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Kingston Ash Recovery Project
Non-Time-Critical Removal Action
for the River System
Long-term Monitoring
Sampling and Analysis Plan (SAP)

Tennessee Valley Authority

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List of Acronyms

°F	degree Fahrenheit
ARAR	Applicable or Relevant and Appropriate Requirement
BERA	Baseline Ecological Risk Assessment
CERCLA	Comprehensive Environment Response, Compensation, and Liability Act
cfs	cubic feet per second
CoC	chain-of-custody
CRM	Clinch River Mile
cy	cubic yard
DOT	U.S. Department of Transportation
DQO	Data Quality Objective
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
ERDC	Engineer Research and Development Center
ERM	Emory River Mile
ft	foot
GPS	global positioning system
ID	identification
IDW	investigation-derived waste
kg	kilogram
KIF	Kingston Fossil Plant
LOAEL	lowest-observed-adverse-effects level
LTM	Long-term Monitoring
MDL	method detection limit
mg/L	milligram per liter
mg/kg	milligram per kilogram
MNR	Monitored Natural Recovery
msl	mean sea level
NOAEL	no-observed-adverse-effects level
NRDA	Natural Resource Damage Assessment
ORNL	Oak Ridge National Laboratory
PAH	polynuclear aromatic hydrocarbon
QC	quality control
RAO	Removal Action Objective
RG	Remediation Goal
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SPM	Sample Planning Module
TDEC	Tennessee Department of Environment and Conservation
TME	Tissue Monitoring Endpoint
TOC	total organic carbon
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority
TWQC	Tennessee Water Quality Criteria
TWRA	Tennessee Wildlife Resources Agency
USACE	U.S. Army Corp of Engineers

1. SITE BACKGROUND

This Sampling and Analysis Plan (SAP) details the data-gathering efforts to support the Long-term Monitoring (LTM) of portions of the Emory and Clinch Rivers that contain the largest deposits of residual ash from the December, 2008 fly ash release at the Tennessee Valley Authority (TVA) Kingston Fossil Plant (KIF) Release Site in Roane County, Tennessee.

On Monday, December 22, 2008, just before 1 a.m., a release of coal fly ash occurred at TVA's KIF, allowing a large amount of fly ash to escape into the adjacent waters of the Emory River. On January 12, 2009, the Tennessee Department of Environment and Conservation (TDEC) issued a Commissioner's Order, Case No. OGC09-0001 (TDEC 2009), requiring action be taken as necessary to respond to the release under Tennessee Code Annotated §69-3-109(b)(1), the Water Quality Control Act. The TDEC Order required a plan for the comprehensive assessment of soil, surface water, and groundwater; remediation of impacted media; and restoration of all natural resources damaged as a result of the coal ash release.

On May 11, 2009, the U.S. Environmental Protection Agency (EPA) and TVA signed an Administrative Order and Agreement on Consent (EPA 2009b) providing the regulatory framework for the restoration efforts. The Order directed the restoration work to be conducted under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and more specifically, under the removal program. Time-critical removal actions, completed in 2010, consisted of dredging of the ash from the Emory River and disposal of that ash in a permitted offsite landfill. Restoration efforts currently underway as a non-time-critical removal action consist of excavating the remaining ash in the Swan Pond Embayment and disposal of that ash in an onsite ash landfill.

In August 2012, an Engineering Evaluation/Cost Analysis (EE/CA) was issued for public comment that evaluated alternative response actions for the ash remaining in the river system with respect to their effectiveness, implementability, and cost (TVA 2012a). A subsequent Action Memorandum (TVA 2012b) recommended Monitored Natural Recovery (MNR) (Alternative 1 in the EE/CA) as the preferred removal action. The Action Memorandum is the decision document for the selected non-time-critical removal action. A Removal Action Work Plan (TVA 2012c) was subsequently submitted for LTM of the river system in accordance with the selected MNR remedy.

This SAP describes the Data Quality Objectives (DQOs), sampling design, and sampling procedures to be used for collecting the data necessary to assess the effectiveness of the selected removal action. This SAP has been prepared in accordance with EPA's *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (EPA 1993).

1.1 SITE DESCRIPTION

The KIF is located just off Swan Pond Road at the confluence of the Emory and Clinch Rivers on Watts Bar Reservoir in Roane County, near Kingston, Tennessee (Figure 1-1). KIF generates 10 billion kilowatt-hours of electricity a year, enough to supply the needs of about 670,000 homes in the Tennessee Valley. Plant construction began in 1951 and was completed in 1955. KIF has nine coal-fired generating units. The winter net dependable generating capacity is 1,456 megawatts. At full capacity the plant consumes about 14,000 tons of coal a day, producing about 800 cubic yards (cy) of fly ash and 200 cy of bottom ash.

Ash was stored in unlined containment areas, including a former dredge cell. Failure of part of the Dredge Cell dike released about 5.4 million cy of coal ash into Watts Bar reservoir. Coal contains various inorganic constituents that remain in the ash after burning. These include trace amounts of arsenic, chromium, copper, lead, mercury, nickel, selenium, thallium, vanadium, zinc, and other elements. Naturally-occurring radionuclides, such as isotopes of potassium, radium, uranium, and thorium, may also remain in the ash after coal combustion. These metals and radionuclides are typically bound to or incorporated into the glassy materials of the ash. The fly ash itself is primarily composed of fine siliceous spherical glass particles similar in composition to sand.

Rain events and subsequent high flows in the Emory and Clinch Rivers in the winter, spring, and early summer of 2009 (especially a May 2009 storm event), scoured the released ash and moved much of it further downstream. Two-dimensional ash transport modeling conducted by the U.S. Army Engineer Research and Development Center indicates that subsequent high flows, particularly after completion of the time-critical removal action, have moved much smaller quantities of ash downstream. The initial sediment/ash transport modeling indicated that the May 2009 storm event moved about 120,000 cy of ash downstream, with traces of fine particles of ash being transported into lower Watts Bar Reservoir, downstream of Tennessee River Mile (TRM) 566. The model predicts the primary deposition area for fine particles is between TRM 562 and 568. Sediment investigations performed from October 2011 through March 2012 indicate that about 500,000 cy of residual ash is present in the river system, with most of it occurring in the lower two miles of the Emory River and the two miles of the Clinch River immediately below the mouth of the Emory River. The River System EE/CA (TVA 2012a) identifies areas containing at least 0.5 ft of remaining ash deposits, extending from Clinch River Mile (CRM) 3.0 to Emory River Mile (ERM) 4.0 (Figure 1-2).

1.1.1 Climate

Climate in the region surrounding Kingston, Tennessee is warm during summer when average daily temperatures tend to be in the 70's ºF and cold during winter when temperatures tend to be in the 30's ºF. The warmest month of the year is July with an average maximum temperature of 87 ºF, while the coldest month of the year is January with an average minimum temperature of 25 ºF. Temperature variations between night and day tend to be moderate during summer with a difference that can reach 23 ºF, and moderate during winter with an average difference of 22 ºF.

The annual average precipitation at Kingston is 53.23 inches. Rainfall is fairly evenly distributed throughout the year. The wettest months of the year occur between November and April, with highest average monthly precipitation in March of 5.70 inches. The driest months of the year occur in August through October (National Weather Service 2006).

1.1.2 Surface Water Hydrology

The KIF is on the Emory River, approximately two river miles above the confluence of the Clinch and Emory Rivers. The Emory River drains a watershed area of approximately 865 square miles with daily average flow rates typically between 700 and 1,300 cubic ft per second (cfs). The Emory River is unregulated; therefore, flows react quickly to significant rainfall/runoff events and can increase by two or three orders of magnitude overnight. The reach of the Emory River affected by the release transitions from the more riverine (river-like) conditions between ERM 4.0 and 6.0 to more lacustrine (lake-like) conditions typical of impounded portions of the backwaters of Watts Bar Reservoir below ERM 4.0. At normal summer pool elevations (740 to 741 ft mean sea level [msl]) the impoundment extends upstream to above Harriman, Tennessee (ERM 11.0), while at normal winter pool elevations (735 to 737 ft msl) the impoundment only extends to about ERM 5.0. Consequently, overbank areas in the Swan Pond Embayment are very shallow. Pool levels in Watts Bar Reservoir are maintained by a series of dams to provide flood storage capacity for winter and spring floods and to maintain optimal water levels for summer recreation and hydroelectric power production.

The 100-year flood elevations for this reach of the Emory River vary from elevation 747.6 ft msl at ERM 1.5 to elevation 749.4 ft msl at ERM 3.5. At the Swan Pond Embayment, located at ERM 2.5, the 100-year flood elevation would be approximately 748.5 ft msl. The 100-year flood post-release elevations were higher than pre-release elevations, but returned to pre-release levels after completion of the time-critical removal action.

The Emory, Clinch, and Tennessee Rivers are waters of the state. “Waters of the State” are defined in T.C.A. §69-3-103(33) and are classified by the Tennessee Water Quality Control Board for suitable uses. The three rivers have been classified for the following uses: domestic water supply, industrial water supply, fish and aquatic life, recreation, irrigation, livestock watering and wildlife, and navigation. The Tennessee River is the source of drinking water for the city of Kingston, Tennessee. The downstream Watts Bar Reservoir is used by several municipalities as a source of drinking water.

1.1.3 Ecology

The following summary of ecological conditions and immediate impacts from the release is summarized largely from Section 2.1.6, Natural Resources, of the *Corrective Action Plan for the TVA Kingston Fossil Plant Ash Release* (TVA 2009a), the SAP (TVA 2010b), and the Baseline Ecological Risk Assessment (BERA) (Arcadis 2012). Existing information from various TVA and Tennessee Wildlife Resources Agency (TWRA) projects and surveys were used to describe the aquatic community prior to the release. These included TVA fish and benthic surveys conducted as part of the TVA Reservoir Vital Signs Monitoring Program; TVA fish, mussel, wetlands, and avian surveys conducted in support of permit requirements and National Environmental Policy Act assessments for the plant and other TVA projects in the vicinity; and TWRA fish and mussel surveys and creel data.

Fish and Aquatic Life

TVA has systematically monitored the ecological conditions of its reservoirs since 1990 as part of the Vital Signs Monitoring Program. The fish assemblage in the Clinch River in Watts Bar Reservoir has rated “good” or “fair” on a “Good—Fair—Poor” evaluation system that incorporates several different fish community measures. The quality of the Watts Bar Reservoir sport fishery has consistently rated at or above the valley-wide average.

A total of 43 species of fish were caught during 2009 TVA fish sampling efforts in the general vicinity of the release; predominant species included gizzard shad, bluegill, channel catfish, largemouth bass, and redear sunfish. Two federal- and state-listed threatened fish species, the snail darter and the spotfin chub, may occur within Watts Bar Reservoir. In addition, the blue sucker is state-listed as threatened and the tangerine darter, flame chub, and Tennessee dace are identified by the state of Tennessee as species in need of management.

Prior to the ash release, the mussel fauna in the Emory River near the plant had been substantially altered by the impoundment of Watts Bar Reservoir, by impacts from mining in the headwaters, and by municipal and industrial wastewater discharges further upriver (Yokley 2005). Six mussel species (giant floater, fragile papershell, pistolgrip, pimpleback, wartyback, and three-horn wartyback) and a common aquatic snail (horn snail) were found in a pre-release survey of this area. All of these species, except the pistolgrip, are generally tolerant of reservoir conditions and could have been expected to occur in the area affected by the ash release, but in small numbers due to the low dissolved oxygen conditions that occasionally develop in summer in the impounded part of the Emory River. Eight species of mussels and one species of aquatic snail are federal- and state-listed as endangered. In addition, the state identified the pyramid pigtoe mussel as a species in need of management.

Reservoir bottom sediments provide habitat for a variety of aquatic worms and the larval form of many aquatic insects. The abundance and diversity of these benthic invertebrates depend on factors such as the physical properties of the sediments, presence or absence of dissolved oxygen in the overlying water, and abundance of food. In an area such as the Emory River arm of Watts Bar Reservoir, mayfly and caddisfly larvae and a variety of midges and chironomids, among other benthic fauna are expected to occur.

During the ash release, fish in the area were stranded on adjacent shorelines and experienced physical trauma due to the ash, debris, and high levels of suspended solids in the water. Approximately 200 to 300 dead fish (including threadfin shad, freshwater drum, smallmouth buffalo, largemouth bass, and sunfish) were observed immediately following the release, mostly on stream banks where they were stranded by the initial surge of water. Bottom-dwelling animals (mussels, snails, insects, crayfish, etc.) in areas where large amounts (>0.5 ft) of ash were deposited likely were unable to escape the release and were smothered by ash deposits. TVA fish community and benthic community assessments conducted in 2009 and 2010 indicated that within a few months after the release fish and benthic invertebrates were present in numbers and conditions typically observed for similar water bodies.

Wetlands

Wetland habitats in the vicinity of the plant have been monitored as part of a larger study associated with the 2004 TVA Reservoir Operations Study and Environmental Impact Statement (TDEC 2004). Two wetland study plots are located within the Swan Pond Embayment area north of the Dredge Cell. Baseline data were collected on these plots in 2004 and 2006. One scrub-shrub and one forested wetland plot were part of the original Reservoir Operations Study design. The Swan Pond Embayment plots were chosen because they were high quality wetland plots on TVA land, which ensured access for LTM.

Wetland areas in the Swan Pond Embayment prior to the ash release typically were associated with shoreline margins, floodplains of tributary streams, small islands, and heads of reservoir coves. These wetlands included a mix of forested, shrub, and/or herbaceous vegetation depending on the land use. National Wetland Inventory maps show narrow fringe wetlands along the shorelines of Swan Pond Embayment, and three small island wetlands.

Wetland areas along the Emory and Clinch Rivers also are generally limited to narrow fringe wetlands due to the approximately 5-ft variation in water elevation between winter and summer pool levels and the relatively steep topography along much of the shoreline. Those conditions restrict locations where soils remain saturated to a relatively small area. Exceptions typically are located near shallow inlets fed by springs or small tributaries. The reservoir shorelines have sparse vegetation, with small beds of emergent vegetation located below the summer pool level. Wetland plants along the summer pool shoreline also are limited in distribution, primarily occurring along points and islands. These fringe wetlands appear to be comprised primarily of rushes or cattails.

The ash release eliminated all the wetlands (including three small island wetlands) in the Swan Pond Embayment; some of these wetlands were heavily used by waterfowl and shorebirds. Approximately 2.5 acres of wetlands were affected by the ash release. Restoration of these wetland areas is currently underway as part of the non-time-critical removal action for the Swan Pond Embayment.

Other Ecological Habitat Types

Other ecological habitats, largely riparian interfaces between upland (terrestrial) habitats and aquatic habitats (reservoir and river tributaries), were present in the area prior to the release. Riparian habitats along the Emory, Clinch, and Tennessee Rivers are varied in nature and include mature deciduous (or mixed) forests, scrub/shrub, mixed herbaceous vegetation, rock or concrete retaining walls, and manicured lawns. Riparian zones can be important habitats for a variety of wildlife species. Riparian zones were identified by using a 25-yard wide buffer of pre-release hydrology along the shoreline. Approximately 55 acres of riparian zone habitat may have been affected by the release.

Much of the riparian zone adjacent to the former Dredge Cell consisted of short grasses and a thin marginal strip of shoreline trees. This habitat and manicured residential lawns offered minimal wildlife benefits. Forested habitat along the embayment, east of the former Dredge Cell represented better wildlife habitat.

Because of the shallow depths of the overbank areas (former river terraces and floodplains), a large mudflat is exposed along much of the shoreline during winter months when reservoir levels are lowered for flood storage. The portion of that mudflat adjacent to the ash release site, particularly in the Swan Pond Embayment, was covered by ash following the release. Four islands near the Dredge Cell also were affected by the release. One island was used by a colony of great blue herons and black-crowned night-herons. The islands also provided nesting habitat for Canada geese.

Native terrestrial plant and animal communities in the Ash Pond area were greatly altered by KIF plant operations prior to the release. The dominant plant communities consisted of a variety of wetland species in and on the fringes of the ash Settling Ponds and at the outer base of the dikes. The interiors of the former dredge cells contained no vegetation, although the dikes were vegetated with a mixture of common, weedy, native and nonnative grasses, and herbs. A band of riparian trees and shrubs, including sycamore, willow, boxelder, and alder occurred along much of the outer edge of the dikes adjacent to the reservoir. Similar riparian vegetation occurred along other parts of the shoreline of Swan Pond Embayment and on the islands in the embayment. Other affected areas of the reservoir shoreline were landscaped, suburban lawns or oak-hickory forest.

The Ash Pond, Stilling Pond, Swan Pond Embayment, and the adjacent Emory River were heavily used by Canada geese, wood ducks, great blue and green herons, great egrets, belted kingfishers, osprey, and double-crested cormorants. A variety of songbirds, semi-aquatic mammals, turtles, and water snakes were abundant in the riparian vegetation along the shoreline. Ospreys are common in the area, often nesting on natural and man-made structures on and around the plant properties. Heron colonies also occurred near the plant prior to the release; the closest was approximately 0.3 mile upstream of the Emory River and in direct line of sight of the affected area. A second colony including great blue herons and double-crested cormorants occurred just downstream of the junction of the Emory and Clinch Rivers.

Numerous bird species use the riparian and wetland habitats along the reservoir (Arcadis 2012). Common species include resident populations, wading shorebirds, and migratory species. Some neotropic migrant species, such as killdeer and semi-palmated plover, are commonly found within the reservoir area, as well as waterfowl species, such as mallard, American black duck, hooded merganser, resident Canada goose, and wood duck. There are also other water/wading birds, such as pied-billed grebe, and various tern and gull species. Piscivorous birds, such as double-crested cormorant, great blue heron, black-crowned night-heron, and osprey are common and nest along the river. One federal-listed protected species, the bald eagle, is present within the reservoir area, and one state-listed endangered species, Bachman’s sparrow, is present. Four state-listed species in need of management are also found, including bald eagle, barn owl, least bitten, and sharp-shinned hawk.

The reservoir area supports a number of mammal species in its riparian, wetland, and aquatic habitats. Common mammals seeking food and cover in these habitats include white-tailed deer, eastern mole, eastern cottontail rabbit, groundhog, gray fox, and coyote, along with others. One federal- and state-listed endangered species, the gray bat, is present. Additionally, the eastern small-footed bat, southeastern shrew, and southern bog lemming are state-listed as species in need of management.

The reservoir area supports a number of amphibian and reptile species, such as bullfrog, green frog, eastern narrow-mouth toad, Fowler's toad, northern water snake, common snapping turtle, painted turtles, and red-eared slider. While there are no federally-listed amphibian or reptile species in this area, a number of state-listed species are present, including the Berry cave salamander and northern pine snake. In addition, the eastern hellbender, four-toed salamander, and eastern slender glass lizard are listed by the state as species in need of management.

Various species of wildlife may have been affected by the release, as several wetland and riparian habitats used by these species were destroyed or greatly modified. Samples of mammals, spring breeding frogs, aquatic turtles, and bird resources demonstrate that these organisms remain in the area. Low levels of immediate wildlife mortality were associated with the ash release. Immediately following the release, a great blue heron carcass was found at the Site by the U.S. Fish and Wildlife Service. A small colony of great blue heron located on an island near the release appeared to be unaffected by the release. The Ash Pond and Settling Pond used by shorebirds and waterfowl were not affected by the release; however, ash removal operations reduced shorebird and waterfowl activity at those ponds.

Riparian habitat types were impacted by the release; their overall acreage was changed by the release and by removal actions. The marginal strip of forest habitat was heavily impacted. The portion of the Swan Pond Embayment upstream of Swan Pond Circle Road (referred to as the North Embayment was completely filled by ash. From the time of the release until it was cleared of ash in late 2011 it consisted of a narrow stream corridor with a riparian zone consisting of grasses, rip-rap, and other erosion control measures. A small slough north of the Dredge Cell (Church Slough) and a slough directly across the Swan Pond Embayment from the Dredge Cell (referred to as the East Embayment) were cleared of ash in 2009 and 2010, respectively, and exhibit vegetation regrowth and wildlife activity, as does the North Embayment. The island with the large heron colony remains intact; ash removal operations have not disturbed heron reproduction. Osprey and Canada geese also continue to breed in proximity to the Site. Tree swallow colonies continue to produce viable eggs and young. Restoration of remaining disturbed riparian zones is underway as part of the non-time-critical removal action for the Swan Pond Embayment.

