Date

**August 2017**

# HERRINGTON LAKE
# CORRECTIVE ACTION PLAN
## MERCER COUNTY, KENTUCKY

Prepared For: Kentucky Utilities Company
For Submittal To: Kentucky Division of Water
Agreed Order No. DOW - 17001

Prepared by: Ramboll Environ

RAMBOLL ENVIRON

# HERRINGTON LAKE CORRECTIVE ACTION PLAN
# MERCER COUNTY, KENTUCKY

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| Approved by | **JM Nielsen** |
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Ramboll Environ
1600 Parkwood Circle
Suite 310
Atlanta, GA 30339
USA
T +1 770 874 5010
F +1 770 874 5011
www.ramboll-environ.com

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| % | percent |
| AMEC | AMEC Foster Wheeler Environment & Infrastructure |
| ATB | Ash Treatment Basin |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| BERA | baseline ecological risk assessment |
| Cabinet | Kentucky Energy and Environment Cabinet |
| CAP | corrective action plan |
| CCR | coal ash and coal combustion residue |
| CFD | Central Fisheries Department |
| COCs | constituents of concern |
| COPC | chemical of potential concern |
| COPEC | chemical of potential ecological concern |
| CPUE | catch per unit effort |
| CSM | conceptual site model |
| DGA | dense graded aggregate |
| Dix Dam | Dix River hydroelectric dam |
| ERA | ecological risk assessment |
| ERAGS | Ecological Risk Assessment Guidance for Superfund |
| ESV | ecological screening value |
| FSP | field sampling plan |
| g | gram(s) |
| GPP | Gypsum processing plant |
| GPS | global positioning system |
| GWAR | groundwater assessment report |
| GWRAP | groundwater remedial action plan |
| HDPE | High density polyethylene |
| HHRA | human health risk assessment |
| HPLC | High Performance Liquid Chromatography |
| HQ | hazard quotient |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometry |
| IDs | Identification Numbers |
| IRIS | Integrated Risk Information System |
| IRM | interim remedial measure |
| ITRC | Interstate Technology and Regulatory Council |
| KDFWR | Kentucky Department of Fish and Wildlife Resources |
| KDOW | Kentucky Division of Water |
| KPDES | Kentucky Pollution Discharge Elimination System |
| KRAG | Kentucky Risk Assessment Guidance |
| KU | Kentucky Utilities |
| LHL | Lower Herrington Lake |
| LLDPE | Linear low-density polyethylene |
| LVWA | Lake Village Water Association |
| µg/L | microgram(s) per liter |
| µm | micron / micrometer |
| mg/kg | milligram(s) per kilogram |
| MCLs | Maximum Contaminant Levels |
| MHL | Middle Herrington Lake |

| | |
|---|---|
| MS/MSD | matrix spike/matrix spike duplicate |
| MW | Megawatts |
| ND | Non-Detect/Not Detected |
| NELAP | National Environmental Laboratory Accreditation Program |
| NOV | Notice of Violation |
| NPDES | National Pollutant Discharge Elimination System |
| oz | ounce(s) |
| plant | The E.W. Brown Generating Station |
| QA/QC | quality assurance/quality control |
| RAOs | remedial action objectives |
| RME | reasonable maximum exposure |
| ROI | receptors of interest |
| RSL | regional screening level |
| SETAC | Society of Environmental Toxicology and Chemistry |
| SF | square foot/feet |
| SLERA | screening-level ecological risk assessment |
| SMDP | Scientific management decision point |
| SOP | standard operating procedure |
| TGI | Tri-State Geographic Initiative |
| UCL | upper confidence limit |
| UHL | Upper Herrington Lake |
| SMDP | Scientific management decision point |
| SLERA | screening-level ecological risk assessment |
| SOP | standard operating procedure |
| USEPA | United States Environmental Protection Agency |
| USFWS | United States Fish and Wildlife Service |
| USGS | United States Geological Survey |
| WET | whole effluent toxicity |

# 1. INTRODUCTION

On January 11, 2017, the Kentucky Energy and Environment Cabinet (Cabinet) issued a Notice of Violation (NOV) to the Kentucky Utilities Company (KU) due to the detection of selenium in whole body fish tissue from Herrington Lake at concentrations above Kentucky's water quality standard for protection of aquatic life. In order to resolve the NOV, KU entered into an Agreed Order with the Cabinet on January 30, 2017 that required an investigation of sediment and surface water in Herrington Lake. Specifically, the Agreed Order directs KU to develop and submit for review and approval:

> *"A plan for (1) the further investigation of sediments, surface water quality and biological receptors in Herrington Lake, including an appropriate assessment of human health and ecological risks, (2) an assessment of the sources of selenium impacts, and (3) a consideration of remedial actions, if necessary, to supplement the Groundwater Remedial Action Plan (GWRAP), and a schedule for implementation of such plan for selenium impacts found to be from the E.W. Brown Station."*

This Corrective Action Plan (CAP) is submitted in fulfilment of that obligation.

Although the primary focus of the investigation proposed in this CAP is selenium as identified by the Cabinet, samples also will be analyzed for other metals potentially associated with disposal of coal combustion residuals (CCR) at the E.W. Brown Generating Station (arsenic, boron, cadmium, lead, zinc, mercury) and other parameters needed to better understand the aquatic system (sulfate, total organic carbon, hardness). These potential constituents of concern (COCs) are discussed further in Section 2.

The E.W. Brown Generating Station (plant) is located in the southern portion of the Inner Bluegrass region, on the east edge of Mercer County, approximately 3.8 miles northeast of the city of Burgin (Figure 1-1A). The plant is located on the west side of the Herrington Lake portion of the Dix River next to a hydroelectric dam (Dix Dam) built by KU in the 1920s. A coal-fired generating plant (currently consisting of three units) has operated at the site since the 1950s, and more recently a combustion turbine generating plant (consisting of seven combustion turbine units that can be fueled by either fuel oil or natural gas) was added to the plant to meet peak demands. In 2016, KU commenced operation of a 10 Megawatt (MW) universal solar facility comprised of more than 44,000 solar panels on a 50-acre tract at the plant site. A site layout map is provided in Figure 1-1B.

The plant has generated and disposed of CCR since coal combustion began in the 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. At E.W. Brown, bottom ash from all units (1,2 & 3) is sluiced to Aux Pond. Fly ash from units 1 & 2 is sluiced to Aux Pond. Fly ash from Unit 3 is handled dry since early October 2015. The first pond, referred to as the Main Ash Pond, or Main Pond, was located directly south of the Generating Station. As the Main Pond filled, it was expanded twice, in 1973 and 1989, to the surface area at the time of its closure (approximately 114 acres). In 2008, a second pond (referred to as the Auxiliary Pond) was constructed as a temporary settling pond until the Main Pond could be expanded again. In late 2008, the Main Pond was taken out of service, and the sluicing operation was switched to the Auxiliary Pond. Much of the Main Pond was covered with soil in 2011 during the landfill application process. Construction of a special waste landfill over the top of the Main Pond was permitted in 2015 and completed in 2016 and is currently receiving CCR (including bottom ash, fly ash and gypsum) generated by the plant. Construction of landfill atop the former Main Ash Pond also served to cap the former pond.

Beginning in 2015, KU initiated additional remediation activities to address elevated levels of certain metals in on-site groundwater believed to be associated with CCR disposal in the Main Ash Pond. This work is being conducted in accordance with the GWRAP approved by the Cabinet in October 2015 (AMEC Foster Wheeler Environment & Infrastructure [AMEC] 2015a, Kentucky Division of Waste Management [KDWM] 2015). These remedial actions are underway and most have been completed.

The remainder of this section describes:

- a summary of KU's completed and planned corrective actions;
- the definition of the Herrington Lake study area as it pertains to the investigation of sediments, surface water quality, and biological receptors;
- available information for investigations and studies of the plant and the lake; and
- a preliminary conceptual model for selenium in the environment that guides the CAP field sampling program.

Subsequent sections of the document contain other elements of the CAP. Section-specific information is described.

## 1.1 Summary of Completed and Planned Remedial Actions

As a condition of the issuance of an operating permit for the new CCR landfill to be constructed at the plant, KU was required to (1) develop a closure plan for the Main Pond; and (2) develop a remedial action plan to define specific methods to be used to abate groundwater contamination from the facility and prevent further groundwater contamination. The *Main Ash Pond Closure Plan* (AMEC 2014) was submitted by KU in 2014; this plan describes the final capping of the Main Pond with the construction of the new CCR landfill over the Main Pond. In addition, as described in the GWRAP, KU has initiated significant remedial actions (referred to as interim remedial measures, or IRMs) that are designed to mitigate the release of constituents of interest into groundwater and limit the migration of impacted groundwater from on-site sources. It is expected that these remedial actions will limit contributions of constituents of interest, including selenium, to Herrington Lake, mostly by preventing surface water infiltration and recharge of groundwater in target areas.

The IRMs implemented at the site during the period of 2014 through 2016 are summarized below; the performance of these IRMs is being monitored by KU in accordance with the GWRAP, and are expected to become part of the permanent remedial action for the site, as recognized by the Agreed Order.

## Summary of Interim Remedial Measures

| Area | IRM Description | Schedule of Implementation |
|---|---|---|
| Gypsum Processing Plant (GPP) | • Installed a liner for the Gypsum Pond and the area draining to the pond (55,600 SF total) to prevent infiltration of gypsum-impacted water in the area of the GPP<br>• Liner system consists of the following, from bottom to top:<br>  o 4 inches of dense graded aggregate (DGA) over grade (rough rock surface) – to support membrane<br>  o 60-mil LLDPE flexible membrane liner between two geotextile layers<br>  o 6-inch fabric form concrete mat | Completed: Late 2015 |
| West Quarry (non-CCR) | • Drained accumulated storm water<br>• Filled the quarry with inert structural fill (i.e., soil and rock)<br>• Graded surface to promote drainage<br>• Covered surface with topsoil and vegetated to minimize erosion | Completed: April 2016 |
| Auxiliary Pond Discharge Pipeline | • Replaced existing sections of the HDPE pipeline and manholes (based on 2014 evaluation by AMEC)<br>• Reduced the number of manholes<br>• Tightness tested system on completion. | Completed: November 2016 |
| Main Pond | Final Capping of Existing CCR<br>• Installation of the cap will be phased so that it is integrated into construction of the new lined landfill over the top of the covered existing CCR<br>• See Main Ash Pond Closure Plan (AMEC 2014) for final design details | Phases I, II, and III of the capping work is complete |
| | Abutment Drain Collection[1]<br>• Installed pumping station to capture the north abutment drain discharge and transfer it to the Auxiliary Pond(see Note 1) | Complete: July 2014 |
| | Toe Drain Collection[1]<br>• Installed collection system for discharges at the toe of the Main Pond Dam and to transfer them to the Auxiliary Pond(see Note 1)<br>• Constructed a cut-off wall across the valley downstream of the toe | Completed: April 2016 |

Notes:
1. Transfer of discharges to the Auxiliary Pond is intended as a short-term IRM. Once the design and construction of a new wastewater treatment unit for certain wastewater streams from the plant are completed to comply with newly promulgated effluent limitation guidelines, water pumped from the toe of the dam will likely be treated with other remaining wastewater streams (AMEC 2015a) as necessary to comply with Kentucky Pollution Discharge Elimination System [KPDES] discharge requirements).

As noted on the table above, KU is designing a new wastewater treatment unit for the facility to ensure compliance with discharge requirements. The new wastewater treatment plant is also being designed to accommodate groundwater collected at the Main Pond abutment and toe drain collection systems, and so will be integral to KU's long-term corrective action plan for the facility.

In order to verify performance of the IRMs, KU is conducting ongoing monitoring of groundwater. The results of this monitoring are reported semiannually to the Cabinet. KU is also monitoring changes to conditions in the Main Pond as a result of the IRMs and construction of the new overlying CCR landfill.

## 1.2 Herrington Lake Study Area and Existing Information

This section briefly summarizes available information as it pertains to the Herrington Lake Study Area defined for the purpose of this CAP. The information discussed in this section includes the following:

- Herrington Lake boundaries
- The fish community within the lake
- Plant studies, including groundwater assessment, springs monitored, Kentucky Pollutant Discharge Elimination System (KPDES) permitted discharges
- Additional water quality information available for the lake, including water levels and hydrodynamic cycles

### 1.2.1 Herrington Lake Study Area Boundaries

Herrington Lake is located within the Dix River watershed (refer to Figures 1-2A, 1-2B, and 1-2C). The lake is comprised of approximately 35 miles of the Dix River and several embayments (Figures 1-2B). The main channel of the Dix River portion of the lake is 33 miles from the dam to the headwaters at Highway 52. Approximately two additional miles of the lake are comprised of the Rocky Run embayment just above and east of the dam and the Cane Run embayment southwest of the plant (Figure 1-2B).

There are seven Commonwealth of Kentucky Department of Fish and Wildlife Resources (KDFWR) Fishery Districts. Herrington Lake is located within the Central Fisheries Division (CFD). KDFWR CFD provides Annual Sportfish Lake Performance Reports for Herrington Lake (KDFWR 2008, 2014, 2016). The CFD described the lake sections in terms of CFD-A and CFD-B Subdivisions (KDFWR 2008). For the purpose of this CAP, those general areas identified by the CFD for the lake were used to identify three sections of Herrington Lake: Upper, Middle, and Lower Herrington Lake, as illustrated on Figure 1-2C and described below:

- Lower Herrington Lake (LHL): Camp Kennedy @ Highway 152 Crossing to Dix Dam
- Middle Herrington Lake (MHL): Camp Kennedy @ Highway 152 Crossing to Highway 34
- Upper Herrington Lake (UHL): Highway 34 South to Highway 52

### 1.2.2 Existing Information

Existing information for Herrington Lake and the E.W. Brown Generating Station are available from a variety of sources. Because a primary focus of the Agreed Order is selenium as a constituent of interest associated with the plant, this section provides a brief overview of the KY water quality standards for selenium for the protection of aquatic life (KDOW 2016). Where data were used to inform the field sampling program described in Section 2 of this CAP, the data are briefly discussed.

This section summarizes studies that contribute to decisions regarding proposed sampling, including the Groundwater Assessment Report (GWAR, AMEC 2013), Groundwater Assessment

Update (GWAR Update, AMEC 2015b), the KPDES Discharge Monitoring Reports, spring sampling data, sediment data (AMEC 2017), and fish tissue data (Kentucky Division of Water [KDOW] 2016).

#### 1.2.2.1 KDOW Water Quality Standards for Selenium

KDOW's water quality standard acknowledges that selenium geochemistry is relevant to an understanding of toxicity. The standard states that in natural environments, selenium exists in four oxidation states (KDOW 2013):

- Selenide (-II)
- Elemental Selenium - Se (0)
- Selenite, $SeO_3^{2-}$ (IV)
- Selenate $SeO_4^{2-}$ (VI)

Where:

- the two predominate selenium species that constitute total selenium in the water column are selenite and selenate;
- … the presence of sulfate in the water column modifies or attenuates the potential acute toxicity effects of selenite; and,
- Toxicity is generally ranged as Se-met (selenomethionine, se-amino acids) > SeIV > SeVI.

The primary KDOW chronic water quality standard for selenium is based on whole fish tissue concentration for protection of aquatic life. KDOW (2016) states:

- *If fish tissue data are available, fish tissue data shall take precedence over water column data.*
- *The whole body fish tissue water quality standard is 8.6 mg/kg total Se, dry weight.*
- *A concentration of 5.0 µg/L or greater selenium in the water column shall trigger further sampling and analysis of whole-body fish tissue or alternately of fish egg/ovary tissue.*

Although KDOW and the United States Environmental Protection Agency (USEPA) acknowledge that fish egg and ovary data also provide an understanding of water quality conditions and potential impairment of fish communities, there is no consensus on a single value that is considered protective.

KDOW deleted its acute water column criterion for selenium from its water quality standards in 2016 on the basis that the prior standard of 20 micrograms per liter (µg/L) is not supported by underlying scientific data. That regulatory action was review and accepted by USEPA Region 4 (USEPA 2017).

#### 1.2.2.2 Groundwater Assessment Report and Groundwater Assessment Report Update

The GWAR (AMEC 2013) and the GWAR Update (AMEC 2015b) provide groundwater and spring water quality information that informed the development of this CAP. Historically, Herrington Lake has received diffuse groundwater flows from the springs east of the CCR ponds, via both Curds and HQ Inlets (Figure 1-3). The flows to Curds Inlet are now being intercepted by a cutoff wall that was installed in 2016. In addition, Herrington Lake receives surface water discharges permitted under the KPDES program, which are all routed to Curds Inlet. Discharges under the KPDES permit (KY0002020) include Outfall 001 for the Ash Treatment Basin (ATB) discharge, and Outfalls 002 and 003 from cooling towers. Outfall 001 enters Curds Inlet on the south side, just downstream from the toe of the Main Pond eastern embankment. Outfalls 002 and 003 enter Curds Inlet from the north, just downstream from the toe of the Main Pond eastern embankment. Water intake for the plant occurs through the KPDES intake outfall 005. The intakes for the pumps are set at an elevation between 661 and 664 feet. Typical lake surface elevations are at 740 feet at summer pool and 725 feet at winter pool.

Cedar Branch flows along the western boundary of the E.W. Brown Generating Station to the Kentucky River. There are currently no permitted surface water discharges to the west, toward the Cedar Branch watershed. Cedar Branch receives intermittent runoff from precipitation, and groundwater flow from springs apparently originating west of the topographic divide between the watersheds.

Herrington Lake discharges through Dix Dam to the lower Dix River, which flows north about 2 miles to its confluence with the Kentucky River above Lock 7. Cedar Branch also flows north and discharges to the Kentucky River, less than a half-mile west of the Dix River confluence.

As part of the GWAR:

- Baseline monitoring was initiated at six long-term monitoring springs, identified in Figure 1-3. Five rounds of monitoring were performed at the six springs between January and December of 2012. The springs were Stonewall Spring, Railroad Spring, Webb Spring Complex, Dam Toe Right Spring, Ditch Spring, and Briar Patch Spring. In addition, Beaver Dam Cave Spring, HQ Spring, Hardin Spring, and Rockhouse Spring were sampled.
- Surface water samples were collected from four locations in Curds Inlet and Herrington Lake and the plant water intake. Surface water samples were also collected from the Cedar Branch watershed and compared to the water samples from Herrington Lake.
- A risk assessment was performed for the human health and ecological exposures to groundwater.

The GWAR stated that groundwater flow at the site occurs primarily in fractured bedrock. Extensive hydrogeologic characterization activities were performed in 2011 and 2012, relying primarily on dye tracing, to confirm groundwater flow paths.

Curds and HQ Inlets receive surface water discharges permitted through the KDOW KPDES program. A surface water divide occurs immediately west of Main Pond between the watershed containing the CCR ponds and the Cedar Branch watershed to the west. Dye tracing has confirmed that a groundwater divide is coincident with this surface water divide, and that groundwater does not flow west into the Cedar Branch watershed from the area of the CCR ponds. There is also no connection to the north (area of Webb Spring Complex, upstream of the Lower Dix River) based on dye tracing.

Samples were collected over multiple sampling rounds in 2011, 2012 and early 2013 from 12 springs in the vicinity of the site, including three springs designated as background springs, seven springs and seeps identified by dye tracing as being downgradient from the Main Pond, and two additional springs to the north and northwest. They were analyzed for the full water quality characterization list required by the KDWM Solid Waste regulations and guidance for sampling groundwater in the vicinity of coal ash landfills (as specified in specified in 401 KAR 45:160, Section 7.2 (a)). That list contains 23 parameters, including 5 indicator parameters (pH, SC, COD, total organic carbon and total dissolved solids) and 18 individual inorganic elements and compounds, mostly metals. Boron was also required to be monitored. More limited sampling was performed of various surface water bodies, including Herrington Lake, Cedar Branch, and their tributaries.

A risk assessment was performed by AMEC in 2013 to further evaluate the potential impacts associated with the ten specific elements or compounds, referred to as constituents of interest. As part of the risk assessment, the conceptual site model (CSM) was refined based on the understanding of groundwater and surface water flow pathways developed in the hydrogeologic characterization of the site, supplemented with literature and site-specific information on surface water hydrology and land use. The potentially affected pathways and the exposure routes associated with them were evaluated in development of the CSM, in order to identify the most sensitive routes and receptors.

The GWAR Update (AMEC 2015b):

- further evaluated the groundwater flow pathways site-wide, and specifically the hydraulics of the Main Pond and its relationship to the local groundwater flow system;
- provided a more comprehensive review of chemical parameters associated with source waters;
- performed a geochemical evaluation of groundwater; and
- characterized baseline conditions for evaluating future effectiveness of designated remedial actions.

The GWAR Update further observed the following:

- Water quality parameters for sampling performed in 2014 included samples from potential source waters (the deep CCR in the Main Pond and a sampled from the Auxiliary Pond) and an expanded parameter list. Water sampled from the Auxiliary Pond discharge was found to be distinct from background water, primarily on the basis of its anionic composition. Background water consists of calcium bicarbonate water of near-neutral to slightly alkaline pH, low chloride concentration, and relatively low dissolved solids content. By contrast, water in the Auxiliary Pond has high dissolved solids content, and is dominated by sulfate in its anionic content.
- Water sampled from test wells installed at the bottom of the Main Pond CCR is distinguished from the Auxiliary Pond/GPP water type primarily on the basis of a higher proportion of chloride to sulfate in its anionic make-up, as well as a dissolved solids content that is even higher than in the Auxiliary Pond /GPP water type. The only groundwater sampling point where this water type was observed was the Dam Toe Right (CH-040). Samples collected at this monitoring point in 2014 were reported to be a mix of the two source water types.

- Redox conditions within the saturated CCR in the Main Pond are reducing, and may become more so as infiltration of aerated water is further reduced, depending on the amount of sulfate (which acts as a reservoir for oxygen) that is present in the CCR. More reducing conditions, if they occur, could limit the solubility of arsenic and reduce concentrations of arsenic in the water exiting the Main Pond CCR.

The GWAR and GWAR Update groundwater data and spring data were reviewed in preparation of the field sampling program described in Section 2 of this CAP, particularly the results for selenium, given that selenium is a primary focus of the Agreed Order. The spring sampling data indicated that the majority of sample results for selenium were less than the KDOW chronic water quality standard trigger threshold of 5 µg/L. Fish tissue sampling data is the primary indicator of potential chronic impacts to aquatic life (KDOW 2016). Where no fish tissue data are available for sampling, the 5 µg/L water column standard applies. Two springs had detections exceeding the chronic value of 5 µg/L.

Based on sampling data, focused sampling of Curds Inlet and areas proximate to Curds Inlet is proposed as part of the field sampling program described in Section 2 of this CAP.

#### 1.2.2.3 KPDES Monitoring Data

The GWAR and GWAR Update discuss monitoring data from KPDES outfalls at the E.W. Brown Station. While the KPDES permit does not set limit for individual metals, the Discharge Monitoring Reports data indicates concentrations of certain constituents have at times been above surface water quality criteria for certain metals, including selenium and mercury. The GWAR also discusses the whole effluent toxicity (WET) testing performed for effluent from KPDES Outfall 001 on a quarterly basis for acute toxicity from 2009 to 2013. The WET test results indicated that the discharge from KPDES Outfall 001 (Auxiliary Ash Pond) was not exhibiting toxicity to the indicator species following the WET testing protocol.

The KPDES outfalls discharge into Curds Inlet, and therefore, the field sampling program described in Section 2 of this CAP includes additional sampling of Curds Inlet.

#### 1.2.2.4 Herrington Lake Sediment Data

A sediment investigation of Curds Inlet and Hardin Inlet was conducted in February 2017 (AMEC 2017). Selenium concentrations in sediment samples from Curds Inlet ranged from less than 1 milligram per kilogram (mg/kg) to 5.9 mg/kg except for one location with a detection of 16 mg/kg (Figure 1-3). The selenium concentrations in sediment from Hardin Inlet ranged from less than 1 mg/kg to 2 mg/kg. The single location with the 16 mg/kg of selenium also had the highest concentration of arsenic (350 mg/kg) and total organic carbon (14 percent [%]).

Based on these sediment results, additional sediment sample collection in Curds Inlet is identified in Section 2 of this CAP. In addition, focused pore water sampling in Curds Inlet, HQ Inlet, and Hardin Inlet are proposed. The pore water sampling will include selenium speciation so that an understanding of the sediment cycle for selenium as it pertains to sediment contributions to the water column and biota can be better understood and evaluated as a contributing source to the biological food web of Herrington Lake.

#### 1.2.2.5 Fish tissue data for Herrington Lake

There are no fish consumption advisories specifically listed for Lake Herrington per the KDOW (KDOW 2017a). However, the lake is subject to the state-wide advisories for mercury in fish, which are summarized in Table 1-1 (KDOW 2017a).

Fish tissue samples were collected from Herrington Lake in 2016 by the KDOW from locations near the dam and from the Rocky Run embayment portion of Herrington Lake (Figure 1-3) (KDOW 2017b).

Fish fillet tissues were collected from five bluegill (*Lepomis macrochirus*), seven largemouth bass (*Lepomis macrochirus*) and one spotted bass (*Micropterus punctulatus*) at the Herrington Lake dam sampling station. Selenium results for whole body fish are summarized below in milligram per kilogram (mg/kg) dry weight:

- Bluegill selenium fillet concentrations ranged from 9.7 mg/kg to 11.5 mg/kg
- Spotted bass fillet selenium concentration was 10.7 mg/kg
- Largemouth bass fillet selenium concentrations ranged from 4.9 mg/kg to 11.7 mg/kg

These fish tissue selenium concentrations exceed the KDOW whole body standard for fish tissue of 8.6 mg/kg dry weight for protection of aquatic life from chronic impacts.

The KDOW fish tissue data informed the sampling program described in Section 2. It was noted that the KDOW fish tissue sampling locations indicate that fish tissues were collected from a residential cove on the Rocky Run embayment portion of the lake (Figure 1-3). However, the fish tissue lab reports do not include selenium whole body fish tissue analytical data for review from the residential cove. Largemouth bass ovary samples were collected from near the dam and from the residential cove. Selenium was detected in the fish ovary sample collected from near the dam at a concentration of 7.93 mg/kg. Selenium was detected in ovary samples from the residential cove at concentrations of 11 mg/kg and 11.3 mg/kg.

These fish tissue data are still being evaluated, and may be included in the future human health and ecological risk assessments, as described in Section 3 and 4 of this CAP, respectively. Any additional fish tissue data that is possessed by KDOW from lake fish tissue studies will be requested and considered in the database of this CAP.

#### 1.2.2.6 Fish Tissues from the Ash Pond

The USFWS conducted a study of selenium concentrations in fish tissues from the Main Ash Pond (USFWS 2007). The purpose of the study was to provide a biological assessment related to gray bats that may forage on emergent insects from the Main Ash Pond. Based upon the findings of the study, the opportunistic nature of foraging events at the plant combined with the presence of alternate, high-quality forage opportunities within typical feeding range of local gray bats, the USFWS report concluded that the Main Ash Pond was "*insignificant when compared to all other potential foraging opportunities available to resident gray bats in this population's range.*"

The report also concluded that

> "*a comparison of fish tissue data from KDOW's nearest stream reference site and fish tissue data from the (main) ash pond at E.W. Brown indicates that fish from the reference reach streams contain even higher concentrations of mercury than fish in the (main) ash pond.*"

This study is relevant to this CAP because 30 individual fathead minnows (*Pimephales promelas*) and 15 individual bluegill were collected from the Main Ash Pond. The following were the composite fish samples collected:

- 3 Fathead minnow samples (10 fish/composite), ~ 2 ounces [oz]/sample (~50 grams [g])
- 3 Bluegill samples (5 fish/composite), ~9oz/sample (~250g)

The selenium whole body results for fish from the ash pond were reported as follows:

- Fathead minnow: 17 to 18 mg/kg dry weight
- Bluegill: 14 to 16 mg/kg dry weight

1.2.2.7 KY Department of Fish and Wildlife Studies (Fish Community)

There are 242 fish species in Kentucky, 226 of which are native (KDFWR 2016). About 40 fish species are important to anglers, and 15 species are common in Kentucky's major lakes, all of which are manmade impoundments. Three black bass species—the largemouth, smallmouth (*Micropterus dolomieu*), and spotted bass—are Kentucky's most popular game fish. Other popular and widely distributed game fish are crappie (*Poxomis sp*), catfish (*Ictalurus punctatus*), bluegill, and white (*Morone chrysops*) and hybrid bass (*Morone chrysops x Morone saxatilis*). Movement patterns for species typical of Herrington Lake are provided in Table 1-2.

Annual largemouth bass population data are available covering the period of 1996 to 2016 for Herrington Lake, as illustrated in Figure 1-4A, which is an extracted figure from the 2016 Largemouth Bass Assessment Report. During the years of 2004-2015, KDFWR used standardized sampling methods to collect sport fish species from Herrington Lake by electrofishing or gill netting. Monitored measures included otolith-derived age/growth, catch rate, mortality, recruitment, length/weight, water temperature, and dissolved oxygen. Angler surveys were also conducted during a few study years. The sampling and survey results included species composition, relative abundance, and catch per unit effort (CPUE). As indicated in Figure 1-4A, the total assessment score for largemouth bass from Herrington Lake range from "good" to "excellent," with exception for the years 2009 and 2011 which were reportedly impacted due to fluctuating water levels during fish spawning seasons.

Performance reports are also available, as follows:

- Black bass: During the springs of 2004–2015, KDFWR electrofished for black bass in Herrington Lake. Each spring survey included 2.5 hours of sampling for each of the upper, middle, and lower lake sections to produce estimates of species composition relative abundance, and CPUE for largemouth, spotted, and smallmouth bass. Largemouth bass are, by far, the most abundant black bass species in Herrington Lake.

Spotted bass, on average, comprised roughly 15% of collected samples. Smallmouth bass are rare in Herrington Lake and none were collected during most years.

