Tennessee Valley Authority
Regulatory Submittal for Kingston Ash Recovery Project

Documents submitted:
Kingston Fly Ash Recovery Project Non-Time Critical Action Scope and EE/CA Work Plan for Public Review

Date submitted
10/16/2009

Submitted to whom
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October 16, 2009

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Dear Mr. Zeller:

Please find enclosed the revised Non-Time-Critical Removal Action Scope and Work Plan. The enclosed plan fulfills the requirements of Section IX, paragraph 30, of the Administrative Order and Agreement on Consent. This document will be available for public comment from October 21, 2009 until November 20, 2009. Please contact me if you have any questions.

Sincerely,

Anda A. Ray

Anda A. Ray

Enclosure

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Kingston Fly Ash Recovery Project
Non-Time Critical Removal Action Scope and Engineering Evaluation/Cost Analysis (EE/CA) Work Plan

Prepared by:
Jacobs Engineering

For the Tennessee Valley Authority

Revision	Description	Date
1	Work Plan for Agency Review	August 2009
2	Work Plan for Public Review	October 16, 2009

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List of Acronyms

ARARs	Applicable or Relevant and Appropriate Requirements
BERA	Baseline Ecological Risk Assessment
BSCP	Background Soil Characterization Project
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
CCW	Condenser Cooling Water
CSM	Conceptual Site Model
CERCLA	Comprehensive Environmental Response Compensation & Liability Act
COI	Constituents of Interest
COPCs	Contaminants of Potential Concern
COPECs	Constituents of Potential Ecological Concern
CRM	Clinch River Mile
DOE	Department of Energy
EcoSSLs	Ecological Soil Screening Levels
EE/CAs	Engineering Evaluation/Cost Analyses
EPA	Environmental Protection Agency
ERA	Ecological Risk Assessment
ERM	Emory River Mile
ESV	Ecological Screening Value
FR	Federal Register
GPS	Global Positioning System
HQs	Hazard Quotients
IEUBK	Integrated Exposure-Uptake Biokinetic
IRIS	Integrated Risk Information System
KIF	Kingston Fossil Plant
MCL	Maximum Contaminant Level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
OREIS	Oak Ridge Environmental Information System
PAHs	Polynuclear Aromatic Hydrocarbons
PbB	Blood Lead Level
PCBs	Polychlorinated Biphenyls
PPRTVs	Provisional Peer Reviewed Toxicity Values
QAPP	Quality Assurance Project Plan
RDA	Recommended Dietary Allowance
SLERA	Screening-Level Ecological Risk Assessment
SMPDs	Scientific Management Decision Points
STSC	Superfund Technical Support Center
TAL	Target Analyte List
TBC	To Be Considered
TCLP	Toxicity Characteristic Leaching Procedure
TDEC	Tennessee Department of Environment and Conservation
TRM	Tennessee River Mile
TWRA	Tennessee Wildlife Resources Agency
TVA	Tennessee Valley Authority
UCL	Upper Confidence Limit
USACOE	United States Army Corp of Engineers
VOCs	Volatile Organic Compounds

EXECUTIVE SUMMARY

This work plan addresses the activities necessary to reach a decision on the restoration of the area impacted by the spilled fly ash at the Kingston Fossil Plant (KIF). On May 11, 2009, an Administrative Order and Agreement on Consent was signed between the Environmental Protection Agency (EPA) and the Tennessee Valley Authority (TVA) providing the regulatory framework for the restoration efforts. The EPA Order requires TVA to "submit to EPA for approval a draft Work Plan for performing one or more Engineering Evaluation/Cost Analyses (EE/CAs) for non-time critical removal actions to be taken at the Site." The work is being conducted under the Comprehensive Environment Response, Compensation, and Liability Act (CERCLA) and more specifically, under the removal program. Ongoing restoration efforts are being conducted as a time-critical removal action. This work plan addresses the activities for the remaining non-time critical removal activities.

Scope of the Decision. In June 22 and 23, 2009, the EE/CA Technical Working Group agreed to split the EE/CA into two concurrent non-time-critical removal actions: one to address the Swan Pond Embayment and dredge cell area, and the second to address the remaining ash in the Emory River as well as ash in the Clinch and Tennessee Rivers. Sufficient data exist to support evaluation of alternatives and move forward with a decision on how to deal with the ash in the embayment and the dredge cell; yet significant data uncertainties exist in characterizing the river systems, so that more study and time are needed for comprehensive assessment of ecological risk in the river. It was therefore decided to prepare two separate EE/CAs and make two separate non-time-critical removal action decisions.

The scope of the embayment/dredge cell action includes removal of the coal ash in the embayment, closure of the dredge cell, and disposal of the removed material, centered around the following questions:

- In what condition should the embayment area be left?
- Should excavated material be disposed onsite or offsite?
- In what condition should the dredge cell be left, including any remaining dike system to contain ash?

The scope of the river action includes addressing any residual ash in the Emory, Clinch, and Tennessee Rivers, centered around the following questions:

- In what condition should the rivers be left?

Site Conditions. Failure of the dredge cell dike released about 5.4 million cy of coal ash. Approximately 2.4 million cy of that ash filled the Swan Pond Embayment, and the remaining 3.0 million cy entered the Emory River. Most of the ash in the river is found between Emory River Mile (ERM) 1.0 and 3.5 and is being removed under the time-critical removal action. Trace amounts of ash occur both upstream in the Emory River and downstream in the Clinch and Tennessee Rivers. The ash is composed of fine silica particles similar to sand. Trace amounts of metals and radionuclides occur naturally in the coal and remain in the ash after coal combustion.

The Emory and Clinch Rivers are on the State list of impaired waters because of sediments contaminated before the ash spill occurred. This legacy contamination includes polychlorinated biphenyls (PCBs) and chlordane from industrial point sources, mercury from atmospheric deposition and other sources, manganese and iron from historic coal mining activities, and impacts from agriculture or development. Some of this legacy contamination occurs as a result of past U.S. Department of Energy (DOE) actions at Oak Ridge, which resulted in contamination of sediments by radionuclides and other wastes.

Soils in the area consist of residual or alluvial deposits overlying low water-producing bedrock. Alluvial soils lie beneath the ash disposal areas of the KIF, in the old floodplain of the Emory River, and are up to

65 feet deep. Groundwater moves from upland areas to the stream valleys, ultimately discharging to the Emory River. This discharge area is characterized by upward gradients toward the river, which minimizes the likelihood that ash-related contaminants could enter groundwater or move toward upland wells or springs.

Ecological conditions after the ash spill are still being studied. Wetlands present within the spill footprint were filled entirely by ash, thus eliminating these areas. Open water areas within the embayments and Emory River have also been filled with ash. The ash occurring above water level has been seeded with temporary grass to minimize erosion.

Sampling and Monitoring Activities. More than 80 samples of the ash have been collected and analyzed for metals, organic chemicals, and radionuclides. Metals, primarily arsenic, have been the focus of this monitoring. Arsenic is present in the ash at an average concentration of 50 mg/kg, which is above the EPA residential Regional Screening Level of 0.39 mg/kg.

Surface water samples have been collected since December 2008 several times a week. Five sampling locations are on the Emory River, four on the Clinch River, and two on the Tennessee River. Of the more than 300 samples analyzed by TVA, the average arsenic concentration was 3.15 ug/L, which is less than TDEC's Ambient Water Quality Criteria (AWQC) of 10 ug/L; however, the maximum arsenic concentration was 189 ug/L. Maximum concentrations of other metals have also exceeded AWQC.

Groundwater monitoring has been conducted since 2005 from four monitoring wells associated with the dredge cell; two of these wells were destroyed during the ash spill. Arsenic levels have been historically low; however in recent sampling arsenic has been detected at 14 ug/L in one well, which slightly exceeds its maximum contaminant level (MCL) of 10 µg/L. Low levels of arsenic could have been present in the groundwater near the dredge cell prior to the spill.

Biota monitoring has including sampling of fish, amphibian, and avian species. Additional ecological sampling, surveys, and testing is being planned.

Human Health Risk Assessment. A screening-level human health risk assessment was conducted for use in making risk management decisions on the path forward for the site. The screening consisted of comparing the maximum detected concentration of each analyte to the lowest applicable screening level for the medium of interest. Results of that screening-level risk assessment indicate that the following list of constituents may be of potential concern to human health (note that radionuclides have not yet been assessed, but will be assessed in the upcoming EE/CA):

- Ash as soil or sediment – aluminum, arsenic, cobalt, iron, lead, manganese, thallium, and vanadium;
- Surface water in the Emory River – aluminum, antimony, arsenic, barium, beryllium, cobalt, copper, iron, lead, manganese, mercury, thallium, and vanadium;
- Surface water in the Clinch River – aluminum, antimony, arsenic, barium, beryllium, cobalt, iron, lead, manganese, thallium, and vanadium;
- Surface water in the Tennessee River – antimony, iron, manganese, and mercury;
- Fish – arsenic, lead, and mercury.

The following Constituents of Interest (COIs) will be carried forward in future human health risk assessments of all media, regardless of the screening results, because they are related to fly ash. These include arsenic, chromium, copper, lead, mercury, nickel, selenium, thallium, vanadium, and zinc along with naturally-occurring radionuclides. The approach, assumptions, and methods intended to be used for future human health risk assessments for both the Embayment/Dredge Cell EE/CA and the River EE/CA are presented in detail in this work plan.

Ecological Risk Assessment. A screening-level ecological risk assessment (SLERA) was also conducted for use in making risk management decisions on the path forward for the site. The screening involved the comparing the maximum detected concentration of each analyte for the medium of concern to ecological screening values (ESVs). ESVs are constituent concentrations in environmental media below which there is negligible risk to receptors exposed to them. The ratio of the maximum concentration to ESV is called the hazard quotient (HQ). Results of the SLERA indicate that the following list of constituents may be of potential concern to ecological receptors:

- Ash as soil: Sixteen inorganic constituents were selected as contaminants of potential ecological concern (COPECs) because maximum concentrations exceeded an HQ of 1, or an ESV was not available.
- Ash as sediment: Seventeen inorganic constituents in ash as sediment were selected as COPECs because maximum concentrations exceeded an HQ of 1, an ESV was not available, or constituents were identified as COIs in fly ash; and
- Surface Water: Seventeen inorganic constituents in the Emory River, seventeen constituents in the Clinch River, and fourteen constituents in the Tennessee River were selected as COPECs because maximum concentrations exceeded an HQ of 1, an ESV was not available, or constituents were identified as COIs in fly ash.

Based on the available evidence, the possibility of adverse ecological risks for ecological receptors potentially exposed to ash and surface water in the rivers cannot be excluded.

Path Forward. The path forward for the site is to prepare two separate EE/CAs and make two separate non-time-critical removal action decisions for the embayment/dredge cell and the river systems.

Sufficient data exist to move forward with a decision on the embayment and the dredge cell. The decision on the type of removal action needed will be a balance of engineering effectiveness, implementability, cost, regulatory requirements, and public input. The human health baseline risk assessment will be completed with existing data using the methods defined in this work plan. No baseline ecological risk assessment (BERA) is warranted, since the EPA Order requires removal of ash, restoration of the embayment, and closure of the dredge cell. These efforts will be documented in an EE/CA for the embayment and dredge cell, scheduled for late in the calendar year of 2009. This schedule will meet the objective of completing the decision in time to support field construction no later than the completion of the time-critical actions (spring of 2010).

However, there are significant uncertainties remaining for the river systems. The decision on the residual ash in the river will depend significantly on balancing future ecological and human health risk with feasibility of retrieving the ash. The human health risk from ingesting fish needs to be defined. The SLERA indicates a potential ecological risk that needs to be better defined to show whether action is really needed after the ash is removed. A detailed sampling and analysis plan, with defined Data Quality Objectives needs to be developed for the river. Data collection should include sampling of fish, sediment, and groundwater, and comprehensive ecological surveys and analyses. Once the data are available, the baseline human health and ecological risk assessments can be completed as part of the EE/CA for the river. Alternatives for the residual ash removal and disposal will be assessed in the EE/CA, scheduled for the summer of 2011, and one selected in the Action Memorandum, scheduled for the end of 2011. This schedule assumes no further removal action would be needed in the river system and that a remedial site evaluation work plan would show no further remediation onsite is required.

Range of Alternatives. A range of alternatives for the embayment and dredge cell has been developed. This range will be the focus of the upcoming EE/CA; other alternatives have been considered, but not retained, as discussed in this work plan. A brief overview of the alternatives is presented below. They will be further developed as the EE/CA proceeds. Each of these alternatives involves removing ash and

restoring the embayment to pre-spill conditions (aquatic environment); therefore, the requirements for a Jurisdictional Assessment will be met.

1. Excavate Embayment and Dispose Offsite (2.7 million cy); Grade and Close Dredge Cell. Alternative 1 would remove the ash in the embayment and the ash from the test embankment within the dredge cell and dispose of this ash offsite. A dike would be installed to keep ash in the cell from entering the embayment in the future and the dredge cell would be graded for drainage. The height of the closed cell would be approximately 780-790 ft above mean sea level (msl).

2. Excavate Embayment and Portions of Dredge Cell and Dispose Offsite (6.3 million cy); Grade and Close Remainder of Dredge Cell. Alternative 2 would remove the ash in the embayment and test embankment, plus enough ash from the dredge cell to limit long-term reliance on a dike between the cell and the embayment, yet would leave enough ash to provide buttressing for the remaining dikes. The removed material would be disposed offsite. The dredge cell would be graded to a gradual slope, with a maximum height of approximately 765-775 ft msl at its highest point.

3. Excavate Embayment and Dispose Onsite in Dredge Cell; Close the Dredge Cell. Alternative 3 would use the dredge cell as a disposal facility. No material would be taken offsite. The ash in the embayment would be removed and stacked in the dredge cell. Material placed in the cell for the test embankment would remain in the cell. A dike would be installed to keep ash in the cell from entering the embayment in the future and the dredge cell would be graded for drainage. The height of the closed cell would be approximately 790-800 ft msl.

A range of alternatives for the river system has not been developed. Alternatives that address any residual ash remaining in the river after completion of the time-critical removal action and areas impacted by restoration activities will be developed at a later date, after completion of additional data collection activities.

Kingston Fly Ash Recovery Project
Non-Time Critical Removal Action Scope and
Engineering Evaluation/Cost Analysis (EE/CA) Work Plan

1 INTRODUCTION

This work plan addresses the activities necessary to reach a decision on the restoration of the area impacted by the spilled fly ash at the Kingston Fossil Plant (KIF). On May 11, 2009, an Administrative Order and Agreement on Consent was signed between the Environmental Protection Agency (EPA) and the Tennessee Valley Authority (TVA) providing the regulatory framework for the restoration efforts. A significant portion of the restoration efforts are currently underway and being conducted as a time-critical removal action. This work plan addresses the activities for the remaining non-time critical removal activities.

1.1 Background

The KIF is located at the confluence of the Emory and Clinch Rivers on Watts Bar Reservoir near Kingston, Tennessee. KIF is one of TVA's larger fossil plants. It 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. The plant consumes some 14,000 tons of coal a day.

On Monday, December 22, 2008, just before 1 a.m., a coal fly ash spill occurred at TVA's KIF, allowing a large amount of fly ash to escape into the adjacent waters of the Emory River. Ash, a by-product of a coal-fired power plant, is stored in containment areas. Failure of the dredge cell dike caused about 60 acres of ash in the 84-acre containment area to be displaced. At the time of the slide, the area contained about 9.4 million cubic yards (cy) of ash. The dike failure released about 5.4 million cy of coal ash that now covers about 300 acres. Fly ash filled the Swan Pond Embayment on the north side of the KIF property adjacent to the failed dredge cell. A dike (Dike 2) has been constructed in the eastern portion of the Swan Pond Embayment to contain the fly ash to the west of the dike until a response action plan is developed, approved by the regulators, and implemented. Fly ash also entered the channel and overbank areas of the riverine section of the Emory River. TVA is recovering the material outside of the Swan Pond Embayment by use of dredging operations under a time-critical removal action.

The fly ash that was released to the Emory River originates from the coal burned in boilers for power production at KIF. The coal, in its natural state, contains various inorganics that can be retained with the ash after burning. The ash itself is primarily composed of fine silica particles very similar to sand. Trace amounts of arsenic, chromium, copper, lead, mercury, nickel, selenium, thallium, vanadium, zinc, and other metals which occur naturally in the coal remain in the ash after coal combustion. 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 the ash.

A decision has been made to remove ash from the river using hydraulic or mechanical dredging and to remove ash beyond a temporary dike using primarily land-based equipment and then process, transport, and dispose of the ash recovered under a Time-Critical Removal Action Memorandum. The purpose of removing the ash from the river is to limit the potential for future ash migration and to prevent upstream flooding in the event of a large rainfall.

As part of the time-critical removal action, dredged material is being pumped into a rim ditch where solids settle out of the solution which is only about 5-10% solids initially. The water continues flowing through a sluice ditch into the ash settling pond and then into the ash stilling pond where further settlement occurs. Settled ash is removed from the ditches through mechanical excavation and windrowed to dry to between 70 and 80% solids in an ash processing area. The ash is then moved to a storage area which is sufficiently large to allow short-term staging of the ash awaiting transportation and disposal. Ash recovered through mechanical dredging or land-based equipment is transported in trucks to one of several ash storage areas, also awaiting transportation and disposal.

1.2 Purpose

The purpose of this work plan is to present the following information.

- Scope of the non-time critical removal action decision(s)
- Summary of the physical site conditions
- Summary of data collection activities that have been conducted to date
- Screening level human health risk assessment and approach for the baseline human health risk assessment
- Screening level ecological risk assessment and approach for completing the baseline ecological risk assessment
- Range of alternatives for response
- Future planned documentation and approximate schedule for activities
- Applicable or relevant and appropriate requirements (ARARs) for the remaining decision(s).

This information will allow the reader to understand the future decision(s) that need to be made as well as the approach and documents that will be used to provide information to support the decision(s).

1.3 Regulatory Setting

Shortly after the ash spill, the Tennessee Department of Environment and Conservation (TDEC) issued a Commissioner's Order, Case No. OGC09-0001 requiring action be taken as necessary to respond to the emergency under Tennessee Code Annotated §69-3-109(b)(1), the Water Quality Control Act. One of the elements required in the TDEC Order includes:

"A plan addressing both the short term and long term management of coal ash at the Kingston Plant, including remediation and stabilization of the failed ash waste cells, proper management of the recovered ash, and a revised closure plan for the Class II ash disposal facility."

As mentioned above, an Administrative Order and Agreement on Consent has been signed by both EPA and TVA. The EPA Order requires "Within ninety (90) days after the effective date of this Order, TVA shall submit to EPA for approval a draft Work Plan for performing one or more Engineering Evaluation/Cost Analyses (EE/CAs) for non-time critical removal actions to be taken at the Site." The work is being conducted under the Comprehensive Environment Response, Compensation, and Liability Act (CERCLA) and more specifically, under the removal program. A Natural Resources Damage Assessment (NDRA) trustee group will be formed with TDEC as the lead agency for handling issues outside of the EE/CA process.

2 SCOPE OF DECISION

In June 22 and 23, 2009, the EE/CA Technical Working Group held a scoping meeting to discuss conditions at the site and the framework for decision-making under the EPA Order. An agreement was

reached at that meeting to split the EE/CA into two concurrent non-time-critical removal actions: one to address the Swan Pond Embayment and dredge cell area, and the second to address the remainder of the river system. The rationale for separating the actions include: (1) Once the ongoing dredging work east of Dike 2 in the Emory River has been completed under the time-critical removal action, portions of the non-time-critical removal action must be ready for mobilization; (2) Sufficient characterization data exist to support evaluation of alternatives and move forward with a decision on the ash in the embayments west of Dike 2 and in the dredge cell; and (3) Significant data uncertainties exist in characterizing the Emory, Clinch, and Tennessee Rivers, so that more study and time is needed for comprehensive assessment of ecological risk in the river system. It was therefore decided to prepare two separate EE/CAs and make two separate non-time critical removal action decisions. Chapter 7.0 further discusses the rationale for this path forward.

The scope of the non-time critical removal action decision for the embayment/dredge cell includes removal of any residual coal ash released into the embayment area west of Dike 2 from the failure of the dredge cell, and closure of the failed dredge cell itself. Not only will the final condition of these geographic areas be decided, but disposal locations of the removed material will be part of the decision. Ultimately, the decision for the embayment/dredge cell will center around the following questions:

- In what condition should the embayment area be left?
- Should excavated material be disposed onsite or offsite?
- In what condition should the failed dredge cell be left, including any remaining dike system to contain ash?

The timing of the decision on the embayments and dredge cell is important. The time-critical action is scheduled to be completed in the spring of 2010. Significant construction and transportation activities will have been underway for over a year to accomplish this goal. The remaining ash in the embayment will have been contained by the construction of Dike 2 as well as drainage features to separate clean water runoff from the ash and to treat water in contact with the ash. However, because the treatment system (settling basins) has been sized for a storm event having only a 2-year rain recurrence interval, a delay in the decision would increase the risk of future ash releases during greater storm events. A decision on these questions and associated removal action scope is needed by the spring of 2010 to allow continuation of removal activities.

The removal action will remove the ash and restore the embayment to pre-spill conditions. The EE/CA will provide the information to satisfy the requirements for a Jurisdictional Assessment on the embayment area, including maps of the site prior to the spill and following the non-time-critical removal action, areas/species/habitat impacted, revegetation with selected species, habitat created, channel slopes, and similar elements.

The scope of the non-time critical removal action decision for the river system includes addressing any residual ash in the Emory, Clinch, and Tennessee Rivers remaining after the time-critical removal action is completed including areas impacted by previous restoration effortsUltimately, the decision for the river will center around the following question:

- In what condition should the rivers be left?

The timing of the decision on the river system is less critical. The time-critical removal action is scheduled to be completed in the spring of 2010. The majority of the ash in the river and east of Dike 2 will have been removed from the environment by that time. Although little ash will remain in the rivers, significant uncertainties exist in evaluating ecological risks, so that time will be needed to perform additional studies in the river systems.

3 SITE CONDITIONS

3.1 Soil/Ash Conditions

Because of the location of the failed portion of the dike (the northern side of the dredge cell area) the dislodged coal ash slurry flowed primarily to the adjacent northwest, north, and northeast areas, filling to varying extents the Swan Pond Embayment, including the North and East Embayment, and the Emory River. Figures 1 and 2 present the key features of the site. Per the EPA Administrative Order, the "site" is defined as those areas of the KIF where waste material has been deposited, stored, disposed of, or placed or has migrated or otherwise come to be located.

The released coal ash was either visible or submerged below the receiving water surface. Estimated volumes of the released ash account for the 5.4 million cy as follows (Figure 3): (1) west of the Dike 2 in the western embayments (primarily Swan Pond Embayment) and sloughs -- 2.4 million cy, (2) east of the Dike 2 (including the East Embayment) visible above the water surface – 0.5 million cy, (3) in the main channel of the Emory River below the water surface -- 1.4 million cy , (4) upstream in the main river channel below the water surface -- 0.5 million cy, and (4) downstream in the main river channel below the water surface -- 0.6 million cy. Further sampling investigations have shown small thicknesses of the ash in the Emory River, upstream of the major ash spill area, but not in the Little Emory River (Figure 4). Smaller amounts have been found downstream in the Clinch and Tennessee Rivers.

It is estimated that about 106,000 cy of this ash actually covers land that was originally beyond TVA's boundary. The majority of this volume is on land that TVA has since purchased. Areas affected in such a manner include the Swan Pond and Lakeshore communities. Private properties affected by the ash spill lie mostly along Berkshire Lane on Swan Pond Embayment, along Swan Pond Circle Road on Lakeshore Slough, and along Lakeshore Drive on the east shore of the Emory River. Of the roughly 300 acres covered by the KIF coal ash, about 8 acres were originally private property.

The depth of ash deposits in the areas nearest the plant (ERM 1.75 to 3.0) range from about 5 feet to complete filling of the navigation channel (greater than 30 feet) and complete filling of the Swan Pond embayment. Ash deposit depths decrease with increased distance downstream from the ash slide site, but the actual amount of deposition in some of these areas has yet to be determined. Deposits greater than 5 feet in depth appear to be confined to the Emory River in the immediate vicinity of the Kingston facility.

Several different field sampling surveys have been performed to characterize the spatial extent of ash deposition. Results indicate that ash may have traveled upstream as far as ERM 5.75, and as far downstream as TRM 564. In the upstream direction, the depth of ash appears to diminish quickly beyond about ERM 3.5. In the downstream direction, ash deposition generally diminishes to trace amounts by about ERM 1.0, with pockets of greater depth (about 2 inches to about a foot in some places) occurring in depositional areas in the Clinch River. Downstream of Clinch River Mile (CRM) 2.0 amounts vary from trace amounts to 2 inches. Ash deposition of 0.5 to 1 inch was observed in the Tennessee River at TRM 566 (mouth of the Clinch River). Only trace amounts of ash have been observed further downstream.

In order to restrict the movement of the spilled ash into and down the Emory River, TVA constructed one temporary underwater rock weir (Weir 1) on the Emory River. TVA constructed Dike 2 near the mouth of the embayment to contain ash within the Swan Pond embayment.

Upon completion of the time-critical removal action, ash will remain in the Clinch River and the Tennessee River as described above. Some additional ash may have migrated into these river systems as a result of high flow events that occurred during the time-critical removal activities. Efforts to remove the

ash from the Emory River will have occurred during the time-critical actions, but because over-dredging will not have occurred, there could be small pockets of residual ash in the Emory River.

3.2 River Conditions

"Waters of the State" are defined by T.C.A. §69-3-103(33) and are classified by the Tennessee Water Quality Control Board for suitable uses. Department Rule 1200-4-4, "*Use classifications for Surface Waters, et al*", is contained in the *Official Compilation of Rules and Regulations for the State of Tennessee.* Accordingly, the Emory River, Clinch River, and Tennessee River are waters of the state. 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 Kingston facility is 2.6 river miles above the confluence of the Clinch and Tennessee rivers at Tennessee River Mile (TRM) 567.7 on the Emory River. The Emory River drains a watershed area of approximately 865 mi^2 with average flow rates between 700 and 1300 cfs. The affected reach of Watts Bar Reservoir at the Kingston facility transitions from the upstream riverine (riverlike) reaches of the Emory River and the Clinch River to the more lacustrine (lakelike) conditions found in the impounded portions of the Clinch and Emory River backwaters of Watts Bar Reservoir. Overbank areas near the Kingston facility in the Swan Pond embayment are very shallow. The Emory River embayment enters Watts Bar Reservoir at the Clinch River about 2 river miles upstream of the Kingston facility condenser cooling water (CCW) discharge. The reservoir pool extends upstream to above Harriman [Emory River Mile (ERM) 11].

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.

3.2.1 Flood Elevations

The area affected by increased flood elevations as a result of the failure of the Kingston ash dredge cells extends generally from ERM 1.5 to 3.5. Prior to the failure of the dredge cells, the 100-year flood elevations for this reach of the Emory River varied from elevation 747.6 feet above msl at ERM 1.5 to elevation 749.4-feet msl at ERM 3.5. The TVA Flood Risk Profile elevations for this reach of the Emory River varied from elevation 749.9 feet above msl at ERM 1.5 to elevation 752.3-feet msl at ERM 3.5.

The 100-year flood post-slide elevations would be about 5 feet higher than preslide elevations immediately upstream of Weir 1 (ERM 2.0) and about 8 feet higher than preslide elevations along Emory River Road and Lakeshore Drive (ERM 2.5 to 3.5).

3.2.2 Navigation

Commercially navigable portions of Watts Bar Reservoir include the Tennessee, Clinch, and Emory rivers to approximately ERM 12 at Harriman, Tennessee. Watts Bar Reservoir is part of the 800-mile, commercially navigable Tennessee River system, which links to the 10,000 mile national inland waterway.

The Emory River has seen little commercial navigation traffic in the last 20 years, as industries have closed in downtown Harriman. Large vessels regularly operating on the Emory River include U.S. Coast Guard (USCG) and TVA boats that maintain navigation aids. Recreational boating is popular on the Emory River.

The ash slide from the Kingston facility partially blocked the marked navigation channel between approximately ERM 1.5 and 3.5. For the first 30 days, the USCG closed the Emory River to boat traffic (except those boats participating in cleanup and monitoring) from ERM 0.0 to ERM 4.0 to prevent accidents and groundings. The USCG has reclosed the river from ERM 1.5 to 3.5 during major dredging activities.. TVA has installed a series of danger buoys to alert recreational boaters of the danger in river navigation and construction-type dredge activities. Additionally, the Swan Pond embayment complex north of the Kingston facility is no longer navigable.

3.2.3 Flow

The Kingston facility pumps cooling water for the facility's condensers from the Watts Bar Reservoir at ERM 1.9. At full operating capacity, cooling water flows through the condensers at a rate of 2,154 cfs. Water used at the Kingston site originates in the Emory and Clinch Rivers. River flow rates are regulated upstream on the Clinch River by Melton Hill and Norris dams and downstream on the Tennessee River by Watts Bar Dam, which is 39.4 river miles below the Kingston facility. The flow rates can also be influenced by upstream operations of the Tellico and Fort Loudoun dams on the Tennessee River.

Flow patterns can be complex in the Emory and Clinch River embayments. When Emory River flow is greater than the 2,100 cfs required by the cooling water system for the Kingston facility, the Emory River flows downstream into the Clinch River, and the Emory River water alone provides all the Kingston facility cooling water. According to stream gauge records, this happens about 18 percent of the time and is most likely in the winter flood season, which occurs December through March.

When Emory River flow is not adequate to provide all of the cooling water needed by the Kingston facility, water flows upstream from the Clinch River through the Emory River embayment. This is encouraged by the presence of an underwater weir in the Clinch River just downstream of the Emory River confluence. Under some other conditions, the Emory River also flows backward upstream of the plant. Water is pushed up the Emory River as a result of inflows that raise the pool elevation in Watts Bar Reservoir. Inflow typically occurs when the reservoir is filling in the spring or during a spring flood event.

Different rates and timing of releases from Watts Bar, Fort Loudoun, and Melton Hill reservoirs can cause reverse flows in the Clinch River arm of Watts Bar Reservoir. There is the potential for the water from the Clinch River to flow upstream on the Tennessee River during filling of Watts Bar Reservoir.

3.2.4 Water Quality

The Emory River arm of Watts Bar Reservoir is on the State 303(d) list of impaired waters because of sediments contaminated with polychlorinated biphenyls (PCBs) and chlordane from industrial point sources. The section of the Emory above the influence of the Watts Bar impoundment is listed because of mercury from atmospheric deposition and other sources. The Emory River may have elevated metal levels because several upstream tributaries are listed for manganese, iron, and pH from historic coal mining activities. Low pH may indicate acidic conditions that could dissolve metals from sediment into the water. Furthermore, a few of the upstream tributaries are also impacted by sediment or other causes from agriculture or development.

The Clinch River arm of Watts Bar Reservoir is also on the State 303(d) list. The Clinch River is on the list due to PCBs, chlordane, and mercury contamination of sediment from industrial point source discharges and atmospheric deposition. Nearby tributaries to the Clinch are also listed for PCBs, chlordane, and mercury and one nearby tributary is listed for arsenic and may be sources of contamination in the Clinch. Some of this contamination occurs as a result of former U.S. Department of Energy (DOE)

operations on the Oak Ridge Reservation. Past DOE actions at Oak Ridge resulted in the contamination of sediments by mercury, PCBs, radionuclides and other wastes. Radionuclides released into the Clinch River from the DOE site (cesium and strontium) are different than the naturally-occurring radionuclides found in coal ash (radium, uranium, and thorium).

In 1991, TVA entered an interagency agreement with DOE, EPA, TDEC, and the U.S. Army Corps of Engineers to establish a procedure for interagency coordination and review of permitting and other use authorizations that could result in the disturbance, resuspension, removal, and/or disposal of DOE-contaminated or potentially contaminated sediment in Watts Bar Reservoir. The interagency group reviews and screens activities that may impact the DOE-contaminated sediment and provides appropriate remediation. Based on information gathered during the implementation of this agreement, the contaminants of interest have been narrowed to cesium-137 and mercury. Projects are reviewed to determine whether the sediment contains cesium-137 or mercury contamination at levels that when disturbed or removed constitute environmental risk or require special handling techniques or equipment to protect human health and the environment from injury or harm.

There are two types of water quality impacts resulting from the ash slide, physical, from the bulk material; and chemical, related to constituents within the ash that enter the water through suspension or dissolution. Ash deposits in the river may physically degrade or eliminate the habitat for bottom-dwelling organisms. At sufficiently high-flow velocities, ash may be suspended in the water column. The small size and lack of cohesion of the ash particles mean that they may be easily detached and entrained in flowing water, so this material would continue moving downstream as suspended sediment during periods of high-flow rates. The fly ash deposits may also exhibit cohesive behavior, and may consolidate over time in the river channel. In addition, cenospheres (inert floating ash material) can move downstream on the water surface. The chemical constituents of greatest concern are the metals contained in the ash. Temperature, pH, and oxygen availability in the water affect the dissolution of metals from the ash. Results of water quality sampling are discussed in Section 4 below.

3.3 Groundwater Conditions

KIF and the area affected by the ash release lie within the Valley and Ridge physiographic province, a region characterized by narrow, subparallel ridges and valleys trending northeast-southwest. The controlling structural feature of the region is a series of northeast-striking thrust faults which have forced older rocks from the southeast over younger units. Bedrock units of the Rome Formation, the Lower Conasauga Group, and the Knox Group occur beneath the affected area in northeast-trending bands (Figure 5). These units generally dip to the southeast at angles averaging 45 to 50 degrees (Benziger and Kellberg 1951).

Alluvial and/or residual deposits generally cover bedrock in the site locality, and form a blanket separating ash deposits from underlying bedrock. Alluvium is generally limited to the natural (pre-reservoir) floodplains of the Emory River and its tributaries. Thickness of the alluvial deposits beneath the ash disposal areas at the plant site ranges up to 65 feet, but thickness is unknown in areas offsite. Residuum is expected to cover the remaining upland areas within the region, but data regarding its thickness offsite is currently unavailable.

Bedrock beneath most of the ash-affected area is represented by the Rome formation and Lower Conasauga Group. The Lower Conasauga Group primarily consists of shale with interbedded siltstone, limestone, and conglomerate, and is locally of low water-producing capacity. The Rome formation consists of interbedded shale, sandstone, and siltstone, and is a poor water producer. The primary water-bearing units of the region are the limestone and dolomite members of the Knox Group and the Maynardville formation (Upper Conasauga). The Knox Group includes several relatively pure, thick-

bedded limestone and dolomite members susceptible to karst development, as evidenced by the sinkholes shown on Figure 5. The only ash-affected areas overlying the Knox Group include the stream bank margins along Swan Pond Embayment.