1.2 SOURCES

1.2.1 Previous Removal Actions

Immediately following the ash release, an Incident Command Center was established and emergency measures were implemented to ensure safety of people in the area, contain and evaluate the damage, and plan for recovery of the ash. Several routine monitoring programs were put in place to monitor river water, drinking water, and air quality. Road, railroads, and utilities were repaired and replaced. Dikes and weirs, both on land and in the water, were constructed to control the ash movement. Dust control activities were implemented and are ongoing. Storm water management systems, such as clean water diversion ditches and ash water collection and settling basins, were constructed.

Time-critical removal actions began immediately following issuance of the EPA Order on May 11, 2009. On August 4, 2009, an Action Memorandum was approved for removing ash from the Emory River east of Dike 2 under a time-critical removal action (TVA 2009b). Actions included hydraulic and mechanical dredging of ash from the Emory River, mechanical excavation of ash from the Swan Pond Embayment, dewatering and processing of the recovered ash (including water management), transport of the ash via rail offsite, and disposal of the ash at the Arrowhead Landfill in Perry County, Alabama. The dredging associated with the time-critical removal action was completed in June 2010, and offsite disposal was completed in December 2010.

On May 18, 2010, an Action Memorandum was approved for removing ash from the Swan Pond Embayment under a non-time-critical removal action (TVA 2010a). The decision was made to remove ash from the embayment using primarily land-based equipment, then process and dispose of the ash in an onsite Ash Landfill. Other related actions include Perimeter Wall Stabilization around the former Dredge Cell and Ash Pond to contain the ash within the Ash Landfill, final cap and cover to close the landfill, and restoration of the aquatic and riparian habitats within the embayment. The non-time-critical removal action is ongoing and is anticipated to be complete by October 2014.

On November 12, 2012, an Action Memorandum (TVA 2012b) was approved that recommended the selection of MNA (Alternative 1 in the EE/CA [TVA 2012a]). A Removal Action Work Plan (TVA 2012c) was subsequently submitted for the LTM of the river system in accordance with the selected MNA remedy. This SAP represents the implementation of the MNA removal action.

1.2.2 Residual Sources of Contamination

Residual ash in the Emory, Clinch, and Tennessee River system following the time-critical dredging activities was assessed under an EPA-approved River System SAP (TVA 2010b). Residual ash deposits greater than 0.5 ft in thickness were identified in downstream reaches of the Emory and Clinch Rivers (Figure 1-2). A total of 189 VibeCore samples were collected in the parts of the Clinch and Emory Rivers where the greatest amount of residual ash was expected to occur. The maximum thickness of ash deposits observed in VibeCore samples was 4.2 ft in Emory River Reach B (ERM 1.5 to 3.5); greater thicknesses of ash deposits may occur in areas not on the sampling grid. Ash deposits are more extensive in Emory River Reach A (ERM 0.0 to 1.5) than in other reaches, in part because time-critical dredging was not conducted below ERM 1.8 due to the presence of legacy constituents (cesium-137) in the sediment. Based on the results of the River SAP sampling, the total volume of measurable ash deposits estimated to remain in the river system is approximately 510,000 cy dispersed over approximately 200 acres of the river system (TVA 2012a).

Numerous samples of cell ash, sediment, surface water, groundwater, and biota were collected and analyzed for metals, metalloids, organic chemicals, radionuclides, and other parameters. Metalloids, primarily arsenic and selenium, were the focus of this monitoring, since they contribute most to potential ecological risk. Arsenic is present in the cell ash at an average concentration of 74.5 milligrams per kilogram (mg/kg); selenium is present in the cell ash at an average concentration of 7.89 mg/kg (TVA 2012a).

Sixty-nine samples of seasonally-exposed sediments (i.e., the mudflats described in Section 1.1.3 Ecology) were collected near the shoreline in the Emory and Clinch River reaches. Arsenic and selenium were detected in 49 and 7 of 53 samples, respectively, collected in Emory River Reaches A through C and Clinch River Reach B. Average arsenic concentrations in seasonally-exposed sediments varied between 14.3 and 19.2 mg/kg in the Emory and Clinch River reaches. Average concentrations of selenium, when detected, were near detection limits, ranging from 1.77 to 2.45 mg/kg in the downstream reaches.

Eighty-one samples of submerged sediments were collected from the river bottom from the 10 river reaches. Average arsenic concentrations in submerged sediment were highest in the lower Emory River, at 25.0 mg/kg, and declined to an average of 12.1 mg/kg in the Tennessee River. Average concentrations of selenium, when detected, were highest in the Emory River at 5.16 mg/kg, then declined to non-detect in the Tennessee River sediment.

Surface water samples were collected during an 8-week period in September and October 2010, from both mid-depth and epibenthic (near the bottom of the river) zones. Eighty-eight mid-depth surface water samples were analyzed from 11 stations located in the Emory, Clinch, and Tennessee Rivers. Average total arsenic concentrations in mid-depth surface water were highest in the Emory River at 0.0020 milligrams per liter (mg/L), then declined to near upstream reference values (0.0007 mg/L) in the Tennessee River. Total arsenic in epibenthic surface water in the Emory River was higher than mid-depth surface water, varying between 0.0030 and 0.0037 mg/L. Selenium was detected infrequently and at low concentrations near reference values (0.00033 mg/L) in surface water samples. No constituents in the mid-depth and epibenthic surface water samples in downstream reaches exceeded Tennessee Water Quality Criteria (TWQC). Total arsenic, lead, and mercury concentrations occasionally, but infrequently, exceeded TWQC during storm event sampling.

Samples of plants and animals were analyzed for evaluation of bioaccumulation and food web modeling in the ecological risk assessment. In addition, results of toxicity testing of sediment and surface water and surveys of fish and benthic invertebrate communities were additional lines of evidence used in evaluating ecological risks.

2. SAMPLING OBJECTIVES (DATA QUALITY OBJECTIVES)

DQOs define the purpose of the data collection effort, clarify what the data should represent to satisfy this purpose, and specify performance requirements for the quality of information required. The DQO process (Figure 2-1) is a seven-step iterative planning approach used to prepare plans for environmental data collection activities. The following DQOs for the river system have been prepared in accordance with EPA's *Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4* (EPA 2006), and *Data Quality Objectives Process for Hazardous Waste Site Investigations, EPA QA/G-4HW* (EPA 2000a).

The baseline ecological risk assessment presented in the River System EE/CA (TVA 2012a) identified low to moderate risks to benthic invertebrates and insectivorous birds; an Action Memorandum (TVA 2012b) was issued and subsequently approved. The approved Action Memorandum recommended MNR (Alternative 1 in the EE/CA) as the preferred action to address the potential risks. The purpose of this SAP is to verify that MNR Removal Action Objectives (RAOs) are achieved. The RAOs outlined in the Action Memorandum are:

- Protect benthic invertebrate populations in Watts Bar Reservoir from adverse effects due to arsenic and selenium in ash-contaminated sediment;
- Protect riparian-feeding bird (e.g., killdeer) and aerial-feeding bird (e.g., tree swallow) populations from adverse effects due to uptake of arsenic and selenium in ash contaminated sediment through their diet (benthic invertebrates);
- Restore the ecological function and recreational use of the river system to pre-release conditions.; and,
- Dispose of waste streams from the removal action in accordance with Applicable or Relevant and Appropriate Requirements.

2.1 DQO STEP 1: STATE THE PROBLEM

The scope of the removal action is to fulfill mid- and long-term strategic objectives for the Site, as defined in the EPA Order. The scope addresses the residual ash in the Emory, Clinch, and Tennessee Rivers remaining after completion of prior removal actions.

Naturally-occurring metals and metalloids are present within the residual ash and sediment; arsenic and selenium are of particular interest. Benthic invertebrates may be exposed to these constituents in the sediment. Riparian- and aerial-feeding birds may be exposed to these constituents via consumption of benthic invertebrate prey. The BERA recommended risk management actions for benthic invertebrates and insectivorous riparian- and aerial-feeding birds.

2.2 DQO STEP 2: IDENTIFY THE DECISION

The principal study question is: Do levels of ash-related constituents in sediment or diet (benthic invertebrates) continue to pose sufficient risk to ecological receptors to warrant additional management actions? Remediation goals (RGs) and tissue monitoring endpoints (TMEs) (Table 2-1) have been selected to be protective of the ecological receptors; therefore, this study question may also be stated as: Do levels of ash-related constituents continue to exceed the RGs in sediment or the TMEs in benthic invertebrates? Secondary study questions are: If so, what is the geographical location and areal extent impacted? Do trends indicate natural attenuation processes (e.g., mixing of ash and sediment, diminishing biouptake) are occurring as predicted?

The ultimate decision to be made is whether the residual ash-related constituents (i.e., arsenic and selenium) show unexpected trends or pose a level of risk requiring further action. Possible further actions include adjusting the MNR sampling and analysis strategy, spot removal of residual ash from the river system, or selective capping of residual ash.

Table 2-1 Selection of Remedial Goals and Tissue Monitoring Endpoints

Remedial Goal Options					
Receptor / Exposure Pathway	**Wet or Dry Weight**	**Equivalent Reference Concentration**	**Threshold Effect Concentration**		**Selected Remedial Goal Range**
			IC_{25} (Midge)	**IC_{25}(Amphipod)**	
Benthic Invertebrates					
Arsenic concentration in sediment	Dry	8.0	29	41	29 - 41
Selenium concentration in sediment	Dry	3.0	2.8	3.2	3.0 - 3.2
Tissue Monitoring Endpoint Options					
Receptor / Exposure Pathway	**Wet or Dry Weight**	**Equivalent Reference Concentration**	**Threshold Effect Concentration**		**Selected Tissue Monitoring Endpoint Range**
			NOAEL	**LOAEL**	
Killdeer					
Arsenic concentration in diet (larval mayfly)	Dry	8.4	34	81	34 - 81
Selenium concentration in diet (larval mayfly)	Dry	7.1	2.3	5.0	7
Tree Swallow					
Selenium concentration in diet (adult mayfly)	Dry	7.0	1.6	2.8	7

Note: All units in mg/kg.

2.3 DQO STEPS 3-7: STUDY DESIGN

The next five steps of the DQO process consist of identifying inputs to the decision (data gaps), defining the study boundaries, developing decision rules, specifying the decision errors, and finally optimizing the sampling design. These DQO steps were addressed for each environmental medium of concern during an interactive DQO workshop attended by TVA, EPA, TDEC, and other agencies. This SAP describes the planned sampling and study design to fill the identified data gaps and address the DQOs.

The study boundaries are ERM 6.0 through CRM 1.5. Ecological exposures typically occur in the upper 6 inches of submerged sediment; therefore, the depth of sampling will be the upper 6 inches of sediment. Sample locations planned for 2013 and beyond are detailed in Appendix B and Figure 2.2.

The proposed LTM plan uses an adaptive monitoring and management framework (Section 3). Study results will be evaluated periodically and the monitoring design will be changed if appropriate. Newly collected data will be compared with previous results to identify trends and inform management decisions. This will provide for effective response to unexpected monitoring results and will provide objective decision points for changing, continuing, or terminating specific monitoring program components. In addition to annually or biennially reviewing the most recent results, a formal evaluation of results will be performed for each 5-year CERCLA review period. If the results of that evaluation indicate changes are needed, the sampling scope, locations, and/or frequency will be adjusted appropriately.

2.3.1 Sediment Transport Modeling and Sediment Monitoring

The BERA presented in the EE/CA (TVA 2012a) indicated that benthic invertebrates (e.g., mayflies or snails) were considered to be at moderate risk in the Emory River and low risk in the Clinch River due to biouptake of arsenic and selenium in ash-contaminated sediment. Therefore, the RAO for sediment is to protect benthic invertebrate populations in Watts Bar Reservoir from adverse effects due to arsenic and selenium in ash-contaminated sediment. In order to evaluate the effectiveness of MNR, sediment sampling will be conducted during LTM to support sediment transport modeling, contaminant monitoring, toxicity testing, and evaluations of benthic community survey results. Scour and sedimentation processes are effective in naturally capping the ash deposits and in reducing concentrations of arsenic and selenium in the river sediments by mixing with inflows of native sediments. The U.S. Army Corp of Engineers (USACE) Engineer Research and Development Center (ERDC) performed baseline fate and transport modeling of the Emory and Clinch Rivers sediments to evaluate long-term effectiveness of MNR (ERDC 2012). Those results indicate that dynamic natural processes yield decreasing proportions of ash and decreasing concentrations of arsenic and selenium in sediments in the Emory and Clinch Rivers. Natural sedimentation and scour is predicted to produce a layer of mixed ash and sediment approximately 6 inches thick in depositional side channel areas that meets the project's RAOs within 10 to 15 years.

The modeling also shows that periodic severe storm flow events (greater than a 10-year recurrence interval) would scour portions of this natural cover, particularly in the main channel and in some of the side channel deposits. Such severe storm events may temporarily expose deeper sediments with higher concentrations of ash and ash-related constituents. However, the model predicts that the natural cover of mixed ash/sediment would redevelop in those areas, and that ash and natural sediment mixtures would continue to deposit in side channel areas of the Emory and Clinch Rivers. Over a period of several cycles of high flows, most of the residual ash in the lower part of the Emory River and Clinch River eventually would be transported downstream and re-deposited as thin layers of mixed sediment and ash in the lower end of Watts Bar Reservoir near Watts Bar Dam.

The sediment fate and transport model will be updated in 2013 with new, higher-resolution bathymetry from the Emory and Clinch Rivers. Modeling will also be used after each storm event of greater than 10-year recurrence interval (>110,000 cfs) to evaluate sediment mixing and transport. If a 10-year storm has not occurred during the initial five-year review period, the model will be re-run in 2017. Following each modeling run, "ground-truth" sediment samples will be collected from several depositional areas to confirm the modeled results and further refine the model, if needed.

Updated bathymetry data to support sediment transport modeling will be collected in 2013 at 200 ft intervals from CRM 2.0 to ERM 5.0. Vertical accuracy of approximately 1 ft is adequate to support the model. Up to four VibeCore sediment samples will be collected in each of four depositional areas identified by model results to re-calibrate the sediment transport model and improve confidence in the accuracy of its predictions of mixing and recovery rates. Samples will be visually evaluated in the field for ash thickness and will be analyzed in offsite analytical laboratories for percent ash, grain size distribution, arsenic, and selenium. Supplemental VibeCore sediment samples will be collected from depositional areas following Emory River flow events greater than 110,000 cfs to confirm results of the sediment fate and transport model runs for those events.

Sediment sampling will be conducted biennially in the fall concurrent with the fall benthic invertebrate community surveys. Composite samples from some sites also may be used for sediment toxicity testing in 2013 and 2017. Sediment samples will be collected in 2013, 2015, and 2017 from four transects on the Emory River and one reference location upstream on the Emory River, and from three transects and one reference location on the Clinch River. Sediment samples also will be collected annually at ERM 1.0 and 0.7, for a total of 11 transect locations for sediment collections.

At each location, a line-of-sight transect will be established across the width of the reservoir. Discrete samples from the upper 6 inches of sediment will be collected using a Ponar dredge at each of ten approximately equally spaced points along a transect where co-located samples are collected for benthic invertebrate identification and enumeration (see Section 2.3.3). The sediment samples will be visually characterized in the field for general substrate composition (i.e., cobble, gravel, sand, silt, detritus). Samples comprised mainly of sand or smaller size particles will be homogenized and sub-sampled, with sub-samples sent to an off-site laboratory for determination of percent ash.

In addition, where possible, transects will be divided into left overbank, mid-channel (thalweg), and right overbank areas. A minimum of three grab samples will be taken from each area and composited by area to create a maximum of three composite samples per transect. Each composite sample will be examined in the field to determine whether the substrate provides suitable habitat for benthic invertebrates. That evaluation will consider type and abundance of sediment present, field assessment of benthic community samples being collected from the same general area concurrent with the composite sediment sampling, and other factors judged relevant by the field biologist and geologists on the sampling crews. All composite sediment samples collected will be analyzed for percent ash, grain size distribution, arsenic and selenium.

2.3.2 Sediment Toxicity Testing

Laboratory bioassays (toxicity testing) in which benthic invertebrate species are exposed to sediment samples in the laboratory were conducted to support the BERA. Adverse effects were observed for growth and survival of test species. Definitive bioassays will be performed using *Hyalella azteca* in 10-day survival and growth tests to evaluate the effectiveness of MNR on reducing the occurrence of adverse effects on benthic invertebrates. Previous testing has shown that *H. azteca* is an appropriate sentinel species for measuring ash-related effects. Bioassays will be conducted in accordance with EPA *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates* (EPA 2000b). The definitive tests will use laboratory-prepared dilution series (0, 20, 40, 60, 80, and 100%) of sediments collected at ERM 1.0 and CRM 3.0 mixed with corresponding reference sediments. Sediment samples for bioassay testing will be collected in 2013 and 2017 (concurrent with the benthic community sampling) from ERM 1.0, one reference location upstream on the Emory River, CRM 3.0, and one reference location on the Clinch River, for a total of four locations for sediment toxicity testing. Only samples from overbank areas judged to provide suitable benthic invertebrate habitats will be used in bioassays.

Consistent with EPA guidance, composite sediment samples for bioassays will be characterized for pH and ammonia of the porewater; organic carbon content; particle size distribution (percent sand, silt, clay); and percent water content. Each composite sediment sample also will be analyzed for percent ash, ash-related metals and metalloids, pesticides, and polynuclear aromatic hydrocarbon. Overlying water used in test exposures will be monitored for hardness, alkalinity, conductivity, pH, and ammonia at the beginning and end of a test, and temperature and dissolved oxygen will be measured daily.

2.3.3 Benthic Invertebrate Bioaccumulation and Community Surveys

The BERA identified a low to moderate risk to benthic invertebrates from exposure to arsenic and selenium in sediment and a low risk to insectivorous birds that feed on benthic invertebrates. Benthic invertebrates are organisms without backbones that live in the sediment on the bottom of the river. They include crustaceans (e.g., crayfish and amphipods), mussels, clams, snails, aquatic worms, and the immature forms of aquatic insects such as mayfly nymphs and midges. Because they inhabit the sediment and are relatively sedentary, benthic invertebrates are highly exposed to constituents in the sediment and porewater, and are therefore good indicators of environmental quality. This is particularly relevant for this site, because the released ash was deposited on the river bottom. Concentrations of ash-related constituents may bioaccumulate in benthic invertebrates. In addition, because they are at the base of the food chain, benthic invertebrates and their emergent adult life stages are prey for other ecological receptors. The birds, amphibians, reptiles, mammals, spiders, and fish that feed on benthic invertebrates or emergent insects are, therefore, additional ecological receptor populations of interest for bio-accumulative constituents.

Biennial samples of larval mayflies for chemical analysis will be collected beginning in 2013 at 12 locations: one reference location upstream in each of the Emory, Little Emory, Clinch, and Tennessee Rivers; four locations in the impacted reaches of the Emory River; two locations in the impacted reaches of the Clinch River, and 2 locations in the Tennessee River. Annual sampling of larval mayflies will be conducted at ERM 1.0. Biennial benthic invertebrate sampling at the Tennessee River, one of the Clinch River locations (CRM 1.5), and the Little Emory River may be discontinued after the 2013 sampling event depending on review of the data for trends and constituent concentrations as discussed in Section 3.

Larval mayflies will be collected by taking multiple grabs of sediment using a Ponar dredge and selectively removing the organisms. Because emergence of adult *Hexagenia* is unpredictable and sporadic, adult mayflies will be collected opportunistically at the same approximate locations as the larval sampling. Adult mayflies will be collected using a combination of methods such as direct removal with forceps from vegetation along the shoreline, sweep nets, and possibly light traps as needed.

Snails will be collected in 2013 for chemical analysis at ten locations: one reference location upstream in each of the Emory, Little Emory, Clinch, and Tennessee Rivers; three locations in the impacted reaches of the Emory River; two locations in the impacted reaches of the Clinch River, and one location in the Tennessee River. Depending on a review of the data for trends and constituent concentrations as discussed in Section 3, snails may not be collected after the 2013 sampling event. Snails will be collected by hand from shallow rocky or stable wooden structures near the shoreline. Individual samples will be composited by species.

Up to six composite samples each of snails and larval mayflies will be collected at most locations; three depurated (i.e., evacuation of their digestive systems) before analysis and the other three analyzed without depuration. Emergent mayflies do not feed, thus do not need to be depurated. Depending on availability of organisms, up to 12 composite samples of adult mayflies, including three each of male and female imagos and subimagos may be analyzed from each location. Sample locations planned for 2013 and beyond are detailed in Appendix B and Figure 2.3.