- Hybrid striped bass and white bass: During the autumns of 2004–2015 KDFWR gill netted for hybrid striped bass and white bass in Herrington Lake. Sampling duration ranged from 12–18 net-night sampling periods. Overall, the results indicate equal abundance for hybrid striped bass and white bass and that both have excellent growth rates in Herrington Lake. The 2015 white/hybrid bass population assessment for Herrington Lake indicated a "fair" population of hybrid striped bass and a "good" population of white bass. The white bass population was recovering from a June 2013 major die-off.
- White and black crappie: During the springs of 2004–2012 KDFWR electrofished for white and black crappie in Herrington Lake. Each spring survey included 1.5 hours of sampling for each of the upper, middle, and lower lake sections to produce estimates of species composition relative abundance, and CPUE for largemouth, spotted, and smallmouth bass. Results of the 2004–2012 survey suggest that the white crappie population is increasing in the middle and upper lake sections but in the lower lake, the black crappie is more abundant than white crappie. Based on the annual reports, no crappie surveys were conducted during 2013–2015.

This information informed the field sampling program in Section 2 of the CAP with regard to fish species selection.

#### 1.2.2.8 Water Levels for Herrington Lake

Water level data for Herrington Lake are available for the United States Geological Survey (USGS) gauging station near Burgin, KY (Station 03286000) (USGS 2016). The data from this station are provided graphically in Figure 1-4B. As indicated in this figure, low flow for 2016 was from December to March. The low flow information corresponds to the winter lake overturn during November and December, making these good times for surface water sampling during a lake overturn limnological cycle. In general terms, lake overturn reflects an opportunity for sediments at depth to become suspended and distributed around a lake. Therefore, the flow and the limnological cycling of the lake is relevant for the sampling program described in Section 2 of the CAP. The limnological cycle is discussed further in Section 1.3.

### 1.3 Preliminary Conceptual Site Model

A preliminary CSM is a planning tool used for identifying chemical sources, complete exposure pathways, and potential receptors on which to focus the ecological and human health risk assessment. This initial CSM describes the network of relationships between chemicals released from past and ongoing site activities and the receptors that may be exposed to the chemicals through pathways such as ingestion of food or water. An exposure pathway is the way a person or ecological receptor is exposed to chemicals of potential concern (COPCs) in exposure media. Exposure pathways consist of the following four elements: (1) a source; (2) a mechanism of release, retention, or transport of a chemical to a given medium (e.g., air, water, soil); (3) a point of where a person or ecological receptor can contact the medium (i.e., exposure point); and (4) a route of exposure at the point of contact (e.g., incidental ingestion, dermal contact). If any of these elements is missing, the pathway is considered incomplete (i.e., it does not present a means of exposure). Only those exposure pathways judged to be potentially complete are of concern for human or ecological exposure.

The CSM examines the range of potential exposure pathways and identifies those that are present and may be important for human and ecological receptors; it eliminates those pathways that are incomplete and therefore do not pose a risk. The following sections identify sources of chemicals and transport mechanisms as well as potential exposure pathways to be considered in the ecological and human health risk assessments. CSMs prepared for the GWRAP (AMEC 2015a) and for the GWAR (AMEC 2013) were considered as part of development of this CSM.

### 1.3.1 Sources and Transport Mechanisms

One key goal of sampling and analyses identified in this CAP work plan is to identify and characterize sources and transport mechanisms, if any for selenium and other metals beyond those identified in the (AMEC 2015a and AMEC 2014). The GWRAP (AMEC 2015a) identified overall site water balance and evaluated sources to groundwater stating that: "Water circulating through the site is influenced by surface water used for cooling, waterborne transport of CCR, infiltration, seepage, and surface water discharges." In addition, the Main Ash Pond Closure Plan (AMEC 2014) identifies remedial actions to address pathways related to the ash pond. Data generated from sampling identified in this CAP will be used to further characterize sources and nature and extent (if any) of selenium and other metals concentrations within the aquatic system due to releases from the E.W. Brown Station. Additional potential selenium sources within the Upper and Lower Dix River Watersheds are discussed in more detail in Section 1.4 as a component of the source assessment obligations of the Agreed Order.

According to Agency for Toxic Substances and Disease Registry (ATSDR 2003), selenium is ubiquitous in the environment, being released from both natural and anthropogenic sources. The principal releases of selenium into the environment from human activities result from the combustion of coal. Other anthropogenic emission sources of atmospheric selenium include oil combustion facilities, selenium refining factories, base metal smelting and refining factories, mining and milling operations, end-product manufacturers (e.g., some semiconductor manufacturers), as well as incineration of rubber tires, paper and municipal waste. For example, selenium was widely used in the glass industry and selenium may be used as a nutritional feed additive for poultry and livestock. Selenium also was used as an accelerator and vulcanizing agent in rubber production. Selenium was used as a catalyst in the preparation of pharmaceuticals including niacin and cortisone, as an ingredient in antidandruff shampoos (selenium sulfide), and as a constituent of fungicides (selenium sulfide). Sewage treatment plants are another source of selenium releases to water. The Agency for Toxic Substances and Disease Registry (ATSDR 2003) reported that in the past, selenium was used in pesticide products, but because of stability in soils and subsequent contamination of food crops, its use in pesticide products is restricted. These potential sources, and the timing associated with restricted use of selenium, will be considered as they may have also influenced the aquatic system.

A preliminary conceptual model of the selenium geochemistry cycle in the aquatic environment is provided in Figures 1-5A and 1-5B. These figures illustrate the cycling of selenium from sediments through primary producers, through consumers, to carnivores. Selenium exists in the natural environment in four oxidation states and forms a diverse and interchangeable array of inorganic and organic species through the action of physical, chemical, and biological processes. The primary species are selenite ($SeO_3^{2-}$, or SeIV), selenate ($SeO_4^{2-}$or SeVI), and organo-selenide (e.g., selenomethionine or org-Se[II]). Unlike most trace elements, the distribution of selenium among dissolved species cannot be predicted from thermodynamics alone. Biological processes are just as important as geochemical processes in determining the forms of selenium that are present (Cutter and Bruland 1984).

Because selenium is an essential nutrient, selenium uptake is facilitated across most biological membranes, making its biogeochemical cycling unique among metal contaminants. While the measurement of total selenium concentration is typically used for assessment and management, it is now recognized that understanding selenium speciation is critical to understanding its mobility, transformation, partitioning in the environment, and potential risk to aquatic ecosystems.

The major redistribution between aquatic compartments occurs immediately on delivery to the aquatic system (e.g., adsorption of selenium on hydrated iron oxides, release of selenium from particles). Selenium redistribution within the system is then dependent on the structure of the aquatic food web (e.g., detrital vs. phytoplankton-based food webs) and the hydraulic residence time (does the water move downstream or does it remain in place [i.e. many lakes]. Microbial organisms are important in transforming selenium in the environment (Figure 1-5A and 1-5B). However, flux estimates and species mass-transfer rate data are virtually non-existent, and thus the overall importance of microbial organisms in selenium transformations, while significant, is not well understood (Chapman et al. 2009).

The selenium geochemical cycle involves three major processes in aquatic systems as follows:

1. Deposition and resuspension (selenite, selenate, elemental Se, and Se-II);
2. Trophic transfer involving algae, plants, and animals (selenomethionine, selenocysteine, Se-II); and
3. Microbial processes (selenate, selenite, elemental Se, Se-II, and in gaseous form dimethylselenide and dimethyldiselenide).

Selenium can be removed from solution and sequestered in sediments through the natural processes of chemical and microbial reduction of the selenate form (SeVI) to the selenite form (SeIV), followed by adsorption (binding and complexation) onto clay and the organic carbon phase of particulates, reaction with iron species, and co-precipitation or settling, resulting in insoluble organic, mineral, elemental, or adsorbed selenium. However, mechanisms present in most aquatic systems effectively mobilize sediment selenium into food chains and thereby cause long-term dietary exposure of fish and wildlife (Chapman et al. 2009). Selenium is made available for biological uptake by four oxidation and methylation processes as follows:

1. Oxidation and methylation of inorganic and organic selenium by plant roots and microorganisms.
2. Biological mixing and associated oxidation of sediments that results from the burrowing of benthic invertebrates and feeding activities of fish and wildlife.
3. Physical perturbation and chemical oxidation associated with water circulation and mixing (current, wind, stratification, precipitation, and upwelling).
4. Oxidization of sediments by plant photosynthesis.

Factors for the bioavailability of selenium from sediments to the food web of Herrington Lake include the following:

- The depth of Herrington Lake. Herrington Lake is very deep in portions of the lake nearest the dam and the plant. The depth of the lake limits the limnologic cycle of lake turnover, and thus, limits the amount of selenium input into the food web from sediments (i.e., sediment suspension, resuspension, and selenium uptake into plants from sediments at depth).
- Selenite in sediments, particularly those at depth which do not cycle or have limited cycling due the limnological stratification, has a strong affinity for sorption iron (Fe) oxides, Fe hydroxide, aluminum (Al) sesquioxides, and sulfates.
- The conversion of selenate to the less mobile form Se (selenite or elemental Se) is a slow process.
- In contrast to selenite, selenate is stable in well-oxidized environments, and not as strongly adsorbed as selenite by solid particles.

This information informs the field sampling program described in Section 2 of this CAP, particularly regarding the timing of surface water sampling with the lake stratification and mixing cycles as well as focused sediment sampling and geochemical sampling planned for the more shallow waters, including Curds Inlet.

### 1.3.2 Potential Human Receptors and Exposure Pathways

The potential for people to contact chemicals in environmental media depends on site use and the resulting potential exposure pathways. Herrington Lake is a popular recreational lake used for boating, swimming and fishing. It is a well-stocked lake and contains bluegill, catfish, crappie, hybrid striped bass, largemouth bass, spotted bass and white bass. As such, fish consumption is the primary pathway for people to be exposed to site COPCs. Thus the most likely human receptors are those who consume fish recreationally caught from the lake.

Use of groundwater as drinking water was ruled out in the GWAR based on data gathered in a Water User Survey performed in 2011 that no complete pathways for use of groundwater as drinking water (AMEC 2013). As described in AMEC (2013) the Lake Village Water Association (LVWA) supplies drinking water in the study area using water drawn from both the Harrodsburg and Danville municipal supplies. The intake for the Danville supply is in Herrington Lake several miles upstream from the E.W. Brown Generating Station. The intake for the Harrodsburg supply is in the Kentucky River just downstream of the confluence with Cedar Branch at Shaker Landing, which is downstream of the groundwater and surface water discharges from the E.W. Brown Generating Station. AMEC (2013) reviewed water quality data obtained through an Open Records Request to KDOW for the Harrodsburg water treatment plant from 2008 through 2012. There were no exceedances of Maximum Contaminant Levels (MCLs) or secondary MCLs in treated water.

On this basis, AMEC (2013) stated that “no potable water users have been identified that could potentially be impacted by the groundwater discharges from the E.W. Brown Generating Station, and therefore potential exposure pathways involving drinking water are considered incomplete.” However, because the analyses underlying the AMEC (2013) assessment are now more than six years old the State’s database of water wells will be reviewed to determine whether there is any indication of current groundwater use for potable purposes in the vicinity of the facility. Although use of groundwater as drinking water was ruled out in the GWAR based on data gathered in a Water User Survey performed in 2011, as part of the CAP implementation, the 2011 groundwater users survey will be updated as follows:

- Property Valuation Records will be reviewed to identify any property transfers that have occurred since completion of the groundwater user survey in 2011.
- Current satellite imagery will be reviewed to identify any new structures within the groundwater survey area that have been constructed since completion of the groundwater user survey in 2011.
- KU will coordinate with KDOW to obtain a list of all reports submitted by certified water supply drillers pursuant to 401 KAR 6:310 of any water wells that have been completed, modified, or abandoned in the survey area since completion of the groundwater user survey in 2011.

While further analysis of groundwater use as drinking water will be conducted to determine whether there is a complete exposure pathway for groundwater, it is understood that Herrington Lake serves as a drinking water supply. Therefore, data for the years from 2013 to the most current available data will be reviewed to further evaluate this pathway. In addition, lake water data will be considered relative to MCLs, or risk-based concentrations protective of residential water consumers. In addition, recreational visitors contact surface water in Herrington Lake while boating or swimming and this exposure pathway will be evaluated in the HHRA.

Sediments are known to have selenium and arsenic at concentrations greater than background in Curds Inlet in close proximity to E.W. Brown Station. Most sediments are under water far too deep to be accessed during wading or swimming. However, some shallower areas may be identified that have elevated COPCs. Thus, there is at least a hypothetical possibility that recreational visitors may contact COPCs in shallower sediments while visiting the lake in vicinity of E.W. Brown Station.

In summary the following exposure pathways are proposed for further evaluation in the HHRA, as described in Section 3 of this CAP:

- Ingestion of COPCs in fish by recreational anglers and their relatives and acquaintances
- Ingestion and dermal contact with COPCs in lake water used as drinking water by residential consumers
- Ingestion and dermal contact with COPCs in sediments within shallower lake areas by a recreational visitor
- Incidental ingestion or dermal contact with in surface water by recreational visitors
- Depending on the outcome of additional review of groundwater use, ingestion and dermal contact with COPCs in groundwater used as drinking water by residential consumers may also be evaluated

### 1.3.3 Potential Ecological Receptors and Exposure Pathway

The potential for aquatic organisms to be exposed to COPCs depends upon the home range and mobility of the species. The dominant route of the past transport of pollutants from the plant to the lake was through Curds Inlet. Aquatic and sediment dwelling organisms as well as small home range species that preferentially use Curds Inlet are likely more exposed to COPCs from the plant than larger home range species that infrequently visit Curds Inlet.

A schematic of the selenium cycle including biological activity is illustrated on Figure 1-5B. Selenium enrichment and trophic transfer in aquatic food webs exists. Selenium concentration between water and the base of the aquatic food web (e.g., algae) increase and these increases are represented as trophic transfer functions. Fish and piscivorous wildlife can be exposed to selenium via tropic transfer. In summary the following ecological exposure pathways may require consideration for the field sampling program described in Section 2 or the ERA described in Section 4 of this CAP:

- Ingestion of constituents in water, sediment, and biological media (aquatic plants, aquatic invertebrates and fish tissue) this includes piscivorous (fish eating) birds and mammals
- Direct contact to surface water and sediment by aquatic wildlife

### 1.4 Assessment of the Potential Sources of Selenium

As part of an initial assessment of potential selenium sources to Herrington Lake, a search of dischargers within the Dix River watershed was conducted. Specifically, sources of selenium were assessed using publically available data from USEPA's Envirofacts Multisystem Search Engine, a tool which integrates information from a variety of databases containing data on facilities that are required to report activities to a state or federal system (USEPA 2017a,b). Databases included in the Envirofacts Multisystem search include (but are not limited to) the Toxics Release Inventory, Superfund Enterprise Management System, Facility Registry Service, and the Integrated Compliance Information Search. Specific information regarding National Pollutant Discharge Elimination System (NPDES) and KPDES facilities were obtained from USEPA's Permit Compliance System database. The locations of the KPDES facilities are illustrated on Figures 1-6A and 1-6B, with a summary of the facility information provided on Table 1-3. As indicated on Table 1-3, these permitted dischargers include facilities such as sewage treatment, manufacturing, crushed stone and concrete mixing, waste management, and roofing. The receiving waters include Herrington Lake and waterbodies that flow to Herrington Lake.

This information has been considered in proposing selenium water column, aquatic life, and sediment sampling in Section 2.1 and 2.2 for the selenium source assessment. Section 2.6 describes the site characterization reporting and the approach for the assessment of potential selenium sources.

# 2. FIELD SAMPLING PLAN AND SITE CHARACTERIZATION REPORTING

## 2.1 Overview, Goals, and Objectives

The overall goal of the Field Sampling Plan (FSP) is to describe the steps necessary to characterize the nature and extent of chemicals in surface water, sediment, sediment pore water, and biological media from the Herrington Lake Study Area. An overview of the FSP is provided in Figure 2-1 and Table 2-1. As described in Section 1 and illustrated on Figure 2-1, the lake is divided into three sections for the purpose of this CAP: Upper, Middle, and Lower Herrington Lake, with:

- LHL designated as Camp Kennedy at Highway 152 Crossing to Dix Dam
- MHL designated as Camp Kennedy at Highway 152 Crossing to Highway 34
- UHL designated as Highway 34 South to Highway 52

The field sampling program described in this section is designed to meet the following overall data collection objectives:

- A phased approach is proposed to allow focused characterization of Herrington Lake. Phase I of the investigation provides characterization of surface water, sediment and fish within Herrington Lake closest to the plant in the LHL region, as illustrated on Figure 2-1. In addition, Phase I will include surface water, sediment and fish sampling from Dix River downstream from the dam and fish sampling from the MHL region. The Phase I and Phase II sampling programs are defined on Table 2-1. The results from the first phase of sampling will be used to determine the extent of Phase II sampling that may be warranted, including sampling further from the LHL region If Phase I data are sufficient to support risk management decisions for the E.W. Brown Station, then Phase II sampling may not be necessary.
- The area of the lake adjacent to and nearest the plant has the highest density of sampling locations so that a focused gradient of chemical concentrations related to the plant, if any, can be detected or ruled out in a statistically robust manner.
- Samples collected from the mid-portion and upper portions of the lake can provide an understanding of potential contributions (if any) from other dischargers in the watershed, and potentially naturally-occurring geologic conditions or ambient deposition that may be present in the watershed.
- Although the primary focus of this investigation is selenium as identified by the Cabinet, additional analyses will also be conducted for other metals (arsenic, boron, cadmium, lead, zinc, mercury) and other parameters needed to better understand the aquatic system and conditions that may influence the bioavailability of selenium and other chemicals (sulfate, total organic carbon, hardness).
- The surface water sampling program is designed to evaluate surface water conditions as related to potential selenium transport through the food web. Because Herrington Lake undergoes stratification and mixing (overturn), surface water sampling will be implemented during two events, one during the fall/winter overturn and one during the summer stratification. All other sampling (sediment, pore water, and biological tissue) will be implemented during one event in the summer. Timing of the summer sampling event will ensure (1) sampling during a stratified water conditions to understand if lake overturn cycle contributes to the selenium cycle in the lake; (2) minimized disruption to breeding periods, particularly for fish; (3) optimized productivity for plants and aquatic invertebrates; and (4) minimal migration of fishes throughout the Study Area.

  - Surface water sampling will be conducted at each Herrington Lake sample location during two sampling events, as specified in Table 2-1. These samples will provide information to characterize the chemical concentrations in the lake and provide information for the assessment of potential selenium sources.
  - Surface water will also be collected at one location downstream from the Herrington Lake Dam and the dam overflow to document selenium and other metals concentrations downgradient from the dam.
- A goal of this sampling program is to evaluate if selenium in sediment is a source for selenium in the food web of Herrington Lake (e.g., the fish that anglers may catch and eat). The sediment sampling approach considers geochemical conditions. Herrington Lake is very deep in the areas nearest the dam and the plant. The depth of the lake limits the limnologic cycle of lake turnover, and thus, limits the amount of selenium input into the food web from sediments (i.e., sediment suspension, resuspension, and selenium uptake into plants from sediments at depth). Sediment sampling will be limited to a maximum depth of approximately 25 to 40 feet below the water surface because sediments within the lake environment at these depths can be expected to be characterized by moderate to low oxygen conditions, and as such, would reflect the most conservative (i.e., highest likelihood) for selenium cycling into the food web, if such cycling does in fact occur. Sediment sampling will target depositional areas, where possible, to provide a conservative measure.
- Sediment pore water sampling locations target Curds Inlet, HQ Inlet, and Hardin Inlet. The purpose of pore water sampling is to evaluate the selenium speciation present which will provide insight into whether or not the sediments are a source of selenium to the geochemical cycle of selenium into biological tissues via microbial activity. The focused pore water sampling in Curds Inlet where selenium and other metals concentrations should be highest will show the maximum amount of biologically active selenium, if any. In addition, pore water sampling in HQ Inlet will provide insight into selenium contributions (if any) from Briar Patch Spring to the sediments of Herrington Lake in the HQ inlet.
- Biological tissue sampling in this program includes fish tissues. The KDOW water quality standards include a whole body fish tissue standard. Therefore, whole body fish tissues are a focus of this sampling program, particularly for small home range species, such as bluegill. In addition, the human health risk assessment (HHRA) will assess consumption of fish tissue by anglers. Therefore, largemouth bass and catfish will be analyzed in such a way that allows analytical results for fillet and whole body fish tissues for each fish sample. The three fish species included for this plan reflect small home range (bluegill), an upper trophic level fish (largemouth bass), and a bottom feeding fish (catfish).
  - Each of the three species (bluegill, largemouth bass, and catfish) will be collected from each sample location, except for the HQ Inlet, where only bluegill will be collected given the small size of the inlet.
  - The small home range of the bluegill make them an optimal species for the evaluation of potential selenium sources to the food web of Herrington Lake.
  - Fish ovary samples will also be collected from a subset of largemouth bass and from catfish. The fish ovary tissue may also be used as part of the consideration of potential selenium effects on fish.
- Biological tissue sampling will include aquatic plant and aquatic invertebrate tissues. Selenium cycling through the food web is expected to be a greater contribution to fish tissues than selenium uptake directly from the water column or from sediment. Direct measurement of the tissue concentrations will provide a greater understanding of the selenium cycle in Herrington Lake. In addition, direct measurement of the aquatic plant and aquatic invertebrate tissue

concentrations from Herrington Lake provides site-specific data that can be used in the Ecological Risk Assessment (ERA).

- The sampling program and analytical methods identified for the sample media will ensure that data are of sufficient quality and quantity to be used for the HHRA and ERA that will be performed as described in Sections 3 and 4.

## 2.2 Sample Locations, Sample Types, Frequency of Sampling, and Sample Depth Intervals

Surface water, sediment, sediment pore water, and biological tissue samples will be collected as part of the sampling program, as described in the following subsections. All samples types are proposed to be collected at the highest density in the LHL so that a clear gradient of selenium concentrations with distance from the plant can be identified, if such a gradient is present. The sampling in the LHL will be conducted as part of Phase I. Depending upon the results from Phase I sampling, the need for additional data collection in the MHL and UHL regions will be considered. Sample locations for Phase I (LHL) and potential locations for Phase II (MHL and UHL) are provided as indicated on Figure 2-1 and Figures 2-2A though 2-2E). In addition, the sample location downstream from the Herrington Lake dam is identified on Figure 2-2F. The specific data quality objectives for each sample location are provided on Table 2-2.

### 2.2.1 Surface Water

Surface water sampling locations will be selected along systematic transects established for each section of the lake (Figures 2-2A through 2-2F), with a total of 17 transects within the Study Area and one sampling station identified on the Dix River downgradient from the dam. For each of the locations within the Study Area (i.e., LHL, MHL, and UHL), one sampling location will be determined along each transect, and either one or two surface water samples will be collected from one or two depth intervals, based on the depth of the lake and proximity to the plant, as presented in Table 2-1. Appendix A (Figures A-1 through A-3) provides bathymetric mapping for the proposed surface water sample transects identified in Figures 2-2A through 2-2E; bathymetry information was obtained from Navionics+ (2017). The water depth information provided by the bathymetry mapping in Appendix A will be used to guide the selection of sampling locations. Three surface water samples will be collected from the Dix River transect downstream from the dam (Figure 2-2F).

Surface water sampling will be implemented during two separate events for certain sections of the lake, as shown in Table 2-1. Surface water sampling during summer stratification of the lake in the LHL and MHL will include each of the stratified layers of the lake (the epilimnion, metalimnion, and hypolimnion). It is noted that the inlets are more shallow and potentially may be well mixed at the time of sampling. As such, sampling in the inlets may only reflect one or two limnological layers, as they exist at the time of sampling. Surface water samples will be collected at the surface (the epilimnion during summer stratification), at a mid-depth water level that reflects the metalimnion (or thermocline), and in the hypolimnion (deepest stratified layer) to a maximum of approximately 150 feet below the water surface. Water temperature and dissolved oxygen sampling at the beginning of sampling and at multiple locations over the lake can be used to determine the depth of the epilimnion, metalimnion, and hypolimnion at the time of the field sampling effort. Surface water sampling during the lake overturn will involve only one sample depth intervals (at approximately 25 feet of water depth). Water depth, temperature, and dissolved oxygen profiles will be provided to document the lake stratification and lake overturn conditions at the time of sampling.

Surface water sampling in the UHL will include just one sample depth interval, as the UHL is shallower than the MHL and LHL areas. However, if field conditions determine there is stratification in the UHL area, then surface water sampling will focus on the epilimnion only. Also, as noted in

Table 2-1, a single depth interval is also considered adequate for more shallow inlets, such as Curds Inlet, HQ Inlet, and Hardin Inlet. There will be a single depth interval sampled in the summer timeframe and in the fall/winter overturn timeframe for these locations. If field conditions indicate stratification in these areas, then two sample intervals may be warranted for the summer timeframe.

Water samples will be collected from approximately the center of the surface water transects depicted on Figures 2-2A through 2-2F. Final sampling locations will be determined in the field, based on field conditions, and at the discretion of the field team leader.

Surface water sampling from the Dix River transect downstream from the dam will target the mid-depth of the water column at three locations along the single transect identified in Figure 2-2F. A single depth is appropriate because the water in the river will be well mixed given flow through the dam and proximity to the dam. Water samples will be collected from each of the three locations from each of the two sampling events planned for the lake (i.e., the summer sampling effort and during the fall/winter overturn). The three sampling locations along the single transect will be near the shoreline on each side of the river and in the middle of the river.

### 2.2.2 Sediment and Sediment Pore Water

Sediment sampling locations will be determined along transects consistent with the surface water, within each section of Herrington Lake (Figures 2-2A through 2-2F). Studies have shown that pore water represents a significant exposure route of selenium to organisms at the base of the food chain (Jung and Batley 2004; Schlekat et al., 2002). Chapman et al. 2009 describe pore water as one of a variety of lines of evidence for consideration of selenium in the environment. Specifically:

- Pore-water exchange can be a significant source or sink of dissolved selenium to a water body (Meseck and Cutter 2006).
- There is a net positive diffusional flux (movement) of contaminants to the overlying water. In sediments, particulate selenium can undergo a variety of oxidation-reduction reactions that may cause selenium to become mobile (Velinsky and Cutter 1991).
- Particulate selenium in sediment can undergo regeneration to dissolved organic selenide. In this way, sediments can become a source of dissolved selenium to the estuary via pore-water exchange with the overlying water (Meseck and Cutter 2006).
- Pore water chemistry data in combination with measures of dissolved organic carbon and sulfides provides essential information for interpreting sediment toxicity data.
- Pore water chemistry data chemistry data also reflects a vital line of evidence that for interpreting of the fate and transport of selenium sources.

Sediment sample locations will include areas closest to the shore along each transect. In addition, mid-channel sample sediment samples will also be collected from Curds Inlet and the HQ Inlet. To the extent practical for Curds Inlet and the HQ Inlet, each proposed transect extends from the center of the channel to the shore with the thickest sediment, and consists of three sampling locations.

The total number of sediment samples per section of Herrington Lake are presented in Table 2-1. Final sampling locations will be determined in the field, based on field conditions, and at the discretion of the field team leader. There will be distinct challenges in the collection of sediment samples given the depth of the lake and the rocky substrates of the lake. Therefore, the sediment locations depicted on Figures 2-2A through 2-2F are approximate only (based on the available bathymetry provided in Appendix A). The water depth at sediment sampling will be limited to a maximum depth of approximately 25 to 40 feet below the water surface. Sediment sampling will target depositional areas, where possible, to provide a conservative characterization of sediment quality, as follows for the Inlets:

- Location A: subaqueous, close to the deepest point in the channel (thalweg),
- Location B: subaqueous, approximately 3-5 feet below the water line at the time of sampling; and,
- Location C: a location above winter pool elevation (~725 feet msl) and below summer pool elevation (~740 feet msl)."

Accessibility of the sampling locations will also be considered when determining final sampling locations. For example, a scoured area has been observed in Curd's Inlet from previous field visits. The westernmost transect as shown in Figure 2-2B may be shifted at the time of sampling depending on water depth and the presence of the scour area.

Exhibit 1 illustrates the sampling depths as proposed in the Draft CAP. The CAP proposes sampling on both sides of the channel and in the deepest thalweg portion of the channel for the inlets. Samples will be collected from each side of the inlets because this allows a more distributed characterization of potential influences in the inlets from the E.W. Brown Station to inform future remedial action decision-making. Sampling planned outside the inlets will be from the B sample depths (3 to 5 feet) to the extent possible, to a maximum depth of 25 to 40 feet as described in the CAP, affording flexibility to the field team in finding sediment particles for sampling from some areas of the lake with steep, rocky topography at short distances from the shoreline.

Exhibit 1: Sample Collection Examples

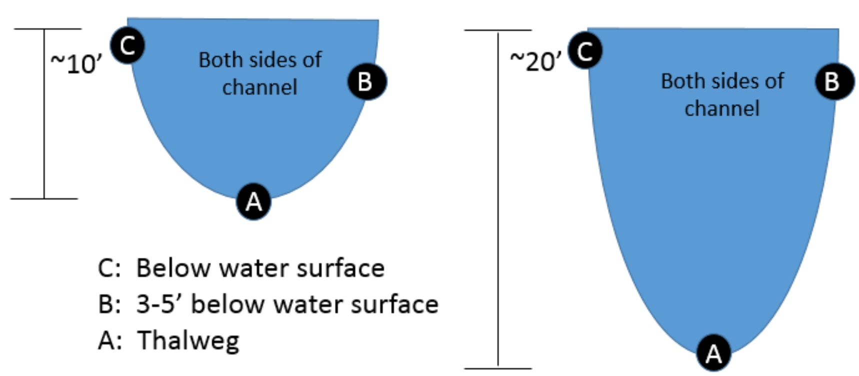


Figure 2-4 and Appendix A-4 of the CAP identifies the transect locations and sample locations, and shows that thalweg sampling will occur for Transects CI-1, CI-2, and CI-3. These figures show that Transect CI-4 does not have a sample planned for the thalweg. As can be seen in the bathymetry from Figure A-4, the deepest water depth at this location is approximately 90 feet below the water surface at summer pool. This deep sample will not be collected given the challenges associated with collecting samples from these depths, particularly if divers are used. It is considered highly likely that sufficient data will be available to make remedial management decisions from the three transects where thalweg data will be collected combined with the two previous thalweg samples collected in February 2017.

