, 2021b). Decanted water from the Aux Pond also was discharged at Outfall BRN001 via an underground pipeline that routed the water to the same discharge channel that previously carried water from the Main Ash Pond to Curds Inlet. During the decades of operation of the Main Ash Pond and Aux Pond, these discharges represented the largest source of CCR-related contaminant loading to Curds Inlet. All process water discharges to Outfall BRN001 were discontinued in 2019 when the plant's KPDES permit was renewed. In accordance with the 2019 KPDES permit, the treated wastewater from the plant now discharges at a new Outfall BRN006 through a multi-port diffuser anchored to the rock wall and extending out into the main body of Herrington Lake.

1.2. Summary of Completed and Planned IRMs

IRMs have been implemented at the E.W. Brown Station from 2014 to present, as briefly summarized in Table 1-1. These IRMs limit the contributions of CCR-related constituents of interest, including selenium, to Curds Inlet and Herrington Lake by eliminating surface water discharges from the ash ponds (the single largest source of selenium) and preventing surface water infiltration and groundwater migration from source areas at E.W. Brown. Several significant IRMs pertaining to the lake conditions were implemented after sampling in the lake conducted by KU in 2017 and 2018, including the following discussed in more detail in Table 1-1:

- Elimination of Process Water Discharge Via Outfall BRN001
- Treatment and Elimination of Aux Pond Discharge
- Toe Drain and Coal Pile Runoff Treatment System
- Recirculation of Bottom Ash Transport Water
- Treatment and Elimination of Flue Gas Desulfurization Wastewater Discharges

The effect of the various IRMs can be evaluated from monitoring data collected for compliance purposes. In addition to monitoring data required by the new KPDES permit, there is also a requirement for KU to conduct whole-body fish tissue sampling whenever the monthly average concentration of selenium in the effluent at Outfall BRN006 exceeds a trigger level of 0.075 milligram per liter (mg/L). To date, the effluent at Outfall BRN006 has not exceeded the trigger level.

Semi-annual groundwater monitoring data collected pursuant to the CCR rule also can be used to evaluate the effectiveness of the IRMs.

1.3. Key Findings from ISARA Report Human Health and Ecological Risk Assessments

1.3.1. HHRA Key Findings

The HHRA was conducted to evaluate the CCR-related constituents detected in water, sediment, and fish tissue. Health protective assumptions were applied to derive risk-based screening levels that were then compared with site data to identify constituents of potential concern (COPCs) in site media.

- No COPCs were identified for surface water based on residential domestic use. In addition, comprehensive well surveys were conducted in 2011 and 2018 to identify domestic drinking water wells. No drinking water wells were identified within a mile of E.W. Brown Station in any of the surveys performed.
- No COPCs were identified for fish consumption. The measured fish tissue concentrations were below risk-based screening levels for selenium, inorganic arsenic, cadmium, boron, lead, and zinc. The concentrations of methylmercury (the most dominant form of mercury) in fish tissue fillet were below risk-based screening levels for most of the fish samples, with two exceptions. Two flathead catfish had detected fillet tissue concentrations that exceeded the methylmercury risk-based screening criterion based on consuming 50 meals per year. One of these catfish was from Lower Herrington Lake (location LHL4), approximately 3 miles upgradient from E.W. Brown Station. The second catfish was from Middle Herrington Lake (location MHL1), approximately 10 miles upgradient from E.W. Brown Station. These mercury concentrations in the catfish are not considered to be due to discharges from E.W. Brown Station because small home range bluegills did not indicate a pattern of elevated mercury concentrations in Curds Inlet.
- The only COPC identified from the screening analysis for human health risk was arsenic in sediments, using conservative exposure assumptions for recreational visitors (i.e., sediment data were compared with United States Environmental Protection Agency (USEPA) regional screening levels for arsenic in residential soil which were derived by EPA assuming exposure to soil 350 days per year for 30 years, and calculated using a target excess cancer risk level of $1x10^{-6}$). Arsenic in sediments in each of the investigation areas including those with no influence from E.W. Brown exhibited concentrations in certain samples that exceeded the USEPA regional screening level (RSL) for arsenic in residential soil.
- Following the screening level assessment of sediment exposures, a refined assessment of risk from potential human exposures to arsenic in sediment was conducted to account for the fact that there is little potential for human contact with sediments at the frequency assumed in establishing the screening levels for residential soil. For this refined assessment sediments within areas under water 24 feet or less[1] were further evaluated using more realistic exposure assumptions. To determine how frequently people might contact underwater sediments an exposure frequency was developed based on climate data compiled by the United States (US) weather service.[2] It was protectively assumed that an older child or adult might swim and contact sediments for three days per week (i.e., 65 days per year) and that a young child might visit half as often (i.e., 33 days per year) during the warmer weeks of the year.[3]
  - The highest excess lifetime cancer risk estimate from exposure to arsenic in sediment in Curds Inlet derived using the foregoing conservative exposure assumptions was $1x10^{-5}$ (as shown on

---

1 The 24-foot depth of water was chosen as a health protective level because the lake can fluctuate by 20 feet and individuals might wade in water 4 feet deep or shallower.

2 https://www.usclimatedata.com/climate/lexington/kentucky/united-states/usky1079.

3 Data compiled by the US weather service indicate that Lexington, Kentucky experiences average daily low temperatures above 50 degrees for five months (roughly equivalent to 21.7 weeks) per year. The number of days having an average low temperature of greater than 50 degrees is a reasonable universe of possible days, since cooler weather generally means people spend less time swimming in the lake or playing in wet areas.

Table 4-13 of the Corrective Action ISARA Report). This risk estimate is within the target risk range of $1x10^{-6}$ to $1x10^{-4}$ considered acceptable by USEPA.

  - No hazard quotients were greater than 1, indicating no adverse non-cancer effects would be expected for recreational visitors.

- The results presented in the HHRA were based on conservative health protective sediment exposure assumptions that likely substantially overestimated the actual risks to recreational human receptors in Curds Inlet. Specific examples include:
  - The inclusion of sediments under 24 feet or less of water does not account for the fact that during summer months, when most recreation and potential contact with sediment occurs, most of the deeper areas included in the analysis are not practically accessible by recreators, particularly children. Arsenic concentrations in shallow areas of Curds Inlet are lower than concentrations at depths exceeding 4 feet during the summer months.
  - The assumptions that children under the age of six would be exposed to sediments in Curds Inlet 33 times a year and that older children and adults would be exposed 65 times per year do not account for the limited access to the area by recreational visitors, the steep terrain along the shoreline (which is on KU property), the limited use of the shoreline within Curds Inlet for recreational purposes, and the absence of any observed recreational use other than by adult workers from KU who fish in Curds Inlet from shore. Other recreational visitors would have to come to Curds Inlet by boat, further limiting exposure to sediments.
- Based on the foregoing, the potential human health risks from exposure to COPCs in sediment do not exceed target risk levels.

1.3.2. ERA Key Findings

The ERA followed Kentucky and USEPA guidance including comparison to relevant available screening levels with the goal of determining whether there is an adverse impact to the environment from CCR-related constituents in Herrington Lake related to the E.W. Brown Station (KDEP 2002; USEPA 1997, 1998, 2018). The ERA evaluated the following assessment endpoints and measurement approaches identified in Exhibit 1-1 below and described briefly herein.

Exhibit 1-1: Summary of Assessment and Measurement Endpoints used in the ERA	
Assessment Endpoint	**ERA Approach (Measurement Endpoints)**
Survival, growth, and reproduction of fish populations	• Comparison of adult whole-body fish tissue concentrations against the Kentucky water quality standard for selenium in fish tissue and other tissue residue reference values for CCR-related constituents other than selenium • Comparison of selenium in ovary/egg tissues to the USEPA ovary/egg water quality standard • Evaluation of YOY bluegill study for selenium concentrations in YOY and a deformities assessment • Comparison of water concentrations to water quality standards for CCR-related constituents
Survival, growth, and reproduction of aquatic-feeding bird and mammal populations	• Comparison of calculated daily dietary intakes against chemical-specific toxicity reference values for birds and mammals
Aquatic vegetation and water-column invertebrate community structure and function	• Comparison of surface water concentrations against water quality criteria
Sediment dwelling invertebrate community structure and function	• Comparison of sediment concentrations against sediment quality criteria • Evaluation of spiked sediment studies • Comparison of sediment pore water concentrations against water quality criteria

Fish Populations
The ERA evaluated the survival, growth, and reproduction of fish populations, based on the following measurement endpoints:

- CCR-related constituent concentrations in adult and YOY fish tissues collected from Herrington Lake sampling efforts in 2017 and 2018 were compared to whole-body tissue protective criteria for fish. The protective criteria used were from the Cabinet, the USEPA, and scientific literature. For selenium, the Kentucky adult fish whole-body criterion and USEPA ovary/egg standard for selenium were used.
- The adult fish whole-body and the adult fish ovary samples had selenium concentrations less than the Kentucky standards and USEPA standards for whole-body tissues and ovary tissues, respectively.
- The adult fish tissues concentrations for CCR-related constituents other than selenium were detected at concentrations less than protective fish tissue criteria with the exception of limited detections of mercury that were in Middle Herrington Lake more than 10 miles upgradient of influence from Curds Inlet.
- YOY bluegills were collected to inspect for deformities (approximately 3,600 fish) and for tissue residue (approximately 700 additional fish) for a total of approximately 4,300 YOY bluegills.

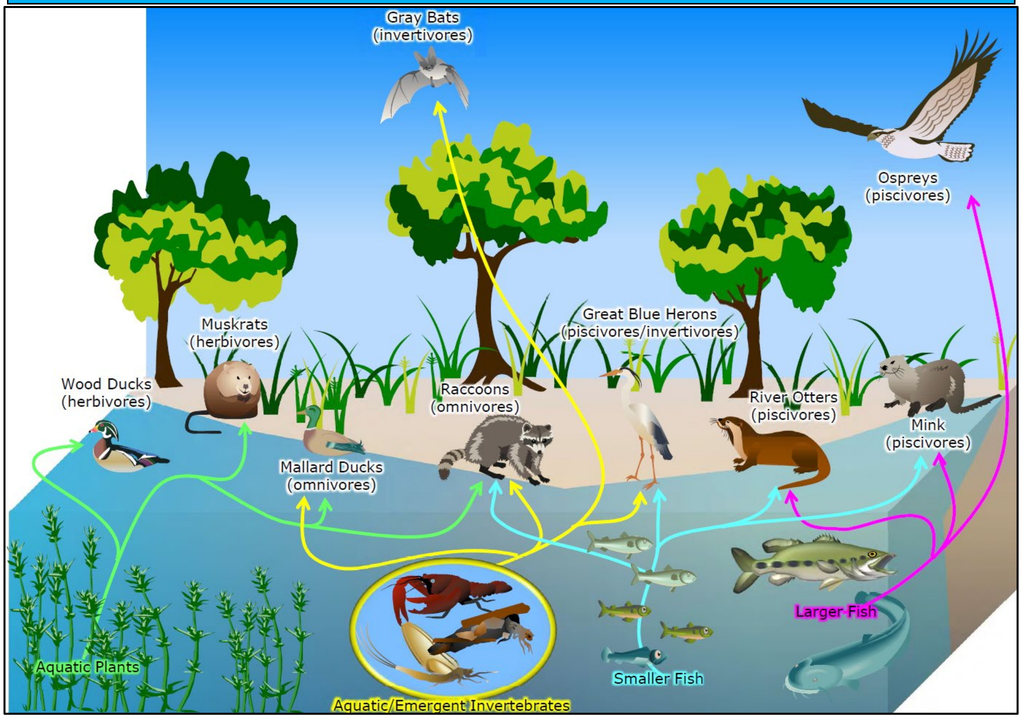
- The 2018 YOY assessment demonstrated that the rate of skeletal, facial, fin, or tail teratogenic deformities was low. Overall, approximately 99 percent (%) of the YOY fish exhibited no skeletal, facial, fin, or tail teratogenic deformities.
  - The deformity rates in Curds and HQ Inlets (0.38–0.83%) were consistent with the rates observed at other locations, with an observed occurrence at Lower Herrington Lake (location LHL1) of 2.1% and Hardin Inlet at 0.96%.
  - The rate of occurrence at location LHL6, approximately 2 miles upgradient from Curds Inlet (outside the influence of E.W. Brown Station), was 0.66%, within a comparable range to that observed in Curds Inlet.
  - These rates of skeletal, facial, fin, or tail teratogenic deformities do not indicate adverse impact to the population of fish in Herrington Lake.
  - The rate of deformities seen in the YOY from within Curds Inlet and the reference areas of Herrington Lake were similar to those seen in other studies of YOY fish (e.g., West Virginia Department of Environmental Protection 2010).
- During the bluegill YOY deformities assessment, a condition called exophthalmia (also known as "popeye") was noticed in approximately 5% of the 3,600 fish evaluated in the assessment. The cause of the popeye was not likely selenium exposure because:
  - Popeye was observed at a similar or lower frequency in Curds Inlet fish compared to the popeye seen in YOY fish collected from reference areas in Herrington Lake.
  - Smaller fish (approximately 1 centimeter) had a higher likelihood of having popeye condition. Small fish are susceptible to popeye from physical stress and findings suggest that the exertion and capture typical of the YOY collection may have contributed to the observed popeye (e.g., Stephens *et al.* 2002, Hargis 1991, Noor El Deen and Zaki 2013).

The only finding related to fish that raised any potential ecological concern was elevated selenium tissue concentrations in YOY bluegills collected in Curds Inlet compared to reference locations in other areas of Herrington Lake. The YOY bluegills collected in 2018 from Upper Curds Inlet, nearest to the Outfall BRN001, had the highest selenium tissue levels, and concentrations decreased with increasing distance away from E.W. Brown Station and from Curds Inlet. Neither USEPA nor Kentucky has developed a selenium standard based on YOY fish tissue concentrations, and as noted above, the adult fish tissue sampling results show no indication of adverse effect to the bluegill population in Herrington Lake. Nonetheless, it is possible that the elevated selenium concentrations measured in certain YOY fish in 2018 in Upper and Middle Curds Inlet may have posed a risk to these individual fish. As noted above, the elimination of process water flows into Curds Inlet as of November 2019 were expected to improve water quality in Curds Inlet.

Bird and Mammal Populations

The ERA used food web modeling to assess the survival, growth, and reproduction of bird and mammal populations. The species evaluated reflect the various tropic levels (i.e., feeding guilds like insectivore or carnivore) that may be present in Herrington Lake, as indicated in Exhibit 1-2.

Exhibit 1-2: Birds and Mammals Considered in the ERA Food Web Model



The results of the ERA food web model indicated that bird and mammal populations are not adversely impacted by CCR-related constituents in Curds Inlet or elsewhere in Herrington Lake.

Aquatic Plants and Aquatic Invertebrates

- The ERA evaluated community composition and function for aquatic plants and aquatic invertebrates based on the comparison of detected CCR-related constituents in water to protective (chronic) Kentucky surface water quality standards and protective USEPA ecological screening levels.
- Based on the comparisons, the conditions in Curds Inlet and Herrington Lake do not pose an unacceptable risk to the aquatic plant or invertebrate communities potentially exposed to CCR-related constituents.

Sediment Dwelling Invertebrates

- The ERA evaluated potential risks to the sediment-dwelling invertebrate community using sediment and pore water concentrations specific to sediment dwelling organisms.
- The ERA concluded that the conditions in Curds Inlet and Herrington Lake are not likely to pose an unacceptable risk to the sediment-dwelling organism community exposed to CCR-related constituents because the majority of detected sediment concentrations were less than the USEPA screening levels for sediment.
- Concentrations of selenium, arsenic, and iron in sediment exceeded the USEPA sediment screening levels, but when those concentrations were evaluated in more detail, they were considered unlikely to adversely impact the sediment-dwelling community, as described further below.

Selenium in Sediment and Sediment Pore Water
The selenium sediment concentrations in samples from Curds Inlet and background locations miles from Curds Inlet exceeded the 2018 USEPA ecological screening levels (USEPA 2018).

- The fact that concentrations of selenium in sediment both within Curds Inlet and well upstream of Curds Inlet exceeded the 2018 USEPA Region 4 screening levels indicated that these values may not be useful for screening purposes given the naturally occurring conditions in Herrington Lake.
- For this reason, the basis of the USEPA Region 4 selenium sediment criteria was closely considered as part of the Corrective Action ISARA Report and, as explained in that document, the prior USEPA sediment ecological screening levels, published in 1995, were deemed more useful for assessing potential risk in Herrington Lake.
    - The prior USEPA Region 4 sediment selenium ecological screening levels are based on "no effects" and "low effects" from Washington state regulations (Washington State Department of Ecology 2013).
    - While three detected selenium concentrations from within Curds Inlet exceeded the Washington State "no effects" value, the majority of selenium sediment concentrations in Curds Inlet were below the ecological "no effects" value.
    - The remainder of the detected concentrations of selenium in sediments in Curds Inlet had concentrations less than "low effect" and many less than the "no effect" value.

    Although some isolated potential impacts to individual sediment dwelling organisms could not be definitively ruled out, adverse impacts to the sediment dwelling community were considered unlikely.

- Speciated selenium concentrations in pore water (selenate and selenite, the toxic forms of selenium) were compared to Kentucky chronic water quality standard and a selenium risk-based criterion from the USEPA ECOTOX database (USEPA 2021) for sediment dwelling organisms.
    - Selenate exceeded the Kentucky water quality standard at only a single location and none of the concentrations of selenate or selenite in sediment pore water exceeded the additional risk-based criterion from the USEPA ECOTOX database (USEPA 2021).
    - These results support the conclusion that selenium in sediment pore water does not pose an unacceptable risk to sediment dwelling organisms.

Arsenic in Sediment and Sediment Pore Water
- Most of the detected concentrations of arsenic in sediment within Curds Inlet and some of the detected concentrations of arsenic in sediment from other locations in Lower Herrington Lake exceeded the USEPA ecological screening levels for arsenic. However, none of the detected concentrations exceeded risk-based screening levels from spiked sediment studies that evaluated the specific toxicity of arsenic for sediment-dwelling organisms similar to those likely to be present in Herrington Lake.
- Speciated arsenic (arsenate and arsenite, the toxic forms of arsenic) concentrations in pore water samples exceeded the USEPA Region 4 screening level (USEPA 2018) at several locations within Curds Inlet.
    - The concentrations of arsenite and arsenate in pore water were also compared to a risk criterion based on the USEPA ECOTOX database (USEPA 2021) specific to sediment-dwelling organisms.
    - Arsenite and arsenate exceeded the risk-based criterion at four locations within Curds Inlet.

  - Based on these findings, some isolated areas along the thalweg in Curds Inlet may pose risk to sediment-dwelling organisms. However, it is not likely that these conditions would adversely impact the sediment-dwelling organism community as a whole.

Iron in Sediment and Sediment Pore Water

- The Corrective Action ISARA Report ERA discussed iron concentrations in sediment and pore water from Curds Inlet and Herrington Lake, and the sampling results for iron were graphically presented in the Coal Pile Addendum.
  - As explained in the Corrective Action ISARA Report and the Coal Pile Addendum, most of the detected concentrations of iron in sediment within Curds Inlet and Herrington Lake exceeded the lower USEPA ecological screening level for iron and 11 of the detected concentrations in Curds Inlet exceeded the upper USEPA ecological screening level. The USEPA Region 4 screening levels for iron are based on an Ontario Ministry of the Environment (1993) study that brackets background values. These are not concentrations that have been observed to be toxic to sediment-dwelling organisms exposed to iron.
  - The Coal Pile Addendum showed that none of the detected concentrations of iron in sediment exceeded the USEPA threshold value for iron toxicity in sediment and sediment-dwelling organisms (188,000 milligram per kilogram [mg/kg], Ingersoll *et al.* 1996). Therefore, iron in sediment from Curds Inlet and Herrington Lake outside of Curds Inlet are not expected to cause adverse impacts to sediment-dwelling organisms.
  - The iron concentrations in sediment pore water exceeded the upper Kentucky water quality standards of 1 mg/L and 3.5 mg/L at five locations within Curds Inlet in the central area of Curds Inlet.
  - The Corrective Action ISARA Report evaluated iron in sediment pore water and noted that some of the concentrations exceeded the Kentucky water quality standard for iron. However, the report did not identify iron as an issue for sediment dwelling organisms because of the geochemistry of iron, the natural occurrence of iron, and bioavailability of iron bound to the sediment matrix.
  - The iron in sediment pore water is considered further in this SRAA Report because some potential impacts to some individual sediment-dwelling organisms cannot be definitely ruled out based on the sediment pore water concentrations at the five highest concentrations that exceeded both the Kentucky water quality standards of 1 mg/L and 3.5 mg/L.
- Based on these findings, it is possible that some isolated impact to sediment-dwelling organisms could occur where concentrations exceed the higher of the iron water quality standards. Because these isolated locations represent only a small portion of the sediment habitat, however, it is unlikely that iron would adversely impact the overall sediment-dwelling organism community as a whole.

1.4. Summary of Risk-Based Conditions Warranting Consideration for Supplemental Performance Monitoring

As discussed above and in the HHRA, there were no human health risks identified for Herrington Lake that warranted consideration for potential remedial action or supplemental performance monitoring as part of the SRAA. The ERA did not identify any population-level impacts to fish, birds, or mammals, and did not identify a likely risk to the sediment-dwelling invertebrate community. However, supplemental performance monitoring was identified because some isolated risk could not be ruled out for individual fish in upper Curds Inlet based on elevated selenium concentrations measured in YOY bluegills in 2018, and some localized risk could not be ruled out for the sediment-dwelling community in isolated areas due to exposure to selenium in sediment, and arsenic and iron in sediment pore water. Furthermore, the elimination of process water flows into Curds Inlet as of November 2019 was expected to decrease the potential loading of selenium, arsenic, and iron to waters in Curds Inlet. This information created uncertainty about whether exposure to selenium currently poses any potential risk to individual YOY fish in Curds Inlet.

As a result, the SRAA Report identified a supplemental performance monitoring approach that focused on the three RAOs, with a sampling program focused on the collection of adult fish, YOY fish, and a benthic community assessment, as summarized in Exhibit 1-2.

Exhibit 1-2. 2022 Performance Monitoring Overview

RAO Performance Measure	Sample Type		Sampling Season	Number of Composite Monitoring Samples
RAO 1		Adult Bluegill	Late May (Prior to Spawning)	13
RAO 1		Adult Bass		10
RAO 2		Young-of-Year Bluegill	June to August	12
RAO 3		Sediment-Dwelling Organism Community Assessment	May to July	12

- **RAO 1**: Sustain the applicable standards for protection of aquatic life in Curds Inlet and Herrington Lake for selenium.
  - **Measurements**: Selenium concentrations in (1) adult whole-body bluegills, (2) bluegill ovary/egg tissues; and (3) adult whole-body largemouth bass.
  - **Number of Samples and Sample Locations**: Thirteen adult bluegill and ten adult bass samples were identified for collection from locations previously sampled as part of the ISARA investigation efforts (Lower Herrington Lake, including Curds Inlet, as well as upgradient locations, including Middle Herrington Lake, approximately 20 miles upgradient from Curds Inlet), as identified on Figure 1-2A.

- **RAO 2**: Reduce selenium concentrations in YOY bluegills from Curds Inlet compared to the 2018 YOY tissue concentrations.
  - **Measurement:** Selenium concentration in YOY bluegill whole-body tissues.
  - **Number of Samples/Locations**: Twelve YOY bluegill samples were identified for collection from locations previously sampled as part of the ISARA investigation efforts, with 9 of the 12 samples planned for Curds Inlet and 3 samples planned for Hardin Inlet as a reference location (Figure 1-2B).
- **RAO 3**: Demonstrate the diversity and abundance of the Curds Inlet sediment-dwelling invertebrate community, considering the presence of selenium in sediment and arsenic iron in sediment pore water.
  - **Measurement:** Sediment dwelling organism community composition, based on taxonomic identification of diversity, abundance, and other community metrics. The sampling approach planned identified the use of artificial substrate samplers.

- **Number of Samples/Locations**: A total of 12 sample locations were identified (Figure 1-2C), with nine locations in Curds Inlet and three locations within the Hardin Inlet reference area. The plan called for three artificial substrate samplers at each location, for a total of 27 samplers in Curds Inlet and nine samplers in Hardin Inlet. The ISARA Report did not previously include a direct assessment of the sediment-dwelling organism community.