While arsenic and selenium are the ash-related constituents of interest, snails, and adult and larval mayflies will be analyzed for percent moisture and whole body metals and metalloids to support the MNR evaluation and non-CERLA goals (e.g., Natural Resource Damage Assessment [NRDA]).

Biosurveys will be conducted to evaluate the response of benthic invertebrate communities to ash through their exposure in ash-contaminated sediments and sediment porewater. TVA conducts benthic community surveys on a rotating basis at reservoirs throughout the TVA system, including locations in the Clinch and

Tennessee Rivers. Biennial sampling of benthic invertebrate communities for the LTM will occur in 2013, 2015, and 2017 at 11 locations: one reference location upstream in each of the Emory and Clinch Rivers; six locations in the impacted reaches of the Emory River, and three locations in the impacted reaches of the Clinch River. Annual community assemblage samples will be collected at ERM 0.7 and ERM 1.0. For correlation with percent ash, arsenic, and selenium in sediments, co-located sediment samples will be collected at the benthic invertebrate sampling locations (see Section 2.3.1).

Samples for biosurveys of benthic communities will be collected in the fall with Ponar grab samplers. At each sample location, a line-of-sight transect will be established across the width of the reservoir, and one grab sample will be collected at 10 equally spaced sites along the transect. The sample substrate at each site will be visually characterized in the field. Standard habitat characterization data (e.g., water depth and substrate type) will be collected for each site. Each benthic invertebrate community sample will be analyzed in an offsite laboratory for taxonomic identification and enumeration of benthic invertebrates, with results reported for taxa abundance, richness and diversity as indicators of environmental quality.

2.3.4 Wildlife

Aerial-feeding birds were considered to be at low risk in the BERA due to bio-uptake of selenium in their diet. Annual sampling of tree swallow eggs will be conducted from a colony established near ERM 1.0 and a reference colony at TRM 572. Sample locations and associated analyses planned for 2013 and beyond are detailed in Appendix B and Figure 2.4.

Concentrations in bird eggs are biomarkers of exposure to constituents. Egg samples will be collected from aerial-feeding insectivorous birds (tree swallows). Egg contents (excluding shells) will be analyzed for metals and metalloids. Biosurveys also will report clutch size, hatching success, and 15-day hatchling survival, along with any relevant field observations.

2.3.5 Fish

The risk assessments conducted for the River System EE/CA (TVA 2012a) identified no unacceptable risks to humans or biota who consume fish, nor unacceptable risks to the fish community. However, sampling of fish will be conducted to evaluate recovery of the ecological function and recreational use of the river system, and for NRDA.

TVA has conducted bioaccumulation studies on several species of fish (largemouth bass, bluegill, redear sunfish, crappie, channel catfish, and gizzard shad) since the fly ash release occurred. Sampling for fish bioaccumulation will continue during the LTM with biennial collections limited to bluegill and redear sunfish (species previously shown to have high site fidelity and selenium bioaccumulation), and largemouth bass (an important sport fish). Sample locations and associated analyses planned for 2013 and beyond are detailed in Appendix B and Figure 2.5.

Biennial samples for fish bioaccumulation will be collected in the spring from three locations (including one upstream reference location) in the Emory River and from two locations (including one upstream reference location) in the Clinch River. Annual sampling will be conducted at ERM 1.0. Fish will be processed for a suite of health and reproductive condition measures concurrent with the 2013 bioaccumulation sampling. Fish health and reproductive metrics will be the same as described in Oak Ridge National Laboratory (ORNL) 2012a and 2012b. Continuation of these measures beyond 2013 will be determined based on evaluation of the initial five-year (2009-2013) dataset as discussed in Section 3.

Fish samples will be collected using a combination of electroshocking, gill netting, or other methods as required for obtaining sufficient sample numbers for analysis. Up to eight replicates may be collected of each species at each location to measure variability within the sample reach. Filet, ovary, and liver samples will be analyzed for metals and metalloids.

Biennial surveys of black bass and crappie populations will be conducted in the spring at one location on the Emory River and one location on the Clinch River for comparison with historical surveys. These surveys provide information on abundance, recruitment, and condition (such as relative weights and incidences of parasites and deformities) of the populations.

Biennial biosurveys of the fish community will be conducted in the fall for comparisons with historical surveys. A total of three reaches will be surveyed; in the Emory and Clinch Rivers. The community biosurvey will collect fish from a variety of habitat types based on their proportions in the study area to provide a good representation of community structure and function. Standard aquatic and riparian habitat characteristics will be recorded for each site and reference survey location. Fish collected will be identified as to species enumerated, and examined for anomalies, with results reported for species abundance, richness, diversity, and physical condition (anomalies).

3. ADAPTIVE MANAGEMENT STRATEGY AND DATA ANALYSIS

Adaptive management methodologies incorporate decision points at which causal effects of changed conditions are explored as an integral component of the process. Adaptive methodologies provide opportunities for effective responses to changes in monitoring results and provide objective decision points for changes in specific monitoring program components.

3.1 ADAPTIVE MANAGEMENT

The LTM plan uses an adaptive monitoring and management framework that includes pre-defined strategies for evaluating results. These periodic evaluations will serve as decision points for responding to monitoring results and recommending changes to optimize data usefulness and cost effectiveness. Adaptive management actions may include off-year follow-up monitoring to investigate unusual results, adjusting sampling locations or frequencies, discontinuing parts of the monitoring plan if results suggest that is appropriate, and adopting new, more effective monitoring tools that may become available. Adaptive management actions also could involve revisiting and possibly revising the selected removal action, if warranted. Monitoring results will be evaluated as results from the most recent sampling become available, and recommendations for appropriate changes will be submitted to EPA and TDEC for approval.

A key component of the adaptive management process is the sediment dynamic modeling performed by USACE-ERDC. Results of sediment and biota monitoring will be used in conjunction with sediment transport modeling results to evaluate the effectiveness of MNR and the rates of decline in concentrations, the locations and movement of ash and sediment deposits, the effectiveness of sediment mixing, and whether contingent response actions or additional data gathering are warranted. Proposed sampling locations and frequencies are summarized in Appendix B. Appendix B also identifies select locations that results from 2009 through 2012 suggest may be candidates for elimination, pending evaluation of 2013 results.

3.2 DATA ANALYSIS AND PLAN OPTIMIZATION

TVA has a robust data set for surface water, sediment, benthic invertebrates, wildlife, and fish from sampling beginning in 2009 immediately after the ash release. Following completion of the River System EE/CA (TVA 2012a) and the associated Human Health and Ecological Risk Assessments, surface water sampling in the Emory and Clinch Rivers, along with sampling of osprey, great blue heron, amphibians, raccoons, reptiles, periphyton, and aquatic plants were discontinued based on findings of negligible risk to human health and these ecological receptors.

The BERA identified a low to moderate risk to benthic invertebrates from exposure to arsenic and selenium in sediment and a low risk to insectivorous birds that feed on benthic invertebrates. Therefore, continued sampling of sediment, benthic invertebrates, and tree swallows is necessary to evaluate the effectiveness of MNR in mitigating risks to these receptors. Fish sampling will continue in order to support the NRDA determination of restoration of ecological function and recreational use of the river system to pre-release conditions. The basis for potential future changes to sampling frequencies or numbers of sampling locations are discussed in the following paragraphs.

3.2.1 Sediment

The sediment transport model predicted minimal accumulation of ash in the Tennessee River; this was confirmed by sampling for the River System EE/CA. Therefore, sampling of sediment in the Tennessee River has been discontinued. Biennial sampling of sediment is scheduled at ERM 6.0, 4.0, 3.0, 2.5, and

2.2, as well as at CRM 6.0, 4.0, 3.0, and 1.5, along with annual sampling at ERM 1.0 and 0.7. The frequency of sampling at any or all of these locations may be changed if the data demonstrate statistically significant changes in arsenic or selenium concentrations with corresponding changes in percent ash, or if there is a large difference between sample results and sediment transport model predictions. Statistical testing may include standard techniques such as trend analysis, outlier testing, or population testing.

3.2.2 Benthic Invertebrates

Sampling of larval and adult mayflies and snails will continue due to the estimated risk to these receptors and birds which may feed on them. Analysis of 2009-2012 data suggests that sampling may be discontinued at Little Emory River Mile 1.0, CRM 1.5, and TRM 572, 566, and 561 for mayflies after 2013, and that collections of snails also can be discontinued after 2013. Final decisions on those reductions will be based on analysis of the full 5-year-post-release (2009-2013) data set. Current trends in arsenic and selenium are discussed in the following paragraphs.

For arsenic, depurated and non-depurated mayfly nymphs concentrations appear to have peaked in 2010 and decreased in 2011 and 2012. For selenium, concentrations in non-depurated nymphs also appear to have peaked in 2010, but depurated nymph concentrations do not appear to have peaked until 2011. Spatially, maximum concentrations of both elements occurred at ERM 1.0 each year.

Results for adult mayflies for 2012 are not yet available. Results from 2009-2011 show temporal patterns for arsenic to be variable, but arsenic concentrations in adult mayflies are about an order of magnitude lower than in nymphs and are only slightly higher at ash-impacted sites than at reference sites. Selenium concentrations in adult mayflies follow a similar temporal pattern as the depurated nymphs, with highest concentrations in 2011. Results for 2012 will be available for comparison in spring of 2013. In contrast to arsenic, selenium concentrations in mayfly nymphs and adults are more similar.

There are several possible reasons for higher selenium concentrations in adult mayflies and depurated nymphs in 2011 as compared to 2010. They may reflect a lag in tissue accumulation following exposure to higher dietary concentrations in 2010 (possibly associated with river dredging in 2009-2010). They may reflect a progression in bioavailability as selenium is incorporated into the food chain. They may reflect differences between larval and adult mayflies related to the life cycle of that organism (e.g., the average duration of exposure of the individuals in larval mayfly samples may have been shorter than that of the larvae from which adult mayflies emerged).

Arsenic and selenium concentrations in snails generally decreased from 2010 to 2011, with concentrations similar to or only slightly greater than reference locations.

Biennial sampling of benthic invertebrate communities for the LTM plan will occur in 2013, 2015, and 2017 at 11 locations: one reference location upstream in each of the Emory and Clinch Rivers; six locations in the impacted reaches of the Emory River, and three locations in the impacted reaches of the Clinch River. Annual community assemblage samples will be collected at ERM 0.7 and 1.0.

All benthic invertebrate results for the period 2009-2013 will be evaluated in 2014 for spatial and temporal trends. Subsequently, results will be re-analyzed as results from the most recent sampling become available. Depending on those analyses, appropriate changes in the benthic invertebrate monitoring strategy may be recommended. Recommendations for monitoring strategy changes might be based on criteria such as consistent annual decreases in constituent concentrations for three or more consecutive years; tissue concentrations consistently less than one-half of the corresponding TME, consistently less than one-half of the lowest-observed-adverse-effects-level (LOAEL) values, or consistently below generally accepted no-observed-adverse-effects-level (NOAEL) values; or combinations of these and other criteria.

3.2.3 Tree Swallows

Aerial-feeding birds were considered to be at low risk in the BERA due to bio-uptake of selenium in their diet. Ecological risk to aerial-feeding insectivores is based on a dietary exposure model that assumes adult mayflies are representative of the tree swallow diet. Limited studies conducted by Virginia Tech in 2011 indicate that mayflies comprise only a small component of tree swallow diet and are virtually absent as a food source during the breeding season. Virginia Tech currently is analyzing a larger set of samples from 2012 to better characterize feeding habits of tree swallows in the study area, with results expected to be available by May 2013. Those results will be considered for possible future changes to tree swallow monitoring.

Samples of tree swallow eggs will be collected annually from a location on the lower part of the Emory River (~ERM 1.4) and a reference site on the Tennessee River (TRM 572), with a target of one egg from 20 to 25 different nests per location. The lower Emory River location is proposed to be sampled annually because this reach of the Emory River was not dredged and contains the greatest deposit of ash, thus would be expected to be the location with the greatest potential for exposure. Egg contents (excluding shells) will be analyzed for arsenic and selenium to evaluate exposure of insectivorous birds to ash-related constituents. In addition, boxes will be placed at the Lakeshore peninsula adjacent to ~ERM 3.5 to maintain a tree swallow colony there for possible future evaluation.

Both bioaccumulation and reproductive success measures (clutch size, hatching success, 15-day hatchling survival, and other field observations) will be evaluated annually. Bioaccumulation results will be compared with TMEs. All results will be evaluated for spatial and temporal trends. Depending on those analyses, appropriate changes in the tree swallow monitoring strategy may be recommended. Recommendations for monitoring strategy changes might be based on criteria such as consistent annual decreases in constituent concentrations for three or more consecutive years; tissue concentrations consistently less than one-half of the corresponding TME, consistently less than one-half of LOAEL values, or consistently below generally accepted NOAEL values; or combinations of these and other criteria.

3.2.4 Fish

Because bluegill and redear sunfish exhibit high site fidelity and bioaccumulate selenium to a greater extent than most other species of fish, the LTM plan includes annual monitoring of bioaccumulation in those two species of fish at ERM 0.0 to 1.8. While bass do not appear to bioaccumulate contaminants to the same extent, because bass are an important sport fish, the LTM plan includes annual bioaccumulation monitoring of largemouth bass in this same reach. Biennial bioaccumulation sampling of bluegill, redear sunfish, and largemouth bass will be conducted at ERM 8.0 and 2.5, and CRM 8.0 and 1.5.

Fish health and reproductive condition will be evaluated for bluegill, redear sunfish, and largemouth bass concurrent with spring 2013 bioaccumulation sampling at ERM 8.0, 2.5, and 1.0, and CRM 8.0 and 1.5. While results to date suggest no ecologically significant adverse impacts on fish health or reproductive condition, the most recent histopathology data (fall 2011 samples) indicates that fish collected at locations near the release have higher scores (i.e., more lesions) than those from reference locations and that fall 2011 samples have higher scores than samples from 2010. Continuation of fish health and reproductive measures, species sampled, sampling sites, and sampling frequency beyond 2013 will be determined based on evaluation of the initial five-year (2009-2013) dataset.

Biennial fish community sampling will be conducted at ERM 2.5 and CRM 4.0 and 1.5. Biennial sampling of black bass and crappie populations will be conducted at ERM 2.5 and CRM 1.5 for the Spring Sport Fish Survey.

Sampling locations and frequencies, or target species may be modified if evaluation of results indicates changes would provide sufficient benefits in optimizing data usefulness and cost effectiveness. The annual or biennial evaluations will include spatial and temporal trend analysis, along with comparison to appropriate criteria.

3.3 REPORTING

Timely reporting of analytical results, trends, and observations is important for long-term monitoring in order to be able to make adjustments as needed for subsequent year sampling events. Sampling and processing of biota is labor-intensive and time-consuming, and sometimes requires specialized expertise that only a few individuals possess. TVA expects to have reports for individual media (e.g., mayfly bioaccumulation, fish bioaccumulation, etc.) submitted within 9 months or less of the completion of sample collection; this will allow at least 3 months for report review and decision-making on sampling needs for the following year.

4. SAMPLE DESIGNATION

This section presents the sample management protocols associated with sample designation, custody, and labeling. Data management sample plans, chain-of-custody (CoC) forms, and sample container labels will be produced using EQuIS™ 5.0 or higher. EQuIS is the sample planning and data management program developed by Earthsoft, Inc., for which TVA has purchased user and license rights. Environmental Standards, Inc. (ESI) maintains and manages the database and is responsible for the performance and troubleshooting problems with the system. Sample management will follow Standard Operating Procedure (SOP) TVA-KIF-SOP-18 *Management and Implementation of EQuIS-Based Chain of Custody*.

Sample planning steps are required in EQuIS prior to field sampling. First, the Sample Manager will create a data management sample plan in EQuIS for each sampling task and laboratory. The data management sample plan will contain the specific laboratory information and the method analyte groups to be used for each sample matrix that will be collected. The Sample Manager will then create the CoCs, sample identification (ID) numbers for each sample associated with each CoC, and container labels for each sample. Details of each new sampling task will be communicated to the Sample Manager at least one week in advance of sampling so that the necessary data management sample plan(s) can be created in EQuIS.

4.1 SAMPLE CHAIN OF CUSTODY IDENTIFICATION

A unique date-referenced CoC identification number will be assigned to each CoC record generated during the course of the sampling program to facilitate data evaluation and preclude record duplication. The unique CoC identification number is limited to 20 characters or less and is structured as follows:

LTMZZMMDDYYYA, where

LTM = Long-term Monitoring
ZZ = Matrix Code (Table 4-1) or task (e.g., “TOX” for samples associated with toxicity testing)
MM = Month
DD = Day
YYY = Year (first Y remains a “Y” followed by last digits of year–Y13)
A = Alpha character designates an order of sequential CoC records for each sampling event

EQuIS-based CoC records will be created in the Sample Planning Module (SPM) of EQuIS Professional. The SPM User’s Manual is included as an attachment to TVA-KIF-SOP-18 for reference. A CoC form will then be generated by EQuIS.

Table 4-1. Sample Identification Codes

Biota Only: AA = Species Code		Biota Only: B = Body Part Code		Biota Only: C = Sample Type Code		ZZ = Matrix Code	
BG	Bluegill	E	Egg	G	Grab (individual animal)	BD	Bird
RE	Redear Sunfish	F	Filet	C	Composite	FH	Fish
BS	Bass	G	Whole Body (minus gut content)			MS	Benthic invertebrates
MFA	Mayfly – Adult	W	Whole Body	**Biota Only: NN = Number Code**		SED	Sediment
MFN	Mayfly - Nymph	O	Ovary	01	(Sequential Number)	SW	Surface Water
SL	Snail	L	Liver			PORE	Porewater
TS	Tree swallow						

4.2 SAMPLE IDENTIFICATION

Each individual sample will be assigned a unique date-referenced sample ID, referred to as the "sys_sample_code" in EQuIS. The sample ID is limited to a maximum of 40 characters and is be structured as follows:

KIF-QQQ_(AA.B.C.NN)-ZZ-MMDDYY, where

KIF = Kingston Fossil Plant, or {facility_code} in EQuIS
QQQ = Location Code, or {sys_loc_code} in EQuIS
(AA.B.C.NN) = Biota Code (used for biota only) in EQuIS (Table 4-1)
ZZ = Matrix Code, or {matrix_code} in EQuIS (Table 4-1)
MMDDYY = Date of sample collection, or {Sample_Date} in EQuIS (for example: 122808, 020209)

4.2.1 Location Code Identification

A unique location code, referred to as the "sys_loc_code" in EQuIS, will be assigned for each sample location. The same location can be sampled multiple times by changing the sample date or by appending the sample ID with a sequential number for collection of multiple samples from the same location on the same date. The location code will be created using common site descriptors (such as river mile or other KIF common location names).

4.2.2 Quality Control Sample Identification

An additional quality control (QC) sample code, referred to as the "QC_Code" in EQuIS, will be identified for each QC sample. The QC sample code will be entered into the sample ID between the field matrix code and the sample date per the example below.

KIF-QQQ-ZZ-QC-MMDDYY

EQuIS™ provides QC code options to be selected when adding QC samples to a CoC record. Project QC codes are summarized below.

- Equipment rinsate blank = EB
- Matrix spike = MS

- Matrix spike duplicate = MSD

When a field duplicate or co-located sample is required, the first letter of the matrix code will be changed to an "A". This allows the potential for all field duplicate samples to be "blind" to the laboratory.

4.3 SAMPLE CONTAINER LABELING PROCEDURES

The Sample Manager will generate sample container labels from EQuIS and provide the CoC forms and container labels to the field sampling crews in accordance with TVA-KIF-SOP-07 *Sampling, Labeling, Packaging, and Shipping*. When possible, the sample container labels will be pre-printed with the required labeling information (listed below) with the exception of the time, and sampler's initials. The field sampling crews will affix the labels to the appropriate bottles prior to collecting the samples and complete the time and sampler's initials upon sample collection. The following information at a minimum will be included on the sample container labels:

- Project facility name
- Unique sample identification code
- Field matrix code
- CoC number or task code
- Identification of preservatives used
- Analysis requested
- Date and time of collection
- Sampler's initials
- A bar code containing the sample identification code

Whenever field changes or errors in pre-printed labels have occurred, indelible marker such as Sharpie® or Rite-in-the-Rain® pen will be used to write the correct information on the label, and changes will be initialed and dated.