Groundwater within the site locality is derived from infiltration of precipitation through the soil overburden. Direct recharge to bedrock aquifers by storm runoff through sinkholes may also occur in areas underlain by karst bedrock. Shallow groundwater movement is generally from upland areas to adjacent stream valleys with groundwater ultimately discharging to streams and springs. Although some deep recharge of deeper bedrock aquifers may occur elsewhere in the region, it is likely that shallow groundwater recharge originating in the site locality discharges directly to the Emory River, its tributaries, or to springs. The occurrence of numerous springs along the Emory River indicates the site locality lies within a regional groundwater discharge area. Limited stream recharge of shallow groundwater could occur during periods of rapid rise in reservoir elevation causing temporary reversal of groundwater hydraulic gradients.

In a groundwater discharge setting, deeper wells should have higher hydraulic head (higher groundwater elevation) than shallow wells. To assess the potential for upward groundwater gradients, the correlation coefficient of well depth versus groundwater elevation was calculated for the wells in both the dredge and gypsum cells (located east of the main KIF plant area). Results showed correlation coefficients of 0.84 and 0.62 for the dredge cell and gypsum cell, respectively. Similarly, water elevation data were obtained from eight geotechnical borings installed in the ash pond to the top of rock to depths ranging from 43 to 111.2 ft. The boring depth vs. groundwater elevation correlation coefficient was 0.82. These correlations support the expectation of discharge conditions and upward gradients.

The primary affect of the ash release on local groundwater resources would be infiltration of ash leachate below ash-impact areas bordering the Emory River and its tributaries. Preliminary review of available water supply data indicates that the water-supply wells and springs in the site locality are situated upgradient of ash-affected land bordering streams. Consequently, ash-related chemicals entering shallow groundwater beneath affected areas would be transported a short distance to local streams without encountering wells or springs. There are no known water-supply wells downgradient of the ash, between the ash and the reservoir.

The fate and transport of metals in ash and clay-rich materials in groundwater are functions of site characteristics and physical and chemical interactions between contaminants and the ash/soil media. The physical and chemical properties of contaminants that influence these interactions include solubility in water and chemical affinity for solids or organic matter (usually described by a partitioning coefficient such as K_d). Metals tend to adsorb to ash and clay-rich soils (with high K_d values), which retards their migration.

3.4 Ecological Conditions

The area surrounding the wide portion of the embayment was relatively flat, low-lying riparian zone with mid-age sycamore, green ash, and silver maple with considerable amounts of fescue grasses and some scattered kudzu in places. The segment of this area that extended into the main reservoir was comprised of pole to small saw timber sized bottomland hardwood species such as silver maples, sycamore, green ash, and sweetgum with scrub-shrub and emergent wetland fringe in the shallower shoreline areas. There was an active osprey nest on the point of the peninsula.

The area to the northeast end of Pine Ridge adjacent to the railroad track and Swan Pond Road is a steep north facing slope with old age upland hardwood comprised of various oaks and hickories, white ash, black gum, yellow poplar, black cherry, red maple, basswood, American beech, yellow buckeye, and

flowering dogwood. These areas were used by a variety of upland and riparian/wetland wildlife before the spill.

The area at the tip of the embayments (including small western embayment) included wetland areas similar in fauna as described above with younger trees. The shrub layer contained a substantial amount of buttonbush and silky dogwood and the emergent wetland portions had a high diversity of obligate wetland grasses, rushes, sedges, smartweeds, jewelweed and marsh mallow. Hydric soils on most of this area were super saturated with numerous vernal pools. This area was particularly important to various amphibian species such as green frog, gray treefrog, upland chorus frog and spring peepers. The rest of the area includes farm areas, landscaped lawns, and roads.

There were wetland areas present in the embayment before the spill. Wetland acreage affected by the ash spill was determined using land use/land cover data. The data was derived from a baseline stereo-analysis of 1:12000 color-infrared aerial photography dated January 7, 2003. Recent (2006 and 2008) National Agriculture Imagery Program digital imagery was then used to augment the base data where features had changed over the course of time. Classification is based on the standard Anderson system (Anderson et al. 1976), modified to capture additional detail. Acreage calculations are based on the area of each individual polygon classified in the interpretation process.

This analysis determined that there were approximately 2.51 acres of wetlands affected by the ash spill. Habitat types as described by Cowardin et al. (1979) are listed below.

Wetland Type	Acreage by Type
Palustrine Emergent Wetland	1.56
Palustrine Forested Wetland	0.65
Palustrine Scrub-shrub wetland	0.30
Total Acreage	**2.51**

Land use land cover imagery analyzed post-spill indicates the 2.51-acres of wetlands present within the spill footprint were filled entirely by ash, thus eliminating these areas.

In addition, wetland habitats in the vicinity of KIF have been monitored as part of a larger study associated with the 2004 TVA Reservoir Operations Study and Environmental Impact Statement (TVA 2004). There are two wetland study sites within the Swan Pond Embayment area north of the KIF spill incident. Baseline data have been collected on these sites beginning in 2004 and subsequently in 2006. One scrub-shrub and one forested wetland plot were part of the original Reservoir Operations Study design. The Swan Pond sites were chosen because they were high quality wetland sites that were on TVA land, which ensured the long-term accessibility of these sites.

A significant effort is underway to provide drainage through the ash in the embayments. This effort has significantly changed the topography and composition of the material in the embayment. The embayment drainage efforts have been broken into two components. The first component consisted of excavating channels quickly thru the coal ash to alleviate flooding in the upstream areas of the embayments (as mentioned above in Section 2.0). It also included the construction of more permanent channels through the ash as well as several settling basins. This settling basin area collects water that flow thru the ash areas and discharges water via a surface skimmer back to the Emory River. Diversion ditches were excavated thru the ash to drain standing water and direct the flows within the ash to a settling area. Check dams are used in this system to allow ash to settle out of the water as it moves from the basin area to the river. The

second component consists of excavating clean water ditches to carry the clean water around the ash to discharge directly to the Emory River, thereby minimizing the load that is placed on the settling basins.

Construction of the drainage system resulted in considerable amount of ash west of Dike 2 being moved into the ash storage area (over 70,000 cy) for offsite disposal as well as the addition of about 6200 tons of rock to line the drainage system and provide access during construction.

4 SAMPLING AND MONITORING ACTIVITIES

This section presents an overview of the sampling and monitoring activities being conducted in response to the release of ash at KIF. This section specifically discusses sampling to support the Kingston Fly Ash Recovery Project. Only data that have been validated through rigorous quality control processes to ensure data defensibility will be used in calculating risk. Other data will be referenced for comparison purposes and weight-of-evidence evaluations. Additional sampling efforts (such as, plant effluent monitoring, ash characterization for disposal, and ash particle size analysis) that do not support the EE/CA are not discussed.

The EPA, TDEC, and TVA have conducted sampling and analysis of potentially impacted media. The following sections describe the sampling of environmental media and ash and provide a rationale for the collection and the potential use of the various data.

4.1 Soil and Ash Sampling Results

TDEC, EPA, and TVA have collected samples of the ash and, in some cases, nearby potentially affected soil areas. TVA, TDEC, and EPA performed soil and ash sampling at several private residences immediately following the release. The objectives of the soil and ash sampling were to characterize the chemical nature of the ash, determine if the released ash resulted in residual impacts to native soil, and evaluate the potential threat of the released ash to human health and the environment. In addition, the characterization was done to assess disposal options and to guide potential remediation activities.

On December 31, 2008, TVA collected five surface ash samples from ash remaining in the failed dredge cell and 23 Geoprobe® samples from a vertical profile of the dredge cell (Figure 6). The ash samples were analyzed for BTEX by EPA SW-846 Method 8260; total metals by EPA SW-846 Method 6010B; and Toxicity Characteristic Leaching Procedure (TCLP) metals by EPA SW-846 Methods 1311 and 6010B. An additional nineteen, 5-point composite ash samples were collected on January 6 and 12, 2009, from the released ash in Swan Pond Embayment and eight pairings of ash and soil samples were collected from private residential properties on December 27, 28, and 29, 2008. These additional samples were analyzed for total metals and TCLP metals.

Because irregularities were found in the laboratory data, all data analyzed by Microbac Laboratories were rejected. Samples were reanalyzed by TestAmerica Laboratories if not beyond their maximum holding times. Additional ash samples were collected in August 2009 for PAH and mercury analysis. Additional ash samples were collected for TCLP waste characterization from the ash processing area between February and August 2009.

Arsenic is one of the trace elements known to be concentrated in the ash through the coal combustion process at KIF. Arsenic was present above local soil background levels in ash samples collected by TVA. Arsenic concentrations in ash varied from 2.78 mg/kg in the embayment to 166 mg/kg in the dredge cell (at a sampling interval from 44 to 46 ft below ground surface). Most of the concentrations were between 20 and 45 mg/kg. Background arsenic levels for soils in the Roane County region (Table 1) range from 2.2 to 31.2 mg/kg. Levels in the ash therefore generally vary from approximately background levels to

three times background levels. Ash samples collected from residential properties had results similar to those from the released ash in the embayment. Several samples were collected shortly after the release to rule out gasoline-related products, including benzene, toluene, ethylbenzene, and xylene (BTEX). The samples tested were free of gasoline products, and therefore, no additional samples were analyzed for these compounds.

EPA defines a material as a hazardous waste if it exhibits one of four characteristics: ignitability, corrosivity, reactivity, and toxicity (40 CFR Part 261 Subpart C). Toxicity is defined by EPA through the TCLP laboratory procedure, which simulates the leaching of contaminated liquids from the waste. The TCLP helps identify wastes likely to leach concentrations of contaminants that may be harmful to human health or the environment. In all instances, the concentrations of the TCLP metals, including arsenic, found in samples from the KIF release site were below the threshold values that would categorize the ash as hazardous waste material under 40 CFR Part 261. Therefore, the ash does not show any characteristic of a defined hazardous waste.

TDEC collected 12 ash samples and 16 soil samples on December 29 and 30, 2008 and on January 6 and 7, 2009. Two of the ash samples were collected from the dredge cell and the remaining samples were collected from surrounding residential properties or designated background locations (two samples). The samples were analyzed for total metals, TCLP metals, BTEX, radionuclides, and polynuclear aromatic hydrocarbons (PAHs). TDEC has reviewed the data and has posted relevant information on their web site. As reported on their web site, the ash does contain metals and radioactive materials. After review of the metal analyses of the ash samples, the only metal at levels that TDEC identified may present a potential health hazard is arsenic. The TDEC ash samples contained arsenic ranging from 26 to 100 mg/kg (with an average of 74 mg/kg), which agrees with the range found in TVA sampling. TDEC found about 2 mg/kg arsenic in local background soils however, the soils in the area of the spill varied from non-detectable to 83 mg/kg. TDEC did not find any volatile organic compounds (which include BTEX) or PAHs in the ash or soil samples.

EPA's contractor collected an ash sample from a sand bar on the Emory River on December 23, 2008, for the analysis of TAL metals and BTEX. On December 27, 2008, the EPA's contractor collected two 10-point composite samples from the ash pile on site, three grab samples of ash that had been deposited along the roadway, and eleven 5-point composite samples of potentially affected soil along the shoreline of the rivers. Samples collected on December 27, 2008, were analyzed for TAL metals, BTEX, silica, and TCLP metals. Similar to TVA and TDEC sampling results, The EPA testing showed arsenic to be present in the ash at levels ranging from 44.8 to 81.3 mg/kg and in the soil at levels ranging from 1.3 to 34.5 mg/kg. EPA testing of the ash and soil found no gasoline products and showed that the ash and soil would not qualify as hazardous waste. Ash samples collected since the initial assessment for waste disposal purposes have shown consistent results; all samples have passed the TCLP limits.

TVA collected 13 additional ash samples from the dredge cell in August 2009 for the analysis of radionuclides, PAHs, and mercury. These samples are being analyzed; results will be included in the EE/CA for the embayment/dredge cell.

4.2 Sediment Sampling Results

Four sediment sampling events have been performed since the ash release. The first two sediment sampling events were performed on January 31, 2009, and February 13, 2009, in order to compare sediments immediately adjacent to the spill site (ERM 2.1) to those of the sediments upstream of the spill site (ERM 6.3-ERM 7.3 and ERM9.0-ERM10.0). The third sediment sampling event was performed at ERM 0.5 with a gravity tube core sampler; this sampling event was performed by TVA on February 25, 2009, and was designed to investigate an elevated PCB detection reported from a DOE sampling event

designed to investigate legacy sediment contamination. The fourth sediment sampling event was performed on March 17, 2009 with vibracore sampling equipment and consisted of sub-aqueous ash sampling. The objective of the vibracore sampling effort was to collect undisturbed samples of the released ash for biological and toxicological testing to investigate the potential for mobilization of toxic substances during dredging. A fifth vibracore sampling event in June, 2009 was conducted, but validated data were not available in time for this work plan.

EPA has retained the U.S. Army Corps of Engineers Engineering Research and Development Center at Waterways Experiment Station (ERDCWES) to run a quantitative two-dimensional hydrodynamic and sediment fate and transport model, known as Adaptive Hydraulics (AdH). In general, this model uses system bathymetry, grain size distribution, and river flow data to predict the transport characteristics and deposition of fly ash in the system. Both cohesive and non-cohesive sediment transport can be simulated with the model, as well as non-alluvial sediments with unique characteristics such as coal fly ash. Additional information on AdH can be found at the following website: http://adh.usace.army.mil/.

Modeling saturated coal fly ash presents a unique problem. Fly ash has a lower particle density than native sediments, and a spherical shape as opposed to the irregular shapes found in quartz based sediments. In addition, the fly ash deposits exhibit cohesive behavior, and may consolidate over time in the river channel. Because cohesive deposits are more resistant to erosion than non-cohesive deposits, the ERDCWES will be conducting tests in a laboratory flume (SedFlume) to characterize the resistance of fly ash to erosion. The SedFlume will measure the erosion rate of a sample over time as flow is induced over the sample. This erosion rate will then be correlated to the bed shear stress induced by the flow. An empirical equation will be developed from the tests and will be used in the AdH model to specifically predict erosion rates of the fly ash deposits. The natural bed sediment erosion, entrainment, transport, and fate will also be simulated in the model along with the fly ash. Additional information on the SedFlume can be found at the following website: http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=ARTICLES!630.

The AdH model domain will extend from one mile upstream of the KIF on the Emory River to the Watts Bar dam. Both the Clinch and Tennessee rivers will be included in the domain up to Melton Hill and Fort Loudon dams, respectively. Because of the size and complexity of the model domain, the problem will be run on the High Performance Computer system at the ERDCWES.

4.3 Surface Water Sampling Results

Water monitoring in response to the ash spill at KIF initiated with water quality sampling on the afternoon of December 22, 2008 and continues today. Surface water sampling locations were established to assess the impacts of the fly ash release on the local river system and thereby determine if there is any threat to humans or the environment from the impacted surface water quality. TVA, TDEC, and EPA have collected surface water samples in the Emory, Clinch, and Tennessee Rivers for total and dissolved metals analysis. TVA has established five sampling locations on the Emory River (at ERM locations 0.1, 1.75, 2.1, 4.0, and 12.2), four sampling locations on the Clinch River (CRM locations 0.0, 2.0, 4.0, and 5.5), and two sampling locations on the Tennessee River (at TRM locations 563.5 and 568.5). Field measurement of turbidity at CRM 0.0 is used as a trigger for sampling at TRM 563.5. Sampling at TRM 563.5 is only conducted when the turbidity reading at CRM 0.0 exceeds 20 NTU. Figure 7 illustrates the sampling locations. TVA began sampling for nutrients at the monitoring locations once a week to monitor for run-off from fertilization activities at the site in late May 2009. TVA also added a monitoring location at the plant effluent on May 29, 2009. In addition, TVA began monitoring for thermal stratification at the Emory, Clinch, and Tennessee River locations on May 29, 2009. If a thermocline (change in temperature of greater than 1ºC/meter depth) is detected at a location, then samples are collected from the mid-point of both the epilimnion and hypolimnion depths from the location.

TVA has performed sampling at these locations up to three days per week (Monday, Wednesday, and Friday); TDEC has performed surface water sampling at these locations up to two days a week (Tuesday and Thursday). From December 23, 2008, to December 29, 2008, EPA's contractor collected a total of 26 river surface water samples for total and dissolved metals analysis. Both TVA & TDEC conduct sampling following a rain event exceeding 0.5 inch in a 24-hour period. These locations encompass approximately 14 miles of the local river system and establish upstream, point-of-release, and downstream surface water locations. Additionally, field parameters are measured at each location using a multi-analyte programmable data logger (Hydrolab®). The field parameters include temperature, dissolved oxygen, pH, conductivity, and turbidity.

The objective of the routine surface water sampling is to assess the impacts of the fly ash release on the river system and the potential impacts to human health and the environment. Of the more than 300 samples analyzed by TVA, the average arsenic concentration was 3.15 ug/L, which is less than TDEC's Ambient Water Quality Criteria (AWQC) of 10 ug/L; however, the maximum arsenic concentration was 189 ug/L. Maximum concentrations of other metals have also exceeded AWQC.

Because the Tennessee River is a source of drinking water, TDEC has performed weekly sampling of the Kingston and Rockwood water treatment plants since December 23, 2008. Results, available on TDEC website (http://www.state.tn.us/environment/kingston/wtp.shtml), do not indicate any levels above regulatory standards for treated drinking water.

4.4 Groundwater Sampling Results

TDEC has collected samples from private drinking water wells within a 4-mile radius of the KIF ash release site for heavy metals analyses to alleviate fears that the ash release could have impacted local residential drinking water quality. As of February 3, 2009, nearly 100 wells had been sampled and results were shared directly with the property owners. Results to date have not indicated exceedences of the primary drinking water standards for metals. EPA's contractor sampled three residential wells for total and dissolved metals; the results were below drinking water standards (as were TDEC sampling results). TVA also sampled eight private wells prior to TDEC assuming that responsibility. These wells are located upgradient of the release and any metals present would not be as a result of the ash release. Therefore, the results from these wells will not be used in the risk assessments to assess impacts from the ash release.

Groundwater detection monitoring in connection with the KIF ash dredge cell facility solid waste permit has been conducted since June 2005. Unfiltered groundwater samples have been collected semiannually from four monitoring wells associated with the ash dredge cell, and were analyzed for the 17 inorganic constituents listed in Appendix I of the TDEC Rule 1200-1-7-.04. Groundwater samples have not been analyzed for radionuclides. Two of these monitoring wells (4B and 6A) were destroyed in the incident. Monitoring results for arsenic have consistently been below maximum contaminant level (MCLs) of 10 µg/L. The upgradient well had arsenic values around 1 µg/L. Samples from Well 6A have routinely had some type of laboratory interference resulting in higher detection limits. In recent sampling, arsenic has been detected at 14 ug/L in one well, which slightly exceeds its maximum contaminant level (MCL) of 10 µg/L. Low levels of arsenic could have been present in the groundwater near the ash disposal location prior to the spill.

Seven monitoring wells surrounding the Phase 1 gypsum disposal facility have been sampled quarterly for Appendix I inorganics since March 2008 to establish baseline groundwater quality at the disposal site. All unfiltered results have been below MCLs. In the last sampling round, the maximum detected arsenic value was 3.6 µg/L, notably below the MCL of 10 µg/L.

4.5 Ecological Sampling Results

An evaluation is underway to identify the pre-spill conditions of the Emory and Clinch Rivers to assist in determining natural resource damages from the spill. Existing information from various TVA and Tennessee Wildlife Resources Agency (TWRA) projects and surveys are being compiled to provide an estimate of the aquatic community affected by the physical impact of the spill. These data include TVA fish and benthic surveys used to evaluate Tennessee Valley-wide river quality for other TVA projects in the vicinity and TWRA fish stocking data.

Fish (channel catfish and largemouth bass) were collected by TWRA for tissue chemical analysis from two sites in the Emory River and two sites in the Clinch River. The samples were analyzed for metals and organics, PCBs, chlordane, dioxins, and furans, which are part of TWRA's routine sampling of this area associated with human health consumption advisories.

The fish collected by TWRA will be used as baseline data for additional fish health studies on mid-term and long-term exposure to assess sub-lethal effects as a result of ash exposure. These fish health studies will include measurements that represent short-term responses such as physiological bioindicators and intermediate-term and long-term responses (histopathological and morphological indicators). An emphasis will be placed on assessing long-term effects on reproductive fitness of at least three sentinel fish species such as channel catfish, bluegill, and largemouth bass. In addition, these studies will be conducted in conjunction with the bioaccumulation studies so that cause-and-effect relationships between levels of chemicals in fish tissue and biological effects can be established.

On-going fish sampling will be performed by TVA on an annual or semiannual basis to monitor the impacts of the ash release on the local fish community.

TVA has monitored avian resources at KIF for many years. Shorebird and waterfowl information at the site has been collected systematically for 5 years. The remaining ash settling pond, not damaged during the ash spill, is used by a variety of shorebirds, waterfowl, gulls, and other species. TVA is collecting a series of reports from the Oak Ridge National Laboratory that describe avian, reptile, and other terrestrial animal resources in the vicinity. There have been limited systematic terrestrial surveys performed at or near KIF. TVA has also mapped and continues to examine additional wildlife resources near KIF.

Collection of amphibians, tree swallow eggs, and hatchlings were performed in March, April, and May of 2009 for metals analyses. The surveys and sampling for the amphibians and birds are on-going.

4.6 Air Sampling Results

TVA has been testing the air around the KIF since shortly after the ash spill. As of September 1, 2009, more than 100,000 air samples have been taken. Daily total particulates are measured using both hand-held instruments (typically 200-400 readings per day) and laboratory measured particulates from random locations throughout the site, including areas with active ash handling activities. The hand-held instruments measure the particulates smaller than 10 microns in size (PM10), the laboratory can measure particulates smaller than 2.5 microns. Stationary air monitoring has also been performed at five air monitoring locations. These monitors can measure particles smaller than 2.5 microns in diameter. All measurements of particulates have been well below the 24-hour National Ambient Air Quality Standards (NAAQS).

Temporary stationary monitors used filters to collect samples over 24-hour periods from January 1 to March 11, 2009. These samples were analyzed for 21 metals, as well as quartz. Based on potential toxicity, eight metals were selected for reporting: arsenic, beryllium, cadmium, chromium, lead, selenium,

thallium, and vanadium. Concentrations were below detection limits, except for one sample with a low concentration of cadmium and three samples with low concentrations of lead. These concentrations do not pose a health concern, since they are below the Agency for Toxic Substances and Disease Registry (ATSDR) acute minimal risk level for cadmium and below the NAAQS for lead.

A temporary mobile laboratory also used filters to collect samples for metals analysis from January 2 to February 3, 2009. Results showed that the airborne concentrations of the metals detected (arsenic, cadmium, chromium, lead, selenium, thallium and vanadium) were within the lower end of the range of background concentrations in the United States. Background level information came from Toxicological Profiles by the U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. These results confirm the Tennessee Department of Health finding that "The particulate matter and metals measured in air near the site are below national and state standards or are less than any levels of concern."

5 HUMAN HEALTH RISK ASSESSMENT

This section presents the approach, assumptions, and methods to be used for the human health risk assessment for the non-time critical removal actions for both the Embayment/Dredge Cell EE/CA and the River EE/CA. In addition, a screening-level human health risk assessment has been completed for use in making risk management decisions on the path forward for the site. Results of that screening-level risk assessment are presented in this section.

The objective of the human health risk assessment is to develop quantitative and qualitative estimates of potential cancer risks and non-cancer hazards for human receptors exposed to environmental media impacted by the ash remaining following completion of the time-critical removal action. These estimates will be developed to support remediation decision making. Risks to both current (or near-term) and potential future receptors will be evaluated. The risk analysis will be based on analytical data collected from ash, surface water, sediment, and fish sampling.

The human health risk assessment approach will follow EPA guidance documents which may include:

- *Risk Assessment Guidance for Superfund, Vol. 1: Human Health Evaluation Manual (Part A),* EPA/540/1-89/002, (EPA 1989).
- *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors, Interim Final,* OSWER Directive 9285.6-03, (EPA 1991a).
- *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals*), OSWER Directive 9285.7-01B, (EPA 1991b).
- *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments*), OSWER Directive 9285.7-47, (EPA 2001).
- *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final,* OSWER 9285.7-02EP, (EPA 2004b).
- *Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment),* OSWER 9285.7-82, (EPA 2009d).

- *Supplemental Guidance to RAGS: Region IV Bulletins, Human Health Risk Assessment*, (EPA 2000a).
- *Soil Screening Guidance: Technical Background Document*, EPA/540/R-95/128, (EPA 1996).
- *Supplemental Guidance For Developing Soil Screening Levels For Superfund Sites*, OSWER 9355.4-24, (EPA 2002c).
- *Exposure Factors Handbook*, EPA/600/P-95/002Fa, (EPA 1997b).
- *User's Guide for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) Windows version*, OSWER Directive No. 9285.7-42, (EPA 2001e).
- *Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters*, OSWER 9200.2-82, (EPA 2009e).
- *Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil*, EPA-540-R-03-001, (EPA 2003a).
- *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites*, (EPA 2002a).
- *Guidance for Data Usability in Risk Assessment*, OSWER 9285.7-09, (EPA 1992).
- *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*, OSWER Directive No. 9285.6-10, (EPA 2002b).
- *ProUCL Software Version 4.00.04 User Guide, EPA/600/R-07/038, (EPA 2009c).*
- *Human Health Toxicity Values in Superfund Risk Assessments*, OSWER Directive 9285.7-53, (EPA 2003b).
- *Health Effects Assessment Summary Tables (HEAST)*, (EPA 1997a).
- *Integrated Risk Information System (IRIS) Database* (EPA 2009a), (EPA 2009a).

Risk assessment as defined in the CERCLA process consists of (1) data evaluation, (2) exposure assessment, (3) toxicity assessment, and (4) risk characterization. An uncertainty analysis is completed at the conclusion of the risk assessment.

5.1 Data Evaluation

All data collected by TVA, TDEC, and EPA that are from a relevant medium and that meet the data quality objectives for the project will be used in the quantitative risk assessment. Environmental data will be evaluated for use in the risk assessment based on the following:

- Sample locations are applicable to potential exposures to be evaluated such as in the Emory River and Swan Pond Embayment;
- Sample depths are applicable to potential exposures to be evaluated, sediment data from locations not exposed during winter pool surface water elevations may be excluded from the human health risk assessment if they demonstrate significant differences in analytical or physical characteristics from the near shore sediments;
- The data have been validated according to the project quality assurance project plan (QAPP) or EPA's National Functional Guidelines (EPA 2004a, 2008a).

The data evaluation for data that meet the above conditions will consist of four components: (1) review of analytical data adequacy, (2) identification of site related contaminants, (3) determination of exposure

point concentrations, and (4) identification of contaminants of potential concern (COPCs), The first three components are the same for the human health and the ecological risk assessments and are only presented once, here in Sections 5.1.l through 5.1.3.

5.1.1 Review of Analytical Data Adequacy

The primary objective for the review of analytical data is to ensure that environmental data of acceptable quality and quantity are used in the risk assessment. Guidance for evaluating the usability of environmental analytical data for risk assessments is provided by EPA in *Guidance for Data Usability in Risk Assessment* (EPA 1992b).

Only data that are "definitive" under current EPA quality assurance guidelines will be used for the quantitative risk assessment. Such data are generated using analytical methods that unambiguously identify and confirm the presence of the compound, and provide a reliable quantification of the concentration present. Quality checks incorporated into the analytical methods will be performed by the laboratories to generate definitive data and to document any issues that might impair the quality or usability of the resulting data, such as instrumental problems, bias in the data, or contamination introduced in the laboratory. Data will be inspected for analytical quality problems during data validation. Evaluation of data quality checks such as instrument calibrations, blank analysis, spike recoveries, etc., will be reported in data validation memoranda and appropriate qualifier flags are applied to the data in accordance with the QAPP. Data adequacy will also be evaluated through review of the QAPP, chain of custody and other inputs beyond data validation, per *Data Quality Assessment: A Reviewer's Guide* EPAQA/G-9R (EPA/240/B-06/002)

Before the data are released to the risk assessor, the analytical results for an entire sampling effort will be presented in a data summary report that discusses overall data quality and any resulting limitations on the use of the data. Data completeness will be reviewed to confirm whether the available data adequately represent the site spatially (locations sampled) and statistically (sufficient number of values available to have an acceptable level of confidence in the data set). Data that have been rejected by the validator for failure to pass a quality check or for noncompliance with the requirements of the QAPP will not be used in the risk assessment.

Potential health effects from exposure to some contaminants may occur at concentrations lower than current analytical technology can measure. In project planning, analytical methods will be chosen to ensure sufficient analytical sensitivity to detect potentially harmful analytes at concentrations below the levels of concern, or, if this is not possible, at concentrations as low as can be practicably achieved. Review of analytical sensitivity in the data reported by the laboratories versus the project data quality objectives is essential, because nondetect results above the levels of concern can lead to unacceptable uncertainty in the risk estimates. A higher priority will be placed on preventing false negatives than false positives. These false negatives (nondetects reported when the analyte is actually present in the sample) can occur not only from elevated detection limits due to required sample dilution, but also when analytical spike or standard recoveries are extremely low. Nondetects associated with these extremely low recoveries may be rejected by the data validator, reducing not only the uncertainty due to false negatives, but also data completeness for that analyte.

One outcome of the data quality review will be an assessment of the uncertainty associated with the data so that its impact on the risk assessment is understood and acceptable. Uncertainty will be evaluated by reviewing such aspects as the sources of the data, consistency in data collection methods and handling, analytical methods and detection limits, data quality indicators (precision, accuracy, representativeness, comparability, and completeness), and data qualifiers. Data collected by EPA and TDEC will be evaluated for adequacy and the potential for introduction of uncertainty using the same process as for data

collected by TVA and its subcontractors. Application of data qualifiers, adequacy of method-specific detection limits, etc will be based on the Quality Assurance and Field Sampling Plans of the respective agencies. Regardless of its source, analytical data for which the associated uncertainties cannot be determined, or which introduce an unacceptable uncertainty into the risk assessment will be used qualitatively, such as to assess the nature and extent of contamination, but will not be used in the quantitative risk assessment.

5.1.2 Identification of Site Related Contaminants

The following sections describe the steps that will be employed to determine the constituents that are associated with the fly ash release. These constituents will be evaluated in the human health and ecological risk assessments to identify COPCs. EPA (1989) defines COPCs as "Chemicals that are potentially site-related and whose data are of sufficient quality for use in the quantitative risk assessment." These chemicals may contribute significantly to human or ecological risk and are carried through the risk assessment process.

Coal Combustion Byproducts. The burning of coal in coal-fired power plants generates coal combustion byproducts including fly ash, bottom ash, boiler slag, and flue gas desulfurization gypsum. EPA has identified 41 common constituents of coal combustion byproducts, including 23 metals and 14 inorganic ions, but no organic compounds (EPA 2007). The trace metals commonly found in fly ash, by relative frequency are vanadium, zinc, copper, chromium, nickel, lead, arsenic, and mercury (EPA 2008a and 1999a). Selenium and thallium were identified by the EE/CA Technical Working Group as additional constituents in fly ash that are of interest in both human health and ecological risk assessment. Additionally, ash is known to contain naturally occurring radionuclides, specifically isotopes of uranium, thorium, and potassium, and their short-lived daughter products e.g. (radium). Therefore the ten metals and the naturally-occurring radionuclides are considered Constituents of Interest (COIs) and will be carried forward in both the human health and ecological risk assessments regardless of the outcome of the screenings described below.

Frequency-of-Detection Screen. Each contaminant in each medium will be evaluated to determine its frequency of detection. Contaminants that were never detected will be eliminated from the COPC list. Any contaminant detected at least once within a given medium will be considered further in the COPC screening process.

Determination and Use of Background Concentrations. EPA Region 4 Risk Assessment Bulletins (EPA 2000) state: "For naturally occurring inorganics and radionuclides, compare the on-site maximum detected concentration to two times the average site-specific background concentration. Eliminate the chemical as a COPC if it is less than two times the background level. It should be noted that one background sample, if elevated, is usually not acceptable for comparison or elimination purposes." For this risk assessment, background concentrations will be presented as a range of concentrations found in soils typical of the Roane County Region. Background screening will not be used to eliminate COPCs, rather background will be used in the uncertainty analysis of the risk assessments to place the risk estimates in context with local or regional concentrations.

<u>Soil</u>. KIF is located in the Valley and Ridge physiographic province of the Appalachian Highland region and is underlain by the Conasauga Group with the exception of the northern portions of the ash response area where the Knox and Rome formations are present. Specific geologic groups within the Conasauga Group represented at the site include the Maynardville, Nolichucky, Maryville, Rogersville, Rutledge, and Pumpkin Valley formations. These formations are locally of low water-producing capacity and predominantly consist of shale with interbedded siltstones, limestones, and conglomerates. Total thickness of the Consauga Group beneath the site is unknown but is estimated to be approximately 1500

ft. Pine Ridge which borders the ash pond area to the northwest is underlain by interbedded shale sandstone and siltstone of the Rome formation (TVA 2006).

Immediately following the ash release, TDEC collected native soil samples on residential properties from locations free of ash. The study was meant to provide initial information about native soil conditions in the vicinity of the site and the constituents of the ash on residential properties (TDEC 2009)

In addition, soil samples were collected in August 2009 at the site of the Peninsula Borrow Area at the KIF. Samples were collected from several depths at each of six locations. Results of these samples are indicative of site-specific naturally-occurring background soil concentrations. Results are not yet available, but will be presented in the EE/CA for the embayment/dredge cell.

In 1993, the DOE published its *Final Report on the Background Soil Characterization project at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE 1993). The results of the BSCP are applicable to the KIF ash response project because both facilities are underlain by the same geologic formations, specifically, the Conasauga and Knox groups. As previously stated, a portion of the ash response area is also underlain by the Rome formation which was not sampled as part of the Oak Ridge BSCP. The BSCP collected samples from the Dismal Gap and Nolichucky formations of the Conasauga Group and the Copper Ridge and Chepultepec formations of the Knox Group on DOE's Oak Ridge Reservation and at off-site locations in Anderson and Roane counties.

Analytical results from these sampling events were combined to derive representative background concentrations for the Kingston area. Table 1 presents the representative background soil concentrations for the Kingston ash response project.

Emory River Surface Water. An upstream surface water sampling location at ERM 12.2 was established and routinely monitored for total and dissolved metals, mercury, hardness, alkalinity, total suspended solids, and total dissolved solids. Analytical data from samples collected by TVA contract personnel from ERM 12.2 will be used as background for the Emory River monitoring locations. Summary statistics and representative background concentrations are provided in Table 2.