The remainder of this report provides details of the 2022 performance monitoring, including a more detailed description of the sampling as implemented, the laboratory analytical results including third-party data validation, and an evaluation of the results for each RAO in accordance with the performance criteria established in the SRAA Report. As such, the remainder of this report is organized as follows:

- Section 2 addresses adult fish (RAO 1)
- Section 3 addresses YOY fish (RAO 2)
- Section 4 describes the assessment of the sediment-dwelling organism community (RAO 3)
- Section 5 provides conclusions and recommendations based on the 2022 performance monitoring results
- Section 6 provides information for references cited

2. MONITORING ADULT WHOLE-BODY FISH AND OVARY TISSUES (RAO 1)

The SRAA Report identified RAO 1 as "*Sustain the applicable standards for protection of aquatic life in Curds Inlet and Herrington Lake for selenium*." The supplemental performance monitoring for RAO 1 involved collection of (1) adult whole-body bluegills, (2) bluegill ovary/egg tissues; and (3) adult whole-body largemouth bass. The RAO 1 performance criteria and the thresholds used to determine if RAO monitoring is complete, as identified in the SRAA Report, are identified below:

- **RAO 1 Performance Criteria**: Adult fish whole-body dry weight tissue analytical results for bluegill and bass will be compared to the Kentucky Surface Water Quality Standard (WQS) for Warm Water Habitat for selenium in whole body fish tissues (KDOW 2019a). Bluegill ovary/egg concentrations will be compared to the USEPA ovary/egg criterion (USEPA 2016).
- RAO monitoring will be considered complete (i.e., RAO 1 achieved) if the following criteria are met:
    - Selenium concentrations in whole body adult fish tissues are less than the Kentucky Surface WQS for Warm Water Habitat for selenium in whole body fish tissues (KDOW 2019a; 8.6 milligram per kilogram [mg/kg]).
    - Selenium concentrations in bluegill ovary/egg tissues from Curds Inlet are less than the USEPA ovary/egg criterion (USEPA 2016; 15.1 mg/kg).

This section provides the following:

- Adult Fish Sampling Field Collection and Laboratory Information (Section 2.1)
- Selenium Analytical Results for Adult Fish (Section 2.2)
- Evaluation of Performance Criteria and Conclusions (Section 2.3)

2.1. Adult Fish Sampling Field Collection and Laboratory Information

Adult fish sampling was performed in May 2022 in accordance with the Standard Operating Procedure (SOP) for Performance Monitoring of Adult and Young of Year Fish, and Surface Water Sampling (hereafter referred to as the Adult and YOY Fish SOP) provided as part of the SRAA Report (Ramboll 2021). The Adult and YOY Fish SOP is consistent with the KDOW SOPs for fish sample collection and for fish sample preparation (KDOW 2016, 2019b). In addition, the Adult and YOY Fish SOP is consistent with USEPA sample collection guidance in *Concepts and Approaches for the Bioassessment of Non-wadeable Streams and Rivers (Flotemersch et al. 2006*) and *Guidance for Assessing Chemical Contamination Data for Use in Fish Consumption Guidelines* (USEPA 2000).

Target Fish:

1. Lower trophic level, small home range predator/prey fish: adult bluegills (*Lepomis macrochirus*).
2. Upper trophic level, large home range predator fish: largemouth bass (*Micropterus salmoides*) (or spotted (Kentucky) bass (*Micropterus punctulatus*) as a substitute for the closely related largemouth bass if bass were not available).

Adult Fish Collection Locations:

Adult fish collection locations for 2022 were the same as those from the 2017 and 2018 Herrington Lake sampling efforts, as indicated on Figure 1-2A:

- Curds Inlet
- Lower Herrington Lake outside Curds Inlet three locations LHL 1, LHL 2, and LHL 6
- Middle Herrington Lake (near Gwinn Island Fish Camp located, near lake-mile 20)

Sample Collection Overview:

The number of fish collected by region is summarized on Table 2-1 and Exhibit 2-1 below. As can be seen, a total of 95 bluegills were collected, comprising 13 samples. A total of 23 bass were collected, comprising 10 samples.

Exhibit 2-1. 2022 Adult Fish Monitoring Overview

RAO 1		Sampling Season	Number of Composite Monitoring Samples	Number of Individuals per Sample	Total Individuals Collected	Target Analyte/ Metrics
 	Adult Bluegill	Late May (Prior to Spawning)	13	4 to 5	95	Selenium in Fish Tissues
	Adult Bass		10	2 to 3	23	

Field Collection and Handling:

- Adult bluegill and bass collected for whole-body tissue sampling were composite fish samples, consisting of 4 to 5 bluegills or 2 to 3 largemouth bass collected via electroshocking methods.
- The individual adult fish within each composite sample were of similar age-class, each measuring at least 75% in length, compared to the longest fish in the sample. Once collected and visually assessed, the adult fish were grouped by location and species, then grouped again into composite whole-body samples of 1-5 fish, where sufficient fish numbers were collected.
- For the 2017 and 2018 sampling, KDOW requested a 16-inch minimum bass length. To the extent possible, similar sized fish were targeted for the 2022 performance monitoring.
- Sample geographic coordinates for the 2022 field efforts were recorded using a Global Positioning System for use in a Geographic Information System (GIS), as indicated in Appendix A.
- Individual adult fish were photographed to document length and key data were recorded in field data sheets, including species, number of fish per sample, and individual weight. Adult fish photos are provided in Appendix B1. Adult fish field data are summarized in Appendix C, based on individual field data sheets provided in Appendix D1.
- The gravid bluegill ovaries were removed, including egg tissue, and the ovary/egg tissues were submitted for analysis separately from the remaining carcass ("remains" or "offal") by Ramboll biologists that performed the fish sampling.
- Adult largemouth bass ovary tissues were not collected for RAO 1 because ovary tissues were analyzed for largemouth bass and catfish in 2017 and the results did not exceed the USEPA ovary criterion (Ramboll 2019). In addition, studies indicate that bluegill are more sensitive to selenium exposure than largemouth bass (USEPA 2016).

Fish were frozen after the information was recorded (weight, number of fish per composite) and shipped to the laboratory on ice under chain of custody seal in accordance with the Adult and YOY Fish SOP.

Laboratory Analyses:

- The adult fish tissue samples (whole-body, remains, and ovary/egg tissues) were analyzed by ALS Laboratory in Kelso, Washington for selenium using USEPA SW846 Method 6020. This is the same laboratory that performed the 2017 and 2018 analyses for the Herrington Lake ISARA efforts. The laboratory prepared the tissue samples via lyophilization (i.e., freeze dried) aliquots, in accordance with the KDOW 2019 Fish Standard Operating Procedure for Preparation and Homogenization of Fish Tissue Samples. Laboratory reports are provided in Appendix E.

Third-Party Data Validation:

- A third-party validation was performed on the adult fish tissues by Validata, LLC, the same company that provided data validation for the 2017 and 2018 analyses for the Herrington Lake ISARA efforts. Data validation reports are provided in Appendix F.

2.2.Selenium Analytical Results for Adult Fish

2.2.1. 2022 Adult Female Bluegill Results

The adult bluegill samples were analyzed as ovary tissues and remains, with selenium results summarized for each compartment (ovary tissues and remains) provided on Table 2-2. The data for ovary and remains were combined to mathematically reflect the whole-body tissue concentrations, as indicated in Table 2-2, as follows:

$$WB_{BLUEGILL} = C_{OVARY} * P_{OVARY} + C_{REMAINS} * P_{REMAINS}$$

Where:

$WB_{BLUEGILL}$ = Constituent concentration in whole-body bluegill (mg/kg, dry weight)

C_{OVARY} = Constituent concentration in fish ovaries composite sample (mg/kg, dry weight)

$C_{REMAINS}$ = Constituent concentration in fish remains composite sample (mg/kg, dry weight)

P_{OVARY} = Percent of fish ovaries composite sample (%)

$P_{REMAINS}$ = Percent of fish remains composite sample (%)

The 2022 bluegill whole-body selenium tissue concentrations ranged from 0.98 mg/kg to 2.44 mg/kg, dry weight, as indicated on Table 2-2 and Figure 2-1A. These results are less than the Kentucky WQS of 8.6 mg/kg, dry weight.

2.2.2. Adult Bluegill 2022 Ovary Selenium Results

The 2022 bluegill ovary selenium tissue concentrations ranged from 1.16 mg/kg to 3.53 mg/kg, dry weight, as indicated on Table 2-2 and Figure 2-1B. These results are less than the USEPA ovary/egg criterion of 15.1 mg/kg, dry weight.

2.2.3. Adult Largemouth Bass 2022 Whole-Body Selenium Results

The 2022 largemouth bass whole-body selenium tissue concentrations ranged from 0.94 mg/kg to 1.53 mg/kg, dry weight, as indicated on Table 2-3 and Figure 2-1C. These results are less than the Kentucky WQS of 8.6 mg/kg, dry weight.

2.2.4. Cabinet Split Samples for Selenium Adult Fish

The following blind[4] split samples for adult fish were submitted to the Cabinet, as follows (with results from the ALS Laboratory and the Cabinet provided in Table 2-4 along with Cabinet lab reports provided in Appendix E):

- Bluegill remains: FOF001(BG)-LHL6, with the ALS Laboratory result of 1.09 mg/kg, dry weight, and Cabinet split results of 1.27 mg/kg, dry weight.
- Bluegill ovary: FO001(BG)-LHL6, with the ALS Laboratory result of 2.91 mg/kg, dry weight, and Cabinet split results of 3.51 mg/kg, dry weight.
- Whole body bass: FWB002(LMB)-CI, with the ALS Laboratory result of 1.53 mg/kg, dry weight, and Cabinet split results of 1.59 mg/kg, dry weight.

The Cabinet split sample results are all within an acceptable relative percent difference to be considered duplicates in a data validation process.

2.3.Evaluation of RAO Performance Criteria and Conclusions

The 2022 adult fish selenium tissue concentrations are uniformly below the Kentucky WQS for whole-body fish and the USEPA ovary/egg criterion for ovary tissues (Figures 2-1A, 2-1B, and 2-1C). The 2022 selenium tissue concentrations are also lower than tissue concentrations observed from 2017 and 2018, with one exception, as indicated below:

- The maximum detected selenium in adult bluegill from 2022 was 2.44 mg/kg, dry weight. These results reflect a reduction of selenium whole-body tissue concentrations compared to 2017 and 2018, as indicated in Figure 2-2A. The maximum whole-body selenium concentration from 2017 and 2018 was 7.38 mg/kg, dry weight. The exception is a single bluegill sample from Middle Herrington Lake (approximately 20 miles upgradient from Curds Inlet), which had a 2022 concentration of 2.44 mg/kg, slightly greater than seen in 2017 at approximately 1.6 mg/kg.
- The maximum detected selenium in adult bluegill ovary tissues from 2022 was 3.53 mg/kg, dry weight, as shown in Table 2-2. Bluegill ovary tissues were not sampled as part of the 2017 field efforts, but bass and catfish ovary tissues were. The maximum bass or catfish selenium concentration from 2017 was 14.5 mg/kg, dry weight, which was slightly less than the USEPA egg/ovary criterion of 15.1 mg/kg, dry weight. The bluegill ovary tissue results from 2022 are compared to the bass and catfish ovary results from 2017 on Figure 2-2B. As indicated in Figure 2-2B, the bluegill ovary tissues are lower than all of the bass and catfish ovary concentrations from 2017.
- The maximum detected selenium in adult bass from 2022 was 1.53 mg/kg, dry weight. These results reflect a reduction of selenium whole-body tissue concentrations compared to 2017 and 2018, as indicated in Figure 2-2C. The maximum whole-body selenium concentration from 2017 and 2018 was 5.5 mg/kg, dry weight.

The results of the 2022 adult bluegill and adult bass performance monitoring indicate that the performance criterion for this RAO has been met and that monitoring of RAO 1 is considered complete. Additional adult fish tissue testing will continue in accordance with the 2019 KPDES permit if effluent sampling for outfall BRN006 exceeds the trigger value for selenium.

[4] The Cabinet did not have ALS Laboratory results at the time of analysis.

3. MONITORING YOY BLUEGILL TISSUES (RAO 2)

The SRAA Report identified RAO 2 as "*Reduce selenium concentrations in young-of-the-year (YOY) bluegills from Curds Inlet compared to the 2018 YOY tissue concentration.*" The supplemental performance monitoring for RAO 2 involved measurement of selenium concentration in YOY bluegill whole-body tissues. The RAO 2 performance criteria and the threshold used to identify if RAO monitoring is complete, as identified in the SRAA Report, are identified below:

- **Performance Criteria:** There are no promulgated WQS for YOY fish tissues similar to the adult fish and ovary/egg tissues WQS discussed in Section 2. The YOY composite whole body dry weight tissue analytical results for Curds Inlet will be compared to the 2018 YOY sampling results. The SRAA Report stated that at least two monitoring events were considered necessary to confirm tissue concentration trends.
- Monitoring will be considered complete (i.e., RAO 2 achieved) if the following criteria are met:
    - The SRAA stated that monitoring would be considered complete if the first and second sampling events show an overall declining trend in YOY selenium concentrations compared with the 2018 YOY sampling.

This section provides the following:

- YOY Sampling Field Collection and Laboratory Information (Section 3.1)
- Selenium Analytical Results for YOY Fish (Section 3.2)
- Evaluation of Performance Criteria and Conclusions (Section 3.3)

3.1. YOY Sampling Field Collection and Laboratory Information

The YOY fish sampling was performed during July and August 2022 in accordance with the Adult and YOY Fish SOP.

YOY Fish Collection Locations:

For consistency and to allow direct comparison to the summer 2018 YOY study results reported in the Corrective Action ISARA Report, the 2022 YOY bluegill monitoring locations focused on the following (Figure 1-2B):

1. Upper Curds Inlet (UCI) located near the outfalls
2. Middle Curds Inlet (MCI) the middle portion of the inlet
3. Lower Curds Inlet (LCI) / HQ Inlet (HQ)
4. Hardin Inlet (HI) (reference site)

The LCI and HQ Inlet areas were considered collectively because the 2018 results showed similarity in selenium concentrations between these two areas and the possibility of movement of YOY fish between the areas cannot be ruled out. Hardin Inlet was chosen as the YOY reference area, the same as for the ISARA 2018 YOY study. Hardin Inlet is located approximately three-fourths of a mile upstream from Curds Inlet and shares physical features with Upper Curds Inlet.

Sample Collection Overview:

The number of fish collected by region is summarized on Table 2-1 and Exhibit 3-1 below. A total of more than 1,100 YOY bluegills were collected, comprising 12 samples, with 9 samples from Curds Inlet and 3 samples from the Hardin Inlet reference location. The number of individual fish for each composite sample ranged from 8 to 539 individuals, with two size classes of YOY fish described further below.

Exhibit 3-1. 2022 YOY Fish Monitoring Overview						
RAO 2		Sampling Season	Number of Composite Monitoring Samples	Number of Individuals per Sample	Total Individuals Collected	Target Analyte/ Metrics
	Young-of-Year Bluegill	June to August	12	8 to 539	1,114	Selenium in Fish Tissues

Field Collection and Handling:

- The juvenile bluegills were collected using seine nets, minnow traps, dip nets, and by electrofishing, with the majority of the smaller YOY bluegills collected via opportunistic dip netting.

- The size and number of fish per composite sample were similar to results obtained in the previous 2018 sampling of YOY fish. Table 3-1 provides the 2022 YOY bluegill sample sizes including number of individual fishes collected from each of the three Curds Inlet sampling regions and the Hardin Inlet reference sampling region. YOY fish were grouped by size into two groups, as indicated in Table 3-1. The samples with the highest number of individuals were the youngest fish, collected within days post swim-up. Most samples were within an average weight of YOY fish from 0.02 to 1.2 grams per fish. Two samples, one from Middle Curds Inlet and one in Hardin Inlet, had fish the size of approximately 0.02 grams per fish.

- YOY fish were photographed, and data recorded in field data sheets, including species, number of fish per sample, and collective weights for the fish captured by various methods. YOY fish photos are provided in Appendix B2. YOY fish field data sheets provided in Appendix D2.
- Surface water samples were also collected from each of the four YOY sampling areas. Samples were collected from approximately 1 foot below water surface using a Kemmerer water collection sampler. Samples were analyzed for total selenium and dissolved selenium analyses. The dissolved selenium samples were filtered in the field during the collection effort.

Laboratory Analyses:

The YOY fish tissue samples and the surface water samples were analyzed by ALS Laboratory in Kelso, Washington, for selenium using USEPA SW846 Method 6020, same as for the adult fish samples. The laboratory prepared the YOY tissue samples via lyophilization (i.e., freeze dried) using all YOY fish sent per sample. Laboratory reports are provided in Appendix E.

Third-Party Validation:

A third-party validation was performed on the adult fish tissue analytical data by Validata, LLC, the same company that provided data validation for the 2018 YOY fish analyses for the Herrington Lake ISARA efforts. The YOY tissue validation included 100% Level II data validation and 20% Level IV data validation using USEPA Data Quality Evaluation guidelines. The validation indicated that the data quality are appropriate for use in environmental management decision-making. The YOY data validation reports are provided in Appendix F.

3.2.Selenium Analytical Results for YOY Fish

The 2022 bluegill YOY selenium tissue concentrations ranged from 1.18 mg/kg to 2.08 mg/kg, dry weight, as indicated on Table 3-1 and Figure 3-1A. These results are less than the Kentucky WQS of 8.6 mg/kg and the USEPA ovary/egg criterion of 15.1 mg/kg, dry weight.

A split sample for YOY fish was submitted to the Cabinet (sample ID YOY(BG)-001-LCI), from lower Curds Inlet, which was detected at a concentration of 1.8 mg/kg, dry weight, with the Cabinet split results of 1.88 mg/kg, dry weight, as indicated in Table 2-4.

3.3.Selenium Analytical Results for Surface Water

Selenium was not detected in surface water from the 2022 sampling, with detection limits of 1 microgram per liter (µg/L) (Table 3-2), which is less that the KY WQS for surface water of 5 µg/L.

3.4.Evaluation of RAO Performance Criteria and Conclusions

The 2022 YOY selenium tissue concentrations are also lower than YOY tissue concentrations observed from the 2018 YOY study, as indicated below:

- The maximum detected YOY bluegill selenium concentration from 2022 was 2.08 mg/kg, dry weight. These results reflect a reduction of selenium whole-body tissue concentrations compared to 2018, as indicated in Figure 3-1B. The YOY bluegill selenium concentrations from 2018 ranged from 3.20 mg/kg to 24.8 mg/kg, dry weight. The maximum 2022 result was lower than all of the 2018 results.
- The 2022 YOY selenium tissue concentrations are also less than the Kentucky WQS for whole body fish and the USEPA ovary/egg criterion. Although neither of these standards is a promulgated WQS for YOY fish, they nonetheless provide a basis in this case to conclude that the current YOY concentrations are not indicative of unacceptable ecological risk.
- The SRAA Report stated that two monitoring periods would be needed to confirm tissue concentration trends, and monitoring would be considered complete if the first and second sampling events show an overall declining trend in YOY selenium concentrations compared with the 2018 YOY sampling. The 2022 showed a significant decline in selenium concentrations, with the UCI area of Curds Inlet showing approximately a 90 percent reduction in selenium concentrations in the YOY fish. The maximum concentrations of YOY whole-body tissue concentrations from 2018 was from the UCI area of Curds Inlet, closest to the former KPDES permitted Outfall BRN001. As suspected, the elimination of the source flow via KPDES Outfall BRN001 appears to have resulting in improved conditions for YOY fish.
- At the time of the SRAA Report when two YOY monitoring periods were discussed, it was not anticipated that the first sampling event would show such a dramatic reduction in YOY tissue concentrations. Given these results, KU proposes that additional YOY monitoring is not warranted and performance monitoring for RAO 2 should be considered complete.

4. SEDIMENT-DWELLING INVERTEBRATE COMMUNITY ASSESSMENT (RAO 3)

The SRAA Report identified RAO 3 as "*Demonstrate the diversity and abundance of the Curds Inlet sediment-dwelling invertebrate community, considering the presence of selenium in sediment and arsenic and iron in sediment pore water*." The supplemental performance monitoring for RAO 3 involved assessment of the sediment dwelling organism community composition, based on taxonomic identification of diversity, abundance, and other community metrics. Sediment-dwelling invertebrates are benthic organisms, meaning they live in and on the sediment surface, which is also commonly referred to as the benthic organism community.

- **RAO 3 Performance Criteria**: The results of benthic community assessment (BCA) for Curds Inlet will be compared to results from the reference area. The USEPA metrics and scoring approach for non-wadeable streams (2006, 1999, and 1989) will be used to evaluate the benthic community in Curds Inlet for RAO 3. The final list of metrics most appropriate to Herrington Lake will be identified based on the benthic community observed at the Herrington Lake reference area(s) selected for the assessment. In accordance with the USEPA scoring approach, multi-metric scoring and indices will be considered for Curds Inlet compared to Herrington Lake reference area(s) for RAO 3, as follows:
    - Conditions in Curds Inlet greater than or equal to 80% of the reference area(s) in Herrington Lake will be considered comparable (i.e. not impaired);
    - Conditions between 50 and 79% in Curds Inlet relative to reference area(s) in Herrington Lake will be considered slightly impaired;
    - Conditions between 21 and 49% in Curds Inlet relative to reference area(s) in Herrington Lake will be considered moderately impaired; and,
    - Conditions less than 20% in Curds Inlet relative to reference area(s) in Herrington Lake will be considered severely impaired.
- **Monitoring will be considered complete (i.e., RAO 3 achieved)**: Performance monitoring will be considered complete if the assessment demonstrates that the community composition between Curds Inlet and the reference area are designated "comparable," defined as multi-metric scoring for Curds Inlet within 80% of the reference locations.

This section provides the following:

- Process for Selection of Sample Locations (Section 4.1)
- BCA Field Sampling Approach (Section 4.2)
- BCA Multi-Metric Scoring and Results (Section 4.3)
- Evaluation of BCA Performance Criteria and Conclusions (Section 4.4)

4.1. Process for Selection of Sample Locations

The sample locations identified for the BCA are identified on Figures 1-2C, 4-1A, 4-1B, and 4-1C, taking into account the sediment and sediment pore water concentrations for Curds Inlet from the ISARA Report and Coal Pile Addendum (Ramboll 2019, 2020) as well as acoustic surveys of Curds Inlet performed in 2022.

4.1.1. Sediment and Sediment Pore Water Concentrations

The purpose of the supplemental monitoring is to better understand potential risks for the sediment-dwelling organism community due to isolated, elevated concentrations of selenium in sediment, arsenic in sediment pore water, and iron in sediment pore water. Therefore, the concentrations of each constituent/media were evaluated using data from the ISARA report, as indicated in Figure 4-1A. The top 10 highest concentrations for each constituent were identified in a single map so that BCA sample locations could be aligned with the locations with the highest concentrations (Figure 4-1B).

4.1.2. Acoustic Surveys of Curds Inlet

Aqua Survey Inc. (hereafter ASI) conducted bathymetry, sub-bottom profile and side-scan acoustic surveys.

- Bathymetry data provided insight to water depths that were previously uncertain, particularly given the flow changes in Curds Inlet following the closure of Outfall BRN001.
- The sub-bottom profile provided insights into the presence of areas with sediment deposits to target for the BCA and ensured that BCA samplers were not placed on bedrock.
- The side scan sonar was conducted to provide information about submerged debris, including fallen rock, submerged logs, and stumps that could obstruct or entangle sampling equipment.

The acoustic surveys were conducted March 2022, as follows:

- The surveys included real-time kinematic global positioning, single beam fathometer, side scan sonar, and sub-bottom profiling in accordance with the SOP for acoustic surveys that was provided in the SRAA Report.
- Acoustic survey transects were spaced at 25 feet and spanned from shore to shore. A single survey transect was also completed longitudinally down the thalweg (A locations) of Curds Inlet.
- The sub-bottom profilers use acoustic methods to generate high-resolution cross-sectional images of the subsurface sediment surface.