It is noted that the Cabinet identified an area of potential scour in Curds Inlet near Transect CI-2. The conditions in Curds Inlet for Transect CI-2 will be evaluated at the time of sampling for scour conditions. Sediment deposits along Transect CI-2 will be sampled if present and characteristic of localized deposition conditions.

Sediment pore water sampling locations target Curds Inlet, HQ Inlet, and Hardin Inlet only (Figure 2-2B and 2-1C), with a total of 14 pore water samples. Where practical, sediment pore water samples will be collected at the same locations as sediment. However, final sampling locations will be determined in the field, based on field conditions, and at the discretion of the field team leader.

### 2.2.3 Biological Tissues

Several types of biological tissue will be collected from the Herrington Lake Study Area, including fish, aquatic vegetation, and aquatic invertebrates. The fish sample collection will be conducted in accordance with the KDOW fish collection protocols (KDOW 2014a), as applicable for the habitats that will be sampled in Herrington Lake. Whole body fish and fish fillet samples will be collected. All fish collected from each target area will be pooled together, and both composite and individual samples will be selected from the pooled sample. Composite whole body samples will consist primarily of smaller individual fish, representing prey-size fish for higher trophic level ecological receptors.

Three different trophic levels and feeding guilds of fish will be targeted at each of the fish sampling locations to provide a representative characterization of the contaminant transport among fish within the Herrington Lake. Each trophic level and/or feeding guild is represented by the following target species:

- Upper trophic level – largemouth bass
- Bottom-feeder – channel catfish (or flathead catfish)[1]
- Forage fish – bluegill as the target species, or minnows if bluegill are unavailable

The above species are the anticipated target species, based on previous surveys and general knowledge of the Study Area aquatic environment. Actual fish selected to represent the various trophic levels and feeding guilds will be determined in the field based on the pool of collected species for each sampling area of the lake. All reasonable effort will be made to keep the types of fish selected consistent among the sampling areas, but there may be variations among the areas due to habitat availability, water depth, size of the sampling area, and other physical factors.

Fish sampling data will be used for both the HHRA and ERA, as described in Sections 3 and 4 of this CAP, respectively. The following sampling is planned to support these assessments:

- Bluegill fish will be characterized using composite fish (i.e., 2 to 5 fish per sample) whole body tissue samples.
- Largemouth bass and catfish will include both fillet and whole body tissue analyses. These will also be based on composite samples (i.e., 2 to 5 fish per sample). In order to limit the number of fish needed for analyses, selected individual fish will be filleted, and the fillet and corresponding carcass will be submitted separately for analysis, allowing for estimation of the whole body chemical tissue concentration. This will satisfy sample volume requirements,

[1] Targeting of bottom dwellers (catfish) addresses the issue of potential selenium uptake into the food web from fish feeding at the sediment surface.

reduce the number of fish required for collection, and allow the analyses to inform both the HHRA and ERA.

- Eight fish sampling areas are identified in the LHL area, as indicated on Figure 2-2A. Seven of the eight locations will include sampling of the three target species (bluegill, largemouth bass, and catfish). Bluegill will be the target species for the small area of the HQ Inlet.

For a subset of fish, fish ovary tissues will also be removed from the fish and analyzed separately. Fish ovary samples will be collected from one largemouth bass and from one catfish sample from each of the LHL fish sampling stations. This will amount to a total of 14 ovary samples for two species from 7 fish sampling stations.

Proposed aquatic vegetation and aquatic invertebrate sampling locations are shown along transects within each section (lower, mid, and upper) of the lake on Figures 2-2A through 2-2F. However, because aquatic vegetation and aquatic invertebrates are anticipated to be generally lacking in the Herrington Lake Study Area given the depth of water, water level fluctuations, and the lack of fine sediment substrates in the littoral zone of the lake, samples of plants and invertebrates may be collected opportunistically throughout each lake section. Aquatic vegetation will preferentially consist of macrophytes when available and phytoplankton if macrophytes are unavailable. Aquatic invertebrates may consist of zooplankton and benthic (bottom-dwelling) invertebrates, if available. A total of up to 16 aquatic vegetation and aquatic invertebrate samples will be collected throughout the Study Area, as shown in Table 2-1. It must be acknowledged that the collection of biological organisms is dependent upon the presence of those organisms and they are not always evenly distributed in the natural environment. As such, fewer samples may be collected due to general lack of availability and the ability to meet analytical volume requirements. A reasonable catch (or collection) per unit effort will govern the actual collection from any given location depicted on the figures.

## 2.3 Field Collection Approach

Sampling procedures for surface water, sediment, pore water, and biological tissue samples are described in this section.

### 2.3.1 Sampling Procedures

Surface water, sediment, sediment pore water, and biological tissue samples will be collected following the procedures outlined in these subsections. Sampling information and activity will be recorded in field logbooks and/or field data sheets. Following collection of a sample, the position of the sample will be recorded using global positioning system (GPS), if practical. Digital photographs will be taken to supplement and verify information and will be recorded in the logbook and/or field data sheets. All field instruments requiring calibration, such as a water quality meter, will be calibrated at least once per day prior to the beginning of the sampling activities.

#### 2.3.1.1 Surface Water

Surface water samples will be collected using grab sampling methodology (e.g., Beta bottle or Kemmerer sampler). The sampler will be lowered to the desired depth and a messenger will then close the sampling container. The sampler will be lowered several times until all laboratory containers are filled. To the extent practical, surface water samples will be collected at the same locations as sediment sampling locations (i.e., co-located) but will be collected prior to collection of sediment samples. Surface water will be collected sequentially from downstream to upstream locations, if practicable.

Surface water samples will be field filtered for dissolved metals. Following collection of the total metals surface water samples the sample for filtered metals analysis will be collected using a 0.45-micron (μm) filter on the end of the tubing with the filtered water collected directly into the sample container.

#### 2.3.1.2 Sediment and Pore water

Sediment sampling locations will target areas of depositional sediment and consistent geochemical composition. The upper 0 to 6 inches of sediment will be collected. Depending on the consistency of the sediment and water depth, a push corer (intermediate areas) or a petite ponar (deeper areas) will be used to collect sediment. Divers or remote active sampling equipment may be required for sediment sampling. Several grab samples will be collected from the same location to acquire the appropriate volume of sediment for the laboratory containers. Individual grab samples will be gently mixed until visually observed to be homogeneous. Sampling containers will be filled using the homogeneous sample. The general lithology (e.g., texture, color) of the sediment will be recorded.

Sediment pore water will be collected via the use of passive sampling devices (hereafter referred to as peepers). Peepers will consist of a passive diffusion bag or passive diffusion chambers placed within a perforated push point casing. The diffusion bag (or chambers) consists of a semipermeable membrane (0.45 μm polysulfone) filled with deionized water that allows dissolved metals and sulfate to diffuse into the sampler, providing an estimate of the time-averaged concentration of metals in sediment pore water. Before deployment, the casing will be rinsed by soaking in deionized water. The assembled peepers will be deoxygenated by nitrogen purging for at least 24 hours.

The peepers will be buried within the sediment as deep as possible to allow the surrounding interstitial water to infiltrate the sampler. If the sediment is soft, the peepers will be pressed into the sediment by hand (if wadeable or divers are used) or with a weighted frame. An underwater camera can potentially be used to verify that the peepers are placed appropriately. The peepers can be connected with leader lines attached to the shoreline, if possible, to facilitate retrieval. If attachment to the shoreline is not possible, the leader lines will be attached to floating buoys to identify their locations. GPS coordinates will also be recorded. Concentration equilibrium between the pore water and the sampler generally requires approximately 4 weeks.

#### 2.3.1.3 Biological Tissues

Fish will be collected in accordance with the fish collection protocols (KDOW 2014a), as applicable for the habitats that will be sampled in Herrington Lake. Whole body fish and fish fillet samples will be collected. Fish collection areas illustrated on Figures 2-1 and 2-2A though 2-2F reflect approximately 500-meter areas. Fish collection will occur primarily via electroshocking, although other methods of collection may be employed (gill nets, long lines, fishing poles), as necessary. Fish collection will be opportunistic within the epilimnion and the metalimnion.

During collection, fish will be placed into temporary holding containers until sampling for the area is completed. Effort will be made to minimize disturbance to the aquatic habitat while sampling. When sampling is completed, individual fish will be identified to the lowest taxonomic level practical. Three species of fish will be selected, if available, from the pooled sample from each sampling area, according to Table 2-1. Individual fish may be composited to satisfy sample volume requirements. A composite, whole body sample shall consist of two to five individuals. The composite sample shall consist of individuals of the same taxon (i.e., composites of multiple species is not acceptable). The individuals of a composite sample shall be, at a minimum, within 75% of the length of the longest individual (KDOW 2014a). The weight of the samples will be determined in the field. Samples will be filleted in the laboratory to ensure consistent handling and preparation of samples. Any individual not used for this sampling effort will be released into the environment at the sampling location from which the individual was collected. The samples will be wrapped in aluminum foil (dull side against the sample) and placed into a plastic bag. The bag will be labelled with project name, sample identification, sample date and time, and the analyses requested. Samples will be placed immediately on wet or dry ice (or refrigerated or frozen, if available). The samples shall be kept on ice in a cooler until transported to a freezer for long-term storage. Maximum holding time on ice in a cooler is 12 hours. Samples shall be processed and analyzed in the lab within 30 days of collection (KDOW 2014a). Fish preparation will be conducted in a laboratory environment, and processing will be conducted in accordance with the standard operating procedures for preparation and homogenization of fish tissue samples (KDOW 2017c).

Aquatic vegetation and aquatic invertebrates will be collected opportunistically throughout each target sampling location and/or area and will likely consist of phytoplankton and/or macrophytes (plants) and zooplankton (invertebrates). The sample location denoted on the figures are approximate locations and any plants and invertebrates within the littoral zone approximately 100 meters (i.e., 50 meters in each direction, parallel to the transect) is appropriate for collection along any given transect. Samples will be collected on the shoreline closest to the E.W. Brown Station Auxiliary Pond and Main Pond Landfill when sufficient biotic material is available because this collection will allow insight into influences from potential groundwater influences from these areas, if any. The compositing of multiple plant species is acceptable for plant samples and compositing of multiple aquatic invertebrates species is acceptable).

Plant and invertebrate material will be collected using nets and transferred to a holding container until the appropriate sample volume is achieved for each location. If larger submerged or emergent aquatic vegetation is located within a target area, a sample will be collected from that area and this would be included as part of a composite aquatic vegetation sample. Similarly, aquatic macroinvertebrates could be collected using a multiplate sampler, such as a Hester Dendy sampler, but this method may prove challenging for the length of deployment time, given the close proximity to human activity within the lake. Effort will be made to minimize disturbance to the aquatic habitat while sampling. When sampling is completed, individual plants and invertebrates, if appropriate, will be identified to the lowest taxonomic level practical. Individuals will be composited to satisfy sample volume requirements. The weight of the composite sample will be determined in the field. Samples will be rinsed, patted dry, wrapped in aluminum foil (dull side against the sample), and placed into a small, plastic zip-top bag. The bag will be labelled with project name, sample identification, sample date and time, and the analyses requested. Samples will be placed immediately on wet or dry ice (or frozen if a freezer is available).

### 2.3.2 Field Measurements

Water quality parameters (i.e. pH, dissolved oxygen, oxidation reduction potential, specific conductivity, temperature, and turbidity) will be recorded at each surface water, sediment, and pore water sampling location using a multi meter.

### 2.3.3 Sample Designation, Quality Assurance/Quality Control, and Handling

#### 2.3.3.1 Sample Designation

To maintain consistency, a unique sample identification convention will be developed and will be followed while implementing this FSP. The sample identification numbers (IDs) will be entered onto the sample labels, field forms, chain-of-custody forms, logbooks, and other records documenting sampling activities.

#### 2.3.3.2 Field Quality Assurance/Quality Control Procedures

Field quality assurance/quality control (QA/QC) samples collected during the proposed investigation include field duplicate samples and equipment blanks. The field duplicate is a replicate sample collected as close as possible to the same time that the primary sample is collected and from the same location, depth, or source, and is used to document analytical precision. Field duplicate samples will be labelled and packaged in the same manner as primary samples but with “FD” appended to the sample ID. Field duplicates will be collected at a frequency of one in every 10 primary samples and will be analyzed for the same suite of parameters as the primary sample.

Equipment blank samples are used to assess the effectiveness of decontamination procedures. Equipment blank samples are obtained by pouring deionized water over or through the decontaminated sampling equipment and then collecting and submitting for analysis. Equipment blanks will be collected once per field event, if necessary. In addition, matrix spike/matrix spike duplicate (MS/MSD) procedures are used as a laboratory control measure, and while not defined as field QA/QC samples, they do require additional sample volume. MS/MSD procedures are performed on field samples at a frequency of 1 per 20 samples.

#### 2.3.3.3 Sample Handling, Custody, and Transport

Surface water, sediment, and sediment pore water samples will be placed in the specified laboratory containers, capped, labelled, placed in plastic bags, and stored in coolers on ice for shipment to the analytical laboratories. Biological tissue samples will be wrapped in aluminum foil, placed into plastic bags, and stored in coolers on wet or dry ice (or in a freezer, if available) until shipment. Under appropriate chain-of-custody procedures, samples will be shipped via overnight or expedited courier to the identified laboratory (or laboratories).

## 2.4 Laboratory Methods and Data Validation

The analytical laboratory, methods, and data validation procedures are described below.

### 2.4.1 Analytical Laboratory, Laboratory Preparation, and Analytical Methods

All samples will be sent to a National Environmental Laboratory Accreditation Program (NELAP) for analysis. The laboratory will be selected upon agreement with the Cabinet about the scope of the field sampling program.

Fish tissues collected in the field will be prepared for analysis by the laboratory. Fillet samples will be separated from remaining carcass and ovary tissues, as specified, so that tissue sample volume is sufficient for analyses. In particular, fish fillets will be with skin on and belly flap tissue included will be prepared for scaled finfish species (e.g., largemouth bass, crappie, and bluegill) and skinless fillets for scaleless finfish species (e.g., catfish) in accordance with USEPA Guidance for Assessing Chemical Contamination Data for Use in Fish Consumption Guidelines (USEPA 2000a). Minnows, if collected, are only planned as whole body fish, so this does not apply.

The focus of the Agreed Order is selenium, but additional analyses will also be conducted for Herrington Lake samples. Samples will be analyzed for the following parameters, as appropriate for the medium, per USEPA SW846 methods and other standards as indicated in Table 2-3, and briefly summarized below.

- Metals (selenium, arsenic, cadmium, lead, zinc, iron, boron, and magnesium; USEPA Method 200.8 for water and 6010/6020 for solids)
- Metals (selenium, arsenic, cadmium, lead, and zinc; USEPA Method 200.8 for biological tissues)
- Mercury (USEPA Method 7470 water and 7471 for solids and biological tissues)
- Methylmercury (USEPA Method 1631 for water and Lab SOP for solids and biological tissues)
- Sulfate (USEPA 300.0 for water and Lab SOP for solids, no analysis for biological samples)
- Total organic carbon (Lloyd Kahn, sediment only, SM 5310 surface water)
- Dissolved organic carbon (SM 5310, surface water and pore water)
- Hardness (USEPA Method 130.2, water and pore water only)
- Speciated selenium (HPLC with ICP-MS, water and pore water only)
- Speciated arsenic (USEPA Method 1632A, pore water and fish tissues)

Details regarding sample volume required and sample container type for each type of sample will be determined prior to sampling in consultation with the selected laboratory. All samples will be analyzed within appropriate laboratory and method compliant hold times.

### 2.4.2 Data Validation

Data generated during performance of the field work will undergo two levels of review and validation: one at the laboratory and a second review after the data are received by Ramboll Environ. Ramboll Environ and a designated independent data validation contractor will perform the second data validation review. All data will be validated at Level II, with 20% of the samples validated at Level IV.

## 2.5 Proposed Schedule for Field Efforts and Reporting

A proposed schedule for the field effort and reporting is provided in Section 6 of this CAP.

### 2.6 Site Characterization, Risk Assessment, and Source Assessment Reporting

The data gathered through the field sampling program will be analyzed to characterize the past and ongoing sources and the nature and extent of constituents in surface water, sediment, sediment pore water, and biological media from the Herrington Lake Study Area. Site data will be used to refine the preliminary CSM described in Section 1.3. Data gathered through the field sampling program will also be used to conduct the HHRA and ERA as described in Sections 3 and 4, respectively. Constituents (if any) that may pose an unacceptable risk to human health and the environment will be identified within the HHRA and ERA. The findings from the Herrington Lake investigation described in this section of the CAP will be reported in the *Draft Corrective Action Investigation, Risk Assessment, and Source Identification Report,* which will submitted to the Cabinet as described in Section 6.

A key aspect of this analysis will be to identify past and/or ongoing sources of constituents detected in study area media. This evaluation will include the following:

- Characterization of the nature and extent of selenium and other metals concentrations within Herrington Lake, with the highest density of sampling nearest to the E.W. Brown Station so that gradients of concentrations, if any, can be clearly identified in each of the media sampled.
- Evaluation the potential for and relative contribution of plant-related selenium sources, such as groundwater flow, the Auxiliary Pond, and the former Main Ash Pond. This will include consideration of data from the field sampling program described in this section and may also include information from on-site studies, such as the Updated Groundwater Assessment Report.
- The evaluation of data for Herrington Lake, particularly the biological data, will include consideration of the timing of remedial actions that have been implemented to date so that it is understood if observed concentration trends reflect past releases that are now controlled. For example, historically, Herrington Lake has received diffuse groundwater flows from the springs east of the CCR ponds, toe/abutment drains, and seepage via both Curds and HQ Inlets (Figure 1-3). Some of these flows are now being intercepted by a cutoff wall that was installed in 2016. Improvements resulting from additional remedial actions implemented as discussed in Section 1.1 of this CAP will also be considered.
- Identification of whether the sediment is a source of selenium contribution to the Herrington Lake food web. The focused sampling in Curds Inlet and HQ Inlet, particularly the speciation of selenium in sediment pore water, will address the bioavailability of selenium from sediment to biological organisms.
- Further evaluation of other sources of selenium in the watershed, expanding upon the understanding of current and historic KPDES dischargers to Herrington Lake identified in Section 1.4 using data from the lake as well as additional information that may be obtained following the submittal of this CAP). Samples collected from the mid-portion and upper portions of the lake can provide an understanding of potential contributions (if any) from other dischargers in the watershed, and potentially naturally-occurring geologic conditions or ambient deposition that may be present in the watershed.

Findings regarding unacceptable risks and source identification will be further evaluated within the assessment of supplemental remedial actions, as described in Section 5. This evaluation will be provided in the Draft Corrective Action Remedy Evaluation Report to be submitted to the Cabinet as described in Section 6.

# 3. HUMAN HEALTH RISK ASSESSMENT WORK PLAN

## 3.1 Introduction

This section of the CAP describes the Human Health Risk Assessment Work Plan (HHRA Work Plan). The purpose of the baseline HHRA is to present an assessment of the theoretical human health risks associated with potential exposure to COPCs at the site now or in the future. The HHRA findings can be used by risk managers to evaluate the need for further characterization and whether steps should be taken to mitigate risks.

### 3.1.1 Steps of the HHRA

The initial step of the HHRA is development of the CSM described in Section 1.3, which identifies potential exposure pathways for human receptors that may contact site media now or in the future. All complete exposure pathways will be quantitatively evaluated (i.e., risk estimates will be calculated) using available data and data to be gathered. Exposure pathways identified in this HHRA Work Plan will be refined with site data.

The HHRA will include the following four steps identified in USEPA guidance (USEPA 1989):

- **Step 1 – Identification of COPCs**, through screening site data for chemicals in surface water, sediment, and fish tissue. Depending on the outcome of the evaluation of groundwater use as drinking water, groundwater data may also be screened. The methods proposed to screen site data to identify COPCs are described in this HHRA Work Plan (Section 3.2)**.**
- **Step 2 – Exposure Assessment.** This step includes gathering relevant data for site media; deriving exposure point concentrations for those media; identifying algorithms and exposure assumptions for all complete exposure pathways; and deriving exposure estimates for use in the HHRA. Section 3.3 provides proposed methods to derive exposure point concentrations and the general methods to quantify complete exposure pathways identified in the CSM.
- **Step 3 - Toxicity Assessment.** This step will describe the available toxicological data for the COPCs related to the Site and will assemble appropriate USEPA-recommended toxicity values for all COPCs. This HHRA Work Plan (Section 3.4) describes the hierarchy to be used in selecting toxicity values for use in the HHRA (USEPA 2003).
- **Step 4 - Risk Characterization.** This step will integrate the information of the previous three steps to combine exposure and toxicity assessments to derive cancer risk estimates and noncancer hazard indices for all complete exposure pathways. In addition to these four steps, the HHRA will provide a summary and conclusions that will also include an Uncertainty Assessment that will discuss the uncertainties inherent in conducting a HHRA. At a minimum, the Uncertainty Assessment will qualitatively consider whether identified uncertainties over or underestimate risks. Methods to be used in the Risk Characterization are briefly described in Section 3.5.

### 3.1.2 Guidance Documents for HHRA

The HHRA will be conducted consistent with guidance on the conduct of HHRA provided by the Cabinet (2017)[2] and by the USEPA. The approach and methods that will be used to perform the baseline HHRA will be consistent with applicable risk assessment guidance published by USEPA.

[2] Available at: http://www.lrc.ky.gov/kar/401/100/030.htm

Currently identified applicable USEPA guidance includes, but is not limited to, the following:

- *Risk Assessment Guidance for Superfun*d, Volume 1: Human Health Evaluation Manual (Part A) (USEPA 1989).
- *Supplemental Guidance to RAGS: Calculating the Concentration Term (USEPA 1992)*
- *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (USEPA 2002).
- *Human Health Toxicity Values in Superfund Risk Assessments. OSWER Directive 9285.7-53* (USEPA 2003)
- *Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessments)* (USEPA 2004a)
- *Exposure Factors Handbook (USEPA 2011)*
- *Statistical software ProUCL 5.1.00 for environmental applications for data sets with and without nondetect observations* (USEPA 2017c)
- *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors.* OSWER Directive 9200.1-120. (USEPA 2014)
- *Regional Screening Levels (RSLs)* (USEPA 2016) Revision date May, 2016.
- *Kentucky Risk Assessment Guidance* (KRAG 2002) Prepared by the Kentucky Natural Resources and Environmental Protection Cabinet
- *Angler Attitudes and Behavior Associated with Ohio River Health Advisories" (*Knuth et al, 2003.
- *Human Health Fish Consumption Risk Assessment for the Tri-State Geographic Initiative; Kenova Cluster (TGI, 1998).*

Additional regulatory guidance technical references will be relied upon as appropriate.

## 3.2 Data Analysis and Identification of COPCs

In the HHRA, site data for fish tissue, sediments, and surface water will be evaluated to identify a list of COPCs to be further considered in the HHRA. The objective of this step, is to identify any constituents that could potentially pose a risk for human receptors at the site. Consequently, methods used here are intended not to overlook any COPCs. Risk estimates derived for the COPCs will be based on exposure scenarios intended to represent current or potential future site uses and exposures. Review of site data to identify COPCs will include two steps: comparison with background concentrations for metals in sediment and comparison with risk-based concentrations for metals exceeding background and all other chemicals.

### 3.2.1 Comparison with background concentrations

Because selenium and other metals occur naturally in the earth's crust, they are present in all media and are anticipated to be detected in site sediments, surface water and fish tissue. Constituents present at naturally occurring background conditions cannot be altered, and therefore, an understanding of these conditions is necessary to interpret the potential for site-specific risks. For this assessment, development of comprehensive background datasets are not planned for surface water or for fish tissue. Background datasets for surface water or fish may be proposed to the Cabinet after Phase I and/or Phase II efforts, depending upon concentration gradients observed in the sampling program for these media.

The Cabinet (2017) and the 2004 document entitled *Kentucky Guidance for Ambient Background Assessment* provide generic state-wide ambient background data for metals in soil (Cabinet 2004; Table 2). Site data for metals in sediments will be compared with concentrations in Table 2 of the Cabinet (2004) document. As described in Cabinet Guidance (2004), three criteria can be used to demonstrate that sampling data at a given location reflect background conditions:

1. The mean site concentration for inorganic constituents must be below the 95% upper confidence limit (UCL) of the mean concentrations of background for inorganic constituents.
2. At least half of the data points should be less than the 60th percentile.
3. No data points should be above the upper bound value (95th percentile).

3.2.2 Also as identified in Cabinet Guidance (2004) other statistical comparisons may be used, if appropriate. Comparison with risk-based concentrations

Consistent with guidance from the Cabinet (2017)[3] risk-based screening levels identified by USEPA Region 9 will be used to further identify COPCs. Region 9 has combined their screening levels within the RSL tables (USEPA 2016) and these are proposed for use here.

**Sediments:** For identification of COPCs in sediments including metals present at concentrations greater than background, the maximum detected concentrations of each detected constituent in sediments will be compared with the USEPA Residential Soil RSLs (USEPA 2016) for screening purposes. This provides a health protective means to identify COPCs because sediments are anticipated to be rarely contacted. Any identified COPCs will be further evaluated in a more realistic site-specific exposure scenario.

**Surface water:** To evaluate potential COPCs present in surface water, the maximum detected concentrations of each detected constituent will be compared with USEPA Maximum Contaminant Levels (MCLs) (USEPA 2017d). Chemicals that do not have MCLs will be compared with USEPA Residential Tap Water RSLs (USEPA 2016). Constituents detected at concentrations greater than MCLs or RSLs will be considered further in the risk assessment.

**Fish:** Constituents present in fish tissue will be further considered in the HHRA.

### 3.3 Exposure Assessment

Exposure assessment is the process of identifying human populations that could potentially contact COPCs in site media, in this case fish tissue and to a lesser extent surface water and sediment, and air, and estimating the magnitude, frequency, duration, and route(s) of potential exposures. As identified in USEPA guidance reasonable maximum exposure (RME) estimates will be derived for COPCs in site media. Because this assessment is intended to not underestimate exposures and risks, many health protective assumptions are proposed here to avoid underestimating potential exposure. As such, these estimates likely overestimate exposures and risks for most individuals.

An initial step in the exposure assessment is to assemble site data for COPCs and calculate exposure point concentrations that are representative of potential site exposure areas. Exposure point concentrations will be developed for site media using representative exposure areas that will be documented in the HHRA. Consistent with USEPA guidance exposure point concentrations will be derived as the 95th percentile UCL on the mean concentration (USEPA 2002) and will be calculated using the current ProUCL software 5.1 (USEPA 2017c). Nondetect (ND) data will be treated as recommended in USEPA (2017c).

[3] Available at: http://www.lrc.ky.gov/kar/401/100/030.htm

As described in the CSM, the following exposure pathways are proposed for further evaluation in the HHRA:

- Ingestion of fish from Herrington Lake by anglers
- Ingestion and dermal contact with COPCs in lake water used as drinking water by residential consumers
- Incidental ingestion and dermal contact with COPCs in sediments by lake users
- Incidental ingestion or dermal contact with COPCs in surface water by lake users

Depending on the outcome of additional review of groundwater use, ingestion and dermal contact with COPCs in groundwater used as drinking water by residential consumers may also be evaluated. Exposure to COPCs in site media will be evaluated through the following general algorithm as identified in USEPA (1989):

**Equation 1**:

$$\mathrm{CDI} = (\mathrm{C} \times \mathrm{CF} \times \mathrm{CR} \times \mathrm{ED} \times \mathrm{EF} \times \mathrm{FI} \times \mathrm{AB})/(\mathrm{BW} \times \mathrm{AT})$$

Where:

| | |
|---|---|
| CDI | = Chronic Daily intake (mg/kg-day) |
| C | = Concentration of COPCs in fish fillets, sediment, or surface water (mg/kg, or mg/L) |
| CF | = Conversion factor(s) as necessary (fraction) |
| CR | = Contact rate – amount ingested or in contact with skin (kg/day) |
| ED | = Exposure duration in years of exposure (years) |
| EF | = Exposure frequency ranging from 365 days to one day (days) |
| FI | = Fractional intake from the source (fraction) |
| AB | = Absorption from site media (fraction) |
| BW | = Body weight of receptor (Kg) |
| AT | = Averaging time (days)<br>For noncancer risk estimates = exposure duration x 365 days<br>For carcinogenic effects: = 70 year lifetime x 365 days |

Dermal exposure estimates for contact with COPCs in sediment and water will include consideration of chemical-specific absorption through the skin (USEPA 2004a).

### 3.3.1 Exposure estimates for consumption of fish

Exposure to COPCs through consumption of fish will be estimated. Herrington Lake is a recreational fishery. To the extent that site concentrations differ between upper, mid, and lower lake fish tissue, separate exposure estimates may be calculated for those areas. Site-specific consumption rates will be estimated through consideration of the following: consumption rates identified in USEPA guidance (USEPA 2011) or other more recent relevant studies of similar lakes or freshwater resources including, but not limited to (TGI 1998, Knuth et al. 2003); consideration of the demographics of area anglers; considering what fish are present in Herrington Lake what are anglers most preferred fish for eating. These factors will be considered to identify appropriate fish consumption rates.

### 3.3.2 Exposure estimates for ingestion and dermal contact with sediments

Exposure to COPCs through ingestion and dermal contact with sediments will be considered for site COPCs that are present under water less than 6 feet deep. Most of Herrington Lake is much too deep for wading and is much deeper than a recreational visitor might contact during swimming. For the HHRA a recreational scenario will be developed that will estimate risks for recreational visitors whom might swim or visit in areas of the lake where COPCs are present in sediments under shallower water through application of appropriate guidance (USEPA 2004a, 2011, 2008a). This scenario will identify RME exposure estimates for ingestion and dermal contact with sediments.

3.3.3 Exposure estimates for ingestion and dermal contact with surface water

Exposure to COPCs through ingestion and dermal contact with surface water will be considered for residential water consumers and for site recreational visitors. A recreational scenario will be developed to estimate RME exposures for ingestion and dermal contact with surface water during recreation.