Emory River Sediment. Upstream sediment sampling locations were established at Emory River Miles - ERM 6.0, ERM 6.3, ERM 6.4, ERM 6.6, ERM 6.7, ERM 6.9, ERM 7.1, ERM 7.4, ERM 7.7, ERM 9.0, ERM 9.1, ERM 9.3, ERM 9.4, ERM 9.5, ERM 9.6, ERM 9.6, ERM 9.7, ERM 9.8, and ERM 9.9. Analytical data from samples collected by TVA contract personnel from these locations will be used as background for the Emory River monitoring locations. Summary statistics and representative background concentrations are provided in Table 3.

Clinch River Surface Water. An upstream surface water sampling location at CRM 5.5 was established and routinely monitored for total and dissolved metals, mercury, hardness, alkalinity, total suspended solids, and total dissolved solids. Analytical data from samples collected by TVA contract personnel from CRM 5.5 will be used as background for the Clinch River monitoring locations. Summary statistics and representative background concentrations are provided in Table 4.

Clinch River Sediment. Analytical data collected for the DOE Clinch River Environmental Restoration Program from sediment sampling locations on the Clinch River were obtained from the Oak Ridge Environmental Information System (OREIS) for sampling locations between CRM 4.8 and CRM 12.0. Analytical data from these locations will be used as background for the Clinch River monitoring locations. Summary statistics and representative background concentrations are provided in Table 5.

Fish. Reference data for metals in fish tissue include post-release samples from upstream locations in the Emory River and Clinch River, as well as historical samples from the Clinch River and Tennessee River. These data are predominately comprised of concentrations in fillets, rather than whole fish. Summary statistics and representative reference concentrations for the post-release reference locations (ERM 8.0 and CRM 9.5) are included in Table 6. Historical data and representative reference concentrations retrieved from OREIS are presented in Table 7. The selected OREIS data include sample locations in the Clinch River between CRM 0.0 and CRM 23 (Melton Hill Dam) and in the Tennessee River between TRM 530 (Watts Bar Dam) and TRM 572 (upstream of confluence with the Clinch River); however, the OREIS data are predominantly from locations within the Clinch River. Selected OREIS data include samples collected between 1987 and 2008, though metals other than mercury were not sampled until 1992. Historical reference data from other sources (e.g., TVA) also will be used if appropriate.

5.1.3 Determination of Exposure Point Concentrations

Quantification of exposure provides an estimate of the chemical intake for various exposure pathways identified at the site. To quantify exposure, exposure point concentrations must be determined and chemical intakes calculated for the various exposure pathways identified for the site. Potential receptors are assumed to move randomly across the site spending equivalent amounts of time in each location, contact with a contaminated medium over time is best represented by the average concentration of the detected analytes. The exposure medium (ash) is a well-mixed homogenous substance and therefore it is not necessary to divide the ash into smaller exposure units. The use of small exposure units for individual properties would result in risk assessments based on a single ash sample from each property; use of the full data set to determine exposure point concentrations is more conservative and representative of ash as a homogeneous substance.

Because of the uncertainty associated with estimating the true average concentration at a site, the representative concentration used is the 95 percent upper confidence limit (UCL_{95}) on the arithmetic mean (EPA 1992c). The UCL_{95} is defined as a value that, when calculated repeatedly for randomly drawn subsets of site data, equals or exceeds the true mean 95 percent of the time. When limited data are available or when the data are extremely variable, the UCL_{95} can be greater than the highest detected concentration. Therefore, the exposure point concentration represents the UCL_{95} or the maximum detected concentration whichever is smaller.

Data of acceptable quality for use in the risk assessment will be treated as follows for calculation of exposure point concentrations:

- Results from normal/field duplicate sample pairs will be treated as follows:
  - The greater of the normal and field duplicate results will be used if are both detects,
  - The greater of the detection-limit and reporting-limit will be used if the normal and field duplicate results are both non-detect,
  - The detected value will be used when either the normal or field duplicate result is a detect and the other is a non-detect;
- Analytical summary statistics will be calculated using one-half the method detection limit for results reported as non-detect (such as “U” flagged or “ND”).
- Exposure to ash will be evaluated by treating ash as soil or ash as sediment. Since the data for ash are not dependent on depth, data summaries will not be segregated by depth.
- The most current version of EPA’s ProUCL software will be used to the determine exposure point concentrations for each COPC in each medium. The data will be tested to determine which statistical distribution (e.g., normal, lognormal, or gamma) best fit the concentrations. If the data do not fit a statistical distribution, nonparametric statistics will be applied. The UCL_{95} recommended by ProUCL will generally be used. Additional logic may be applied to the

recommendations from the ProUCL software in cases where the calculation of the UCL_{95} may be unreliable such as:

- Values for non-detects will be included at the lowest quantitation or detection limit reported by the laboratory. ProUCL will handle non-detect values according to the internal rules of the software.
- For data sets with fewer than 10 samples, fewer than four distinct detected values, or 50% or more non-detects, estimated UCLs are considered unreliable. ProUCL recommends a minimum of 10 to 15 samples and four or more distinct detected values for meaningful results. Data set central tendencies such as means, medians, and confidence limits on means, cannot be accurately estimated when more than half the data are censored or non-detect. Therefore, the maximum detected concentration will be selected as the exposure point concentration.
- For non-parametric UCL estimations, bootstrap methods will not be used, even when computed, for data sets with fewer than four distinct detected values. UCLs will not be estimated for data sets with fewer than two distinct detected values. The maximum detected concentration will be selected as the exposure point concentration.
- Estimated UCLs are considered to be unrealistic if they equal or exceed the maximum detected concentration. Therefore, the maximum detected concentration will be selected as the exposure point concentration in such cases.

5.1.4 Identification of Contaminants of Potential Concern

The following sections describe the steps that will be employed to determine COPCs for the human health risk assessment. Ash samples have been analyzed for total metals, radioisotopes, PAHs, and BTEX. Because of the coal burning process and a review of literature results, other types of contaminants were known to not be present. The analytical results showed no presence of the PAHs and BTEX. Therefore, only metals and radioisotopes are potential COPCs. The radioisotope data were not screened at this time because the data have not yet been validated; these data (including data from samples collected the week of August 24, 2009, in the dredge cell) will be screened in the EE/CA.

Risk-based Screen. Site-related constituents and COIs will be evaluated against risk-based concentration screening levels also known as preliminary remediation goals (PRGs). Chemical data will be compared to the most recent version of the EPA regional residential risk-based screening levels (EPA 2009b) for soil or tap water as appropriate for the matrix. Fish data will be compared to PRGs obtained from the Oak Ridge National Laboratory Risk Assessment Information System. A target cancer risk level of 1.0E-06 will be used as a screening level for carcinogens; a target hazard index (HI) of 0.1 will be used as a screening level for non-carcinogens. Additional screening values include State and Federal MCLs and the State and Federal Ambient Water Quality Criteria for human consumption of water and organisms or human consumption of organisms only. The screen will employ the lowest applicable value and the maximum detected concentration of each constituent will be compared to its respective screening level. If the maximum detected concentration is below its screening level, then the contaminant will be eliminated as a COPC; if the maximum detected concentration exceeds its screening level, or if there is no screening level available for the detected contaminant, then the contaminant will be retained as a COPC.

Quantitation limits for constituents which do not have any detected concentrations in a given medium will be compared to the appropriate risk-based screening levels to determine if the constituent should be evaluated further in the risk assessment. Constituents whose maximum quantitation limit exceeds the risk-based screening level will be evaluated qualitatively in the uncertainty analysis of the risk assessment. This evaluation will address the potential under estimation of cancer risks or non-cancer hazards.

Essential Human Nutrient Screen. Chemicals that are considered essential nutrients (i.e., calcium, chloride, iodine, magnesium, phosphorus, potassium, and sodium) are an integral part of the human food supply and are often added to foods as supplements (EPA 2001c). EPA recommends that these chemicals not be evaluated as COPCs so long as they are (1) present at low concentrations (i.e., only slightly elevated above naturally occurring levels) and (2) toxic at very high doses (i.e., much higher than those that could be associated with contact at the site). A screening process will be employed whereby daily intakes (in mg/day) will be estimated and compared with recommended dietary allowance (RDA) values (also in mg/day).

Daily intakes will be estimated from maximum detected concentrations in soil (mg/kg of chemical in soil × 0.0001 kg/day of soil = daily intake in mg/day). The intake rate used in these calculations (0.0001 kg/day of soil) represents conservative adult ingestion rates for a residential receptor. Screening concentrations for essential nutrients will be calculated so that the resulting concentration would produce an intake equal to the RDA value. RDA values will be obtained online from the U.S. Department of Agriculture at http://www.cnpp.usda.gov/DietaryGuidelines.htm. Essential nutrients whose maximum detected concentrations are less than their calculated screening concentrations will be eliminated as COPCs.

5.1.5 Preliminary Screening Results

A screening-level human health risk assessment has been completed for use in making risk management decisions on the path forward for the site. Results are presented below. Preliminary summary statistics and screening results of analytical data for ash, surface water, sediment, and fish are presented in Tables 8 through 12, respectively. A comparison of chemical data to human health screening levels has been performed.

The human health screening levels for ash consist of the most recent version of the EPA regional residential soil screening levels (EPA 2009b). The screening consisted of comparing the maximum detected concentration of each analyte to the lowest applicable screening level for the medium of interest. The list of constituents of potential concern based on the preliminary screening of data for all ash samples collected on land and in the Emory River (Table 8), surface water samples from the Emory, Clinch, and Tennessee Rivers (Tables 9, 10, and 11) and fish samples (Table 12) are:

- Ash as soil or sediment – aluminum, arsenic, cobalt, iron, lead, manganese, thallium, and vanadium;
- Surface water in the Emory River – aluminum, antimony, arsenic, barium, beryllium, cobalt, copper, iron, lead, manganese, mercury, thallium, and vanadium;
- Surface water in the Clinch River – aluminum, antimony, arsenic, barium, beryllium, cobalt, iron, lead, manganese, thallium, and vanadium;
- Surface water in the Tennessee River – antimony, iron, manganese, and mercury;
- Fish – arsenic, lead, and mercury.

However, as previously stated the following analytes are considered COIs related to fly ash and will be carried forward in the human health risk assessment: arsenic, chromium, copper, lead, mercury, nickel, selenium, thallium, vanadium, and zinc.

5.2 Exposure Assessment

The term “exposure pathway” describes the mechanism by which an individual or population may be exposed to chemicals originating from an area of contamination. An exposure pathway analysis links the sources, locations, and types of environmental releases with population locations and activity patterns to determine the potential human exposure pathways. An exposure pathway generally consists of five

elements: (1) a source and mechanism of chemical release, (2) transport medium (or media in cases involving media transfer of chemicals), (3) a point of potential human contact with the contaminated media, (4) an exposure route at the point of contact, and (5) a receptor. Identification of current and future exposure pathways of concern is determined by evaluating the components necessary to complete a potential exposure pathway. For an exposure pathway to be considered complete, each of these components must exist and be linked to the others. The conceptual exposure model (Figure 8) illustrates the environmental pathways by which receptors could be exposed to contaminants associated with the released ash.

For the human health risk assessment, potential receptors are distinguished as onsite and offsite. Onsite receptors are those who reside, work, or play on the ash, whereas, offsite receptors are those whose activities occur in areas where ash is not present. Exposure scenarios to be evaluated are described below.

EPA default exposure parameters from Office of Solid Waste and Environmental Response Directive – 9285.6-03, Region 4 recommended values, or scenario specific exposure parameters will be used for the human health risk assessment (Table 13). Additionally, exposure scenarios and parameters will be consistent with those presented in the Remedial Investigation/Feasibility Study for Clinch River/Poplar Creek Operable Unit (DOE 1996) where it is applicable to do so, such as for the near shore recreational scenario.

5.2.1 Soil/Ash

Adult and Child Resident: Currently there are no residential properties on-site. Therefore, current off-site residential receptors may only be exposed to ash through inhalation of fugitive dust dispersed in the air away from the ash. However, under the assumption that TVA abandons or releases all or part of the site and no institutional controls are implemented, future residential receptors living on-site may be exposed to ash through incidental ingestion, inhalation of fugitive dust, dermal contact, and external exposure from radionuclides. Exposure parameters for this scenario will be the default values established by EPA (EPA 1991). The residential exposure scenario is appropriate due to current use of surrounding properties.

Indoor Worker (office or light industrial worker): Under current land use scenarios off-site indoor workers involved in office or light industrial work may be exposed to ash that has been deposited by wind or tracked by human or vehicle traffic to a point of exposure away from the ash flow area. Exposure parameters for this scenario will be the default values established by EPA (EPA 1991). Indoor workers may be exposed to ash through incidental ingestion, inhalation of particulates, and external exposure from radionuclides from material tracked indoors. Under future land use assumptions, on-site indoor workers may be exposed to ash through incidental ingestion, inhalation of particulates, and external exposure from radionuclides from material tracked indoors from unpaved and unvegetated portions of the ash. The future industrial scenario assumes that TVA abandons or releases parts of the site and no institutional controls are implemented and industrial exposures occur on the ash.

Outdoor Worker: Under current land use assumptions an off-site individual involved in routine outdoor work not associated with removal or management of ash may be exposed to ash that has been deposited by wind or tracked by human or vehicle traffic to a point of exposure off the ash flow area. Under future land use assumptions an on-site individual involved in routine outdoor work may be exposed to ash. Exposure parameters for this scenario will be the default values established by EPA (EPA 2002c). The outdoor worker may be exposed to ash through incidental ingestion, inhalation of particulates, dermal contact, and external exposure from radionuclides.

Groundskeeper (plants and maintains landscape material): Future land use scenarios may include onsite groundskeeper personnel employed to plant and maintain landscape material. Exposure parameters for

this scenario will be the default values established by EPA (EPA 2002c) for a construction worker with modifications for the frequency and duration of exposure as described here. The groundskeeper may be exposed to ash through incidental ingestion, inhalation of particulates, dermal contact, and external exposure from radionuclides. Inhalation of particulates would be of particular concern during activities such as mowing which cause an increase in local inhalable particulates. Based upon professional judgment, the groundskeeper is assumed to have intensive contact with ash 5 days/week for 7 months each year for an exposure frequency of 140 days per year. The exposure duration for the groundskeeper is assumed to be 25 years. Because the groundskeeper scenario as described is more conservative than a construction worker scenario, a separate assessment of a construction worker is not needed.

On-site trespasser: An adolescent receptor may currently trespass onto the ash spill area and subsequently be exposed to ash related constituents. Exposure parameters for this scenario will be the default values established by EPA Region 4 (EPA 2000a). Exposure to ash related constituents may occur through incidental ingestion, inhalation of particulates, dermal contact, and external exposure from radionuclides. EPA Region 4 considers the typical trespasser to be an adolescent aged 7-16 (10 year exposure duration) with a body weight of 45 kg. Exposure frequency is assumed to be limited by the presence of TVA security personnel for most areas, however, ash in the sloughs and embayment areas are adjacent to current or former residential properties and trespassing may be harder to regulate. Therefore, based on best professional judgment, the adolescent trespasser is assumed to frequent these areas an average of 3 days per week from April through October or 84 days per year. The exposure frequency is based on the assumption that outdoor activity is likely to be more frequent when temperatures are at or above 70° F which are common for the months identified (USDA 2009).

Recreator (Adult hiker/spectator, child participant in sports or play): Onsite future recreational use of the Kingston site is a plausible scenario. In the past, part of the site was used for athletic fields. Potential receptors are children involved in sports such as baseball, soccer, or football and their parents who attend their practices and games or use the site for recreational activity. Exposure parameters for this scenario will be a combination of default values established by EPA Region 4 (EPA 2000a) and site-specific values as discussed in this section. The child recreator is assumed to be between the ages of 7 and 16 participating in organized youth athletics. These youths are assumed to participate in 2 practice sessions and one game per week over the course of 7 months. Game and practice sessions are assumed to last 1.5 hours each. These estimates are based on best professional judgment of schedules for organized youth athletics. The adult recreator is assumed to attend the practice sessions and games of the child recreator or is otherwise engaged in recreational activities on the site. The adult is also assumed to be on-site 1.5 hours/day, 3 days/week over the course of 7 months. Exposure to ash related constituents may occur through incidental ingestion, inhalation of particulates, dermal contact, and external exposure from radionuclides. While the younger siblings of children engaged in recreational or sporting activities would reasonably be expected to be on-site during practice or games, their potential exposures would be greater under the residential scenario and as such will not be evaluated under the recreational scenario.

5.2.2 Sediment/Ash

Recreator (adolescent-adult recreator or fisher): Adolescent or adult recreators or fishers may be exposed to residual ash impacted sediment during the winter when Watts Bar Reservoir is lowered to winter pool potentially exposing ash impacted sediment in the Emory, Clinch, and Tennessee Rivers. Recreational receptors may be exposed to residual ash and sediment via incidental ingestion, dermal contact, and external exposure to radionuclides. Inhalation of fugitive dust would be negligible due to the water content of the exposed sediments. The Clinch River Poplar Creek Remedial Investigation assessed receptors for exposure to near shore sediments. The receptors were assumed to be an adult or child living adjacent to the river. Exposure to near shore sediments is assumed to occur less frequently than for the

on-site trespasser since exposure would occur during the late fall through early spring. Therefore the exposure frequency is assumed to be two days per week from October through March or 48 days per year.

5.2.3 Surface Water

Recreator (adolescent-adult swimmer): Adolescent or adult swimmers may be exposed to ash related constituents in surface water while swimming. Incidental ingestion and dermal contact with surface water during swimming are the exposure pathways of concern. The potential receptors for exposure to surface water in the Emory, Clinch, or Tennessee Rivers are assumed to be adults and children who are old enough to be away from parental supervision for extended periods. Exposure parameters for this scenario will be the default values established by EPA Region 4 (EPA 2000a). The child age group considered is 9 to 18 years old. For the recreational scenario, swimming in these rivers is assumed to occur 45 days a year. An exposure time of 1.4 hours a day is used for both scenarios based on activity pattern data by the EPA (1997cb).

Adult and Child Resident: Future residential receptors may be exposed to surface water via ingestion and dermal contact. Exposure parameters for this scenario will be the default values established by EPA (EPA 1991). This scenario assumes that the resident draws water directly from the river for household use without filtration or treatment, by-passing the available public water supply or installation of a groundwater well.

Recreator (fisher): Recreational fishing is known to occur in the Emory River, however, subsistence level fish consumption is not known to occur. Currently, there are fish consumption advisories in place for the Emory River and Watts Bar Reservoir; however, it may be assumed that not all potential receptors adhere to the advisories. Therefore, ingestion of recreationally caught fish from the Emory River will be evaluated. The ingestion rate for recreationally caught fish isfrom the EPA (1991b) and (TDEC 2007). The average fish consumption rate of 54 grams/day is the default rate presented in EPA 1991b. This rate was calculated for an exposure frequency of 350 days per year and is approximately equal to two 8-ounce meals per week. To be consistent with TDEC's methods (TDEC 2007) for determining the need for fish consumption advisories, an ingestion rate of 6.5 grams/day will also be used. The use of two ingestion rates for the fish consumption scenario allows for the evaluation of the potential for adverse health impacts across the typical range of fish consumption habits. Data from fish filets will be assessed; data from whole body fish will not be used in the human health risk assessment.

5.2.4 Groundwater

Adult and Child Resident: Exposure parameters for this scenario will be the default values established by EPA (EPA 1991). Future on-site residential receptors may be exposed to groundwater used for household water supply through ingestion, inhalation of water vapor, and dermal contact. The residential exposure scenario is appropriate due to current use of surrounding properties.

Indoor Worker (office or light industrial worker): Future on-site indoor workers involved in office or light industrial work may be exposed to groundwater used as a potable water supply. Exposure parameters for this scenario will be the default values established by EPA (EPA 1991). Indoor workers may be exposed to groundwater through ingestion. Dermal contact and inhalation of water vapor are not considered to be significant pathways of exposure for indoor workers due to the limited use of water in industrial or office settings.

5.2.5 Quantification of Exposure

The basic equations used to calculate cancer risk and noncancer hazard estimates for the identified exposure scenarios are taken from Risk Assessment Guidance for Superfund Volume 1: (EPA 1989a) and *Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)*, (EPA 1991a).

Toxicity values are not available for the evaluation of lead. Instead, two models will be employed to evaluate potential exposures to lead. The EPA integrated exposure-uptake biokinetic (IEUBK) blood lead model for young children, developed for residential scenarios, will be used to predict blood lead level (PbB) for children hypothetically exposed at the site (EPA 2009e). This model estimates the PbB in children exposed to the environmental media, and compares this estimate with the threshold level of 10 µg/dL (micrograms per deciliter). The IEUBK is a self-contained DOS-based computer program. Average lead concentrations in the various media are entered into the model; default values provided by the IEUBK are used when site-specific data are not available. Arithmetic mean values, rather than conservative estimates of average, are used because the IEUBK contains a statistical module that addresses individual variation in exposure and physiological parameters. The output is a probability density histogram of predicted PbB. The risk assessment is considered to "pass" if the IEUBK predicts that not more than 5 percent of young children exposed in this manner would experience a mean PbB above the 10 µg/dL threshold.

The Adult Lead Methodology will be employed to examine adult exposures to lead in ash in nonresidential exposure scenarios (EPA 2009e). The method focuses on the estimation of PbB in fetuses carried by women exposed to average concentrations of lead . The method is based on a probability model for PbB in adult women exposed to lead in ash coupled with an estimated constant of proportionality between fetal and maternal PbBs, a geometric mean fetal PbB concentration and empirically determined geometric standard deviation. The statistical terms used in the method permit an equation to be used to establish an average adult PbB such that a fetus has not more than a 5 percent probability of PbB exceeding 10 µg/dL. The risk assessment is considered to pass if the average adult PbB does not predict an excess of 5 percent probability that fetal PbB exceed 10 µg/dL.The most recent Integrated Exposure Uptake Biokinetic Model (EPA 2009e) will be used to assess hazards to children from lead and the most recent guidance for assessing adult exposures to lead (EPA 2009e) will be used to quantify the hazards to adults from lead.

Incidental Ingestion of Ash

The ingested dose of COPCs in ash will be estimated by the following equation:

$$I_{chem} = \frac{(C_{so})(FI_{so})(IR_{so})(EF)(ED)(CF_2)}{(BW)(AT)} \qquad \textbf{Eq. 5.1}$$

$$I_{rad} = (C_{so})(FI_{so})(IR_{so})(EF)(ED)(CF_3) \qquad \textbf{Eq. 5.2}$$

where:

I_{chem}	=	ingested dose of chemical COPC in ash (mg/kg-day, calculated)
I_{rad}	=	ingested dose of radionuclide COPC in ash (pCi, calculated)
C_{so}	=	concentration of COPC in ash (mg/kg or pCi/g)
FI_{so}	=	fraction of exposure attributed to site ash (unitless)
IS_{so}	=	ingestion rate of ash (mg/day)
EF	=	exposure frequency (days/year)

ED	=	exposure duration (years)
CF_2	=	conversion factor (1E-6 kg/mg)
CF_3	=	conversion factor (1E-3 g/mg)
BW	=	body weight (kg)
AT	=	averaging time (days)

Dermal Contact with Ash

Unlike the methodologies for estimating inhaled or ingested doses of COPCs, which quantify the dose at the barrier membrane (the pulmonary or gastrointestinal mucosa), dermal dose is estimated as the dose that crosses the skin and is systemically absorbed. The absorbed dose of COPCs will be estimated from the following equation (EPA 1992):

$$DAD = \frac{(DA)(SA)(EF)(ED)}{(BW)(AT)} \qquad \textbf{Eq. 5.3}$$

where:

DAD	=	average dermal absorbed dose of COPC (mg/kg-day, calculated)
DA	=	dose absorbed per unit body surface area per day (mg/cm2-day)
SA	=	surface area of the skin exposed to the medium (cm2)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)

Dermal uptake of constituents from ash assumes that exposure is a function of the fraction of a dermally applied constituent that is absorbed, as calculated from the following equation (EPA 1992):

$$DA_s = (C)(FI)(CF_2)(AF)(ABS) \qquad \textbf{Eq. 5.4}$$

where:

DA_s	=	dose absorbed per unit body surface area per day for ash (mg/cm^2-day)
C	=	concentration of COPC in medium (mg/kg)
FI	=	fraction of exposure attributed to site medium (unitless)
CF_2	=	conversion factor (1E-6 kg/mg)
AF	=	ash-to-skin adherence factor (mg/cm^2-day)
ABS	=	absorption fraction (unitless, chemical-specific)

External Exposure to Radionuclides in Ash

External exposure to radionuclides in ash will be estimated by the following equation:

$$EE_{rad} = C_s \times EF \times ED \times ACF \times [ET_o \times (ET_i \times GSF)] \qquad \textbf{Eq. 5.5}$$

where

EE_{rad}	=	External Exposure dose (pCi-year/g)
C_s	=	radiological soil concentration (pCi/g)
EF	=	exposure frequency (day/year)
ED	=	exposure duration (years)
CF	=	units conversion factor (years/day)

ACF	=	area correction factor (unitless)
ET_o	=	outdoor exposure time fraction (unitless)
ET_i	=	indoor exposure time fraction (unitless)
GSF	=	gamma shielding factor (unitless)

Inhalation of Particulates in Air

The inhaled dose of COPCs in air will be estimated by the following equation:

$$EC = \frac{(C_a)(ET_a)(EF)(ED)}{(AT)} \qquad \textbf{Eq. 5.6}$$

$$I_{rad} = (C_a)(IR_a)(ET_a)(EF)(ED) \qquad \textbf{Eq. 5.7}$$

where:

EC	=	exposure concentration of chemical COPC (µg/m^3, calculated)
I_{rad}	=	inhaled dose of radionuclide COPC (pCi, calculated)
C_a	=	concentration of COPC in air (µg/m^3)
ET_a	=	exposure time (hours/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
AT	=	averaging time (days)

EPA (1996) derived a model for estimating a dust particulate emission factor based on an "unlimited reservoir" model and the assumption that the source area is square:

$$PEF = Q/C \times \frac{3600}{0.036 \times (1-V) \times \left(U_m/U_t\right)^3 \times F(x)} \qquad \textbf{Eq. 5.8}$$

where:

PEF	=	particulate emission factor (m^3/kg, calculated)
Q/C	=	inverse of the mean concentration at center of square source
3600	=	seconds/hour
V	=	fraction of surface covered with vegetation (0.8, unitless, assumed)
U_m	=	mean annual wind speed (default, 4.69 m/second)
U_t	=	equivalent threshold value of wind speed at 7 m (default, 11.32 m/second)
F(x)	=	function dependent on U_m/U_t (default, 0.194)

EPA (2002c) presents a modification to the method for calculation of the dispersion factor for wind erosion, Q/C, to reflect updated dispersion modeling. As a result of the update, Q/C values can now be derived for any source size between 0.5 and 500 acres. The equation for calculating Q/C is:

$$Q/C = A \times exp\left[\frac{(ln\, A_{site} - B)^2}{C}\right] \qquad \textbf{Eq. 5.9}$$

where:

Q/C	=	Inverse of the ratio of the geometric mean air concentration to the emission flux at the center of the source or at the boundary of the source (g/m2 - s per kg/m2)
A	=	Constant based on air dispersion modeling for specific climate zone
A_{site}	=	Areal extent of the site (acres)
B	=	Constant based on air dispersion modeling for specific climate zone
C	=	Constant based on air dispersion modeling for specific climate zone

The concentrations of COPCs in air will be calculated as follows:

$$C_a = \frac{C_{so}}{PEF} \qquad \textbf{Eq. 5.10}$$

where:

C_a	=	contaminant concentration in air (mg/m^3, calculated)
C_{so}	=	contaminant concentration in ash (mg/kg)
PEF	=	particulate emission factor (m^3/kg)

Ingestion of Surface Water

The ingested dose of COPCs in surface water while swimming will be estimated by the following equation:

$$I_w = \frac{(C_w)(IR_w)(ET)(EF)(ED)}{(BW)(AT)} \qquad \textbf{Eq. 5.11}$$

where:

I_w	=	ingested dose of COPC in surface water (mg/kg-day, calculated)
C_w	=	concentration of COPC in surface water (mg/L)
IR_w	=	surface water ingestion rate (L/day)
ET	=	exposure time (hours/days)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)

The exposure time factor is not used for the residential scenario.

Dermal Contact with Surface Water

The absorbed dose of COPC from surface water will be estimated by the following equation (EPA 1992):

$$DAD = \frac{(DA)(SA)(EF)(ED)}{(BW)(AT)} \qquad \textbf{Eq. 5.12}$$

where:

DAD	=	average dermal absorbed dose of COPC (mg/kg-day, calculated)
DA	=	dose absorbed per unit body surface area per day: The absorbed dose per event from surface water will be calculated using the spreadsheet for inorganic constituents that accompanies *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)* (EPA 2004b) (mg/cm^2-day).
SA	=	surface area of the skin exposed to the medium (cm^2)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)

The absorbed dose per event from surface water will be calculated using the spreadsheet for inorganic constituents that accompanies *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)* (EPA 2004b) (mg/cm^2-day) which employs the following equation:

$$DA_{event} = K_p \times C_w \times t_{event} \qquad \textbf{Eq. 5.13}$$

where:

DA_{event}	=	Absorbed dose per event (mg/cm-event)
K_p	=	Dermal permeability coefficient of compound in water (cm/hr)
C_w	=	Chemical concentration in water (mg/cm3)
t_{event}	=	Event duration (hr/event)

Ingestion of Fish

The ingested dose of COPCs in fish will be estimated by the following equation:

$$I_F = \frac{(C_F)(IR_F)(EF)(ED)}{(BW)(AT)} \qquad \textbf{Eq. 5.14}$$

where:

I_F	=	ingested dose of COPC in fish (mg/kg-day, calculated)
C_F	=	concentration of COPC in fish (mg/kg)
IR_F	=	ingestion rate of fish (mg/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days)

5.3 Toxicity Assessment

The purpose of the toxicity assessment is to weigh available evidence regarding the potential for a chemical to cause adverse effects in exposed individuals (hazard identification), and to provide an estimate of the relationship between exposure to the chemical and the likelihood of adverse effects (dose-response assessment). The human health risk assessment will use EPA-derived toxicity values. There are

two types of toxicity values: cancer slope factors for evaluating carcinogenic effects and reference doses for evaluating noncarcinogenic effects. Slope factors and reference doses used in the risk assessment will be obtained from the latest version of the region screening levels tables which follows EPA's three tiered hierarchy (EPA 2003b):

- Tier 1- EPA's Integrated Risk Information System (IRIS)
- Tier 2- EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) – The Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center (STSC) develops PPRTVs on a chemical specific basis when requested by EPA's Superfund program.
- Tier 3- Other Toxicity Values – Tier 3 includes additional EPA and non-EPA sources of toxicity information. Priority should be given to those sources of information that are the most current, the basis for which is transparent and publicly available, and which have been peer reviewed.

Oral toxicity values will be used to evaluate potential toxic effects from the dermal contact pathway without modification for this risk assessment. The over- or under-estimation of potential cancer risks or non-cancer hazards associated with this approach will be addressed in the uncertainty analysis. Additionally, a qualitative evaluation of the potential for toxic effects will be performed for constituents that do not have toxicity values available from one of the above sources.

5.4 Risk Characterization

Risk characterization integrates the results of the exposure and toxicity assessments to estimate potential cancer risks and noncancer hazards. Carcinogenic risk is expressed in terms of the probability that an individual will contract cancer over a lifetime of exposure. Cancer risk attributable to exposure from a single chemical or radionuclide by a single exposure route is estimated by multiplying the exposure dose for that chemical through the exposure route by the chemical's cancer slope factor. Chemical-specific and radionuclide-specific risks are then summed to determine the total cancer risk associated with each exposure route. Risks for each exposure route of concern are then summed to estimate a total risk for an individual receptor exposed through more than one route at a site. When appropriate, risk will be summed across media. The calculated cancer risk estimates are compared to the range specified in the National Oil and Hazardous Substances Pollution Contingency Plan of 10^{-6} to 10^{-4}, or 1 in 1 million to 1 in 10,000 exposed persons developing cancer (EPA 1990). ILCRs below 10^{-6} are considered acceptable. ILCRs above 10^{-4} are considered unacceptable. The range between 10^{-6} and 10^{-4} is an area of concern, and any decisions to address ILCRs further in this range, either through additional study or engineered control measures, should account for the uncertainty in the risk estimates.

Noncarcinogenic hazards are expressed in terms of hazard quotients (HQs) and HIs. An HQ is calculated for each chemical for each exposure route by dividing the exposure dose by the chemical-specific reference dose. An HI is calculated for each exposure route by summing the HQs. HIs for each exposure route are summed to derive a total HI for each scenario. When appropriate, HIs will be summed across media. An HI greater than 1 has been defined as the level of concern for potential adverse non-carcinogenic health effects (EPA 1989). This approach differs from the probabilistic approach used to evaluate carcinogens. An HQ of 0.01 does not imply a "1-in-100" chance of an adverse effect but indicates only that the estimated intake is 100 times less than the threshold level at which adverse health effects may occur.

5.5 Uncertainty Analysis

The primary purpose of the human health risk assessment is to determine whether there is a current or potential future threat to human health or the environment that warrants remedial action. The nature of cancer risk and noncancer hazard estimates requires the use of multiple assumptions in their development,

including assumptions relative to exposure and site conditions. The uncertainty analysis will be a qualitative assessment of how these assumptions and their potential impact on the risk estimates to place the numerical estimates in the proper context; namely, whether the risk assessment process may have over- or under-estimated the hazard and risk levels. The uncertainty analysis will also address the risk estimates for exposure to ash relative to regional soil background concentrations, to place the estimates in the proper context.

6 ECOLOGICAL RISK ASSESSMENT

This section presents the ecological risk assessment (ERA) approach for the TVA Ash Response EE/CAs for Non-Time Critical Removal Actions. The objective of the ERA process is to evaluate potential risks to terrestrial and aquatic ecological receptors from exposure to constituents in ambient media. A screening-level ERA (SLERA) has been completed for use in making risk management decisions on the path forward for the site following completion of the time-critical removal action, as discussed in Section 7. Specifically, the scope of this SLERA includes the failed dredge cell, the embayment west of Dike 2, and the associated river system (i.e., the Emory River, the Clinch River, and the Tennessee River). A detailed ecological conceptual site model (CSM) is presented in Appendix A and the results of the SLERA are presented in Appendix B.

In accordance with EPA guidance, an ERA is comprised of a screening-level ERA (SLERA) and, if necessary, a baseline ERA (BERA) (EPA 1997c). Figure 9 provides an overview of the ecological risk approach that encompasses the EPA eight-step ERA process (EPA 1997c). An expanded view of the components of each step is provided on Figure 10 (EPA, 1999c; 2000b). The SLERA provides a conservative estimate of potential ecological risks and compensates for uncertainty by incorporating numerous conservative assumptions. The purpose of a SLERA is to determine whether there is a high probability that there are no ecologically significant risks (EPA 2000b; 1997c); otherwise, a BERA is warranted, except where early actions will reduce potential ecological risks to acceptable levels. If need for a BERA is indicated, the information developed in the SLERA is used to help focus the BERA. The BERA is more complex than the SLERA and uses more realistic and site-specific information about potential exposures and effects in order to evaluate potential ecological risks.