The results from the ASI Survey are provided in Appendix G and are briefly described below.

- Bathymetry and side scan sonar were incorporated into GIS for the development of maps used to guide placement of sample locations (Figure 4-1C and 4-1D).
- Sub-bottom profile imagery indicated that sediment is distributed across Curds Inlet and there were no large areas of exposed bedrock to be avoided. This is in contrast to the observations by divers in 2017 and 2018, where they reported many areas of exposed bedrock were observed, and divers had difficulty finding deposits of sediment to sample at some locations. The sub-bottom profile imagery demonstrates that Curds Inlet is a depositional environment, likely following the closure of the Outfall BRN006, which changed the hydrology of the inlet considerably as a result of the rerouting of 5.3 million gallons of water per day that previously flowed through the inlet.
- Side scan sonar imagery provided insight into debris within Curds Inlet to be avoided.

4.2. BCA Field Sampling and Laboratory Approach

Hester Dendy artificial substrate samplers (HD samplers) were deployed in May 2022 and retrieved in July 2022. The HD sampler deployment and retrieval methodology was consistent with the BCA SOP provided as part of the SRAA Report. The BCA approach outlined in the SOP is consistent with KDOW guidance (KDOW 2002, 2003, 2015) and USEPA Guidance (1989, 1999, 2001, 2006, 2009). An overview of the BCA sampling approach is provided in Table 2-1 and Exhibit 4-1 below.

Exhibit 4-1. 2022 Benthic Community Assessment Overview

RAO 3		Sampling Season	Number of Sample Locations By Region				Total Number of Locations	Number of Replicate Samplers per Location	Total Number of Artificial Samplers
			UCI	MCI	LCI	Hardin Inlet			
	Sediment Dwelling Organism (Benthic) Community Assessment	May to July	3	3	3	3	12	3	36

- HD samplers were deployed in May 2022. As indicated in Table 4-1, water quality parameters for each location were recorded as of the date of deployment.
- The HD samplers were positioned directly on the sediment surface to facilitate the colonization of the sampler by organisms in the associated sediment environment to reflect the benthic community conditions associated with residual constituents in sediment and sediment pore water. GIS coordinates are provided in Appendix A.
- HD samplers were secured to the shore using ropes and flagging to avoid human disturbance as much as possible during the time deployed.
- The HD samplers remained in situ on the sediment surface for 6 weeks to allow full colonization, and then were retrieved in late June 2022.
- HD samplers were retrieved using a protective plastic cover designed for the purpose of retrieving the HD samplers with the least amount of flushing possible. The protective plastic cover was directed down the rope to the Hester Dendy sampler using a weight threaded by the rope connected to the sampler.
- Once retrieved, the HD samplers were covered in 10% ethanol and placed in secured containers with ice under chain-of-custody until shipped to a taxonomic laboratory for enumeration and processing.
- Field data sheets completed during the BCA field effort are provided in Appendix H.
- Watershed Associates, Inc. performed the taxonomic identification of organisms to the genus and species. The taxonomic data are provided in Appendix H. In addition, the taxonomic laboratory SOP for the BCA as well as the Watershed Assessment laboratory certifications are provided in Appendix H. Following the taxonomic identification and enumeration of the benthic community samples, benthic community health assessment metrics were calculated to compare the condition of the benthic community in each location, as described in Section 4.3 and Appendix H.

4.3.BCA Multi-Metric Results and Scoring

As specified in the SRAA Report (and associated BCA SOP to the SRAA Report), the assessment of the benthic community in Curds Inlet would be based on a comparison to the Hardin Inlet reference area using metrics developed by USEPA (2006, 1989, 1999) and KDOW (2003) and scored according to the USEPA Concepts and Approach for the Bioassessment of Non-Wadeable Streams and Rivers (USEPA Bioassessment Approach) (2006). The SRAA Report and BCA SOP also discuss three additional indexes for evaluating benthic community conditions in Curds Inlet: the Kentucky Macroinvertebrate Bioassessment Index (KY MBI), the Non-Wadeable Macroinvertebrate Assemblage Condition Index (NMACI), and the Lake Bioassessment Integrity Index (LBII). The results from all four indexes are presented in Appendix H, and the results are generally consistent across the indexes and confirm that the overall condition of the benthic community in Curds Inlet is comparable to Hardin Inlet. Only the results of the USEPA Bioassessment Approach and the KY MBI are discussed in this section.

The BCA is based on a comparison of overall conditions in Curds Inlet to conditions in Hardin Inlet because the community of sediment dwelling organisms is best understood by the conditions of the inlets as a whole rather than individual specific sampling locations. Accordingly the assessment is based on the aggregate scoring of the individual locations to yield and understanding of the overall community for each inlet, as illustrated in Exhibit 4-2 below. In addition, to explain the derivation of the aggregate results, the scoring of the BCA analysis is provided for each replicate from each sample location, as described in detail in Appendix H.

Exhibit 4-2. BCA Data Used in the Evaluation of Replicates, Locations, Areas, and Inlets

Individual Replicates	Individual Locations	Individual Areas	Hardin Inlet vs Curds Inlet for Community Composition
HIA-1	**HIA**	**Hardin Inlet**	**Hardin Inlet**
HIA-2			
HIA-3			
HIB-1	**HIB**		
HIB-2			
HIB-3			
HIC-1	**HIC**		
HIC-3			
HIC-4			
Curds 1A-1	**Curds 1A**	**Upper Curds Inlet**	**Curds Inlet**
Curds 1A-2			
Curds 1A-3			
CI1A-1	**CI1A**		
CI1A-2			
CI1A-3			
Curds 2A-2	**Curds 2A**		
Curds 2A-3			
Curds 2A-4			
CI2.1A-1	**CI2.1A**	**Middle Curds Inlet**	
CI2.1A-2			
CI2.1A-3			
CI2.2A-2	**CI2.2A**		
CI2.2A-4			
CI2.2A-5			
CI3A-1	**CI3A**		
CI3A-2			
CI3A-3			
CI3.1A-1	**CI3.1A**	**Lower Curds Inlet**	
CI3.1A-2			
CI3.1B-1	**CI3.1B**		
CI3.1B-2			
CI3.1B-4			
CI3.2A-2	**CI3.2A**		
CI3.2A-4			
CI3.2A-5			

A metric is one piece of information that characterizes the benthic community. An index is a group of metrics that are assessed concurrently to produce a score and that score is linked to a measure of community health or impairment. For instance, the number of species is a metric, and the KDOW Macroinvertebrate Bioassessment Index uses six metrics to calculate water quality that ranges from "very poor" to "excellent".

The benthic community metrics used in the USEPA Bioassessment Approach and KY MBI are provided in Exhibit 4-3.

Exhibit 4-3. USEPA and KDEP Metrics Considered	
USEPA METRICS • Number of species • Hilsenhoff Biotic Index (HBI) • Ratio of scraper vs filterer feeding groups • Ratio of mayflies, stoneflies, and caddisflies versus midges • Number of mayflies, stoneflies, and caddisflies • % Community from dominant taxon • Number of EPT taxa • Community loss index (CLI) • % Community from shredder feeding group	**KDOW METRICS** • Genus Level Taxa Richness • EPT Genera • Modified HBI • Modified % EPT individuals • % Chironomids+ Oligochaete Individuals • % Clinger Individuals

EPT mayfly (Ephemeroptera), stonefly (Plecoptera), and caddisfly (Trichoptera)

In the USEPA Bioassessment Approach, the Curds Inlet BCA results are compared the Hardin Inlet reference area. Each of these metrics (and more, as discussed in Appendix H) were calculated for each replicate, each sampling location, each section of Curds Inlet, and for Curds Inlet as a whole. The details of these analyses are shown in Appendix H and the results of the Hardin Inlet reference location versus the Curds Inlet average are summarized here.

This BCA was comprised of taxonomy data from 35 Hester Dendy samplers from the 12 sampling areas. One of the samplers from Curds Inlet (location CI3.1A) had no organisms, likely because the organisms were washed out during retrieval; therefore, that one sample was excluded from the analysis.

The sediment dwelling organism community in Curds Inlet and Hardin Inlet was robust, as summarized on Figures 4-2A through 4-2C and Table 4-1, which show some basic metrics for the Hardin Inlet reference versus Curds Inlet taken as a whole. For most metrics, the higher the metric is the better the community is, however, there are four metrics where the lower value is better, as shown on Table 4-2 and summarized in Exhibit 4-4.

Exhibit 4-4. Guidance for Interpreting Metric Graphics	
Metrics where a higher score indicates a healthier community • # Species • EPT Species • EPT Individuals • Ratio of EPT to Chironomids • Shannon Diversity	**Metrics where a lower score indicates a healthier community** • % Chironomids and Oligochaetes • Hilsenhoff Biotic Index • Kentucky Modified Hilsenhoff Biotic Index • % Dominance

EPT mayfly (Ephemeroptera), stonefly (Plecoptera), and caddisfly (Trichoptera)

Each of the metrics considered for the BCA is described below. The metric results are provided on Table 4-2 and illustrated on Figures 4-2A, 4-2B, and 4-2C.

- **# Organisms** - the number of organisms in Hardin Inlet ranges from 127-641 and ranges from 1-740 in Curds Inlet (Figure 4-2A).
- **# Species** - the number of species in Hardin Inlet ranges from 7-12 and ranges from 1-15 in Curds inlet. Curds Inlet has a slightly higher average number of species (9.8 vs 9.1 in Hardin Inlet) (Figure 4-2A). This indicates that the Curds Inlet macroinvertebrate community is comparable to Hardin Inlet.
- **# EPT Species** – Several metrics include "EPT" species or organisms. Larval mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) are pollution sensitive – they tend to diminish in the presence of watershed disturbance (like siltation) or pollution. EPT species are generally sensitive to pollution so the greater number of EPT species, the better the community. The number of species in Hardin Inlet ranges from 3-4 and ranges from 0-5 in Curds inlet. Curds Inlet has a lower average number of species (2.5 vs 3.8 in Hardin Inlet) (Figure 4-2A). This indicates that the Curds Inlet macroinvertebrate community does not have as many of these pollution species as the Hardin Inlet community but these sensitive species are present in Curds Inlet. This could be due to the change of conditions in Curds Inlet from the closure of Outfall BRN001, as the change in flow allowed sediment accumulation in Curds Inlet.
- **# EPT Individuals** – As in "# of EPT Species" the greater number of EPT individuals, the better the community. The number of EPT individuals in Hardin Inlet ranges from 17-41 and ranges from 0-67 in Curds inlet (Figure 4-2A). Curds Inlet has a slightly lower average number of EPT individuals (22.3 vs 25.1 in Hardin Inlet, so on average, 2 fewer individuals in Curds compared to Hardin). This indicates that the Curds Inlet macroinvertebrate community is comparable to the Hardin Inlet community.
- **Ratio of EPT to Chironomids** - The ratio of pollution sensitive EPT individuals compared to pollution tolerant Chironomid individuals in Hardin Inlet ranges from 0.047-0.186 and ranges from 0-2.056 in Curds inlet. Curds Inlet has a higher average ratio (0.413 vs 0.105 in Hardin Inlet) (Figure 4-2B). This indicates that the Curds Inlet macroinvertebrate community is comparable to Hardin Inlet.
- **% Chironomids and Oligochaetes** - Chironomids and oligochaetes are generally tolerant of pollution, so this metric measures the percentage of the community that can survive under disturbed or polluted conditions. A low score indicates that the community is composed of mostly pollution sensitive organisms, and that the water quality is better. A higher score indicates an greater abundance of pollution tolerant organisms, and that the water quality is worse. The percent of chironomids ranges from 84-85% in the Hardin Inlet reference and from 31-100% in Curds Inlet (Figure 4-2B). Curds Inlet as a whole has a lower average % chironomids and oligochaetes (74% vs 90% in Hardin Inlet). This indicates that the Curds Inlet macroinvertebrate community is comparable to Hardin Inlet. The highest number of Chironomidae in Curds Inlet was seen in Upper Curds Inlet, which may reflect the change in conditions in Curds Inlet which has become more depositional since Outfall BRN001 was closed.
- **Hilsenhoff Biotic Index (HBI)** - This metric (though it is called an index) is a measure of how much of the community is comprised of pollution-tolerant organisms. For this metric, lower values indicate better environmental quality. The HBI ranges from 6.9-8.4 in the Hardin Inlet reference and from 5.6-8.9 in Curds Inlet (Figure 4-2B). Curds Inlet has a lower average HBI (7.3 vs 8.0 in Hardin Inlet). This indicates that the Curds Inlet macroinvertebrate community is comparable to Hardin Inlet.

- **Kentucky Modified HBI (KY mHBI)** - This metric functions exactly like the HBI (described above) but is calculated using a maximum of 25 organisms of each taxon in the sample (i.e., if there were 82 organisms of a particular species, they are treated as 25 organisms to help reduce the influence of highly abundant organisms). The KY mHBI ranges from 6.4-7.7 in the Hardin Inlet reference and from 5.6-8.9 in Curds Inlet (Figure 4-2B). Curds Inlet has a lower average KY mHBI (6.9 vs 7.1 in Hardin Inlet). This indicates that the Curds Inlet macroinvertebrate community is comparable to the Hardin Inlet community. The average and individual measurements of number of species are shown on Figure 4-2B and Table 4-1.
- **% Dominance** - This metric is simply the percentage of the community made up of the most populous organism. High dominance generally indicates low diversity of organisms and an unhealthy benthic community. Lower percent dominance is indicative of a healthier, more-diverse benthic community. The % dominance ranges from 43-90% in the Hardin Inlet reference and from 16-100% in Curds Inlet. Curds Inlet has a lower average % dominance (56% vs 74% in Hardin Inlet) (Figure 4-2C). This indicates that the Curds Inlet macroinvertebrate community is comparable to the Hardin Inlet community.
- **Shannon Diversity Index (SDI)** - This metric (though it is called an index) is a measure of the community diversity and is essentially the inverse of % dominance (above). The higher this metric, the more diverse the community is, and the more indicative of better environmental quality. The SDI ranges from 0.51-1.71 in the Hardin Inlet reference and from 0.51-2.33 in Curds Inlet (Figure 4-2C). Curds Inlet has a higher average SDI (1.39 vs 0.98 in Hardin Inlet). This indicates that the Curds Inlet macroinvertebrate community is comparable to the Hardin Inlet community.

The USEPA Bioassessment Approach (2006, 1989, 1999) and the KY MBI (2003) specifies a methodology to score and aggregate these metrics (details in Appendix H) so that the overall condition of the benthic community can be characterized using a narrative measurement. The average and individual calculated metrics are shown on Figure 4-3, with the full details of the scoring results in Appendix H. As indicated on Figure 4-3, the USEPA Bioassessment Approach calculates that Curds Inlet averages as 92% of the reference and is considered comparable to (i.e., "non-impaired") when compared to the Hardin Inlet reference. The KY MBI method calculates that Curds Inlet averages as 111% when compared to the Hardin Inlet reference. This indicates that the Curds Inlet community is healthier than the reference community and is assessed as having an "excellent" benthic community compared to the Hardin Inlet reference.

4.4. Evaluation of BCA Performance Criteria and Conclusions

As stated in the SRAA Report BCA SOP, the results of benthic community assessment for Curds Inlet compared to Hardin Inlet were used to evaluate RAO 3 based on the following scale:

- Conditions greater than or equal to 80% in Curds Inlet relative to the Hardin Inlet reference area are comparable.
- Conditions between 50 and 79% in Curds Inlet relative to the Hardin Inlet reference area are slightly impaired.
- Conditions between 21 and 49% in Curds Inlet relative to the Hardin Inlet reference area are moderately impaired; and,
- Conditions less than 20% in Curds Inlet relative to the Hardin Inlet reference area are severely impaired.

This assessment demonstrates that the community composition between Curds Inlet and the Hardin Inlet reference area are designated “comparable”, defined as multi-metric scoring within 80% between Curds Inlet and the reference location. This finding is supported by the results of the subbottom profile for Curds Inlet conducted to target areas for placement of Hester Dendy samplers, which identified a greater distribution of sediment in Curds Inlet compared to previous observations from divers who performed the sediment and sediment pore water sampling in 2017 and 2018. The 2022 subbottom profiling suggests that sediment deposition has occurred in Curds Inlet since 2019 when the flow from Outfall BRN001 (5.2 million gallons per day) to Curds Inlet was eliminated. This apparent sediment deposition by cleaner sediments, combined with the reduction in contaminant loading following the closure of Outfall BRN001, would be expected to promote a robust sediment dwelling organism community. Based on the findings of the BCA, performance monitoring is considered complete for RAO 3.

5. CONCLUSIONS

The 2022 supplemental performance monitoring data for adult fish (whole-body and ovary tissues) and YOY fish confirm that conditions in the lake have improved since the 2017 and 2018 timeframe when the previous sampling was done to support the ISARA Report and Coal Pile Addendum. As a result, the performance criteria for RAO 1 were considered met and performance monitoring considered complete.

The performance monitoring criteria for RAO 2 also were met. Although the SRAA Report contemplated that two rounds of monitoring would be necessary to confirm a downward concentration trend, the unexpected large decrease in concentration between 2018 sampling and the 2022 performance monitoring supports a determination that no further performance monitoring is necessary for RAO 2.

The 2022 performance monitoring conducted for RAO 3, which characterized the health of the sediment dwelling organism community in Curds Inlet compared to a reference area in the lake (Hardin Inlet), which provided data that were not previously available for Curds Inlet. The conditions that prompted the supplemental performance monitoring were based on the ERA using sediment and sediment pore water concentrations.

The results of the 2022 monitoring for RAO 3 shows that the sediment dwelling organism community in Curds Inlet is comparable to the sediment dwelling organism community in Hardin Inlet. Therefore, the 2022 monitoring results meet the RAO 3 performance criteria and RAO 3 performance monitoring is considered complete.

6. REFERENCES

Barbour, M. T., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. 2nd edition. EPA 841-B-99-002. US Environmental Protection Agency, Office of Water, Washington, DC.

Blocksom, K. A., and Johnson, B. R. 2009. Development of a regional macroinvertebrate index for large river bioassessment. Ecological Indicators, 9(2), 313–328.

Flotemersch, J., Stribling, J., and Paul, M. 2006. Concepts and Approaches for the Bioassessment of Non-Wadeable Streams and Rivers. EPA/600/R-06/127.

Hargis, W.J. 1991. Disorders of the eye in finfish. Annual Review of Fish Diseases (1): 95-117.

Ingersoll, C.G., P.S. Haverland, E.L. Brunson, T.J. Canfield, F.J. Dwyer, C.E. Henke, N.E. Kemble, and D.R. Mount. 1996. Assessment and remediation of contaminated sediments (ARCS) program: Calculation and evaluation of sediment effect concentrations for the amphipod *Hyalella azteca* and the midge *Chironomus riparius*.

Lewis, P.A., D.J. Klemm, W.T. Thoeny. 2001. Perspectives on Use of a Multimetric Lake Bioassessment Integrity Index Using Benthic Macroinvertebrates. Northeastern Naturalist 8(2): 233–246. doi:10.1656/1092-6194(2001).

KDEP. 2002. Kentucky Risk Assessment Guidance. Available at https://eec.ky.gov/Environmental-Protection/Waste/superfund/Documents/KY%20Risk%20Assessment%20Guidance%20_Final_.pdf

KDOW. 2002. Methods for Assessment Biological Integrity of Surface Waters in Kentucky. Commonwealth of Kentucky, Natural Resources and Environmental Protection Cabinet, Division of Water, Water Quality Branch. July.

KDOW. 2003. The Kentucky Macroinvertebrate Bioassessment Index: Derivation of Regional and Narrative Ratings for Assessing Wadeable and Headwater Streams. Kentucky Department for Environmental Protection, Division of Water, Water Quality Branch. September.

KDOW. 2015. Methods for Sampling Benthic Macroinvertebrate Communities in Wadeable Waters. Commonwealth of Kentucky, Energy and Environment Cabinet, Department for Environmental Protection, Division of Water. March.

KDOW. 2016a. Fish Study for Dix Dam and Residential Cove. Data provided by KU September 2017.

KDOW. 2019a. Kentucky Administrative Record 401 KAR 10:031. Surface Water Standards. Section 4. Aquatic Life. Accessed October 2022.

KDOW. 2019b. Methods for the Collection of Selenium Residue in Fish Tissue Used to Determine KPDES Permit Compliance. Effective Date April 9, 2014. Revision Date: December 9, 2019. Revision No: 2.0. Document Control No: DOWSOP03031.

Kentucky Energy and Environment Cabinet (Cabinet). 2021a. Corrective Action ISARA Report Review Completion and Approval Letter addressed to the KU, E.W. Brown Station. May.

Kentucky Utilities. 2021a. E.W. Brown Generating Station Permit Modification Request: January 7th, 2021, Letter to KDOW, Agency Interest# AI 3148. KPDES Permit No. KY0002020. January.

Kentucky Utilities. 2021b. E.W. Brown Generating Station Permit Modification Request: April 26th, 2021, Letter to KDOW - Supplemental Information, Agency Interest# AI 3148. KPDES Permit No. KY0002020. April.

KPDES 2019a. Draft Authorization to Discharge Under the Kentucky Pollutant Discharge Elimination System (Permit Number KY0002020). Pending Approval.

KDPES 2019b. KPDES Fact Sheet KY0002020. October 2019.

Noor El Deen, A.I.E. and M.S. Zaki. 2013. Eye Affection Syndrome Wild and Cultured Fish. Life Science Journal 10(1): 643-50.

Plafkin, J. L., M. T. Barbour, K. D. Porter, S. K. Gross, and R. M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: benthic macroinvertebrates and fish. EPA 440/4/89/001. US Environmental Protection Agency, Office of Water Regulations and Standards, Washington, DC.

Ramboll. 2017a. Corrective Action Plan. Prepared For: Kentucky Utilities Company for Submittal to KDOW Agreed Order No. DOW - 17001. August.

Ramboll. 2017b. Quality Assurance Project Plan. Herrington Lake, E.W. Brown Station. Prepared For: Kentucky Utilities Company for Submittal to KDOW Agreed Order No. DOW - 17001. October.

Ramboll. 2019. Corrective Action Investigation Source Assessment, and Risk Assessment (ISARA) Report for E.W. Brown Station. Prepared For: Kentucky Utilities Company for Submittal to KDOW. Agreed Order No. DOW - 17001. June.

Ramboll. 2020. E.W. Coal Pile Addendum to the Response to the Cabinets Comments on the Corrective Action Investigation Source Assessment, and Risk Assessment Report for E.W. Brown Station. Prepared For: Kentucky Utilities Company for Submittal to KDOW. Agreed Order No. DOW - 17001. March.

Ramboll. 2021. Supplemental Remedial Alternatives Assessment Report, E.W. Brown Station, Herrington Lake, Mercer County, Kentucky. Prepared for Kentucky Utilities Company for Submittal to KDOW. Agreed Order No. DOW - 17001. December.

Stephens F.J., J.J. Cleary, G. Jenkins, B. Jones, S.R. Raidal, and J.B. Thomas. 2002. Health Problems of the Western Austrialian dhufish. Fisheries Research and Development Corporation Report FRDC Project No. 1998/328.

USEPA. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish. EPA 444-4-89-001. Also cited as Plafkin et al. 1989. https://nepis.epa.gov/Exe/ZyNET.exe/9100LGCA.txt?ZyActionD=ZyDocument&Client=EPA&Index=1986%20Thru%201990&Docs=&Query=plafkin&Time=&EndTime=&SearchMethod=2&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&UseQField=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5CZYFILES%5CINDEX%20DATA%5C86THRU90%5CTXT%5C00000022%5C9100LGCA.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=15&FuzzyDegree=0&ImageQuality=r85g16/r85g16/x150y150g16/i500&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionE&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x

USEPA. 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Interim Final. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response Washington, DC. EPA 540-R-97-006. June.

USEPA. 1998. Guidelines for Ecological Risk Assessment. Federal Register 63(93):26845-26924. May 14.

USEPA. 1999. Rapid Bioassessment Protocols for Use in Streams and Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. EPA 841-B-99-002. 2nd Edition. https://www.epa.gov/aboutepa/about-office-water#wetlands. Also cited as Barbour et al. 1999.

USEPA. 2000. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1, Fish Sampling and Analysis, Third Edition (EPA 823-B-00-007). November.