## 3.4 Toxicity Assessment

The toxicity assessment will quantitatively evaluate the hazards associated with COPCs identified in site media. In the toxicity assessment, toxicity values will be assembled for COPCs for the relevant exposure pathways including ingestion and dermal contact with skin. Toxicity values for oral exposure include reference doses for evaluation of noncancer endpoints and carcinogenic slope factors for cancer endpoints. Toxicity values for oral exposure are also used to estimate dermal contact after considering dermal absorption from the skin.

The hierarchy identified in the USEPA (2003) *Human Health Toxicity Values in Superfund Risk Assessments* will be applied to select toxicity values for use in the risk assessment. The 2003 USEPA hierarchy has first level reliance on the USEPA Integrated Risk Information System (IRIS) tables (USEPA 2017e), which will serve as the primary basis for toxicity values in the HHRA.

## 3.5 Risk Characterization

In risk characterization, quantitative exposure estimates and toxicity factors are combined to calculate numerical estimates of potential health risk. Noncancer health hazards and cancer risk estimates will be derived using methods identified in USEPA guidance (USEPA 1989, 2014).

3.5.1 Cancer risk

Quantifying total excess cancer risk requires calculating risks associated with exposure to individual carcinogens (summed across pathways of exposure) and aggregating risks associated with simultaneous exposure to multiple carcinogenic COPCs. A cancer risk estimate for a single carcinogen will be calculated by multiplying the lifetime average daily intake of the contaminant by its carcinogenic slope factor.

**Equation 2:**

Excess lifetime cancer risk = Chronic daily intake estimate (from exposure assessment) x Cancer slope factor.

Consistent with USEPA guidance, risks associated with simultaneous exposure to more than one carcinogen in a given medium will be aggregated to determine a total cancer risk for each exposure pathway. Cancer risk estimates will be considered relative to the Kentucky Department for Environmental Protection "bright line" *de minimis* value of $1x10^{-6}$ cumulative risk (i.e., added across all pathways and chemicals for each receptor). Cancer risk estimates can also be considered relative to the USEPA cancer risk range of $1x10^{-6}$ to $1x10^{-4}$.

3.5.2 Noncancer Risk

Hazards for effects other than cancer are expressed as hazard quotient calculated through the following algorithm:

**Equation 3:**

Noncancer Hazard Quotient = Chronic daily intake estimate / Noncancer reference dose

A hazard quotient less than 1 for a given COPC indicates there is a very low probability of any adverse effect. A hazard quotient greater than 1 does not necessarily mean that an effect would occur, but rather that exposure may exceed a level that calls for more investigation of potential health effects in sensitive populations. USEPA states that the range of possible uncertainty around RfDs is "perhaps an order of magnitude" (USEPA 2017e).

All findings of the HHRA will be provided in text and summary tables. Key uncertainties will be described along with discussion about whether those uncertainties are considered as potentially overestimating or underestimating risks.

# 4. ECOLOGICAL RISK ASSESSMENT WORK PLAN

The overall goal of the ERA is to assess the potential for ecological risks for selenium and other constituents of potential ecological concern (COPECs) within the Herrington Lake Study Area. This ERA Work Plan outlines the proposed approach to derive risk estimates for complete pathways identified in the CSM (Section 1.3). Environmental samples and pertinent information collected under the FSP (Section 2) will inform the ERA.

## 4.1 Technical Approach for the ERA

The ERA approach will be consistent with relevant ERA guidance provided by the Cabinet (2017)[4] and USEPA, as follows:

- Framework for Ecological Risk Assessment (USEPA 1992)
- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA 1997)
- Guidelines for Ecological Risk Assessment (USEPA 1998)
- ECO Update: The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments (USEPA 2001)
- Kentucky Risk Assessment Guidance (KRAG 2002) Prepared by the Kentucky Natural Resources and Environmental Protection Cabinet

The ERA will follow the USEPA (1997) eight-step ERA process, as illustrated on Figure 4-1. Steps 1 and 2 comprise the screening-level ERA (SLERA). The SLERA provides a conservative estimate of the maximum potential ecological risks and incorporates uncertainty in a precautionary (i.e., conservative) manner. The overall goal of the SLERA is to determine whether (1) there is a high probability that there are no significant ecological risks; or (2) there is a need for additional evaluation of potential risks (USEPA 1997, 2000b).

The second tier of the screening process offers an opportunity to consider additional information, such as alternative benchmarks, factors that limit bioavailability, and/or additional toxicological information, to further evaluate the potential for COPECs to adversely affect target organisms. This second tier is referred to as Step 3A of the baseline ERA, or baseline ecological risk assessment (BERA). According to USEPA (2000b):

> "*Problem Formulation [i.e., Step 3] is commonly thought of in two parts: Step 3a and Step 3b…step* 3a serves *to introduce information to refine the risk estimates from steps one and two. For the majority of Sites, ecological risk assessment activities will cease after completion of Step 3a. At many Sites, a single deliverable document consisting of the reporting of results from Steps 1, 2 and 3a may be submitted. At those Sites with greater ecological concerns, the additional problem formulation is called Step 3b. It is very important at this stage to perform a 'reality check.' Sites that do not warrant further study should not be carried forward."*

At this point in the process, a scientific management decision point (SMDP) may be implemented which includes reporting of results to stakeholders. If potentially adverse effects are identified, the iterative risk assessment process continues with Steps 3 through 8 or a BERA. A BERA provides an opportunity for iterative refinement of potential risks identified in the SLERA, but are typically more complex than SLERAs and incorporate more realistic exposure and effects information. Following the

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[4] Available at: http://www.lrc.ky.gov/kar/401/100/030.htm

BERA, there is another opportunity for a scientific management decision point, which is communicated to the stakeholders.

## 4.2 Preliminary Problem Formulation

Problem formulation provides the foundation for the ERA establishing the goals, scope, and focus of the assessment. Ultimately the problem formulation section will clarify what is known about potential ecological resources within the Study Area and will provide a basis for the ERA. Problem formulation synthesizes what is known about or predicted for a given site in order to develop a CSM that will guide the ERA process. The problem formulation phase typically requires describing or defining the following:

- Environmental setting
- Study Area definition
- Potentially exposed ecological receptors
- Potentially complete exposure pathways
- CSM
- Assessment and measurement endpoints

A complete exposure pathway is one in which constituents can be traced or are expected to travel from the source to a receptor (USEPA 1997). Therefore, a chemical and an exposure point (e.g., surface water or sediment), its release and migration from the source, a receptor, and an exposure route through which the receptor takes up the chemical must all be present in order for a pathway to be considered complete. Areas that do not support significant or complete ecological exposure pathways are excluded from the ERA.

Both direct and indirect exposure pathways may exist for plants, invertebrates, and fish in the Herrington Lake Study Area and for birds and mammals that utilize the lake. Biota potentially act as both a receptor and a secondary source of chemical contamination. Possible exposure routes include inhalation, dermal contact, ingestion through diet, and ingestion of surface water and/or sediment. Aquatic plants and invertebrates are potentially exposed to chemicals in surface water through direct contact. Benthic invertebrates (e.g., crayfish, insect larvae) are potentially exposed to chemicals in sediment through direct contact between sediment pore water (i.e., the interstitial water within the sediment) and structures, such as gills and setae, and ingestion of sediment. Fish may be potentially exposed via gill transfer from water, water and/or sediment ingestion, prey ingestion, or dermal contact with surface water. Wildlife are potentially exposed via inhalation, dermal contact, and ingestion of aquatic prey, drinking water, and incidental sediment ingestion. Although inhalation and dermal exposures occur, these routes are poorly characterized for most wildlife species. Ingestion of prey is assumed to dominate wildlife exposure. Since some chemicals bioaccumulate throughout the food web, concentrations of chemicals in prey may be elevated relative to concentrations in surface water or sediment.

Assessment endpoints are the overarching ecological resources that will be evaluated for protection. Table 4-1 provides a summary of the assessment endpoints planned for the Herrington Lake ERA. Assessment endpoints often cannot be directly measured or it is impracticable to perform such measures. Therefore, measurement endpoints are identified and used. The measurement endpoints planned for the Herrington Lake ERA are identified on Table 4-1. These are the specific measures that will be used to evaluate potential risks for the assessment endpoints identified.

### 4.3 Exposure Assessment

The exposure assessment identifies potential ecological receptors, exposure pathways, and an evaluation of the constituent concentrations to which ecological receptors may be exposed.

As part of the exposure assessment, both Federal and state special status species are identified. The Herrington Lake Study Area is located in Garrard County (to the east) and Mercer County (to the west) in Kentucky. According to the Kentucky Department of Fish & Wildlife Resources[5], four species are Federally listed as endangered within Garrard and Mercer counties (Table 4-2). Two species, a bivalve (Clubshell; *Pleurobema clava*) and a bat (Gray myotis; *Myotis grisescens*) are endangered in Garrard County. Two species, a bird (Interior least tern; *Sternula antillarum athalassos*) and a bat (Gray myotis) are endangered in Mercer County. The Kentucky Department of Fish & Wildlife Resources also lists 3 bird, 1 bivalve, 1 insect, 2 mammal, and 1 reptile species as endangered, threatened, or special concern in Garrard County, and 1 amphibian, 23 bird, 2 insect, and 3 mammal species as endangered, threatened, or special concern in Mercer County (Table 4-2).

It is not feasible to complete risk calculations for all species potentially exposed. Such an effort would also be duplicative because of the similarity of exposure patterns among closely related species and those with similar feeding guilds. For these reasons, representative receptors of interest (ROIs) are selected. These ROIs are representative of entire classes of organisms (i.e., functional groups). Table 4-1 identifies the organisms and wildlife species that will be evaluated in the ERA for Herrington Lake. These ROIs were selected to include consideration of chemical sensitivity, exposure potential, expected presence at the Site, ecological relevance, trophic level, feeding habits, and the availability of life history information. The rationale for selecting each ROI is discussed below.

- *Aquatic plants.* The aquatic plant community lives in constant and direct contact with surface water. Plants serve as a prey base for higher trophic level organisms and cycling of nutrients and other chemicals into the food web. Sample collection for aquatic plants can be used to understand the uptake of chemicals in the food web.
- *Aquatic Invertebrates*. The aquatic invertebrate community lives in constant and direct contact with surface water and/or sediment and sediment pore water. Invertebrates have vital functions within the ecosystem, including serving as a prey base for higher trophic level organisms and cycling of nutrients and other chemicals into the food web. Sample collection for aquatic invertebrates can be used to understand the uptake of chemicals in the food web.
- *Fish*. The fish community lives in constant and direct contact with surface water. Exposures are also possible via sediment and the food chain (i.e., secondary consumers). The fish community often dominates the aquatic ecosystem, in terms of biomass, and fish serve as a prey base for piscivorous wildlife. Fish species (bass, catfish, and bluegill) will be collected from Herrington Lake. A cold water species (trout) may also be collected from the Dix River downstream from the dam (if found).
- *Wildlife*. Birds and mammals are exposed to chemicals in surface water, surface sediment, and sediment pore water primarily through prey ingestion. As higher trophic level species, birds and mammals are susceptible to compounds that bioaccumulate through the food chain. Individual foraging strategies and choices of prey may also promote incidental sediment ingestion. Birds and mammals that will be considered in the Herrington Lake ERA are identified in Table 4-1.

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[5] Available at http://app.fw.ky.gov/speciesinfo/speciesinfo.asp. Accessed on March 24, 2017.

Exposure estimates for both direct contact to and food web trophic transfer of contaminants, as applicable, will be developed using data described in Section 1.2 and collected under the FSP as described in Section 2 of this CAP. Given the conservative nature of SLERAs, maximum exposure estimates are typically initially employed. However, the use of maximum concentrations is overly conservative and therefore, more realistic exposure scenarios, will also be used in this ERA, as appropriate. Exposure assumptions that reflect realistic conditions are the most relevant to inform risk management decisions protective of fish and wildlife related to the E.W. Brown Station. This may include consideration of central tendency chemical exposure estimates and exposure estimates that include information related to chemical bioavailability. For mammals and birds, food web modeling is planned as part of the ERA. The food web modeling will include consideration of central tendency estimates for exposure, including ecological exposure parameters such as those in the Ecological Wildlife Exposure Factors Handbook (1993). In addition, the home range of birds and mammals may be considered relevant for understanding potential exposures.

### 4.4 Toxicity Assessment

Initially, the ecological effects evaluation involves the identification of appropriate ecotoxicity screening levels for detected constituents in each environmental medium. Ecological screening values (ESVs) are chemical concentrations in environmental media below which there is negligible risk to receptors exposed to those media (USEPA 2000b). The ESVs used in the selection of preliminary COPECs will be purposefully chosen to ensure that the process is inherently conservative, by focusing on values that reflect adverse effects in individual organisms. This means that a larger number of constituents may be identified as COPECs than are likely to pose significant risks of population-level effects. Although the first of USEPA's (1999) risk management principles is to reduce risks to levels that will result in recovery and maintenance of healthy local populations and communities of biota, SLERAs typically focus on individual-level effects to ensure the conservatism of the outcome. The ESVs that will be considered in the ERA include:

- USEPA Region 4 Ecological Risk Assessment Supplemental Guidance, including surface water and sediment ecological screening values (2015)
- Kentucky Surface Water Quality and Fish Tissue Standards (401 KAR 10:031) (KDOW 2016)

In addition to the SLERA ESVs, the understanding of potential toxicity will be refined using a range of effect values, used to evaluate responses of organisms to COPECs, and site-specific information that may be available. This may include consideration of bioavailability conditions that effect toxicity, such as dissolved phase metals or binding with organic carbon. In addition, for some receptors (birds and mammals), food web modeling may be conducted and a range of protective ecological benchmarks (i.e., toxicity reference values [TRVs]) that reflect no observable adverse effects levels (NOAELs) and lowest observable adverse effects levels (LOAELs) will be considered.

### 4.5 Risk Characterization

The screening level risk characterization involves the calculation of hazard quotients (HQs), which are the ratio of the maximum exposure estimate with the ESVs identified in the screening level ecological effects characterization. HQs will also be used when evaluating food web ingestion exposures for mammals and birds relative to protective NOAEL and LOAEL ingestion-based TRVs. The unitless HQs are considered a measurement endpoint that can provide understanding of potential ecological risks. An HQ equal to or less than a value of 1 (to one significant figure) indicates that adverse impacts are considered unlikely (USEPA 1997, 2001, 2004b). An HQ greater than 1 is an indication that further evaluation may be necessary to evaluate the potential for adverse impacts. Therefore, those constituents in surface water, sediment, fish tissues, and sediment pore water with HQs greater than 1 are carried forward as preliminary COPECs into the refinement step (Step 3A) of the BERA.

In a manner consistent with USEPA ERA guidance and KY ERA guidance (KRAG 2002), the risk characterization for Herrington Lake will:

- Evaluate the exposure and effects data to assess the risk to the assessment endpoints (risk estimation).
- Present information necessary to interpret the risk assessment and to decide upon adverse effect thresholds for the assessment endpoints (risk description).
- Include a qualitative and quantitative summary of risk results and uncertainties.
- Describe the lines of evidence integrated in the risk characterization to support a conclusion about the significance of ecological risk (e.g., the different possible lines of evidence could be tissue concentration data, toxicity test results, and/or population/community data).

By the end of the risk characterization for Herrington Lake, the uncertainty about the risk posed by a COPECs will be described to a level that allows risk managers to make a technically defensible remedial decision.

# 5. ASSESSMENT OF SUPPLEMENTAL REMEDIAL ACTIONS

## 5.1 Introduction

As summarized in Section 1, KU has implemented a number of remedial actions to mitigate groundwater impacts at the plant, and control migration of impacted groundwater toward Herrington Lake. It is expected that these remedial actions will limit selenium and other metal loading to Herrington Lake, as demonstrated by ongoing monitoring being conducted by KU. As such, the sampling data collected in accordance with sampling program described in Section 2 of this CAP will reflect conditions at various discrete points in time within the context of anticipated improvements resulting from recently completed and ongoing remedial actions implemented per the GWRAP.

The need for supplemental remedial actions will depend upon the results of ongoing performance monitoring, and the findings of the field sampling program described in Section 2 of this CAP as evaluated in the human health and ecological risk assessments described in Sections 3 and 4, respectively, of this CAP. Specifically, the risk assessments may identify one or more of the following:

- Data gaps, if any, that need further investigation
- Biological monitoring that can be conducted to evaluate the potential trajectory of improving conditions from those remedial actions already implemented
- Physical and chemical monitoring of natural processes that may augment the remedial actions already implemented
- Supplemental remedial actions that may be warranted beyond those already being implemented per the GWRAP

## 5.2 Remedial Alternatives Evaluation Approach

A remedial alternatives evaluation will be conducted, if needed, and will be based on relevant USEPA guidance for remedy alternatives analysis and by the Cabinet standards. A remedial alternatives evaluation may include the following elements:

- Identification of conditions warranting supplemental actions. A fundamental goal in the remedial action program is to control or eliminate unacceptable risks to human health and the environment. Therefore, risk-based decision making is especially important in the remedial action program, where it should be used to ensure that remediation activities are fully protective given reasonable exposure assumptions and consistent with the degree of threat to human health and the environment at a given facility. Therefore, the identification of site conditions warranting evaluation of supplemental remedial actions, if needed in accordance with the Agreed Order, will be based on the evaluation of the GWRAP performance, the expected reductions in pollutant loadings under the Auxiliary Pond Discharge CAP submitted by June 30, 2017, and findings of the human health and ecological risk assessments.
- Definition of remedial action objectives (RAOs). RAOs are intended to provide a general description of what the remedial measures is expected to accomplish, and help focus the development of the remedial alternatives in the remedial alternatives analysis. RAOs are typically derived from the CSM and address the significant exposure pathways identified in the risk assessment.
- Identification of potentially applicable additional remedial action alternatives. The remedial alternatives analysis does not necessarily have to address all potential remedies, rather, USEPA advises that the analysis be focused on realistic remedies and tailored to the extent, nature and

complexity of releases and contamination at a given facility (USEPA 1996). Identification of potentially applicable alternatives will consider the following:

- Protection of human health and the environment. Proposed remedies must be protective of human health and the environment through active (e.g., source control, media cleanup, containment) and/or protective (e.g., institutional controls, deed restrictions) means.
- Performance, reliability and ease of implementation, potential impacts of remedial measures including at a minimum safety, effects, cross-media effects and control of any probable residual contamination
- Time to begin and complete
- Cost/benefit
- State and local permits or other public health or environmental requirements that may affect the remedy implementation

- Evaluation of remedial alternatives. For those identified alternatives that are determined to meet the overarching objective of being protective of human health and the environment, a comparative analysis of remedial alternatives will be performed following the framework defined in 401 KAR 100:030 and will identify the alternative that provides the best combination of the following performance attributes in light of ongoing remedial measures and those to be proposed under the Auxiliary Pond Discharge CAP.
  1. The compliance with any other applicable requirements;
  2. The long-term effectiveness and permanence of the remedial option;
  3. The reduction of toxicity, mobility, or volume through the use of treatment;
  4. The short-term effectiveness of the remedy;
  5. The ability to implement the remedy;
  6. The cost of the remedy; and
  7. Community acceptance of the remedy.

  This evaluation will consider the elements of each of these criteria as defined in 40 CFR 257, as relevant to each alternative:

  - Long-term and short-term effectiveness and protectiveness.
    - Magnitude of reduction of existing risks;
    - Magnitude of residual risks in terms of likelihood of further releases due to waste remaining following implementation of a remedy;
    - The type and degree of long-term management required, including monitoring, operation, and maintenance;
    - Short-term risks that might be posed to the community, workers, or the environment during implementation of such a remedy, including potential threats to human health and the environment associated with excavation, transportation, and re-disposal or containment;
    - Time until full protection is achieved;
    - Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment;
    - Long-term reliability of the engineering and institutional controls; and
    - Potential need for replacement of the remedy.

- The effectiveness of the remedy in controlling the source to reduce further releases
  - The extent to which containment practices will reduce further releases;
  - The extent to which treatment technologies may be used.
- The ease or difficulty of implementing a potential remedy(s)
  - Degree of difficulty associated with constructing the technology;
  - Expected operational reliability of the technologies;
  - Need to coordinate with and obtain necessary approvals and permits from other agencies;
  - Availability of necessary equipment and specialists; and
  - Available capacity and location of needed treatment, storage, and disposal services.

- Sustainability. As part of the evaluation of the remedial alternatives, the sustainability of the remedial alternatives will be considered, consistent with USEPA's April 2008 *Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites* (USEPA 2008b) and the Interstate Technology and Regulatory Council's (ITRC) November 2011 *Green and Sustainable Remediation: A Practical Framework* (ITRC 2011). Specifically, alternatives meeting the above-defined evaluation criteria that are expected to require an overall lower level of manpower, energy and/or materials consumption to achieve the same level of protectiveness will be identified. In particular, in selecting a remedial action it is important to understand the potential benefits (i.e., gains in ecosystem service value) and costs (i.e., losses in ecosystem service value) associated with the implementation of various remedial alternatives and their relationship to predicted ecosystem service injury that is suggested by a risk assessment. As described by USEPA, the following five elements of a green cleanup assessment may assist in the evaluation and documentation used in selecting and implementing protective cleanup activities (USEPA Greener Cleanup Principles; August 2009):
  - total energy use and renewable energy use
  - air pollutants and GHG emissions
  - water use and impacts to water resources
  - materials management and waste reduction
  - land management and ecosystems protection
- The overall goal of this comparative analysis will be to evaluate the identified alternatives in terms of their ability to manage risks, benefits and trade-offs between the alternatives.

The results of this evaluation will serve as the basis for selecting any preferred supplemental remedial measures.

# 6. SCHEDULE DEVELOPMENT

An implementation schedule (Figure 6-1) for completing the characterization and analyses elements identified in this CAP is dependent upon the timing of Cabinet approval of the field sampling program identified in Section 2 of this plan. The field program is based on three elements that influence the timing for sampling (1) the lake limnologic cycle of fall/winter overturn and summer stratification, (2) sampling of biological tissues requires summer sampling, and (3) implementation of a phased approach with Phase I focused on the LHL area nearest to the plant and Phase II dependent upon the results from Phase I efforts. As such, the schedule herein is flexible to the extent reasonable for Cabinet reviews and concurrence with the sampling program and time necessary for KU to obtain contractors and mobilize for a substantive Phase I field effort. Note also that this schedule is aligned with other regulatory controls that may govern the facility operations and ash pond closure, such as key regulatory milestones that may not yet be fully understood or developed. Finally, it is important to KU that the Cabinet and public citizens recognize that KU is responsive to the Agreed Order with the proposed schedule.

Specific milestones are as follows:

- The draft CAP was submitted to the Cabinet per the Agreed Order on April 14, 2017.
- Phase I of Herrington Lake sampling will be conducted in late 2017 and in the first or second quarter of 2018, allowing flexibility for review of this CAP, and implementation of two surface water field sampling events in summer stratification and fall/winter lake overturn timeframes. Following the Phase I effort, a Phase I Technical Memorandum will be provided to the Cabinet describing the results of the Phase I effort and changes (if any) to the Phase II sampling effort. If Phase I data are sufficient to support risk management decisions for the E.W. Brown Station, then Phase II sampling may not be necessary.
- Laboratory analyses, reporting, and data validation will follow each effort, as noted below.
- Two Herrington Lake Corrective Action Reports are anticipated:
  - The first report will present investigation, risk assessment, and selenium source identification results from the Phase I effort (or Phase I and Phase II efforts, as appropriate).
  - The second report will provide the supplemental remedial alternatives evaluation.
  - Data gaps, if any, will be identified in one or both of these reports, as appropriate for the evaluations provided within each report.
  - Reporting for investigation, risk assessments, and source identification will be provided approximately 4 months of the receipt of the Cabinet approved Phase I Technical Memorandum. If Phase II sampling is warranted, reporting for investigation, risk assessments, and source identification will be provided approximately 4 following receipt of the Phase II validated data.

Phase I, and Reporting schedule milestones are summarized on Figure 6-1, and incorporate the following assumptions regarding timeframes for each significant task:

### Phase I Schedule Milestones

| Phase I Task Description | Phase I Approximate Schedule |
|---|---|
| Preparation for Phase I Field Effort | • Approximately 2 months from Cabinet formal approval of the CAP field sampling program |
| Initiate Phase I Field Effort | • Initial sampling of surface water, sediment, pore water, and biological tissues is targeted in 2017, dependent upon Cabinet approvals. Additional sampling of water during overturn is targeted for 2017 or 2018, as possible, depending upon Cabinet approval of the CAP field sampling program |
| Phase I Sample Collection for Surface Water | • Two events are proposed for surface water, during lake overturn (late fall or late winter) and during summer stratification. Stratified lake sampling will be targeted for late 2017; lake overturn sampling will target late 2017, or as early in 2018 as possible. |
| Phase I Sample Collection for Fish, Aquatic Vegetation, and Aquatic Invertebrates | • Suggested sampling in late 2017, timed with the summer stratification field effort for surface water, |
| Phase I Sample Collection for Sediment | • The timing of sediment collection will be concurrent with water and biological sample event |
| Phase I Sample Collection for Sediment Pore Water | • Sediment pore water passive diffusion samplers need to be in the lake for up to 30 days to ensure equilibration, as such, timing around water level rise and drop must be considered |
| Phase I Laboratory Analysis | • The laboratory results for each sample medium can be expected approximately 3 weeks following final sample collection (though as noted on Figure 6-1, the total time for analysis may include 30 to 45 days, as analyses will occur throughout the field effort and end approximately 3 weeks after the last sample is submitted to the laboratory). |
| Phase I Data Validation | • The laboratory results for each sample medium can be expected approximately 2 weeks following final laboratory analysis is completed. Validation may occur as analyses are completed, and thus, the timeframe for validation as shown on Figure 6-1 may include 30 days. |
| Phase I Decision Point | • A Phase I decision point allows the Cabinet to review data from Phase I sampling and agree on the need for Phase II sampling or not.<br>• For the Phase I decision point, the Cabinet will receive one or more of the following:<br>– A meeting with the Cabinet may be requested to discuss Phase I results and the need for Phase II sampling (if any);<br>– If Phase II sampling is not considered necessary, a Phase I Technical Memorandum will be provided to the Cabinet summarizing Phase I data;<br>– If Phase II sampling is considered necessary, a brief Phase I Technical Memorandum may be provided to the Cabinet for notification that the Phase II sampling will may proceed as indicated in Section 2 of this CAP or any changes to the Phase II sampling program that may be considered appropriate.<br>• The Phase I Technical Memorandum will be submitted to the Cabinet approximately one month following the completion of the summer stratification and lake overturn sampling events. |

### Reporting Schedule Milestones (Assuming Phase II Sampling is Not Required)

| Reporting Tasks | Approximate Timing |
|---|---|
| Draft Corrective Action Investigation, Risk Assessment, and Source Identification Report submitted to the Cabinet | Within approximately 4 months after the Cabinet approval of the Phase I Technical Memorandum. |
| Draft Corrective Action Remedy Evaluation Report submitted to the Cabinet | Within approximately 4 months from the Cabinet approval of the Corrective Action Investigation, Risk Assessment, and Source Identification Report (for example, mid 2019 if no Phase II sampling is needed) |

### Phase II Schedule Milestones(if Required)

| Phase II Task Description | Phase II Approximate Schedule |
|---|---|
| Obtain Consultant Quotes and Mobilize for Phase II Field Effort | • Approximately 2 months following:<br>– Cabinet approval of the Phase I Technical Memorandum with changes to the scope of Phase 2 sampling efforts (if provided), or,<br>– The Cabinet notification that Phase II sampling will proceed as indicated in Section 2 of this CAP |
| Initiate Phase II Field Effort | • 2018 or 2019, depending upon the Phase I decision point |
| Phase II Sample Collection for Surface Water | • Two events are proposed for surface water, during summer stratification and during lake overturn (late fall or late winter) |
| Phase II Sample Collection for Fish, Aquatic Vegetation, and Aquatic Invertebrates | • Suggested sampling in summer months, timed with the summer stratification field effort for surface water |
| Phase II Sample Collection for Sediment | • The timing of sediment collection can be concurrent with either sample event |
| Phase II Laboratory Analysis | • Approximately 3 weeks following final sample collection |
| Phase II Data Validation | • Approximately 2 weeks following final laboratory analysis |

### Reporting Schedule Milestones (Assuming Phase II Sampling Is Required)

| Reporting Tasks | Approximate Timing |
|---|---|
| Draft Corrective Action Investigation, Risk Assessment, and Source Identification Report submitted to the Cabinet | • Within approximately 4 to 6 months of the receipt of final, validated data from Phase II sampling (anticipated earliest in 2019) |
| Draft Corrective Action Remedy Evaluation Report submitted to the Cabinet | • Within approximately 4 to 6 months from the Cabinet Approved Corrective Action Investigation, Risk Assessment, and Source Identification Report |

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# Tables

**Table 1-1: Fish Consumption Advisory for Mercury in all Kentucky Waters**
**Herrington Lake Corrective Action Plan**
**Mercer County, Kentucky**

| Species | Population of Concern | |
|---|---|---|
| | General Population | Sensitive population |
| Predatory fish | 1 meal per month | 6 meals per year |
| Bottom feeder fish and Panfish | 1 meal per week | 1 meal per month |
| All other fish | No advisory | 1 meal per week |

Notes:
General Population: Not defined, but presumably all others except sensitive populations.
Sensitive Populations: Women of childbearing age and children 6 years and younger.

Predatory fish include largemouth bass, smallmouth bass, spotted bass, white bass and striped bass and their hybrids, yellow bass, flathead catfish, blue catfish, musky, sauger and walleye and their hybrids, bowfin, chain pickerel and all gars.

Panfish include bluegill, green sunfish, longear sunfish, redear sunfish, rock bass, and crappie species.

Bottom feeder fish include channel catfish, drum, carp sucker, white sucker, common carp, bullhead species, northern hog sucker, buffalo species, spotted sucker, redhorse species, sturgeon and creek chub.

Other fish include: Asian carp, trout species, minnows, etc.

References:
Source: KYDOW 2017.