The ERA guidance (EPA 1997c) includes clearly identified points in the process for stakeholder communication and decision-making, consistent with EPA guidelines (EPA 1998; 1999c; 2000b). These scientific management decision points (SMDPs) allow for collaborative decision-making that results in the efficient use of time and resources. These decisions must then be captured in subsequent decision-making documents and actions. Generally, the following types of decisions are considered at the SMDPs:

- Whether no further action is appropriate based on concerns for wildlife,
- Whether further ERA is warranted, and
- Whether remedial actions can be implemented to reduce or prevent risks to wildlife.

For this site, the SLERA evaluates the potential risks to terrestrial and aquatic ecological receptors exposed to detected constituents in ash and surface water in the vicinity of the site. A detailed CSM of potentially complete pathways for ecological receptors was developed for the TVA Kingston ash release site (Appendix A). A summary level CSM for use in the SLERA is presented in Figure 11. The ash that will remain in the area west of Dike 2 at the conclusion of the time-critical removal action is primarily considered a potential risk to terrestrial ecological receptors; however, this assessment will also assess potential risks to aquatic and sediment-associated biota. To be conservative, the SLERA evaluates potential exposures to ash in this area as if it were soil (ash as soil) and as if it were sediment (ash as sediment). The ash that will remain in the rivers at the conclusion of the time-critical removal action is primarily considered a potential risk to aquatic ecological receptors; however, this assessment will also

assess potential risks to aquatic and sediment-associated biota. To be conservative, the SLERA evaluates potential exposures to ash in these areas as if it were sediment (ash as sediment). The SLERA also evaluates potential exposures to constituents in surface water, for which the Emory River data represents the most robust data set and conservative exposure assumptions. At the time of the assessment, surface water samples from west of Dike 2 that are representative of potential current and near-term aquatic exposures had not yet been validated. This data gap is addressed as an uncertainty in the SLERA. In addition, potential ecological risks associated with groundwater releases to surface water will be evaluated as part of the BERA for the river system.. The SLERA details and results are presented in Appendix B and Table 14 through Table 24.

The SMDP that follows the SLERA addresses the failed dredge cell and ash-filled embayment separately from the area east of Dike 2 and in the river system. Where a BERA is deemed necessary, that evaluation will be presented in future reports, as discussed in Section 7.

6.1 Conclusions of the SLERA

This first SMDP is purposefully flexible (per the EPA paradigm) to occur after Steps 2 or 3a, depending on the results obtained at Step 2. The purpose of the flexibility of the first SMDP is so that additional evaluation of risks can occur and reporting can be streamlined into a single report, where warranted. The results of the SLERA are expressed in terms of the following conclusions or recommended actions:

- There is adequate information to conclude that ecological risks are negligible and therefore no need for remediation on the basis of ecological risk;
- The information is not adequate to make a decision at this point, and the ecological risk assessment process will continue to Step 3; or
- The information indicates a potential for adverse ecological effects, and a more thorough assessment is warranted.

6.1.1 Terrestrial Environment

As described above, and summarized in Table 23, the SLERA for terrestrial exposures at the TVA Kingston Ash Release indicates the following:

- Ash as soil: Sixteen inorganic constituents in ash as soil were selected as constituents of potential ecological concern (COPECs) because maximum concentrations exceeded an HQ of 1, or an ecological screening value (ESV) was not available.

Based on the available evidence, the possibility of adverse ecological risks for ecological receptors potentially exposed to ash as soil cannot be excluded. However, the viable remedial action alternatives for the Dredge Cell and Embayment entail the complete excavation of ash or capping with clean soil (Section 7). Given that viable remedies for this area of the site would eliminate the potential exposure pathways for terrestrial ecological receptors, a BERA is not warranted for the terrestrial environment and no additional data are needed to support the selection of a remedial action to protect ecological receptors in the Dredge Cell and Embayment.

6.1.2 Aquatic Environment

As described above and summarized in Table 23, the SLERA for aquatic exposures at the TVA Kingston Ash Release indicates the following:

- Ash as sediment: Seventeen inorganic constituents in ash as sediment were selected as COPECs because maximum concentrations exceeded an HQ of 1, an ESV was not available, or constituents were identified as COIs in fly ash; and
- Surface Water: Seventeen inorganic constituents in the Emory River, seventeen constituents in the Clinch River, and fourteen constituents in the Tennessee River were selected as COPECs because maximum concentrations exceeded an HQ of 1, an ESV was not available, or constituents were identified as COIs in fly ash.

Based on the available evidence, the possibility of adverse ecological risks for ecological receptors potentially exposed to COPECs in surface water or to ash as sediment cannot be excluded.

6.1.3 SMDP for Dredge Cell and Embayment

The information indicates a potential for adverse ecological effects for terrestrial and aquatic receptors in the areas west of Dike 2. Although a more thorough assessment is warranted, all viable remedial action alternatives for the Dredge Cell and Embayment entail the complete excavation of ash or capping with clean soil (Section 7). Given that the remedies for this area of the site will eliminate the potential exposure pathways for ecological receptors, a BERA is not warranted and no additional data are needed to support the selection of a remedial action to protect ecological receptors in the Dredge Cell and Embayment.

6.1.4 SMDP for Dredge Cell and Embayment

The information indicates a potential for adverse ecological effects for receptors east of Dike 2, and a more thorough assessment is warranted (Section 7). A sampling and analysis plan will be developed to support a BERA for the river system.

The general types of information that will likely be needed to support a decision for the aquatic environment include the following: concentrations of COPECs in the ash and sediment, biogeochemical data for the ash and sediment, fate and transport information for the ash and COPECs, bioavailability of COPECs in the ash and sediment, concentrations of COPECs in fish, concentrations of COPECs in aquatic and riparian prey species, information on dietary exposures for birds and mammals, and community survey information for fish and benthic invertebrates. Some of these data have been collected. At this time the list of COPECs (i.e., metals) is adequately defined and the COPEC concentration data for surface water and ash are adequate to support the BERA. Bioavailability and dietary exposure information are the most likely types of data for which additional collection efforts may be warranted. However, the identification of data needs will require careful consideration of the intended uses of the data and of the adequacy of the data that is already available. These factors will be addressed during development of the sampling and analysis plan for the BERA.

7 PATH FORWARD

The path forward for the site, as mentioned in Section 2.0, is to prepare two separate EE/CAs and make two separate non-time critical removal action decisions for the embayment/dredge cell and the river systems. This chapter further discusses the rationale for this path forward.

The embayment and the dredge cell are connected physically. Ash in the embayment is holding back ash in the dredge cell. A decision on the embayment would dictate action required in the dredge cell and vice versa. A decision to remove material from the embayment would require a decision on where to dispose of that material. The volume of material in the embayment is large, hence the disposal element of the decision is important. Since the dredge cell is one of several disposal options, closure of the dredge cell

needs to consider whether or not material from the embayment would be placed there first. Therefore, a decision on the dredge cell can only be made along with a decision on the embayment. Likewise, final restoration of areas used to process or store ash during the response will generate ash and soil and should be decided with the embayment and dredge cell.

While the dredge cell and the embayment decisions are intertwined, the decision between the residual ash in the river and the embayment are independent. With removal of the material east of Dike 2 completed as part of the time-critical removal action, and with the presence of Dike 2, there is no dependency on ash stability between residual ash in the river and ash in the embayment. Likewise, the volume that may remain in the river is sufficiently small that having onsite disposal not be an option to evaluate along with residual ash removal is not a problem. Therefore, a decision can be made independently on the river residual ash.

Because there are two potentially unrelated decisions, an assessment of the potential data needs for the decisions was made to see if one of the decisions could be made quicker due to fewer data needs than the other.

The ash is fairly homogeneous and numerous samples of ash have been collected and analyzed. Most of the ash samples have been analyzed for naturally-occurring metals, and radionuclides, which are of primary concern, so that a suitable data set exists to assess risk from ash. The pathways of concern for the embayment and the dredge cell are from direct exposure to the ash. Any decision to remove ash would be based on physical observations of the presence of ash; the expected residual soil concentrations would be similar to background. A suitable background data set exists for soil. Because of the location of the ash spill in an area of upward gradients, and based on historical data of ash in contact with groundwater, a suitable data set exists for evaluating potential groundwater contamination. Therefore, sufficient data exist to move forward with a decision on the embayment and the dredge cell.

The screening level human health and ecological risk assessments concluded that the ash is a potential future risk to humans or to the environment if left uncontrolled. Because the EPA's Order requires removal of ash, restoration of the embayment, and closure of the dredge cell, a decision to take action in the embayment is required, so that a BERA is not warranted. The decision on the type of removal action needed will be a balance of engineering effectiveness, implementability, cost, regulatory requirements, and public input.

Therefore, the path forward for the decision on the embayment and dredge cell is to proceed with developing a range of alternatives and selecting the remedy. The human health baseline risk assessment will be completed with existing data using the method discussed in Section 5. The screening level ecological risk assessment will be the end of the ecological risk work, since no BERA is warranted. These efforts will be documented in an EE/CA for the embayment and dredge cell, scheduled for late in the calendar year of 2009. This schedule will meet the objective of completing the decision in time to support field construction no later than the completion of the time-critical actions (spring of 2010).

However, the decision on the residual ash in the river will depend significantly on balancing future ecological and human health risk with feasibility of retrieving the ash. The residual ash is any ash remaining after implementation of removal actions that use best available technology for retrieving the ash. The site will be restored consistent with the EPA Administrative Order and TDEC Commissioner's Order. As noted in the screening level risk assessments, there are significant uncertainties remaining for the river systems. The human health risk from ingesting fish needs to be defined. The screening level ecological risk assessment indicates a potential risk but that risk needs to be better defined. A lower risk may result in a no action decision so better definition of the ecological risk is needed.

Therefore, the path forward for the river is to develop a detailed sampling and analysis plan. Data Quality Objectives need to be established to identify data needs and to guide the development of a sampling and analysis plan for the river. Data collection may include fish for whole body analysis of metals, sediment and ash for additional toxicity tests, sediment samples for chemical characterization, benthic invertebrate community surveys for recolonization data, lower trophic level tissue analysis for modeling dietary exposures to upper trophic levels, evaluation of site-specific bioavailability of metals from the ash, and a comparative evaluation of ash-related risks and risks associated with pre-existing sediments. Although ash-related physical effects will be addressed under the Natural Resource Damage Assessment, future sampling should consider whether physical impacts of the ash can be studied at the same time as chemical impacts, to save cost or time. Future sampling should consider analysis for the constituents associated with legacy contamination (such as mercury, PAHs, PCBs, chlordane, or radionuclides). Such data needs should be established during the DQO session. The groundwater pathway will be further evaluated for human health and ecological risk assessments. Additional wells may be installed to supplement the existing network and sampled for (1) confirming vertical and horizontal gradients; (2) estimating horizontal conductivity, velocity, and flow rates; and (3) conducting qualitative fate and transport evaluations to estimate order-of-magnitude mass contaminant loading to the Emory River. Future sampling may include analysis for radionuclides.

The sampling and analysis plan will consider the intended uses of the data and the adequacy of data already being collected. These data will be used to refine the characterization of potential human health and ecological risks. Once the data are available, the baseline human health and ecological risk assessments can be completed as part of the EE/CA. Risks associated with legacy contamination from past releases from the DOE site or other upstream sources will be summarized from publicized DOE reports. Results of the risk assessments will be used in making future risk management decisions. Alternatives for the residual ash removal and disposal will be assessed in the EE/CA and one selected in the Action Memorandum.

The schedule for these activities is shown in Figure 12.

8 RANGE OF ALTERNATIVES

A range of alternatives has been developed for the embayment and dredge cell. This range will be the focus of the upcoming EE/CA. A brief overview of the alternatives is presented below. They will be further developed as the EE/CA proceeds.

1. Excavate Embayment and Dispose Offsite (2.7 million cy); Grade and Close Dredge Cell. Alternative 1 would remove the ash in the embayment (2.4 million cy) and the ash from the test embankment within the dredge cell (0.3 million cy) and dispose of this ash offsite. A dike would be installed to keep ash in the cell from entering the embayment in the future and the dredge cell would be graded for drainage. The height of the closed cell would be approximately 780-790 ft msl. The embayment would be restored to an aquatic environment.

2. Excavate Embayment and Portions of Dredge Cell and Dispose Offsite (6.3 million cy); Grade and Close Remainder of Dredge Cell. Alternative 2 would remove the ash in the embayment (2.4 million cy), the ash from the test embankment within the dredge cell (0.3 million cy), plus enough ash from the dredge cell (3.6 million cy) to limit long-term reliance on a dike between the cell and the embayment, yet would leave enough ash to provide buttressing for the remaining dikes. The removed material would be disposed offsite. The dredge cell would be graded to a gradual slope, with a maximum height of the closed cell of approximately 765-775 ft msl at its highest point. The embayment would be restored to an aquatic environment.

3. Excavate Embayment and Dispose Onsite in Dredge Cell; Close the Dredge Cell. Alternative 3 would use the dredge cell as a disposal facility. No material would be taken offsite. The ash in the embayment (2.4 million cy) would be removed and stacked in the dredge cell. Material placed in the cell for the test embankment would remain in the cell. A dike would be installed to keep ash in the cell from entering the embayment in the future and the dredge cell would be graded for drainage. The height of the closed cell would be approximately 790-800 ft msl. The embayment would be restored to an aquatic environment.

Each of these alternatives involves removing ash and restoring the embayment to pre-spill conditions. The EE/CA will provide information to satisfy the requirements for a Jurisdictional Assessment. Aerial photographs and maps will be used to show pre-spill jurisdictional wetlands, post-spill conditions, and what the areas will look like after the non-time-critical removal action is completed. The EE/CA will discuss the areas, habitat, and species impacted by the fly ash release and the type of restoration planned for the embayments and sloughs once the ash has been removed. Details of the restoration component may include revegetation with selected species, habitat creation, channel slopes, and other features.

In developing these alternatives, several options were considered, but not retained for further consideration. These options that were rejected included the following:

- Leaving the ash within the embayment and covering it in-place was considered. This would minimize further hauling of recovered ash from the site to reduce impacts to public safety. The former embayment would be restored to a different use, such as a potential future recreational park or ballfield. However, this option would clearly violate the terms of both the TDEC Commissioner's Order and the EPA Administrative Order. The TDEC Commissioner's Order requires "restoration of all natural resources damaged as a result of the coal ash release". The EPA Administrative Order requires action to "remove coal ash from the embayments and tributaries west of Dike 2, to the maximum extent practicable, … [and] restore area waters impacted by the coal ash release." Because this option would not remove all ash to the maximum extent practicable nor restore all natural resources or area waters, it was rejected.

- Excavating the ash from the embayment, placing a liner on the native ground surface, and replacing the ash back into the embayment was considered. This would minimize hauling of recovered ash from the site and minimize ash placement back in the dredge cell. Whereas this option would remove ash to the maximum extent practicable, it would not restore the natural resources and area waters impacted by the coal ash release. It would involve double-handling of large volumes of ash, and require a large interim storage area for the excavated ash. This alternative would violate substantive requirements of TDEC solid waste regulatrions in that waste materials would be placed within waters of the state, within the 100-year floodplain. Placement of a liner on the bottom of the embayment would be impractical because it would be below lake level and because there are numerous springs that feed the embayment from the surrounding hillsides. Effectiveness of a liner would be limited because ash would remain below water level. For these reasons, this option was rejected.

- Excavating the ash from the embayment, then filling the embayment back up with clean fill dirt was also considered. Doing so would allow the embayment area to be used for recreation, such as a ballfield or community park. Whereas this option would removal ash to the maximum extent practicable, it would not restore the natural resources and area waters impacted by the coal ash release. The option would also double the volume of material hauled away from and back to the site over public roads or railways. This alternative would violate potential ARARs in that fill materials would be placed within waters of the state, within the 100-year floodplain. For these reasons, this option was rejected.

- The use of the Ash or Stilling Ponds for potential disposal of recovered ash removed from the embayment or former dredge cell was considered. TVA is currently evaluating dry processing of fly and bottom ash, so that the ponds would not be needed in the future for ash settling. Use of the ponds for disposal of recovered ash would allow the height of ash within the former dredge cell to be further lowered, and would in turn lower the containment pressures on Dike D. The ponds area already contains ash materials extending to a depth of 30 to 40 ft, so that ash would not be placed on virgin ground. However, the timing of the planned dry processing of fly ash at KIF is such that the ponds would not be available soon enough to be able to accept ash materials removed from the embayment or dredge cell. Removal action construction for the embayment restoration is anticipated to occur between April 2010 and May 2011, whereas dry processing is not anticipated to be implemented at KIF until the end of 2011 for fly ash and 2015 for bottom ash. The ponds are not lined, nor permitted as a landfill, and are therefore not able to accept recovered ash containing hazardous constituents. For these reasons, use of the ponds for disposal was rejected.

- Excavating the ash from both the embayment and the entire dredge cell area, and disposing of the material offsite was also considered. Doing so would virtually eliminate the threat of future release of residual ash from the site. However, this would dramatically increase the volumes of materials transported offsite, with associated impacts on area traffic and residents. Over 10 million cy of ash would require transportation and disposal. Implementability would be difficult, as the shear volumes of material would overwhelm existing landfill capacity. Costs of excavation, transportation, and disposal would be twice as high as any other alternative, while the added degree of protectiveness is limited. For these reasons, this option was rejected.

A range of alternatives for the river system has not been developed. Alternatives that address any residual ash remaining in the river after completion of the time-critical removal action and areas impacted by restoration activities will be developed at a later date, after completion of additional data collection activities.

9 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

CERCLA Sect. 121 specifies that actions for cleanup of hazardous substances must comply with requirements or standards under federal or more stringent state environmental laws that are applicable or relevant and appropriate to the hazardous substances or particular circumstances at a site. On-site removal actions conducted under CERCLA are required to attain these ARARs to the extent practicable, considering the exigencies of the situation. This action is being conducted as a non-time-critical removal action. A list of ARARs is provided in Appendix C.

The terms defined below are used.

- Applicable requirements are “those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site” (40 CFR 300.5).

- Relevant and appropriate requirements are “those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site” (40 CFR 300.5).

– In the absence of federal or state-promulgated regulations, there are many criteria, advisories, guidance values, and proposed standards that are not legally binding but can serve as useful guidance for setting protective cleanup levels. These are not potential ARARs but are "to-be-considered" (TBC) guidance [40 CFR 300.400(g)(3)].

CERCLA onsite response actions must comply with only the substantive requirements of a regulation to obtain federal, state, or local permits [CERCLA Sect. 121(e)]. To ensure that CERCLA response actions proceed as rapidly as possible, EPA has reaffirmed this position in the final National Oil and Hazardous Substances Pollution Contingency Plan (NCP) [Title 55, Federal Register (FR), Part 8756, March 8, 1990. Substantive requirements pertain directly to the actions or conditions at a site, while administrative requirements facilitate their implementation.

"Chemical-specific requirements set health or risk-based concentration limits or discharge limitations in various environmental media for specific hazardous substances, pollutants, or contaminants" (55 FR 8741, March 8, 1990). These requirements generally set protective cleanup levels for the contaminants of concern in the designated media or otherwise indicate a safe level of discharge that may be incorporated when considering a specific remedial activity. The anticipated chemical-specific ARARs identified include drinking water standards and the applicable surface water quality standards for the river's designated use.

Location-specific requirements establish restrictions on permissible concentrations of hazardous substances or establish requirements for how activities will be conducted because they are in special locations (wetlands, floodplains). Those location-specific requirements for this action are associated primarily with wetlands and floodplains.

Action-specific ARARs include operation, performance, and design requirements or limitations based on the waste types, media, and response actions.

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APPENDIX A

Ecological Conceptual Site Model

Appendix A
Ecological Conceptual Site Model

The ecological conceptual site model (CSM) provides a framework for identifying potential sources of contaminants at the TVA Kingston Ash Release site and the chemical, physical, and biological processes that could potentially occur as a result of such contamination. This CSM represents the current understanding of potential sources at the TVA Kingston Ash Release site based on the best available information. Some of the transport and fate mechanisms, ecological receptors, and exposure pathways will likely be refined as additional site-specific data are collected and further evaluations are conducted. Primary components of the CSM (i.e., sources, release and transport mechanisms, exposure media, exposure pathways, and ecological receptors) are summarized in the following sections and depicted in Figure A-1.

A.1 SOURCES

This section divides the sources into a primary source, which is the original source of a constituents released at the site, and potential secondary and tertiary sources, which are environmental media (abiotic and biotic) that receive the constituent releases from a primary or secondary source either by direct discharge or through constituent transport and fate mechanisms. Primary, secondary, and tertiary sources are defined below and depicted in Figure A-1.

A.1.1 Primary Source

The Kingston Fossil Plant (KIF) is located on the Emory River close to the confluence of the Clinch and Tennessee rivers near Kingston, Tennessee. Plants such as KIF burn pulverized coal in order to generate energy, and in the process, produce the byproduct fly ash. Fly ash is a fine powdery material that is removed from the plant's exhaust stream by electrostatic precipitators. The collected fly ash is then sluiced in a water-based slurry to a wet ash pond for settling. The ash is then dredged from the settling pond and piped to long-term storage ponds, also known as dredge cells. The three KIF dredge cells covered approximately 84 acres and stored about 9.4 million cubic yards of fly ash as of mid-December 2008.

A.1.2 Secondary Source

After constituents are released from a primary source, they can go through a variety of chemical and physical transport and fate mechanisms. These mechanisms distribute the constituents to various environmental media where they then become secondary or tertiary sources. Potential secondary and/or tertiary sources of constituents at the TVA Kingston Ash Release site include the following environmental media:

- Air
- Groundwater
- Soil/Ash
- Terrestrial Biota
- Surface Water
- Aquatic Biota
- Seasonally Exposed Sediment
- Submerged Sediment

A.2 TRANSPORT AND FATE MECHANISMS

The distribution of constituents is based on a variety of physical, chemical, and biological transport and fate mechanisms that move the released constituents from their primary and secondary sources to other locations or media throughout the site. Constituents are most commonly transported either by means of a solution (i.e., constituents dissolved in water); attached to sediment, soil, or other particulate matter; or via biological matrices (i.e., constituents bioaccumulated in organisms). Several factors influence the transport, fate, and bioavailability of constituents, including the chemical forms and phases in which they occur in the environmental media. In addition to the constituent's chemical properties, the specific environmental conditions at the site (e.g., temperature, pH, total suspended solids, and dissolved oxygen content) also influence the fate and transport of each constituent. The transfer of constituents between phases occurs via primary, secondary, and tertiary release mechanisms described below and presented in Figure A-1.

A.2.1 Primary Release Mechanism

A primary source releases contaminants into environmental media via primary release mechanisms. Constituents released from the primary source into environmental media, which become secondary sources, are then distributed via secondary and tertiary release mechanisms. The primary source at the TVA Kingston Ash Release site is the failed KIF dredge cell. The cell released approximately 5.4 million cubic yards of ash and bottom ash, with the spilled material covering about 300 acres of adjacent parts of the Emory River, including most of Swan Pond Embayment. Potential secondary and tertiary release mechanisms specific to the TVA Kingston Ash Release site are described in the subsections below.

A.2.2 Secondary and Tertiary Release Mechanisms

Potential secondary and tertiary release mechanisms are grouped together by environmental media and are discussed below. As shown in Figure A-1, these transport and fate mechanisms generally are associated with the environmental media in which constituents are contained.

Air: Constituents suspended in the air can potentially be transported through wind dispersion or aerial deposition. Within these processes, constituents are carried various distances and eventually fall out of the air, depositing constituents onto seasonally exposed sediment, soil, or surface water via wet or dry deposition.

Groundwater: Constituent releases to groundwater typically occur through leaching and infiltration of contaminates in soil or surface water down through the soil column. However, these processes do not occur at the TVA Kingston Ash Release area due to the natural advection, or upwelling, of groundwater. The constant upwards movement and pressure of the groundwater at the site prevents the flow of constituents through the soil column, thus eliminating groundwater as a potential source of contamination for ecological receptors that may be exposed to groundwater (i.e., plant root systems or soil invertebrates).

Soil/Ash: Constituents occurring in soils or ash as soil are potentially released and transported through various mechanisms including, fugitive dust, leaching, runoff, and terrestrial uptake and ingestion. Fugitive dust is generated through wind dispersion of fine particles swept away from surface soils. These particles can be transported and further dispersed through the air, surface water, or seasonally exposed sediments. Constituents may also leach from soil through the soil column, transferring to groundwater. As previously discussed, this pathway is considered incomplete given the site-specific conditions of groundwater at the TVA Kingston Ash Release site. Constituents in soil may be transferred through runoff, moving from soil into surface water via storm water runoff. Finally, constituents in soil may be

ingested or taken up through root systems of terrestrial biota (i.e., plants and wildlife), accumulating within the tissues of these receptors.

Terrestrial and Aquatic Biota: Bioaccumulation is the primary transport mechanism of constituents from source media (including primary, secondary, and tertiary) to both terrestrial and aquatic biota. Potential routes of exposure include ingestion of, direct contact with, or inhalation of environmental media. The bioavailability, or the extent to which a constituent in a source is free for uptake, depends on the qualities of the constituent (i.e., the chemical state of the constituent), the ecological receptor consuming the biota, and the environmental conditions (i.e., salinity, temperature, pH, etc.) under which the receptor and constituent interact. Certain constituents also accumulate in different tissues within biota and are passed through the food chain and eventually released back into the environment through death and decomposition.

Surface Water: Constituents in surface water can potentially be transported through various processes, including physical, chemical, or biological avenues. Physical transport processes of constituents in surface water include the horizontal, longitudinal, and vertical movement of constituents within the water column (in-stream flow), and movement of constituents into the seasonally exposed and/or submerged sediment (deposition or infiltration). Chemical transport mechanisms include constituents dissolved within surface water forming solids due to chemical and environmental characteristics (precipitation), as well as dissolved constituents attaching to solid materials (adsorption). In addition, constituents within the water column in both dissolved and particle forms can be taken up by aquatic biota, accumulating within the tissues of these ecological receptors.

Sediment/Ash: Constituents in sediment or ash as sediment, including near-shore or seasonally exposed sediments as well as submerged sediments, can be affected by deposition, settling, and accumulation of contaminants moving from surface water. In addition, seasonally exposed sediments may accumulate the deposition of constituents that are transported through the air. Physical release mechanisms primarily influenced by in-stream flow include settling and accumulation of sediments (deposition), and the wearing down of banks and floodplain soils into the river systems (erosion). Chemical transport processes include constituents dissolving into solution (dissolution), constituents attaching or detaching to sediment particles (adsorption/desorption), and the wasting or breaking up of particles resulting in constituent releases (decrepitation/weathering). In addition, constituents may be taken up by biological receptors, which may lead to the bioaccumulation of constituents in tissues of those ecological receptors.

A.3 EXPOSURE MEDIA

Constituents are distributed to various environmental media through transport and fate processes, or release mechanisms. These mechanisms may provide exposures to both aquatic and/or terrestrial organisms. As presented in Figure A-1, the potential exposure media associated with the TVA Kingston Ash Release site include air, groundwater, soil/ash, terrestrial biota, surface water, aquatic biota, interstitial sediment water, and sediment (seasonally exposed and submerged). Constituents found within these media can occur in both dissolved and particulate phases, presenting multiple potential exposures for ecological receptors.

A.4 EXPOSURE PATHWAYS

Ecological receptors are potentially exposed to environmental media via four main pathways. These pathways include, 1) direct contact and/or uptake of environmental media such as soil, sediment, or water via dermal contact (i.e., through the skin) or through the gills or roots; 2) ingestion of environmental media; 3) inhalation of vapors or particulates from environmental media; and 4) incidental ingestion of environmental media or dietary consumption of contaminated terrestrial and/or aquatic biota.

These pathways are identified as “potentially complete,” incomplete,”, or “not applicable,” based on site-specific considerations for each exposure pathway and ecological receptor. Only “potentially complete” pathways will be fully evaluated as part of the ecological risk assessment process for the TVA Kingston Ash Release site.

A.5 ECOLOGICAL RECEPTORS

This section discusses groups of ecological receptors potentially occurring at the TVA Kingston Ash Release site that are considered to be of most importance. These receptors include species that 1) potentially occupy existing habitats at the site; 2) are instrumental to the structure and function of the site ecosystem; and 3) that are potentially exposed to constituents at the site or are otherwise toxicologically sensitive.

For this site, the potentially affected receptors include terrestrial and aquatic biota (i.e., plants, invertebrates, and wildlife). These general types of receptors will be refined and expanded to identify representative guilds and surrogate species to be further evaluated. The subsections below describe the individual ecological receptor groups potentially occurring at the site. Select groups will be identified and evaluated for the potential for exposure later in the baseline risk assessment process.

A.5.1 Plankton Communities

Plankton communities, including both phytoplankton and zooplankton, live primarily within the water column and make up the base of the primary aquatic food chain. Phytoplanktons convert the sun’s energy into organic material, and are mainly exposed to constituents occurring within the water column. Zooplankton consumes phytoplankton and other zooplankton and are also exposed to constituents occurring within the water column as well as through sediment contact and consumption of other forms of plankton. Both phytoplankton and zooplankton are an essential part of the aquatic food chain.

A.5.2 Periphyton Communities

Periphyton communities live on bottom substrates, and include organisms such as algae, bacteria, molds, and fungi. Periphyton can be producers (i.e., autotrophs) as well as decomposers, and represent an important source of food for benthic and epibenthic invertebrates. Primary exposure of periphyton communities to constituents occurs within the water column and to sediment.

A.5.3 Macrophyte Communities

Macrophytes found within the aquatic system can include both vascular and nonvascular plants. These plants can live completely within the water column (submerged), or only partially within the water column (emergent). Macrophytes provide habitat and food to other aquatic organisms and wildlife that are dependent on aquatic systems. They are most commonly exposed to constituents via uptake from surface water and sediment porewater.

A.5.4 Benthic Invertebrate Communities

Benthic macroinvertebrates live within and on top of sediment and may include aquatic insects (e.g., mayflies and midges), mussels, amphipods (e.g., scuds), and oligocheates (worms). They consume plankton (both phytoplankton and zooplankton), algae, detritous, and various macrophytes. These benthic organisms are then consumed by other macroinvertebrates, fish, and wildlife, making them a key component within the aquatic food chain. Benthic invertebrates are most often exposed to constituents found in the sediments, overlying surface water, and within the food items they consume.

A.5.5 Fish Communities

Fish communities make up a key component of aquatic food chains, playing a role in various trophic groups as planktivores, omnivores, and piscivores. Fish inhabit different areas within the aquatic system, including bottom-dwelling species as well as species occurring mainly within the water column (pelagic). Fish make up an important dietary component of piscivorous wildlife as well as humans. Bottom-dwelling fish commonly found at the site include various species of catfish and suckers, while pelagic species may include bluegill, sunfish, and bass. In general, fish are exposed to constituents found within the water column that can be taken up through their gills or consumed through their food items. In addition, bottom-dwelling fish may also be exposed via incidental ingestion of sediment while feeding.

A.5.6 Amphibians

Amphibians inhabit both aquatic and terrestrial habitats, depending on their life stage. Within their early life stages, amphibians are generally aquatic, consuming mainly plants and insects. However, as they mature, amphibians develop lungs and their diet changes to a variety of aquatic and terrestrial organisms. Amphibians provide food sources for other forms of aquatic life as well as wildlife dependent on the aquatic habitat. Exposure of amphibians to constituents within the environment changes throughout their life. In early life stages, amphibians are most commonly exposed to dissolved forms of constituents through their gills or by aqueous diffusion through egg membranes or skin. However, as amphibians mature, the majority of their exposure occurs through ingestion of contaminated food items, incidental ingestion of sediments and soil, or dermal exposure of constituents in surface water and/or sediment and soil.

A.5.7 Reptiles

Reptiles include omnivores, invertivores, herbivores, and carnivores. This group of organisms inhabits both aquatic and riparian habitats, in turn consuming a variety of plants, invertebrates, amphibians, fish, small birds, and small mammals. Throughout their lifespan, reptiles make up an important dietary component for many birds and mammals. The primary exposure of reptiles to constituents occurs through the ingestion of surface water and incidental ingestion of sediment and soil, as well as through their diet of other organisms.

A.5.8 Birds

Various avian species occur near the TVA Kingston Ash Release area. These species can be segregated into water-associated and terrestrial species, and span the trophic groups with piscivores, omnivores, invertivores, herbivores, aerial insectivores, and carnivores. Water-associated species of birds include those that are dependent on the aquatic habitat, and include species such as bald eagles, ospreys, herons, shorebirds, and various kinds of waterfowl. These species commonly consume macrophytes, invertebrates, fish, and amphibians. Terrestrial species of birds are not dependent on the aquatic habitat, including birds such as raptors, passerines (i.e., perching birds such as swallows, warblers, and sparrows), and galliformes (e.g., grouse and quail). These species primarily consume plants, invertebrates, reptiles, and small mammals. In addition, some groups of birds, such as shorebirds and swallows, use both aquatic and terrestrial habitats. Birds can be consumed by other avian species as well as mammalian carnivores. They are most commonly exposed to constituents through the ingestion of food and surface water, as well as incidental ingestion of sediment and soil.

A.5.9 Mammals

Mammals inhabiting the TVA Kingston Ash Release site include those that live within terrestrial and riparian areas of the site. Terrestrial receptors, including species such as mice, deer, coyotes, and livestock consume mainly terrestrial plants and invertebrates, amphibians, reptiles, birds, or other mammals. Mammals that are more dependent on the aquatic habitat and exist in both habitats include species such as raccoons and mink. These species consume aquatic and terrestrial plants, invertebrates, amphibians, reptiles, birds, fish, and other mammals. Mammals are primarily consumed by reptiles, birds, or other mammalian predator species. Mammals can occur within various trophic groups, and include piscivores, omnivores, herbivores, aerial insectivores (i.e., bats), and carnivores. Mammals are most commonly exposed to constituents through the ingestion of food and surface water, but can also be exposed via incidental ingestion of sediment and soil.

A.5.10 Soil Invertebrates

Soil invertebrates, including microinvertebrates, macroinvertebrates, and various other insects, live within the soils of riparian and upland areas at the TVA Kingston Ash Release site. These organisms consume plants, and are then consumed by other invertebrates, reptiles, amphibians, birds, and mammals, making them an integral part of the terrestrial food chain. Soil invertebrates are generally exposed to constituents through soil ingestion and consumption of plants.