USEPA. 2001. Perspectives on Use of a Multimetric Lake Bioassessment Integrity Index Using Benthic Macroinvertebrates. Northeastern Naturalist, 8(2), 233–246. Also cited as Lewis *et al.* 2001.

USEPA. 2006. Concepts and Approaches for the Bioassessment of Non-Wadeable Streams and Rivers. EPA/600/R-06/127. Also cited as Flotemersch *et al.* (2006).

USEPA. 2009. Development of a regional macroinvertebrate index for large river bioassessment. Ecological Indicators, 9(2), 313–328. Also cited as Blocksom and Johnson (2009).

USEPA. 2016. Technical Support for Fish Tissue Monitoring for Implementation of EPA's 2016 Selenium Criterion – Draft Report. EPA 820-F-16-007. September.

USEPA. 2018. Supplemental Guidance to ERAGS: Region 4, Ecological Risk Assessment. Originally published November 1995 and updated March 2018. Scientific Support Section, Superfund Division, EPA Region 4.

USEPA. 2021. ECOTOX User Guide: ECOTOXicology Knowledgebase System. Version 5.3. Available at http:/www.epa.gov/ecotox/ (data retrieval performed July 2021).

Washington State Department of Ecology. 2013. Sediment Management Standards Chapter 173-204 WAC. Revised February 2013, Effective September 2013. Publication no. 13-09-055. https://fortress.wa.gov/ecy/publications/documents/1309055.pdf

West Virginia Department of Environmental Protection. 2010. Selenium-induced Developmental Effects Among Fishes in Select West Virginia Waters. January. Available at https://dep.wv.gov/WWE/watershed/wqmonitoring/Documents/Selenium/Se%20Larvae%202010%20final.pdf.

TABLES

Table 1-1. E.W. Brown Station Completed, Underway, and Planned Remedial Measures

Corrective Action Plan, 2022 Supplemental Performance Monitoring Report

Herrington Lake, Mercer County, Kentucky

Site Area	Remedial Measure	Status and Timeline	Descriptions of the Completed, Underway, and Planned Remedial Measures
Herrington Lake	Redirection of process water flows from Outfall BRN001 to new Outfall BRN006	Completed: November 2019	- Per the 2019 renewed KPDES permit, treated wastewater from the plant no longer discharges to Curds Inlet via Outfall BRN001. - Flow from the Aux Pond now discharges through BRN006, located in main lower Herrington Lake, at 40 feet below winter pool. - BRN006 discharges through a multi-port diffuser anchored to the rock wall and extending out into the main body of Herrington Lake. - The new Process Pond handles dewatering of the Aux Pond and other plant process wastewater prior to discharge via Outfall BRN006. - Mass loading of constituents through Outfall BRN006 will also be substantially reduced after dewatering of the Aux Pond is completed (expected in 2021). - The flows to Outfall BRN001 now consist solely of stormwater drainage and are required to be monitored in accordance with the 2019 renewed KPDES permit. - These changes should improve environmental conditions in Curds Inlet, including surface water quality.
Former Main Ash Pond	CCR Capping	Completed: Phase I, II, and III	- Final Capping of Pond.
			- Cap installation was phased to integrate it into the construction of the new lined landfill over top of the covered existing CCRs. Construction of a special waste landfill over the top of the Main Ash Pond was permitted in 2015 and completed in 2016. The landfill is currently receiving plant-generated CCRs including bottom ash, fly ash, and gypsum. The constructed landfill also serves as a remedial cap for the Main Ash Pond.
			- See the Main Ash Pond Closure Plan (AMEC 2014) for final design details.
	Abutment Drain Collection System (ADCS)	Completed: July 2014	- Discharges from the Abutment Drain Collection System (ADCS) were redirected to the Aux Pond as a short-term IRM. - Per the 2019 renewed KPDES permit, all discharges from ADCS are treated in the new Process Pond prior to final discharge to Herrington Lake via new Outfall BRN006.
	North Abutment Drain Pump Station	Completed: April 2016	- Installed pumping station to capture the north abutment drain discharge and transfer it to the Aux Pond; per the 2019 renewed KPDES permit, disharge, all discharges from north abutment drain are treated in the new Process Pond prior to final discharge to Herrington Lake via new Outfall BRN006
	Toe Drain Collection System (TDCS) (Part of TDCPRTS)		- Part of the approved Toe Drain and Coal Pile Runoff Treatment System (TDCPRTS). - TDCS captures flows at the toe of the Main Ash Pond Dam (Dam Toe Springs Left, Middle, and Right); per the 2019 renewed KPDES permit, all discharges from TDCS are treated in the new Process Pond prior to final discharge to Herrington Lake via new Outfall BRN006.
	Cut-Off Wall Construction		- Constructed a cut-off wall across the valley downstream of the Toe Drain Collection System.
Auxiliary Pond	Redirection of Aux Pond Flow from BRN001 to Newly Constructed BRN006	Completed: November 2019	- Per the 2019 renewed KPDES permit, all flows from Aux Pond have been redirected from Outfall BRN001 to new Outfall BRN006 located in main lower Herrington Lake, at 40 feet below winter pool. - Outfall BRN006 discharges through a multi-port diffuser anchored to the rock wall and extending out into the main body of Herrington Lake.
	Convert Wet to Dry Handling of CCRs	Completed: November 2019	- Replace wet handling of CCRs in Aux Pond with dry handling in the landfill.
	Discharge Pipeline Maintenance	Completed: November 2016	- Replaced existing sections of the HDPE pipeline and manholes based on 2014 evaluation by AMEC. - Reduced the number of manholes. - Tightness tested system on completion.
	Dewatering and Treatment System	Started: December 2019	- Dewatering of the Aux Pond commenced upon the effective date of the renewed 2019 KPDES permit. - Free water and interstitial water removed from the Aux Pond is pumped to a dewatering treatment system. After treatment, the water is pumped to a storage basin from where it is pumped to the Process Pond and then discharged through KPDES Outfall BRN006. - Aux Pond dewatering flows, which are addressed in Outfall BRN006A conditions and limits, have been substantially reduced and are expected to be discontinued by the end of 2021.
	Aux Pond Closure	Completed: Dec 2021	- Aux Pond closure activities are substantially complete and full completion is expected by the end of 2021. - Cover soil and storm water runoff management channel construction will continue into mid-2021.

Table 1-1. E.W. Brown Station Completed, Underway, and Planned Remedial Measures

Corrective Action Plan, 2022 Supplemental Performance Monitoring Report

Herrington Lake, Mercer County, Kentucky

Site Area	Remedial Measure	Status and Timeline	Descriptions of the Completed, Underway, and Planned Remedial Measures
Coal Pile	Coal Pile Runoff Treatment Enhancement (Part of TDCPRTS)	Initial System Start: December 2019	- Part of the approved Toe Drain and Coal Pile Runoff Treatment System (TDCPRTS); provides enhanced physical/chemical treatment of coal pile runoff system water. - Initial system start-up commenced in late 2019.
Gypsum Processing Pond	Liner Installation	Completed Late 2015	- Installation of a liner under the Gypsum Processing Pond (GPP) and the area draining to the pond (55,600 SF total) to prevent infiltration of gypsum-impacted water in the area of the GPP. - The Gypsum Pond liner system consists of the following three layers ordered from bottom to top: - Bottom Layer: A 4-inch-layer of dense graded aggregate (DGA) over grade (rough rock surface) to support the membrane liner. - Middle Layer: A 60-millimeter LLDPE flexible membrane liner between two geotextile layers. - Top Layer: A 6-inch fabric form concrete mat.
West Quarry	Drained, Filled, and Covered	Completed: April 2016	- Drained accumulated storm water. - Filled the quarry with inert structural fill of soil and rock. - Graded surface to promote drainage. - Covered surface with topsoil and vegetated to minimize erosion.
Process Pond	New Construction	Completed	- The new Process Pond replaces the Aux Pond for treatment of plant process flows including treated FGD wastewater, TDCPRTS flows, plant sumps, coal/limestone piles runoff waters, landfill leachate/CCR-contact runoff flow, incidental fractions of bottom ash recycle water flows, and other low volume wastewaters.
E.W. Brown Station Facility Waste Ash and Water	Dry Handling of Fly Ash	Completed: Prior to Nov 2019	- Conversion to dry handling for all fly ash systems to eliminate the discharge of fly ash sluice waters.
	Bottom Ash Transport Water (BATW) Management System	System in operation as of 2015; upgrades planned by July 2023	- Since 2015, the Bottom Ash Transport Water (BATW) management system recirculates the Unit 3 bottom ash sluice water. - Two remote submerged flight conveyors were installed in 2015 at Unit 3 to manage bottom ash, coal mill rejects/pyrites, and any boiler air-heater wash water flows. - As of the renewal of the KPDES permit in November of 2019, wastewater from the BATW management system discharges to the new Process Pond and then to Herrington lake via Outfall BRN006. In addition, KU will be upgrading the existing BATW management system to meet the requirements for recirculation of BATW flows under the applicable USEPA ELGs. - KU recently received a modified KPDES permit that specifies an ELG applicability date of July 1, 2023 for operation of the BATW high recycle rate management system and allows for a purge rate of 10% in accordance with recent revisions to the ELGs. - Purge flows from the BATW system will be treated in the Process Pond prior to final discharge to Herrington Lake through Outfall BRN006 high-rate multiport diffuser.
	Flue Gas Desulfurization Wastewater Recirculation and Treatment	2019	- As of late 2019, most process waters from the Unit 3 Flue Gas Desulfurization (FGD) system are recycled to supply FGD system makeup water. Any surplus FGD process water is treated in a new Process Water System (PWS) using physical-chemical systems. - The PWS is a physical-chemical water treatment system consisting of two reaction tanks, one clarifier, filter system, and an effluent tank. - Within the PWS, the influent is treated with caustic, organosulfide, ferric chloride, and polymer. - This treatment system removes suspended solids, adjusts pH, and removes metals by chemical reactions with organosulfide compounds. - The effluent is then pumped from the effluent tank to the process pond and then discharged through KPDES Outfall 006. - Kentucky Division of Water designed the KPDES permit limits for wastewater discharges to ensure compliance with the applicable Kentucky surface water quality standards (401 KAR 10:031). - KU recently received a modified KPDES permit to reflect its plans to install additional equipment to convert the FGD wastewater system to fully zero liquid discharge to meet the requirements for FGD wastewater under the applicable USEPA ELGs. This conversion is currently expected to be completed July 1, 2023, at which point there will be no further discharges of FGD wastewater to the PWS or Outfall BRN006.

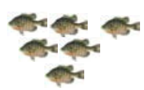
Table 1-1. E.W. Brown Station Completed, Underway, and Planned Remedial Measures Corrective Action Plan, 2022 Supplemental Performance Monitoring Report
Herrington Lake, Mercer County, Kentucky

Site Area	Remedial Measure	Status and Timeline	Descriptions of the Completed, Underway, and Planned Remedial Measures

Acronyms:

%	Percent	HDPE	High density polyethylene	PWS	Process Water System
aka	Also known as	IRM	Interim remedial measures	RTC	Response to Comments
AMEC	Amec Foster Wheeler	ISARA	Investigation, Source Assessment, and Risk Assessment	SF	Square feet
Aux Pond	Auxiliary Pond	KAR	Kentucky Administrative Regulation	SWS	Kentucky Surface Water Standards
BATW	BATW Bottom Ash Transport Water	KEEC	Kentcky Energy and Environmental Cabinet	TBD	To be determined
BMP	Best Management Practice	KDOW	Kentucky Division of Water	SWS	Kentucky Surface Water Quality Standards
BRN	Brown (as in E.W. Brown Station)	KPDES	Kentucky Pollution Discharge Elimination System	TDCS	Toe Drain Collection System
CCR	Coal Combustion Residuals	KU	Kentucky Utilities Company	TDCPRTS	Toe Drain Collection System
DGA	Dense Graded Aggregate	Ky	Kentucky	US EPA	United States Environmental Protection Agency
ELG	Effluent Limitation Guideline	LLDPE	Linear low-density polyethylene	WWTP	Waste Water Treatment Plant
FGD	Flue Gas Desulfurization	MGS	Mechanical Drag System	WWTS	Waste Water Treatment System
FGDWW	Flue Gas Desulfurization Wastewaters	OE	Owners Engineer	YOY	Young-of-the-Year
GPP	Gypsum Processing Pond	pH	Potential Hydrogen	ZLD	Zero Liquid S Discharge System

Table 2-1: Herrington Lake 2022 Monitoring Phase Sample Collection Overview
Corrective Action Plan, 2022 Supplemental Performance Monitoring Report
E.W. Brown Station, Mercer County, Kentucky

	RAO Performance Measure	Sampling Media	Sampling Season	Number of Sample Locations By Region								Total # of Samples per Media	# of individuals per Sample	Total Individuals Collected
				UCI	MCI	LCI/ HQ Inlet	Hardin Inlet	LHL1 (Rocky Run)	LHL6 (Near Sunset Marina)	LHL2 (Dix Dam)	MHL			
2022 MONITORING (After BRN001 Retirement)	RAO 1	 Adult Fish Bluegill (a,b)	Late May (Prior to Spawning)	3			2	2	2	2	2	13	4 to 5	95
	RAO 1	 Adult Fish Bass (b)		2			—	2	2	2	2	10	2 to 3	23
	RAO 2	 YOY Fish	June to August	3	3	3	3	—				12 to 15	8 to 539	>1,100
	RAO Performance Measure	Sampling Media	Sampling Season	Number of Sample Locations By Region								Total Number of Locations	Number of Replicate Samplers per Location	Total Number of Artificial Samplers
				UCI	MCI	LCI	Hardin Inlet	LHL1 (Rocky Run)	LHL6 (Near Sunset Marina)	LHL2 (Dix Dam)	MHL			
	RAO 3	 Sediment Dwelling Organism (Benthic) Community Assessment	May to July	3	3	3	3	NA	NA	NA	NA	12	3	36

Abbreviations:
BCA - Benthic Community Assessment
CI - Curds Inlet
HQ - HQ (Rumored to have previously been Headquarters but no information found for this acronym)
LCI - Lower Curds Inlet
LHL - Lower Herrington Lake
MHL - Middle Herrington Lake
RAO - Remedial Alternative Objective
UCI - Upper Curds Inlet
YOY - young-of-the-year

Table 2-2: Adult Bluegill 2022 Selenium Analytical Results and Calculated Female Bluegill Whole-Body Tissue Concentrations (RAO 1)
Corrective Action Plan, 2022 Supplemental Performance Monitoring Report
E.W. Brown Station, Mercer County, Kentucky

Sampling Area	Sample ID	Tissue Type	Sample Portion Wet Weight (grams)	% Solids	Sample Portion Dry weight (a) (grams)	Whole Fish Dry Weight (grams)	% Contribution of Each Portion (b)	Selenium Concentration (mg/kg dry weight)	Whole-Body Selenium Concentration (c) (mg/kg dry weight)
Curds Inlet	FO001	Ovary	9.4	32	3.0	65.5	4.6%	3.18	**1.56**
	FOF001	Remains	229.6	27.2	62.5		95.4%	1.48	
	FO002	Ovary	5.2	33.5	1.7	55.1	3.2%	3.53	**2.11**
	FOF002	Remains	177.1	30.1	53.3		96.8%	2.06	
	FO003	Ovary	4.2	34.8	1.5	43.2	3.4%	3.24	**2.08**
	FOF003	Remains	140.0	29.8	41.7		96.6%	2.04	
Hardin Inlet	FO001	Ovary	10.24	35.1	3.6	65.9	5.5%	2.78	**1.37**
	FOF001	Remains	208.3	29.9	62.3		94.5%	1.29	
	FO002	Ovary	9.48	35.5	3.4	52.4	6.4%	2.56	**1.21**
	FOF002	Remains	162.92	30.1	49.0		93.6%	1.12	
LHL1 (Rocky Run Residential Cove)	FO001	Ovary	4.54	33	1.5	32.5	4.6%	2.38	**1.30**
	FOF001	Remains	111.15	27.9	31.0		95.4%	1.25	
	FO002	Ovary	7.15	35.8	2.6	34.8	7.3%	2.85	**1.48**
	FOF002	Remains	119.1	27.1	32.3		92.7%	1.37	
LHL2 (Dix Dam)	FO001	Ovary	5.68	35.5	2.0	43.1	4.7%	2.96	**1.47**
	FOF001	Remains	148.71	27.6	41.0		95.3%	1.40	
	FO002	Ovary	6.61	36.2	2.4	42.4	5.6%	3.05	**1.40**
	FOF002	Remains	141.77	28.2	40.0		94.4%	1.30	

Table 2-2: Adult Bluegill 2022 Selenium Analytical Results and Calculated Female Bluegill Whole-Body Tissue Concentrations (RAO 1)
Corrective Action Plan, 2022 Supplemental Performance Monitoring Report
E.W. Brown Station, Mercer County, Kentucky

Sampling Area	Sample ID	Tissue Type	Sample Portion Wet Weight (grams)	% Solids	Sample Portion Dry weight (a) (grams)	Whole Fish Dry Weight (grams)	% Contribution of Each Portion (b)	Selenium Concentration (mg/kg dry weight)	Whole-Body Selenium Concentration (c) (mg/kg dry weight)
LHL6 (Herrington Lake Mile 3 near Sunset Marina)	FO001	Ovary	9.2	31.1	2.9	109.6	2.6%	2.91	**1.14**
	FOF001	Remains	362.9	29.4	106.7		97.4%	1.09	
	FO002	Ovary	5.65	34.8	2.0	33.1	5.9%	2.29	**1.22**
	FOF002	Remains	110.0	28.3	31.1		94.1%	1.15	
MHL1 (Middle Herrington Lake near Gwinn Island)	FO001	Ovary	6.65	33.5	2.2	51.0	4.4%	2.63	**0.98**
	FOF001	Remains	178.5	27.3	48.7		95.6%	0.90	
	FO002	Ovary	2.85	25.5	0.7	36.9	2.0%	1.16	**2.44**
	FOF002	Remains	105.27	34.4	36.2		98.0%	2.47	

Notes:
DW = dry weight
kg = kilogram
mg = milligram
WW = wet weight

$$WB_{BLUEGILL} = C_{OVARY} * P_{OVARY} + C_{REMAINS} * P_{REMAINS}$$

Where:
$WB_{BLUEGILL}$ = Constituent concentration in whole-body bluegill (mg/kg, dry weight)
C_{OVARY} = Constituent concentration in fish ovaries composite sample (mg/kg, dry weight)
$C_{REMAINS}$ = Constituent concentration in fish remains composite sample (mg/kg, dry weight)
P_{OVARY} = Percent of fish ovaries composite sample (%)
$P_{REMAINS}$ = Percent of fish remains composite sample (%)

(a) $\text{Dry Weight of Portion} = \text{grams WWt} \times \frac{\text{\% solids}}{\text{1 gram WW}}$

(b) $\text{Percent contribution} = \frac{\text{Weight of portion}}{\text{Weight of whole fish}}$

(c) Whole Body Concentration DW = (ovary concentration DW x Ovary % contribution) + (remains concentration DW x Remains % Contribution)

Table 2-3: Adult Bass 2022 Selenium Analytical Results (RAO 1)
Corrective Action Plan, 2022 Supplemental Performance Monitoring Report
E.W. Brown Station, Mercer County, Kentucky

Adult Bass Sample Location	Adult Bass Sample ID	Bass Collection Date	No. of Individuals	Field Length (mm)	Field Weight (g)	% Moisture	Dilution Factor	Selenium Concentration (mg/kg dw)
Curds inlet	LMB-1	May 4th, 2022	2	333 348	480 580	73.3	5	**1.27**
	LMB-2		2	403 402	920 1040	74.2	5	**1.53**
LHL1 Residential Cove	LMB-1	May 4th, 2022	3	310 284 286	380 390 300	70.3	5	**0.9J**
	LMB-2		3	360 400 385	680 880 820	70.2	5	**1.28**
LHL2 Dix Dam	LMB-1	May 4th, 2022	3	370 423 400	700 1140 980	72.4	5	**1.55**
	LMB-2		2	327 322 376	400 510 740	75.3	5	**1.6**
LHL6 Cove (Mile 3 near Sunset Marina)	LMB-1	May 5th, 2022	2	406 462	920 1540	70.6	5	**1.18**
	LMB-2		2	325 312	420 58	72.6	5	**1.03**
MHL1 (Guinn Island Fish Camp)	LMB-1	May 7th, 2022	2	385 400	680 800	72	5	**0.95J**
	LMB-2		2	341 354	550 600	71.8	5	**0.94J**

Notes:
% (Percent) Solids = 100 - Percent (%) Moisture
CI = Curds Inlet
(DW) Dry Weight = Concentration in Wet Weight/(1-% solids)
ESB = Kentucky Environmental Services Branch
FD = Field Duplicate
J = Lab Qualifier for
LMB = Largemouth Bass
i.e. (in other words)
mg/kg (DW) = Milligrams per kilogram dry weight
mg/kg (WW) = Milligrams per kilogram wet weight

Table 2-4: 2022 Monitoring Phase Split Samples to the Kentucky Cabinet
Corrective Action Plan: 2022 Supplemental Performance Monitoring Report
E.W. Brown Station, Mercer County, Kentucky

Fish Sampling Location	Fish Sample ID	Laboratory Sample ID	Fish Species	Age Class	Tissue Type	ALS Results for Selenium Concentration (mg/kg dry wt.)	Kentucky Cabinet Split Results for Selenium Concentration (mg/kg dry wt.)	Relative Percent Difference Between ALS and Cabinet Results (%)
Curds Inlet (Lower Curds Inlet)	YOY(BG)-001 -LCI-220726	K2210477-003	Bluegill	Young-of -the-Year	Whole-Body	1.80	1.88	4
Curds Inlet	FWB002(LMB) -CI-220504	K2205153-002	Largemouth Bass	Adult	Whole-Body	1.53	1.59	4
LHL6 (Near Sunset Marina)	FO001(BG) -LHL6-220505	K2205153-015	Bluegill	Adult	Ovaries	2.91	3.51	17
LHL6 (Near Sunset Marina)	FOF001(BG) -LHL6-220505	K2205153-016	Bluegill	Adult	Offal	1.09	1.27	14

Notes:
% Percent
RPD = 100 - ((ALS Result / Cabinet Result)*100)
BG Bluegill (*Lepomis macrochirus*)
CI Curds Inlet
FWB Fish Whole-Body
FO Fish Ovaries
FOF Fish Remains (also known as the Offal)
HI Hardin Inlet
HQ HQ Inlet
LCI Lower Curds Inlet
LHL Lower Herrington Lake
LMB Largemouth Bass (*Micropterus salmoides*)
mg/kg Milligams/kilogram
MHL Middle Herrington Lake
MCI Middle Curds Inlet
RAO Remedial Action Objective
UCI Upper Curds Inlet
wt. Weight
YOY Young-of-the-Year

Table 3-1. Young-of-Year Bluegill Whole-Body Selenium Analytical Results 2022 Corrective Action Plan, 2022 Supplemental Performance Monitoring Report E.W. Brown Station, Mercer County, Kentucky

Sample Location	Sample ID	Collection Date	No. of Individuals	Field Weight (g)	Average Individual Field Weight (g)[b]	Selenium Concentration (mg/kg dw)
Upper Curds Inlet	BG-1	July 25th, 2022	14	6.06	0.4	**1.18**
	BG-2	Aug 16th, 2022	10	5.51	0.6	**1.56**
	BG-3	Aug 19th, 2022	10	11.35	1.1	**1.3**
	BG-3 FD					**1.32**
Middle Curds Inlet	BG-1	Aug 16th, 2022	15	7.66	0.51	**1.2**
	BG-2	June 30th, 2022	8	3.46	0.43	**1.36**
	BG-3	Aug 17th, 2022	356	5.98	0.02	**1.45**
Lower Curds Inlet/ HQ Inlet	BG-1	Aug 26th, 2022	593	12.77	0.02	**1.8**
	BG-2		25	10.44	0.42	**1.29**
	BG-3	Aug 17th, 2022	29	9.8	0.34	**1.44**
Hardin Inlet	BG-1	Aug 15th, 2022	9	10.58	1.2	**2.08**
	BG-2	Aug 16th, 2022	15	12.68	0.85	**1.78**
	BG-3	July 26th, 2022	20	15.13	0.76	**1.72**
			Total =1114			

Abbreviations:

YOY - young-of-the-year
FD - Field duplicate

Table 3-2. Surface Water Quality Measurements from Young-of-the-Year Collection
Corrective Action Plan, 2022 Supplemental Performance Monitoring Report
E.W. Brown Station, Mercer County, Kentucky

YOY and SW Sampling Location	Surface Water Sample ID	Sample Depth	Analytical Method	Fraction	Selenium Concentration (µg/L)
Upper Curds Inlet (UCI)	SW(D)-1	0.5 to 1.5 ft. bws (same as average YOY collection depth for each location)	E200.8	Dissolved	**< 1.0**
	SW(T)-1			Total	**< 1.0**
	SW(D)-1 FD			Dissolved	**< 1.0**
	SW(T)-1 FD			Total	**< 1.0**
Middle Curds Inlet (MCI)	SW(D)-1			Dissolved	**< 1.0**
	SW(T)-1			Total	**< 1.0**
Lower Curds Inlet HQ Inlet (LCI)	SW(D)-1			Dissolved	**< 1.0**
	SW(T)-1			Total	**< 1.0**
Hardin Inlet	SW(D)-1			Dissolved	**< 1.0**
	SW(T)-1			Total	**< 1.0**

Notes:
µg/L = Micrograms per Liter
ft. bws = Feet below water surface

Table 4-1. Benthic Community Assessment Collection Locations 2022 (RAO 3)
Corrective Action Plan, 2022 Supplemental Performance Monitoring Report
E.W. Brown Station, Mercer County, Kentucky

Benthic Community Assessment Collection Locations	**Hardin Inlet**			**Upper Curds Inlet**			**Middle Curds Inlet**			**Lower Curds Inlet**		
	HIA	HIB	HIC	Curds 1A	CI1A	Curds 2A	CI2.1A	CI2.2A	CI3A	CI3.1A	CI3.1B	CI3.2A
Date Deployed	9-May-2022			9-May-2022			9-May-2022			9-May-2022		
# Replicates Deployed	5	5	5	3	6	4	6	6	6	5	4	5
Approximate Deployment Depth (ft. bws)	12 to 15			23 to 28			25 to 35			35 to 50		
Date Retrieved	28-Jun-2022		29-Jun-2022	3-Jul-2022	2-Jul-2022		2-Jul-2022	3-Jul-2022	3-Jul-2022	3-Jul-2022		1-Jul-2022
Deployed Days in Water	50	50	51	55	54	54	54	55	55	55	55	53
# Replicates Retrieved	5	5	5	3	6	4	6	6	6	5	4	5
# Replicates Analyzed	3	3	3	3	3	3	3	3	3	3	3	3
Grain Size												
% Clay	2.5%			1.9%			3.5%			3.1%		
% Silt	50.0%			43.5%			47.2%			49.8%		
% Sand	9.5%			9.0%			9.0%			9.4%		
% Gravel	38.0%			45.6%			40.3%			37.7%		
Water Quality*												
Temperature C	30			29.9			29.6			30.5		
Dissolved Oxygen mg/L	10.6			10.5			10.7			10.6		
Conductivity mS/cm3	0.213			0.22			0.22			0.219		
pH	8.9			9.0			9.1			9.1		
Oxidation/Reduction Potential (ORP) mV	77.5			70.3			144.5			169.5		
Turbidity NTU	-0.058			-0.16			-0.83			-0.66		
Secci Depth ft. bws	3			2.5			2.25			3		

Notes:

Grain size is based on an average of measurements taken within this water body during June 2018.