**Table 1-2. Fish Movement Patterns for Typical Fish of Herrington Lake**
**Herrington Lake Corrective Action Plan**
**Mercer County, Kentucky**

| Common Name (Scientific Name) | Home Range, Migratory Patterns & Timing | Spawning Habitat / Behavior | Habitat | Abundance | Diet and Feeding Behavior | Adult Size Range |
|---|---|---|---|---|---|---|
| Largemouth Bass (LMB) | In Herrington Lake, at first signs of water warming, they prefer sloping rocky banks. Also can be found in timber cover in creeks and bays (Game and Fish Magazine 2016). | Spawning occurs in late spring and early summer in shallow marshy areas (MDNR 2007). Male constructs a nest on rocky or gravelly bottoms. Occasionally eggs are deposited on leaves and roots of submerged vegetation (Becker 1983). | Shallow vegetated areas. Clear water with no currents. In winter, they stay near bottom. Prefer warm water (80ºF to 82°F), rarely deeper than 20 feet (MDNR 2007).<br><br>In Herrington Lake, the largest bass are around shoreline cover in March and April. At first signs of water warming, they prefer sloping rocky banks. Also can be found in timber cover in creeks and bays (Game and Fish Magazine 2016). | In Herrington Lake, LMB are, by far, the most abundant black bass species, with the best fishing success in the upper half of lake (KDFWR 2004-2016). | Upper trophic level piscivore. Eat minnows, carp, and any other available fish including other bass (MDNR 2007).<br><br>In Herrington Lake feeding at night during the summer (KDFWR 2017).<br><br>Bass are caught in good numbers in front or the Dix Dam with a jig / minnow combination (Sportsman's Connection 2016).<br><br>In Herrington Lake, they are attracted to orange and brown-colored crankbaits and jig combinations (Game and Fish Magazine 2016). | Length: 30-50 cm (12-20in).<br>Weight: Up to 10 kg (22 lbs.)<br><br>Female Age of Maturity: 4-5yrs.<br><br>Male Age of Maturity: 3-4 yrs.<br><br>Life Expectancy: 5-15 yrs.<br><br>In Herrington Lake, good numbers of fish over 12 inches, many over 15 inches (KDFWR 2017). |
| Hybrid Bass (Morone chrysops x Morone saxatilis) | In Herrington Lake, Hybrid Bass are most actively feeding from May through August. Rainy, overcast days appear to spur feeding activity.<br>In early summer, schools of hybrids chase swarms of newly spawned shad, schooling at the waters surface (Lander 2005). | In Herrington Lake, hybrid fry, hatched at the Frankfort Hatchery in mid-May, are raised on a plankton diet and are stocked in June when the measure 1 1/2 inches. Typical stock is the reciprocal cross--a male striped bass and a female white bass (Lander 2005). | Unlike white bass, adult hybrid bass don't have a preference for cold water and have about the same temperature and oxygen requirements as white bass. In late summer hybrids can live in the upper levels of the thermocline. They are tolerant of water in the 70-80f range (Lander 2005).<br><br>In Lower Herrington Lake, Hybrid Bass concentrate and suspend near a submerged 16 feet deep hump at the mouth of Curds Branch where hot water discharges from the E.W. Brown Generating Station. Around the shallow hump, water depth drops off sharply to 70 ft (Lander 2005). | Herrington Lake is known as one of Kentucky's good hybrid bass fishing locations. Angler surveys indicated good numbers 3 pounds and larger, including some >8 pounds The white bass population suffered a major die-off in June 2013 but 2014 white bass surveys indicated excellent growth rates (Sportsman's Connection 2016).<br>Similar overall densities and CPUE for both hybrid white/striped bass (Morone chrysops x Morone saxatilis) and white bass (Morone chrysops) have been recorded throughout Herrington Lake, with specific productivity varying by year and fishing location (KDFWR 2004-2016). | Hybrid Morone can be caught in all seasons but are best fished for in autumn using nighttime gill netting or late at night under lights using both artificial and live bait (KDFWR 2004-2016)<br>In Herrington Lake, hybrid bass feed primarily on abundant gizzard and threadfin (KDFWR 2004-2016). | 2- to 5-lb fish are present some up to 8lbs<br>(KDFWR 2017). |
| White Bass (Morone chrysops) | In March and April. white bass in Herrington Lake migrate to the headwaters at Dix Dam. | | Occupy main channels of rivers and most major reservoirs<br>Spring spawning runs are common in some rivers where large numbers aggregate in flowing waters over rocky bottoms (Thomas 2011) | In Herrington Lake, numbers of white bass are slightly increasing. and similar overall densities and CPUE for both white bass (Morone chrysops) and hybrid white/striped bass (Morone chrysops x Morone saxatilis) have been recorded throughout Herrington Lake, with specific productivity varying by year and fishing location (KDFWR 2004-2016). | Fishers have success for white bass by watching for surfacing baitfish and casting a spinner or other shiny baits into<br>the roils. | Adults grow to 18 in. (5.5 lbs.) but are commonly 10-15 in. (1-2 lbs.)(Thomas 2011).<br><br>Fair to good numbers of fish in the 12- to 14-inch range (KDFWR 2017)<br>3/4lb to 1 3/4lb and some as large as 3lbs.<br>Hicks 1988. |

**Table 1-2. Fish Movement Patterns for Typical Fish of Herrington Lake**
**Herrington Lake Corrective Action Plan**
**Mercer County, Kentucky**

| Common Name (Scientific Name) | Home Range, Migratory Patterns & Timing | Spawning Habitat / Behavior | Habitat | Abundance | Diet and Feeding Behavior | Adult Size Range |
|---|---|---|---|---|---|---|
| White Crappie (Pomoxis annularis) and Black Crappie (Pomoxis nigromaculatus) | In Herrington Lake, black crappie are more common in the lower section of the lake, while white crappie dominate the mid and upper sections of the lake.<br>Overall, white crappie, make up 85% of the crappie caught in Herrington Lake in 2012. | | Black crappie occurs statewide in streams, rivers, and reservoirs, but less common than white crappie. Black crappie are less tolerant of turbid waters. and tend to be more abundant in natural lakes and reservoirs having clearer water. http://fw.ky.gov/Fish/Pages/Black-Crappie.aspx<br><br>In Herrington Lake, both White and Black Crappie can be caught in all three of the Herrington Lake parts but are particularly abundant in the upper and middle sections of the lake (KDFWR 2013).<br><br>Crappie Can be found in upper half of Herrington near brush or fallen trees Potential for large black crappie around debris in inlets in main lake (KDFWR 2017).<br><br>In Herrington Lake, crappie prefer submerged structure-root wads, stumps, and sunken tree tops. During high water there are large drift piles in many of the shallow coves. Sometimes black crappie suspend under this floating debris. Preferred habitat also includes manmade cover, such as old boat docks, fish attractors, and brush piles tied to standing timber. In the spring expect crappie to be holding in 4 to 6 feet of water (Lander 2005). | The white crappie population is increasing in the middle and upper lake sections but in the lower lake, the black crappie is more abundant than white crappie (KDFWR 2013). | | Adult black crappie can grow to 19 in. (6 lbs.), but most range from 8-15 in. (1-2 lbs.). http://fw.ky.gov/Fish/Pages/Black-Crappie.aspx<br><br>In Herrington Lake, both white and black crappie reach 9 inches by age 2, and 11 inches by age 3 (KDFWR 2013).<br><br>In Herrington Lake, many crappie 9 inches or larger available to catch (KDFWR. 2017). |
| Channel Catfish (*Ictalurus punctatus*) Forage – YOY[a]<br><br>Harvested by commercial & recreational fisheries. | Channel catfish are solitary except during mating courtship and protection of young. They are active at night, moving around and finding food after dusk. During the day, they are found in deep water with little activity. There is no definitive home range for channel catfish. Channel catfish will migrate up and down stream (NPCC 2004). Channel catfish demonstrate a home range of 3.5 miles on average (Wendel and Kelsch 1999). | Spawn late spring or early summer (water temps 75° F). Male channel catfish builds a nest in underwater holes, logs or among submerged rocks. Eggs hatch in 5 days to 10 days and grow rapidly (Schoonover and Fink 2004). | Cool, deep, clean water with a sand or gravel bottom. Mostly nocturnal (Schoonover and Fink 2004).<br><br>In Herrington Lake, they can sometimes be found along the main river channel south of the dam near the mouth of Hardin Inlet (Sportsman's Connection 2016). | | Demersal, benthic omnivore. Insects, mollusks, crustaceans, fish, and some plant material.They are also predominantly nocturnal feeders (Schoonover and Fink 2004). | Adults can grow to about 4 ft. (60 lbs.), but typically range from 12-32 in. (1-15 lbs.) (Thomas 2011). |
| Bluegill (*Lepomis macrochirus*) | (MDNR 2011) The home range does not exceed 0.25 miles (Gunning and Shoop 1963). | April-June (KDFWR 2017). | Found frequently in lakes, ponds, reservoirs and sluggish stream (FishBase 2017).<br><br>In Herrington Lake, bluegill can be found around cover in embayments and inlets of rock walls (KDFWR 2017a). | | Carnivorous-Adults feed upon snails, small crayfish, insects, worms and small minnows. Young feed on crustaceans, insects and worms (FishBase 2017). | L:19-41cm<br>W: (max) 2.1kg<br>(FishBase 2017).<br>In Herrington Lake - up to 8 inches is common (KDFWR 2004-2016). |

**Table 1-2. Fish Movement Patterns for Typical Fish of Herrington Lake**
**Herrington Lake Corrective Action Plan**
**Mercer County, Kentucky**

| Common Name (Scientific Name) | Home Range, Migratory Patterns & Timing | Spawning Habitat/ Behavior | Habitat | Abundance | Diet and Feeding Behavior | Adult Size Range |
|---|---|---|---|---|---|---|
| Spotted Bass (*Micropterus punctulatus*) | 2 ha home range, 2-8 m depth (deeper in summer) (Hunter and Maceina 2008). | Rock and gravel are usually chosen as suitable spawning areas at water temperatures of 57-74°F (State of Texas 2017). Some migrate upstream to spawn in tributaries of larger rivers as temperatures warm in the spring. Eggs laid on rocky substrate in areas of moderate current near cover 2-3m deep. (Lee and Terrell 1987). | Common statewide, except for the Mississippi Coastal Plain of far western Kentucky. The Spotted Bass occupies primarily streams and rivers, but also occurs in lake (e.g., oxbows) and reservoir habitats. It is less numerous in reservoirs than Largemouth Bass and far less common than Smallmouth Bass in cool, clear upland streams. As with other black basses, Spotted Bass tend to associate with cover in the form of logs, stumps, and other submerged structures (KDFWR 2017b). | Spotted Bass (Micropterus punctulatus) comprise roughly 5-20% of the total yearly black bass caught in Herrington Lake surveys (KDFWR 2004-2016). | As young fish grow their diet shifts from zooplankton to insects, and finally to fish and crayfish (State of Texas 2017) | Age at Maturity: 3 to 4 years<br>Life expectancy: 5 years |
| Flathead Catfish (*Pylodictis olivaris*) | Young flathead catfish are often found in riffles. Adolescent catfish are associated with intermediate depths and cover (logs, brush piles, and downed trees), and catfish >40 cm are solitary and associated with cover in deep pools (Lee and Terrell 1987). | Usually, flathead catfish move to the spawning sites and spawn during June and July. Males establish territories for spawning. Nests are usually located in holes in the stream bank (Lee and Terrell 1987). | Common statewide in sluggish streams, rivers, and reservoirs. Adults occupy deep pools around fallen timber, brush piles, and other debris. Juveniles and smaller individuals occur in swift, shallow areas (e.g., riffles) over rocky or firm sand bottoms (KDFWR 2017d). | | Adult flatheads move from deep water or cover at night to feed in riffles and the shallows of pools. Fish 20-50 cm eat benthic macroinvertebrates and fish. Fish larger than that are solely piscivorous (Lee and Terrell 1987).<br><br>In Herrington Lake, usually feed at night on sunfish and shad (KDFWR 2004-2016). | Age at maturity 3-7 years<br>Life Expectancy 14-16 years (Lee and Terrell 1987).<br><br>In Herrington Lake, All sizes present (KDFWR 2017). |

**Notes:**

a "Forage" indicates species MDNR (Fielder and Thomas 2006) designates as forage for game species (i.e. walleye). "All ages" designates species that provide a food source at all ages. "YOY" designates species that are a suitable forage source only as young-of-year.

c Other forage species not on this table include freshwater drum, gizzard shad, Johnny darter, rainbow smelt, spottail shiner, white perch and white crappie.

b Rotenone is an organic fish toxicant made from derris root. When added to water, rotenone makes fish gills hemorrhage, causing death by suffocation.

| | | | |
|---|---|---|---|
| cm | centimeters | lb. | pounds |
| F | Fahrenheit | MDNR | Michigan Department of Natural Resources |
| in | inches | oz. | ounces |
| kg | kilograms | YOY | young-of-year |
| | | yrs | years |

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**Table 1-3. Pollution Elimination Discharge System Permitted Facilities Within the Upper and Lower Dix River Watersheds**
**Herrington Lake Corrective Action Plan**
**Mercer County, Kentucky**

| Facility Name | County | NPDES No. | Permit Issue Date | Permit Expiration Date | Waterbody | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| KTC GARRARD CO MAINT GARAGE | GARRARD | KYG500079 | 1/24/2003 | 3/31/2008 | | 37.59889 | -84.56806 |
| GREENVIEW MHP | MERCER | KY0075272 | 1/15/2008 | 2/28/2013 | MOCKS CRK / UT | 37.71861 | -84.81639 |
| VICWEST STEEL | BOYD | KYR001736 | 9/13/2002 | 9/30/2007 | UT / CLARKS RUN | 37.62611 | -84.79278 |
| KY UTIL E W BROWN GEN STA | MERCER | KY0002020 | 1/15/2010 | 2/28/2015 | HERRINGTON LAKE | 37.78778 | -84.71306 |
| CHIMNEY ROCK WASTE MGMT LLC | MERCER | KY0092631 | 5/2/2007 | 6/30/2012 | HERRINGTON LAKE | 37.76056 | -84.71889 |
| CATERPILLAR TRACK COMPONENTS | BOYLE | KYR001692 | 9/13/2002 | 9/30/2007 | CLARKS RUN CRK | 37.62389 | -84.82028 |
| DANVILLE WTP | BOYLE | KYG640084 | 2/15/2011 | 3/31/2016 | CLARKS RUN | 37.70889 | -84.73111 |
| STANFORD WTP | LINCOLN | KYG640036 | 2/15/2011 | 3/31/2016 | NEALS CRK | 37.48778 | -84.67528 |
| DIX RIVER STONE | GARRARD | KYG840118 | 6/22/2007 | 6/30/2012 | DIX RIVER | 37.64 | -84.66194 |
| VILLAGE INN RESTAURANT | MERCER | KY0027499 | 9/20/2007 | 10/31/2012 | CANE RUN CRK | 37.75222 | -84.76111 |
| DANVILLE STP | BOYLE | KY0057193 | 1/31/2003 | 1/31/2007 | CLARKS RUN | 37.62917 | -84.73944 |
| TEXAS EASTERN TRANS CORP | LINCOLN | KY0096229 | 6/13/2007 | 7/31/2012 | KNOBLICK CRK | 37.58 | -84.75 |
| BROCK RESIDENCE | GARRARD | KYG401500 | 11/30/2007 | 12/31/2012 | MCKENNIE CRK | 37.71083 | -84.69083 |
| BURGIN INDEPENDENT SCHOOL | MERCER | KY0040231 | 2/19/2007 | 3/31/2012 | CANE RUN CRK | 37.75417 | -84.76306 |
| KTC LINCOLN CO MAINT GARAGE | LINCOLN | KYG500025 | 1/24/2003 | 3/31/2008 | LOGAN CRK / UT | 37.5375 | -84.65167 |
| STANFORD STP | LINCOLN | KY0024619 | 3/6/2001 | 12/31/2006 | LOGAN CRK | 37.54 | -84.63611 |
| PARADISE CONDOMINIUM CO | MERCER | KY0086550 | 9/7/2007 | 10/31/2012 | HERRINGTON LAKE | 37.72611 | -84.72 |
| CALDWELL STONE CO INC | BOYLE | KYG840008 | 6/22/2007 | 6/30/2012 | CLARKS RUN | 37.62833 | -84.7475 |
| RR DONNELLEY & SONS CO | BOYLE | KY0080616 | 2/26/2007 | 3/31/2012 | CLARKS RUN | 37.62222 | -84.80833 |
| HERRINGTON HAVEN SUBD | GARRARD | KY0053431 | 9/5/2007 | 10/31/2012 | DIX RIVER | 37.66139 | -84.68972 |
| KTC BOYLE CO MAINT GARAGE | BOYLE | KYG500126 | 1/24/2003 | 3/31/2008 | CLARKS RUN / UT | 37.62694 | -84.79 |
| PHILIPS LIGHTING CO | BOYLE | KY0002607 | 10/30/2007 | 11/30/2012 | CLARKS RUN / UT | 37.64028 | -84.78806 |
| BRODHEAD STP | ROCKCASTLE | KY0047431 | 8/24/2007 | 9/30/2012 | DIX RIVER | 37.40806 | -84.42 |
| LANCASTER STP | GARRARD | KY0020974 | 3/23/2001 | 1/31/2007 | WHITE OAK CRK | 37.61444 | -84.58639 |
| LANCASTER WTP | GARRARD | KYG640101 | 2/15/2011 | 3/31/2016 | WHITE OAK CRK | 37.60611 | -84.59222 |
| LINCOLN COUNTY READY MIX INC | LINCOLN | KYR001054 | 9/13/2002 | 9/30/2007 | NEALS CRK | 37.50306 | -84.65306 |
| BRAKE PARTS INC | LINCOLN | KYR001774 | 9/13/2002 | 9/30/2007 | ST ALAPH CRK | 37.53 | -84.6525 |
| WESTERFIELD RESIDENCE | BOYLE | KYG400035 | 11/30/2007 | 12/31/2012 | HERRINGTON LAKE | 37.69056 | -84.70222 |
| CRAB ORCHARD STP | LINCOLN | KY0065897 | 10/24/2008 | 11/30/2013 | DIX RIVER | 37.46583 | -84.49556 |
| DENYO MANUFACTURING CORP | BOYLE | KYR001569 | 9/13/2002 | 9/30/2007 | CLARKS RUN | 37.62972 | -84.80417 |
| NOF - DANVILLE | BOYLE | KYR001791 | 9/13/2002 | 9/30/2007 | CLARKS RUN CRK | 37.625 | -84.79361 |
| KY ARMY NATIONAL GUARD | LINCOLN | KYG640018 | 2/15/2011 | 3/31/2016 | KNOBLICK CRK | 37.57222 | -84.78611 |
| HUSTONVILLE ELDERLY APTS | LINCOLN | KY0097713 | 6/13/2007 | 7/31/2012 | HANGING CRK | 37.47333 | -84.81333 |

**Table 2-1. Herrington Lake Field Sampling Plan Summary**
**Herrington Lake Corrective Action Plan**
**Mercer County, Kentucky**

| Herrington Lake Areas | | Number of Sample Transects, Locations, and Sampling Areas | | | | | | Sum of Samples By Media | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Phase I: Lower Herrington Lake (LHL)** | | | | | | | | | | | | |
| **Area (Figure 2-1, 2-2A, 2-2B, 2-2C)** | **Transect ID** | **SW Transects** | **SD Locations** | **PW Locations** | **AV Locations** | **AI Locations** | **Fish Sampling Areas** | **SW Samples (Stratified)[a]** | **SW Samples (Overturn)[a]** | **Fish Samples[b]** | **PW, AV, AI, SD Samples** | **Sum of Samples (All Media)** |
| **Rocky Run Embayment** | **LHL-1** | 1 | 2 | 0 | 1 | 1 | 1 | 3 | 1 | 6 | 4 | 14 |
| **Dix River Dam** | **LHL-2** | 1 | 2 | 0 | 1 | 1 | 1 | 3 | 1 | 6 | 4 | 14 |
| **Dix River Main Chan** | **LHL-3, 4, 6** | 3 | 6 | 0 | 3 | 3 | 3 | 9 | 3 | 18 | 12 | 42 |
| **Cane Run Embayment** | **LHL-5** | 1 | 2 | 0 | 1 | 1 | 1 | 3 | 1 | 6 | 4 | 14 |
| **Curds Inlet** | **CI-1,2,3,4; Curds-1, 2; Curds NB** | 4 | 12 | 15 | 4 | 4 | 1 | 12 | 4 | 6 | 35 | 57 |
| **HQ Inlet** | **HQ-1** | 1 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 8 | 12 |
| **Hardin Inlet** | **Hardin-1** | 1 | 0 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 3 | 5 |
| **Sum for this area/region** | | 12 | 27 | 21 | 11 | 11 | 8 | 32 | 12 | 44 | 70 | 158 |
| **Phase I: Middle Herrington Lake (MHL)** | | | | | | | | | | | | |
| **Area (Figure 2-1, 2-2D)** | **Transect ID** | **SW Transects** | **SD Locations** | **PW Locations** | **AV Locations** | **AI Locations** | **Fish Sampling Areas** | **SW Samples (Stratified)[a]** | **SW Samples (Overturn)[a]** | **Fish Samples[b]** | **PW, AV, AI, SD Samples** | **Sum of Samples (All Media)** |
| **Cane Run SW** | **MHL-1** | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 6 | 0 | 6 |
| **Mocks Branch SW** | **MHL-3** | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 6 | 0 | 6 |
| **Sum for this area/region** | | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 12 | 0 | 12 |
| **Phase I Dix River - Downstream from Herrington Lake Dam** | | | | | | | | | | | | |
| **Area (Figure 2-1, 2-2F)** | **Transect ID** | **SW Transects** | **SD Locations** | **PW Locations** | **AV Locations** | **AI Locations** | **Fish Sampling Areas** | **SW Samples (Stratified)[a]** | **SW Samples (Overturn)[a]** | **Fish Samples[b]** | **PW, AV, AI, SD Samples** | **Sum of Samples (All Media)** |
| **Dix River** | | 1 | 2 | 0 | 1 | 1 | 1 | 1 | 0 | 6 | 4 | 11 |
| **Phase I Program Summary** | | | | | | | | | | | | |
| **Phase I Program Summary** | | **SW Transects** | **SD Locations** | **PW Locations** | **AV Locations** | **AI Locations** | **Fish Sampling Areas** | **SW Samples (Stratified)[a]** | **SW Samples (Overturn)[a]** | **Fish Samples[b]** | **PW, AV, AI, SD Samples** | **Sum of Samples (All Media)** |
| **Total Program Summary** | | 13 | 29 | 21 | 12 | 12 | 11 | 33 | 12 | 62 | 74 | 181 |
| | | | | | | | | | | | | |
| **with Fish Ovary Samples** | | | | | | | | | | 10 | | |
| **Phase II: Middle Herrington Lake (MHL)[c]** | | | | | | | | | | | | |
| **Area (Figure 2-1, 2-2D)** | **Transect ID** | **SW Transects** | **SD Locations** | **PW Locations** | **AV Locations** | **AI Locations** | **Fish Sampling Areas** | **SW Samples (Stratified)[a]** | **SW Samples (Overturn)[a]** | **Fish Samples[b]** | **PW, AV, AI, SD Samples** | **Sum of Samples (All Media)** |
| **Cane Run SW** | **MHL-1,2** | 2 | 2 | 0 | 2 | 2 | 0 | 4 | 2 | 0 | 6 | 12 |
| **Mocks Branch SW** | **MHL-3** | 1 | 1 | 0 | 1 | 1 | 0 | 2 | 1 | 0 | 3 | 6 |
| **Sum for this area/region** | | 3 | 3 | 0 | 3 | 3 | 0 | 6 | 3 | 0 | 9 | 18 |
| **Phase II: Upper Herrington Lake (UHL)[c]** | | | | | | | | | | | | |
| **Area (Figure 2-1, 2-2E)** | **Transect ID** | **SW Transects** | **SD Locations** | **PW Locations** | **AV Locations** | **AI Locations** | **Fish Sampling Areas** | **SW Samples (Stratified)[a]** | **SW Samples (Overturn)[a]** | **Fish Samples[b]** | **PW, AV, AI, SD Samples** | **Sum of Samples (All Media)** |
| **Clarks Run SW** | **UHL-1** | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 6 | 3 | 11 |
| **Boone Creek-Dix River** | **UHL-2** | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 6 | 3 | 11 |
| **Sum for this area/region** | | 2 | 2 | 0 | 2 | 2 | 2 | 2 | 2 | 12 | 6 | 22 |
| **Phase II Program Summary[c]** | | | | | | | | | | | | |
| **Phase II Program Summary** | | **SW Transects** | **SD Locations** | **PW Locations** | **AV Locations** | **AI Locations** | **Fish Sampling Areas** | **SW Samples (Stratified)[a]** | **SW Samples (Overturn)[a]** | **Fish Samples[b]** | **PW, AV, AI, SD Samples** | **Sum of Samples (All Media)** |
| **Total Program Summary** | | 5 | 5 | 0 | 5 | 5 | 2 | 8 | 5 | 12 | 15 | 40 |
| | | | | | | | | | | | | |
| **with Fish Ovary Samples** | | | | | | | | | | | | |
| **Total Program Summary (Phase I and Phase II)[c]** | | | | | | | | | | | | |
| **Phase I and Phase II Program Summary** | | **SW Transects** | **SD Locations** | **PW Locations** | **AV Locations** | **AI Locations** | **Fish Sampling Areas** | **SW Samples (Stratified)[a]** | **SW Samples (Overturn)[a]** | **Fish Samples[b]** | **PW, AV, AI, SD Samples** | **Sum of Samples (All Media)** |
| **Total Program Summary** | | 18 | 34 | 21 | 17 | 17 | 13 | 41 | 17 | 74 | 89 | 221 |
| | | | | | | | | | | | | |
| **with Fish Ovary Samples** | | | | | | | | | | 14 | | |

**Notes:**

a Water sampling during summer stratification will involve three sample depths if water is stratified, and one sample depth during summer or lake overturn if water is not stratified.

b Fish sampling will include 3 species, 2 composites /species. HQ Inlet will be bluegill fish only. Dix River downstream from the dam will include three species of fish, including a cold water species, if present. Fish ovary samples will be collected from largemouth bass and from catfish from each of the Phase I fish sampling stations. This will amount to 14 ovary samples for two species from 7 fish sampling stations.

c The Phase I sampling effort may be sufficient for risk management decision-making. As such, the need for the Phase II sampling will be based on the Phase I sampling

AI Aquatic invertebrates
AV Aquatic vegetation
Fish Fish study area
NB North Bank
PW Pore water
SD Sediment
SW Surface water

**Table 2-2. Herrington Lake Field Sampling Plan Summary**
**Herrington Lake Corrective Action Plan**
**Mercer County, Kentucky**

| Herrington Lake Areas | Sample Location Data Quality Objectives |
|---|---|
| **Phase I: Lower Herrington Lake (LHL) (Figure 2-1, 2-2A, 2-2B, 2-2C, 6-1)** | |
| **Rocky Run Embayment** | This location is northeast from the plant and will be used to characterize the influence of flow from the Rocky Run portion of the Can Run-Dix River Sub watershed. There are no known KPDES permitted dischargers in this area. KYDOW identified fish tissue samples were collected in this area in 2016, but no fish tissue data were available for review at the time of CAP plan development. |
| **Dix River Dam** | This location is near the plant and near the dam. Data from this location will be used to characterize the potential influence from the plant. KYDOW fish sampling in this area did not include bluegill. |
| **Dix River Main Channel** | There are 3 samples on the main channel of the Dix River in the LHL area at approximately RM 0.5, 1, and 3. Data from these locations will be used to identify a gradient of concentration with distance from Curds Inlet, if such a gradient exists, particularly for small home range fish (bluegill) and the other biological samples (aquatic vegetation and aquatic invertebrates). |
| **Cane Run Embayment** | This sample location reflects a large embayment to the lake. The location is placed near a permitted KPDES outfall location, with two additional KPDES permits also present upgradient from this location. Data from this location will be used to characterize the potential influence from the other sources. |
| **Curds Inlet** | Curds Inlet reflects the area proximate to the plant. This area has the highest density of sediment sampling, augmenting the sediment locations sampled in 2017. In addition, this is the key area of focus for the pore water selenium speciation. This area reflects one fish collection area for three species of fish. Three aquatic vegetation and three aquatic invertebrate samples are planned from this area as well. Data from the sampling of the inlet will be used to evaluate the potential contribution of sediment to the food web of Herrington Lake. Data from this inlet will also be used to identify the potential sources of selenium to the lake from the plant. |
| **HQ Inlet** | The HQ Inlet is also proximate to the plant. Surface water, sediment and vegetation sampling is identified for this inlet. Data from the sampling of the inlet will be used to evaluate the potential contribution of sediment to the food web of Herrington Lake. Data from this inlet will also be used to identify the potential sources of selenium to the lake from the plant. |
| **Hardin Inlet** | Hardin Inlet reflects a small inlet removed from the plant. The focus of sampling in this area is surface water and pore water to augment the sediment samples collected in this area in 2017. The data from the sampling of this inlet will be used to compare against surface water, sediment, and sediment pore water from Curds Inlet and the HQ Inlet to understand potential influences from the plant to the lake. Hardin Inlet is not considered a presumptive ambient background. Rather, all samples in Phase I will be evaluated collectively to understand a gradient of concentrations (if any) relative to the E.W. Brown Station so that background naturally occurring inorganic conditions can be identified, if appropriate. |

**Table 2-2. Herrington Lake Field Sampling Plan Summary**
**Herrington Lake Corrective Action Plan**
**Mercer County, Kentucky**

| Herrington Lake Areas | Sample Location Data Quality Objectives |
|---|---|
| **Phase II: Middle Herrington Lake (MHL) (Figure 2-1, 2-2D, 6-1)** | |
| **Cane Run SW** | The samples in this portion of the MHL include a transect at RM 10 (including fish) and a transect at RM 14. Data from these locations will be used to characterize influence of the flow from the Can Run-Dix River Subwatershed, including potential influence from KPDES permitted locations. |
| **Mocks Branch SW** | The samples in this portion of the MHL include a transect at RM 20 (including fish) and a transect at RM 23. Data from these locations will be used to characterize influence of the flow from the Mocks Branch Subwatershed, including potential influence from KPDES permitted locations. |
| **Phase II: Upper Herrington Lake (UHL) (Figure 2-1, 2-2E, 6-1)** | |
| **Clarks Run SW** | The sample location at RM 25 (including fish) was placed just downgradient of the Clarks Run Subwatershed. Data from this location will be used to evaluate flow from the subwatershed, including potential influence from 8 KPDES permitted dischargers. |
| **Lower Hanging Fork Creek SW** | The sample location at RM 28 reflects the furthest upgradient Herrington Lake location. Data from this location will be used to evaluate flow from the subwatershed, including potential influence from a KPDES permitted discharger. |
| **Phase I: Dix River Downstream from Herrington Lake Dam (Figure 2-1, 2-2F, 6-1)** | |
| **Dix River** | The sample location is downgradient from the dam and the dam overflow. Three locations along the transect will be sampled. Data from these locations will be used to evaluate the potential flow of selenium out of Herrington Lake (if any). |

Notes:
RM — River mile, with the mileage estimates starting at the Herrington Lake dam.