4.4 CHAIN-OF-CUSTODY PROCEDURES

CoC procedures will be followed in accordance with TVA-KIF-SOP-06 *Field Documentation* and TVA-KIF-SOP-18 *Management and Implementation of EQuIS-based Chain-of-Custody*. Sample custody will be implemented to document sample history from the time of sample collection through shipment, analysis, and disposal. A sample is considered to be in one's custody if one or more of the following conditions apply:

- The sample is in an individual's actual possession,
- The sample is in view after being in an individual's physical possession,
- It was in the physical possession of an investigator and then they secured it to prevent tampering, and/or
- It is placed in a designated secure area.

Each individual field sampler is responsible for the custody of the samples collected until the samples are properly transferred to temporary storage or are shipped to the laboratory. Custody transfer will be documented by both the relinquishing and accepting parties signing and dating the CoC form. The only exception is the transfer to the laboratory. In this case the samples and CoC forms will be sealed in the shipping coolers with custody seals, and the courier or shipping company will not need to sign the CoC. The laboratory sample custodian will sign the CoC upon opening the coolers and verifying sample receipt. The shipping company or courier will sign a completed courier form or bill of lading since they are not provided access to the inside of the cooler. Custody is maintained by custody seals on the shipping cooler and on individual sample containers inside the cooler. As per Section 3.4 of TVA-KIF-SOP-07 *Sampling, Labeling, Packaging, and Shipping,* if multiple coolers are required, a copy of the original CoC form shall accompany each cooler that contains the samples identified on the CoC. The original CoCs will accompany the first cooler. This document will be used to demonstrate that a sample has been obtained from a specific location and has reached the laboratory without alteration. Accordingly, each EQuIS-based CoC record will document evidence of the collection, shipment, laboratory receipt, and laboratory custody of each sample included in a shipment.

The Sample Manager is responsible for setting up new data management sample plans and generating the CoC forms for new sampling tasks. When possible, the EQuIS-generated CoC forms will be pre-populated with the following information:

- Site ID, number, and site address
- Laboratory name and address
- Preservative used (if applicable)
- Sample ID, sample location, and sample type
- Number of sample containers
- Sample matrix
- Sample date
- Analyses (method analyte group) requested
- Sample reason (for this sampling event, only "Long-term Monitoring" reason code).
- Any special instructions and/or sample hazards

The field sampling crews are responsible for completing the EQuIS-generated sample CoC form in the field by recording sample custody and documenting sample collection. The field sampling crews will complete the following information on the CoC form:

- Sample collection time
- Sample start depth, sample end depth (if applicable)
- Sample depth units (if applicable)
- Sample type (grab or composite)
- Name of lead sampler, signature of lead sampler, and date and time of lead sampler's signature
- Sampling company

When new locations are initially sampled, the field sampling crews will complete a sample location form with Global Positioning System (GPS) coordinates for loading into EQuIS. The field sampling crews will document the new location coordinates on the form using a TVA-approved Trimble GPS unit or other approved unit. The completed Sample Location Form will then be forwarded to the data management team for entering the new location information into the EQuIS database.

5. SAMPLING PROCEDURES AND EQUIPMENT

5.1 FIELD SAMPLING PROCEDURES

Field sampling will be conducted in accordance with TVA SOPs for the Kingston Ash Recovery Project, EPA's *Field Branches Quality Management Plan* (EPA 2009a), and with applicable industry-based standards, as referenced below. TVA SOPs are available online at http://public.tva.gov:8161/kingston/sop/.

5.1.1 Sediment Sampling

Samples of sediments will be collected from boats using either a Ponar grab sampler or VibeCore or similar sampling equipment per TVA-KIF-SOP-05 *Sediment Sampling.* Plastic or Lexan™ tubes will be utilized with the VibeCore equipment to collect the samples.

Composite sediment samples will be collected for use in conducting dilution series bioassays. Composite sediment samples will be taken in accordance with TVA-KIF-SOP-05 *Sediment Sampling* and homogenized in accordance with TVA-KIF-SOP-20 *Bulk Ash Homogenization*.

5.1.2 Benthic Invertebrates Sampling

Samples of aquatic snails will be collected by handpicking snails from shallow rocky or wooden structures in accordance with TVA-KIF-SOP-30 *Aquatic Snail Sampling*. Samples of larval mayflies will be collected by taking multiple Ponar/Peterson grabs of sediment and selectively removing the organisms by washing the sediment over a screen to separate the sediment from the nymphs in accordance with TVA-KIF-SOP-29 *Mayfly Nymph Sampling*. Adult mayflies will be collected using a combination of methods, such as direct removal with forceps from branches along the shoreline, sweep nets, and possibly light traps as needed. Individual samples will be composited by species into a single sample representative of a particular reach of the river. At least two composite samples each of snails and larval mayflies will be collected at most locations; one depurated (i.e., evacuation of their digestive systems) before analysis and the other non-depurated. Emergent mayflies do not feed and do not need to be depurated. The adult mayflies will be taken to the laboratory where species identification will be confirmed and individuals will be separated by life stage (sub-imago and imago) and sex. Replicate samples will be collected at some locations, dependent on availability of organisms, to evaluate variability at that location.

For the biosurvey of benthic communities, benthic samples will be collected with a Ponar/Peterson grab sampler. Samples will be washed over a mesh screen and the remaining content preserved for laboratory processing and taxonomic analysis in accordance with TVA-KIF-SOP-35 *Benthic Macroinvertebrate Community Sampling*.

5.1.3 Fish Sampling

Fish samples will be collected using a combination of techniques, depending on success in capturing the target species (largemouth bass, bluegill, and redear sunfish). Fish samples will be collected in accordance with the following procedures:

- TVA-KIF-SOP-31 *Fish Sampling with Gill Nets*
- TVA-KIF-SOP-32 *Fish Sampling with Seines*
- TVA-KIF-SOP-33 *Fish Sampling – Boat Mounted Electrofishing*

For the biosurvey of fish communities, the fish collected will be identified as to species, counted, and examined for anomalies (such as disease, deformations, or hybridization). The fish will be field identified and returned to the river unless either (1) laboratory identification is required for some specimens or (2) the specimens are to be utilized for bioaccumulation studies (constituent concentration analysis).

For bioaccumulation studies, individual fish specimens will be collected and separated into species-specific subsamples. Samples of largemouth bass, bluegill, and redear sunfish will be processed in a biological laboratory. Muscle tissue (filets) will be removed, and placed into labeled containers for shipment to the analytical laboratory. For purposes of fish health and reproductive studies, the non-filet portions may be further dissected for separate additional analysis.

5.1.4 Wildlife Sampling

Egg samples (tree swallows) will be collected from the nesting colonies in accordance with TVA-KIF-SOP-28 *Sampling Tree Swallow Eggs and Nestlings*.

Tree swallow nests will be accessed by foot or by boat. Boxes will be monitored daily (except Sunday) once eggs are observed. Once the sampler has gained access to the nest, the sampler will note the absence/presence and number of eggs or young in each nest (clutch size). One egg will be randomly selected from each nest, sealed in a labeled plastic bag, placed in a labeled plastic container for transport, and cooled on ice. Collected eggs will be weighed and measured (length and width), and egg volume will be calculated (length x width^2 x 0.51) (Hoyt 1979). Each egg will then be repackaged in a labeled plastic bag, placed in a labeled glass jar and custody sealed, and then frozen. Samples will be shipped to the lab on dry ice for chemical analysis. Up to 25 individual nests will be sampled within each colony. Contents of the eggs will be removed from the shell prior to analysis at the lab. Hatching success and nestling survival (assumed to be equivalent to fledging success) will also be recorded.

5.2 DECONTAMINATION PROCEDURES

Equipment used for collecting samples or field measurements, that comes into contact with potentially contaminated media will be decontaminated prior to use unless the equipment is received sealed and certified clean from the manufacturer. Reusable sampling equipment will be decontaminated between sampling locations. This project will use disposable equipment to the extent feasible that does not require an initial decontamination and will be properly disposed after use at a single location. Dedicated sampling equipment that is not certified clean by the manufacturer will be decontaminated prior to the initial use and will not require decontamination prior to subsequent use at the same location. Specific step-wise equipment decontamination procedures for sampling and heavy equipment will be in accordance with TVA-KIF-SOP-08 *Decontamination of Equipment.*

5.3 PACKAGING/SHIPPING PROCEDURES

Sample packing and shipping procedures will follow the general guidance in TVA-KIF-SOP-07 *Sample Labeling, Packing, and Shipping*. Upon completion of sampling activities, field sampling crews will return to the field sampling house and relinquish samples to the Sample Custodian or designee, who either ships the samples to the laboratory the same day or stores them in a designated secure area for later shipment. The Sample Custodian or designee is responsible for reviewing the field documentation and packaging samples from the field crews for shipment to the appropriate analytical laboratories.

The initial step, to packaging/shipping includes a quality assurance check of the field sampling crew documentation. The Sample Custodian or designee will review each CoC and bottle label to verify that there are no errors and that documentation has been accurately completed. The Sample Custodian or designee will check that sample containers are accounted for and match the quantities on the CoC records, and that the dates and times are correct and accurate on the CoCs and labels. Any inconsistencies or errors will be corrected using indelible ink by striking through the erroneous entry with a single line and initialing and dating the corrected entry. Once the sample documentation has been verified, the samples will be packaged in sturdy ice chests for shipment as follows:

1. If the cooler has a drain, completely duct tape the inside and outside of the drain.
2. Place a new large sturdy garbage bag in the cooler.
3. Place wet ice (double bagged in sturdy plastic bags) inside the garbage bag.
4. Check that each sample container has an initialed/signed custody seal and is intact.
5. Package all sample containers in sturdy plastic bags (i.e., Ziploc bags).
6. Place the bagged sample containers inside the wet ice packed garbage bag.
7. Place the temperature samples in the center of the samples in the garbage bag, if applicable.
8. Seal the garbage bag containing the samples and double bagged ice.
9. Place the original executed CoCs in a sturdy plastic bag and tape to the inside lid of the cooler. If multiple coolers, include copies of original CoC in all coolers.
10. Seal the cooler with duct/strapping tape and place custody seals on two opposite corners of the cooler.
11. Place “Fragile” and “This Side Up” stickers on at least two sides of the cooler (preferably all four sides), if sample containers are glass bottles.
12. Add the appropriate U.S. Department of Transportation (DOT) placarding to the cooler (if required).
13. Complete the appropriate bill of lading or courier documentation form for the shipment.

The Sample Custodian or designee is responsible for making copies of the CoCs and shipping paperwork and distributing them for filing in the central data management filing system.

5.4 FIELD NOTEBOOK PROCEDURES

Field logbooks will be prepared in accordance with the general guidance in TVA-KIF-SOP-06 *Field Documentation* and as described below. Each field sampling crew and the Field Team Leader will maintain field sampling logbooks to document the activities conducted by the field crew for each day fieldwork is conducted.

Each field logbook will be assigned a unique number and maintained in a locked fire-proof cabinet/safe. Field logbooks will be bound with sequentially numbered pages. Logbook entries will be made with black indelible ink (preferably with a Rite-in-the-Rain® pen). Each entry will be recorded chronologically with a time notation. Unused sections or blank pages will be lined out and initialed and dated. Each bottom page with entries will be signed and dated by the recorder. Errors in the logbook will be lined out (with a single line strike through) with the corrected entry initialed and dated. Copies of the field logbooks will be made at least weekly to minimize loss of data that could result from the loss or destruction of a logbook during field activities. The logbook copies will be reviewed by the Sample Manager (or designee) to verify that entries are legible.

At a minimum the following elements will be recorded in the field logbooks:

- Name and location of the site
- Date(s) of sample collection or event

- Name and affiliation of the Field Team Leader
- Names of field team members and responsibilities
- Daily time of arrival to the site
- Daily weather conditions
- Pertinent field observations
- Daily summary of equipment preparation procedures and identification/serial numbers of equipment, if appropriate
- Time of sample collection
- Numbers and types of samples collected and sample identification numbers and analysis, preservatives, etc.
- A description of sampling methodology by reference to the project control documents (such as the SAP, Quality Assurance Project Plan [ESI 2010], or SOPs)
- Specific sampling characteristics (such as depth, temperature, turbidity, etc.) as outlined in specific sampling SOPs
- Physical description and sketch of the sample collection location(s)
- Provide a reference to GPS data collected, if applicable
- Record of daily phone calls and/or contact with individuals at the site
- Management or disposal of investigation-derived wastes (IDW)

5.5 INVESTIGATION-DERIVED WASTE MANAGEMENT PROCEDURES

As part of field investigation activities, various types of IDW may be generated including standard municipal refuse (e.g., cardboard, plastic, paper), solid (e.g., ash, soil and sediments), and liquid (e.g., decontamination fluids) wastes. This section identifies the various waste streams expected to be generated and the procedural steps for the disposition of these waste streams. If additional waste streams are identified during field investigation activities that are not already addressed in this section, appropriate actions will be taken to ensure that proper waste disposition requirements are followed.

IDW will be handled in accordance with TVA-KIF-SOP-12 *Management of Investigation-Derived Waste.* Table 5.1 lists the anticipated waste streams that may be generated in association with the sampling and investigative activities and the disposition pathway for each waste stream. Drums or waste containers stored onsite will be inspected weekly and the results of the inspection recorded in a field logbook.

Different IDW streams (e.g., soil and water) will not normally be containerized together; therefore, separate containers will be used for each IDW stream. However, IDW with similar levels of contamination (based on field screening or previous analytical results) may be containerized together.

To determine if contamination of IDW material is suspected, the following evaluation procedure will be used. Note that no field screening with a photoionization detector is required, since no volatile organic compounds are present at the site.

- Evaluate previous analytical results, if available;
- Inspect the material for visual or olfactory evidence of contamination;
- Utilize additional field tests (e.g., pH, color, and other chemical or physical characterizations) to the extent possible; and
- Utilize generator knowledge to help characterize the IDW to the extent possible.

Drums and containers used to store IDW will be appropriately labeled with the following information:

- Site name and address

- Type of material (see Table 5.1)
- Accumulation date(s)
- Additional Comments
- Site contact name and phone number

In addition, a "Hazardous Waste" label will be used with the notation of "pending analysis," if a waste is known or suspected to be characteristically hazardous per the Resource Conservation and Recovery Act. The outside of the drums may need to be cleaned prior to labeling. If the waste is to be transported across or onto public roadways, DOT-applicable labeling and shipping papers will be used.

Table 5-1. Investigation-Derived Waste Streams and Disposition Pathways

IDW Stream	Disposition Pathway
General refuse (paper, plastic bags, cardboard, etc.)	Place in municipal trash or recycling receptacle as appropriate.
Personal protective equipment (nitrile gloves, Tyvek, etc.)	Return to KIF site and place in municipal trash receptacle.
Ash (obtained from river characterization activities)	Containerize in plastic bucket, tub, etc., and return to KIF site for disposition in ash management system..
Sediment (obtained during river characterization activities)	Return small volumes (<1 gallon) to the river where the sampling occurred. Containerize larger volumes and return to KIF for storage in a waste accumulation area pending analysis.
Decontamination fluid	Collect and containerize decontamination fluids and return to KIF site for disposition.

6. REFERENCES

Arcadis 2012. *Kingston Ash Recovery Project Non-Time Critical Removal Action River System Baseline Ecological Risk Assessment*. Document No. EPA-AO-050. August 3, 2012.

EPA 1993 (August). *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA*, Publication 9360.0-32, Washington, D.C.

EPA 2000a (January). *Data Quality Objectives Process for Hazardous Waste Site Investigations*, EPA QA/G-4HW, EPA/600/R-00/007, Washington, D.C.

EPA 2000b (March). *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates.* Second Edition. EPA 600/R-99/064. U.S. Environmental Protection Agency, Office of Research and Development, Mid-Continent Ecology Division, Duluth, Minnesota.

EPA 2006 (February). *Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4*, EPA/240/B-06/001, Washington, D.C.

EPA 2009a (May 8). *Field Branches Quality Management Plan*, U.S. EPA Region 4, Science and Ecosystem Support Division, Atlanta, Georgia.

EPA 2009b (May 11). *Administrative Order and Agreement on Consent, Docket No. CERCLA-04-2009-3766*, Region 4.ERDC 2012 (June). *Long Term Simulation of Residual Fly Ash Transport and Fate in the Watts Bar Reservoir System*. Stephen H. Scott. Coastal and Hydraulics Laboratory; U.S. Army Engineering Research and Development Center, Waterways Experimentation Station. Vicksburg, Mississippi.

Environmental Standards, Inc. (ESI) 2010 (August 16). *Quality Assurance Project Plan for the Tennessee Valley Authority Kingston Ash Recovery Project. TVA-KIF-QAPP*. Prepared for the Tennessee Valley Authority, Office of Environment and Research, Environmental Resources.

Hoyt, D. F. *Practical methods of estimating volume and fresh weight of bird eggs*, Auk 96:73-77, 1979.

National Weather Service 2006 (March 7). Oak Ridge Climate Normals and Records (1971-2000), National Weather Service Forecast Office, Morristown, Tennessee.

Oak Ridge National Laboratory (ORNL) 2012a. *Evaluating The Effects Of The Kingston Fly Ash Release On Fish Reproduction: Spring 2009 – 2010 Studies*, ORNL/TM-2012/142.

ORNL 2012b. *Fish Health Studies Associated with the Kingston Fly Ash Spill, Spring 2009 – Fall 2010*, ORNL/TM-2012/154.

Tennessee Department of Environment and Conservation (TDEC) 2004. *Reservoir Operations Study-Final Programmatic Environmental Impact Study, Record of Decision*. Prepared by TVA in cooperation with the U.S. Army Corps of Engineers and U.S. Fish and Wildlife Service. May 2004.

TDEC 2009 (January 12). *Commissioner's Order, Case No. OGC09-0001*, Division of Water Pollution Control.

Tennessee Valley Authority (TVA) 2009a. *Corrective Action Plan for the TVA Kingston Fossil Plant Ash Release*. Document No. EPA-AO-023. Prepared by the Tennessee Valley Authority. March 2, 2009.

TVA 2009b. *Action Memorandum: Request for Removal Action at the TVA Kingston Fossil Fuel Plant Release Site, Roane County, Tennessee*. Document No. EPA-AO-005. Prepared by the Tennessee Valley Authority. August 4, 2009 (EPA approval).

TVA 2010a. *Kingston Ash Recovery Project Non-Time-Critical Removal Action Embayment/Dredge Cell Action Memorandum*. Document No. EPA-AO-024. May 18, 2010 (EPA approval).

TVA 2010b. *Kingston Ash Recovery Project Non-Time-Critical Removal Action Embayment/Dredge Cell Action Memorandum*. Document No. EPA-AO-024. May 15, 2010 (EPA approval).

TVA 2010c. *Non-Time-Critical Removal Action for the River System, Sampling and Analysis Plan (SAP)*. Revision 3. Document No. EPA-AO-021. June 1, 2010 (EPA approval).