Water quality is based on the average of measurements taken halfway through the water column during August 2022.

%/L = Dissolved POxygen in Percent per liter

C = Celsius degree

mS/cm3 = microseimens per centimeter cubed

DO = Dissolved Oxygen

ft. bws = Feet below water surface

NTU = Nephelometric Turbidity Unit (NTU).

ORP = Oxygen Reduction Potential in millivolts

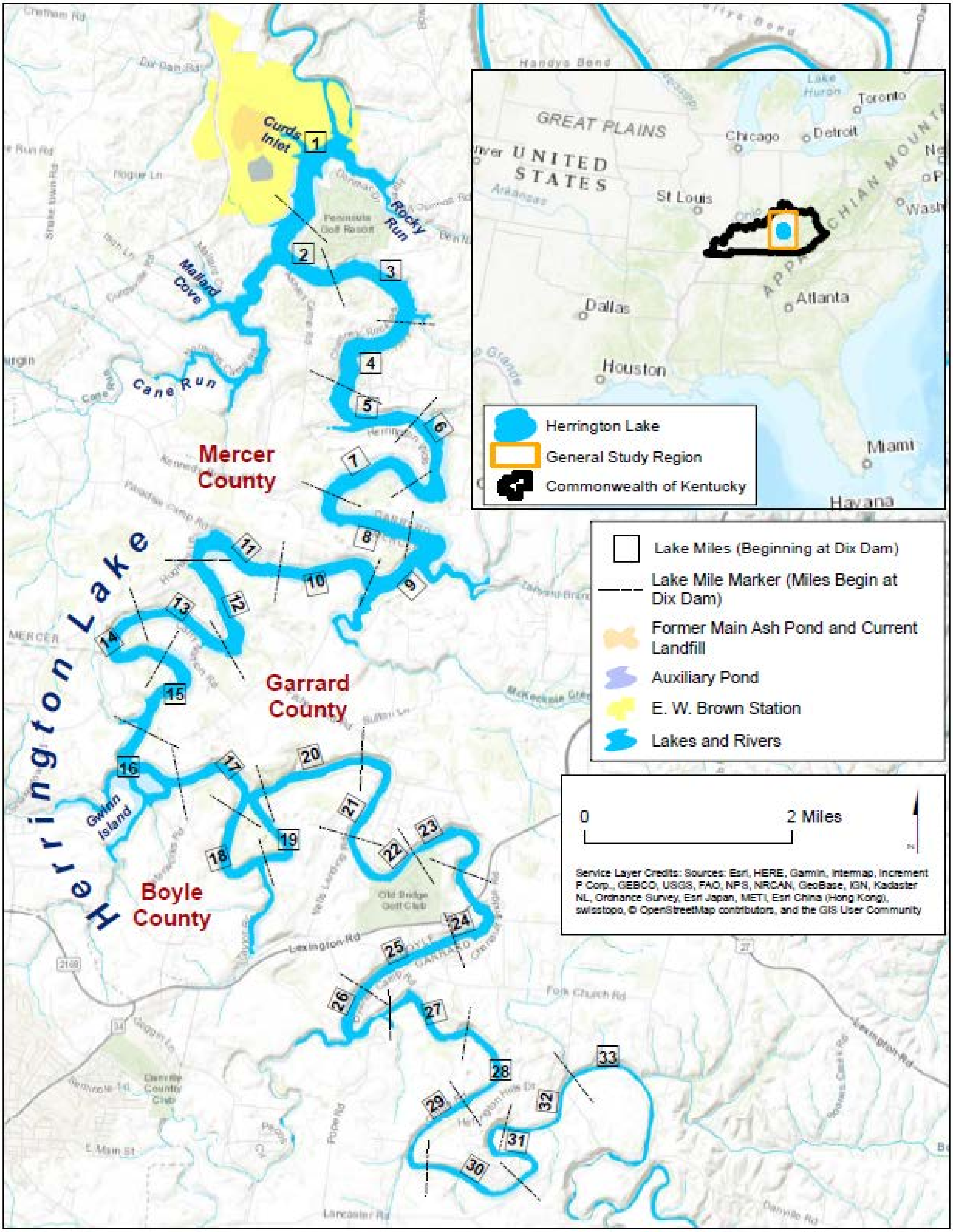
pH = Potential Hydrogen

Table 4-2: Comparison of Curds Inlet and Hardin Inlet Metrics
Corrective Action Plan, 2022 Supplemental Performance Monitoring Report
E.W. Brown Station, Mercer County, Kentucky

Metric	Hardin Inlet Minimum	Hardin Inlet Maximum	Curds Inlet Minimum	Curds Inlet Maximum	Hardin Inlet Average	Curds Inlet Average	Response to Disturbance
Number of Organisms	127	641	1	740	313.0	220.6	Variable
Number of Species	7	12	1	15	9.1	**9.8**	Higher score is better
EPT Species	3	4	0	5	**3.8**	2.5	
EPT Individuals	17	41	0	67	**25.1**	22.3	
Ratio of EPT to Chironomids	0.047	0.186	0	2.056	0.105	**0.413**	
% Chironomids and Oligochaetes	84%	94%	31%	100%	90%	**74%**	Lower score is better
Hilsenhoff Biotic Index	6.9	8.4	5.6	8.9	8.0	**7.3**	
Kentucky Modified Hilsenhoff Biotic Index	6.4	7.7	5.6	8.9	7.1	**6.9**	
% Dominance	43%	90%	16%	100%	74%	**56%**	
Shannon Diversity	0.51	1.71	0.51	2.33	0.98	**1.39**	Higher score is better

Notes:
% Percent
BOLD Bold highlighted cells indicate which location has the best score for this metric.
EPT Mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera).

FIGURES



RAMBOLL

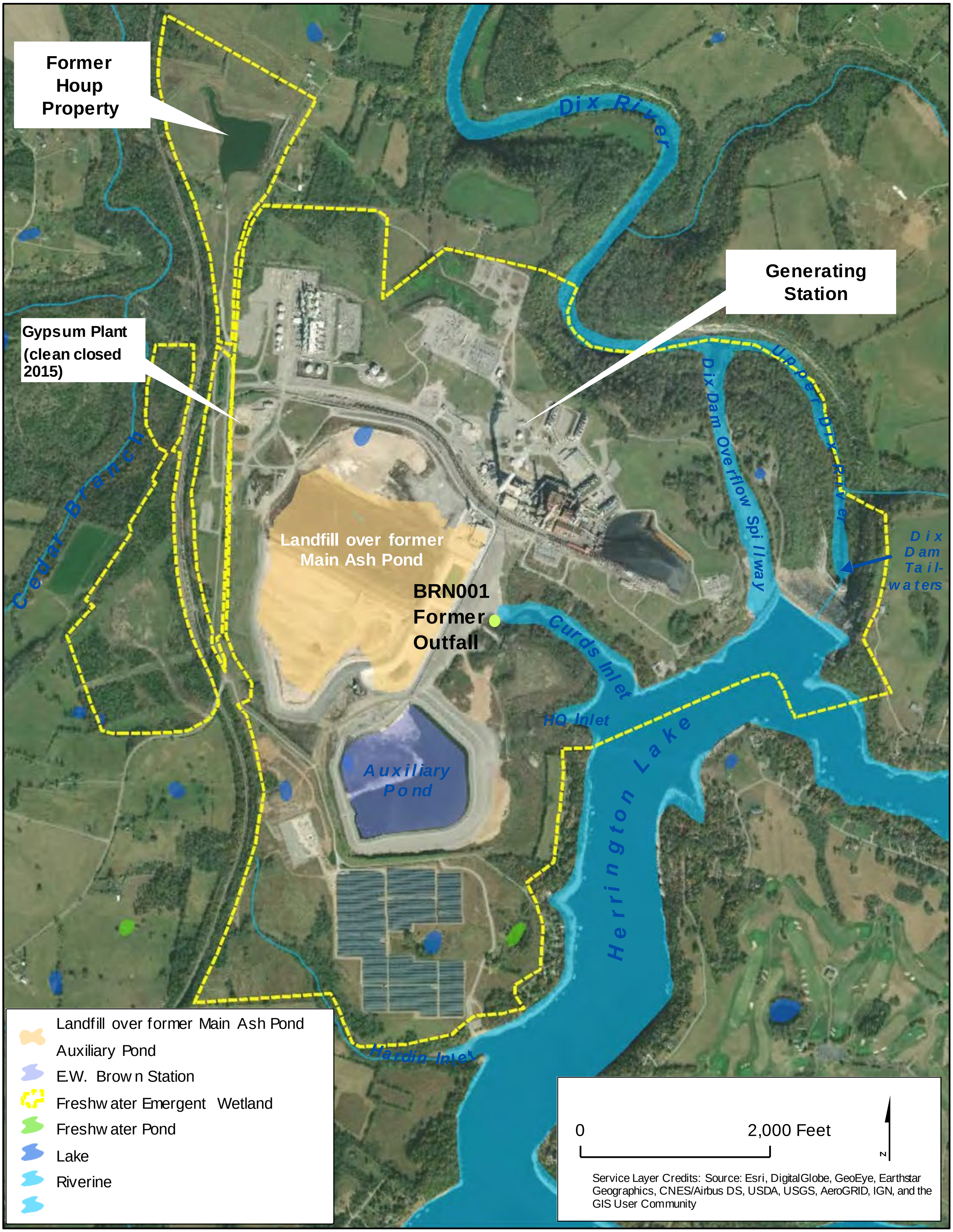
DRAFTED BY: PAL

DATE: 10/31/2022

E.W. BROWN STATION LOCATION MAP

Herrington Lake Corrective Action Plan: 2022 Monitoring Phase
Mercer County, Kentucky

FIGURE
1-1A



RAMBOLL

Map Design: AJS, Date: Jan 16, 2019

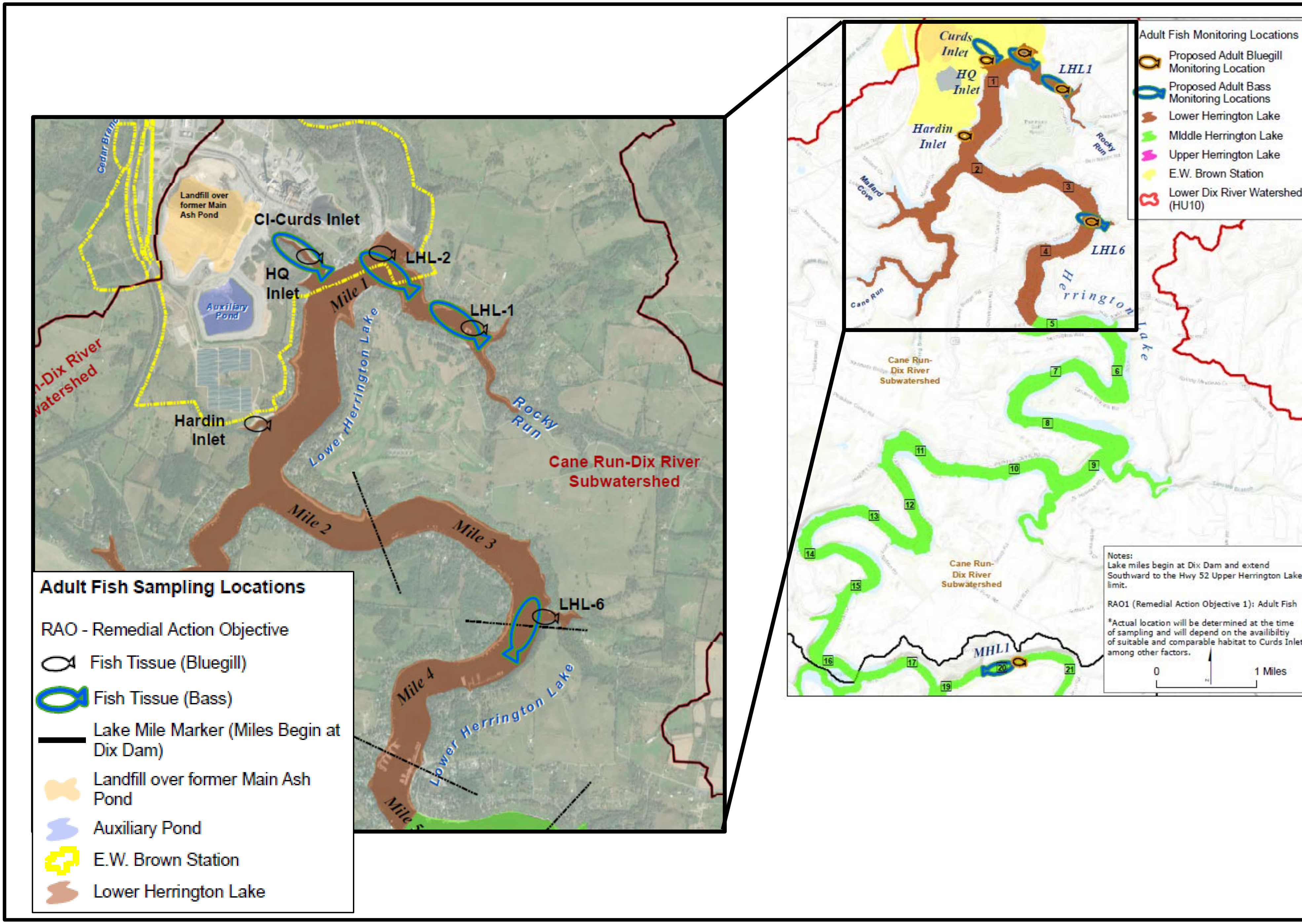
E.W. Brown Station Layout Map

Herrington Lake Corrective Action Plan: 2022 Monitoring Phase

E.W. Brown Station, Herrington Lake, Mercer County, Kentucky

FIGURE 1-1B

Project Code:



RAMBOLL

DRAFTED BY: PAL

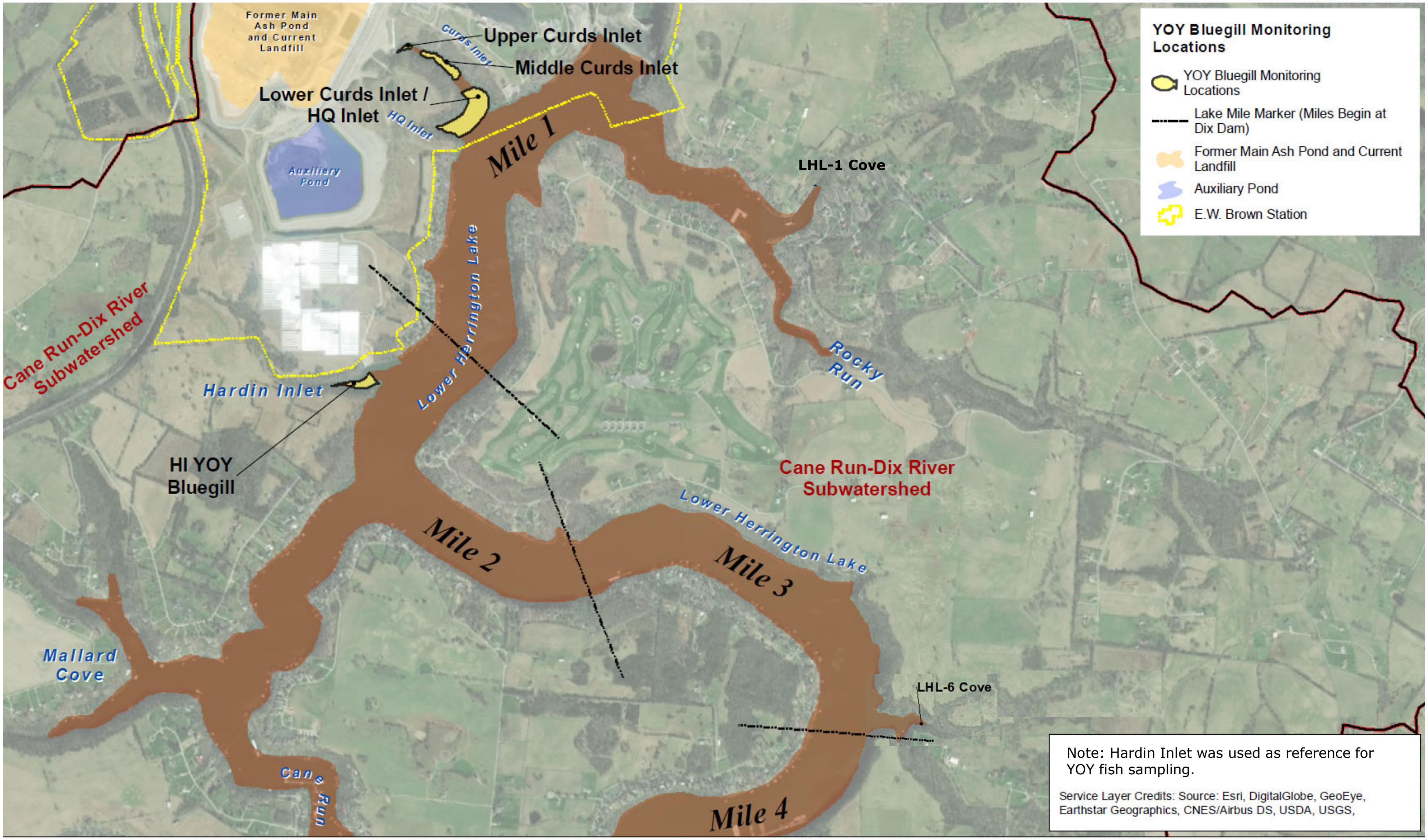
DATE: 10/31/2022

MONITORING LOCATIONS FOR ADULT BLUEGILL AND BASS IN 2022 (RAO 1)

Herrington Lake Corrective Action Plan: 2022 Monitoring Phase
Mercer County, Kentucky

FIGURE

1-2A



RAMBOLL

DRAFTED BY: PAL

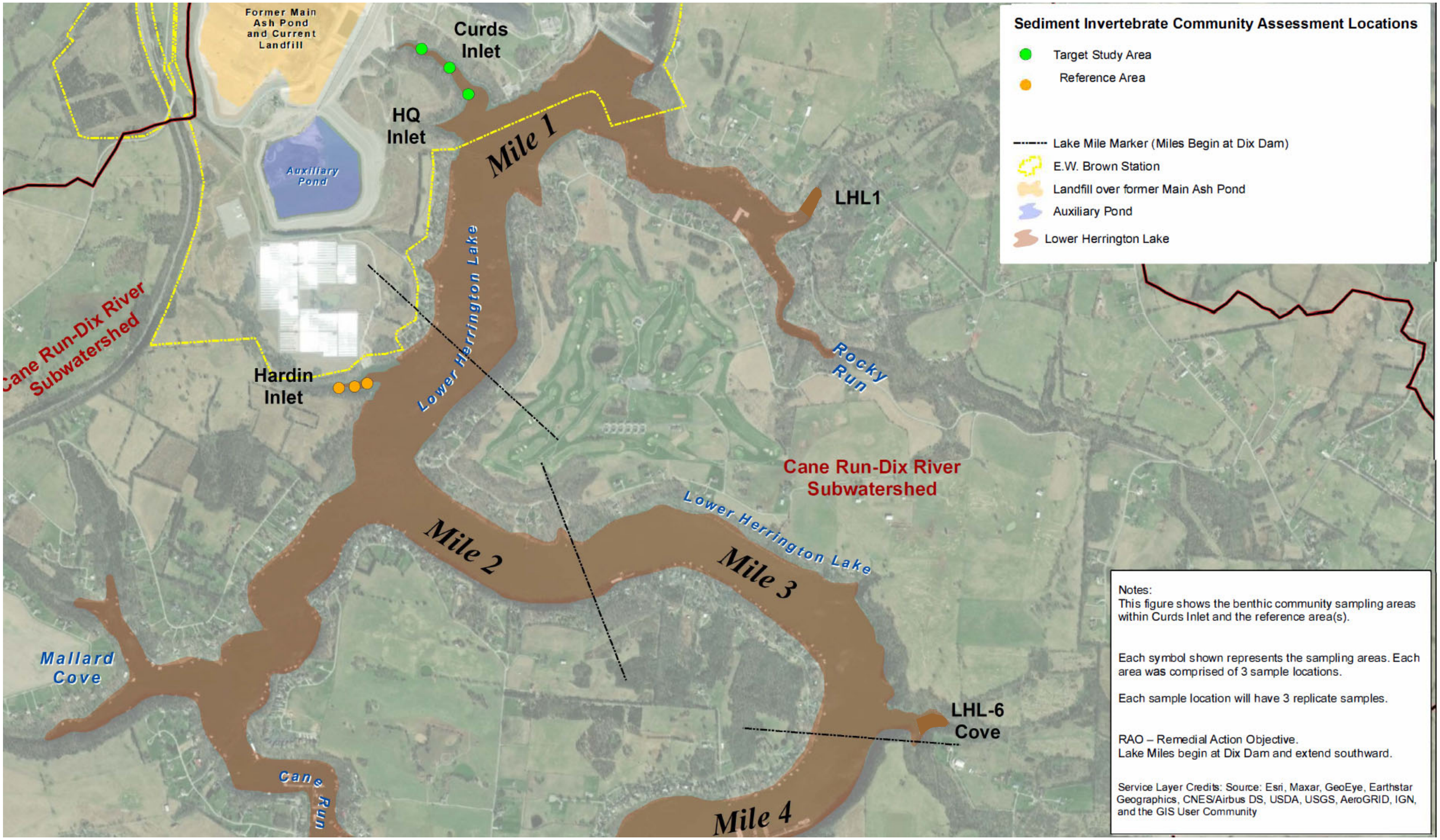
DATE: 10/31/2022

MONITORING LOCATIONS FOR YOUNG-OF-YEAR BLUEGILL IN 2022 (RAO 2)