**Table 2-3. Analytical Methods Per Sample Matrix**
**Herrington Lake Corrective Action Plan**
**Mercer County, Kentucky**

| Test | Methods | Surface Water | Sediment | Porewater | Aquatic Vegetation | Aquatic Invertebrates | Fish Tissues |
|---|---|---|---|---|---|---|---|
| Total Metals (selenium, arsenic, cadmium, lead, zinc, iron, boron, and magnesium) | USEPA 200.8 and 6010/6020 | X | X | X | | | |
| Dissolved Metals (selenium, arsenic, cadmium, lead, zinc, iron, boron, and magnesium) | USEPA 200.8 and 6010/6021 | X | | X | | | |
| Metals (selenium, arsenic, cadmium, lead, and zinc) | USEPA 6010/6020 | | | | X | X | X |
| Mercury | USEPA 7470 and EPA 7471 | X | X | X | X | X | X |
| Methylmercury | USEPA 1630 and USEPA 1631E | X | X | X | X | X | X |
| Sulfate | USEPA 300.0 | X | X | X | | | |
| Total organic carbon | Lloyd Kahn (sediment)<br>SM 5310 (water) | X | X | X | | | |
| Dissolved organic carbon | SM 5310 | X | | X | | | |
| Hardness | 130.2 | X | | X | | | |
| Percent Solids | SM 2540G | | X | | | | |
| Percent Lipids | Lab SOP | | X | | | X | X |
| Percent Moisture | Lab SOP | | X | | X | X | X |
| Speciated selenium | HPLC with ICP-MS | | | X | | | |
| Speciated arsenic | 1632 | | | X | | | X |

**Notes:**

| | |
|---|---|
| USEPA | United States Environmental Protection Agency |
| HPLC | High performance liquid chromatography |
| ICP-MS | Inductively coupled plasma/mass spectrometry |
| SOP | Standard operating procedure |

**Table 4-1. Assessment and Measurement Endpoints for the Ecological Risk Assessment**
**Herrington Lake Corrective Action Plan**
**Mercer County, Kentucky**

| Assessment Endpoint | Measurement Endpoint | Receptors |
|---|---|---|
| Health of the aquatic invertebrate community | Comparison of constituent concentrations in water and sediment to protective water quality and sediment ecological benchmarks | Aquatic and Benthic invertebrate community |
| Survival and reproduction of fish populations | Comparison of constituent concentrations in whole body fish tissues to protective levels of chemicals in fish tissues; comparison of fish ovary tissues to protective levels for fish ovary tissues; Comparison of constituent concentrations in water to water quality standards | Fish |
| Survival and reproduction of avian populations | Comparison of modeled dietary intakes using fish, aquatic plant, and aquatic invertebrate tissue concentrations compared to literature-based ingestion TRVs protective of birds | great blue heron, osprey, belted kingfisher |
| Survival and reproduction of mammalian populations | Comparison of modeled dietary intakes using fish, aquatic plant, and aquatic invertebrate tissue concentrations compared to literature-based ingestion TRVs protective of mammals | Mink |

Notes:
TRV: Toxic Reference Value

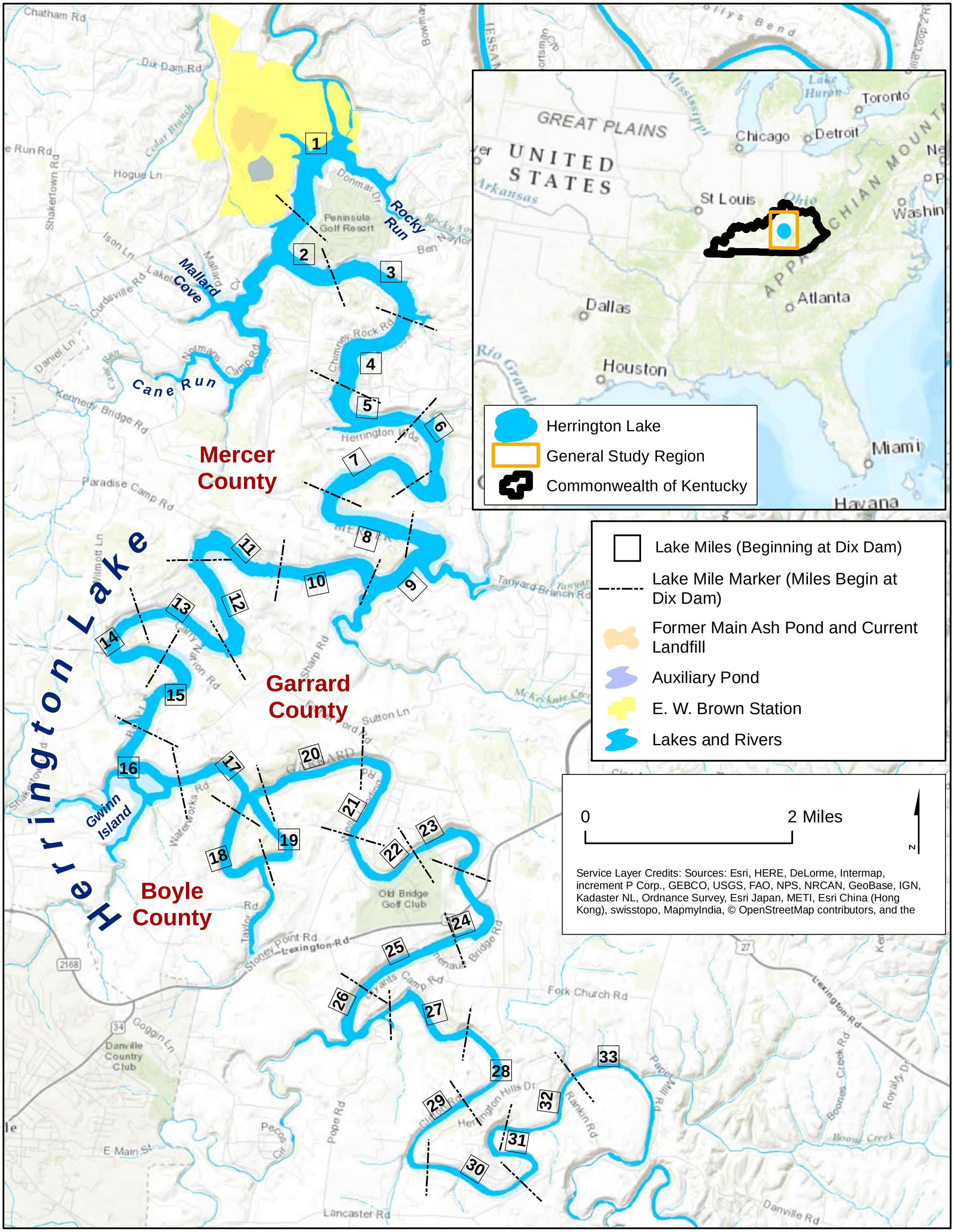
**Table 4-2. Special Status Species for Garrard and Mercer Counties, Kentucky**
**Herrington Lake Corrective Action Plan**
**Mercer County, Kentucky**

| County | Scientific Name | Common Name | Class | State Status | Federal Status |
|---|---|---|---|---|---|
| Garrard | *Ammodramus henslowii* | Henslow's Sparrow | Aves | S | N |
| Garrard | *Junco hyemalis* | Dark-Eyed Junco | Aves | S | N |
| Garrard | *Tyto alba* | Barn Owl | Aves | S | N |
| Garrard | *Pleurobema clava* | Clubshell | Bivalvia | E | E |
| Garrard | *Pseudanophthalmus elongatus* | A Cave Obligate Beetle | Insecta | S | N |
| Garrard | *Myotis grisescens* | Gray Myotis | Mammalia | T | E |
| Garrard | *Nycticeius humeralis* | Evening Bat | Mammalia | S | N |
| Garrard | *Eumeces anthracinus* | Coal Skink | Reptilia | T | N |
| Mercer | *Rana pipiens* | Northern Leopard Frog | Amphibia | S | N |
| Mercer | *Accipiter striatus* | Sharp-Shinned Hawk | Aves | S | N |
| Mercer | *Actitis macularius* | Spotted Sandpiper | Aves | E | N |
| Mercer | *Ammodramus henslowii* | Henslow's Sparrow | Aves | S | N |
| Mercer | *Anas clypeata* | Northern Shoveler | Aves | E | N |
| Mercer | *Anas discors* | Blue-Winged Teal | Aves | T | N |
| Mercer | *Ardea alba* | Great Egret | Aves | T | N |
| Mercer | *Bartramia longicauda* | Upland Sandpiper | Aves | H | N |
| Mercer | *Cardellina canadensis* | Canada Warbler | Aves | S | N |
| Mercer | *Certhia americana* | Brown Creeper | Aves | E | N |
| Mercer | *Chondestes grammacus* | Lark Sparrow | Aves | T | N |
| Mercer | *Dolichonyx oryzivorus* | Bobolink | Aves | S | N |
| Mercer | *Empidonax minimus* | Least Flycatcher | Aves | E | N |
| Mercer | *Falco peregrinus* | Peregrine Falcon | Aves | E | N |
| Mercer | *Fulica americana* | American Coot | Aves | E | N |
| Mercer | *Junco hyemalis* | Dark-Eyed Junco | Aves | S | N |
| Mercer | *Passerculus sandwichensis* | Savannah Sparrow | Aves | S | N |
| Mercer | *Phalacrocorax auritus* | Double-Crested Cormorant | Aves | T | N |
| Mercer | *Pheucticus ludovicianus* | Rose-Breasted Grosbeak | Aves | S | N |
| Mercer | *Setophaga fusca* | Blackburnian Warbler | Aves | T | N |
| Mercer | *Sternula antillarum athalassos* | Interior Least Tern | Aves | E | E |
| Mercer | *Thryomanes bewickii* | Bewick's Wren | Aves | S | N |
| Mercer | *Tyto alba* | Barn Owl | Aves | S | N |
| Mercer | *Vermivora chrysoptera* | Golden-Winged Warbler | Aves | T | N |
| Mercer | *Callophrys irus* | Frosted Elfin | Insecta | E | N |
| Mercer | *Pseudanophthalmus elongatus* | A Cave Obligate Beetle | Insecta | S | N |
| Mercer | *Pseudanophthalmus puteanus* | Old Well Cave Beetle | Insecta | T | N |
| Mercer | *Mustela nivalis* | Least Weasel | Mammalia | S | N |
| Mercer | *Myotis grisescens* | Gray Myotis | Mammalia | T | E |
| Mercer | *Myotis leibii* | Eastern Small-Footed Myotis | Mammalia | T | N |

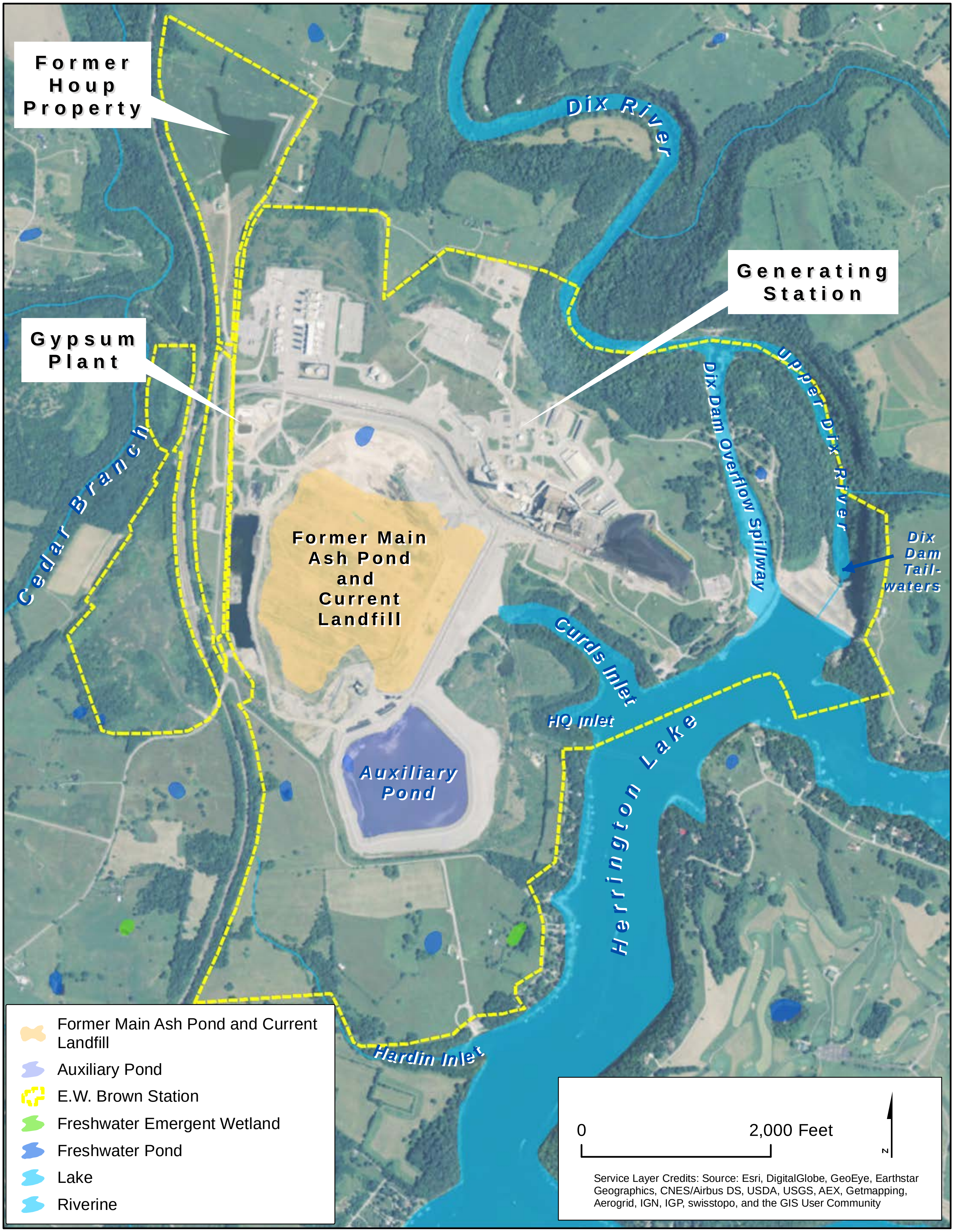
Notes:

| | |
|---|---|
| Source | Kentucky Department of Fish & Wildlife Resources |
| E | Endangered |
| H | Historic |
| N | Not listed |
| S | Special concern |
| T | Threatened |

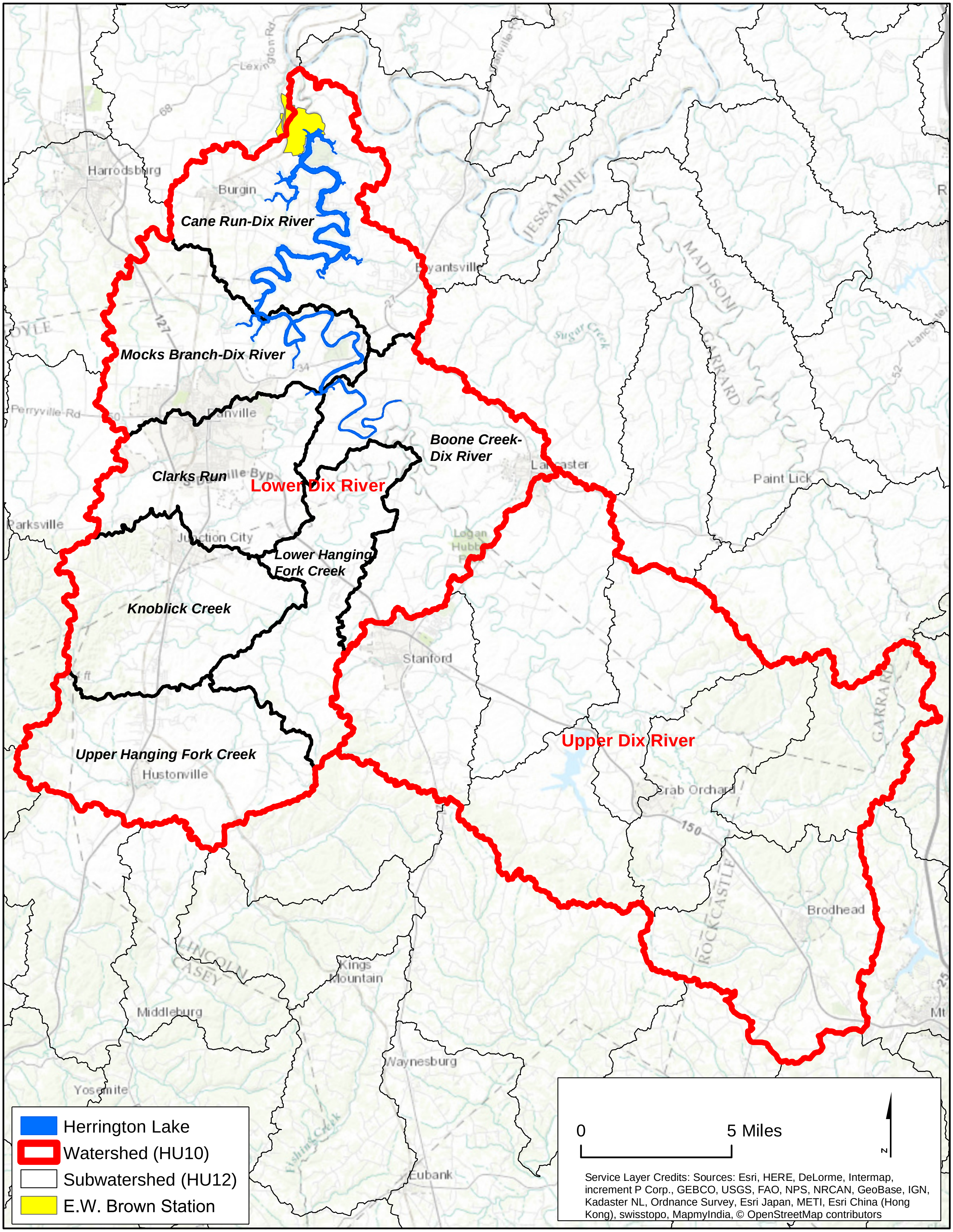
# Figures




| RAMBOLL ENVIRON<br>Map Design: AJS, Date: March 7, | E.W. Brown Station Location Map<br>Herrington Lake Corrective Action Plan<br>Mercer County, Kentucky | FIGURE 1-1A<br>Project Code: |
|---|---|---|




| RAMBOLL ENVIRON<br>Map Design: AJS, Date: March 7, | Site Layout<br>Herrington Lake Corrective Action Plan<br>Mercer County, Kentucky | FIGURE<br>1-1B<br>Project Code: |
|---|---|---|



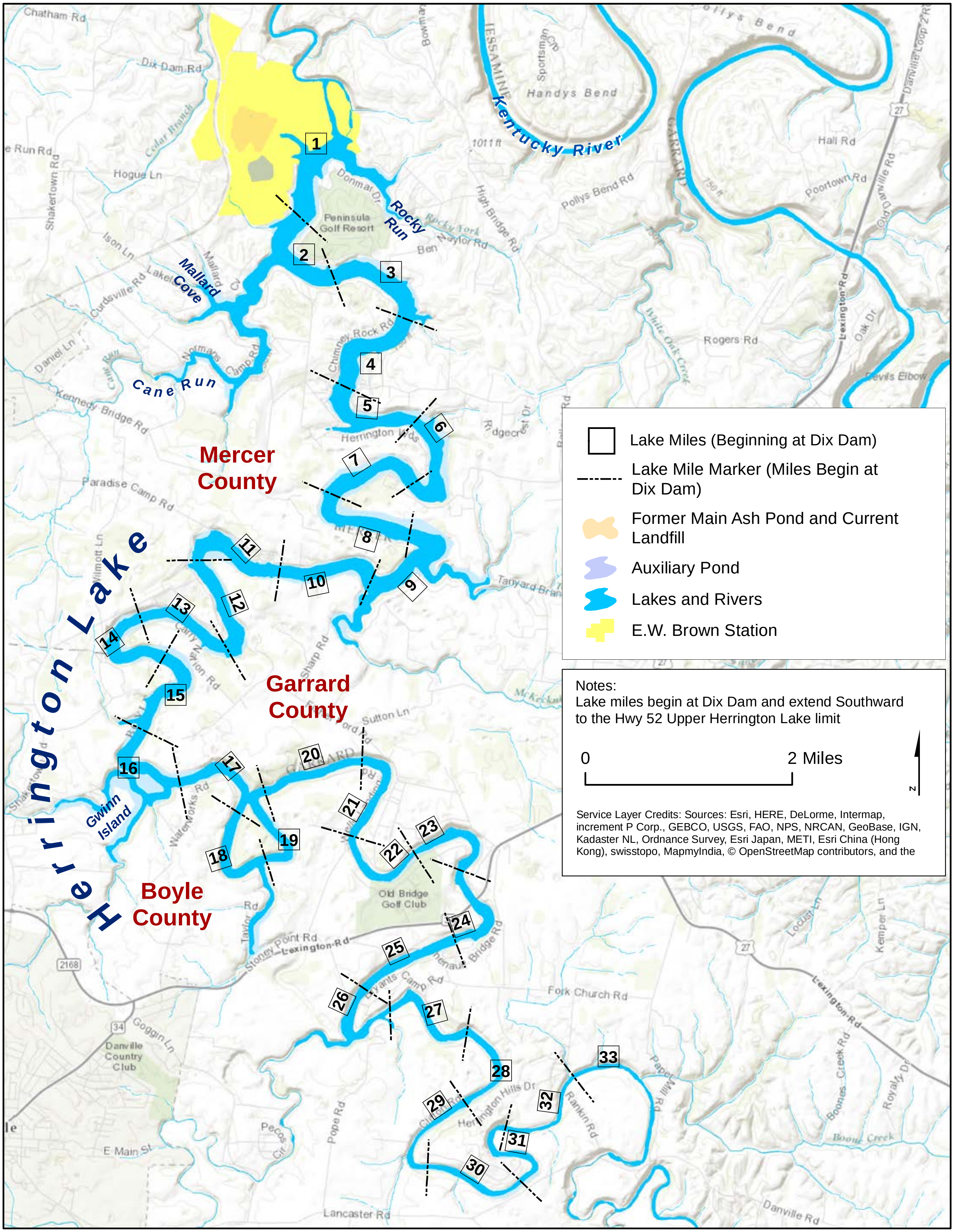

RAMBOLL ENVIRON

Map Design: AJS, Date: March 22, 2017

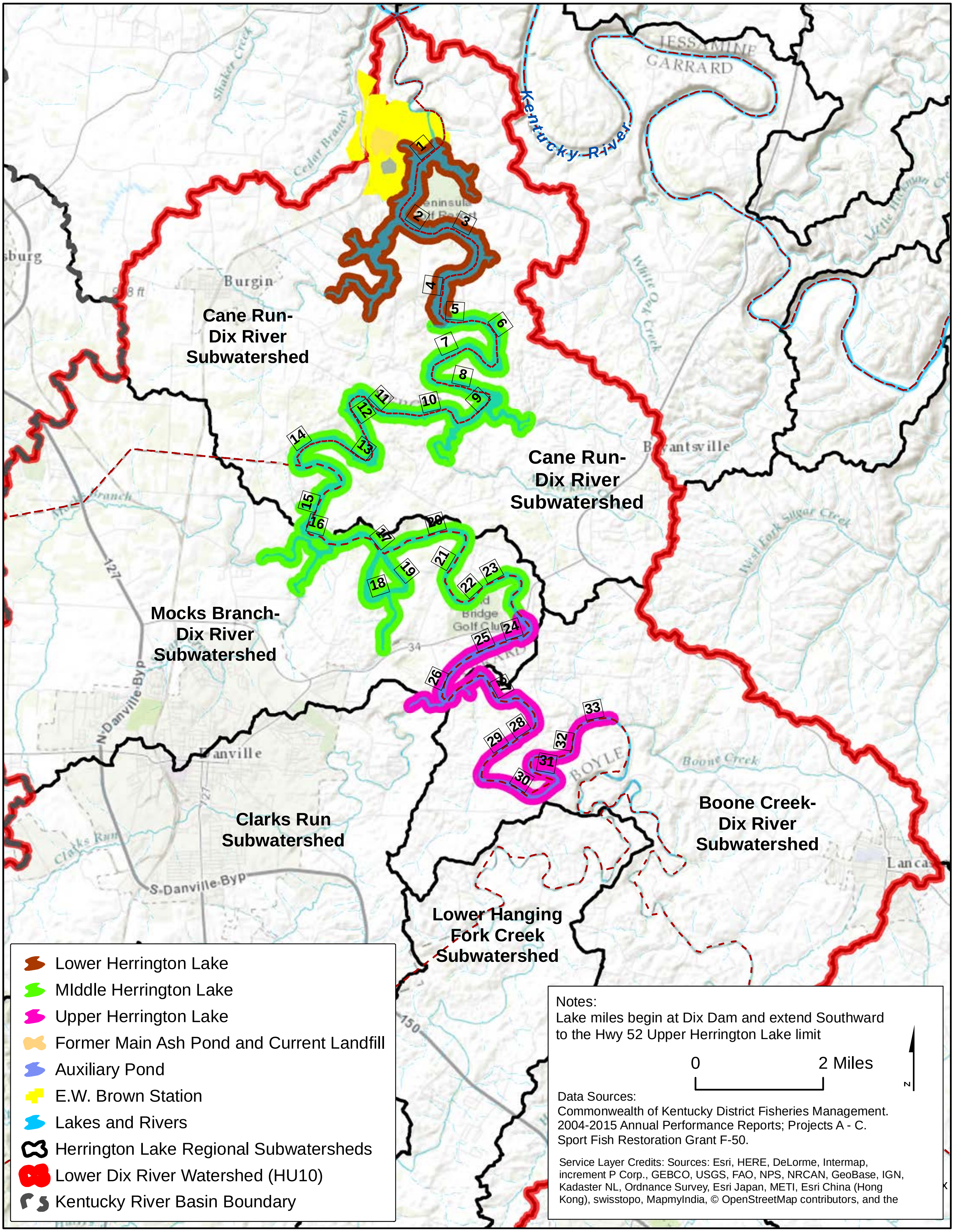
Upper and Lower Dix River Watershed Map
Herrington Lake Corrective Action Plan
Mercer County, Kentucky

FIGURE 1-2A

Project Code:




| | | |
|---|---|---|
| RAMBOLL ENVIRON<br>Map Design: AJS, Date: March 7, | Herrington Lake Overview Map<br>Herrington Lake Corrective Action Plan<br>Mercer County, Kentucky | FIGURE 1-2B<br>Project Code: |



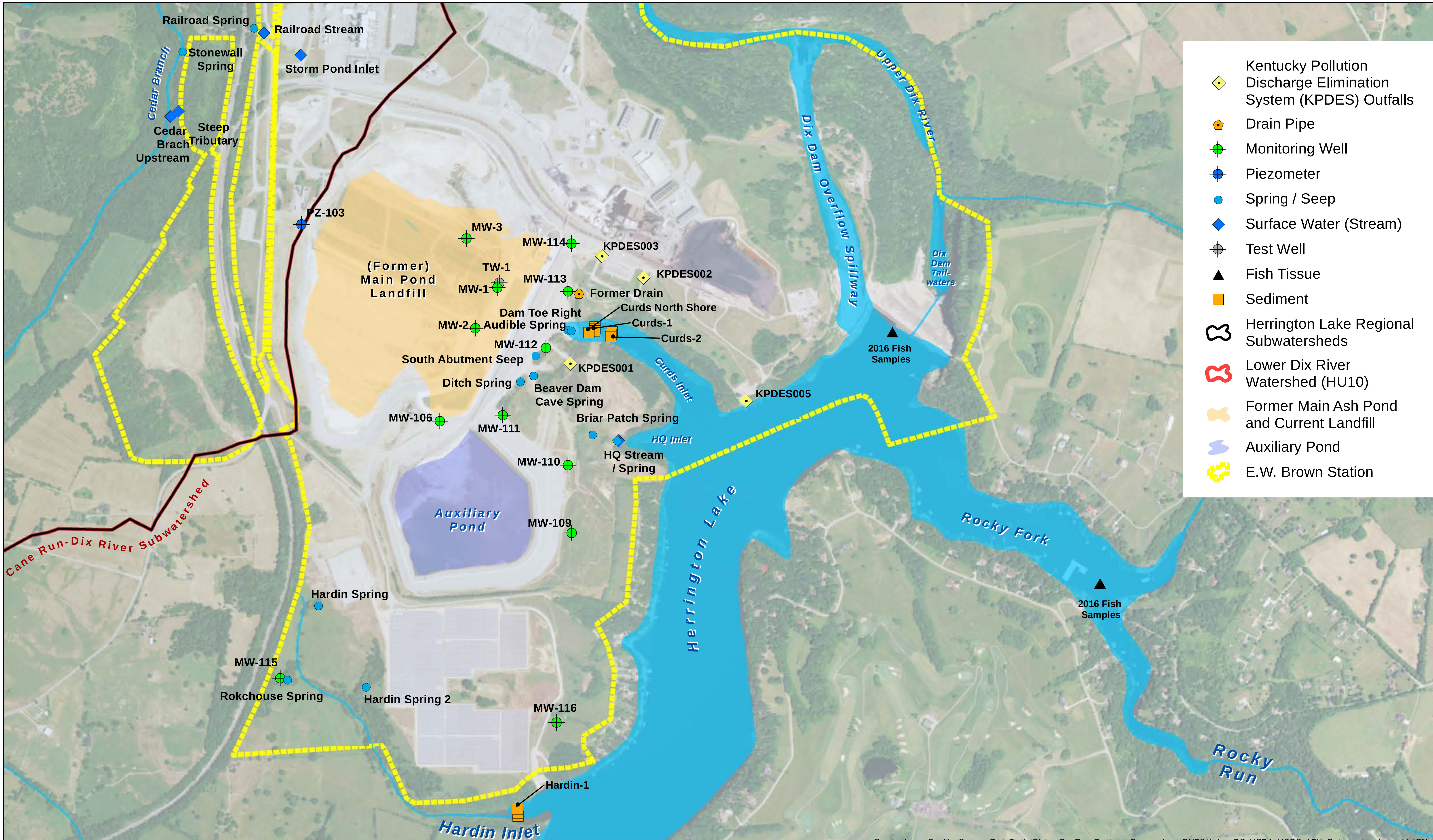

RAMBOLL ENVIRON

Map Design: AJS, Date: March 20,

Herrington Lake Sections for CAP Sampling Program
Herrington Lake Corrective Action Plan
Mercer County, Kentucky