A.5.11 Terrestrial Plant Communities

Terrestrial plants are primary producers occurring in upland habitats. They include a variety of species such as mosses, grasses, forbs (i.e., broad-leafed herbs and grasses), shrubs, and trees. Plants provide a food source for a variety of herbivorous and detritivorous receptors and also give cover and habitat for terrestrial and aquatic-dependent species. Dominant plant communities at the TVA Kingston site include a variety of wetland species such as sycamore, willow, boxelder, and alder. In addition, there are stands of oak-hickory forests mixed with landscaped lawns. The most common pathway of constituent exposure for plants includes uptake of constituents that are dissolved within the groundwater, surface water, or porewater, through the root system into the plant. Foliar uptake can also be important for some constituents.

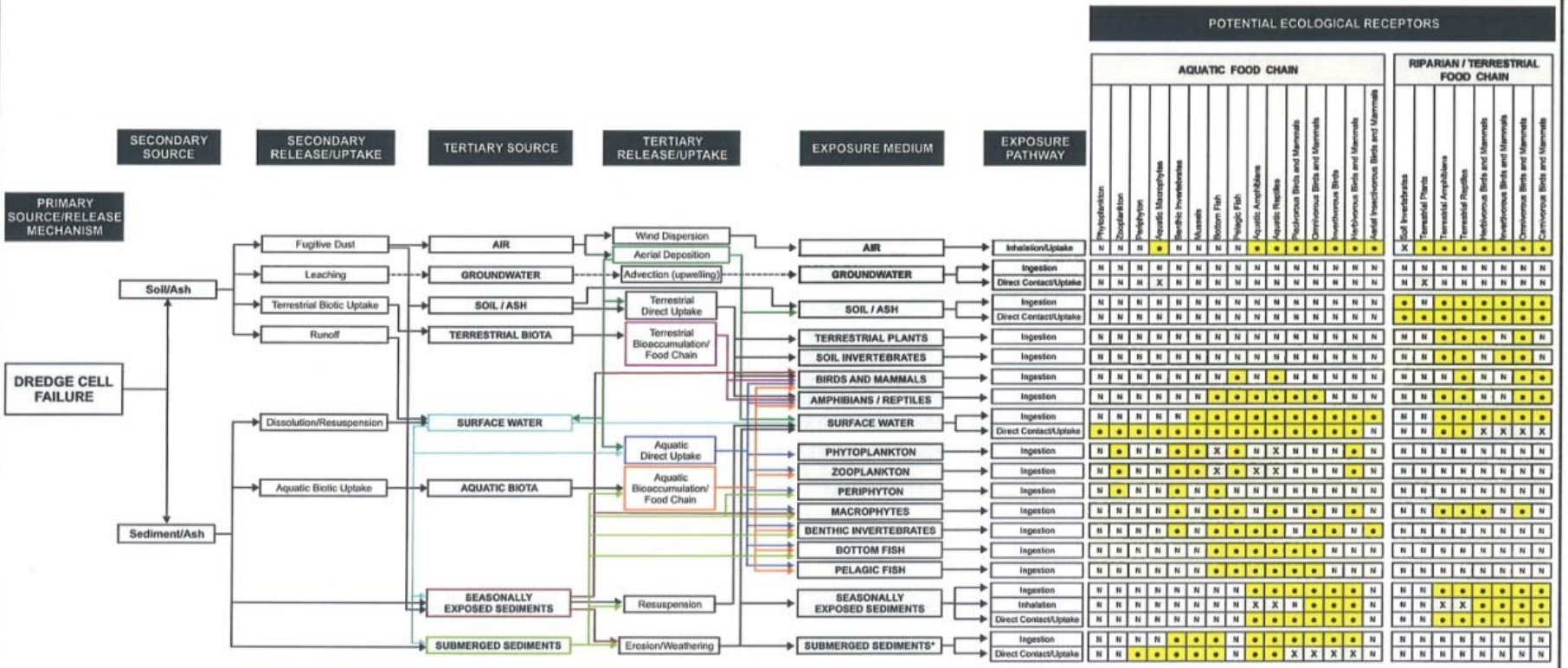


Figure A-1. Conceptual Site Model for Ecological Risk Assessment

TVA KINGSTON FLY ASH RECOVERY PROJECT
KINGSTON, TENNESSEE

APPENDIX B

Screening-Level Ecological Risk Assessment

Appendix B
Screening-Level Ecological Risk Assessment

This appendix presents the screening-level ecological risk assessment (SLERA) for the Tennessee Valley Authority (TVA) Ash Response Engineering Evaluation/Cost Analysis (EE/CA) for Non-Time Critical Removal Actions. The objective of the SLERA is to evaluate potential risks to terrestrial and aquatic ecological receptors from exposure to constituents in ambient media. The SLERA has been completed for use in making risk management decisions on the path forward for the site following completion of the time-critical removal action, as discussed in Section 7. Specifically, the scope of this SLERA includes the failed dredge cell, the embayment west of Dike 2, and the associated river system (i.e., the Emory River, the Clinch River, and the Tennessee River). Results of the SLERA are presented in this appendix.

In accordance with U.S. Environmental Protection Agency (EPA) guidance, an ecological risk assessment (ERA) is comprised of a SLERA and, if necessary, a baseline ERA (BERA) (EPA 1997c). Figure 9 provides an overview of the ecological risk approach that encompasses the EPA eight-step ERA process (EPA 1997c). An expanded view of the components of each step is provided on Figure 10 (EPA, 1999c; 2000b). The SLERA provides a conservative estimate of potential ecological risks and compensates for uncertainty by incorporating numerous conservative assumptions. The purpose of a SLERA is to determine whether there is a high probability that there are no ecologically significant risks (EPA 2000b; 1997c); otherwise, a BERA is warranted, except where early actions will reduce potential ecological risks to acceptable levels. If need for a BERA is indicated, the information developed in the SLERA is used to help focus the BERA. The BERA is more complex than the SLERA and uses more realistic and site-specific information about potential exposures and effects in order to evaluate potential ecological risks.

The ERA guidance (EPA 1997c) includes clearly identified points in the process for stakeholder communication and decision-making, consistent with EPA guidelines (EPA 1998; 1999c; 2000b). These scientific management decision points (SMDPs) allow for collaborative decision-making that results in the efficient use of time and resources. These decisions must then be captured in subsequent decision-making documents and actions. Generally, the following types of decisions are considered at the SMDPs:

- Whether no further action is appropriate based on concerns for wildlife,
- Whether further ERA is warranted, and
- Whether remedial actions can be implemented to reduce or prevent risks to wildlife.

In this assessment, the SLERA evaluates the potential risks to terrestrial and aquatic ecological receptors exposed to detected constituents in ash and surface water in the vicinity of the site. The ash that will remain in the area west of Dike 2 at the conclusion of the time-critical removal action is primarily considered a potential risk to terrestrial ecological receptors; however, this assessment will also assess potential risks to aquatic and sediment-associated biota. To be conservative, the SLERA evaluates potential exposures to ash in this area as if it were soil (ash as soil) and as if it were sediment (ash as sediment). The ash that will remain in the rivers at the conclusion of the time-critical removal action is primarily considered a potential risk to aquatic ecological receptors. To be conservative, the SLERA evaluates potential exposures to ash in these areas as if it were sediment (ash as sediment). The SLERA also evaluates potential exposures to constituents in surface water, for which the Emory River data represents the most robust data set and conservative exposure assumptions. At the time of the assessment, surface water samples from west of Dike 2 that are representative of potential current and near-term aquatic exposures had not yet been validated. This data gap is addressed as an uncertainty in this SLERA. In addition, potential ecological risks associated with groundwater releases to surface water will be evaluated as part of the BERA for the river system.

The SMDP that follows the SLERA addresses the failed dredge cell and ash-filled embayment (i.e., terrestrial exposure pathways) separately from the area east of Dike 2 and in the river system (i.e., riparian and aquatic exposure pathways). Where a BERA is deemed necessary, that evaluation will be presented in future reports, as discussed in Section 7.

A SLERA evaluates the potential risk to ecological receptors exposed to site-related constituents. The SLERA conducted for the TVA Kingston Ash Release consists of the first two steps of the eight-step approach illustrated on Figures 9 and 10. The remainder of this appendix discusses those steps for terrestrial and aquatic receptors, and the resultant SMDP, as follows:

- Section B.1 – Step 1: Screening-Level Problem Formulation and Ecological Effects Evaluation
- Section B.2 – Step 2: Screening-Level Exposure Estimate and Risk Calculation
- Section B.3 – SMDP and Reporting

B.1 STEP 1: SCREENING-LEVEL PROBLEM FORMULATION AND ECOLOGICAL EFFECTS CHARACTERIZATION

The screening-level problem formulation serves to define the reasons for the SLERA and to define the methods for analyzing/characterizing risks (EPA 1998; 1997c). The background information on site characterization, receptors, and ecosystem characteristics is vital to the problem formulation, as is information on the sources and effects of the stressors (EPA 1998).

B.1.1 Screening-Level Problem Formulation

The screening-level problem formulation provides information used to establish the overall goals of an ERA (EPA 1999c; 1998). In addition, once these are established, the problem formulation is used to develop a conceptual site model (CSM) for the ERA. The specific goal of this effort is a conservative evaluation of the likelihood for adverse effects (and the ecological significance of predicted adverse effects) to wildlife that may be exposed to site-related constituents.

The screening-level problem formulation encompasses a variety of topics for areas where ecological exposures are likely to occur, and remedial actions to eliminate exposure pathways are not yet selected. Problem formulation produces three outputs: (1) assessment endpoints that adequately reflect management goals and the ecosystem the goals are meant to protect, (2) a CSM that describes the relationships between stressors and the assessment endpoints, and (3) a plan for analyzing the potential risks to the assessment endpoints (EPA 1998; 2000b).

The remainder of this section provides an overview of the following components that comprise the screening-level problem formulation for the sites.

- Characterization of Environmental Setting,
- Identification of Constituents Detected in Relevant Media,
- Description of Constituent Fate and Transport Pathways,
- Description of Constituent Mechanisms of Ecotoxicity,
- Description of Potentially Affected Receptors,
- Identification of Potentially Complete Exposure Pathways and Conceptual Site Model, and
- Identification of Generic Assessment and Measurement Endpoints.

Characterization of Environmental Setting. The TVA Kingston Ash Release occurred at the Kingston Fossil Plant (KIF), which is located in the Tennessee River Valley near the confluence of the Emory and

Clinch Rivers. The river valley is bounded on the northwest and southeast by ridges reflective of the Valley and Ridge Physiographic Province, and is impounded by Watts Bar Dam.

On Monday, December 22, 2008, a dike containing the KIF dredge cells failed, releasing about 5.4 million cubic yards of ash and bottom ash. The spilled material now covers about 300 acres of adjacent parts of the Emory River, including most of Swan Pond Embayment, and reservoir shorelands. The remainder of this section describes the terrestrial and aquatic habitat included in the evaluation of the Kingston Ash Release.

Terrestrial Habitat. Dominant plant communities at the TVA Kingston Ash Release site included a variety of wetland species found along the outer base of the dikes. A band of riparian trees and shrubs, including sycamore, willow, boxelder, and alder occurred along much of the outer edge adjacent to the reservoir. Similar bottomland hardwoods and riparian vegetation occurred along other parts of the shoreline of Swan Pond Creek embayment and on the islands in the embayment. Other affected areas of the reservoir shoreline included landscaped areas, farms, suburban lawns, bottomland hardwoods, and upland hardwoods.

The vegetation at the Kingston Ash Release site appeared to support a diversity of wildlife and livestock, including shorebirds and waterfowl, amphibians, reptiles, and small mammals. Swan Pond Creek embayment and the adjacent Emory River were heavily used by Canada geese, wood ducks, great blue and green herons, great egrets, belted kingfishers, and double-crested cormorants. A variety of songbirds, semi-aquatic mammals, turtles, and water snakes were also abundant in the riparian vegetation along the shoreline of these rivers. Ospreys are common in the area, often nesting on natural and man-made structures on and around the site. Heron colonies also occur near the fossil plant; the closest being approximately 0.3 mile upstream of the release. A second colony including great blue herons and double-crested cormorants occurs just downstream of the junction of the Emory and Clinch rivers.

Aquatic Habitat. The TVA Kingston Ash Release site is 2.6 river miles above the confluence of the Clinch and Tennessee Rivers at TRM 567.7 on the Emory River. The Emory River drains a watershed area of approximately 865 mi^2 with average flow rates between 700 and 1300 cubic feet per second (cfs). The reach of Watts Bar Reservoir at the Kingston facility transitions from the upstream riverine (riverlike) reaches of the Emory River and the Clinch River to the more lacustrine (lakelike) conditions found in the impounded portions of the Clinch and Emory rivers backwaters of Watts Bar Reservoir. Overbank areas near the Kingston facility in the Swan Pond embayment are very shallow. The Emory River embayment enters Watts Bar Reservoir at the Clinch River about 2 river miles upstream of the Kingston facility condensing cooling water (CCW) discharge. The reservoir pool extends upstream to above Harriman at ERM 11.

The river system at the Kingston Ash Release site supported a diversity of aquatic biota, including various species of plankton and zooplankton, macrophytes, benthic invertebrates (i.e., insects, clams, and mussels), amphibians, reptiles, and bottom and pelagic fish species. A mixture of mussel species potentially present in the rivers include, ebony shell, washboard, threeridge, southern mapleleaf, mapleleaf, and Wabash pigtoe. While the rivers have a relatively low diversity of fish species, the four main functional feeding groups (i.e., planktivores, detritivores, omnivores, and piscivores) are present, including various types of bass (i.e., smallmouth, largemouth, spotted, striped, and black), white and black crappie, catfish (i.e., channel, blue, and flathead), bluegill, carp, sunfish, carp, and suckers.

Wetlands in the vicinity of the site were typically associated with shoreline margins, in floodplains of tributary streams, small islands, and at the 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 and three small island wetlands in this area.

Above the mouth of the Emory, there was one small forested, island wetland. Between the mouth of Swan Pond reek embayment and Swan Pond Circle Road, there were narrow fringe wetlands along the shoreline, and wetlands occur in narrow patches along the margins of the southernmost ash cells.

The dredge cell failure released ash into the Swan Pond Embayment and into the Emory River, completely covering the aquatic habitat in this portion of Watts Bar Reservoir. Recent aerial photographs show that the ash slide eliminated wetlands (including three small island wetlands) in the spill area. The ash spill also affected wetlands in the ash pond area.

Identification of Constituents Detected in Relevant Media. Ash as soil, ash as sediment, and surface water are the environmental media associated with the TVA Kingston Ash Release EE/CA with which direct contact by ecological receptors is possible. . In addition, potential ecological risks associated with groundwater releases to surface water will be evaluated as part of the BERA for the river system.

Description of Constituent Fate and Transport Pathways. Knowledge about the potential constituent fate and transport pathways is vital to understanding which constituents and receptors are associated with complete exposure pathways. This is because a constituent may reach an ecological receptor in a variety of ways. In addition, the pathway and route of exposure may have a strong influence on the ecological effect of a constituent. This information is used in the development of a CSM. Constituent fate and transport pathways for the TVA Kingston Ash Release (i.e., constituents dissolved in water) are illustrated in the screening level CSM (Figure 11). A more detailed CSM, with site-specific fate and transport pathways, is presented and discussed in Appendix A.

Description of Constituent Mechanisms of Ecotoxicity. The mechanisms of ecotoxicity for constituents vary depending on a wide range of factors, such as constituent concentrations, the receptor species exposed, the exposure route (e.g., ingestion or direct contact), and physical factors (e.g., soil pH, temperature, moisture content). Some of the effects that could be observed in wildlife are mortality, reduced reproductive ability, decreased fertility, decreased offspring survival, alteration of immune and behavioral function, decreased hatching success of eggs/larvae, and retarded growth (Sample et al. 1996; EPA 2001a). Described below are the mechanisms of ecotoxicity for several of the inorganic constituents of ash detected at the TVA Kingston ash release. These descriptions of constituent mechanisms of toxicity are presented without consideration of constituent concentrations, as the descriptions are intended to convey an understanding of possible effects, rather than to describe the concentrations at which these effects might occur.

Trace metals (such as chromium, copper, lead, mercury, and zinc) are relatively well understood with respect to their potential adverse impacts on plants and wildlife (Newman, 1998). Chromium, copper, and zinc are among the trace metals that are essential for healthy enzyme function, and some organisms cannot survive without these metals. However, these and other naturally occurring constituents may cause adverse effects when exposure occurs at concentrations that significantly exceed background concentrations. The toxicity and effects of trace metals may be greatly influenced by biotic and abiotic factors, including pH, organic carbon content, and the presence of sulfides in sediments of the matrix in which they occur (Leland and Kuwabara, 1985). These factors affect the nature of the inorganic and organic complexes formed by the metal and its bioavailability. For conservative purposes, metal bioavailability in the SLERA is assumed to be 100 percent for constituents of potential ecological concern (COPECs) identified at the site.

Imbalances in the essential trace metals may cause a decrease in photosynthetic ability, poor spawning/hatching success, teratogenesis, susceptibility to predation and disease, reduced growth, mortality, histopathological changes, organ dysfunction of the liver or kidneys, neurological defects, changes in respiration and osmoregulation, and anemia. Trophic transfer is a pathway of concern for

some metals, notably selenium and mercury, which are known to bioaccumulate to varying degrees in the environment. Because these constituents are naturally occurring, many organisms have a limited capacity to biotransform and/or eliminate naturally occurring inorganics (Leland and Kuwabara, 1985; Newman, 1998).

Description of Potentially Affected Receptors. The identification of the categories of receptors potentially affected at the site is integral to the development of the CSM. The categories of receptors are intentionally generic at this stage of the assessment process. For this site the potentially affected receptors include herbivorous mammals, omnivorous mammals, carnivorous mammals, piscivorous mammals, herbivorous birds, omnivorous birds, carnivorous birds, piscivorous birds, soil invertebrates, herbaceous plants, woody plants, rooted macrophytes, benthic invertebrates, bottom fish, and pelagic fish. Where a BERA is warranted, these general types of receptors will be refined and expanded to identify representative guilds and surrogate species to be further evaluated.

This stage of the screening-level problem formulation typically involves the identification of threatened and endangered species potentially exposed at the site. There are several plants, invertebrates, amphibians, reptiles, fish and birds listed as species of conservation concern in Roane County, as evaluated by the TVA Regional Natural Heritage Program. This list, which is presented on Table 14, consists of 38 plants, 11 invertebrates, three amphibians, one reptile, five fish, five birds, and two mammals, which includes all rare, threatened or endangered species known or expected to occur in the habitat present at the site. Where a BERA is warranted, this list of species of concern will be used to inform the process of selecting the representative guilds and surrogate species to be further evaluated. However, the assessment and protection of individuals of any species is outside the scope and intent of the ERA process for CERCLA sites.

Identification of Potentially Complete Exposure Pathways and Conceptual Site Model. A complete exposure pathway is "one in which the constituent can be traced or expected to travel from the source to a receptor that can be affected by the chemicals" (EPA 2001b). Therefore, a constituent, its migration from the source, a receptor, and the mechanisms of toxicity of that constituent must be demonstrated before a complete exposure pathway can be identified. The components of an exposure pathway have already been discussed. The table below summarizes the possible exposure routes for the two general types of terrestrial and aquatic receptors (EPA, 1999c).

Organism	Possible Exposure Routes
Terrestrial animals	Ingestion, inhalation, dermal contact, food chain
Soil invertebrates	Ingestion, inhalation, dermal contact
Terrestrial plants	Direct contact, leaf absorption of fugitive dust, leaf absorption of constituents in dust deposited on leaves, root uptake of groundwater, surface water, or porewater
Aquatic animals	Dermal or gill absorption, ingestion, food chain
Benthic invertebrates	Ingestion, inhalation, dermal contact
Aquatic plants	Direct contact, leaf absorption of fugitive dust, leaf absorption of constituents in dust deposited on leaves , root uptake of groundwater, surface water, or porewater

Although inhalation is listed as a possible exposure route, under most exposure conditions inhalation pathways do not represent a significant contribution to receptor risk (EPA 2005), and are not evaluated quantitatively under most circumstances. Given that fugitive dust is a release mechanism of particular

interest at the site, inhalation will be qualitatively evaluated if a BERA is warranted for areas with exposed ash. In addition, while the dermal exposure route is listed as a possible exposure route, under most exposure conditions dermal pathways do not represent a significant contribution to receptor risk. Feathers of birds, fur on mammals, and scales on reptiles are thought to reduce dermal exposure by limiting the contact of the skin surface with the contaminated media (EPA, 2005b).

A CSM of potentially complete pathways was developed for the TVA Kingston ash release site. The CSM includes a graphical illustration of the potentially complete exposure pathways (Figure 11). It integrates the potential sources of concern, the media in which they are present, the exposure routes by which they interact with ecological receptors, and the various types of potentially exposed ecological receptors. The receptors depicted in the CSM are representative of potential receptor categories (e.g., trophic levels and feeding guilds) and are presented only for visual aid; the receptors in the CSM are not necessarily the specific species that will be included in the ERA should one become necessary. It serves as a predictive model to link the constituents and the receptors. The CSM helps to identify uncertainties and key assumptions about the site and is patterned after the EPA guidance on building appropriate CSMs (EPA 1999c; 1998).

Identification of Generic Assessment and Measurement Endpoints. Assessment endpoints are the explicit expression of the ecological values to be protected (EPA 1999c). The selection of assessment endpoints depends on knowledge of the receiving environment, knowledge about the constituents released (including ecotoxicological properties and concentrations that cause adverse impacts), and understanding of the values that will drive risk management decision-making (Suter, et al., 1995).

The EPA (1997c) guidance states "For the SLERA, assessment endpoints are any adverse effects on ecological receptors, where receptors are plant and animal populations and communities, habitats, and sensitive environments. Many of the screening ecotoxicity values are based on generic assessment endpoints (e.g., protection of aquatic communities from changes in structure or function) and are assumed to be widely applicable to sites around the United States". However, the identification of assessment endpoints is limited by the availability of ecotoxicity screening values for all media.

Since direct measurement of assessment endpoints is often difficult (or impossible), surrogate endpoints (called measurement endpoints) are used to provide the information necessary to evaluate whether the values associated with the assessment endpoint are being protected. A measurement endpoint is a measurable ecological characteristic and/or response to a stressor (EPA 1998). Measurement endpoints are also referred to as measures of potential effect (EPA 1998). For the SLERA, the measurement endpoints for assessing effects are the constituent screening toxicity values.

B.1.2 Screening-Level Ecological Effects Characterization (Screening Ecotoxicity Values)

The screening-level ecological effects characterization involves the identification of screening ecotoxicity values that are used for the medium of concern at the sites. Screening ecotoxicity values are constituent concentrations in environmental media below which there is negligible risk to receptors exposed to those media (EPA 2000b).

The following sources of screening values have been identified for use in the screening-level ecological effects characterization for this site:

- Soil: EPA Ecological Soil Screening Levels (EcoSSLs) (EPA, 2008c; http://www.epa.gov/ecotox/ecossl/) and EPA Region 4 Ecological Soil Screening Values (ESVs) (EPA, 2001c).
- Sediment: EPA Region 4 Ecological Sediment Screening Values (EPA, 2001c); and

- Surface Water: National Recommended Water Quality Criteria (EPA, 2006) and EPA Region 4 Ecological Surface Water Screening Values (EPA, 2001c).

These screening values are presented in Tables 15 (soil), 16 (sediment), and 17 (surface water) for the constituents evaluated at the site. Ambient water quality criteria for hardness-dependant metals were adjusted to account for the relatively low hardness of water in the Emory River.

B.2 STEP 2: SCREENING-LEVEL EXPOSURE ESTIMATE AND RISK CALCULATION

This step of the SLERA is comprised of the estimation of ecological exposures, risk estimation, risk characterization, and the evaluation of uncertainties (EPA 1999c; 2001a). These form the foundation of evidence to support the scientific management decision point.

B.2.1 Estimation of Screening-Level Exposures

The exposure concentrations used in the SLERA are the maximum detected concentrations (EPA 2000b; 2001d). For conservative purposes, data collected for risk assessment purposes from the initial time of release up until May 31, 2009 have been used to generate maximum concentrations for ash as surface soil, ash as sediment, and surface water. These data are expected to be a conservative representation of the conditions that will exist following completion of the time-critical removal action, because there has been no evidence of temporal trend in surface water and the constituent concentrations in ash will not increase over time. Regardless of the potential movement of ash within the river system, the maximum measured concentrations are expected to be the appropriate screening-level exposure concentrations over current and near-future time scales. The ash data have been pooled into a single data set to identify the maximum concentration for both soil and sediment. Surface water habitats have been broken into river systems to present a more representative evaluation for each body of water. The evaluations include the Emory River, the Clinch River, and the Tennessee River.

B.2.2 Screening-Level Risk Calculations

To estimate risk in the SLERA, hazard quotients (HQs) were calculated for each medium. An HQ is the unitless ratio of a constituent concentration in media to the screening ecotoxicity value for that constituent in that medium considered protective of wildlife. As indicated previously, maximum constituent concentrations and conservative screening ecotoxicity values for ash as soil, ash as sediment, and surface water were used for the SLERA calculations. HQs equal to or less than a value of 1 (reported using one significant digit) indicate that adverse impacts to wildlife are unlikely (EPA, 2000b; 2001d). Background concentrations were also considered within the screening process for comparative purposes only, as described in Section 5 for surface water and sediment. Constituents detected below their corresponding background concentration were not screened out, since background screening does not occur until later in the BERA process. HQs exceeding a value of 1 indicate that further assessment may be necessary to evaluate the potential for adverse impacts to wildlife. Therefore, the constituents with HQs greater than 1 are identified as COPECs and, where a BERA is deemed necessary, carried forward further evaluation at a later time. In addition, constituents commonly associated with fly ash will be carried forward regardless of the SLERA HQ screening results, including: arsenic, chromium, copper, lead, mercury, nickel, selenium, thallium, vanadium, and zinc.

The lack of screening ecotoxicity values for some constituents is one of the main contributors to uncertainty associated with the SLERA evaluation. HQs cannot be calculated for constituents that lack screening ecotoxicity values. Therefore, a constituent that lacks a screening value will be identified as a COPEC and carried forward to the BERA.

The occurrence of constituents detected in each medium are presented in Tables 18 through 22, along with the total number of collected samples, the frequency of detection, the range of method detection limits, the range of detected concentrations for each constituent detected, and the mean for each detected constituent. In the SLERA, the exposure point concentrations (EPCs) for each constituent are set equal to the maximum detected concentration. These tables also include maximum HQs.

The occurrence of constituents detected in ash as soil is summarized on Table 18. Sixteen inorganics were detected with maximum concentrations above their corresponding ESVs (i.e., an HQ greater than 1) and four constituents were identified as essential nutrients.

The occurrence of constituents detected in ash as sediment is summarized on Table 19. Five inorganics were detected with maximum concentrations above their corresponding ESVs and 15 constituents did not have an ESV available, including 4 essential nutrients.

The occurrence of constituents detected in surface water for the Emory River, the Clinch River, and the Tennessee River is each summarized on Tables 20 through 22, respectively.

- Emory River: As shown on Table 20, nine inorganics were detected with maximum concentrations above their corresponding ESVs (i.e., an HQ greater than 1); however, of those only eight constituents had dissolved phase concentrations greater than the ESV. An additional 14 constituents did not have an ESV, including 4 essential nutrients. In addition, three constituents were identified as COIs and were also carried forward as COPECs.

- Clinch River: As shown on Table 21, eight inorganics were detected with maximum concentrations above their corresponding ESVs; however, of those only seven constituents exceed in the dissolved phase. An additional 14 constituents did not have an ESV, including 4 essential nutrients. In addition, four constituents were identified as COIs and were also carried forward as COPECs.

- Tennessee River: As shown on Table 22, three inorganics were detected with maximum concentrations above their corresponding ESVs and seven constituents did not have an ESV, including 4 essential nutrients. In addition, eight constituents were identified as COIs and were also carried forward as COPECs.

COPECs for ash as soil, ash as sediment, and surface water are presented in Table 23.

B.2.3 Evaluation of Uncertainties

Uncertainty is "the imperfect knowledge concerning the present or future state of the system under consideration; a component of risk resulting from imperfect knowledge of the degree of hazard or of its spatial and temporal distribution," (EPA, 1997c). Uncertainties that may lead to either an overestimate or underestimate of risk are associated with each stage of risk assessment. Uncertainty is inherent to ERA, in part, because the sciences of ecology and ecotoxicology are relatively young and not yet fully developed (Kapustka and Landis, 1998; Newman, 1998; Emlen and Springman, 2007; Kapustka, 2008; Suter, 2008). Uncertainty also exists in many aspects of the toxicology relied upon for conducting ERAs (Newman, 1998; Lovett Doust, et al., 1993; Dale, et al., 2008). The types of uncertainties that may exist in an ERA are discussed in greater detail in Table 24.

B.3 SMDP AND REPORTING CONCLUSIONS

This first SMDP is purposefully flexible (per the EPA paradigm) to occur after Steps 2 or 3a, depending on the results obtained at Step 2. The purpose of the flexibility of the first SMDP is so that additional

evaluation of risks can occur and reporting can be streamlined into a single report, where warranted. While the final results of the SLERA will not be presented until the EE/CA, the preliminary results of the SLERA are expressed in terms of the following conclusions or recommended actions:

- There is adequate information to conclude that ecological risks are negligible and therefore no need for remediation on the basis of ecological risk;
- The information is not adequate to make a decision at this point, and the ecological risk assessment process will continue to Step 3; or
- The information indicates a potential for adverse ecological effects, and a more thorough assessment is warranted.

B.3.1 Terrestrial Environment

As described above, and summarized in Table 23, the SLERA for terrestrial exposures at the TVA Kingston Ash Release indicates the following:

- Ash as soil: Sixteen inorganic constituents in ash as soil were selected as COPECs because maximum concentrations exceeded an HQ of 1, or an ESV was not available.

Based on the available evidence, the possibility of adverse ecological risks for ecological receptors potentially exposed to ash as soil cannot be excluded. However, the viable remedial action alternatives for the Dredge Cell and Embayment entail the complete excavation of ash or capping with clean soil (Section 7). Given that viable remedies for this area of the site would eliminate the potential exposure pathways for terrestrial ecological receptors, a BERA is not warranted for the terrestrial environment and no additional data are needed to support the selection of a remedial action to protect ecological receptors in the Dredge Cell and Embayment.

B.3.2 Aquatic Environment

As described above and summarized in Table 23, the SLERA for aquatic exposures at the TVA Kingston Ash Release indicates the following:

- Ash as sediment: Seventeen inorganic constituents in ash as sediment were selected as COPECs because maximum concentrations exceeded an HQ of 1, an ESV was not available, or constituents were identified as constituents of interest (COIs) in fly ash; and
- Surface Water: Seventeen inorganic constituents in the Emory River, seventeen constituents in the Clinch River, and fourteen constituents in the Tennessee River were selected as COPECs because maximum concentrations exceeded an HQ of 1, an ESV was not available, or constituents were identified as COIs in fly ash.

Based on the available evidence, the possibility of adverse ecological risks for ecological receptors potentially exposed to COPECs in surface water or to ash as sediment cannot be excluded. Viable remedies for the Dredge Cell and Embayment would eliminate the potential exposure pathways for aquatic ecological receptors west of Dike 2. Therefore, a BERA is not warranted for that area and no additional data are needed to support the selection of a remedial action to protect aquatic ecological receptors in the Dredge Cell and Embayment.

However, the aquatic environment for the site is primarily located east of Dike 2 in the river system. Given that the available information for the aquatic environment is not adequate to make a decision at this point, a BERA is warranted for the river system (Section 7).

The general types of information that will likely be needed to support a decision for the aquatic environment include the following: concentrations of COPECs in the ash and sediment, biogeochemical data for the ash and sediment, fate and transport information for the ash and COPECs, bioavailability of COPECs in the ash and sediment, concentrations of COPECs in fish, concentrations of COPECs in aquatic and riparian prey species, information on dietary exposures for birds and mammals, and community survey information for fish and benthic invertebrates. Some of these data have been collected. At this time the list of COPECs (i.e., metals) is adequately defined and the COPEC concentration data for surface water and ash are adequate to support the BERA. Bioavailability and dietary exposure information are the most likely types of data for which additional collection efforts may be warranted. However, the identification of data needs will require careful consideration of the intended uses of the data and of the adequacy of the data that is already available. These factors will be addressed during development of the sampling and analysis plan for the BERA.