Herrington Lake Corrective Action Plan: 2022 Monitoring Phase
Mercer County, Kentucky

FIGURE

1-2B



RAMBOLL

DRAFTED BY: PAL

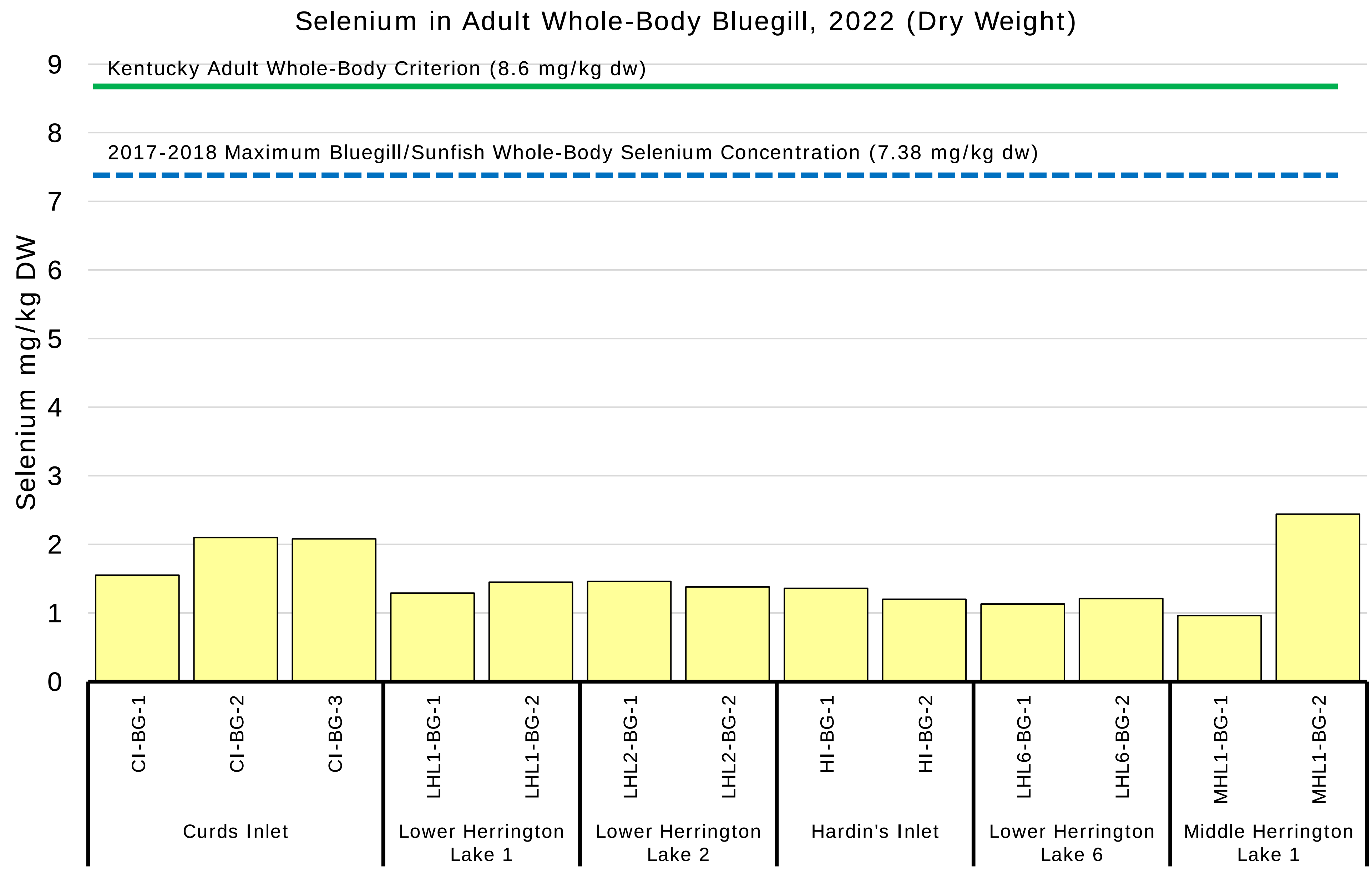
DATE: 10/31/2022

MONITORING LOCATIONS FOR BENTHIC COMMUNITY ASSESSMENT IN 2022 (RAO 3)

Herrington Lake Corrective Action Plan: 2022 Monitoring Phase
Mercer County, Kentucky

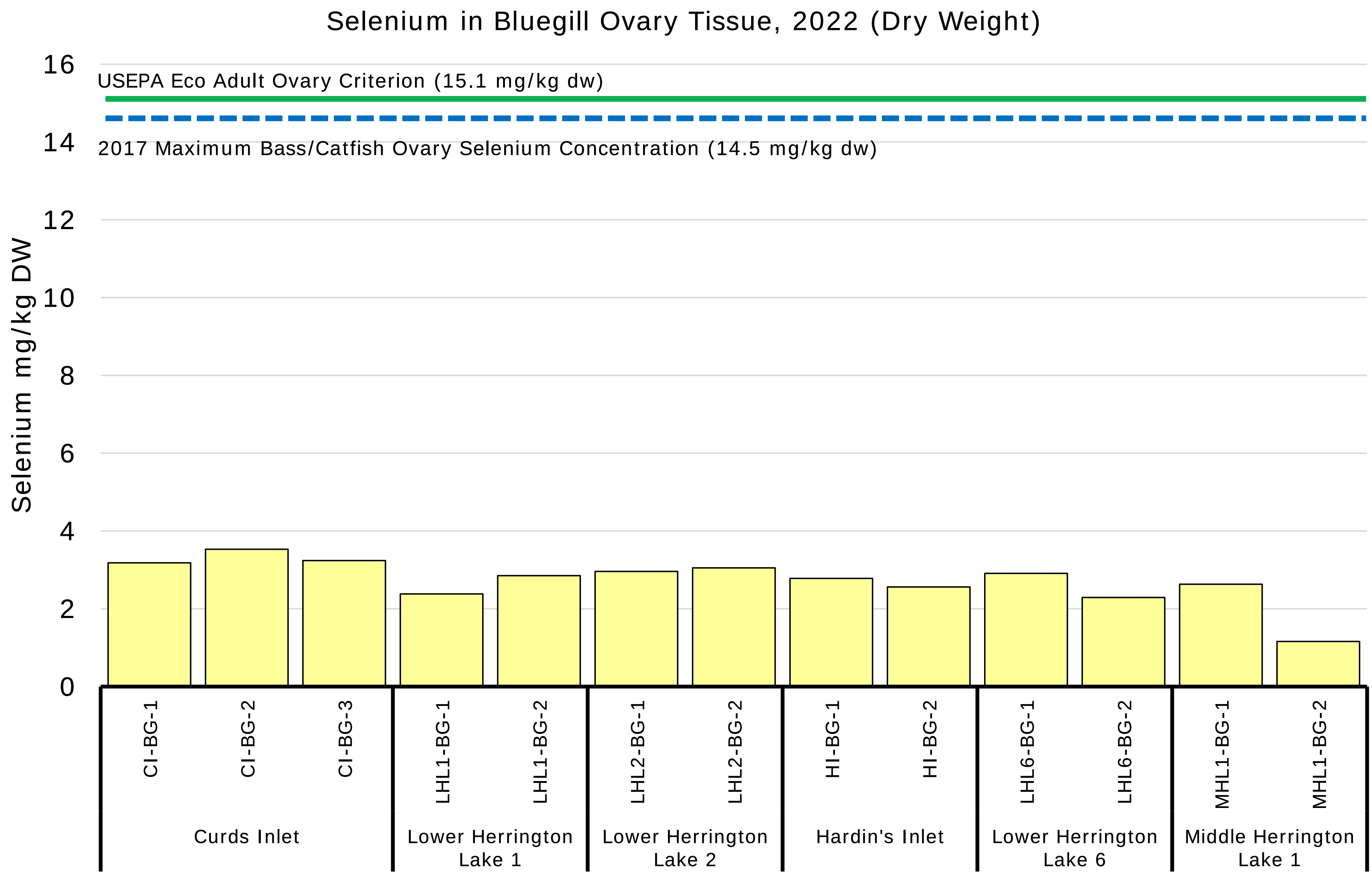
FIGURE

1-2C



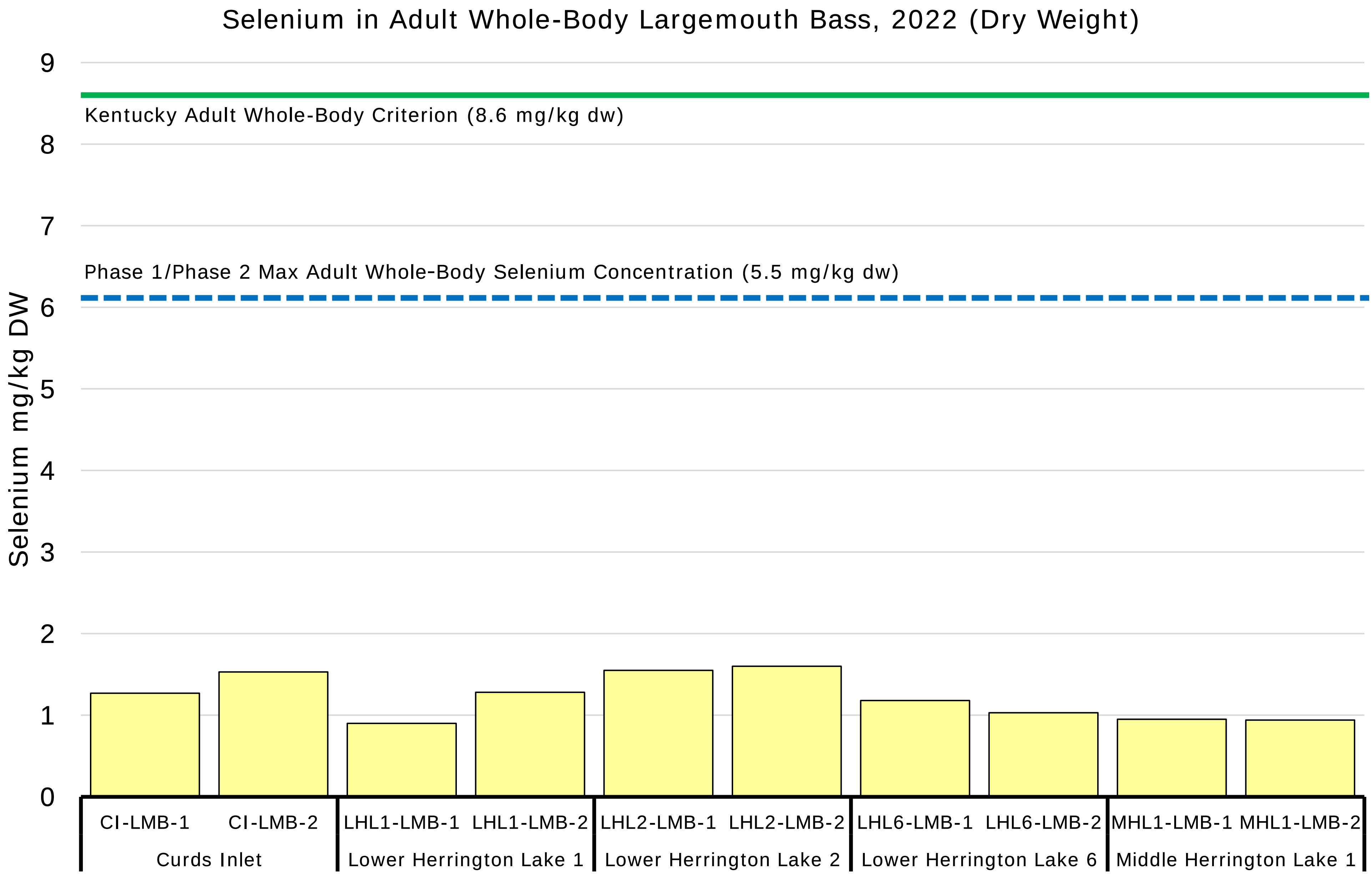
Bluegill (BG), Curds Inlet (CI), dry weight (dw), Kentucky Ecological Criterion (KY Eco Criterion), Lower Herrington Lake (LHL), Middle Herrington Lake (MHL), milligrams per kilogram dry weight (mg/kg dw)

RAMBOLL	**ADULT BLUEGILL WHOLE-BODY SELENIUM ANALYTICAL RESULTS 2022 (RAO 1)**	FIGURE
DRAFTED BY: PAL — DATE: 10/31/2022	Herrington Lake Corrective Action Plan: 2022 Monitoring Phase Mercer County, Kentucky	2-1A



Bluegill (BG), Curds Inlet (CI), Hardin's Inlet (HI), Lower Herrington Lake (LHL), Middle Herrington Lake (MHL), milligrams per kilogram dry weight (mg/kg dw), United States Environmental Protection Agency (USEPA), Young-of-Year (YOY)

RAMBOLL		ADULT BLUEGILL OVARY SELENIUM ANALYTICAL RESULTS 2022 (RAO 2) Herrington Lake Corrective Action Plan: 2022 Monitoring Phase Mercer County, Kentucky	FIGURE 2-1B
DRAFTED BY: PAL	DATE: 10/31/2022		



Curds Inlet (CI), dry weight (dw), Kentucky Ecological Criterion (KY Eco Criterion), Largemouth Bass (LMB), Lower Herrington Lake (LHL), Middle Herrington Lake (MHL), milligrams per kilogram dry weight (mg/kg dw)

RAMBOLL

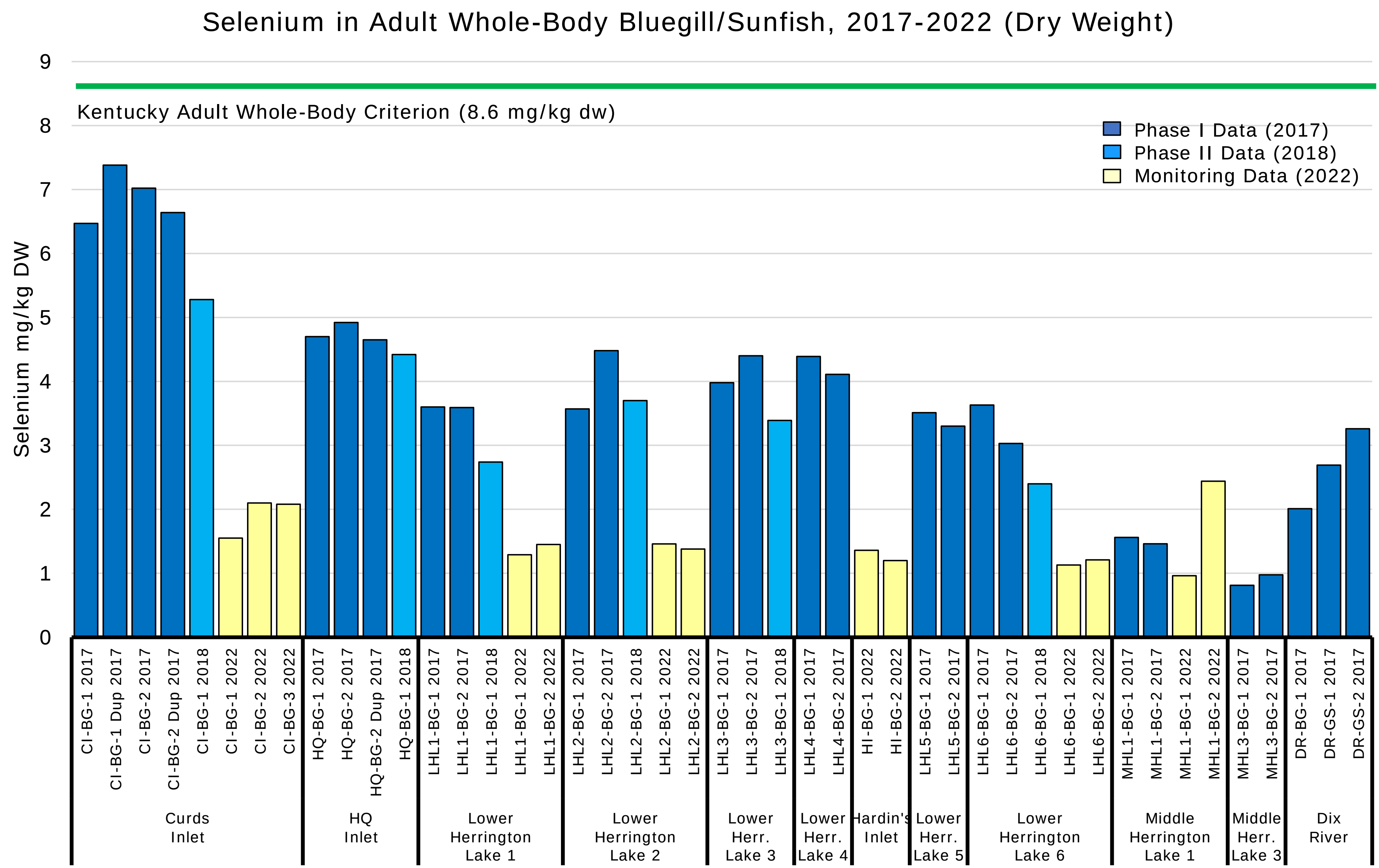
DRAFTED BY: PAL | DATE: 10/31/2022

ADULT BASS SELENIUM ANALYTICAL RESULTS 2022 (RAO 2)

Herrington Lake Corrective Action Plan: 2022 Monitoring Phase
Mercer County, Kentucky

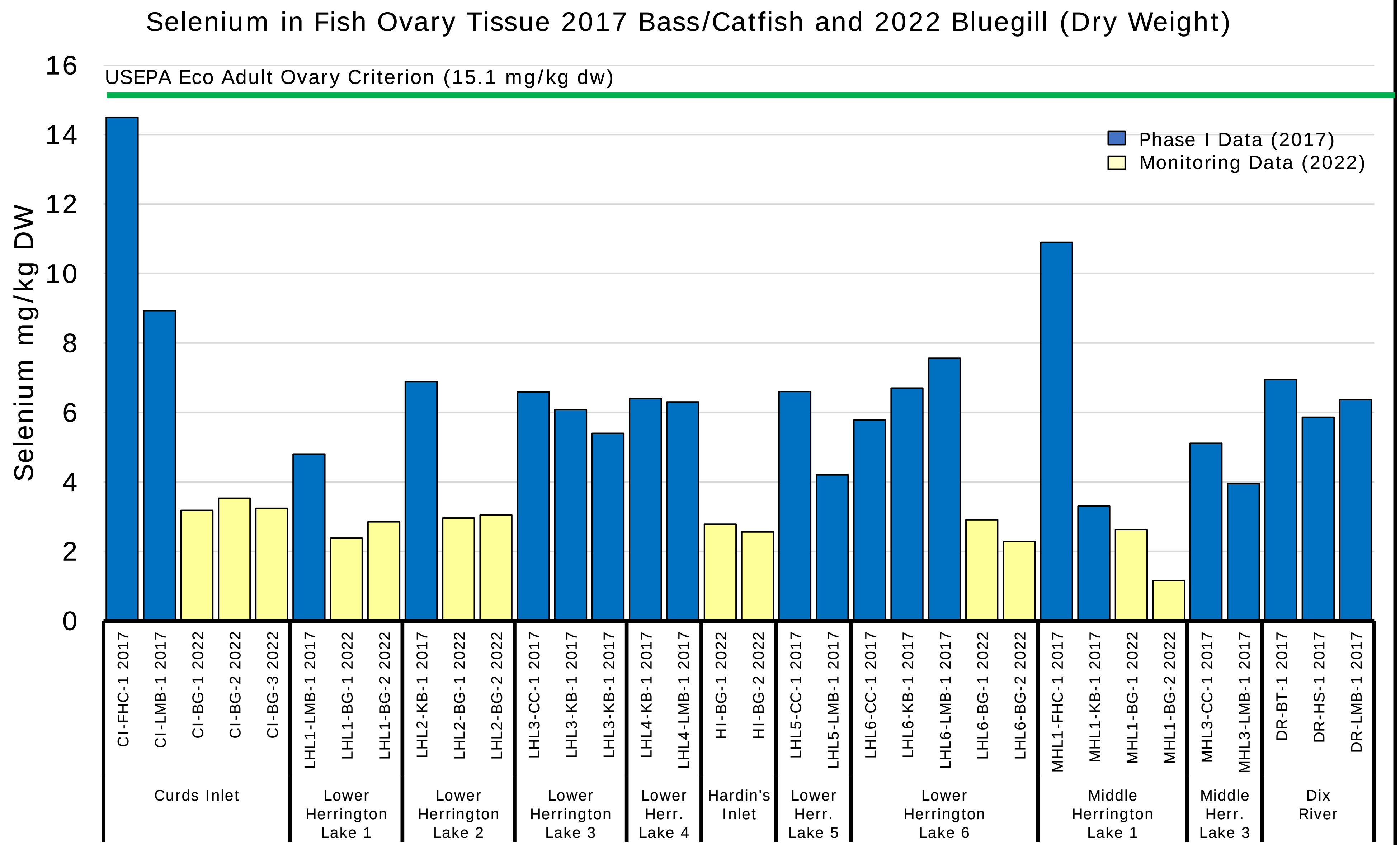
FIGURE

2-1C



Bluegill (BG), Curds Inlet (CI), Dix River (DR), Duplicate (Dup), Green Sunfish (GS), Hardin's Inlet (HI), Herrington (Herr.), HQ Inlet (HQ), Kentucky Ecological Criterion (KY Eco Criterion), Lower Curds Inlet (LCI), Lower Herrington Lake (LHL), Middle Herrington Lake (MHL), milligrams per kilogram dry weight (mg/kg dw), Phase I (P1), Phase II (P2)

RAMBOLL		**ADULT BLUEGILL (AND SUNFISH) WHOLE-BODY SELENIUM ANALYTICAL RESULTS 2022 VS 2017/2018** Herrington Lake Corrective Action Plan: 2022 Monitoring Phase Mercer County, Kentucky	FIGURE 2-2A
DRAFTED BY: PAL	DATE: 10/31/2022		



Bluegill (BG), Brown Trout (BT), Channel Catfish (CC), Curds Inlet (CI), Dix River (DR), Field Duplicate (FD), Flathead Catfish (FHC), Herrington (Herr.), Kentucky Bass (KB), Largemouth Bass (LMB), Lower Herrington Lake (LHL), Middle Herrington Lake (MHL), milligrams per kilogram dry weight (mg/kg dw), Northern Hogsucker (HS), Spotted Sucker (SS), United States Environmental Protection Agency (USEPA), Young-of-Year (YOY)