FIGURE 1-2C

Project Code:




RAMBOLL ENVIRON

Map Design: AJS, Date: Mar 22, 2017

E.W. Brown Station and Herrington Lake Historical Sampling Locations
Herrington Lake Corrective Action Plan
Mercer County, Kentucky

FIGURE 1-3

Project:

KENTUCKY DEPARTMENT *of* FISH & WILDLIFE RESOURCES

BUY LICENSES | TELECHECK | SEASONS | MAPS | GIFT CERT. | CONTACT US

Licenses | Hunt | Wildlife | Fish | Boat | Education | Enforcement | KY Afield | More

Kentucky Department of Fish & Wildlife / Fish / Fisheries Management / Sportfish Assessments

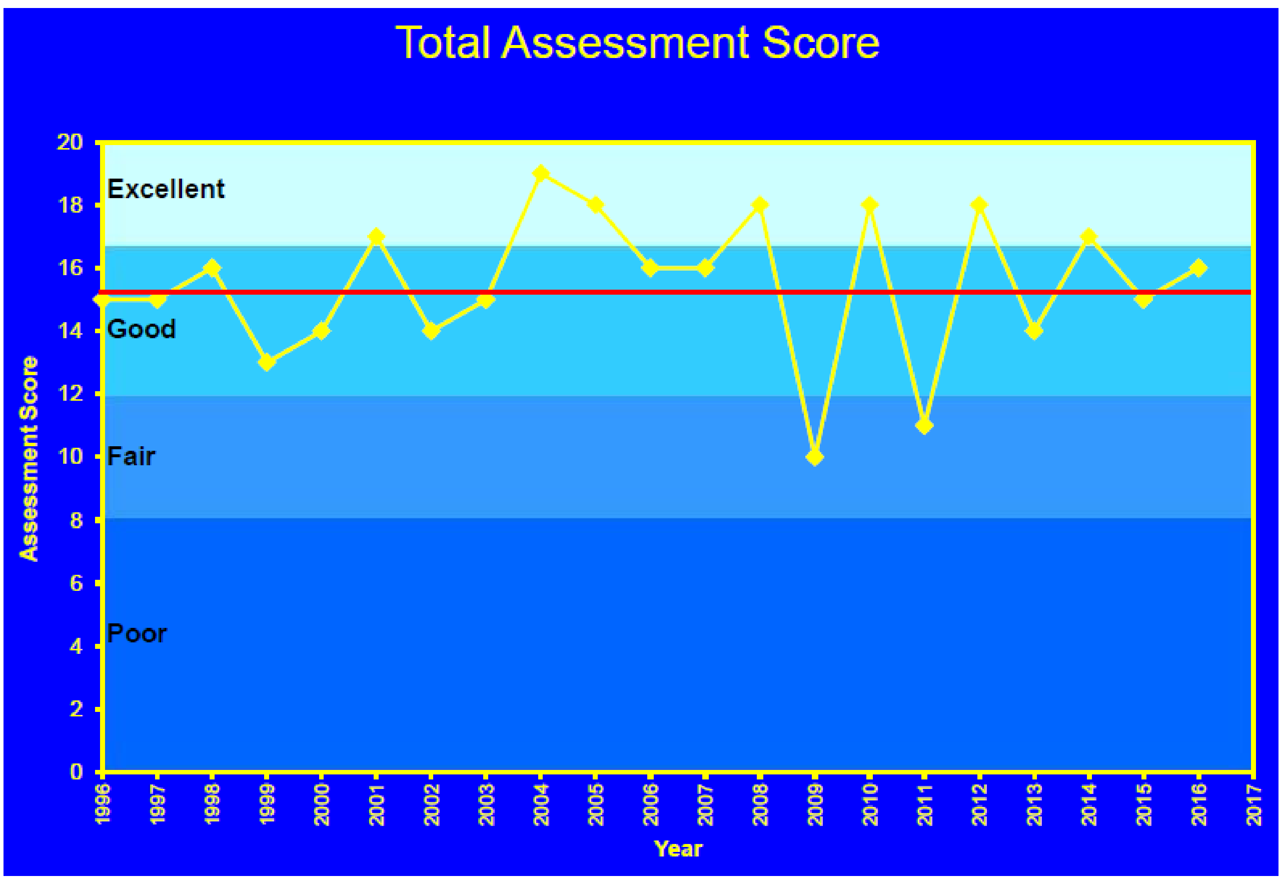
Recreational Fishing

## Sportfish Assessments

### The Largemouth Bass Assessment

In 2003, the Kentucky Department of Fish and Wildlife developed methods to assess black bass populations, using multiple years of data collected on lakes across Kentucky. The assessments were developed to assist biologists with describing the overall well-being of the black bass population and to assist them with forecasting fishing trends in each lake. The assessment is based on the five population parameters that are shown below.

Bass length at Age-3 is an index of how fast the fish are growing in that lake (growth). Number of Age-1 bass is an index of how good the spawn was the year before (recruitment). Number of bass collected in each of the three size groups give biologists an idea of what fishing will be like in the lake that year (size structure).




| | | |
|---|---|---|
| RAMBOLL ENVIRON | **LONG-TERM LARGEMOUTH BASS PERFORMANCE FOR HERRINGTON LAKE**<br>Herrington Lake Corrective Action Plan<br>Mercer County, Kentucky | FIGURE<br>1-4A |
| DRAFTED BY: PAL   DATE: 5/22/2013 | | |


Source: USGS 2016.

RAMBOLL ENVIRON

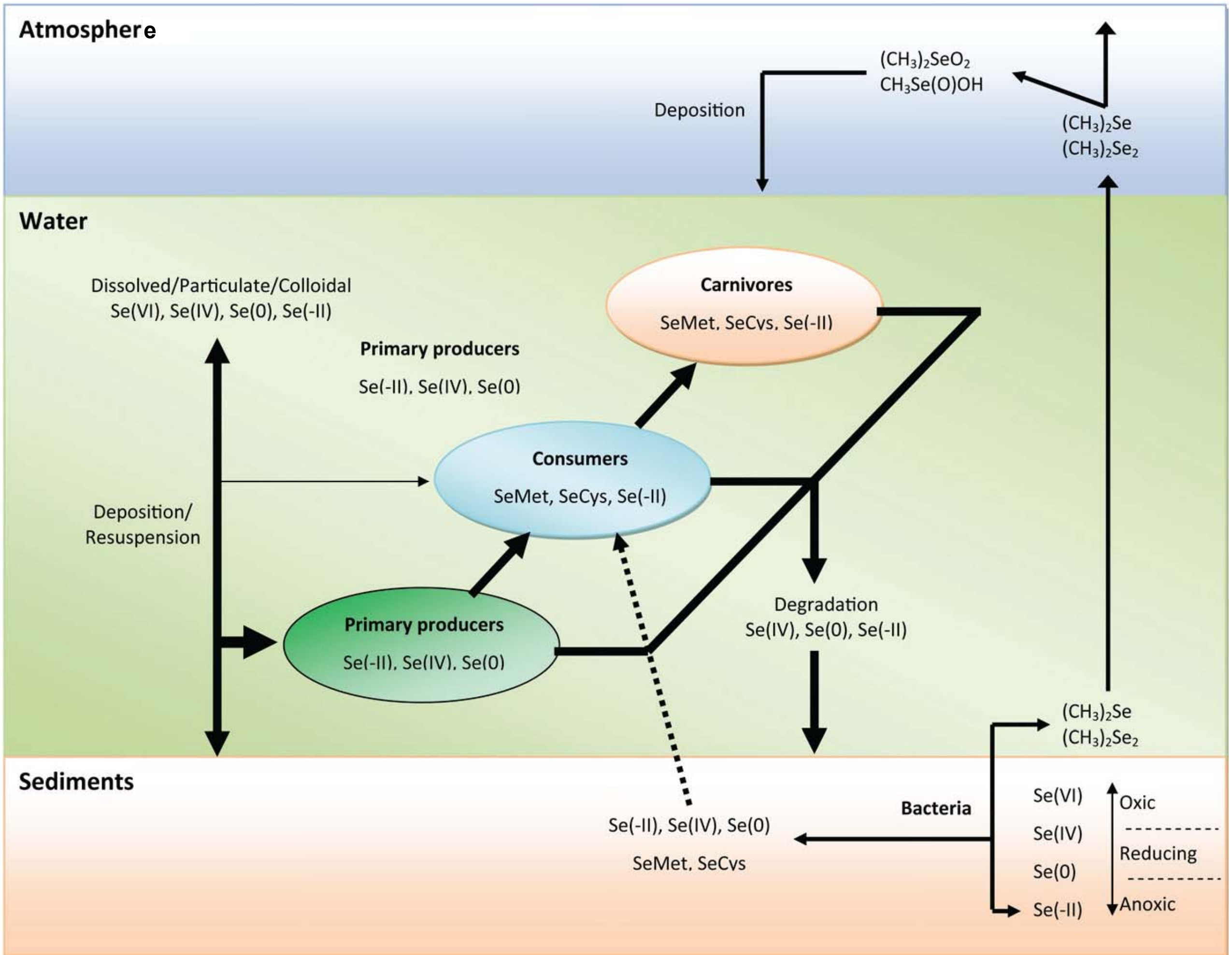
**HERRINGTON LAKE WATER LEVELS**

Herrington Lake Corrective Action Plan
Mercer County, Kentucky

FIGURE 1-4B

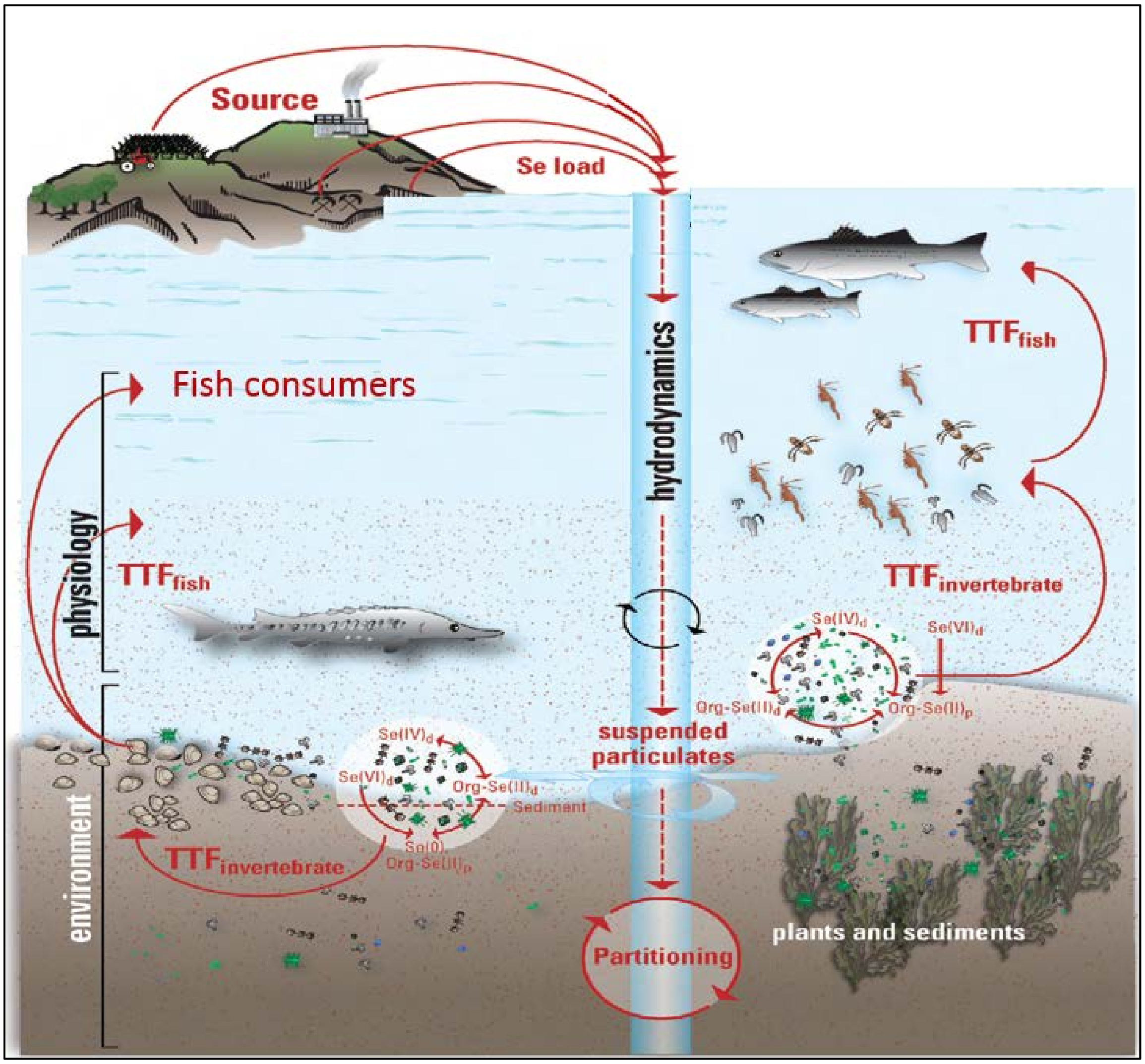
DRAFTED BY: PAL

DATE: 5/22/2013



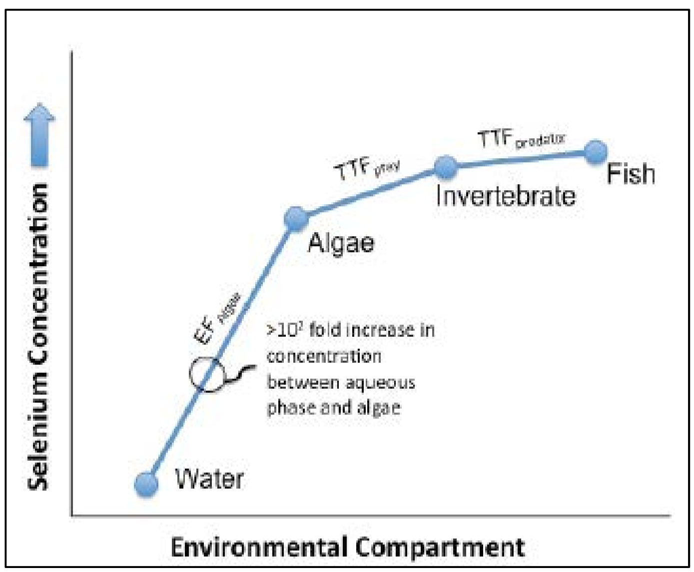

(Chapman et al. 2009)

| | | |
|---|---|---|
| RAMBOLL ENVIRON | **PRELIMINARY CONCEPTUAL MODEL OF SELENIUM GEOCHEMICAL CYCLE**<br>Herrington Lake Corrective Action Plan<br>Mercer County, Kentucky | FIGURE<br>1-5A |
| DRAFTED BY: PAL   DATE: 5/22/2013 | | |




Above: Conceptual model of selenium fate and effects emphasizing the roles of speciation, biogeochemical transformation, and trophic transfer factors in modeling two aquatic food webs: a water column food web and a benthic food web.
TTF = trophic transfer factor
Subscript d = dissolved
Subscript p = particulate
(Luoma and Presser 2009).

Right: Trophic transfer functions demonstrate that water to algae is the largest increase function in the food web.



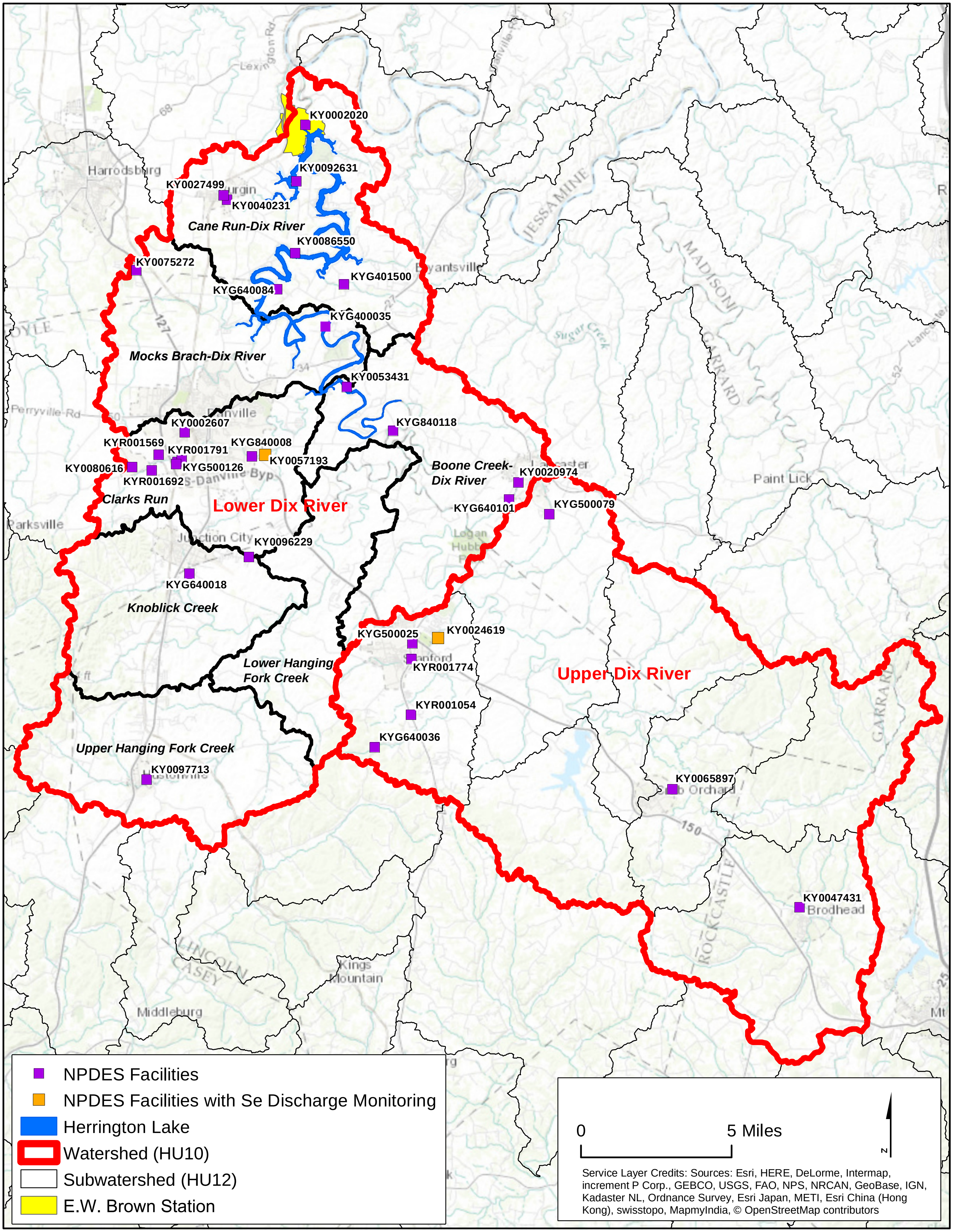

RAMBOLL ENVIRON

DRAFTED BY: PAL | DATE: 5/22/2013

**PRELIMINARY CONCEPTUAL SELENIUM FOOD WEB MODEL**

Herrington Lake Corrective Action Plan
Mercer County, Kentucky

FIGURE 1-5B



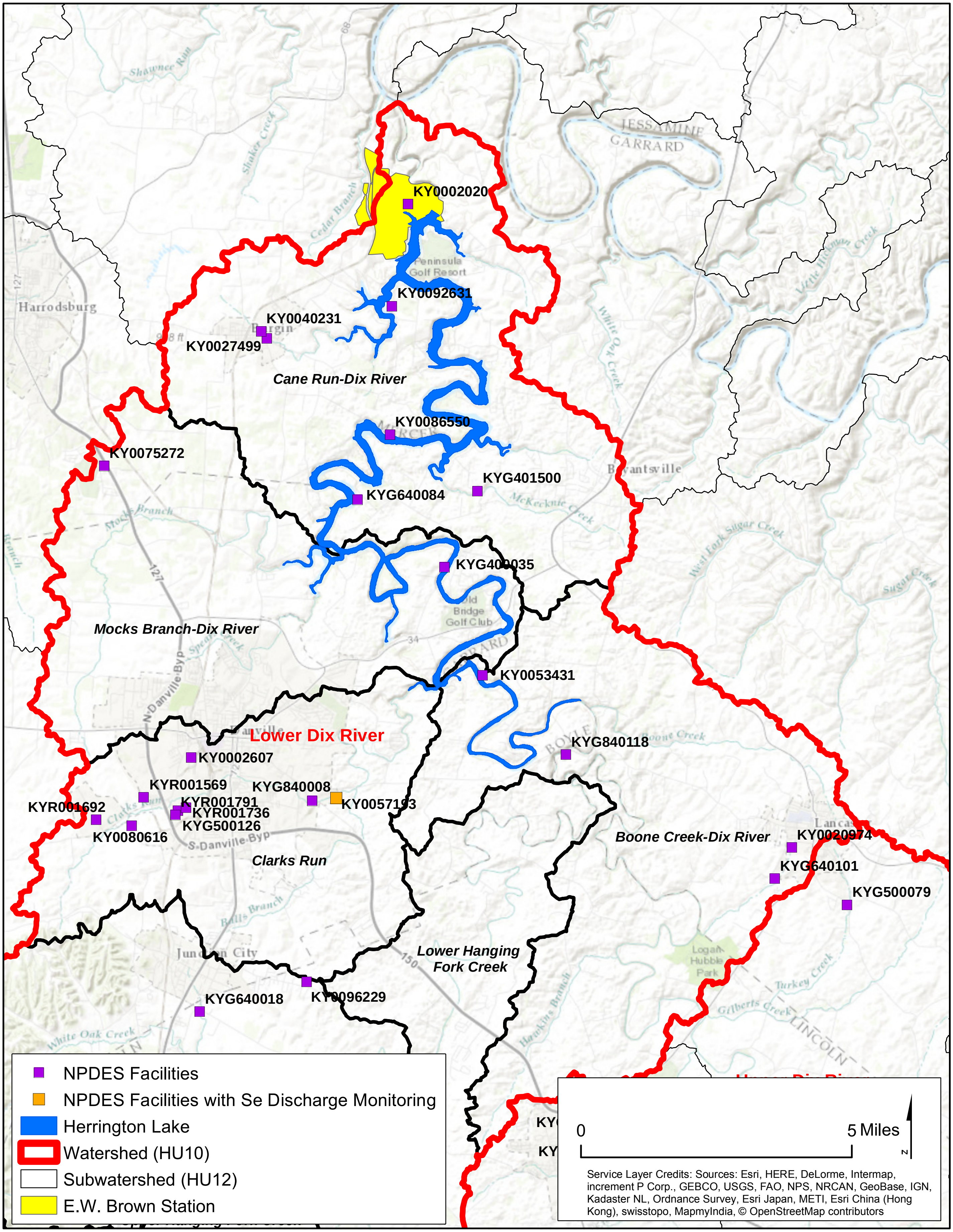

RAMBOLL ENVIRON

Map Design: AJS, Date: March 22, 2017

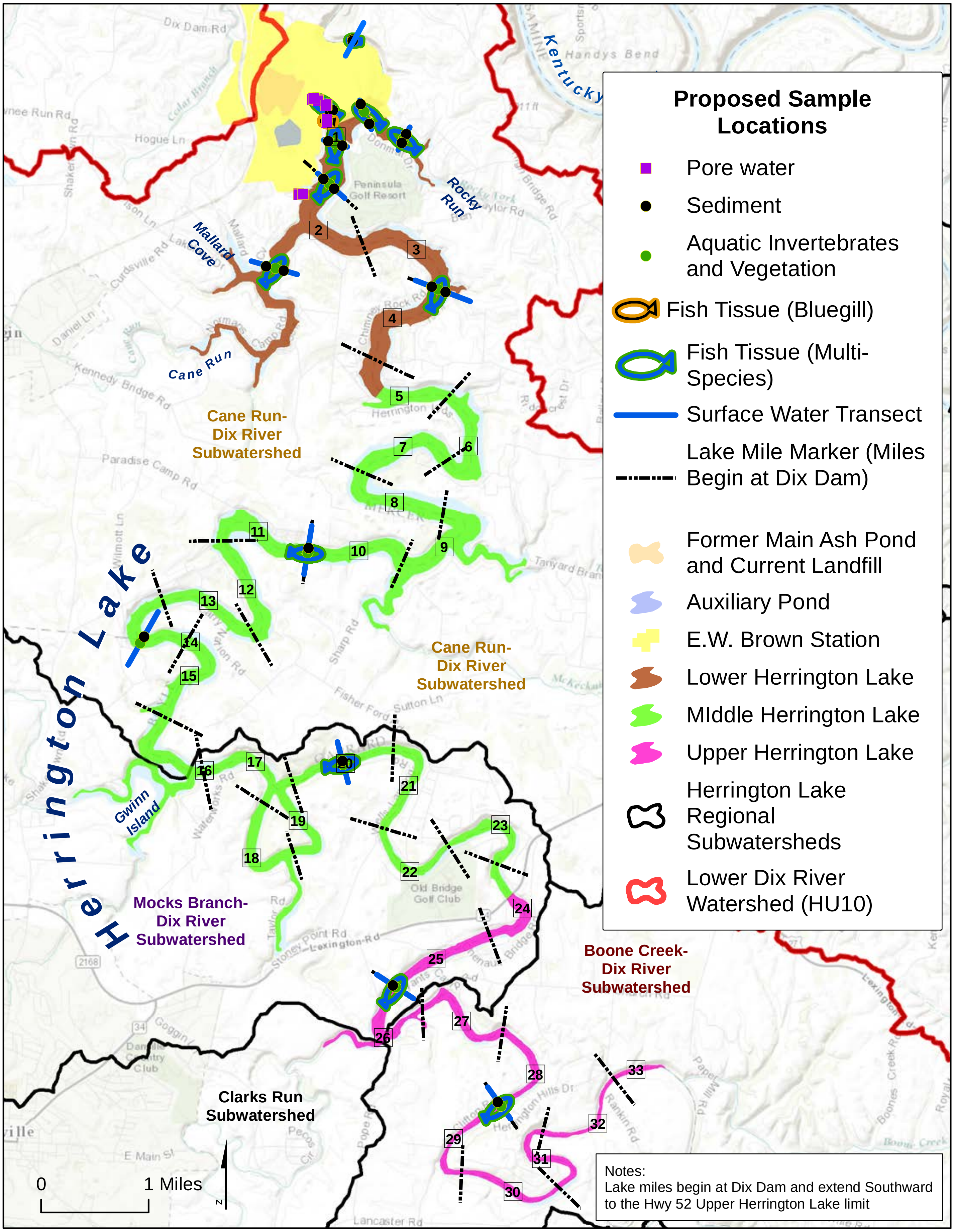
Permitted Dischargers within Upper and Lower Dix River Watersheds
Herrington Lake Corrective Action Plan
Mercer County, Kentucky