APPENDIX C

Proposed Applicable or Relevant and Appropriate Requirements

Potential ARARs and TBC guidance for CERCLA response actions at the Kingston Fossil Plant Ash Spill, Roane County, Tennessee

Media/Resource/Action	Requirement	Prerequisite	Citation
Chemical-specific ARARs			
Restoration of Rivers classified for *Domestic Water Supply*	Waters shall not contain toxic substances, whether alone or in combination with other substances, which will produce toxic conditions that materially affect the health and safety of man and animals, or impair the safety of conventionally treated water supplies.	Presence of pollutant(s) in waters of the State as defined in TCA 69-3-103(33) — **relevant and appropriate**	TDEC 1200-4-3-.03(1)(j)
	May not exceed AWQC in surface water(s) for the listed toxic substances.		TDEC 1200-4-3-.03(1)(j)
	Shall not violate physical and chemical parameters or conditions related to Dissolved Oxygen, pH, Total Dissolved Solids, Solids, Turbidity, and Temperature.		TDEC 1200-4-3-.03(1)(a) through (g)
	Waters shall not contain other pollutants in quantities that may be detrimental to public health or impair the usefulness of the water as a source of domestic water supply.		TDEC 1200-4-3-.03(1)(k)
Restoration of Rivers classified for *Industrial Water Supply*	The waters shall not contain toxic substances whether alone or in combination with other substances, which will adversely affect industrial processing.	Presence of pollutant(s) in waters of the State as defined in TCA 69-3-103(33) — **relevant and appropriate**	TDEC 1200-4-3-.03(2)(i)
	Shall not violate physical and chemical parameters or conditions related to Dissolved Oxygen, pH, Total Dissolved Solids, Solids, Turbidity, and Temperature.		TDEC 1200-4-3-.03(2)(a) through (g)
	Waters shall not contain other pollutants in quantities that may adversely affect industrial processing.		TDEC 1200-4-3-.03(2)(j)
Restoration of Rivers classified for *Fish and Aquatic Life*	Waters shall not contain toxic substances or a combination of substances including disease-causing agents that, by way of either direct or indirect exposure through food chains, may cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, physical deformations, or restrict or impair growth in fish or aquatic life or their offspring.	Presence of pollutant(s) in waters of the State as defined in TCA 69-3-103(33) — **relevant and appropriate**	TDEC 1200-4-3-.03(3)(g)

Potential ARARs and TBC guidance for CERCLA response actions at the Kingston Fossil Plant Ash Spill, Roane County, Tennessee
(continued)

Media/Resource/Action	Requirement	Prerequisite	Citation
	May not exceed AWQC in surface water(s) for the listed toxic substances.		TDEC 1200-4-3-.03(3)(g)
	Shall not violate physical and chemical parameters or conditions related to Dissolved Oxygen, pH, Total Dissolved Solids, Turbidity, and Temperature.		TDEC 1200-4-3-.03(3)(a) through (g)
	Waters shall not contain other pollutants that will be detrimental to fish or aquatic life.		TDEC 1200-4-3-.03(3)(h)
	The waters shall not contain iron at concentrations that cause toxicity or in such amounts that interfere with habitat due to precipitation or bacteria growth.		TDEC 1200-4-3-.03(3)(i)
	The waters shall not be modified through the addition of pollutants or through physical alteration to the extent that the diversity and/or productivity of aquatic biota within the receiving waters are substantially decreased or adversely affected, except as allowed under 1200-4-3-.06.		TDEC 1200-4-3-.03(3)(m)
	The quality of stream habitat shall provide for the development of a diverse aquatic community that meets regionally-based biological integrity goals. Types of habitat loss include, but are not limited to: channel and substrate alterations, rock and gravel removal, stream flow changes, accumulation of silt, precipitation of metals, and removal of riparian vegetation. For wadeable streams, the instream habitat within each subecoregion shall be generally similar to that found at reference streams.		TDEC 1200-4-3-.03(3)(n)
	Stream or other waterbody flows shall support the fish and aquatic life criteria.		TDEC 1200-4-3-.03(3)(o)
Restoration of Rivers classified for *Recreation*	Waters shall not contain toxic substances, whether alone or in combination with other substances, that will render the water unsafe or unsuitable for water contact activities including the capture and subsequent consumption of fish and shellfish, or will propose toxic conditions that will adversely affect man, animal, aquatic life or wildlife	Presence of pollutant(s) in waters of the State as defined in TCA 69-3-103(33) — **relevant and appropriate**	TDEC 1200-4-3-.03(4)(j)

Potential ARARs and TBC guidance for CERCLA response actions at the Kingston Fossil Plant Ash Spill, Roane County, Tennessee
(continued)

Media/Resource/Action	Requirement	Prerequisite	Citation
	May not exceed AWQC in surface water(s) for the listed toxic substances (applies to waters classified for both recreation & domestic water supply)		TDEC 1200-4-3-.03(4)(j) As written in TDEC 1200-4-3-03
	Shall not violate physical and chemical parameters or conditions related to Dissolved Oxygen, pH, Solids, Total Suspended Solids, Turbidity, and Temperature		TDEC 1200-4-3-.03(4)(a) through (e)
	Waters shall not contain other pollutants in quantities that may have a detrimental effect on recreation		TDEC 1200-4-3-.03(4)(k)
Restoration of Rivers classified for *Irrigation* and/or *Livestock Watering and Wildlife*	Waters shall not contain toxic substances, whether alone or in combination with other substances, that will produce toxic conditions that adversely affect the quality of the waters for irrigation and/or livestock watering and wildlife.	Presence of pollutant(s) in waters of the State as defined in TCA 69-3-103(33) — **relevant and appropriate**	TDEC 1200-4-3-.03(5)(f) and (6)(f)
	Shall not violate physical and chemical parameters or conditions related to Dissolved Oxygen, pH, Solids, and Temperature.		TDEC 1200-4-3-.03(5)(a) through (e); and TDEC 1200-4-3-.03(6)(a) through (e)
	Waters shall not contain other pollutants in quantities that may be detrimental to the waters used for irrigation and/or for livestock watering and wildlife.		TDEC 1200-4-3-.03(5)(g) and (6)(g)
ARAR for radium at Superfund sites, is 40 CFR 192, which contains a criteria of 5 pCi/g above the established background [usually around 1 to 2 pCi/g in the Southeast U.S.].	The concentration of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than 5pCi/g, averaged over the first 15 cm of soil below the surface and 15pCi/g averaged over 15cm thick layers of soil more than 15cm below the surface.	Remediation Goals for CERCLA sites — **to be considered**	40 CFR 192.12 (a)(1) and (2)

Potential ARARs and TBC guidance for CERCLA response actions at the Kingston Fossil Plant Ash Spill, Roane County, Tennessee
(continued)

Media/Resource/Action	Requirement	Prerequisite	Citation
Location-specific ARARs			
Floodplains			
Presence of floodplain	An evaluation shall consider (1) the effect of the proposed action on natural and beneficial floodplain and wetland values and (2) alternatives that would eliminate or minimize such effects. The initiating office shall determine if there is no practicable alternative to siting in a floodplain or constructing in a wetland. If a determination of no practicable alternative is made, all practical measures to minimize impacts on the floodplain or wetland shall be implemented. If at any time prior to commencement of the action it is determined that there is a practicable alternative that will avoid affecting floodplains or wetlands, the proposed action shall not proceed.	Federal actions that involve potential impacts to, or take place within, floodplains — **to be considered**	Tennessee Valley Authority Instruction, Section IX, Environmental Review: Procedures for Compliance with the National Environmental Policy Act, April 28, 1983, which incorporates E011988 and E011990 requirements.
Aquatic resources			
Waters of the State as defined in *TCA* 69-3-103(33)	Must comply with the substantive requirements of the Aquatic Resources Alteration Permit (ARAP) for erosion and sediment control to prevent pollution. Pollution control requirements include, but are not limited to the following: • Limit clearing, grubbing, and other disturbances in areas in, or immediately adjacent to Waters of the State to the minimum necessary to, accomplish the proposed activity; • Unnecessary vegetation removal is prohibited, and all disturbed areas must be properly stabilized and revegetated as soon as practicable.	Action potentially altering the properties of any Waters of the State — **applicable**	*TCA* 69-3-108(b)(1) TDEC ARAP Program general requirements **(to be considered guidance)**
	• Limit excavation, dredging, bank reshaping, or grading to the minimum necessary to install authorized structures, accommodate stabilization, or prepare banks for revegetation; • Maintain the erosion and sedimentation control measures throughout construction period; and • Upon achievement of a final grade, stabilize and revegetate, within 30 days, all disturbed areas by sodding, seeding, or mulching, or using appropriate native riparian species.		

Potential ARARs and TBC guidance for CERCLA response actions at the Kingston Fossil Plant Ash Spill, Roane County, Tennessee
(continued)

Media/Resource/Action	Requirement	Prerequisite	Citation
Waters of the State as defined in *TCA* 69-3-103(33)	Bank stabilization activities along Waters of the State must be conducted in accordance with the requirements of the aquatic resources alteration program (TDEC 1200-4-7). The general permit requirements for stream bank stabilization include the following: • The erosion and sedimentation control practices indicated above under the TDEC ARAP general requirements; • Adverse impacts to T&E species are prohibited; • Placement of rip rap is limited to 300 linear feet of stream bank; • Material may not be placed such that it impairs surface water flow into or out of any wetland area; and • Stabilization materials shall not contain waste metal, construction debris, hazardous substances or toxic pollutants.	Bank-stabilization activities affecting Waters of the State — **to be considered**	ARAP General Permit for Stream Bank Stabilization
Waters of the State as defined as *TCA* 69.3-103(33)	Wet weather conveyances may be altered provided the following conditions are met: • Erosion and sedimentation controls must be maintained throughout the construction period; and • Adverse impacts to T&E species are prohibited.	Activities that alter wet weather conveyances — **to be considered**	ARAP General Permit for Alteration of Wet Weather Conveyances
Within area impacting stream or any other body of water –*and* - presence of wildlife resources (e.g., fish)	The effects of water-related projects on fish and wildlife resources and their habitat should be considered with a view to the conservation of fish and wildlife resources by preventing loss of and damage to such resources.	Action that impounds, modifies, diverts, or controls waters, including navigation and drainage activities — **relevant and appropriate**	Fish and Wildlife Coordination Act (16 *USC* 661 *et seq.*)
Location encompassing aquatic ecosystem as defined in 40 *CFR* 230.3(c)	No discharge of dredged or fill material into an aquatic ecosystem is permitted if there is a practicable alternative that would have less adverse impact.	Action that involves discharge of dredged or fill material into waters of the U.S., including jurisdictional wetlands — **applicable**	40 *CFR* 230.10(a)
	No discharge of dredged or fill material shall be permitted unless appropriate and practicable steps in accordance with 40 *CFR* 230.70 *et seq*. are taken that will minimize potential adverse impacts of the discharge on the aquatic ecosystem.		40 *CFR* 230.10(d)

Potential ARARs and TBC guidance for CERCLA response actions at the Kingston Fossil Plant Ash Spill, Roane County, Tennessee
(continued)

Media/Resource/Action	Requirement	Prerequisite	Citation
Wetlands			
Executive Order 11990 for Protection of Wetlands and 40 CFR Part 6	An evaluation shall consider (1) the effect of the proposed action on natural and beneficial floodplain and wetland values and (2) alternatives that would eliminate or minimize such effects. The initiating office shall determine if there is no practicable alternative to siting in a floodplain or constructing in a wetland. If a determination of no practicable alternative is made, all practical measures to minimize impacts on the floodplain or wetland shall be implemented. If at any time prior to commencement of the action it is determined that there is a practicable alternative that will avoid affecting floodplains or wetlands, the proposed action shall not proceed.	Federal actions that involve potential impacts to, or take place within, floodplains — **to be considered**	Tennessee Valley Authority Instruction, Section IX, Environmental Review: Procedures for Compliance with the National Environmental Policy Act, April 28, 1983, which incorporates E011988 and E011990 requirements.
Endangered, threatened, or rare species			
Presence of Tennessee nongame species as defined in TCA 70-8-103	May not take (i.e., harass, hunt, capture, kill or attempt to kill), possess, transport, export, or process wildlife species.	Action impacting Tennessee nongame species, including wildlife species which are "in need of management" (as listed in TWRCP 94-16 and 94-17) — **applicable**	TCA 70-8-104(c)
	May not knowingly destroy the habitat of such wildlife species.		TWRCP 94-16(II)(1)(a) and TWRCP 94-17(II) **(to be considered guidance)**
	Upon good cause shown and where necessary to protect human health or safety, endangered or threatened species may be removed, captured, or destroyed. …. Provisions for removal, capture, or destruction of nongame wildlife for the purposes set forth above shall be set forth in regulations issued by the executive director pursuant to § 70-8- 104(a).		TCA 70-8-106(e) and TWRCP 94-16(II)(1)(c) **(to be considered guidance)**
Presence of Tennessee-listed endangered or rare plant species as listed in TDEC 0400-6-2-.04	It is a violation for any person other than the landowner, lessee, or other person entitled to possession (or the manager, in the case of publicly owned land) or a person with the written permission of the landowner (or manager) to knowingly uproot, dig, take, remove, damage or destroy, possess or otherwise disturb for any purposes any endangered species.	Action impacting rare plant species including but not limited to federally listed endangered species — **relevant and appropriate**	TCA 70-8-309(a) TWRCP 94-16(II)(1)(a) TWRCP 94-17(II)

Potential ARARs and TBC guidance for CERCLA response actions at the Kingston Fossil Plant Ash Spill, Roane County, Tennessee
(continued)

Media/Resource/Action	Requirement	Prerequisite	Citation
Presence of federally endangered or threatened species, as designated in 50 CFR 17.11 and 17.12 or critical habitat of such species	Actions that jeopardize the existence of a listed species or results in the destruction or adverse modification of critical habitat must be avoided or reasonable and prudent mitigation measures take.	Action that is likely to jeopardize fish, wildlife, or plant species or destroy or adversely modify critical habitat — **applicable**	16 U.S.C. § 1536(a)(2) – Sect. 7(a)(2)
Action-specific ARARs			
Site preparation, construction, and excavation activities			
Activities causing fugitive dust emissions	Shall take reasonable precautions to prevent particulate matter from becoming airborne. Reasonable precautions shall include, but are not limited to, the following:	Fugitive emissions from land-disturbing activities (e.g., excavation, construction) — **applicable**	TDEC 1200-3-8-.01(1)
	• Use, where possible, of water or chemicals for control of dust and in demolition of existing buildings or structures, construction operations, grading of roads, or the clearing of land; and		TDEC 1200-3-8-.01(1)(a)
	• Application of asphalt, oil, water, or suitable chemicals on dirt roads, materials stock piles, and other surfaces which can create airborne dusts.		TDEC 1200-3-8-.01(1)(b)
	Shall not cause or allow fugitive dust to be emitted in such a manner to exceed 5 minutes/hour or 20 minutes/day beyond property boundary lines on which emission originates.		TDEC 1200-3-8-.01(2)
Activities causing storm water runoff (e.g., demolition)	Implement good construction management techniques (including sediment and erosion controls, vegetative controls, and structural controls) in accordance with the substantive requirements of *General Permit No. TNR10-0000, Appendix F* to ensure water discharge:	Storm water runoff discharges from land disturbed by construction activity— disturbance of ≥1 acre total — **applicable**	TCA 69-3-108(j) TDEC 1200-4-10-.03(2)(a)

Potential ARARs and TBC guidance for CERCLA response actions at the Kingston Fossil Plant Ash Spill, Roane County, Tennessee
(continued)

Media/Resource/Action	Requirement	Prerequisite	Citation
	• Does not violate water quality criteria as stated in TDEC 1200-4-3, including but not limited to prevention of discharges that cause a condition in which visible solids, bottom deposits, or turbidity impairs the usefulness of water of the state for any of the uses designated for that water body by TDEC 1200-4-4, and • Does not violate other conditions detailed in *General Permit No. TNR10-0000.*	Stormwater discharges from construction activities — **to be considered**	*General Permit No. TNR100000* Section 4.3.2(a) (**to be considered**)
	• Does not contain distinctly visible floating scum, oil, or other matter.		*General Permit No. TNR10-0000* Section 4.3.2(b)
	• Results in no materials in concentrations sufficient to be hazardous or otherwise detrimental to humans, livestock, wildlife, plant life, or fish and aquatic life in the receiving stream.		*General Permit No. TNR10-0000* Section 4.3.2(d)
Technology-based limitations on direct discharges to surface waters	Where promulgated effluent limitations guidelines only apply to certain aspects of the discharger's operation, other aspects or activities are subject to regulation on a case-by-case basis considering the appropriate technology and other unique factors.	Discharges of pollutants to surface waters — **to be considered**	40 C.F.R. § 125.3(c)(1)-(3)
Technology-based limitations on direct discharges to surface waters	In considering best available technology requirements, consider: • Age of equipment and facilities involved; • Process employed; • Engineering aspects of the application of various types of control techniques; • Process changes • Cost of achieving effluent reduction; and • Non-water quality environmental impact.	Discharges of pollutants to surface waters — **to be considered**	40 C.F.R. § 125.3(d)(3)

Potential ARARs and TBC guidance for CERCLA response actions at the Kingston Fossil Plant Ash Spill, Roane County, Tennessee
(continued)

Media/Resource/Action	Requirement	Prerequisite	Citation
Dredging and Filling			
Clean Water Act §404, Dredge and Fill of Material in Waters of the U.S.	No discharge of dredged or fill material into an aquatic ecosystem is permitted if there is a practicable alternative that would have less adverse impact.	Action that involves discharge of dredged or fill material into waters of the U.S., including jurisdictional wetlands — **applicable**	40 *CFR* 230.10(a)
	No discharge of dredged or fill material shall be permitted unless appropriate and practicable steps in accordance with 40 *CFR* 230.70 *et seq*. are taken that will minimize potential adverse impacts of the discharge on the aquatic ecosystem.		40 *CFR* 230.10(d)
Waste generation, characterization, management and disposal			
Characterization of solid waste (all primary and secondary wastes)	Must determine if waste is hazardous or is excluded under 40 CFR 261.4; and	Generation of solid waste as defined in 40 CFR 261.2 — **relevant and appropriate**	40 CFR 262.11(a) TDEC 1200-1-11-.03(1)(b)1
	Must determine if waste is listed under 40 CFR Part 261; or		40 CFR 262.11(b) TDEC 1200-1-11-.03(1)(b)2
	Must characterize waste by using prescribed testing methods or applying generator knowledge based on information regarding material or processes used. If waste is determined to be hazardous, it must be managed in accordance with appropriate sections of 40 CFR 260–272.		40 CFR 262.11(c) TDEC 1200-1-11-.03(1)(b)3
Management and disposal of solid waste	If a waste is determined to be a solid waste, it must be managed in accordance with the applicable state regulations at TDEC 1200-1-7 et seq.	Generation of a solid waste — **relevant and appropriate**	TDEC 1200-1-7 et seq.
	May receive for disposal only those solid wastes it is allowed to manage under the terms of its permit (i.e., those which meet its WAC) or “special wastes” as approved in writing by the TDEC Commissioner.	Disposal of solid waste in a class I, II, III, IV disposal facility regulated by TDEC — **relevant and appropriate**	TDEC 1200-1-7-.04(2)(k)

Potential ARARs and TBC guidance for CERCLA response actions at the Kingston Fossil Plant Ash Spill, Roane County, Tennessee
(continued)

Media/Resource/Action	Requirement	Prerequisite	Citation
Temporary storage of remediation waste in staging piles (excavated soils)	An accumulation of solid, non-flowing remediation waste defined in 40 CFR 260.10 not in a containment building may be temporarily stored, including mixing, sizing, blending or other similar physical operations intended to prepare the wastes for subsequent management or treatment, at a facility if used only during remedial operations provided that the staging pile will:	Accumulation of remediation waste on site as defined in 40 CFR 260.10 — **to be considered**	40 CFR 264.554(a)(1)
	• Facilitate a reliable, effective and protective remedy;		40 CFR 264.554(d)(1)(i)
	• Prevent or minimize releases of hazardous wastes and constituents into the environment and minimize or adequately control cross-media transfer as necessary to protect human health and the environment (e.g. use of liners, covers, run-off/run-on controls);		40 CFR 264.554(d)(1)(ii)
Closure of staging piles of remediation waste located in previously contaminated area	Must be closed within 180 days after the operating term by removing or decontaminating all remediation waste, contaminated containment system components, and structures and equipment contaminated with waste and leachate.	Storage of remediation waste in staging pile in previously contaminated area — **to be considered**	40 CFR 264.554(j)
Closure of staging piles of remediation waste located in an uncontaminated area	Must be closed within 180 days after the operating term according to 40 CFR 264.258(a) and 264.111 or 265.258(a) and 265.111.	Storage of remediation waste in staging pile in uncontaminated area — **to be considered**	40 CFR 264.554(k)
Characterization and management of universal waste	A large quantity handler of universal waste must manage universal waste in accordance with 40 CFR 273 (TDEC 1200-1-11-.12) in a way that prevents releases of any universal waste or component of a universal waste to the environment. Must label or mark the universal waste to identify the type of universal waste.	Generation of universal waste [as defined in TDEC 1200-1-11-.12(1)(a)] for disposal — **applicable**	40 CFR 273 TDEC 1200-1-11-.12 40 CFR 273.34 TDEC 1200-1-11-.12(3)(e)
On-site storage of used oil	Used oil shall not be stored in a unit other than a tank or container.	Generation and storage of used oil —**applicable**	40 CFR 279.22(a) TDEC 1200-1-11-.11(3)(c)1

Potential ARARs and TBC guidance for CERCLA response actions at the Kingston Fossil Plant Ash Spill, Roane County, Tennessee
(continued)

Media/Resource/Action	Requirement	Prerequisite	Citation
	Containers and aboveground tanks used to store used oil must be:		40 CFR 279.22(b) TDEC 1200-1-11-.11(3)(c)2
	• In good condition (no severe rusting, apparent structural defects or deterioration); and		40 CFR 279.22(b)(1) TDEC 1200-1-11-.11(3)(c)2(i)
	• Not leaking (no visible leaks).		40 CFR 279.22(b)(2) TDEC 1200-1-11-.11(3)(c)2(ii)
	Containers and aboveground tanks used to store used oil and fill pipes used to transfer used oil into USTs must be labeled or marked clearly with the words "Used Oil".		40 CFR 279.22(c)(1) and (2) TDEC 1200-1-11-.11(3)(c)3(i) and (ii)
Transportation			
Transportation of hazardous materials	Shall be subject to and must comply with all applicable provisions of the HMTA and HMR at 49 *CFR* 171-180.	Any person who, under contract with a department or agency of the federal government, transports "in commerce," or causes to be transported or shipped, a hazardous material — **applicable**	49 *CFR* 171.1(c)
Dam Safety			
National Dam Safety Program Act	Alteration, maintenance and operation of a dam in an approved manner.	Operation and maintenance of a dam — **to be considered**	TDEC 1200-5-7

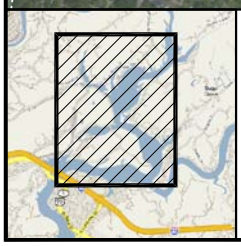
ARAR = applicable or relevant and appropriate requirement
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CFR = *Code of Federal Regulations*
CMBST = combustion
DEACT = deactivation
DOT = U.S. Department of Transportation
EPA = U.S. Environmental Protection Agency
NHPA = National Historic Preservation Act of 1966
NPDES = National Pollutant Discharge Elimination System
PPE = personal protective equipment
S&M = surveillance and maintenance
TBC = to be considered
TCA = *Tennessee Code Annotated*
TDEC = Tennessee Department of Environment and Conservation
USC = *United States Code*
WAC = waste acceptance criteria

Figures 1-12

(File Attached)

Tables 1- 24

(File Attached)



0 1000 2000 4000

SCALE IN FEET

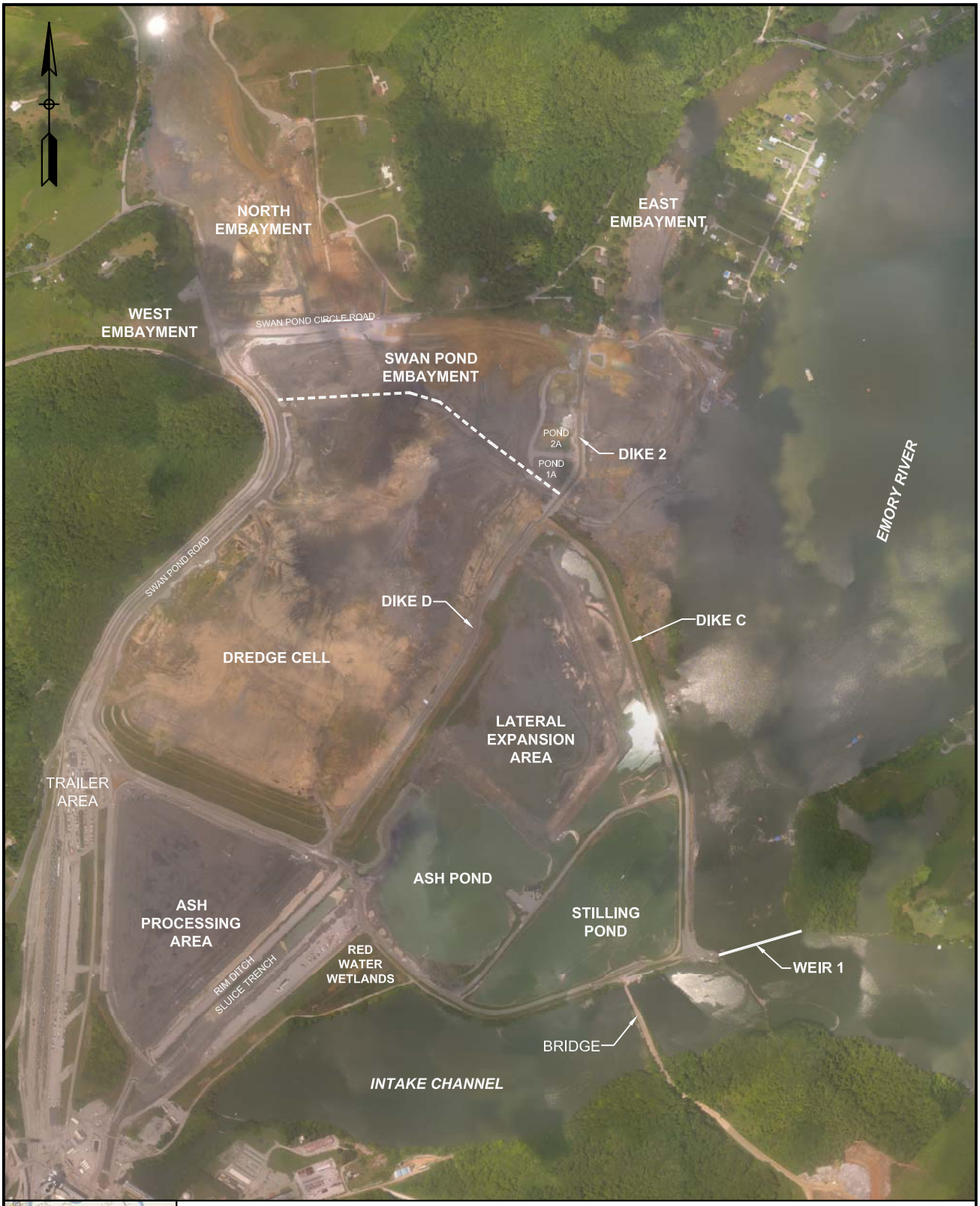
DATE OF PHOTO: AUG. 2009

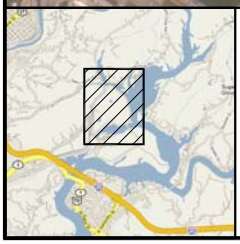
FIGURE 1
LOCATION OF THE SITES

TENNESSEE VALLEY AUTHORITY

DATE:	REVISION:	PHASE:
30 Sept 09	1	EE/CA Work Plan

T:\0002 ENGINEERING\01 DRAWINGS AND SPECS\Report Graphics\004_Fig 1 Location Map_r1.dwg Oct 02,2009 -bperatro





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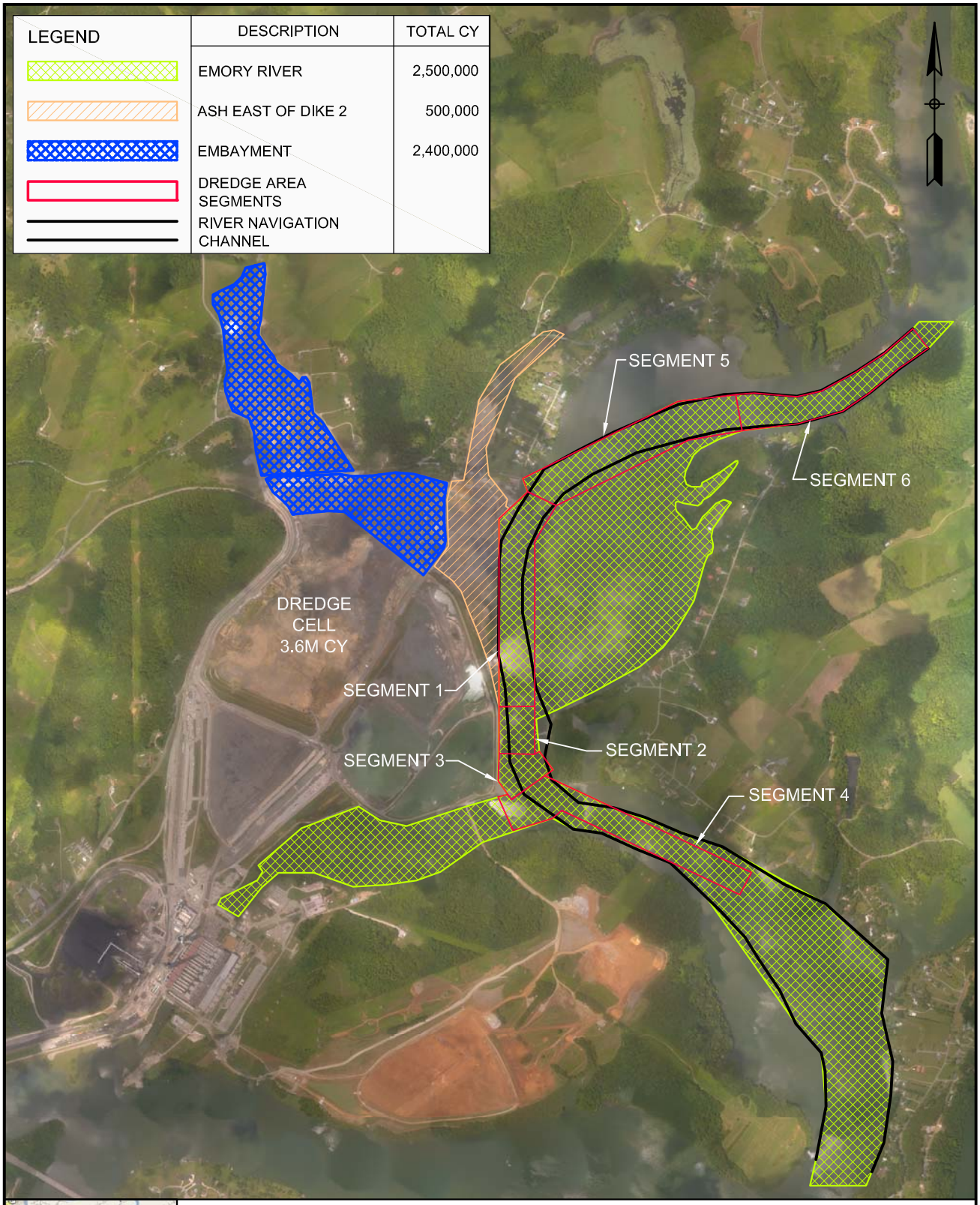
DATE OF PHOTO: AUG. 2009

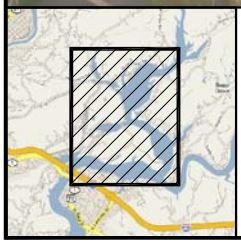
FIGURE 2
KEY FEATURES OF THE SITE

TENNESSEE VALLEY AUTHORITY

DATE:	REVISION:	PHASE:
25 Sept 09	0	EE/CA Work Plan

T:\0002 ENGINEERING\01 DRAWINGS AND SPECS\Report Graphics\005_Fig 2 Key Site Features.dwg Sep 25,2009 -bperatro





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SCALE IN FEET

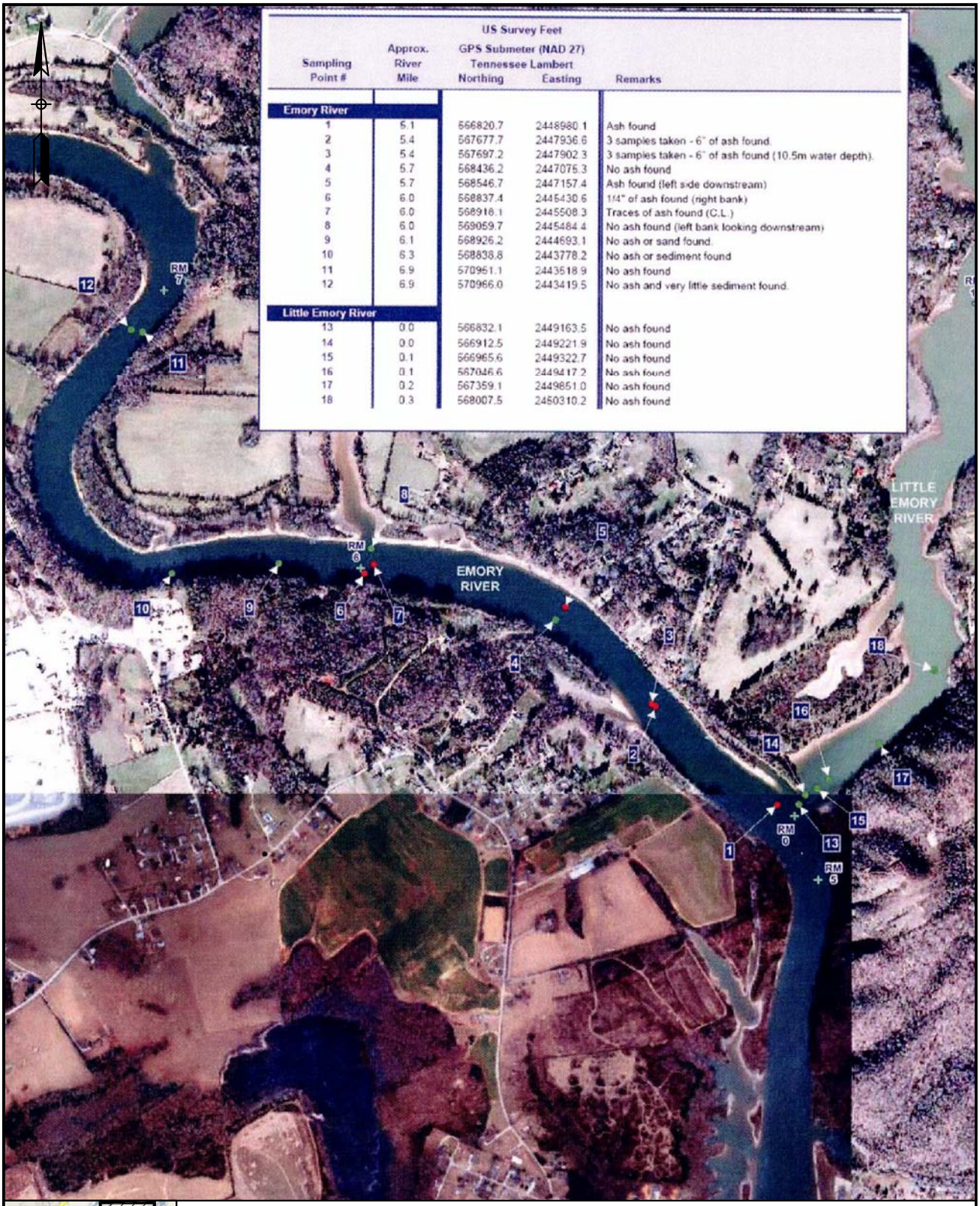
DATE OF PHOTO: AUG. 2009

FIGURE 3
APPROXIMATE ASH VOLUMES

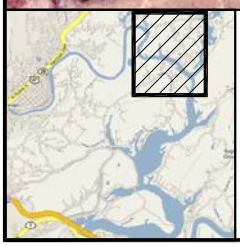
TENNESSEE VALLEY AUTHORITY

DATE:	REVISION:	PHASE:
30 Sept 09	1	EE/CA Work Plan

T:\0002 ENGINEERING\01 DRAWINGS AND SPECS\Report Graphics\006_Fig 3 Ash Volumes_r1.dwg Oct 02,2009 -bperatro