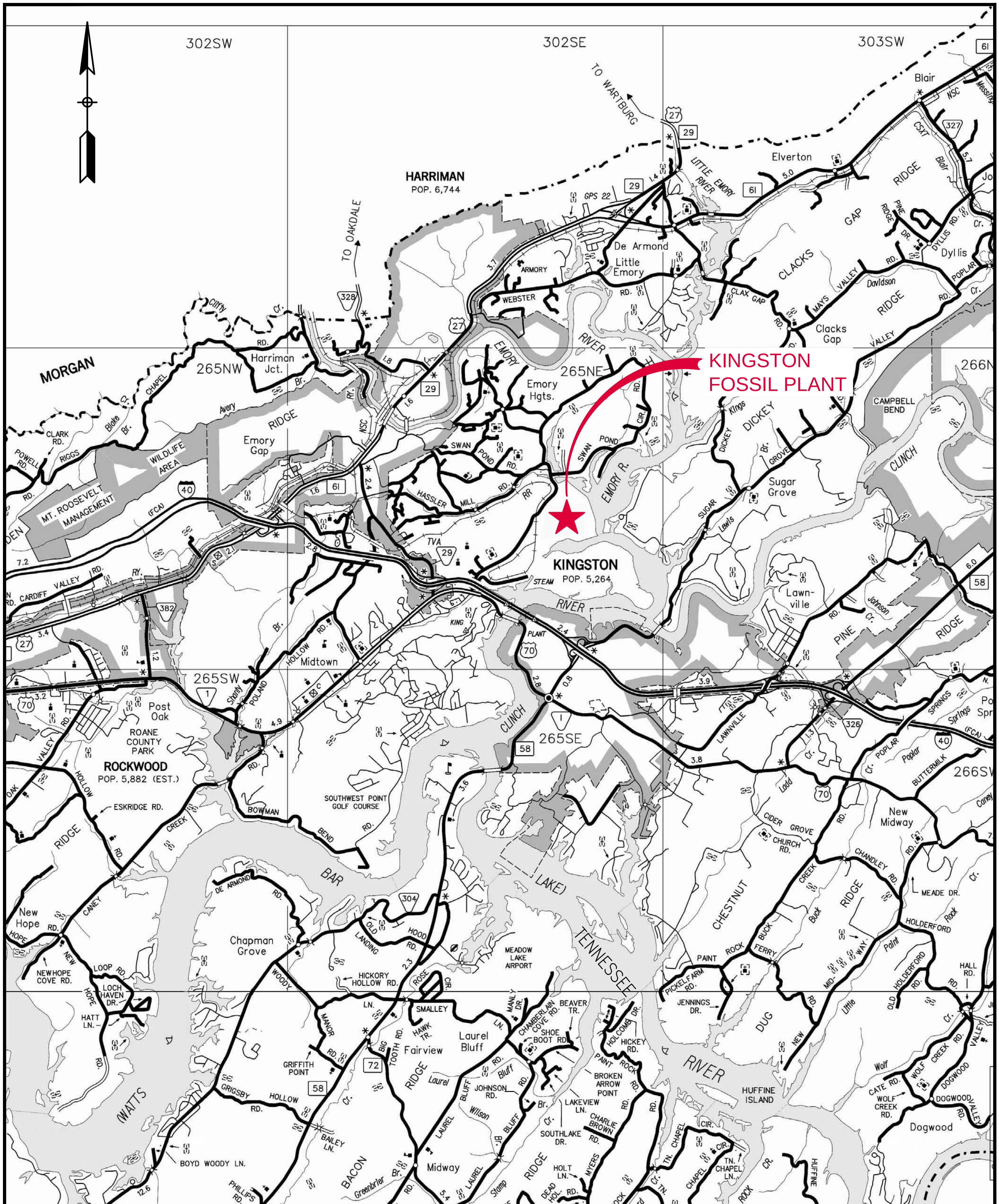
TVA 2012a (August). *Kingston Ash Recovery Project, Non-Time-Critical Removal Action for the River System, Engineering Evaluation/Cost Analysis (EE/CA)*. Document No. EPA-AO-051. August 10, 2012 (EPA approval).

TVA 2012b. *Kingston Ash Recovery Project Non-Time-Critical Removal Action River System Action Memorandum*. Document No. EPA-AO-054. November 7, 2012 (EPA approval).

TVA 2012c. *Kingston Ash Recovery Project Non-Time-Critical Removal Action Work Plan for the River System.* Document No. RAWP-096. December 20, 2012.

Yokley 2005. *Freshwater Mussel Survey of Impounded Area of the Clinch River Adjacent to the Power Plant, TVA, Kingston, Tennessee*. Prepared by the Yokley Environmental Consulting Service. October 14, 2005.

FIGURES



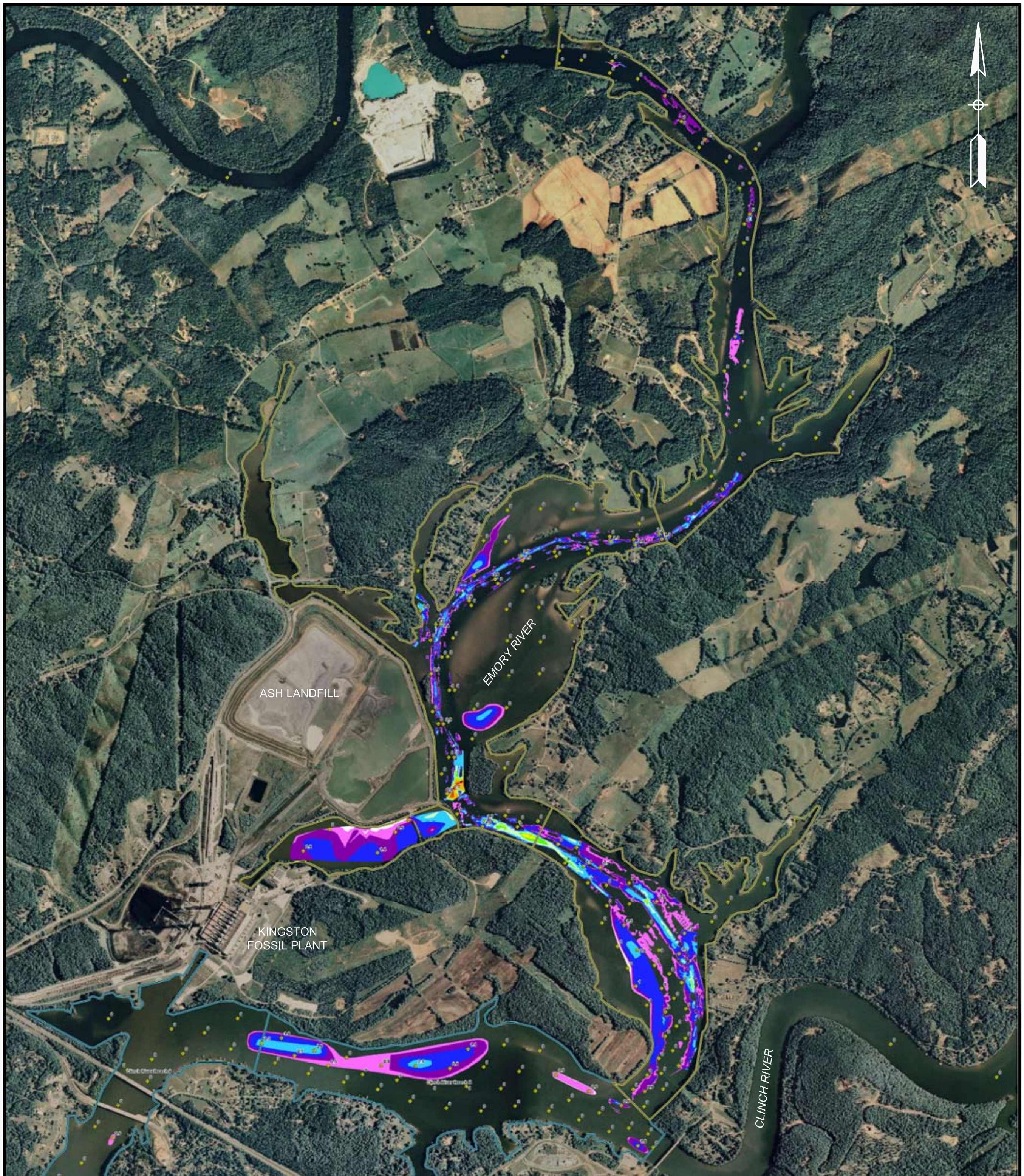
SOURCE:
GENERAL HIGHWAY MAP, ROANE COUNTY, TENNESSEE
TENNESSEE DEPARTMENT OF TRANSPORTATION, 2006

0 1 2 4
SCALE IN MILES

FIGURE 1-1
LOCATION OF THE
KINGSTON FOSSIL PLANT
KINGSTON ASH RECOVERY PROJECT

DATE:	PHASE:
13 Mar 2013	Long-Term Monitoring Plan

I:\0002 ENGINEERING\Civil\Report Graphics\NTC Long-Term Monitoring Plan\288 Location Map.dwg May 09,2013 -bperatro



Legend

- ⊗ Vibracore Location
  Labeled with Ash Thickness (ft)
  (if < 50% Ash, Ash Thickness = 0)
- Emory River Reaches A, B, & C
- Clinch River Reaches A & B

Thickness of Ash in Vibracores >50% Ash

- No Ash
- Less Than 0.5 ft
- 0.5 ft - 1.0 ft
- 1 ft - 2 ft
- 2 ft - 4 ft
- 4 ft - 6 ft
- 6 ft - 8 ft
- 8 ft - 10 ft
- 10 ft - 15 ft
- 15 ft- 20 ft
- 20 ft - 25 ft

FIGURE 1-2
ASH DEPOSITS IN THE CLINCH AND EMORY RIVERS
KINGSTON ASH RECOVERY PROJECT

DATE:	PHASE:
13 Mar 2013	Long-Term Monitoring Plan

I:\0002 ENGINEERING\Civil\Report Graphics\NTC Long-Term Monitoring Plan\289 Ash Deposits.dwg May 09,2013 -bperatro

SEVEN-STEP DATA QUALITY OBJECTIVE (DQO) PROCESS

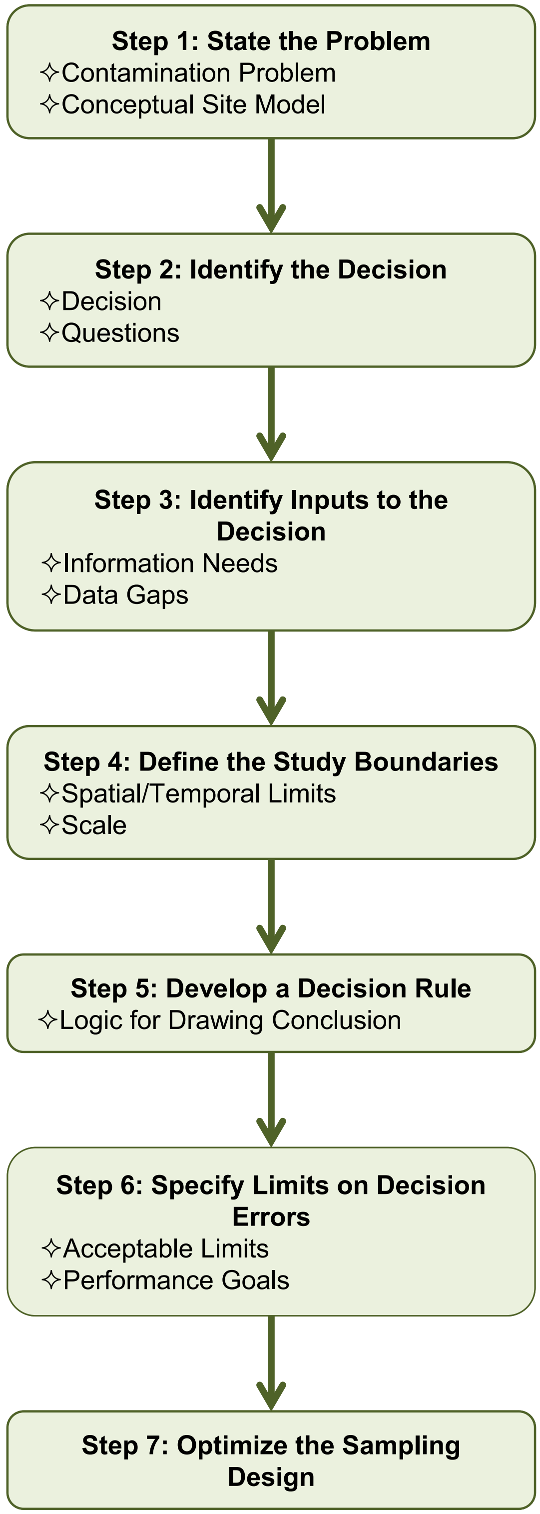


FIGURE 2-1
DATA QUALITY OBJECTIVES (DQO) PROCESS
KINGSTON ASH RECOVERY PROJECT

DATE: 13 Mar 2013	PHASE: Long-Term Monitoring Plan

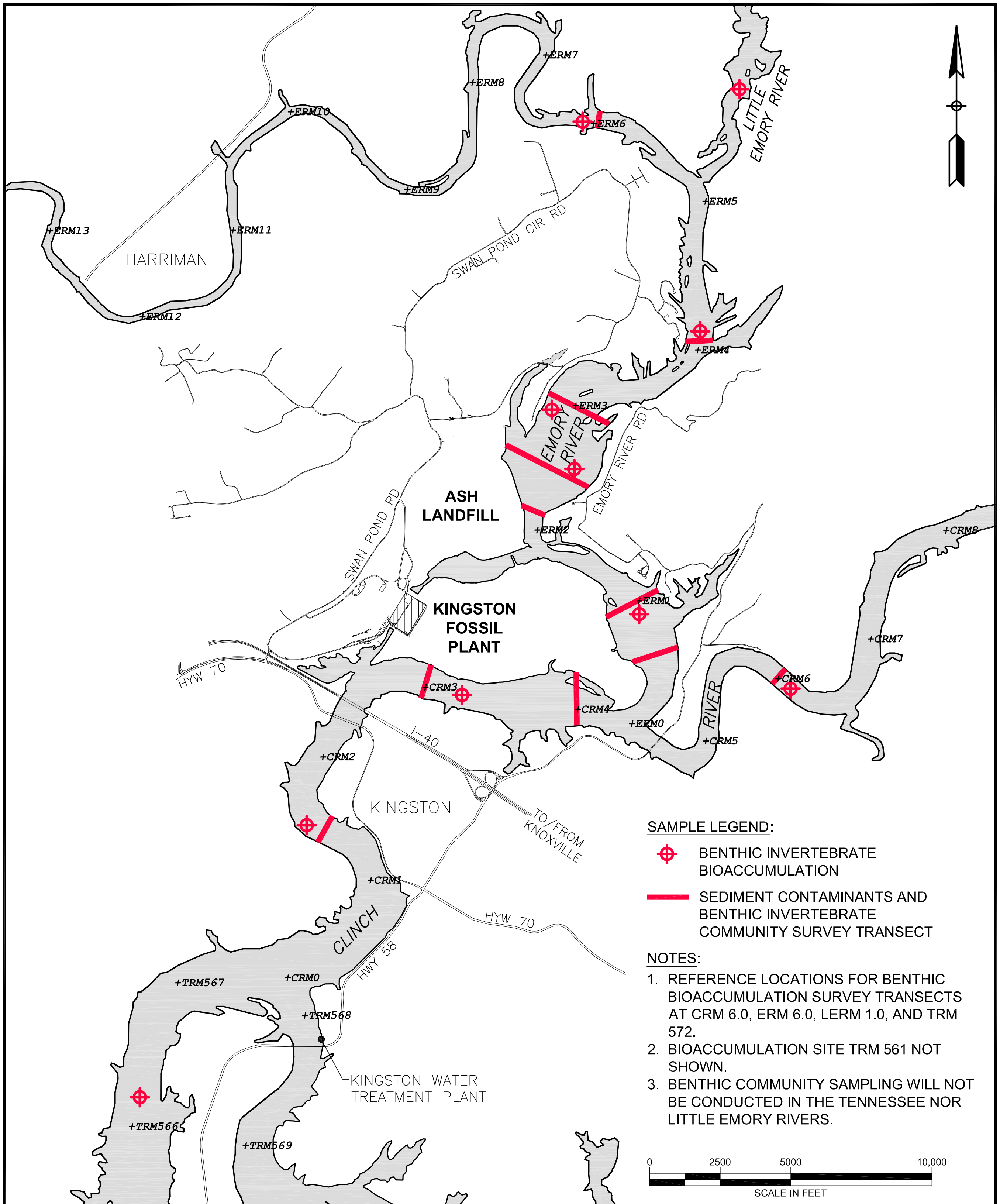


FIGURE 2-2
PROPOSED SEDIMENT CONTAMINANTS & BENTHIC INVERTEBRATE SAMPLING
KINGSTON ASH RECOVERY PROJECT

DATE:	PHASE:
9 May 2013	Long-Term Monitoring Plan

I:\0002 ENGINEERING\Civil\Report Graphics\NTC Long-Term Monitoring Plan\291 Benthic Invertebrates.dwg May 09,2013 -bperatro

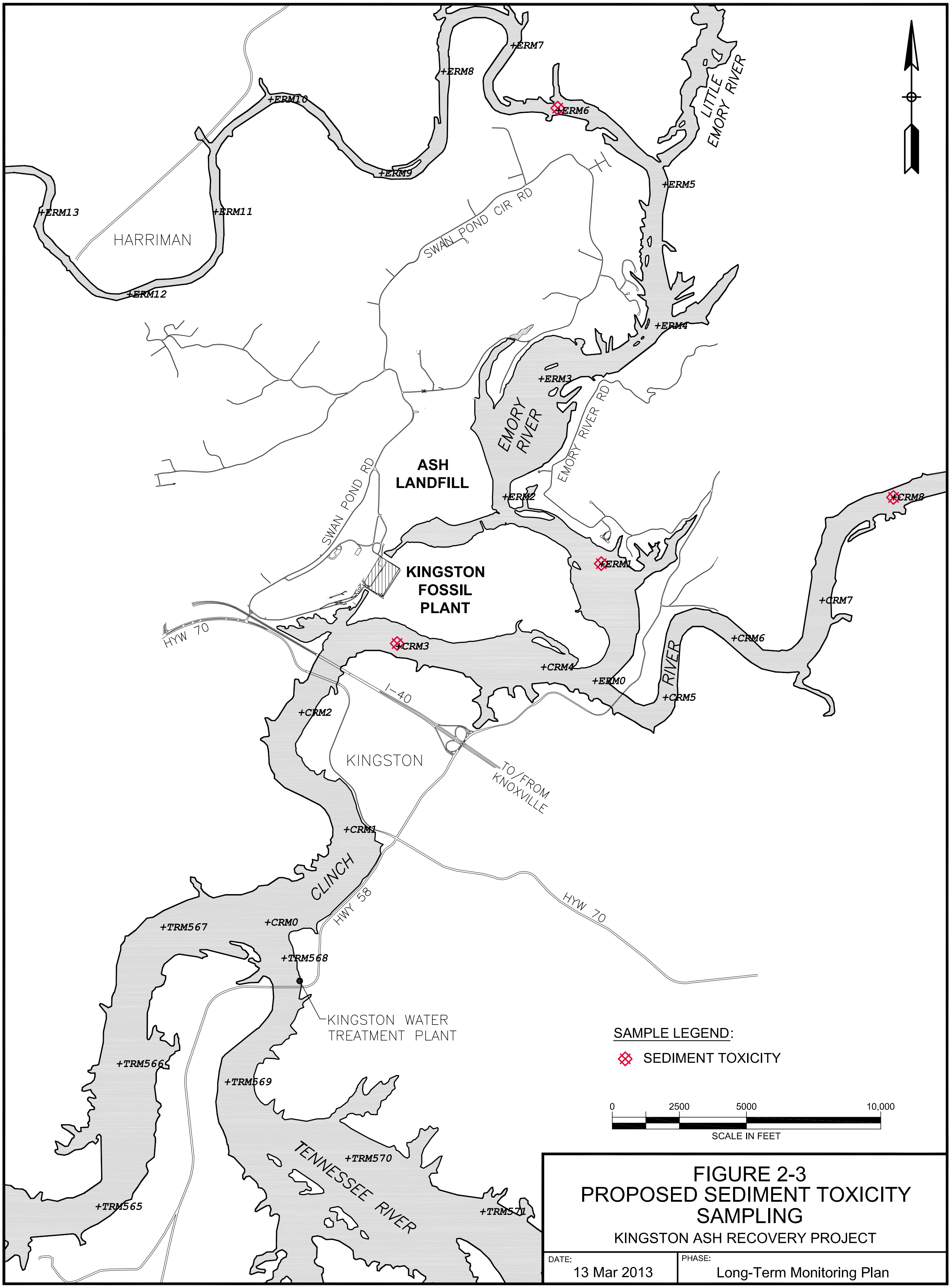


FIGURE 2-3
PROPOSED SEDIMENT TOXICITY SAMPLING
KINGSTON ASH RECOVERY PROJECT

DATE:	PHASE:
13 Mar 2013	Long-Term Monitoring Plan

I:\0002 ENGINEERING\Civil\Report Graphics\NTC Long-Term Monitoring Plan\292 Sediment Toxicity.dwg May 09,2013 -bperatro