RAMBOLL

DRAFTED BY: PAL

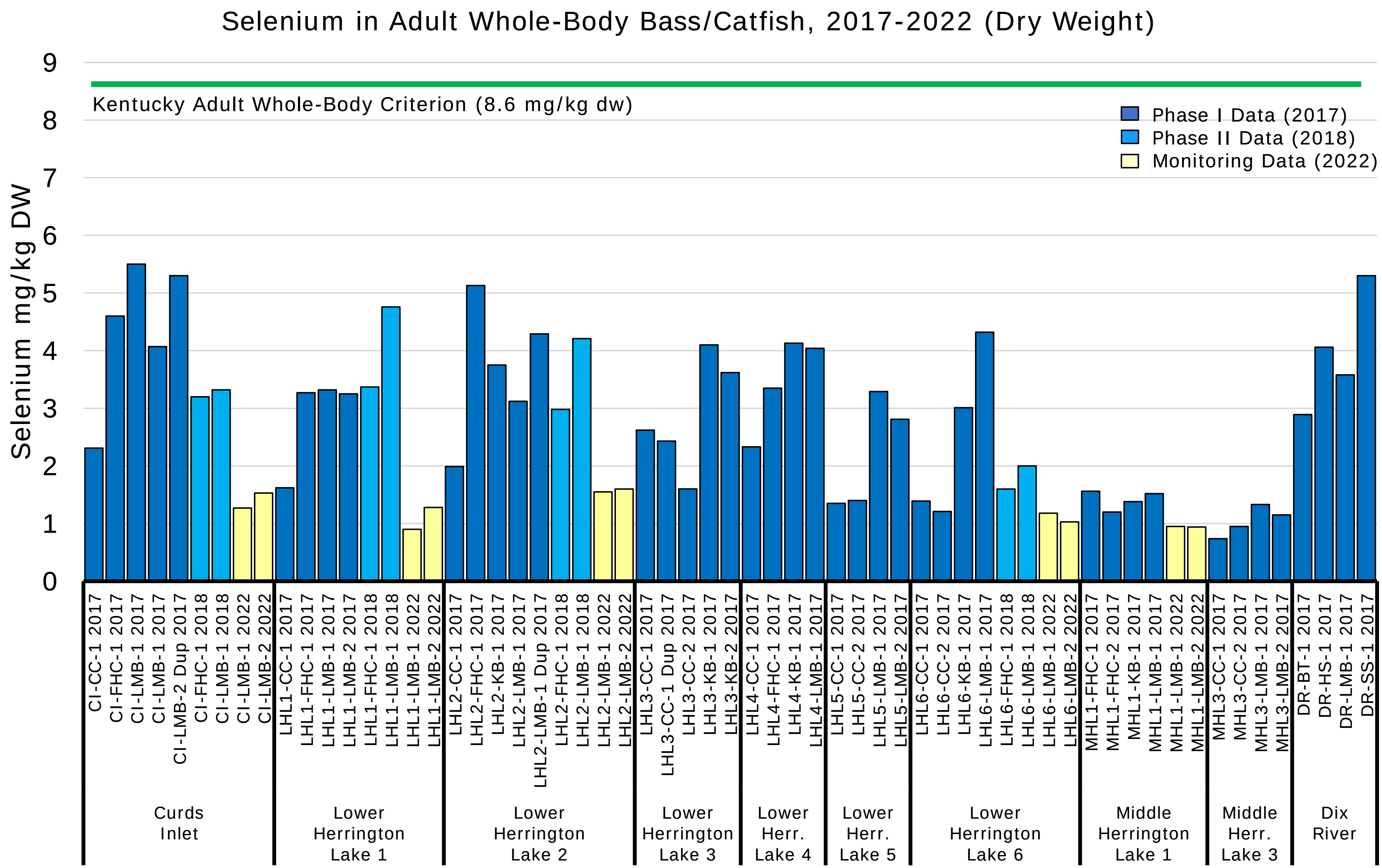
DATE: 10/31/2022

ADULT BLUEGILL OVARY SELENIUM ANALYTICAL RESULTS 2022 VS OVARY BASS/CATFISH OVARY RESULTS 2017

Herrington Lake Corrective Action Plan: 2022 Monitoring Phase
Mercer County, Kentucky

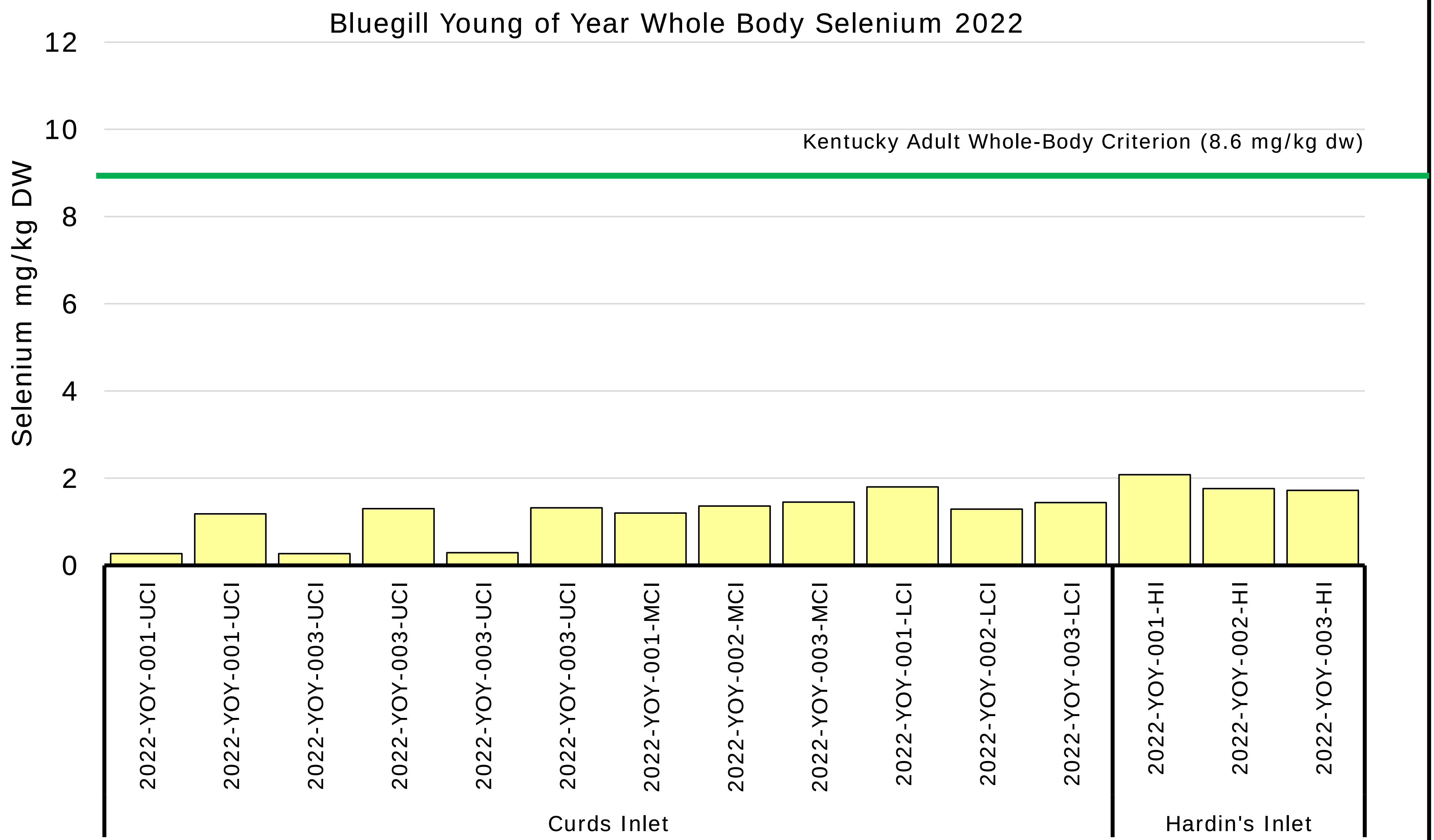
FIGURE

2-2B



Brown Trout (BT), Channel Catfish (CC), Curds Inlet (CI), Dix River (DR), dry weight (dw), Field Duplicate (FD), Flathead Catfish (FHC), Herrington (Herr.), Kentucky Bass (KB), Kentucky Ecological Criterion (KY Eco Criterion), Largemouth Bass (LMB), Lower Herrington Lake (LHL), Middle Herrington Lake (MHL), milligrams per kilogram dry weight (mg/kg dw), Northern Hogsucker (HS), Phase I (P1), Phase II (P2), Spotted Sucker (SS)

RAMBOLL	**ADULT BASS (AND CATFISH) SELENIUM ANALYTICAL RESULTS 2022 VS 2017/2018** Herrington Lake Corrective Action Plan: 2022 Monitoring Phase Mercer County, Kentucky	FIGURE 2-2C
DRAFTED BY: PAL — DATE: 10/31/2022		



Dry weight (DW), Lower Curds Inlet (LCI), Middle Curds Inlet (MCI), milligrams per kilogram dry weight (mg/kg dw), Upper Cruds Inlet (UCI), Young-of-Year (YOY)

RAMBOLL

DRAFTED BY: PAL

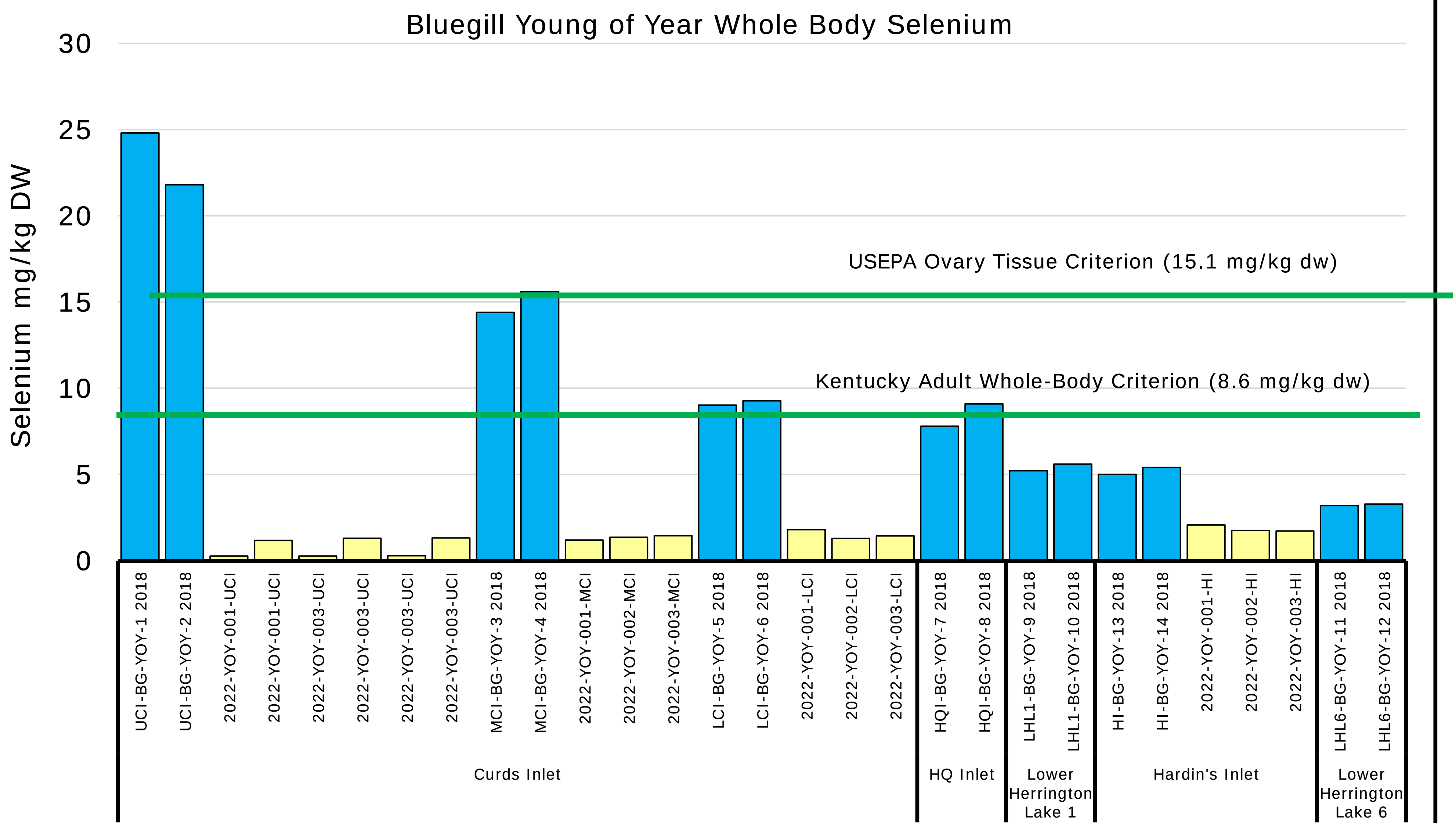
DATE: 10/31/2022

YOUNG-OF-YEAR BLUEGILL WHOLE-BODY SELENIUM ANALYTICAL RESULTS 2022 (RAO 2)

Herrington Lake Corrective Action Plan: 2022 Monitoring Phase
Mercer County, Kentucky

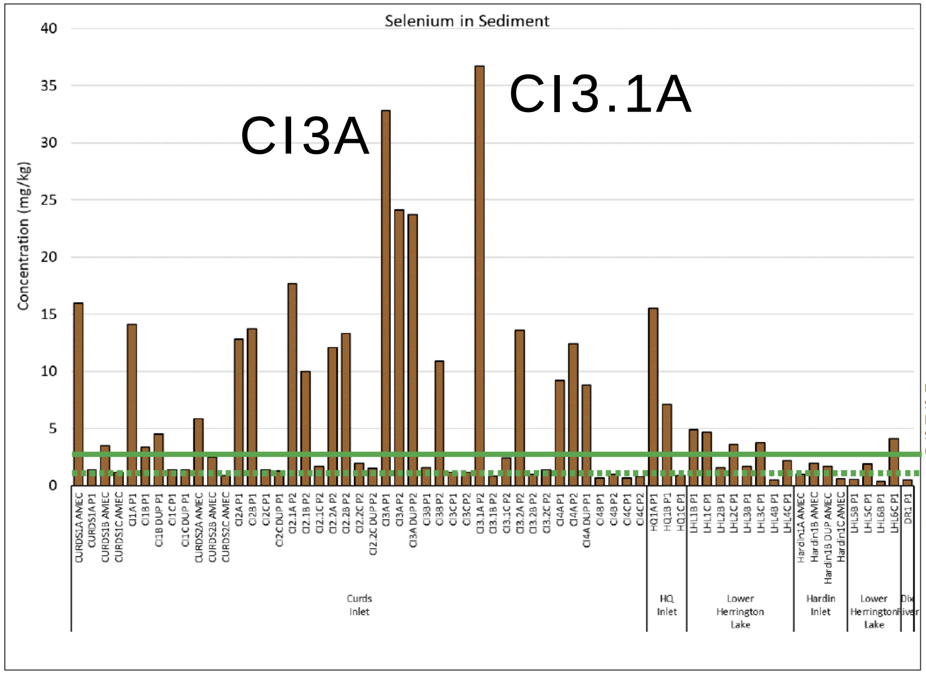
FIGURE

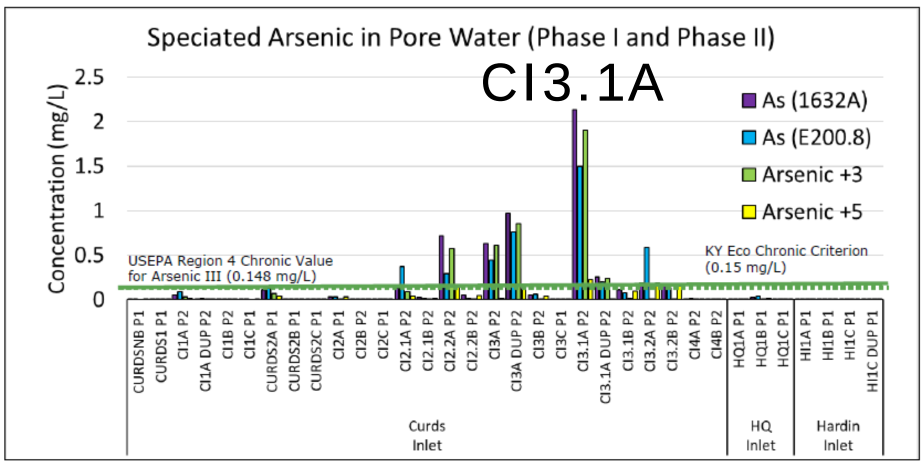
3-1A

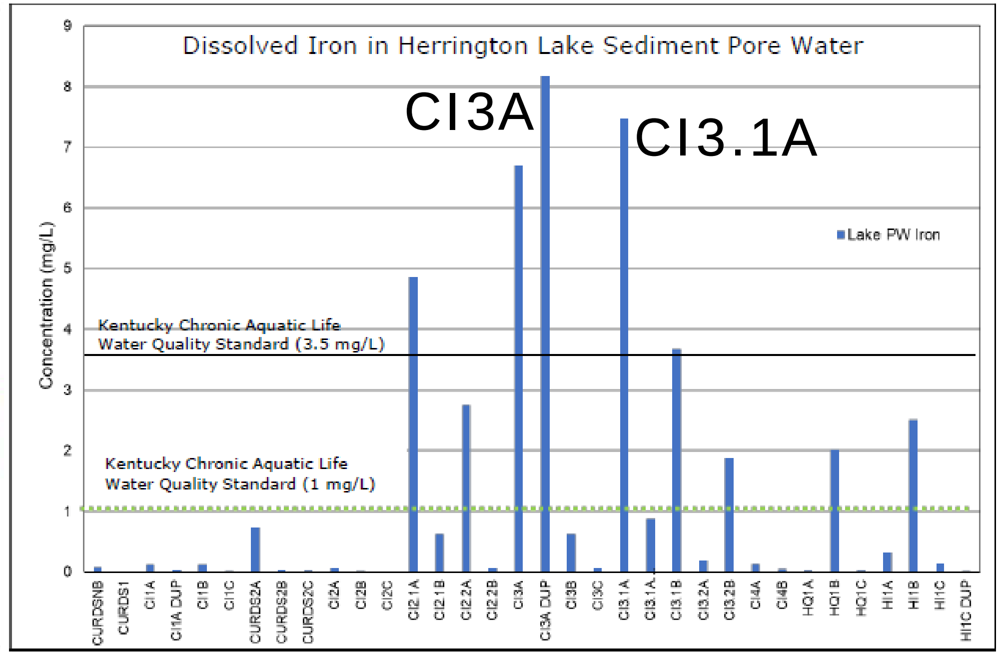


Dry weight (DW), Lower Curds Inlet (LCI), Middle Curds Inlet (MCI), milligrams per kilogram dry weight (mg/kg dw), Upper Cruds Inlet (UCI), Young-of-Year (YOY)

RAMBOLL	**YOUNG-OF-THE-YEAR BLUEGILL SELENIUM TISSUE CONCENTRATIONS 2022 VS 2018** Herrington Lake Corrective Action Plan: 2022 Monitoring Phase Mercer County, Kentucky	FIGURE 3-1B
DRAFTED BY: PAL / DATE: 10/31/2022		







RAMBOLL

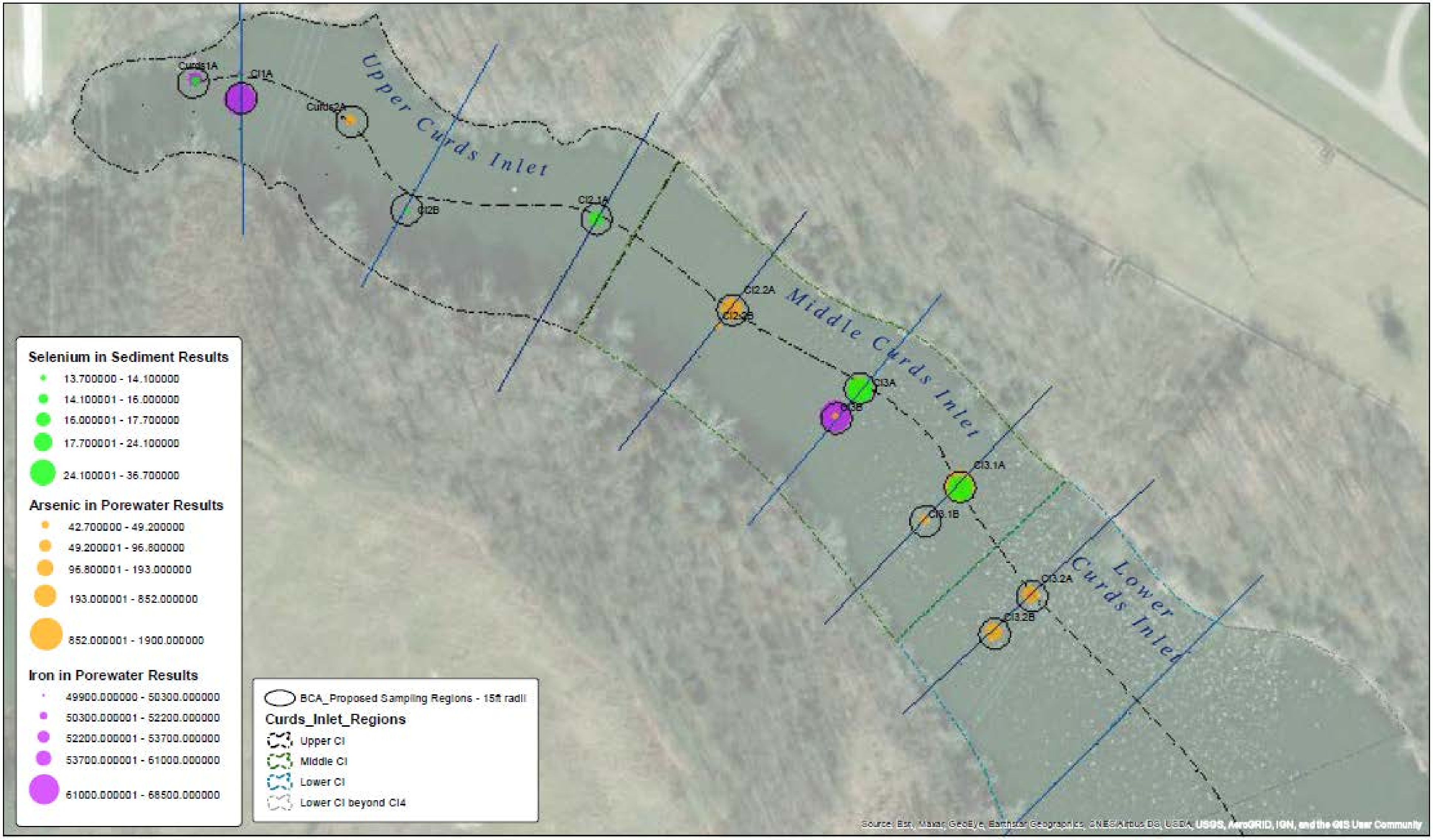
DRAFTED BY: PAL | DATE: 10/31/2022

2017 AND 2018 SELENIUM SEDIMENT AND ARSENIC/IRON PORE WATER CONCENTRATIONS USED TO GUIDE BCA SAMPLING LOCATION SELECTION

Herrington Lake Corrective Action Plan: 2022 Monitoring Phase
Mercer County, Kentucky