FIGURE 1-6A

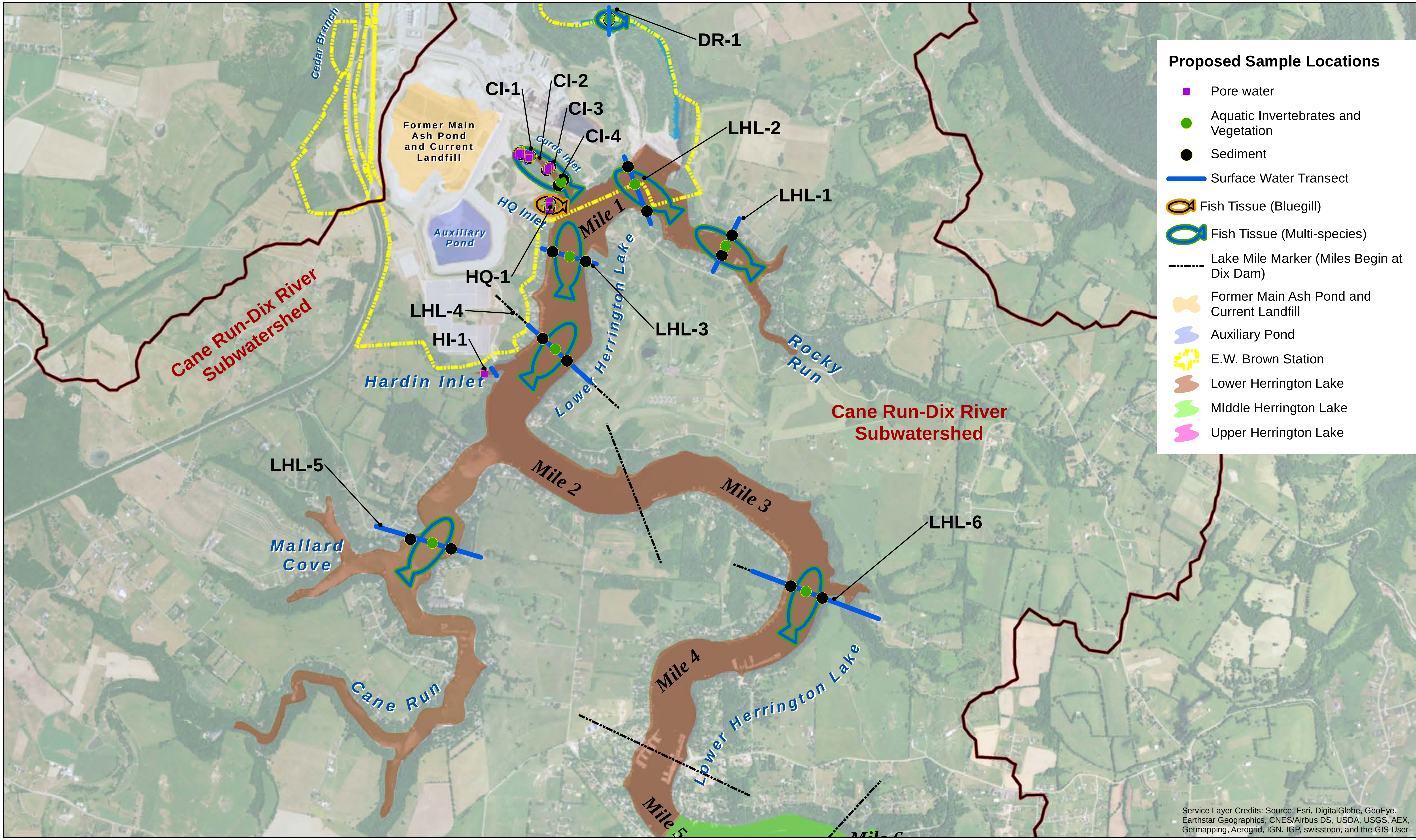
Project Code:




| | | |
|---|---|---|
| RAMBOLL ENVIRON<br>Map Design: AJS, Date: March 22, 2017 | Permitted Dischargers within the Lower Dix River Watersheds<br>Herrington Lake Corrective Action Plan<br>Mercer County, Kentucky | FIGURE 1-6B<br>Project Code: |




| RAMBOLL ENVIRON<br>Map Design: AJS, Date: March 7, | Herrington Lake Field Sampling Plan Overview<br>Herrington Lake Corrective Action Plan<br>Mercer County, Kentucky | FIGURE<br>2-1<br>Project Code: |
|---|---|---|




RAMBOLL ENVIRON

Map Design: AJS, Date: Mar 22, 2017

0 2,000 Feet

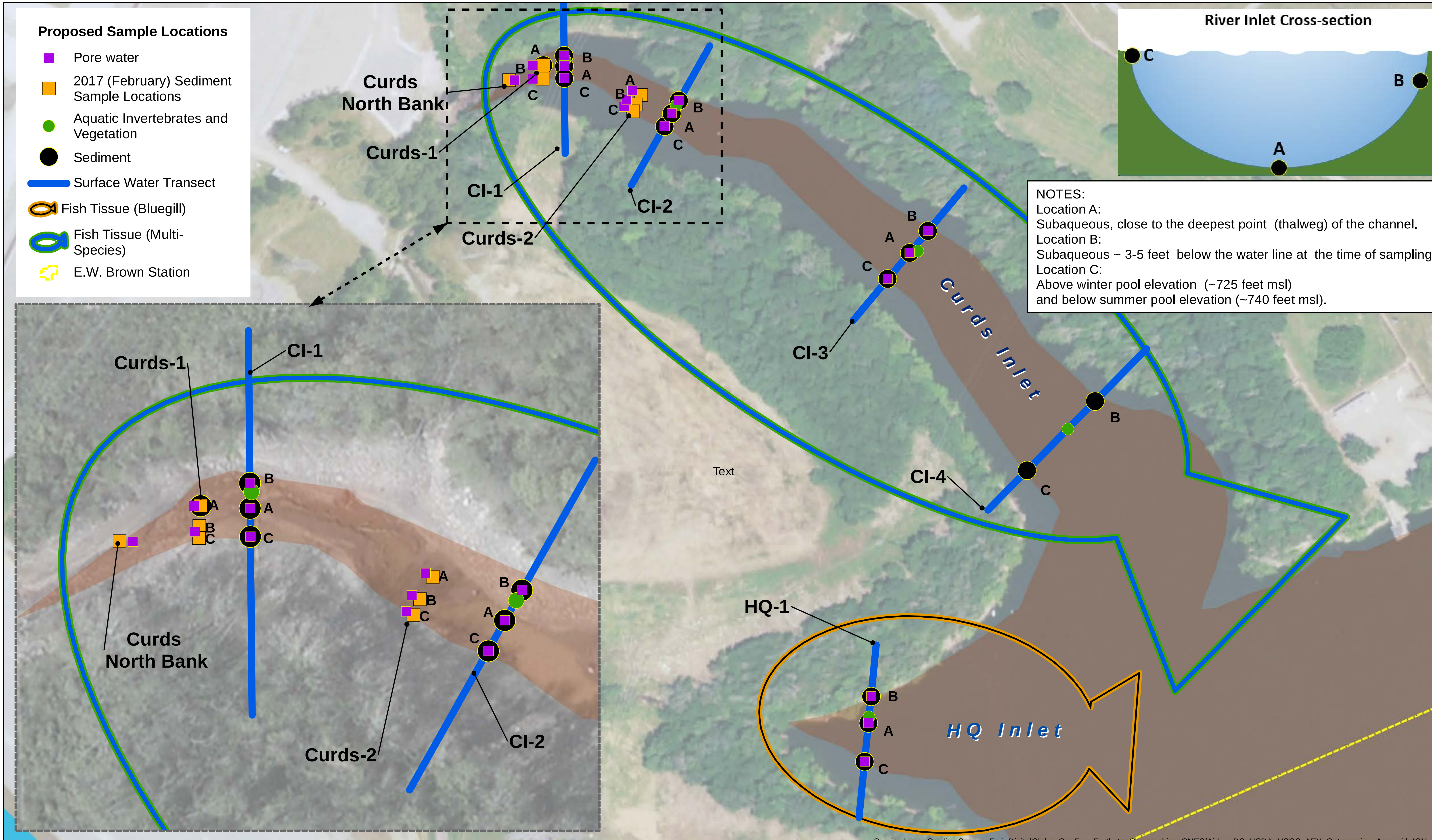
N

Notes:
Lake miles begin at Dix Dam and extend Southward to the Hwy 52 Upper Herrington Lake limit

Proposed Sampling Locations for Lower Herrington Lake
Herrington Lake Corrective Action Plan
Mercer County, Kentucky

FIGURE 2-2A

Project:




RAMBOLL ENVIRON

Map Design: AJS, Date: Mar 22, 2017

0 100 Feet

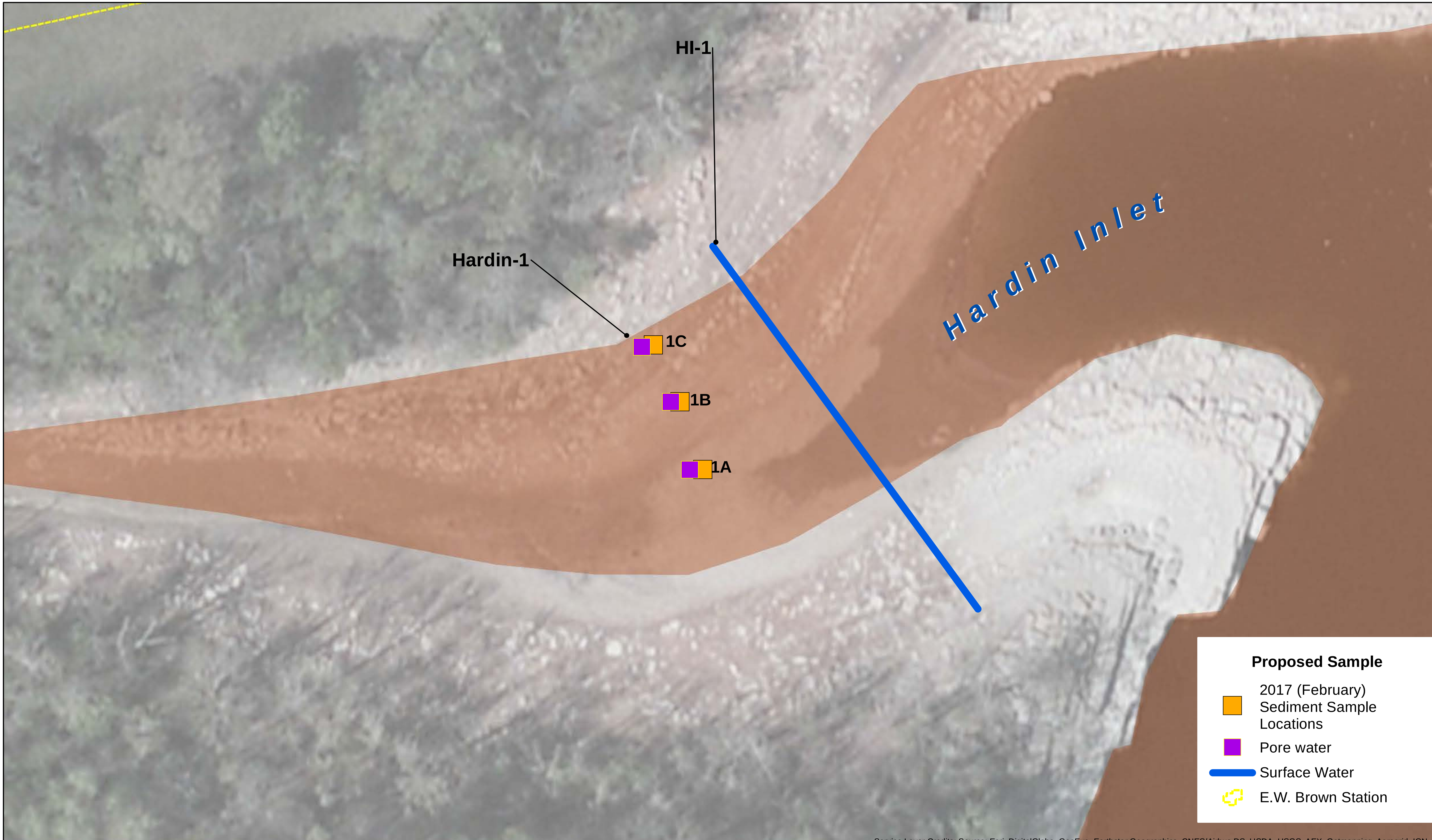
N

**Proposed Sampling Locations for Curds Inlet and HQ Inlet, Lower Herrington Lake, Herrington Lake Corrective Action Plan, Mercer County, Kentucky**

Notes:
Cirds North Bank, Curds-1, and Curds-2 sampling was completed in February 2017.

FIGURE 2-2B

Project:




RAMBOLL ENVIRON

Map Design: AJS, Date: Mar 22, 2017

0 50 Feet

N

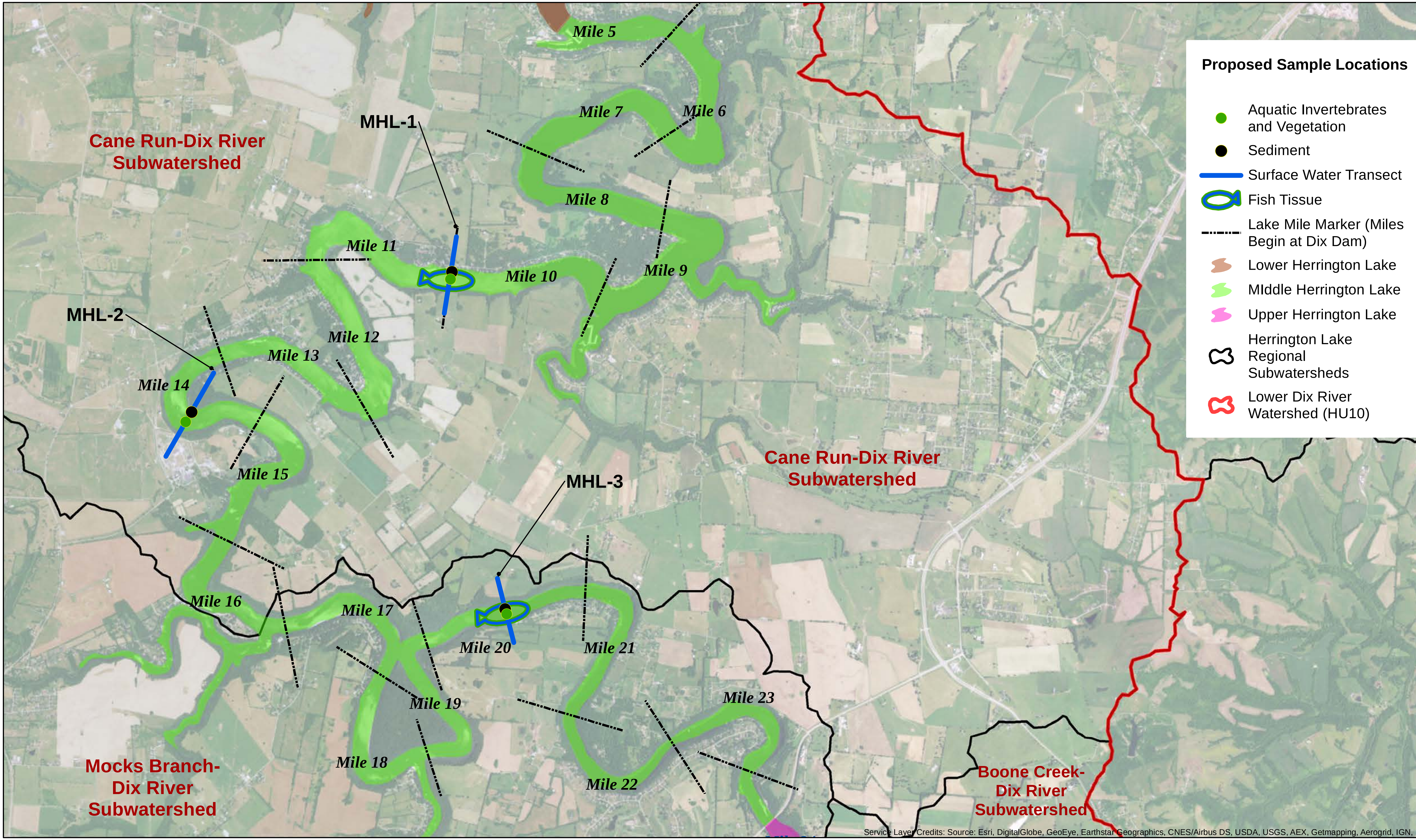
Notes:
Lake miles begin at Dix Dam and extend Southward to the Hwy 52 Upper Herrington Lake limit

## Proposed Sampling Locations for Hardin Inlet, Lower Herrington Lake
## Herrington Lake Corrective Action Plan
## Mercer County, Kentucky

Notes:
Hardin-1 sediment sampling was completed in February 2017.

FIGURE 2-2C

Project:




RAMBØLL ENVIRON

Map Design: AJS, Date: Mar 22, 2017

0 0.5 Miles

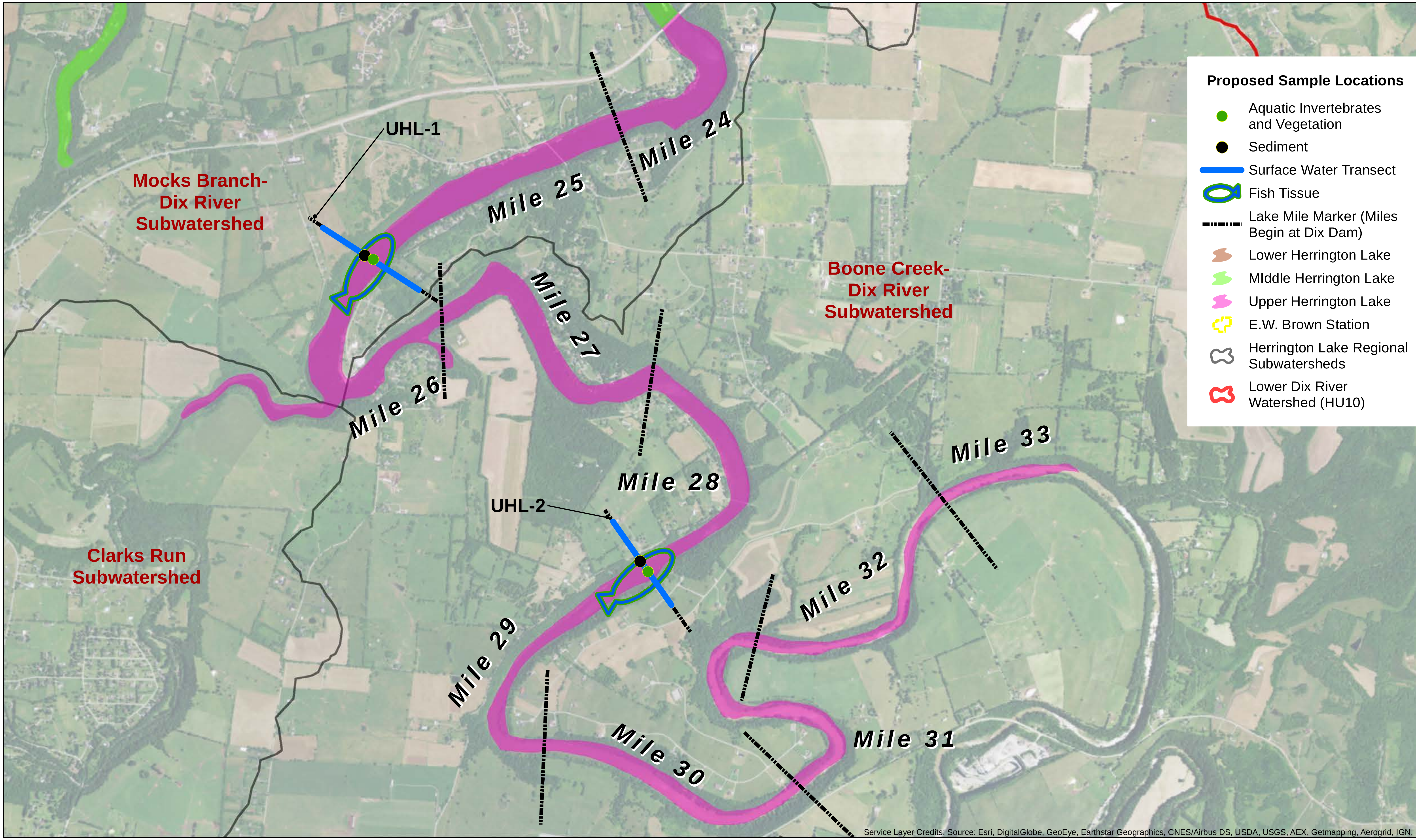
N

Notes:
Lake miles begin at Dix Dam and extend Southward to the Hwy 52 Upper Herrington Lake limit

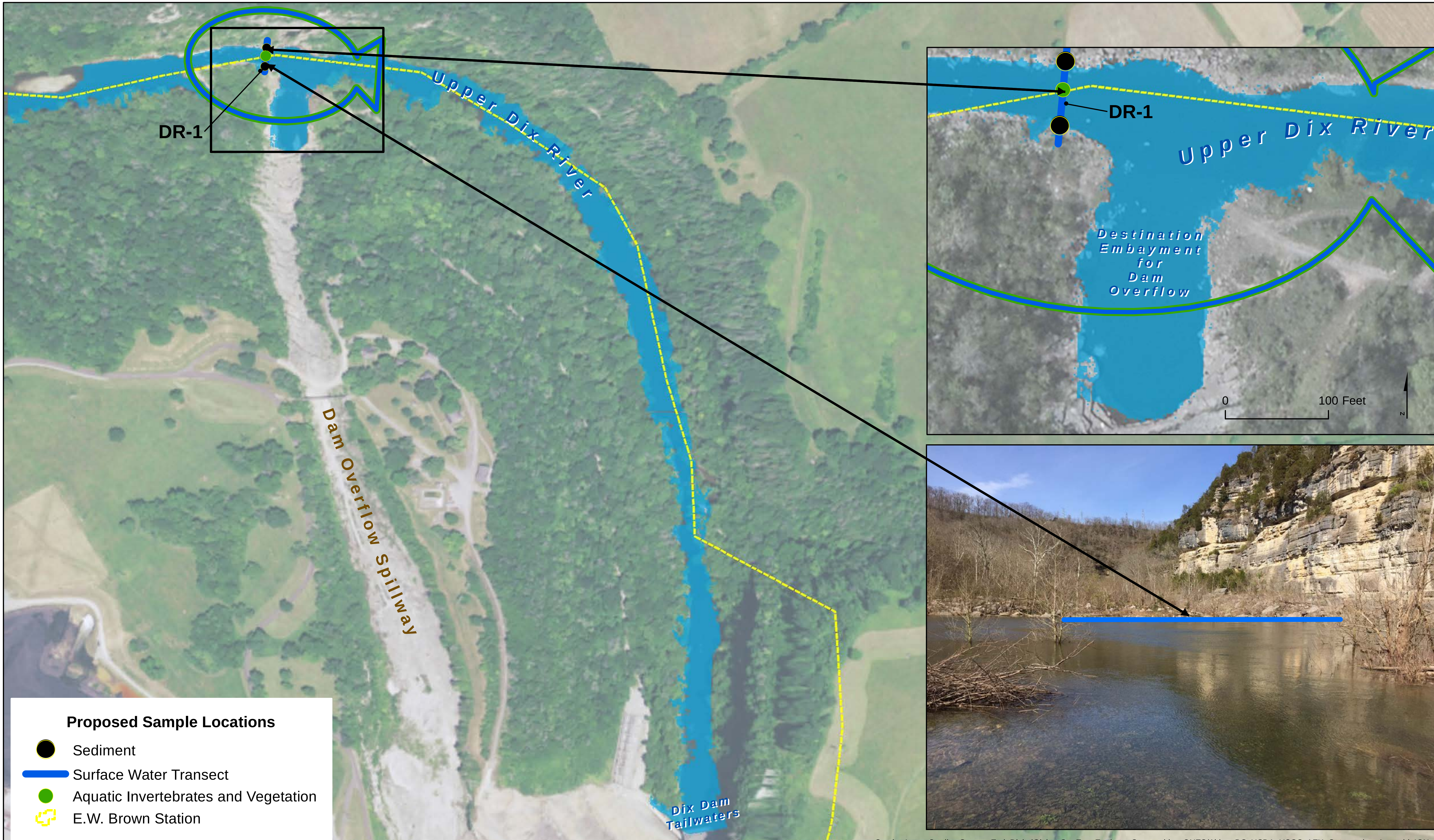
Proposed Sampling Locations for Middle Herrington Lake
Herrington Lake Corrective Action Plan
Mercer County, Kentucky

FIGURE 2-2D

Project:




| | | | |
|---|---|---|---|
| RAMBOLL ENVIRON<br>Map Design: AJS, Date: Mar 22, 2017 | 0 2,000 Feet | Proposed Sampling Locations for Upper Herrington Lake<br>Herrington Lake Corrective Action Plan<br>Mercer County, Kentucky | FIGURE<br>2-2E<br>Project: |




RAMBOLL ENVIRON

Map Design: AJS, Date: Mar 22, 2017

0 200 Feet

N

Proposed Sampling Locations for Dix River, Downstream from Herrington Lake Dam, Herrington Lake Corrective Action Plan, Mercer County, Kentucky

FIGURE 2-2F

Project:

## USEPA Expanded Eight-Step Ecological Risk Assessment Process

**USEPA SLERA**

**STEP 1: SLERA PROBLEM FORMULATION AND ECOLOGICAL EFFECTS CHARACTERIZATION**

- Screening-level problem formulation
  - Identification of environmental setting
  - Identification of constituents detected
  - Description of constituent fate and transport pathways
  - Description of constituent mechanisms of ecotoxicity
  - Description of receptors likely affected (including threatened & endangered species habitat evaluation)
  - Identification of complete exposure pathways; conceptual site model
  - Selection of generic assessment and measurement endpoints
- Screening-level ecological effects characterization
  - Identification of screening ecotoxicity values (ESVs)

**STEP 2: SLERA EXPOSURE ESTIMATE AND RISK CALCULATION**

- Identification of screening-level exposure estimates (maximum concentrations)
- Screening level risk calculations (ratio of exposure estimates and ESVs)
  - Hazard quotients >1 are identified as constituents of potential concern (COPECs) to carry into Step 3a
  - Chemicals without screening values are identified as constituents of potential concern (COPECs) to carry into Step 3a
- Evaluation of uncertainties

SMDP (a)

**USEPA BERA**

**STEP 3a: REFINEMENT OF STEP 2 SLERA EXPOSURE ESTIMATES AND RISK CALCULATIONS (BERA PROBLEM FORMULATION)**

- Refinement of COPECs (consideration of background concentrations, realistic exposure and effects assumptions, habitat characteristics, quantitative and qualitative biological evidence [e.g., biological survey data], additional screening or toxicity values)
- Refinement of assessment and measurement endpoints for bioaccumulative COPECs and preliminary food web modeling (if warranted)
- Refinement of risk characterization by evaluation of weight of evidence and ecological significance
- Refinement of uncertainties

**STEP 3b: REFINEMENT OF MEASUREMENT ENDPOINTS FOR BERA (ADDITIONAL PROBLEM FORMULATION)** → SMDP

- Refinement of the measurement endpoints for the BERA using direct contact approaches
- Refining or expanding food web assessment with the collection of site specific information
- Refinement using the collection of additional site-specific or laboratory data (e.g., mark and recapture studies, aquatic toxicity testing, benthic community assessment, avian nest box studies, tissue collection or bioaccumulation studies, etc.)

**STEP 4: STUDY DESIGN AND DQO PROCESS** → SMDP

- Study Design
- Data Quality Objectives and Statistical Considerations

**STEP 5: VERIFICATION OF FIELD SAMPLING DESIGN** → SMDP

- Determine sampling feasibility
- Final sampling location selection (including reference areas)

(Any changes in Work Plan and Sampling and Analysis Plan agreed upon with stakeholders)

**STEP 6: SITE INVESTIGATION AND DATA ANALYSIS** → SMDP

- Implement Final WP and SAP (SMDP needed only if alterations in WP and SAP are necessary)

**STEP 7: RISK CHARACTERIZATION**

- Analysis of data collected in Step 6 using the methods developed in Step 4

**STEP 8: RISK MANAGEMENT** → SMDP

Notes:

| | |
|---|---|
| (a) | SMDP occurs EITHER after Step 2 or after Step 3a |
| COPECs | Constituents of Potential Ecological Concern |
| DQO | Data Quality Objectives |
| GW | Groundwater |
| SAP | Sampling and Analysis Plan |
| SW/SD | Surface water and sediment |
| WP | Work Plan |
| SMDP | Scientific Management Decision Point [Note that SMDPs do not identify formal reporting requirements, but identify when stakeholder communication should be considered] |
| BERA | Baseline ERA |
| SLERA | Screening-level ERA |
| USEPA | United States Environmental Protection Agency |

Sources: USEPA Process Adapted from USEPA. 1997, 2000, 2001

USEPA. 1997. Ecological Risk Assessment Guidance for Superfund.

USEPA. 2000. Amended Guidance on Ecological Risk Assessment at Military Bases: Process Considerations, Timing of Activities, and Inclusion of Stakeholders .

USEPA. 2001. ECO-Update: Role of Screening-level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments.

RAMBOLL ENVIRON

DRAFTED BY: PAL | DATE: 5/22/2013

**USEPA'S EIGHT-STEP PROCESS**

Herrington Lake Corrective Action Plan
Mercer County, Kentucky

FIGURE 4-1

**Figure 6-1. Proposed Approximate Schedule for Activities and Reporting Through Phase I**
**Herrington Lake Corrective Action Plan**
**Mercer County, Kentucky**

| Tasks and Proposed Schedule Assuming Phase I Sampling Is Sufficient for Remedial Decision-making | Estimated Time By Task | 2017 | | | | | | 2018 | | | | | | | | | | | | 2019 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| **Public Review & Cabinet Approval** | 30 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Field Planning** | 60 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Phase I Field Sampling Effort (Summer Stratification Sampling Event)** | 30-45 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Laboratory Analysis | 30-45 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Data Validation & Data Mgt | 30 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Data Anaysis | 60 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Draft Phase I Tech Memo | 60 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Phase I Field Sampling Effort (Overturn Water Sampling Event)** | 7 days | | | | | | | | | ← | → | | | | | | | | | | | | | | | | | | | | |
| Laboratory Analysis and Validation | 30 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Data Analysis | 14 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Draft Phase I Tech Memo | 30 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Draft Phase I Tech Memo to Cabinet | ~June 15 | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | |
| Cabinet Review | 30 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Respond to Cabinet Comments and Submit Final Memo | 45 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cabinet Review and Approval of Final Memo | 30 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Develop Draft Investigation, Risk Assessment, Source Identification Report** | 90 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Submit Draft Report to Cabinet | ~Jan 15 | | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | |
| Cabinet Review | 45 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Response to Cabinet Comments and Submit Final Report | 60 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Develop Draft Corrective Action Remedy Evaluation Report** | 120 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Submit Draft Corrective Action Remedy Evaluation Report to Cabinet | ~Aug 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | X | | | |
| Cabinet Review | 45 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Response to Cabinet Comments and Submit Final Report | 60 days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

O Overturn
SS Summer Stratification assumes that sampling will include surface water, sediment, pore water, and biological tissues.

Schedule that involves Cabinet Reviews
Schedule that involves field or reporting efforts
← Schecule notation reflects that overturn sampling is not certain.

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