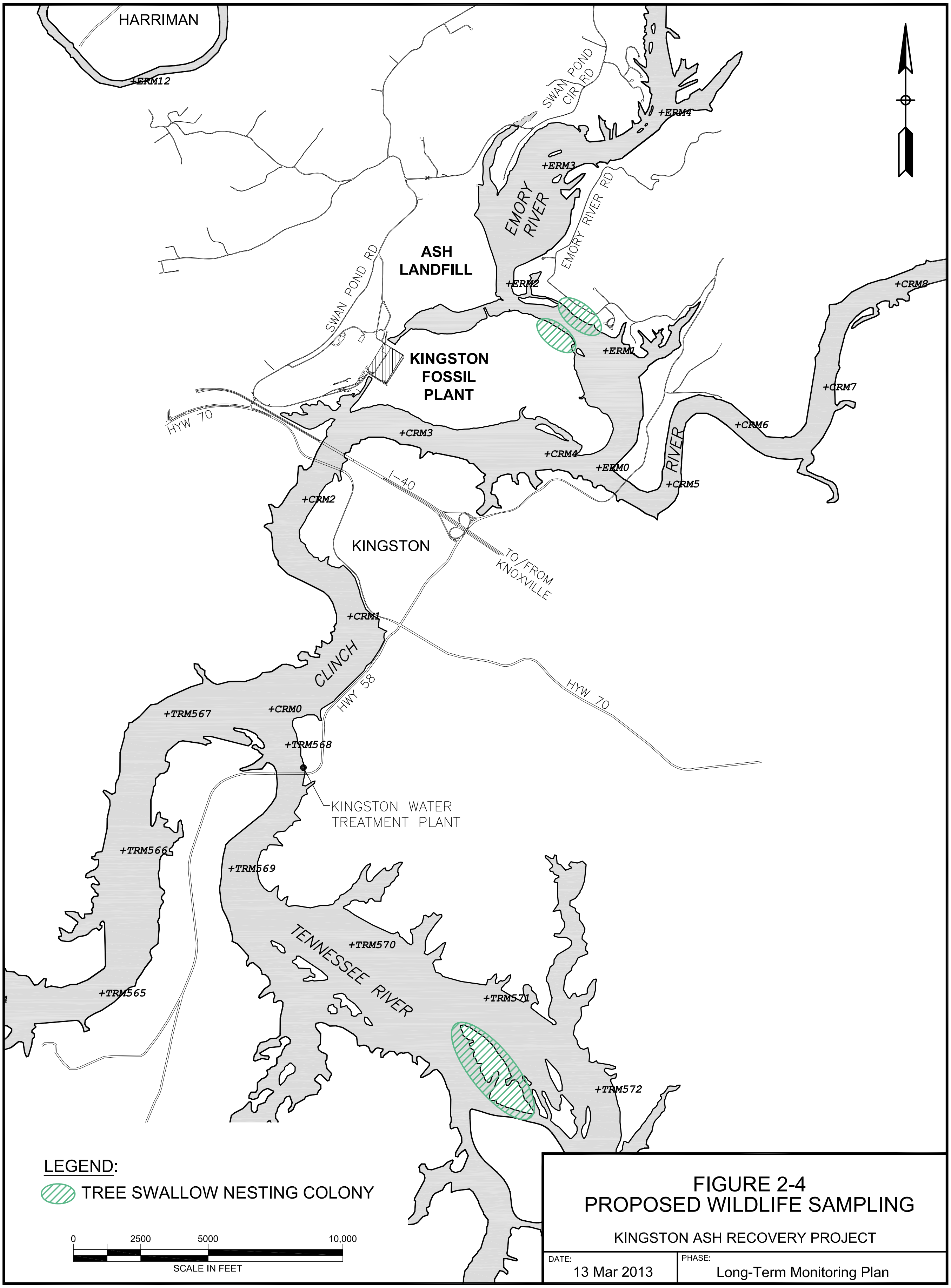


FIGURE 2-4
PROPOSED WILDLIFE SAMPLING

KINGSTON ASH RECOVERY PROJECT

DATE:	PHASE:
13 Mar 2013	Long-Term Monitoring Plan

I:\0002 ENGINEERING\Civil\Report Graphics\NTC Long-Term Monitoring Plan\293 Wildlife Sampling.dwg May 09,2013 -bperatro

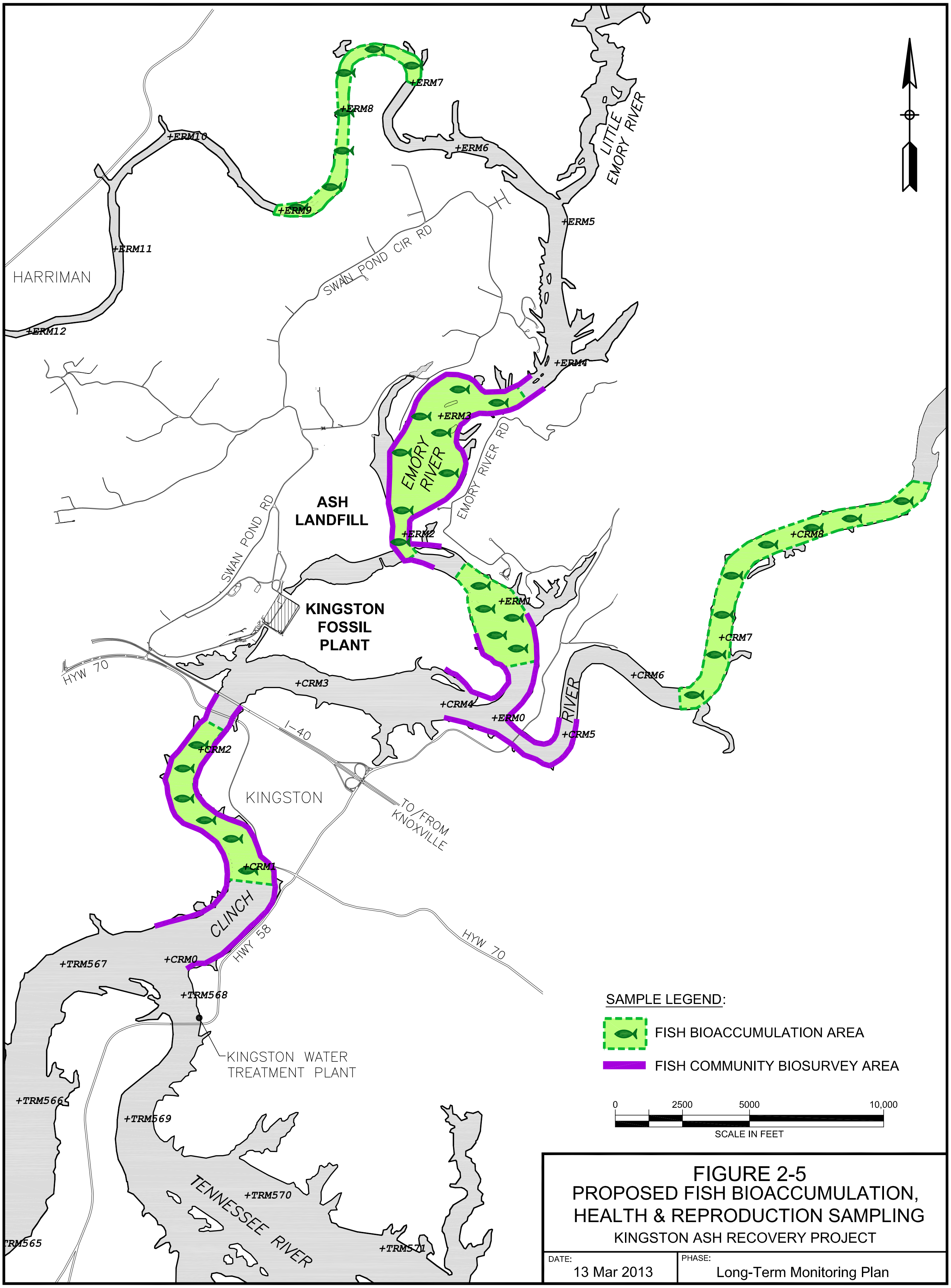


FIGURE 2-5
PROPOSED FISH BIOACCUMULATION, HEALTH & REPRODUCTION SAMPLING
KINGSTON ASH RECOVERY PROJECT

DATE:	PHASE:
13 Mar 2013	Long-Term Monitoring Plan

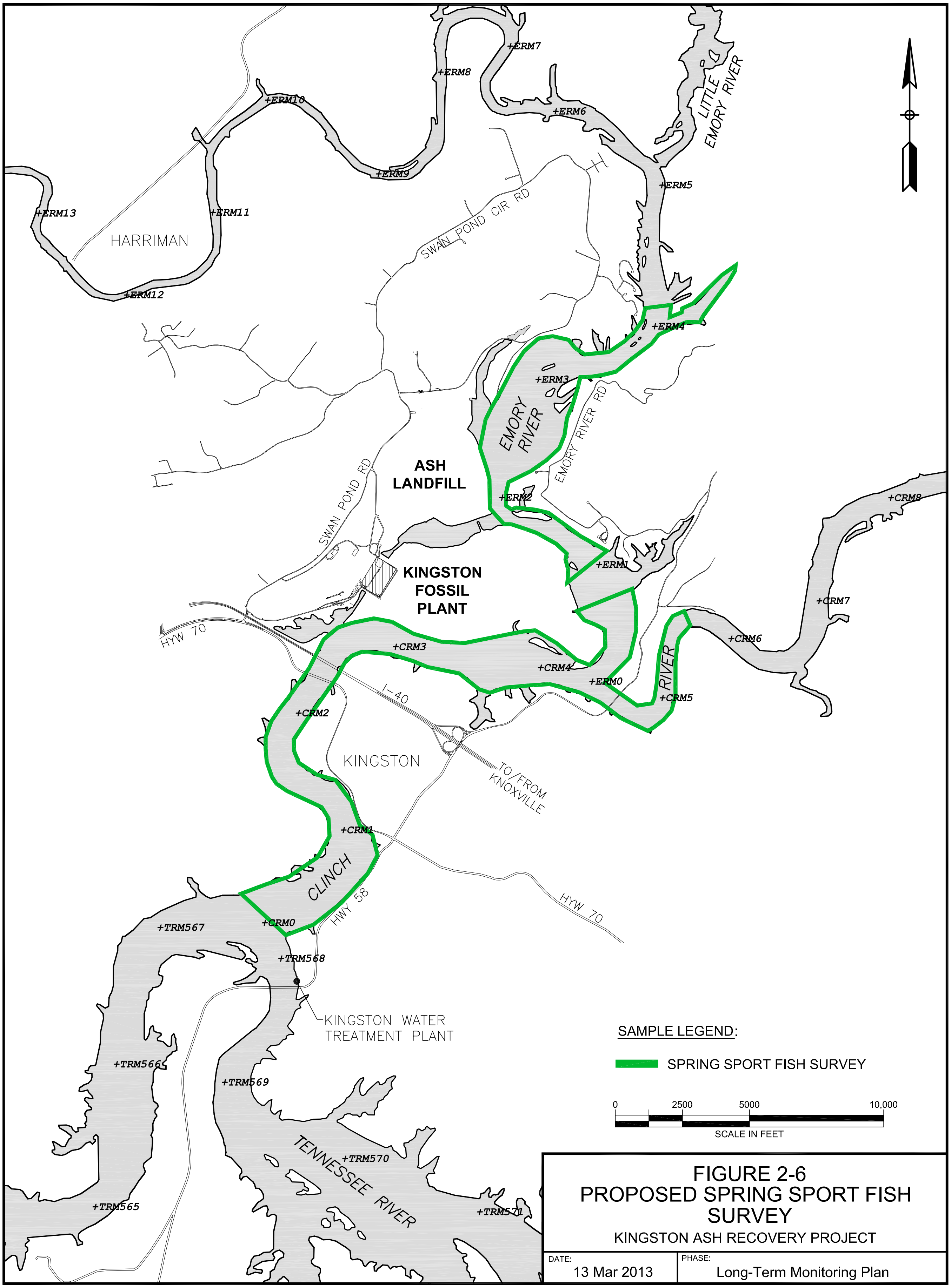


FIGURE 2-6
PROPOSED SPRING SPORT FISH SURVEY

KINGSTON ASH RECOVERY PROJECT

DATE:	PHASE:
13 Mar 2013	Long-Term Monitoring Plan

I:\0002 ENGINEERING\Civil\Report Graphics\NTC Long-Term Monitoring Plan\295 Sport Fish Sampling.dwg May 09,2013 -bperatro

APPENDIX A

Data Quality Objectives for Environmental Media

Appendix A
Data Quality Objectives for Environmental Media

DQO Step	SUBMERGED SEDIMENT
State the Problem	Ash-related constituents (particularly arsenic and selenium) are present within the residual ash and sediment in the Emory and Clinch Rivers. These sediments may be present where exposure by ecological receptors (benthos, fish) may occur. Aquatic- and riparian-feeding birds and/or aerial-feeding birds may also be potentially exposed to these constituents in their diet (consumption of benthic invertebrate prey).
Identify the Decision	The principal study question is: Do levels of ash-related constituents in sediment continue to pose sufficient risk to ecological receptors to warrant additional management action(s)? Do levels of ash-related constituents continue to exceed the RGs in sediment or the TMEs in benthic invertebrates? If so, what is the geographical location and remaining extent impacted? Do trends indicate natural attenuation processes (e.g., mixing of ash and sediment, diminishing biouptake) are occurring as predicted? The ultimate decision to be made is whether the residual ash-related constituents show unexpected trends or pose a level of risk such that further action, beyond monitored natural attenuation, would be required.
Identify Inputs to the Decision	• Updated sediment transport modeling using 2013 bathymetry and following flow event(s) greater than 110,000 cfs on Emory River. • Concentrations of ash-related constituents in sediment. • Ash depth, percent ash and particle grain size distribution, and concentrations of ash-related constituents in sediment. • Bioavailability of these constituents (e.g., bioassays, biosurveys of benthos and fish). • 10-day Definitive Survival and Growth toxicity test results.
Define the Study Boundaries	The ecological receptor populations of interest are benthic invertebrate communities, particularly burrowing benthos (benthic in fauna) and fish. The spatial boundaries of the river study are areas impacted by the ash spill, upstream to downstream. Ecological exposures are more likely to occur in the upper 0.5 ft of sediment. The following sections are differentiated for data needs: • Background (“reference”) locations upstream of ERM 6.0 and CRM 4.5. • Emory River sections, ERM 0.0 to 4.0. • Clinch River sections; CRM 1.5 to 4.0.
Develop a Decision Rule	For ecological receptors, a weight-of-evidence process is used to characterize the magnitude and likelihood (uncertainty) of risks. The following lines of evidence will be considered for characterizing on-going risks: • Comparison of sediment concentrations with site-derived RGs. If the concentration of an analyte exceeds its RG value for benthos, then this may indicate potential risk. • Comparison of biosurveys of benthic invertebrate communities in site-related locations with those in reference locations. If significant reductions in species abundance, richness, or diversity are observed in site-related locations, that may indicate on-going environmental stress. • Comparison of laboratory bioassays (toxicity testing) conducted on site-related sediments with those conducted on reference sediments. If effects on growth or survivability of benthic or epi-benthic invertebrates are observed in site-related sediments, that may indicate bioavailability and on-going risk.
Specify Limits on Decision Errors	Concentrations in sediment are will be determined with detection limits below the ecological sediment effects values. Project method detection limits (MDLs) will be used to ensure that data are defensible to a concentration sufficient to achieve the lowest applicable regulatory standard for an analyte.

Appendix A
Data Quality Objectives for Environmental Media

DQO Step	SUBMERGED SEDIMENT
Optimize the Design	Update bathymetry to support sediment transport modeling. Bathymetry will be collected from ERM 5.0 to CRM 2.0 at 200 ft intervals. Ponar or VibeCore sediment samples will be collected in depositional areas identified by model results following flow event greater than 110,000 cfs on Emory River. Samples will be analyzed for ash depth, percent ash, grain size distribution, and arsenic and selenium in upper 6 inches of sediment. Sediment samples for chemical analysis will be taken using Ponar techniques. Sample locations are presented in Appendix B. Samples will be analyzed for percent ash, total organic carbon (TOC), grain size distribution, and ash related metals. Whole sediment samples for laboratory bioassays will be collected from the locations presented in Appendix B. Samples will be collected from upper 6 inches using Ponar sampling techniques. A minimum of three to five grab samples from each location will be composited to create one test sample per location. Whole sediment bioassay tests will be performed using *H. azteca* in a 10-day definitive Survival and Growth test. Samples of sediment and renewal water will be analyzed for EPA toxicity testing list of parameters, including metals, semi-volatile organic compounds, polychlorinated biphenyls, pesticides, TOC, polarized light microscopy, and grain size. Dilution series laboratory bioassays will be performed using ash mixed with reference sediment at the following proportions: 100, 80, 60, 40, 20, and 0% ash. Each dilution will be homogenized to represent a range of site conditions.
	Applicable SOPs: • TVA-KIF-SOP-05 *Sediment Sampling* (Off-shore Method) • TVA-KIF-SOP-04 *Soil Sampling for Inorganic Analysis* • TVA-KIF-SOP-04 *Bulk Ash Homogenization* • TVA-KIF-SOP-05 *Sediment Sampling*

DQO Step	BENTHIC INVERTEBRATES
State the Problem	Ash-related constituents (particularly arsenic and selenium) are present within the residual ash and sediment in the Emory and Clinch Rivers. Benthic invertebrates may be potentially exposed to these constituents in the sediment.
Identify the Decision	The principal study question is: Do levels of ash-related constituents in sediment or diet (benthic invertebrates) continue to pose sufficient risk to ecological receptors to warrant additional management action(s)? Do levels of ash-related constituents continue to exceed the RGs in sediment or the TMEs in benthic invertebrates?
Identify Inputs to the Decision	• Concentrations of ash-related constituents. • Bioavailability of these constituents (e.g., biosurveys). • Community survey results.
Define the Study Boundaries	The ecological receptor populations of interest are benthic invertebrates or emergent aquatic insects and the birds that feed on them. The spatial boundaries are those areas impacted by the ash spill, upstream to downstream. The following sections are differentiated for data needs: • Background (“reference”) locations upstream of ERM 6.0 and upstream of CRM 4.5. • Emory River sections; ERM 0.0 to 4.0. • Clinch River sections; CRM 1.5 to 4.0. There is no temporal boundary of the study. Evaluation of the concentrations of ash related constituents in benthic invertebrates presented in the BERA indicate higher levels of these constituents in samples collected in the impacted area than in background. Concentrations of ash-related constituents may increase in benthic invertebrates over time; therefore collection of data over more than one sampling period is necessary for long-term management.

Appendix A
Data Quality Objectives for Environmental Media

DQO Step	BENTHIC INVERTEBRATES
Develop a Decision Rule	Benthic invertebrates represent a critical link in evaluation of food web exposures from ash/sediment to wildlife. The BERA indicated low to moderate risk to benthic invertebrates and avian receptors that feed on them. Therefore, comparison of biosurveys of benthic invertebrate communities and ash-related constituent concentrations in site-related locations with those in reference locations will be used to evaluate changes in the potential risks to these receptors. If reductions in taxa abundance, richness, or diversity are observed in site-related locations, that may indicate on-going environmental stress. If concentrations of ash-related constituents increase in benthic invertebrates, that may indicate on-going risk to avian insectivores.
Specify Limits on Decision Errors	Concentrations in benthic invertebrates will be determined with detection limits below the respective risk-based levels for fish or wildlife. However, limited sample volumes typically drive the best available technology. Project MDLs will be used to ensure that data are defensible to a concentration sufficient to achieve the lowest applicable regulatory standard for an analyte.
Optimize the Design	Samples of larval mayflies will be collected by taking multiple Ponar samples of sediment and selectively removing the target organisms. Samples of snail will be collected by hand from structures near the shoreline. Individual specimens then will be composited into a single sample representative of a particular location of the river system. Up to three composites of larval mayflies and aquatic snails may be collected at each sample location to evaluate variability at that location. Some snails and larval mayflies will be depurated in the laboratory before analysis. Samples of emergent adult mayflies will be collected by hand from vegetation, sweep nets, or light trap sampling. Samples will be composited into a sample representative of each location. If sample volumes are sufficient at some locations, up to three composite samples will be collected to evaluate variability at each location. Under the adaptive monitoring framework, TVA will initially sample established benthic invertebrate locations and alter the number of locations as appropriate. The sampling locations are described in Appendix B. Composite samples of depurated larval mayflies and snails, and non-depurated adult mayflies will be analyzed for whole body ash-related constituents. Benthic invertebrate community surveys will be performed at upstream and downstream locations in the Emory and Clinch Rivers. The sampling locations are described in Appendix B. Biosurvey samples will be collected by taking Ponar samples of sediment at each of 10 locations across each transect. Samples will be analyzed in the laboratory for taxonomic identification and enumeration of benthic invertebrates, with results reported for taxa abundance, richness, and diversity. The sampling locations are described in Appendix B.
	Applicable SOPs: • TVA-KIF-SOP-05 *Sediment Sampling* (Off-shore Method) • TVA-KIF-SOP-04 *Soil Sampling for Inorganic Analysis* • TVA-KIF-SOP-04 *Bulk Ash Homogenization* • TVA-KIF-SOP-05 *Sediment Sampling* • TVA-KIF-SOP-29 *Mayfly Nymph Sampling* • TVA-KIF-SOP-30 *Aquatic Snail Sampling* • TVA-KIF-SOP-35 *Benthic Macroinvertebrate Sampling for Community Survey*

DQO Step	WILDLIFE
State the Problem	Ash-related contaminants (particularly selenium) are present within the residual ash and sediment in the Emory and Clinch Rivers. Aerial-feeding birds may be exposed to these constituents in their diets through consumption of emergent benthic invertebrate prey.