Sampling Point #	Approx. River Mile	US Survey Feet GPS Submeter (NAD 27) Tennessee Lambert Northing	Easting	Remarks
Emory River				
1	5.1	566820.7	2448980.1	Ash found
2	5.4	567677.7	2447936.6	3 samples taken - 6" of ash found.
3	5.4	567697.2	2447902.3	3 samples taken - 6" of ash found (10.5m water depth).
4	5.7	568436.2	2447075.3	No ash found
5	5.7	568546.7	2447157.4	Ash found (left side downstream)
6	6.0	568837.4	2445430.6	1/4" of ash found (right bank)
7	6.0	568918.1	2445508.3	Traces of ash found (C.L.)
8	6.0	569059.7	2445484.4	No ash found (left bank looking downstream)
9	6.1	568926.2	2444693.1	No ash or sand found.
10	6.3	568838.8	2443778.2	No ash or sediment found
11	6.9	570961.1	2443518.9	No ash found
12	6.9	570966.0	2443419.5	No ash and very little sediment found.
Little Emory River				
13	0.0	566832.1	2449163.5	No ash found
14	0.0	566912.5	2449221.9	No ash found
15	0.1	566965.6	2449322.7	No ash found
16	0.1	567046.6	2449417.2	No ash found
17	0.2	567359.1	2449851.0	No ash found
18	0.3	568007.5	2450310.2	No ash found



LEGEND

- Sample Point - No Ash Found
- Sample Point - Ash Found

0 500 1000 2000
SCALE IN FEET

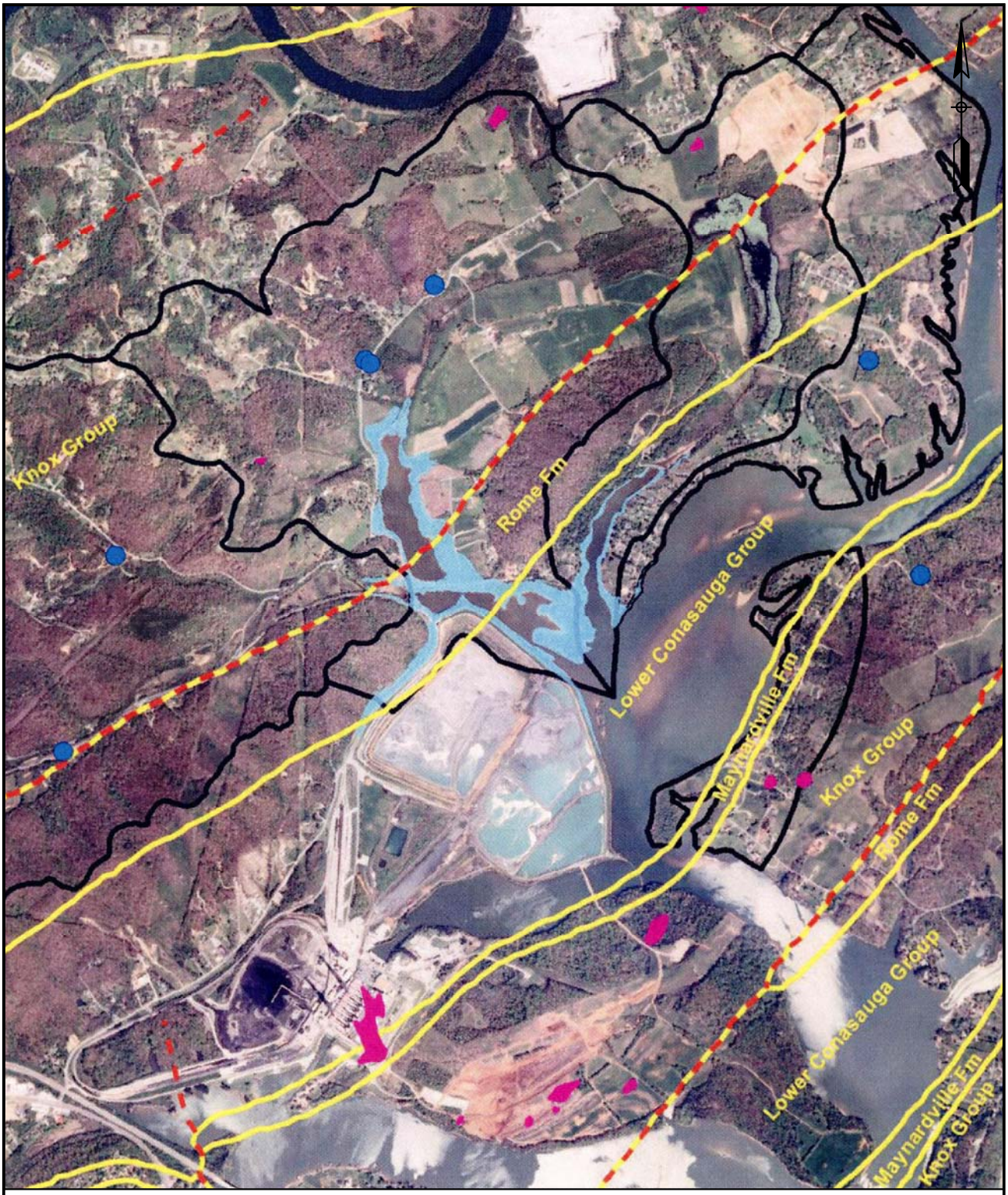
DATE OF PHOTO: 2008

FIGURE 4
EXTENT OF ASH UPSTREAM OF THE KIF SITE

TENNESSEE VALLEY AUTHORITY

DATE:	REVISION:	PHASE:
25 Sept 09	0	EE/CA Work Plan

T:\0002 ENGINEERING\01 DRAWINGS AND SPECS\Report Graphics\007_Fig 4 Extent of Upstream Ash.dwg Sep 25,2009 -bperatro



DATE OF PHOTO: 2008

0 1000 2000 4000
SCALE IN FEET

LEGEND

- SPRING
- ASH-IMPACTED LAND ABOVE WINTER POOL SHROELINE
- GEOLOGIC CONTACT
- GEOLOGIC FAULT
- SINKHOLE
- WATERSHED BOUNDARY

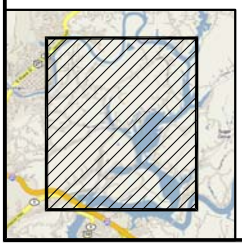


FIGURE 5
HYDROGEOLOGIC FEATURES
OF THE KIF SITE
TENNESSEE VALLEY AUTHORITY

DATE:	REVISION:	PHASE:
25Sept 09	0	EE/CA Work Plan

T:\0002 ENGINEERING\01 DRAWINGS AND SPECS\Report Graphics\008_Fig 5 Hydrogeologic Features.dwg Sep 25,2009 -bperatro

DATE OF PHOTO: AUG. 2009

LEGEND

ASH SAMPLING LOCATION

PR-3 ID LABLE FOR PRIVATE RESIDENCE

0 1000 2000 4000

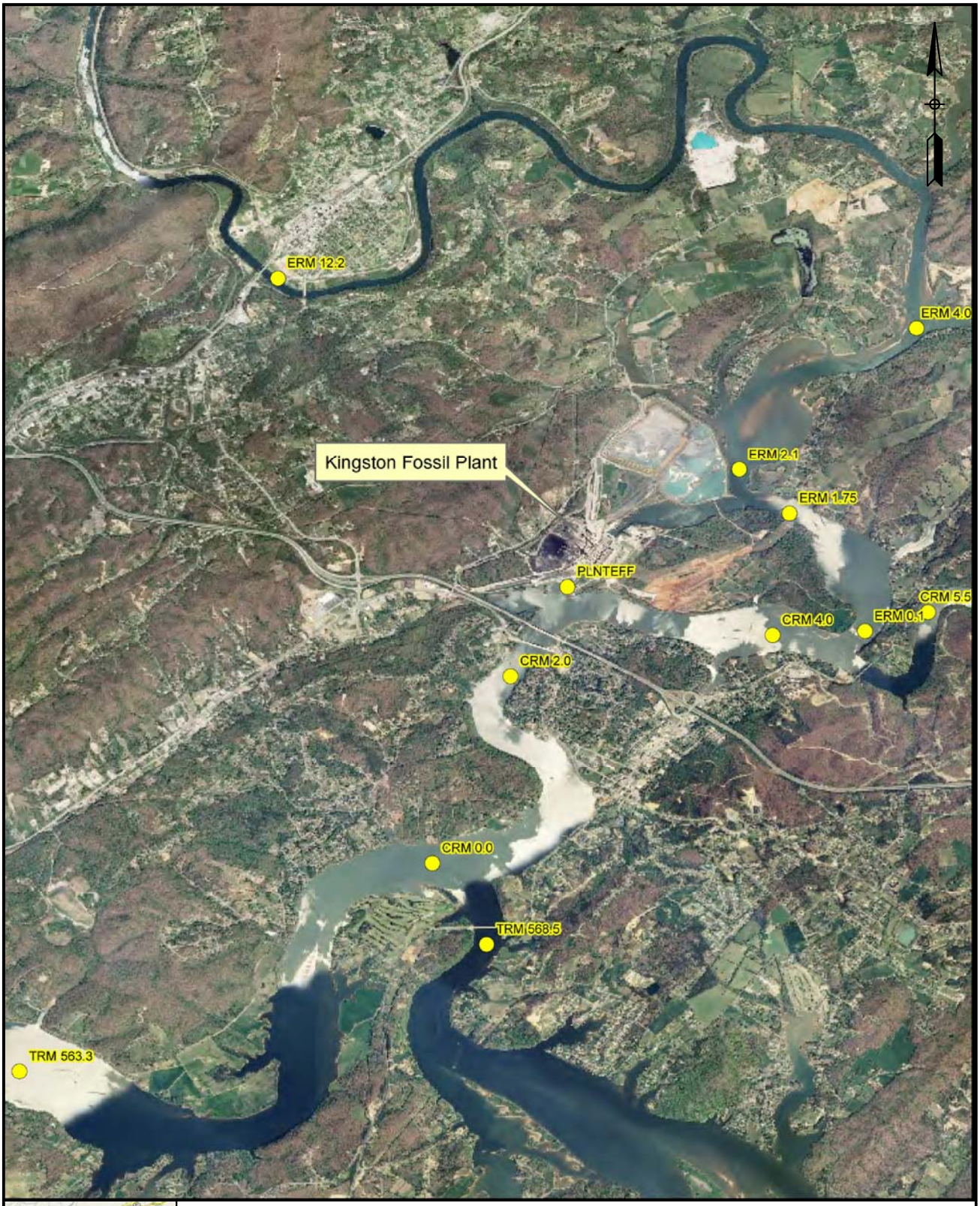
SCALE IN FEET

FIGURE 6
TVA ASH SAMPLE LOCATIONS

TENNESSEE VALLEY AUTHORITY

DATE:	REVISION:	PHASE:
25 Sept 09	0	EE/CA Work Plan

T:\0002 ENGINEERING\01 DRAWINGS AND SPECS\Report Graphics\009_Fig 6 Ash Sampling Locations.dwg Oct 13,2009 -bperatro



DATE OF PHOTO: JUNE 2009

0 0.5 1 2
SCALE IN MILES

FIGURE 7
ROUTINE SURFACE WATER SAMPLING LOCATIONS
TENNESSEE VALLEY AUTHORITY

DATE:	REVISION:	PHASE:
25 Sept 09	0	EE/CA Work Plan

T:\0002 ENGINEERING\01 DRAWINGS AND SPECS\Report Graphics\010_Fig 7 Surface Water Sample Locations.dwg Sep 25,2009 -bperatro

Figure 8. Conceptual Site Model
TVA Kingston Flyash Recovery Project

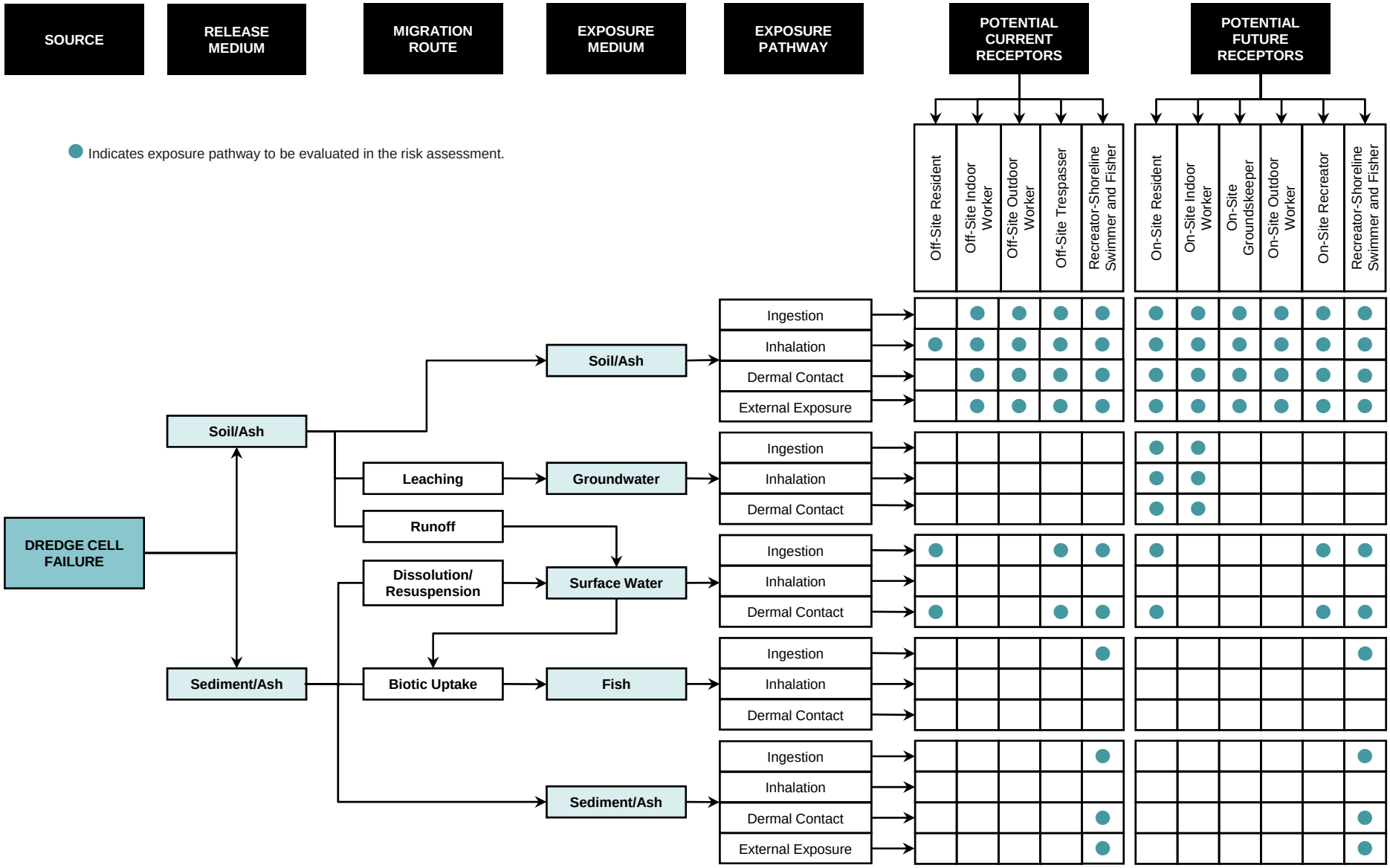


Figure 9. Eight-Step Ecological Risk Assessment Process
TVA Kingston Flyash Recovery Project

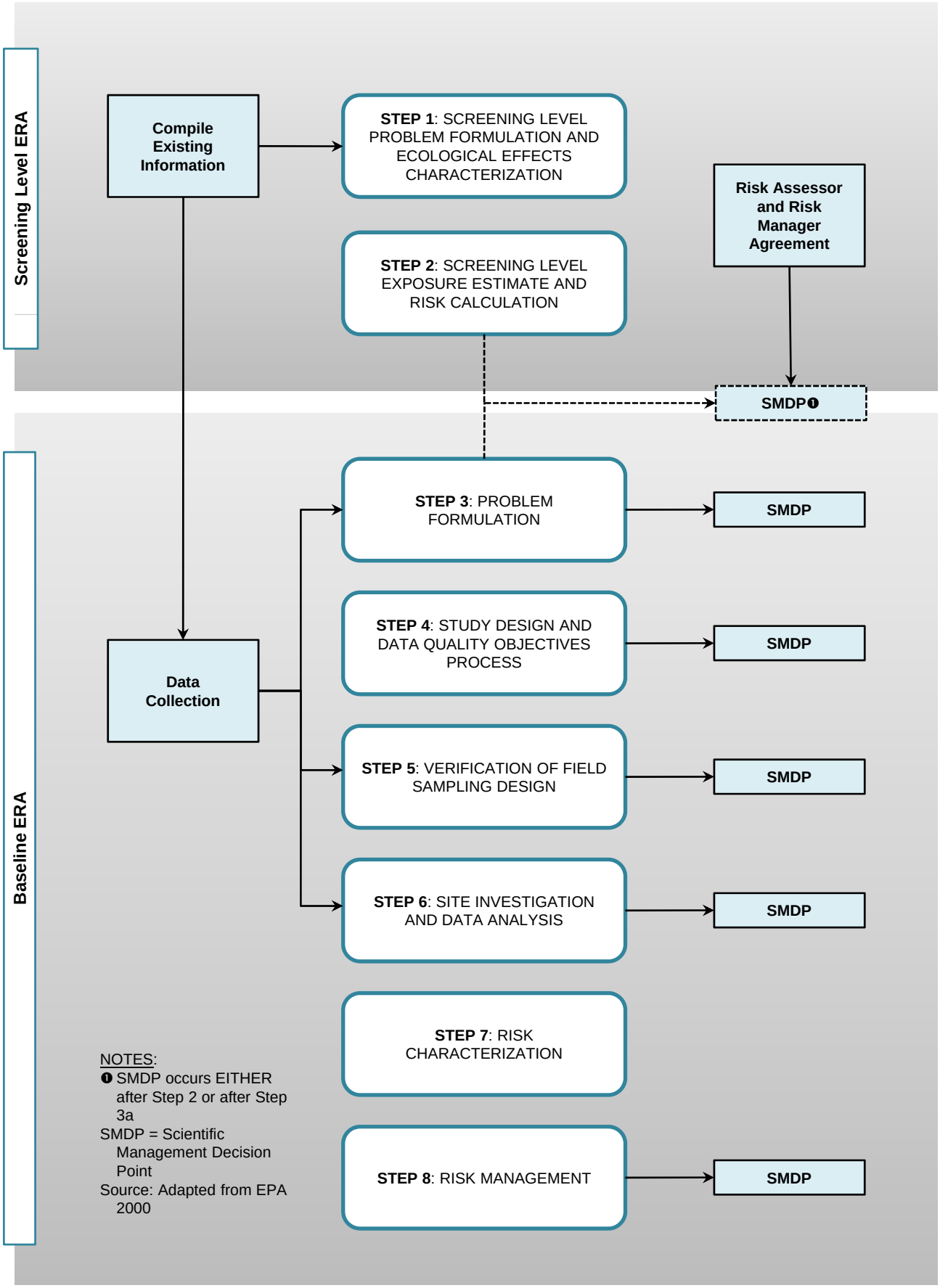


Figure 10. Expanded Eight-Step Ecological Risk Assessment Process
TVA Kingston Flyash Recovery Project

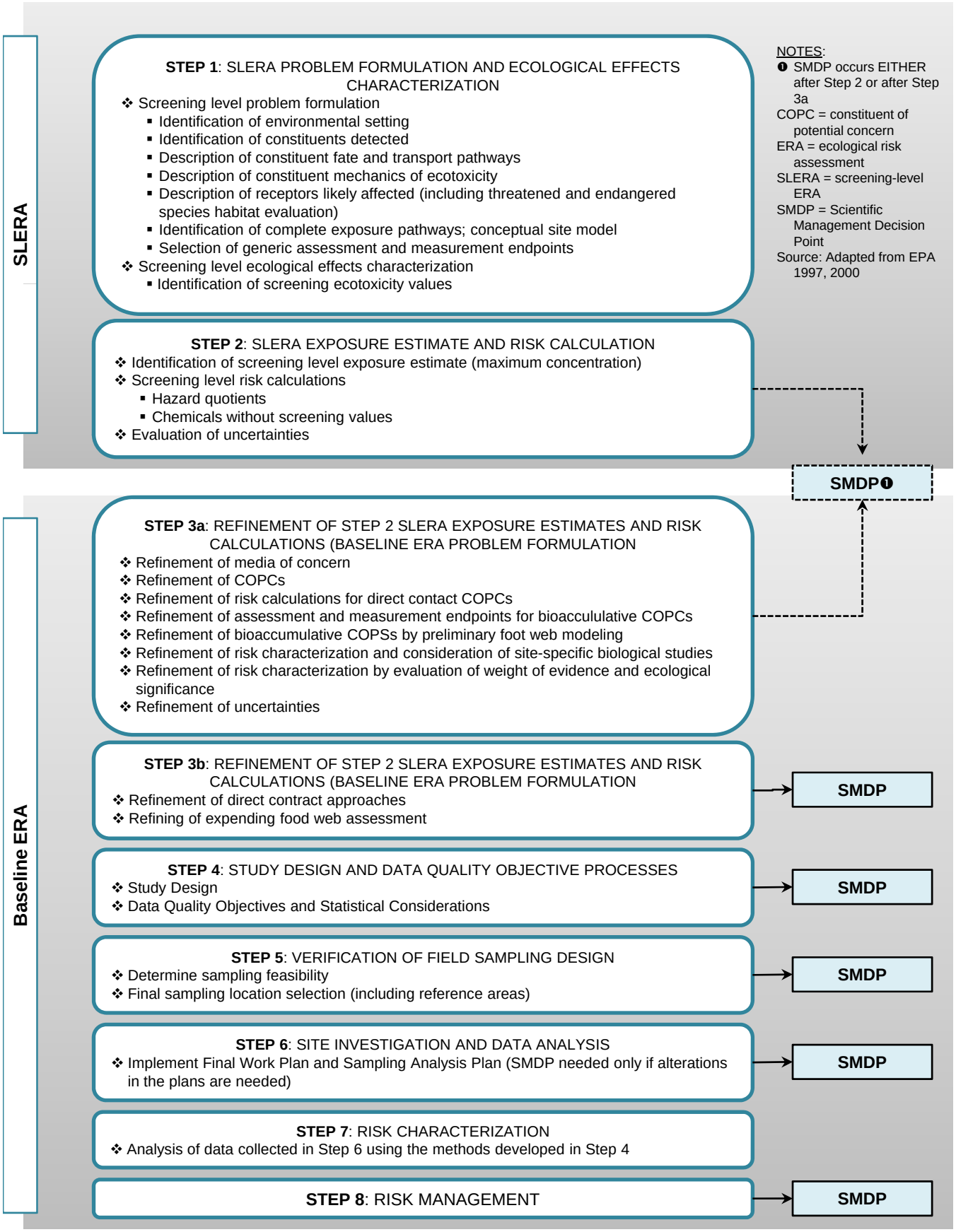
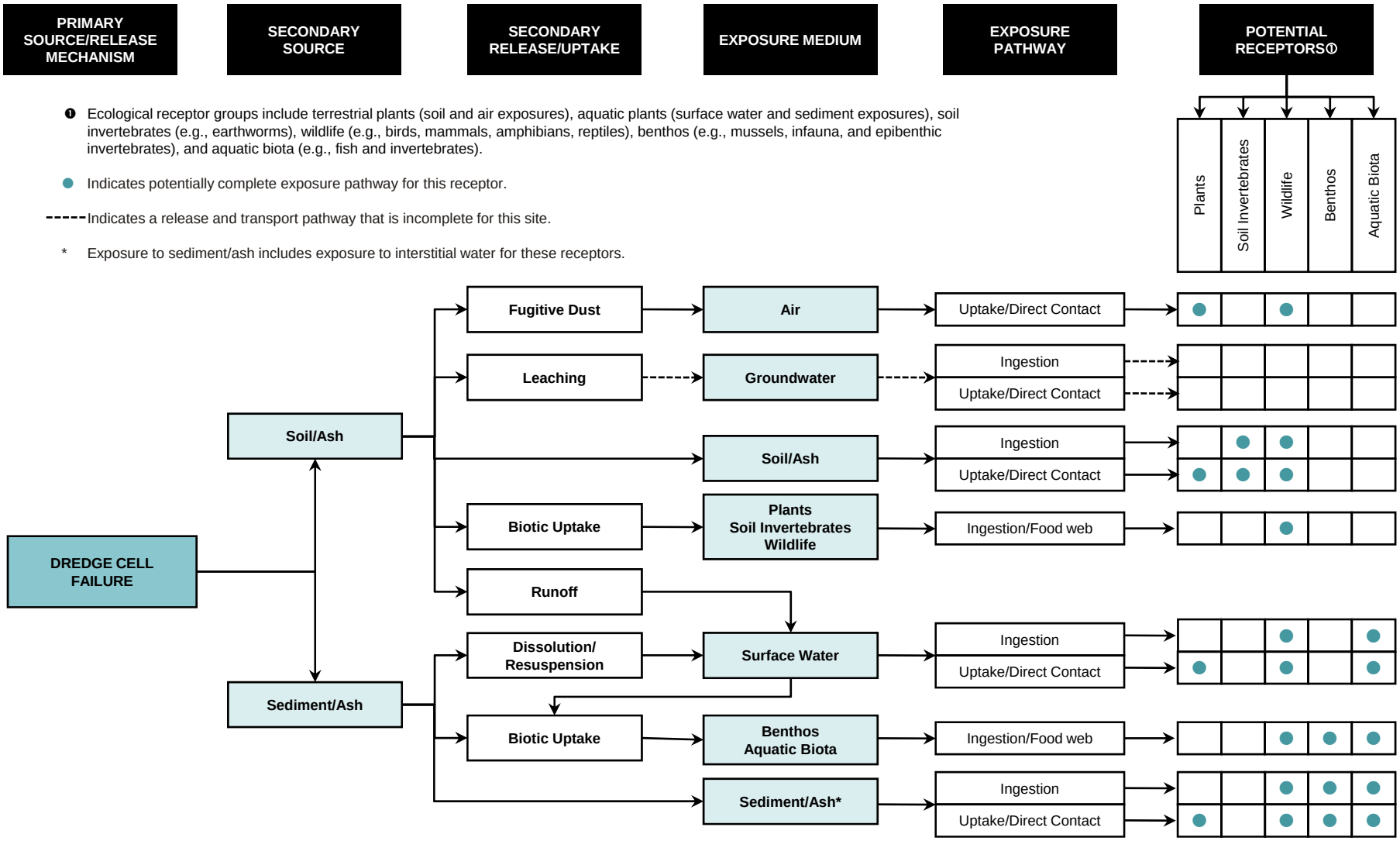


Figure 11. Ecological Conceptual Site Model
TVA Kingston Flyash Recovery Project



❶ Ecological receptor groups include terrestrial plants (soil and air exposures), aquatic plants (surface water and sediment exposures), soil invertebrates (e.g., earthworms), wildlife (e.g., birds, mammals, amphibians, reptiles), benthos (e.g., mussels, infauna, and epibenthic invertebrates), and aquatic biota (e.g., fish and invertebrates).

● Indicates potentially complete exposure pathway for this receptor.

----- Indicates a release and transport pathway that is incomplete for this site.

* Exposure to sediment/ash includes exposure to interstitial water for these receptors.

Figure 12. Schedule of Activities for the Kingston Flyash Recovery Project, Non-Time-Critical Removal Actions

Documentation	FY 2009	FY 2010	FY 2011	FY 2012
Work Plan				
Decision 1: Dredge Cell & Embayment				
Engineering Evaluation and Cost Analysis				
Action Memorandum				
Implementation/ Construction				
Decision 2: River				
Sampling and Analysis Plan				
Sampling and Analysis				
Engineering Evaluation and Cost Estimate				
Action Memorandum				
Remedial Site Evaluation Work Plan				

Table 1. Background Concentrations of Inorganic Analytes in Soil
Conasauga Bedrock Formation

Analyte	Units	Number of Samples	Number of detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean
Aluminum	mg/kg	16	16	0	100%	13300	32350	20566
Antimony	mg/kg	16	2	14	13%	0.105	0.9	0.290
Arsenic	mg/kg	16	15	1	94%	0.23	7.3	5
Barium	mg/kg	16	16	0	100%	57.6	180.5	90
Beryllium	mg/kg	16	16	0	100%	0.37	1.65	0.798
Boron	mg/kg	15	6	9	40%	4.65	53	14
Cadmium	mg/kg	16	0	16	0%	0.105	0.1275	0.115
Calcium	mg/kg	16	11	5	69%	211	2110	919
Chromium	mg/kg	16	15	1	94%	0.23	34.7	26
Cobalt	mg/kg	16	16	0	100%	8.9	37	17
Copper	mg/kg	16	16	0	100%	8.9	21.7	14
Iron	mg/kg	16	16	0	100%	20700	36500	27344
Lead	mg/kg	16	15	1	94%	0.115	48.2	23
Lithium	mg/kg	15	13	2	87%	6.85	19.85	12
Magnesium	mg/kg	16	16	0	100%	1180	5410	2366
Manganese	mg/kg	16	16	0	100%	405	3445	1111
Mercury	mg/kg	16	11	5	69%	0.055	0.34	0.176
Molybdenum	mg/kg	16	1	15	6%	0.75	4.975	3
Nickel	mg/kg	16	16	0	100%	11.8	41	20
Potassium	mg/kg	16	16	0	100%	818	5090	2675
Selenium	mg/kg	16	8	8	50%	0.18	1.2	0.575
Silicon	mg/kg	16	16	0	100%	185	579	366
Silver	mg/kg	16	0	16	0%	0.55	1.075	0.802
Sodium	mg/kg	1	0	1	0%	75.725	75.725	76
Strontium	mg/kg	15	15	0	100%	3.2	11.7	6
Thallium	mg/kg	16	2	14	13%	0.105	0.79	0.236
Vanadium	mg/kg	16	16	0	100%	27.8	40.95	32
Zinc	mg/kg	16	16	0	100%	33.9	80.8	45

Table 1. Continued
Knox Bedrock Formation

Analyte	Units	Number of Samples	Number of detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean
Aluminum	mg/kg	20	20	0	100%	7560	19100	10216
Antimony	mg/kg	20	0	20	0%	0.2075	0.25	0.222
Arsenic	mg/kg	20	20	0	100%	5.7	67.1	16
Barium	mg/kg	20	20	0	100%	32.05	196	77
Beryllium	mg/kg	20	17	3	85%	0.255	1	0.507
Boron	mg/kg	16	0	16	0%	2.4	3	3
Cadmium	mg/kg	20	0	20	0%	0.105	0.125	0.111
Calcium	mg/kg	20	20	0	100%	280	1730	640
Chromium	mg/kg	20	20	0	100%	8.175	25.7	16
Cobalt	mg/kg	20	19	1	95%	2.5	35.3	11
Copper	mg/kg	20	14	6	70%	1.35	13.6	6
Iron	mg/kg	20	20	0	100%	9365	20100	13167
Lead	mg/kg	20	20	0	100%	11.7	165	31
Lithium	mg/kg	18	14	4	78%	1.25	13.8	5
Magnesium	mg/kg	20	20	0	100%	311	931	472
Manganese	mg/kg	20	20	0	100%	369	3470	1270
Mercury	mg/kg	20	15	5	75%	0.05	0.19	0.114
Molybdenum	mg/kg	18	1	17	6%	0.7	1.8	1
Nickel	mg/kg	20	9	11	45%	2.45	13.5	6
Potassium	mg/kg	18	12	6	67%	133.5	614	319
Selenium	mg/kg	16	14	2	88%	0.2075	3.6	0.890
Silicon	mg/kg	13	13	0	100%	368	633	510
Silver	mg/kg	20	0	20	0%	0.41	0.6	0.468
Sodium	mg/kg	20	19	1	95%	179.5	463	346
Strontium	mg/kg	18	14	4	78%	0.925	7.7	4
Thallium	mg/kg	16	1	15	6%	0.2075	1.4725	0.345
Vanadium	mg/kg	20	20	0	100%	19.2	44.2	28
Zinc	mg/kg	20	20	0	100%	21.75	87.25	41

Table 1. Continued
Rome Bedrock Formation

Analyte	Units	Number of Samples	Number of detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean
Aluminum	mg/kg	4	4	0	100%	11000	15000	14000
Antimony	mg/kg	4	4	0	100%	0.78	1.2	1
Arsenic	mg/kg	4	4	0	100%	0.77	1.5	1
Barium	mg/kg	4	4	0	100%	49	81	66
Beryllium	mg/kg	4	4	0	100%	0.67	0.77	0.715
Cadmium	mg/kg	4	0	4	0%	0.0095	0.019	0.016
Calcium	mg/kg	4	4	0	100%	80	310	205
Chromium	mg/kg	4	4	0	100%	23	33	27
Cobalt	mg/kg	4	4	0	100%	6.4	9.1	7
Copper	mg/kg	4	4	0	100%	5.9	13	9
Iron	mg/kg	4	4	0	100%	20000	29000	26000
Lead	mg/kg	4	4	0	100%	5	6.4	6
Magnesium	mg/kg	4	4	0	100%	2200	3300	2750
Manganese	mg/kg	4	4	0	100%	78	380	168
Mercury	mg/kg	4	4	0	100%	0.017	0.021	0.019
Nickel	mg/kg	4	4	0	100%	13	17	15
Potassium	mg/kg	4	4	0	100%	1400	2400	2075
Selenium	mg/kg	4	2	2	50%	0.33	1	0.551
Silver	mg/kg	4	0	4	0%	0.029	0.03	0.030
Sodium	mg/kg	4	0	4	0%	16	26	21
Thallium	mg/kg	4	0	4	0%	0.1	0.205	0.176
Vanadium	mg/kg	4	4	0	100%	23	34	28
Zinc	mg/kg	4	4	0	100%	23	28	26

Table 2. Background Concentrations of Inorganic Analytes in Emory River Surface Water

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean
Alkalinity	ug/L	52	37	15	71%	10000	26600	12388
Chloride	ug/L	4	4	0	100%	2420	3870	3180
Hardness (as CaCO3)	mg/L	43	43	0	100%	15.8	36.2	23
Total Dissolved Solids	ug/L	42	41	1	98%	19000	57000	38619
Total Suspended Solids	mg/L	52	50	2	96%	1	23.7	5.3
Aluminum, Total	mg/L	68	41	27	60%	0.102	0.798	0.173
Antimony	mg/L	68	4	64	6%	0.00222	0.00318	0.00109
Antimony, Total	mg/L	68	1	67	1%	0.00599	0.00599	0.00107
Barium	mg/L	68	68	0	100%	0.0177	0.0366	0.0261
Barium, Total	mg/L	68	68	0	100%	0.0195	0.0396	0.0281
Calcium	mg/L	58	58	0	100%	4.34	10.1	6.64
Calcium, Total	mg/L	66	66	0	100%	4.6	10.5	6.45
Cobalt	mg/L	68	1	67	1%	0.00386	0.00386	0.00236
Copper	mg/L	67	2	65	3%	0.0014	0.0108	0.00261
Iron	mg/L	68	25	43	37%	0.0515	0.137	0.0412
Iron, Total	mg/L	68	68	0	100%	0.083	0.922	0.234
Magnesium	mg/L	68	67	1	99%	1.11	2.59	1.66
Magnesium, Total	mg/L	68	68	0	100%	1.04	2.44	1.65
Manganese	mg/L	68	54	14	79%	0.00827	0.0677	0.0228
Manganese, Total	mg/L	68	68	0	100%	0.0219	0.0774	0.0397
Nickel, Total	mg/L	68	1	67	1%	0.0012	0.0012	0.00274
Potassium	mg/L	58	14	44	24%	0.92	1.4	0.654
Potassium, Total	mg/L	58	12	46	21%	0.94	1.26	0.629
Silica	mg/L	10	8	2	80%	1.08	3.72	2.4
Sodium	mg/L	58	58	0	100%	1.06	3.45	2.08
Sodium, Total	mg/L	58	58	0	100%	1.06	2.98	2.04
pH	pH	42	42	0	100%	6.5	7.9	--