FIGURE

4-1A



RAMBOLL

DRAFTED BY: PAL

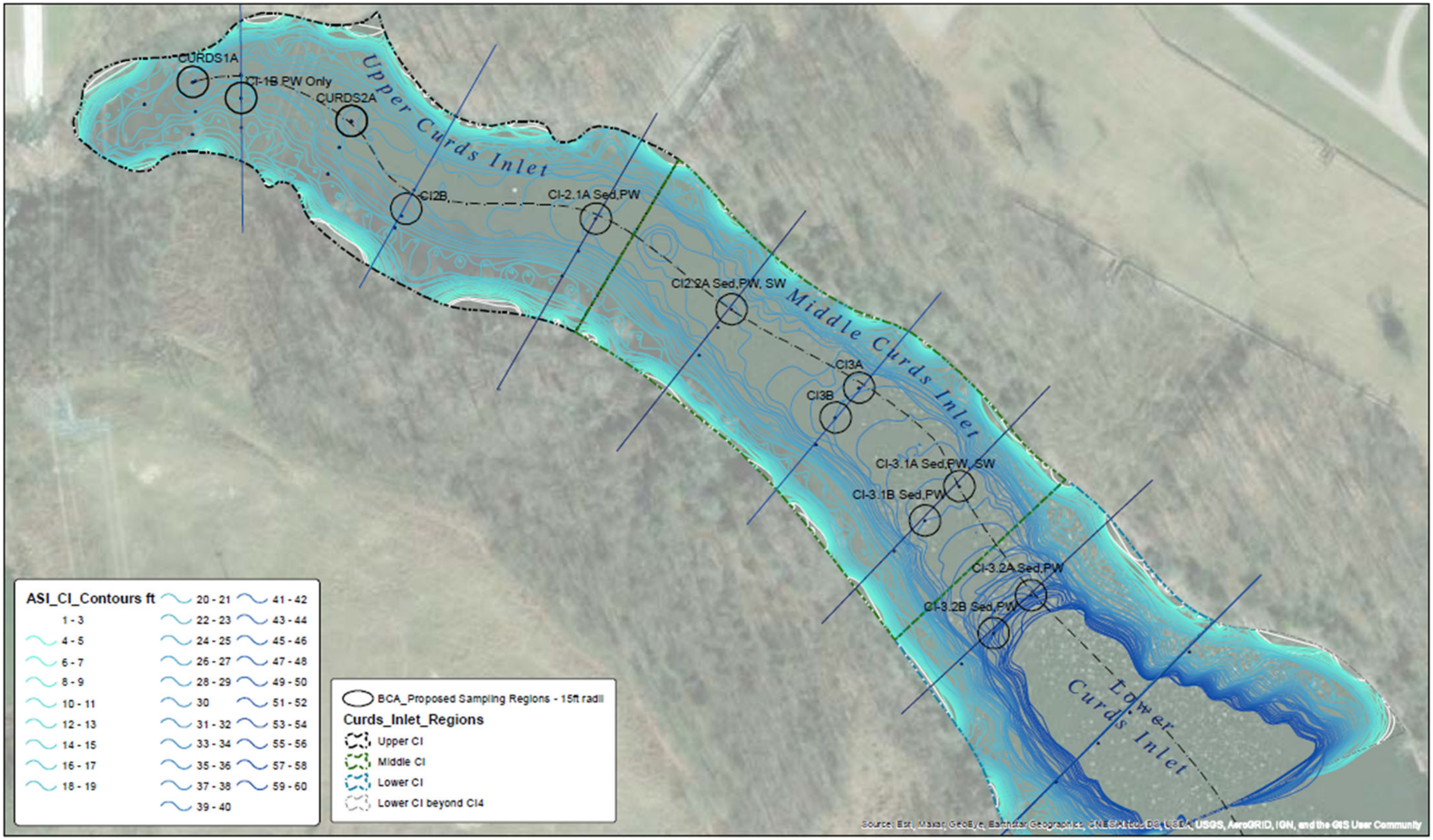
DATE: 10/31/2022

SEDIMENT SELENIUM CONCENTRATIONS AND ARSENIC/IRON PORE WATER CONCENTRATIONS FOR SELECTION OF BCA SAMPLE LOCATIONS

Herrington Lake Corrective Action Plan: 2022 Monitoring Phase
Mercer County, Kentucky

FIGURE

4-1B



RAMBOLL

DRAFTED BY: PAL

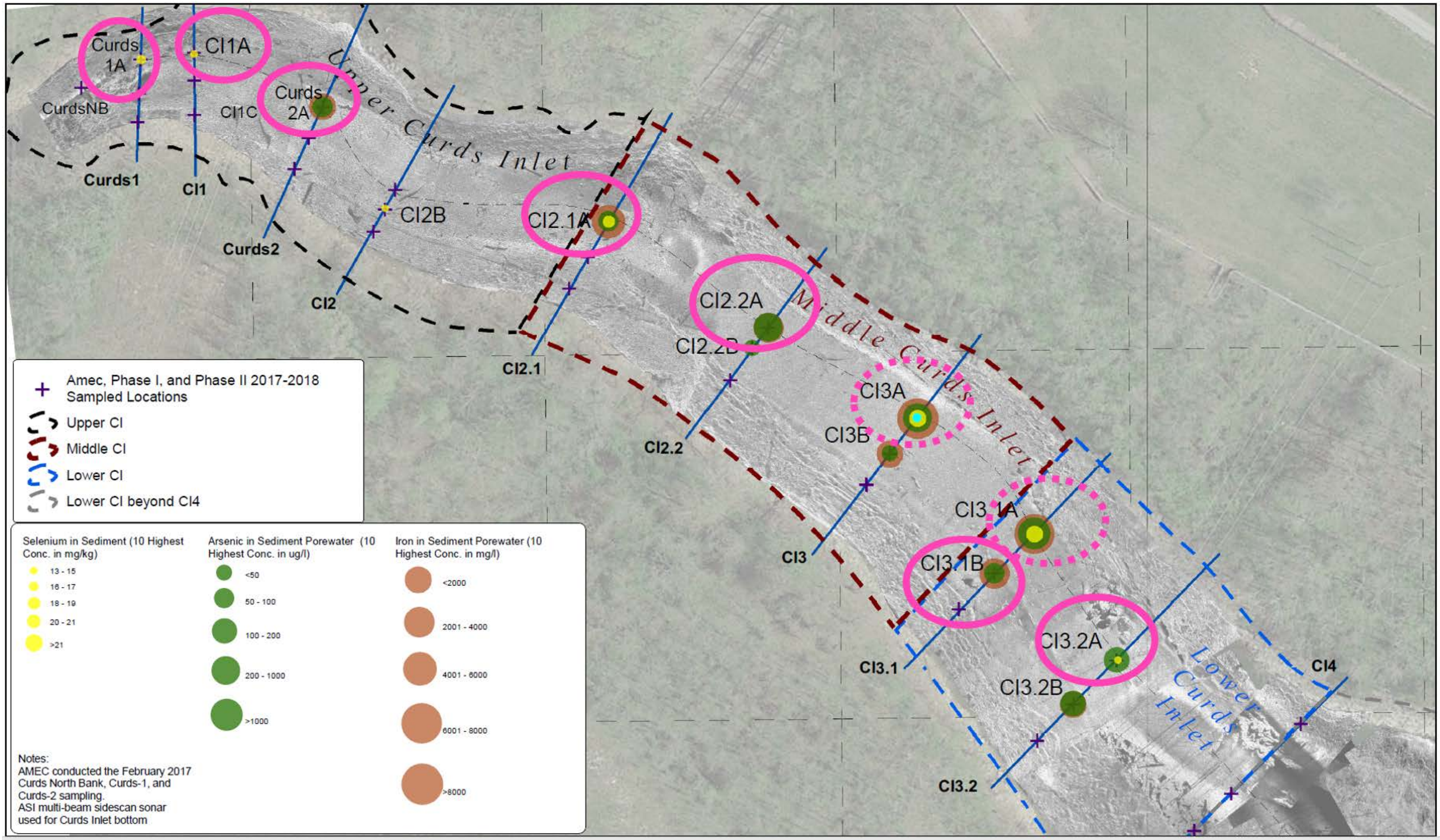
DATE: 10/31/2022

2022 BATHYMETRY FOR SELECTION OF BCA SAMPLE LOCATIONS

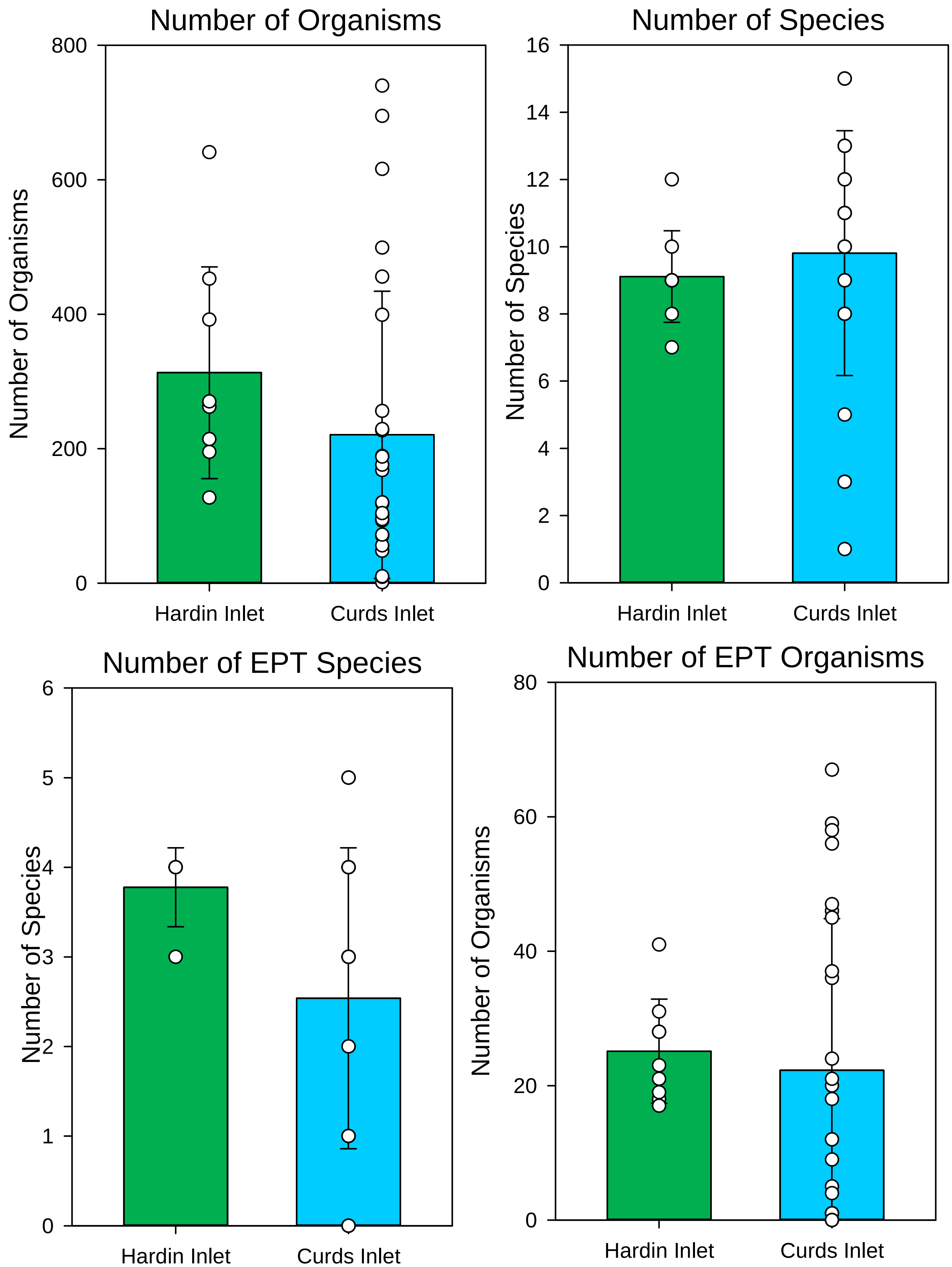
Herrington Lake Corrective Action Plan: 2022 Monitoring Phase
Mercer County, Kentucky

FIGURE

4-1C

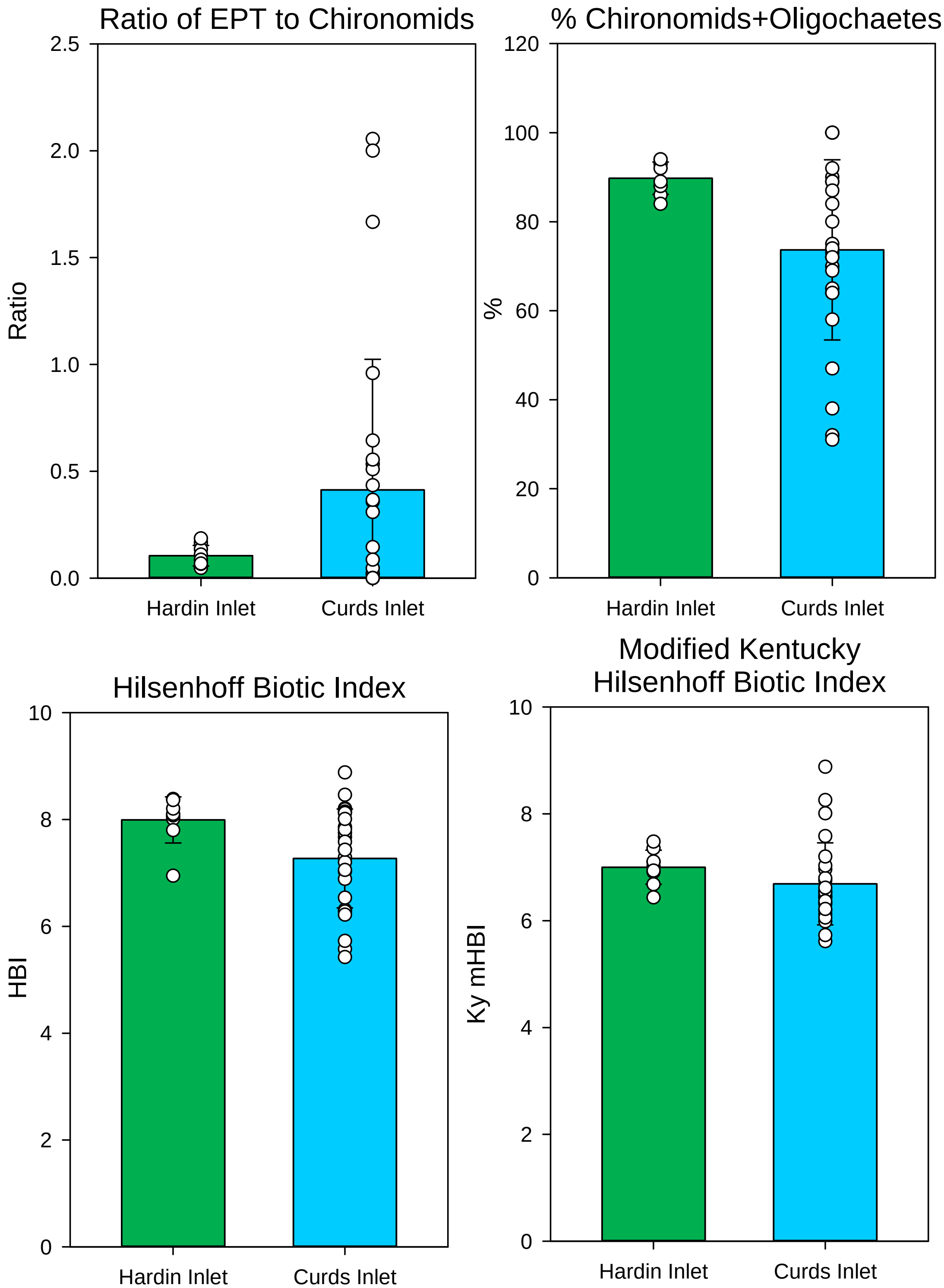


RAMBOLL	2022 SIDE SCAN SONAR FOR SELECTION OF BCA SAMPLE LOCATIONS	FIGURE
DRAFTED BY: PAL / DATE: 10/31/2022	Herrington Lake Corrective Action Plan: 2022 Monitoring Phase Mercer County, Kentucky	4-1D



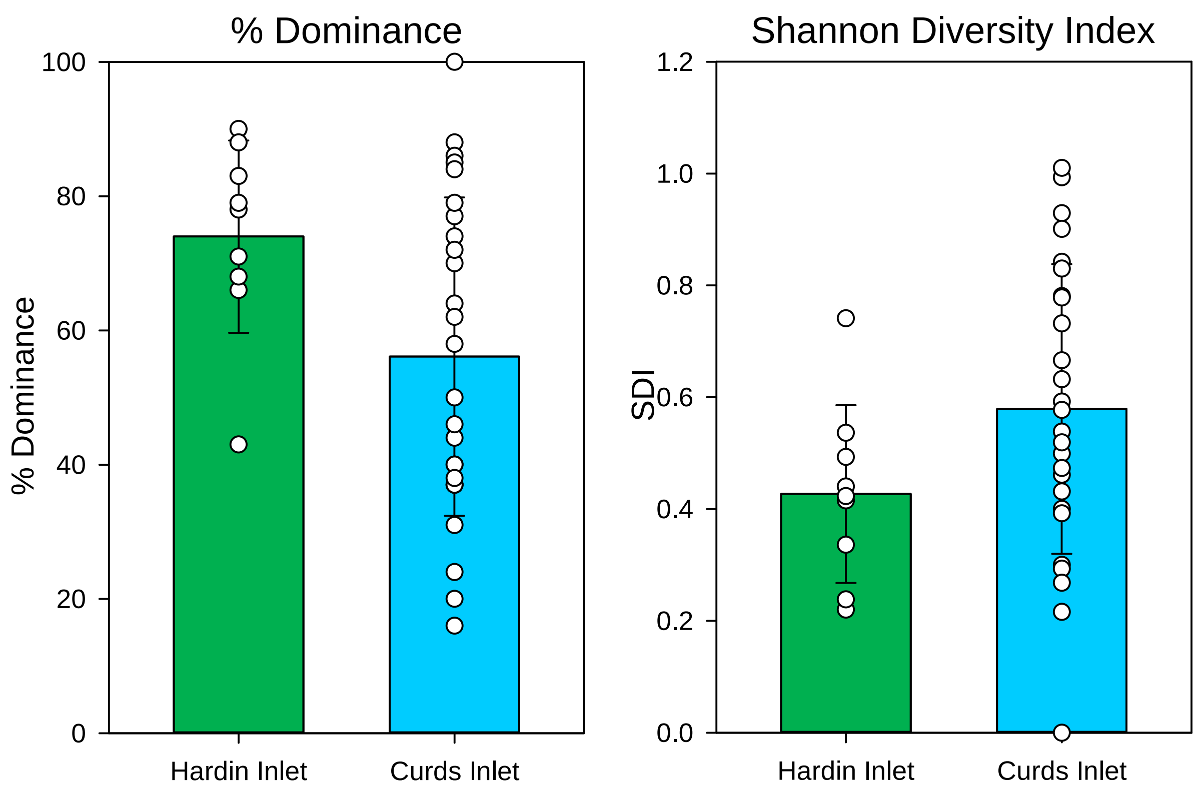
EPT = Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These organisms are pollution sensitive – they generally die off in polluted water.

RAMBOLL	**BENTHIC INVERTEBRATE ABUNDANCE, DIVERSITY AND SPECIES SENSITIVITY IN HARDIN INLET (REFERENCE SITE) AND IN CURDS INLET** Herrington Lake Corrective Action Plan: 2022 Monitoring Phase Mercer County, Kentucky	FIGURE 4-2A
DRAFTED BY: PAL / DATE: 10/31/2022		



EPT = Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These organisms are pollution sensitive – they generally die off in polluted water.
% Chironomids and Oligochaetes – these organisms are pollution tolerant. They generally do not die off in polluted water. The LOWER this value is the BETTER.
HBI = Hilsenhoff Biotic Index. A LOWER score on this index is BETTER, and indicates the community is sensitive to pollution. The Kentucky Modified HBI (Ky mHBI) is based on a max of 25 organisms in each taxon.

RAMBOLL	BENTHIC INVERTEBRATE POLLUTION TOLERANT SPECIES IN HARDIN INLET (REFERENCE SITE) AND IN CURDS INLET	FIGURE 4-2B
DRAFTED BY: PAL / DATE: 10/31/2022	Herrington Lake Corrective Action Plan: 2022 Monitoring Phase Mercer County, Kentucky	



% Dominance = The % of organisms in the sample that are from the most common taxon. The LOWER this metric is the BETTER.
SDI = Shannon diversity index. This is the evenness of the community and is essentially the opposite of % Dominance.

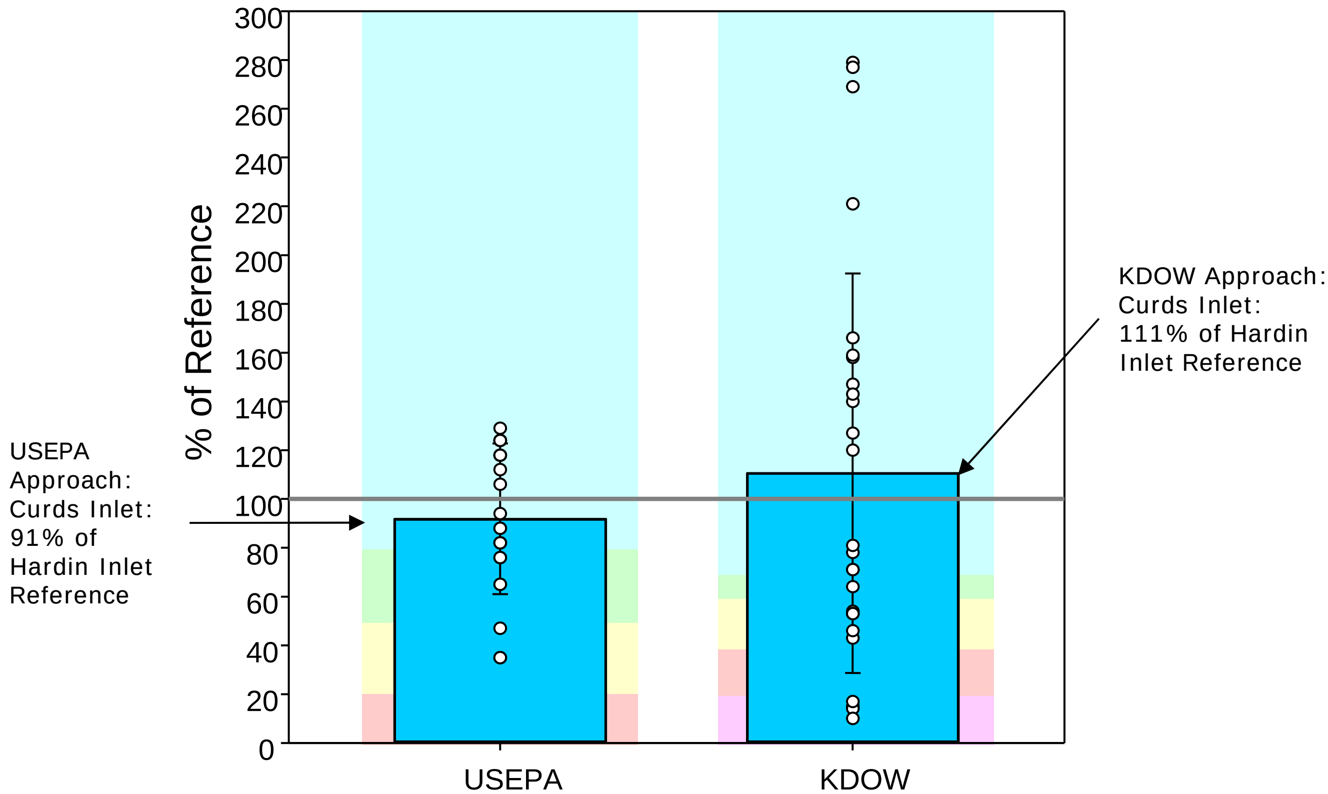
RAMBOLL

DRAFTED BY: PAL | DATE: 10/31/2022

BENTHIC INVERTEBRATE SPECIES DOMINANCE AND DIVERSITY IN HARDIN INLET (REFERENCE SITE) AND IN CURDS INLET

Herrington Lake Corrective Action Plan: 2022 Monitoring Phase
Mercer County, Kentucky

FIGURE
4-2C



USEPA and KDOW Condition Categories			
USEPA		KDOW	
% of Reference	Biological Condition Category	% of Reference	Narrative Rating
≥ 80 %	Non-Impaired (Comparable)	≥ 70 %	Excellent
≥ 50-79 %	Slightly impaired	61-69 %	Good
≥ 20-49 %	Moderately impaired	41-60 %	Fair
< 20 %	Severely impaired	21-40 %	Poor
		0-20 %	Very Poor

USEPA and KDOW BCA Results				
Waterbody	**% of Reference**	**USEPA Impairment Category (vs Hardin Inlet Reference)**	**% of Reference**	**KDOW Bioassessment Index (vs Hardin Inlet Reference)**
Curds Inlet	92%	Non Impaired (Comparable)	111%	Excellent

RAMBOLL

DRAFTED BY: PAL | DATE: 10/31/2022

BENTHIC INVERTEBRATE COMMUNITY ASSESSMENT: KDOW AND USEPA INDICES FOR HARDIN INLET (REFERENCE SITE) AND IN CURDS INLET

Herrington Lake Corrective Action Plan: 2022 Monitoring Phase
Mercer County, Kentucky

FIGURE 4-3