Appendix A
Data Quality Objectives for Environmental Media

DQO Step	WILDLIFE
Identify the Decision	The principal study question is: Do levels of ash-related constituents in sediment or diet (benthic invertebrates) continue to pose sufficient risk to ecological receptors to warrant additional management action(s)? The RGs and TMEs have been selected to be protective of the ecological receptors; therefore, this study question may also be stated as: Do levels of ash-related constituents continue to exceed the RGs in sediment or the TMEs in benthic invertebrates? Several secondary study questions are: If so, what is the geographical location and remaining extent impacted? Do trends indicate natural attenuation processes (e.g., mixing of ash and sediment, diminishing biouptake) are occurring as predicted? The ultimate decision to be made is whether the residual ash-related constituents show unexpected trends or pose a level of risk such that further action would be required.
Identify Inputs to the Decision	• Aerial-feeding Insectivores • Concentrations of ash-related metals in eggs • Reproductive metrics (clutch size, hatchling success, nestling survival to day 15).
Define the Study Boundaries	The ecological receptor populations of interest are aerial-feeding insectivorous birds. The spatial boundaries are those areas impacted by the ash spill, upstream to downstream. Appendix B presents the sampling locations. The temporal boundaries of the study include pre-release (data used as a reference for previous conditions), post-release (data collected during removal), and post-removal data (data collected following completion of the removal action. Evaluation of the concentrations of ash related constituents in benthic invertebrates presented in the BERA indicate higher levels of these constituents in samples collected in the impacted area than in background. Concentrations of ash-related constituents may increase in benthic invertebrates and those receptors that feed on them and therefore collection of data over more than one sampling period may be necessary for long-term management.
Develop a Decision Rule	For ecological receptors, a weight-of-evidence process is used to characterize the magnitude and likelihood (uncertainty) of risks. The following lines of evidence will be considered for characterizing risks to wildlife: • Comparison of biosurveys of bird eggs in site-related locations with those in reference locations and comparisons of biosurveys over time. If differences in clutch size, hatchling success, or physical condition are observed in site-related locations or changes are observed over time, then this may indicate environmental stress and potential risk.
Specify Limits on Decision Errors	Concentrations in wildlife will be determined with detection limits below the respective risk-based levels for wildlife. However, due to limited availability of effects values, the analytical method offering the lowest quantitation limit will be used.
Optimize the Design	Concentrations in tree swallow eggs will be measured as biomarkers of exposure and for comparison with effects values in birds (insectivorous). Only one egg will be taken from any one nest within the colony (approximately 20 to 25 samples from each colony). The sampling locations are presented in Appendix B. Egg contents (excluding shells) samples will be analyzed for ash-related constituents. Reproductive biosurveys will be performed at the same locations (colonies) as sampling. All nests within each colony will be surveyed. Nests will be observed in the field for clutch size, hatchling success, and nestling survival to day 15.
	Applicable SOPs: • TVA-KIF-SOP-28 *Sampling Tree Swallow Eggs & Nestlings*

Appendix A
Data Quality Objectives for Environmental Media

<table>
<tr><th>DQO Step</th><th>FISH</th></tr>
<tr><td>State the Problem</td><td>There were no unacceptable risks to human or ecological health associated with potential consumption of fish due to ash related constituents. However, fish are an important component of the ecological function and recreational use of the river system. Therefore, to support non-CERCLA goals on-going evaluation of the health of the fish population is necessary.</td></tr>
<tr><td>Identify the Decision</td><td>The principal study question is: Do levels of ash-related constituents in fish adversely impact in ecological function and recreational use of the river system?</td></tr>
<tr><td>Identify Inputs to the Decision</td><td>• Concentrations of ash-related constituents in fish.
• Bioavailability of these constituents (e.g., biosurveys).</td></tr>
<tr><td>Define the Study Boundaries</td><td>The ecological receptor populations of interest are fish communities.
The spatial boundaries are those areas impacted by the ash spill, upstream to downstream. Appendix B presents the sampling locations.
There is no temporal boundary of the study. Concentrations of bioaccumulative ash-related constituents may increase in fish tissue overtime and therefore collection of data over more than one sampling period may be preferred to a single round. However, comparison to data from samples collected immediately after the ash spill will provide an indication of trends in bioaccumulation.</td></tr>
<tr><td>Develop a Decision Rule</td><td>The following lines of evidence will be considered for characterizing risks to fish communities:
• Bioaccumulation studies of largemouth bass, blue gill, and red ear sunfish. Comparisons are made of concentrations in fish in downstream areas with those in reference upstream areas, of concentrations in fish at higher trophic levels, and of concentrations in fish over time. If concentrations downstream are greater, if concentrations in higher trophic levels are greater, or if concentrations show increasing trends, then constituents may be bioaccumulating in fish.
• Comparison of biosurveys in site-related locations with those in reference locations and comparisons of biosurveys over time. If differences in species abundance, richness, diversity, or physical condition are observed in site-related locations or changes are observed over time, then this may indicate environmental stress and potential risk.</td></tr>
<tr><td>Specify Limits on Decision Errors</td><td>Concentrations in fish will be determined with detection limits below the respective risk-based levels. Project MDLs will be used to ensure that data are defensible to a concentration sufficient to achieve the lowest applicable regulatory standard for an analyte.</td></tr>
<tr><td>Optimize the Design</td><td>TVA has been conducting bioaccumulation studies of largemouth bass, bluegill, and red ear sunfish, which will continue. Samples of each species will be collected using combination of electroshock, seining, or other methods as required to obtain sufficient volume for analysis. Up to six replicates of each species may be collected at each location to evaluate variability within that location. Sampling locations are presented in Appendix B.
Bioaccumulation study samples will be composited if individual fish specimens are insufficient in volume. Filet, ovary, and liver tissues will be analyzed for metals.
TVA has been conducting fish community biosurveys in the Emory and Clinch Rivers. These same locations will be surveyed to be consistent with historical studies. Survey locations are presented in Appendix B.
Biosurvey samples of fish will be collected using the same methods as bioaccumulation samples, with multiple collections occurring within each reach. Specimens will be analyzed in the field for taxonomic identification and enumeration of fish, with results reported for species abundance, richness, diversity, age-class structure, and physical condition (abnormalities).</td></tr>
<tr><td></td><td>Applicable SOPs:
• TVA-KIF-SOP-31 Fish Sampling with Gill Nets
• TVA-KIF-SOP-32 Fish Sampling with Seines
• TVA-KIF-SOP-33 Fish Sampling – Boat Mounted Electrofishing</td></tr>
</table>

<u>Note</u>: For definitions, see the Acronyms section.

APPENDIX B

Field Sampling Summary

Table B-1
Summary of Long-term Monitoring in Support of Selected Remedial Action: Monitored Natural Recovery (MNR)

Tasks	Organisms	Sampling frequency	Field Method	Approach/Sample Types	Approximate # of Sites		Sites (approximate river miles)																
							Little Emory	Emory River[1]								Clinch River[2]					Tenn River[3]		
					2013	Long-term	1.0	8.0	6.0	4.0	3.0	2.5	2.2	1.0	0.7	8.0	6.0	4.0[4]	3.0	1.5[4]	572	566	561
1. Bathymetry and sediment transport modeling	NA	Bathymetry in spring 2013; rerun model for baseline in summer/fall 2013; re-run for storm events >110,000 cfs as needed.	Combine data from surveys using boat-mounted bathymetric equipment and land surveys for exposed mudflats. Update model with new bathymetry	Bathymetric contours; surface elevations in mudflats Stream flows and water surface elevations for model runs	Spring --Fall	As neede d			Collect new bathymetry in 2013 from ERM 5.0 to CRM 2.0 @ 200 ft intervals. Update sediment transport model with new data and re-run baseline; re-run model after storm events >110,000 cfs														
2. Characterization of ash deposits in support of sediment transport modeling	NA	As needed for confirmation of model results	Discrete VibeCore samples of sediment. Focus on depositional areas identified by model results.	Ash depth, plus percent ash, grain size distribution, and As & Se in upper 6 "of sediments.	Spring	As neede d			As needed only for confirmation of depositional areas after >110,000 cfs storm events														
3. Sediment contaminants monitoring	NA	Biennial in Fall (concurrent with Benthic invertebrate community sampling)	Multiple Ponar samples/transect area (left, center, right—upper 6" of sediments), composited by area. Left and right (where possible) focused on areas with suitable benthic habitat. Discrete, co-located sediment samples collected concurrent with each benthic community sample; 10 points/transect	Composite samples: percent ash, grain size distribution, As & Se. (Composite samples from some locations also used for sediment toxicity tests in 2013, and possibly in 2017—see below) Co-located samples: percent ash only	11	11			▲	▲	▲	▲	▲	⦿	⦿		▲	▲	▲	▲			
4. Sediment toxicity	*Hyalella azteca*	Fall, 2013	Multiple Ponar samples/transect area (left, middle, right), composited by area.	Definitive 10-d Survival & Growth Test w/ *Hyalella azteca*	4	4			◆					◆		◆			◆				
5. Benthic invertebrate community sampling	Invertebrate assemblage	Biennial in Fall	10 discrete Ponar samples/site	Population abundance and diversity	11	11			▲	▲	▲	▲	▲	⦿	⦿		▲	▲	▲	▲			
6. Benthic invertebrate bioaccumulation	Mayfly nymphs (non-depurated)	Biennial in Spring	Ponar dredge	Metals; 3 composite samples of non-depurated nymphs/site	12	7	X		▲	▲	▲	▲		⦿			▲		▲	X	X	X	X
	Mayfly nymphs (depurated)	Biennial in Spring	Ponar dredge	Metals; 3 composite samples of depurated nymphs/site	9	4			▲	X		▲		⦿			X		▲	X	X	X	

Table B-1
Summary of Long-term Monitoring in Support of Selected Remedial Action: Monitored Natural Recovery (MNR)

Tasks	Organisms	Sampling frequency	Field Method	Approach/Sample Types	Approximate # of Sites		Sites (approximate river miles)																
							Little Emory	Emory River[1]								Clinch River[2]					Tenn River[3]		
					2013	Long-term	1.0	8.0	6.0	4.0	3.0	2.5	2.2	1.0	0.7	8.0	6.0	4.0[4]	3.0	1.5[4]	572	566	561
6. Benthic invertebrate bioaccumulation (continued)	Mayfly adults	Biennial in Summer	Sweep net	Metals; up to 3 composite samples each of male and female imagos and subimagos	11	7	X		▲	▲	▲	▲		⦿			▲		▲	X	X	X	
	Snails (non-depurated)	Summer, 2013	Hand-sampling	Metals; up to 3 composites of non-depurated snails	6	NA			X			X		X			X		X	X			
	Snails (depurated)	Summer, 2013	Hand-sampling	Metals; up to 3 composites of depurated snails	10	NA	X		X	X		X		X			X		X	X	X	X	
7. Aerial-feeding insectivores	Tree swallows	Annual	Field observation, hand-sampling of eggs	Bioaccumulation in eggs, clutch size, hatching success, 15-day hatchling survival	2	2								⦿							⦿		

Reference Sites

▲ Biennial, long-term monitoring site (2013, 2015, 2017; re-evaluate frequency periodically as indicated in Section 3 of the LTM SAP.

⦿ Annual, long-term monitoring site (2013, 2014, 2015, 2016, 2017; re-evaluate frequency periodically as indicated in Section 3 of the LTM SAP.

◆ Fall, 2013 and Fall, 2017 only

X Sampling at the site expected to be discontinued after 2013 if review of the five year dataset reveals no ecological significant change(s) in spatial and temporal trends.

Notes:

1. Benthic community sampling at Emory River Miles 5.0 and 3.5 to be discontinued in 2013; sites not listed.
2. Benthic community sampling at Clinch River Miles 0.5 and 8.7 to be discontinued in 2013; sites not listed.
3. Benthic community sampling in Tennessee River (miles 572 and 566) discontinued in 2012. Benthic community sampling at Tennessee River Mile 561 will continue in accordance with TVA's Valley-wide monitoring program.
4. Benthic invertebrate community sampling is conducted at Clinch River Miles 1.5 and 4.0 in support of the Kingston Fossil Plant NPDES permit.

Table B-2
Kingston Ash Recovery Project Supplemental Long-term Monitoring

Tasks	Organisms	Sampling frequency	Field Method	Sample Types	Approximate # of Sites		Sites (approximate river miles)																
							Little Emory	Emory River								Clinch River					Tenn River		
					2013	Long-term	1.0	8.0	6.0	4.0	3.0	2.5	2.2	1.0	0.7	8.0	6.0	4.0[1]	3.0	1.5[1]	572	566	561
1. Fish bioaccumulation	Bluegill, redear sunfish, largemouth bass	Biennial in Spring	Boat electrofishing	6 females per species/site; Metals: fillets, ovary, and liver	5	5		▲				▲		◉		▲				▲			
2. Fish health and reproduction	Concurrent with fish bioaccumulation monitoring; Bluegill, redear sunfish, largemouth bass Fish health and reproductive measures, species, sampling sites, and frequency to be determined based on evaluation of the initial five-year (2009-2013) dataset.			8 females per species/site Health metrics: organ and body condition indicators and histopathology Reproductive condition and fecundity	5	5		▲				▲		▲		▲				▲			
3. Fish community	Fish assemblage	Biennial in Fall	15 electrofishing transects and 10 gill net sets/site	Population abundance and diversity (Reservoir Fish Assemblage Index)	3	3						▲						▲		▲			
4. Spring Sport Fish Survey	Black bass and crappie	Biennial in Spring	12 electrofishing transects/site	Fisheries information (abundance, recruitment, condition)	2	2						▲								▲			

Reference Sites

▲ Biennial, long-term monitoring site (2013, 2015, 2017; re-evaluate frequency in 5-yr review)

◉ Annual, long-term monitoring site (2013, 2014, 2015, 2016, 2017; re-evaluate frequency in 5-yr review)

* Fish health and reproduction studies expected o be discontinued after 2013.

Note:

1. Fish and benthic invertebrate community sampling is conducted at Clinch River Miles 1.5 and 4.0 in support of the Kingston Fossil Plant NPDES permit.

Table B-3
2013 Field Sampling Summary

Sample Task	Sample Point	Sample Frequency	Approx Sample Quantity	Matrix	Sampling Method/ Equipment	Required Analysis	Analytical Method	Holding Time	Sample Preservation	Containers
Bathymetry and Sediment Transport Modeling	Bathymetry in spring 2013 from ERM 5.0 to CRM 2.0 at 200 ft intervals to support model re-run for baseline in summer/fall 2013, re-run model for storm events >110,000 cfs as needed			Data from surveys using boat-mounted bythmetric equipment and land surveys for exposed mudflats		Bathymetric contours and surface elevations in mudflats. Stream flows and water surface elevations for model runs	none	none	none	none
Ash Deposit Characterization (sampling to support sediment transport modeling)	Spring 2013 - sample approximately 30 depositional areas, and after >110,000 cfs storm events. Sampling at the direction of Steve Scott (ERDC).			Ash/ Sediment	'VibeCore-D	Ash thickness % Ash (offsite lab) Grain size distibution Metals (As and Se only)	**Ash thickness** - field observation **PLM** - EPA-600/M4-82-020 **Grain size** - ASTM D 422 **Metals** - SW-846 6020	**PLM** - none **Grain size** - none **Metals** - 180 days	**PLM** - none **Grain size** - none **Metals** - Cool <6°C	**PLM** - 1 x 4-oz. jar **Grain size** - 1 x 16-oz. jar **Metals** - 1 x 8-oz. jar
Sediment Contaminant Monitoring **Discrete, co-located sediment samples.** 10 points per transect, co-located with each benthic community sample.	ERM 6.0 ERM 4.0 ERM 3.0 ERM 2.5 ERM 2.2 ERM 1.0 ERM 0.7 CRM 6.0 CRM 4.0 CRM 3.0 CRM 1.5	10 samples per transect at 11 transects (where substrate suitable for benthic invertabrates is present)	Up to 110 samples	Sediment	Ponar	% ash (offsite lab)	**PLM** - EPA-600/M4-82-020	**PLM** - none	**PLM** - none	**PLM** - 1 x 4-oz. jar
Sediment Contaminant Monitoring **Composite sediment samples**. Multiple ponar samples per transect area. (left, center, right - where possible of upper 6" of sediment) focused on areas with suitable benthic habitat.	ERM 6.0 ERM 4.0 ERM 3.0 ERM 2.5 ERM 2.2 ERM 1.0 ERM 0.7 CRM 6.0 CRM 4.0 CRM 3.0 CRM 1.5	Up to 3 samples per transect at 11 transects	Up to 33 samples	Sediment	Ponar	% Ash (offsite lab) Grain Size Distibution Metals (As and Se only)	**PLM** - EPA-600/M4-82-020 **Grain size** - ASTM D 422 **Metals** - SW-846 6020	**PLM** - none **Grain size** - none **Metals** - 180 days	**PLM** - none **Grain size** - none **Metals** - Cool <6°C	**PLM** - 1 x 4-oz. jar **Grain size** - 1 x 16-oz. jar **Metals** - 1 x 8-oz. jar

Table B-3
2013 Field Sampling Summary

Sample Task	Sample Point	Sample Frequency	Approx Sample Quantity	Matrix	Sampling Method/ Equipment	Required Analysis	Analytical Method	Holding Time	Sample Preservation	Containers
Sediment Toxicity Multiple ponar samples per transect area (right, center, left) composited by area collected at same time as benthic community sampling.	ERM 6.0 ERM 1.0 CRM 8.0 CRM 3.0	3 composite samples per transect at 4 transects	12 - samples	Sediment	Ponar	Definitive 10-day Survival and Growth Test w/ *Hyalella azteca* % Ash (offsite lab) TOC Grain Size Distribution Metals (As and Se only) Pesticides PCBs PAHs	Inland Testing Manual, EPA 600/R-99/064 (Method 100.1) **PLM** - EPA-600/M4-82-020 **TOC** - Walkley Black **Grain size** - ASTM D 422 **Metals** - SW-846 6020 **Pest** - SW-846 8081 **PCBs**- SW-846 8082 **PAHs** - SW-846 8270 SIM (incuding alkylated PAHs)	8 weeks **PLM** - none **TOC** - 14 days **Grain size** - none **Metals** - 180 days **Pest/PCBs/PAHs** - 14 days to extract/ 40 days to analysis	Cool <6°C **PLM** - none **TOC** - Cool <6°C **Grain size** - none **Metals** - Cool <6°C **Pest/PCBs/PAHs** - Cool <6°C	2 x 5-gal buckets **PLM** - 1 x 4-oz. jar **TOC** - 1 x 8-oz. jar **Grain size** - 1 x 16-oz. **Metals** - 1 x 8-oz. jar **Pest /PCBs/PAHs**- 2 x 8-oz. jar
Benthic Invertebrate Community Sampling Benthic invertebrate population abundance and diversity. 10 discrete points per transect.	ERM 6.0 ERM 4.0 ERM 3.0 ERM 2.5 ERM 2.2 ERM 1.0 ERM 0.7 CRM 6.0 CRM 4.0 CRM 3.0 CRM 1.5	10 samples per transect at 11 transects	110 - samples	Invertebrate assemblage	Ponar	Population abundance and diversity	Field measurements and observations	none	Formalin	pint or quart jars

Table B-3
2013 Field Sampling Summary

Sample Task	Sample Point	Sample Frequency	Approx Sample Quantity	Matrix	Sampling Method/ Equipment	Required Analysis	Analytical Method	Holding Time	Sample Preservation	Containers
Benthic Invertebrate Bioaccumulation **Mayfly nymphs (non-depurated)** composited at 3 points per transect (right, center, left).	LERM 1.0 ERM 6.0 ERM 4.0 ERM 3.0 ERM 2.5 ERM 1.0 CRM 6.0 CRM 3.0 CRM 1.5 TRM 572 TRM 566 TRM 561	3 samples per transect at 12 transects	36 - samples	Mayfly nymphs (non-depurated)	Peterson dredge	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	**Metals/Hg** - 1 x 8-oz. jar (20 g min.)
Benthic Invertebrate Bioaccumulation **Mayfly nymphs (depurated)** composited at 3 points per transect (right, center, left).	ERM 6.0 ERM 4.0 ERM 2.5 ERM 1.0 CRM 6.0 CRM 3.0 CRM 1.5 TRM 572 TRM 566	3 samples per transect at 9 transects	27 - samples	Mayfly nymphs (depurated)	Peterson dredge	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	**Metals/Hg** - 1 x 8-oz. jar (20 g min.)
Benthic Invertebrate Bioaccumulation **Mayfly adults** composited at 3 points per transect (right, center, left) of each male and female and imagos and subimagos.	LERM 1.0 ERM 6.0 ERM 4.0 ERM 3.0 ERM 2.5 ERM 1.0 CRM 6.0 CRM 3.0 CRM 1.5 TRM 572 TRM 566	Up to 12 samples per transect (3 samples per transect of each; male imago, male subimago, female imago, and female subimago) at 11 transects	Up to 132 samples	Mayfly adults	Sweep net	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	**Metals/Hg** - 1 x 8-oz. jar (20 g min.)

Table B-3
2013 Field Sampling Summary

Sample Task	Sample Point	Sample Frequency	Approx Sample Quantity	Matrix	Sampling Method/ Equipment	Required Analysis	Analytical Method	Holding Time	Sample Preservation	Containers
Benthic Invertebrate Bioaccumulation **Snails (non-depurated)** composited at 3 points per transect (right, center, left) .	ERM 6.0 ERM 2.5 ERM 1.0 CRM 6.0 CRM 3.0 CRM 1.5	3 samples per site at 6 sites	18 - samples	Snails (non-depurated)	Hand	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	**Metals/Hg** - 1 x 8-oz. jar (20 g min.)
Benthic Invertebrate Bioaccumulation **Snails (depurated)** composited at 3 points per transect (right, center, left) .	LERM 1.0 ERM 6.0 ERM 4.0 ERM 2.5 ERM 1.0 CRM 6.0 CRM 3.0 CRM 1.5 TRM 572 TRM 566	3 samples per site at 10 sites	30 - samples	Snails (depurated)	Hand	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	**Metals/Hg** - 1 x 8-oz. jar (20 g min.)
Aerial-feeding Insectivores Bioaccumulation	ERM 1.0 TRM 572	25 egg samples per location at 2 locations	50 - samples	Tree swallow eggs	Hand	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	Plastic bag
Tree swallow monitoring at two locations (35 boxes at each location).	ERM 1.0 TRM 572	Wildlife survey	Bird box monitoring 6 days a week for approximately 12 weeks at 70 boxes	Tree swallows	None	Field Observations	Clutch size, hatching success, 15-day hatchling survival	none	none	none
Fish Bioaccumulation Monitoring Collection of 6 female of each species per site.Test fillets, ovaries, and liver.	ERM 8.0 ERM 2.5 ERM 1.0 CRM 8.0 CRM 1.5	6 females of each species at 5 sites (analysis of fillets, ovaries and liver)	270 - samples	Fish (bluegill, redear sunfish, largemouth bass	Boat electrofishing	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	Plastic bag Metals - 20 g min

Table B-3
2013 Field Sampling Summary

Sample Task	Sample Point	Sample Frequency	Approx Sample Quantity	Matrix	Sampling Method/ Equipment	Required Analysis	Analytical Method	Holding Time	Sample Preservation	Containers
Fish Health and Reproduction Performed concurrently with bioaccumulation monitoring.	ERM 8.0 ERM 2.5 ERM 1.0 CRM 8.0 CRM 1.5	8 females of each species at 5 sites	120 - samples	Fish (bluegill, redear sunfish, largemouth bass	Boat electrofishing	Health metrics and reproductive condition and fecundity	Physical examination performed by ORNL	none	none	Plastic bag
Fish Community Survey	ERM 2.5 CRM 4.0 CRM 1.5	15 electrofishing transects and 10 gill net sites	25 - sites/transects	Fish assemblage	Boat electrofishing/ gill nets	Population abundance and diversity	Field observations	none	none	none
Spring Sport Fish Survey	ERM 2.5 CRM 1.5	12 electrofishing transects/sites	12 - sites/transects	Black bass, crappie	Boat electrofishing/	Fisheries information	Field observations	none	none	none

Table B-4
2014 2016 Tentative Field Sampling Summary

Sample Task	Sample Point	Sample Frequency	Approx Sample Quantity	Matrix	Sampling Method/ Equipment	Required Analysis	Analytical Method	Holding Time	Sample Preservation	Containers
Bathymetry and Sediment Transport Modeling	Re-run model for storm events >110,000 cfs as needed			none		Modeling	none	none	none	none
Ash Deposit Characterization (sampling to support sediment transport modeling)	As needed for confirmation of depositional areas after >110,000 cfs storm events. Sampling at the direction of Steve Scott (ERDC).			Ash/ Sediment	'VibeCore-D/ Ponar	Ash thickness % ash (offsite lab) Grain size distibution Metals (As and Se only)	**Ash thickness** - field observation **PLM** - EPA-600/M4-82-020 **Grain size** - ASTM D 422 **Metals** - SW-846 6020	**PLM** - none **Grain size** - none **Metals** - 180 days	**PLM** - none **Grain size** - none **Metals** -Cool <6°C	**PLM** - 1 x 4-oz. jar **Grain size** - 1 x 16-oz. jar **Metals** - 1 x 8-oz. jar
Sediment Contaminant Monitoring Discrete, co-located sediment samples. 10 points per transect, co-located with each benthic community sample.	ERM 1.0 ERM 0.7	10 samples per transect at 2 transects (where substrate suitable for benthic invertabrates is present)	Up to 22 samples	Sediment	Ponar/ 'VibeCore-D	% ash (offsite lab)	**PLM** - EPA-600/M4-82-020	**PLM** - none	**PLM** - none	**PLM** - 1 x 4-oz. jar
Sediment Contaminant Monitoring Composite sediment samples. Multiple ponar samples per transect area. (left, center, right - where possible of upper 6" of sediment) focused on areas with suitable benthic habitat.	ERM 1.0 ERM 0.7	Up to 3 samples per transect at 2 transects	Up to 6 samples	Sediment	Ponar/ 'VibeCore-D	% ash (offsite lab) Grain Size Distibution Metals (As and Se only)	**PLM** - EPA-600/M4-82-020 **Grain size** - ASTM D 422 **Metals** - SW-846 6020	**PLM** - none **Grain size** - none **Metals** - 180 days	**PLM** - none **Grain size** - none **Metals** -Cool <6°C	**PLM** - 1 x 4-oz. jar **Grain size** - 1 x 16-oz. jar **Metals** - 1 x 8-oz. jar

Table B-4
2014 2016 Tentative Field Sampling Summary

Sample Task	Sample Point	Sample Frequency	Approx Sample Quantity	Matrix	Sampling Method/ Equipment	Required Analysis	Analytical Method	Holding Time	Sample Preservation	Containers
Benthic Invertebrate Community Sampling Benthic invertebrate population abundance and diversity. 10 discrete points per transect.	ERM 1.0 ERM 0.7	10 samples per transect at 2 transects	20 - samples	Invertebrate assemblage	Ponar	Population abundance and diversity	Field measurements and observations	none	Formalin	pint or quart jars
Benthic Invertebrate Bioaccumulation **Mayfly nymphs (non-depurated)** composited at 3 points per transect (right, center, left).	ERM 1.0	3 samples per transect at 1 transects	3 - samples	Mayfly nymphs (non-depurated)	Peterson dredge	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	**Metals/Hg** - 1 x 8-oz. jar (20 g min.)
Benthic Invertebrate Bioaccumulation **Mayfly nymphs (depurated)** composited at 3 points per transect (right, center, left).	ERM 1.0	3 samples per transect at 1 transect	3 - samples	Mayfly nymphs (depurated)	Peterson dredge	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	**Metals/Hg** - 1 x 8-oz. jar (20 g min.)
Benthic Invertebrate Bioaccumulation **Mayfly adults** composited at 3 points per transect (right, center, left) of each male and female and imagos and subimagos.	ERM 1.0	Up to 12 samples per transect (3 samples per transect of each; male imago, male subimago, female imago, and female subimago) at 1 transects	Up to 12 - samples	Mayfly adults	Sweep net	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	**Metals/Hg** - 1 x 8-oz. jar (20 g min.)

Table B-4
2014 2016 Tentative Field Sampling Summary

Sample Task	Sample Point	Sample Frequency	Approx Sample Quantity	Matrix	Sampling Method/ Equipment	Required Analysis	Analytical Method	Holding Time	Sample Preservation	Containers
Aerial-feeding Insectivores Bioaccumulation Tree swallow monitoring at two locations (35 boxes at each location).	ERM 1.0 TRM 572	25 egg samples per location at 2 locations	50 - samples	Tree swallow eggs	Hand	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	Plastic bag
	ERM 1.0 TRM 572	Wildlife survey	Bird box monitoring 6 days a week for approximately 12 weeks at 70 boxes	Tree swallows	None	Field Observations	Clutch size, hatching success, 15-day hatchling survival	none	none	none
Fish Bioaccumulation Monitoring Collection of 6 female of each species per site.Test fillets, ovaries, and liver.	ERM 1.0	6 females of each species at 1 site (analysis of fillets, ovaries, and livers)	54 - samples	Fish (bluegill, redear sunfish, largemouth bass	Boat electrofishing	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	Plastic bag Metals - 20 g min

Table B-5
2015 2017 Tentative Field Sampling Summary

Sample Task	Sample Point	Sample Frequency	Approx Sample Quantity	Matrix	Sampling Method/ Equipment	Required Analysis	Analytical Method	Holding Time	Sample Preservation	Containers
Bathymetry and Sediment Transport Modeling	Re-run model for storm events >110,000 cfs as needed			Data from surveys using boat-mounted bythmetric equipment and land surveys for exposed mudflats		Bathymetric contours and surface elevations in mudflats. Stream flows and water surface elevations for model runs	none	none	none	none
Ash Deposit Characterization (sampling to support sediment transport modeling)	As needed for confirmation of depositional areas after >110,000 cfs storm events. Sampling at the direction of Steve Scott (ERDC).			Ash/ Sediment	'VibeCore-D/ Ponar	Ash thickness % ash (offsite lab) Grain size distibution Metals (As and Se only)	**Ash thickness** - field observation **PLM** - EPA-600/M4-82-020 **Grain size** - ASTM D 422 **Metals** - SW-846 6020	**PLM** - none **Grain size** - none **Metals** - 180 days	**PLM** - none **Grain size** - none **Metals** -Cool <6°C	**PLM** - 1 x 4-oz. jar **Grain size** - 1 x 16-oz. jar **Metals** - 1 x 8-oz. jar
Sediment Contaminant Monitoring Discrete, co-located sediment samples. 10 points per transect, co-located with each benthic community sample.	ERM 6.0 ERM 4.0 ERM 3.0 ERM 2.5 ERM 2.2 ERM 1.0 ERM 0.7 CRM 6.0 CRM 4.0 CRM 3.0 CRM 1.5	10 samples per transect at 11 transects (where substrate suitable for benthic invertabrates is present)	Up to 110 samples	Sediment	Ponar/ 'VibeCore-D	% ash (offsite lab)	**PLM** - EPA-600/M4-82-020	**PLM** - none	**PLM** - none	**PLM** - 1 x 4-oz. jar

* Sampling at these locations expected to be discontinued after 2013 if review of the five year dataset reveals no ecological significant change(s) in spatial and temporal trends.

Table B-5
2015 2017 Tentative Field Sampling Summary

Sample Task	Sample Point	Sample Frequency	Approx Sample Quantity	Matrix	Sampling Method/ Equipment	Required Analysis	Analytical Method	Holding Time	Sample Preservation	Containers
Sediment Contaminant Monitoring Composite sediment samples. Multiple ponar samples per transect area. (left, center, right - where possible of upper 6" of sediment) focused on areas with suitable benthic habitat.	ERM 6.0 ERM 4.0 ERM 3.0 ERM 2.5 ERM 2.2 ERM 1.0 ERM 0.7 CRM 6.0 CRM 4.0 CRM 3.0 CRM 1.5	Up to 3 samples per transect at 11 transects	Up to 33 samples	Sediment	Ponar/ 'VibeCore-D	% ash (offsite lab) Grain Size Distibution Metals (As and Se only)	**PLM** - EPA-600/M4-82-020 **Grain size** - ASTM D 422 **Metals** - SW-846 6020	**PLM** - none **Grain size** - none **Metals** - 180 days	**PLM** - none **Grain size** - none **Metals** -Cool <6°C	**PLM** - 1 x 4-oz. jar **Grain size** - 1 x 16-oz. jar **Metals** - 1 x 8-oz. jar
Sediment Toxicity Multiple ponar samples per transect area (right, center, left) composited by area collected at same time as benthic community sampling.	ERM 6.0 ERM 1.0 CRM 8.0 CRM 3.0	3 composite samples per transect at 4 transects	12 - samples	Sediment	Ponar	Definitive 10-day Survival and Growth Test w/ *Hyalella azteca* % Ash (offsite lab) TOC Grain Size Distribution Metals (As and Se only) Pesticides PCBs PAHs	Inland Testing Manual, EPA 600/R-99/064 (Method 100.1) **PLM** - EPA-600/M4-82-020 **TOC** - Walkley Black **Grain size** - ASTM D 422 **Metals** - SW-846 6020 **Pest** - SW-846 8081 **PCBs** - SW-846 8082 **PAHs** - SW-846 8270 SIM (incuding alkylated PAHs)	8 weeks **PLM** - none **TOC** - 14 days **Grain size** - none **Metals** - 180 days **Pest/PCBs/PAHs** - 14 days to extract/ 40 days to analysis	Cool <6°C **PLM** - none **TOC** - Cool <6°C **Grain size** - none **Metals** - Cool <6°C **Pest/PCBs/PAHs** - Cool <6°C	2 x 5-gal buckets **PLM** - 1 x 4-oz. jar **TOC** - 1 x 8-oz. jar **Grain size** - 1 x 16-oz. **Metals** - 1 x 8-oz. jar **Pest /PCBs/PAHs**- 2 x 8-oz. jar

* Sampling at these locations expected to be discontinued after 2013 if review of the five year dataset reveals no ecological significant change(s) in spatial and temporal trends.

Table B-5
2015 2017 Tentative Field Sampling Summary

Sample Task	Sample Point	Sample Frequency	Approx Sample Quantity	Matrix	Sampling Method/ Equipment	Required Analysis	Analytical Method	Holding Time	Sample Preservation	Containers
Benthic Invertebrate Community Sampling Benthic invertebrate population abundance and diversity. 10 discrete points per transect.	ERM 6.0 ERM 4.0 ERM 3.0 ERM 2.5 ERM 2.2 ERM 1.0 ERM 0.7 CRM 6.0 CRM 4.0 CRM 3.0 CRM 1.5	10 samples per transect at 11 transects	110 - samples	Invertebrate assemblage	Ponar	Population abundance and diversity	Field measurements and observations	none	Formalin	pint or quart jars
Benthic Invertebrate Bioaccumulation **Mayfly nymphs (non-depurated)** composited at 3 points per transect (right, center, left).	LERM 1.0 * ERM 6.0 ERM 4.0 ERM 3.0 ERM 2.5 ERM 1.0 CRM 6.0 CRM 3.0 CRM 1.5 * TRM 572 * TRM 566 * TRM 561 *	3 samples per transect at 12 transects (or 7 transects if * locations are discontinued)	36 - samples (or 21 samples if * locations discontinued)	Mayfly nymphs (non-depurated)	Peterson dredge	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	**Metals/Hg** - 1 x 8-oz. jar (20 g min.)
Benthic Invertebrate Bioaccumulation **Mayfly nymphs (depurated)** composited at 3 points per transect (right, center, left).	ERM 6.0 ERM 4.0 * ERM 2.5 ERM 1.0 CRM 6.0 * CRM 3.0 CRM 1.5 * TRM 572 * TRM 566 *	3 samples per transect at 9 transects (or 4 transects if * locations are discontinued)	27 - samples (or 12 samples if * locations discontinued)	Mayfly nymphs (depurated)	Peterson dredge	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	**Metals/Hg** - 1 x 8-oz. jar (20 g min.)

* Sampling at these locations expected to be discontinued after 2013 if review of the five year dataset reveals no ecological significant change(s) in spatial and temporal trends.

Table B-5
2015 2017 Tentative Field Sampling Summary

Sample Task	Sample Point	Sample Frequency	Approx Sample Quantity	Matrix	Sampling Method/ Equipment	Required Analysis	Analytical Method	Holding Time	Sample Preservation	Containers
Benthic Invertebrate Bioaccumulation **Mayfly adults** composited at 3 points per transect (right, center, left) of each male and female and imagos and subimagos.	LERM 1.0 * ERM 6.0 ERM 4.0 ERM 3.0 ERM 2.5 ERM 1.0 CRM 6.0 CRM 3.0 CRM 1.5 * TRM 572 * TRM 566 *	Up to 12 samples per transect (3 samples per transect of each; male imago, male subimago, female imago, and female subimago) at 11 transects (or 7 transects if * locations discontinued)	Up to 132 - samples (or 84 samples if * locations discontinued)	Mayfly adults	Sweep net	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	**Metals/Hg** - 1 x 8-oz. jar (20 g min.)
Benthic Invertebrate Bioaccumulation **Snails (non-depurated)** composited at 3 points per transect (right, center, left) .	ERM 6.0 * ERM 2.5 * ERM 1.0 * CRM 6.0 * CRM 3.0 * CRM 1.5 *	3 samples per transect at 6 transects (or 0 transects if * locations discontinued)	18 - samples (possibly no samples if * locations discontinued)	Snails (non-depurated)	Hand	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	**Metals/Hg** - 1 x 8-oz. jar (20 g min.)
Benthic Invertebrate Bioaccumulation **Snails (depurated)** composited at 3 points per transect (right, center, left) .	LERM 1.0 * ERM 6.0 * ERM 4.0 * ERM 2.5 * ERM 1.0 * CRM 6.0 * CRM 3.0 * CRM 1.5 * TRM 572 * TRM 566 *	3 samples per transect at 10 transects (or 0 transects if * locations discontinued)	30 - samples (possibly no samples if * locations discontinued)	Snails (depurated)	Hand	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	**Metals/Hg** - 1 x 8-oz. jar (20 g min.)

* Sampling at these locations expected to be discontinued after 2013 if review of the five year dataset reveals no ecological significant change(s) in spatial and temporal trends.

Table B-5
2015 2017 Tentative Field Sampling Summary

Sample Task	Sample Point	Sample Frequency	Approx Sample Quantity	Matrix	Sampling Method/ Equipment	Required Analysis	Analytical Method	Holding Time	Sample Preservation	Containers
Aerial-feeding Insectivores Bioaccumulation Tree swallow monitoring at two locations (35 boxes at each location).	ERM 1.0 TRM 572	25 egg samples per location at 2 locations	50 - samples	Tree swallow eggs	Hand	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	Plastic bag
	ERM 1.0 TRM 572	Wildlife survey	Bird box monitoring 6 days a week for approximately 12 weeks at 70 boxes	Tree swallows	None	Field Observations	Clutch size, hatching success, 15-day hatchling survival	none	none	none
Fish Bioaccumulation Monitoring Collection of 6 female of each species per site. Assume analysis of fillets only in 2015 and 2017.	ERM 8.0 ERM 2.5 ERM 1.0 CRM 8.0 CRM 1.5	6 females of each species at 5 sites (analysis of fillets only in 2015 and 2017)	90 - samples (assumes analyzing fillets only in 2015 and 2017)	Fish (bluegill, redear sunfish, largemouth bass	Boat electrofishing	Metals (As, Ba, Cd, Cr, Cu, Fe, Mn, Hg, Se, Sr, Tl, Va, Zn)	**Metals/Hg** - SW-846 6020/ 7473	**Metals/Hg** - 365 days	**Metals/Hg** - frozen/freeze dried	Plastic bag Metals - 20 g min
Fish Community Survey	ERM 2.5 CRM 4.0 CRM 1.5	15 electrofishing transects and 10 gill net sites	25 - sites/transects	Fish assemblage	Boat electrofishing/ gill nets	Population abundance and diversity	Field observations	none	none	none
Spring Sport Fish Survey	ERM 2.5 CRM 1.5	12 electrofishing transects/sites	12 - sites/transects	Black bass, crappie	Boat electrofishing/	Fisheries information	Field observations	none	none	none

* Sampling at these locations expected to be discontinued after 2013 if review of the five year dataset reveals no ecological significant change(s) in spatial and temporal trends.