Note the MEAN is calculated using the RL/2 as the value for samples that did not have a detectable concentration

Table 3. Background Concentrations of Inorganic Analytes in Emory River Sediment

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean
Aluminum	mg/kg	17	17	0	100%	1730	28600	8169
Barium	mg/kg	17	17	0	100%	29.8	281	92.5
Calcium	mg/kg	17	16	1	94%	376	12800	2071
Chromium	mg/kg	17	16	1	94%	5.12	32.3	11.4
Copper	mg/kg	17	16	1	94%	3.24	18.4	8.32
Iron	mg/kg	17	17	0	100%	5560	25900	12516
Lead	mg/kg	17	17	0	100%	5.3	178	21.7
Magnesium	mg/kg	17	14	3	82%	436	2410	886
Manganese	mg/kg	17	17	0	100%	62.6	1730	508
Nickel	mg/kg	17	17	0	100%	4.84	41.3	16.6
Potassium	mg/kg	17	13	4	76%	291	3360	772
Selenium	mg/kg	17	2	15	12%	3.08	4.06	2.64
Vanadium	mg/kg	17	2	15	12%	19.7	44	14.2
Zinc	mg/kg	17	16	1	94%	18.5	147	55.1

Note the MEAN is calculated using the RL/2 as the value for samples that did not have a detectable concentration

Table 4. Background Concentrations of Inorganic Analytes in Clinch River Surface Water

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean
Alkalinity	ug/L	52	52	0	100%	94000	124000	113838
Chloride	ug/L	3	3	0	100%	5790	6760	6430
Hardness (As CaCO3)	mg/L	43	43	0	100%	108	144	129
Total Dissolved Solids	ug/L	42	42	0	100%	131000	200000	161214
Total Phosphorus	ug/L	3	1	2	33%	318	318	139
Total Suspended Solids	mg/L	52	52	0	100%	3.8	17.6	8.42
Aluminum, Total	mg/L	84	71	13	85%	0.1	0.689	0.204
Arsenic	mg/L	84	1	83	1%	0.00257	0.00257	0.00101
Arsenic, Total	mg/L	84	1	83	1%	0.00278	0.00278	0.00102
Barium	mg/L	84	81	3	96%	0.0126	0.0444	0.0312
Barium, Total	mg/L	84	84	0	100%	0.0319	0.0493	0.0367
Calcium	mg/L	74	74	0	100%	13.4	40.6	33
Calcium, Total	mg/L	82	82	0	100%	29.2	39.1	35.2
Copper	mg/L	84	2	82	2%	0.0011	0.00756	0.00254
Copper, Total	mg/L	84	2	82	2%	0.001	0.00932	0.00256
Iron, Total	mg/L	84	83	1	99%	0.0922	0.878	0.249
Magnesium	mg/L	84	84	0	100%	8.33	13.5	11
Magnesium, Total	mg/L	84	84	0	100%	8.44	13	10.8
Manganese	mg/L	84	5	79	6%	0.0014	0.00866	0.0033
Manganese, Total	mg/L	84	82	2	98%	0.0265	0.0741	0.0378
Potassium	mg/L	74	74	0	100%	1.42	2.12	1.76
Potassium, Total	mg/L	74	74	0	100%	1.51	2.2	1.78
Silica	mg/L	10	8	2	80%	1.18	3.63	2.26
Sodium	mg/L	74	74	0	100%	5.46	10.6	7.85
Sodium, Total	mg/L	74	74	0	100%	5.5	10.2	7.74
pH	PH	42	42	0	100%	7	8.3	--

Note the MEAN is calculated using the RL/2 as the value for samples that did not have a detectable concentration

Table 5. Background Concentrations of Inorganic Analytes in Clinch River Sediment

Analyte	Units	Number of Samples	Number of detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean
Aluminum	mg/kg	46	46	0	100%	2930	20000	8311.69
Antimony	mg/kg	64	5	59	8%	0.12	5	0.45
Arsenic	mg/kg	84	83	1	99%	1.6	35	7.85
Barium	mg/kg	46	46	0	100%	33.18	163	76.35
Beryllium	mg/kg	84	83	1	99%	0.25	1.1	0.62
Boron	mg/kg	41	36	5	88%	0.6	9	3.36
Cadmium	mg/kg	84	76	8	90%	0.026	2.2	0.50
Calcium	mg/kg	46	46	0	100%	844	195000	7370.02
Chromium	mg/kg	84	84	0	100%	5.80	68.60	17.45
Cobalt	mg/kg	46	46	0	100%	5.14	15.7	9.40
Copper	mg/kg	84	84	0	100%	3.93	51.8	16.32
Iron	mg/kg	46	46	0	100%	8290	24200	14248.02
Lead	mg/kg	84	83	1	99%	5	47.87	17.39
Lithium	mg/kg	12	11	1	92%	3.05	17.8	8.05
Magnesium	mg/kg	46	46	0	100%	629	7590	1872.30
Manganese	mg/kg	46	46	0	100%	140	1830	876.46
Mercury	mg/kg	97	97	0	100%	0.0029	160	6.24
Methylmercury	mg/kg	16	16	0	100%	0.0001	0.0036	0.0012
Molybdenum	mg/kg	37	0	37	0%	0.16	0.85	0.39
Nickel	mg/kg	84	84	0	100%	2.40	57.70	17.61
Potassium	mg/kg	46	46	0	100%	377	1950	924.17
Selenium	mg/kg	67	20	47	30%	0.075	5	0.44
Silver	mg/kg	48	34	14	71%	0.027	1.80	0.28
Sodium	mg/kg	46	45	1	98%	19.30	691	62.76
Strontium	mg/kg	4	4	0	100%	7.30	14.50	9.65
Thallium	mg/kg	82	5	77	6%	0.05	0.72	0.17
Uranium	mg/kg	39	33	6	85%	0.15	16.6	1.71
Vanadium	mg/kg	46	46	0	100%	6.25	33	15.10
Zinc	mg/kg	84	84	0	100%	28.43	102	60.42

Note the MEAN is calculated using the RL/2 as the value for samples that did not have a detectable concentration

Table 6. Reference Concentrations of Inorganic Analytes in Emory River and Clinch River Fish Filets (Post-release)

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean
% Lipids	%	29	29	0	100%	0.08	2.94	0.47
Arsenic	mg/kg	29	10	19	34%	0.05	0.23	0.10
Barium	mg/kg	29	6	23	21%	0.05	0.70	0.08
Calcium	mg/kg	29	22	7	76%	49.54	6327	751.3
Chromium	mg/kg	29	19	10	66%	0.05	0.43	0.12
Copper	mg/kg	29	6	23	21%	0.24	0.76	0.32
Lead	mg/kg	29	1	28	3%	0.05	0.14	0.05
Magnesium	mg/kg	29	29	0	100%	169.08	359.04	231
Manganese	mg/kg	29	4	25	14%	0.25	5.66	0.49
Mercury	mg/kg	29	28	1	97%	0.01	0.22	0.07
Nickel	mg/kg	29	3	26	10%	0.05	0.20	0.06
Potassium	mg/kg	29	29	0	100%	2738.00	3780	3311
Selenium	mg/kg	29	27	2	93%	0.10	0.74	0.40
Sodium	mg/kg	29	29	0	100%	285.12	476.32	379
Zinc	mg/kg	29	29	0	100%	4.18	13.51	7.93

Reference locations at Emory River mile (ERM) 8.0 and Clinch River Mile (CRM 9.5)

Note: Mean concentrations are calculated using 1/2 the reporting quantitation limit for results reported as non-detect.

Table 7. Reference Concentrations of Inorganic Analytes in Clinch River and Tennessee River Fish (Pre-release)

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean
Catfish (*Ictalurus spp.*)								
Aluminum	mg/kg	36	21	15	58%	0.31	3.0	0.96
Antimony	mg/kg	46	6	40	13%	0.055	0.10	0.089
Arsenic	mg/kg	46	20	26	43%	0.071	1.1	0.33
Barium	mg/kg	36	28	8	78%	0.0083	0.20	0.044
Beryllium	mg/kg	46	3	43	7%	0.00040	0.0058	0.0022
Boron	mg/kg	36	7	29	19%	0.038	0.070	0.054
Cadmium	mg/kg	46	7	39	15%	0.0060	0.0078	0.0068
Calcium	mg/kg	36	36	0	100%	70	293	106
Chromium	mg/kg	46	19	27	41%	0.020	0.28	0.071
Cobalt	mg/kg	36	3	33	8%	0.013	0.023	0.018
Copper	mg/kg	46	36	10	78%	0.13	0.59	0.32
Iron	mg/kg	36	36	0	100%	2.4	15	4.8
Lead	mg/kg	46	20	26	43%	0.023	4.4	0.30
Magnesium	mg/kg	36	36	0	100%	181	324	233
Manganese	mg/kg	36	34	2	94%	0.094	0.46	0.22
Mercury	mg/kg	46	46	0	100%	0.050	0.51	0.15
Molybdenum	mg/kg	36	6	30	17%	0.017	0.043	0.030
Nickel	mg/kg	46	4	42	9%	0.045	5.9	2.1
Potassium	mg/kg	36	36	0	100%	1760	4710	3269
Selenium	mg/kg	46	27	19	59%	0.23	1.0	0.53
Silver	mg/kg	46	5	41	11%	0.012	0.096	0.046
Sodium	mg/kg	36	36	0	100%	180	430	356
Thallium	mg/kg	44	30	14	68%	0.0018	0.029	0.0046
Vanadium	mg/kg	36	1	35	3%	0.015	0.015	0.015
Zinc	mg/kg	46	45	1	98%	3.6	15	7.2
Channel Catfish (*Ictalurus punctatus*)								
Mercury	mg/kg	132	130	2	98%	0.029	1.1	0.20
Bluegill Sunfish (*Lepomis macrochirus*)								
Arsenic	mg/kg	120	32	88	27%	0.0060	0.14	0.058
Beryllium	mg/kg	120	26	94	22%	0.0020	0.0060	0.0032
Copper	mg/kg	58	25	33	43%	0.092	55	2.6
Mercury	mg/kg	270	202	68	75%	0.010	0.71	0.12
Selenium	mg/kg	120	112	8	93%	0.15	0.90	0.36

Table 7. Continued

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean
Sunfish (*Lepomis spp.*)								
Aluminum	mg/kg	60	30	30	50%	0.12	163	14
Antimony	mg/kg	132	9	123	7%	0.059	0.14	0.10
Arsenic	mg/kg	132	38	94	29%	0.053	0.83	0.27
Barium	mg/kg	60	47	13	78%	0.073	1.3	0.26
Beryllium	mg/kg	132	15	117	11%	0.0016	0.025	0.0060
Boron	mg/kg	60	9	51	15%	0.040	0.29	0.13
Cadmium	mg/kg	132	11	121	8%	0.0040	0.025	0.010
Calcium	mg/kg	60	60	0	100%	145	6900	1774
Chromium	mg/kg	132	57	75	43%	0.045	0.80	0.17
Cobalt	mg/kg	60	10	50	17%	0.011	0.019	0.014
Copper	mg/kg	132	82	50	62%	0.12	1.5	0.30
Iron	mg/kg	60	50	10	83%	1.5	34	6.0
Lead	mg/kg	120	29	91	24%	0.020	0.60	0.11
Magnesium	mg/kg	60	60	0	100%	230	398	296
Manganese	mg/kg	60	55	5	92%	0.24	8.2	1.6
Mercury	mg/kg	132	120	12	91%	0.015	0.53	0.11
Molybdenum	mg/kg	60	7	53	12%	0.021	0.085	0.048
Nickel	mg/kg	132	10	122	8%	0.020	0.42	0.16
Potassium	mg/kg	60	60	0	100%	2300	4570	3392
Selenium	mg/kg	132	51	81	39%	0.33	1.9	0.82
Silver	mg/kg	132	9	123	7%	0.014	0.11	0.027
Sodium	mg/kg	60	60	0	100%	239	814	519
Thallium	mg/kg	120	38	82	32%	0.0034	0.022	0.0071
Vanadium	mg/kg	60	12	48	20%	0.0099	0.036	0.020
Zinc	mg/kg	132	132	0	100%	7.0	24	13

Source: Oak Ridge Environmental Information System (OREIS)
http://www-oreis.bechteljacobs.org/oreis/help/oreishome.html

Sampling locations include those from Clinch River Mile (CRM) 0.0 to CRM 23 (Melton Hill Dam) and from Tennessee River Mile (TRM) 530 (Watts Bart Dam) to TRM 572.

Sampling dates range from 1987 through 2008.

All concentrations are for fillets on wet weight basis.

Table 8. Summary Statistics and Preliminary Screening Results for Ash

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean	Human Health Soil-Sediment Screen	Number of Detections > Screen
pH	pH	4	4	0	100%	8.1	9	8.5		0
Aluminum, Total	mg/kg	84	84	0	100%	1730	**46000**	20184	7700	**69**
Arsenic, Total	mg/kg	88	79	9	90%	**1.84**	**166**	50	0.39	**79**
Barium, Total	mg/kg	88	88	0	100%	18.3	1410	501	1500	0
Beryllium, Total	mg/kg	84	58	26	69%	1.36	9.6	3.95	16	0
Boron, Total	mg/kg	84	59	25	70%	13	262	66.7	1600	0
Calcium, Total	mg/kg	84	82	2	98%	292	31800	8694		0
Chromium, Total	mg/kg	88	87	1	99%	3.19	68	33.3	280	0
Cobalt, Total	mg/kg	84	48	36	57%	**11.4**	**29.7**	14.6	2.3	**48**
Copper, Total	mg/kg	88	85	3	97%	3.68	102	47.9	310	0
Iron, Total	mg/kg	84	84	0	100%	3650	**39700**	16856	5500	**77**
Lead, Total	mg/kg	88	88	0	100%	2.12	**60.5**	22.2	40	**4**
Magnesium, Total	mg/kg	84	81	3	96%	274	7020	2178		0
Manganese, Total	mg/kg	84	84	0	100%	38.8	**698**	149	180	**16**
Mercury, Total	mg/kg	12	6	6	50%	0.064	0.2	0.0915	4.3	0
Nickel, Total	mg/kg	88	87	1	99%	4.39	64.4	30.2	150	0
Potassium, Total	mg/kg	84	81	3	96%	302	7040	2783		0
Selenium, Total	mg/kg	88	59	29	67%	2.21	17.8	4.61	39	0
Sodium, Total	mg/kg	84	53	31	63%	283	1790	587		0
Thallium, Total	mg/kg	84	4	80	5%	**2.65**	**3.8**	1.47	0.51	**4**
Vanadium, Total	mg/kg	84	74	10	88%	15.6	**175**	79.4	39	**58**
Zinc, Total	mg/kg	88	88	0	100%	15	94.7	50.2	2300	0

Note the MEAN is calculated using the RL/2 as the value for samples that did not have a detectable concentration

Table 9. Summary Statistics and Preliminary Screening Results for Emory River Surface Water (Post-release)

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean	Human Health Surface Water Screen	Number of Detections > Screen
Alkalinity	ug/L	194	172	22	88.7	10000	168000	40838		0
Chloride	ug/L	7	7	0	100	2770	6400	5026		0
Fluoride	ug/L	7	1	6	14.3	600	600	129		0
Hardness (As CaCO3)	mg/L	79	79	0	100	16	135	72		0
Total Dissolved Solids	ug/L	154	154	0	100	11000	185000	72747	250	0
Total Phosphorus	ug/L	7	1	6	14.3	137	137	62.4		0
Total Suspended Solids	mg/L	194	194	0	100	1.7	52	8.95		0
Aluminum	mg/L	318	5	313	1.6	0.125	0.702	0.055	3.7	0
Aluminum, Total	mg/L	320	287	33	89.7	0.101	**96**	1.21	3.7	**8**
Antimony, Total	mg/L	320	5	315	1.6	**0.00225**	**0.00364**	0.00103	0.0015	**5**
Arsenic	mg/L	318	29	289	9.1	**0.00215**	**0.0281**	0.0015	0.000018	**29**
Arsenic, Total	mg/L	320	44	276	13.8	**0.00206**	**0.189**	0.00315	0.000018	**44**
Barium	mg/L	318	316	2	99.4	0.0128	0.11	0.0287	0.73	0
Barium, Total	mg/L	320	320	0	100	0.0215	**1.91**	0.0486	0.73	**3**
Beryllium, Total	mg/L	320	3	317	0.9	0.00208	**0.00878**	0.00112	0.004	**1**
Boron	mg/L	318	7	311	2.2	0.0561	0.113	0.0264	0.73	0
Boron, Total	mg/L	320	8	312	2.5	0.061	0.227	0.0277	0.73	0
Calcium	mg/L	278	278	0	100	4.45	40.7	13.7		0
Calcium, Total	mg/L	312	312	0	100	4.61	38.7	14.5		0
Chromium, Total	mg/L	320	10	310	3.1	0.00268	0.0829	0.0017	0.1	0
Cobalt	mg/L	317	1	316	0.3	0.0014	0.0014	0.00214	0.011	0
Cobalt, Total	mg/L	320	9	311	2.8	0.0022	**0.0546**	0.0026	0.011	**4**
Copper	mg/L	319	6	313	1.9	0.0016	0.0157	0.00257	0.15	0
Copper, Total	mg/L	320	11	309	3.4	0.001	**0.223**	0.00427	0.15	**1**
Iron	mg/L	318	62	256	19%	0.0508	0.287	0.0344	0.3	0
Iron, Total	mg/L	320	320	0	100%	0.0905	**37.5**	0.674	0.3	**105**
Lead, Total	mg/L	285	10	275	4%	0.00323	**0.104**	0.00211	0.005	**8**
Magnesium	mg/L	318	318	0	100%	1.02	13.6	4.2		0
Magnesium, Total	mg/L	320	320	0	100%	1.1	12.9	4.25		0
Manganese	mg/L	318	157	161	49%	0.00517	**0.519**	0.0174	0.05	**12**
Manganese, Total	mg/L	320	318	2	99%	0.0213	**0.666**	0.0543	0.05	**87**
Mercury, Total	mg/L	194	2	192	1%	0.000245	**0.00027**	0.000102	0.00005	**1**
Molybdenum	mg/L	318	2	316	0.6%	0.00515	0.00549	0.00534	0.018	0
Molybdenum, Total	mg/L	320	1	319	0.3%	0.00585	0.00585	0.00555	0.018	0

Table 9. Continued

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean	Human Health Surface Water Screen	Number of Detections > Screen
Nickel, Total	mg/L	320	9	311	3%	0.0011	**0.126**	0.00368	0.073	**2**
Potassium	mg/L	278	131	147	47%	0.93	2.11	0.945		0
Potassium, Total	mg/L	280	135	145	48%	0.93	17.6	1.14		0
Selenium	mg/L	318	3	315	0.9%	0.00233	0.00512	0.00102	0.018	0
Silica	mg/L	40	34	6	85%	1.01	5.05	2.61		0
Sodium	mg/L	278	278	0	100%	1.02	10.7	3.53		0
Sodium, Total	mg/L	280	280	0	100%	1.04	10.1	3.55		0
Thallium, Total	mg/L	320	3	317	0.9%	**0.0033**	**0.00491**	0.00103	0.00024	**3**
Vanadium	mg/L	278	6	272	2%	0.00604	**0.0265**	0.00227	0.018	**2**
Vanadium, Total	mg/L	280	14	266	5%	0.0044	**0.339**	0.00521	0.018	**8**
Zinc	mg/L	318	1	317	0.3%	0.151	0.151	0.0253	7.4	0
Zinc, Total	mg/L	320	2	318	0.6%	0.0527	0.104	0.0269	7.4	0
pH	PH	154	154	0	100%	6.2	8.3	--		0

Note the MEAN is calculated using the RL/2 as the value for samples that did not have a detectable concentration

Table 10. Summary Statistics and Preliminary Screening Results for Clinch River Surface Water (Post-release)

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean	Health Surface Water Screen	Number of Detections > Screen
Alkalinity	ug/L	156	156	0	100%	16800	123000	79353		0
Chloride	ug/L	9	9	0	100%	5370	8720	6603		0
Hardness (As CaCO3)	mg/L	63	63	0	100%	24.7	134	92		0
Total Dissolved Solids	ug/L	126	126	0	100%	44000	204000	114071	250	0
Total Phosphorus	ug/L	9	3	6	33%	291	373	142		0
Total Suspended Solids	mg/L	156	155	1	99%	3.8	80.6	11.1		0
Aluminum	mg/L	249	4	245	2%	0.155	0.378	0.0558	3.7	0
Aluminum, Total	mg/L	250	232	18	93%	0.118	**57.8**	0.776	3.7	**4**
Antimony, Total	mg/L	249	2	247	0.8%	**0.00347**	**0.00347**	0.00101	0.0015	**2**
Arsenic	mg/L	249	14	235	6%	**0.00207**	**0.0242**	0.00127	0.000018	**14**
Arsenic, Total	mg/L	250	33	217	13%	**0.0013**	**0.109**	0.00216	0.000018	**33**
Barium	mg/L	249	245	4	98%	0.0101	0.0923	0.0302	0.73	0
Barium, Total	mg/L	250	250	0	100%	0.0189	**1.04**	0.0441	0.73	**2**
Beryllium, Total	mg/L	250	2	248	0.8%	**0.00614**	**0.0076**	0.00108	0.004	**2**
Boron	mg/L	249	1	248	0.4%	0.0509	0.0509	0.0254	0.73	0
Boron, Total	mg/L	250	2	248	0.8%	0.114	0.143	0.0261	0.73	0
Calcium	mg/L	219	219	0	100%	6.89	40.4	25		0
Calcium, Total	mg/L	244	244	0	100%	6.97	38.6	26.9		0
Chromium, Total	mg/L	250	9	241	4%	0.001	0.0352	0.0013	0.1	0
Cobalt, Total	mg/L	250	4	246	2%	0.00274	**0.0321**	0.00231	0.011	**2**
Copper	mg/L	249	10	239	4%	0.0015	0.00918	0.00266	0.15	0
Copper, Total	mg/L	250	9	241	4%	0.0011	0.0938	0.00326	0.15	0
Iron	mg/L	249	6	243	2%	0.0817	**0.35**	0.0285	0.3	**1**
Iron, Total	mg/L	250	249	1	100%	0.0882	**20.9**	0.451	0.3	**77**
Lead, Total	mg/L	203	7	196	3%	0.00214	**0.0648**	0.00164	0.005	**4**
Magnesium	mg/L	249	249	0	100%	1.71	13.5	8.09		0
Magnesium, Total	mg/L	250	250	0	100%	1.78	12.6	8.06		0
Manganese	mg/L	249	57	192	23%	0.00546	0.0347	0.00553	0.05	0
Manganese, Total	mg/L	250	246	4	98%	0.00956	**0.175**	0.0403	0.05	**37**
Molybdenum, Total	mg/L	250	1	249	0.4%	0.001	0.001	0.00536	0.018	0
Nickel, Total	mg/L	250	7	243	3%	0.0014	0.053	0.0031	0.073	0
Potassium	mg/L	219	207	12	95%	1.01	2.1	1.5		0
Potassium, Total	mg/L	220	215	5	98%	1.04	11.6	1.64		0
Selenium	mg/L	249	2	247	0.8%	0.00264	0.00302	0.00101	0.018	0

Table 10. Continued

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean	Health Surface Water Screen	Number of Detections > Screen
Silica	mg/L	30	26	4	87%	1.21	7.78	2.57		0
Sodium	mg/L	219	219	0	100%	1.34	11.1	6.48		0
Sodium, Total	mg/L	220	220	0	100%	1.42	10.1	6.4		0
Thallium, Total	mg/L	250	2	248	0.8%	**0.00277**	**0.00316**	0.00101	0.00024	**2**
Vanadium	mg/L	219	3	216	1%	0.00434	**0.0231**	0.00217	0.018	**2**
Vanadium, Total	mg/L	220	17	203	8%	0.0012	**0.143**	0.00348	0.018	**3**
Zinc, Total	mg/L	250	2	248	0.8%	0.077	0.0942	0.0252	7.4	0
pH	PH	126	126	0	100%	6.9	8.3	7.56		0

Note the MEAN is calculated using the RL/2 as the value for samples that did not have a detectable concentration

Table 11. Summary Statistics and Preliminary Screening Results for Tennessee River Surface Water (Post-release)

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean	Human Health Surface Water Screen	Number of Detections > Screen
Alkalinity	ug/L	58	58	0	100%	48100	84900	65755		0
Chloride	ug/L	3	3	0	100%	6300	8820	7423		0
Hardness (As CaCO3)	mg/L	21	21	0	100%	53.7	84.7	66.1		0
Total Dissolved Solids	ug/L	48	48	0	100%	70000	126000	94146	250	0
Total Phosphorus	ug/L	3	1	2	33%	312	312	137		0
Total Suspended Solids	mg/L	58	58	0	100%	4.4	12.6	7.21		0
Aluminum, Total	mg/L	91	72	19	79%	0.101	0.826	0.191	3.7	0
Antimony	mg/L	91	1	90	1%	**0.0025**	**0.0025**	0.00101	0.0015	**1**
Antimony, Total	mg/L	90	2	88	2%	**0.00206**	**0.00307**	0.00103	0.0015	**2**
Barium	mg/L	91	91	0	100%	0.0119	0.0311	0.0215	0.73	0
Barium, Total	mg/L	91	91	0	100%	0.0181	0.035	0.0246	0.73	0
Calcium	mg/L	81	81	0	100%	13.8	26	19.3		0
Calcium, Total	mg/L	89	89	0	100%	14.1	25.9	19.4		0
Copper	mg/L	90	2	88	2%	0.00578	0.0133	0.00263	0.15	0
Iron, Total	mg/L	91	91	0	100%	0.0626	**1.21**	0.265	0.3	**21**
Magnesium	mg/L	91	91	0	100%	3.7	7.89	4.92		0
Magnesium, Total	mg/L	91	91	0	100%	3.6	7.82	4.89		0
Manganese	mg/L	91	2	89	2%	0.00533	0.00767	0.00312	0.05	0
Manganese, Total	mg/L	91	90	1	99%	0.0164	**0.14**	0.0435	0.05	**14**
Mercury	mg/L	58	1	57	2%	**0.000245**	**0.000245**	0.000103	0.00005	**1**
Potassium	mg/L	81	80	1	99%	1.06	2.12	1.56		0
Potassium, Total	mg/L	81	80	1	99%	1.09	2.2	1.56		0
Silica	mg/L	10	10	0	100%	1.56	5.3	3.56		0
Sodium	mg/L	81	81	0	100%	3.03	10.9	7.4		0
Sodium, Total	mg/L	81	81	0	100%	3.11	10.4	7.25		0
pH	pH	48	48	0	100%	7	8.6	--		0

Note the MEAN is calculated using the RL/2 as the value for samples that did not have a detectable concentration

Table 12. Summary Statistics and Preliminary Screening Results for Fish

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Mean	Human Health Fish Screen	Number of Detections > Screen
Aluminum, Total	mg/kg	79	3	76	4%	167	226	61.2	1350	0
Arsenic, Total	mg/kg	79	45	34	57%	**0.21**	**1.5**	0.597	0.0021	**45**
Barium, Total	mg/kg	79	41	38	52%	0.45	33	2.83	270	0
Calcium, Total	mg/kg	79	71	8	90%	413	213000	20582		0
Chromium, Total	mg/kg	79	56	23	71%	0.35	2.5	0.544	2030	0
Cobalt, Total	mg/kg	79	3	76	4%	0.11	0.2	0.22	0.406	0
Copper, Total	mg/kg	79	16	63	20%	1.2	7.4	1.47	54.1	0
Iron, Total	mg/kg	79	3	76	4%	111	326	60.6	946	0
Lead, Total	mg/kg	79	5	74	6%	0.24	**0.75**	0.238		**3**
Magnesium, Total	mg/kg	79	79	0	100%	294	3870	1240		0
Manganese, Total	mg/kg	79	37	42	47%	2.5	77.9	7.26	189	0
Mercury, Total	mg/kg	79	57	22	72%	0.07	**1.2**	0.248	0.135	**46**
Nickel, Total	mg/kg	79	17	62	22%	0.35	3.1	0.358	27	0
Potassium, Total	mg/kg	79	79	0	100%	2180	21200	13984		0
Selenium, Total	mg/kg	79	73	6	92%	0.45	3.4	1.81	6.76	0
Sodium, Total	mg/kg	79	79	0	100%	877	6210	2464		0
Vanadium, Total	mg/kg	79	3	76	4%	0.47	1.4	0.463	6.81	0
Zinc, Total	mg/kg	79	79	0	100%	21.1	110	42.8	406	0

Note the MEAN is calculated using the RL/2 as the value for samples that did not have a detectable concentration

Table 13 Exposure Parameters			
Land Use and Exposure Pathway	**Parameter Value**	**Units**	**Source**
Residential			
Ingestion of Potable Water	2	liters	EPA 1991
Ingestion of Soil and Ash	100	mg (adult)	EPA 1991
	200	mg (child)	EPA 1991
Particulate Emission Factor	2.41E+09	m^3/kg	EPA 2002
Skin Surface Area (Dermal Contact - Soil and Ash)	5700	cm^2 (adult)	EPA 2004
	2800	cm^2 (child)	EPA 2004
Skin Surface Area (Dermal Contact - Potable Water)	18000	cm^2 (adult)	EPA 2004
	6600	cm^2 (child)	EPA 2004
Exposure Frequency	350	days/year	EPA 1991
Exposure Duration	6	years (child)	EPA 1991
	24	years (adult)	EPA 1991
Body Weight	15	kg (child)	EPA 1991
	70	kg (adult)	EPA 1991
Indoor Worker			
Ingestion of Soil and Ash	50	mg	EPA 1991
	20	m^3	EPA 1991
Particulate Emission Factor	2.41E+09	m^3/kg	EPA 2002
Exposure Frequency	250	days/year	EPA 1991
Exposure Duration	25	years	EPA 1991
Body Weight	70	kg	EPA 1991
Outdoor Worker			
Ingestion of Soil and Ash	100	mg	EPA 1991
	20	m^3	EPA 1991
Particulate Emission Factor	2.41E+09	m^3/kg	EPA 2002
Skin Surface Area (Dermal Contact - Soil and Ash)	3300	cm^2	EPA 2004
Exposure Frequency	250	days/year	EPA 1991
Exposure Duration	25	years	EPA 1991
Body Weight	70	kg	EPA 1991
Groundskeeper			
Ingestion of Soil and Ash	330	mg	EPA 2002
	20	m^3	EPA 1991
Particulate Emission Factor	1.51E+09	m^3/kg	EPA 2002
Skin Surface Area	3300	cm^2	EPA 2002
Exposure Frequency	140	days/year	BPJ[1]
Exposure Duration	25	years	EPA 1991
Body Weight	70	kg	EPA 1991

Table 13. Continued			
Land Use and Exposure Pathway	**Parameter Value**	**Units**	**Source**
Recreational			
Ingestion of Surface Water	0.05	liters/hour	EPA 2000
Ingestion of Soil, Sediment, and Ash	100	mg (adult)	EPA 1991
	200	mg (child)	EPA 1991
Particulate Emission Factor	1.51E+09	m^3/kg	EPA 2002
Skin Surface Area (Dermal Contact - Soil, Sediment, and Ash)	5,700	cm^2 (adult)	EPA 2004
	2,800	cm^2 (child)	EPA 2004
Skin Surface Area (Dermal Contact - Surface Water)	18,000	cm^2 (adult)	EPA 2004
	14,675	cm^2 (child)	EPA 2004
Exposure Frequency - Soil and Ash	84	days/year	BPJ[2]
	84	days/year	BPJ[3]
Exposure Frequency - Sediment	48	days/year	BPJ[4]
Exposure Time - soil	1.5	hours/day	BPJ[5]
Exposure Frequency - Surface Water	45	days/year	DOE 1996
Exposure Time - Surface Water	1.4	hours/day	DOE 1996
Exposure Duration	6	years (child)	EPA 2000
	10	years (adult)	EPA 2000
Body Weight	51	kg (child)	EPA 2000
	70	kg (adult)	EPA 1991
Consumption of Locally Caught Fish	54	g/day	EPA 1991
Consumption of Locally Caught Fish	6.5	g/day	TDEC 1200-4-03
Adolescent Trespasser			
Ingestion of Soil, Sediment, and Ash	120	mg	EPA 1991
Particulate Emission Factor	1.51E+09	m^3/kg	EPA 2002
Skin Surface Area (Dermal Contact - Soil, Sediment, and Ash)	3,522	cm^2	EPA 2004
Exposure Frequency - Soil, Sediment, and Ash	84	days/year	BPJ[3]
Exposure Duration	10	years	EPA 2000
Body Weight	45	kg	EPA 2000

Notes:

1. Assumes intensive ground contact activities occur 5 days/week for 7 months.
2. Assumes child participates and parents watch children participating in sporting activities including practices, games, and tournaments 3 days/week for 7 months.

3. Assumes outdoor activity occurs 3 days per week between April and October when temperatures are at or above 70 degrees F.
4. Assumes outdoor activity occurs 2 days per week from October through March when Watts Bar Reservoir is a winter pool.
5. Assumes participation in sporting activities including practices, games, and tournaments lasts 1.5 hour.

BPJ = Best Professional Judgment

kg = kilogram

cm^2 = square centimeter

m^3 = cubic meter

g = gram

mg = milligram

Table 14. Summary of Federal and State Listed Species Based on Records of Occurrence

Scientific Name	Common Name	EO Ranks	County	State Status	Federal Status
Plants					
Agalinis auriculata	Earleaf Foxglove	E	ROANE	END	
Asplenium scolopendrium var. americanum	American Hart's-tongue Fern	X?	ROANE	END	LT
Aureolaria patula	Spreading False-foxglove	E	ROANE	SPCO	
Bolboschoenus fluviatilis	River Bulrush	E	ROANE	SPCO	
Carex gravida	Heavy-fruited Sedge	E	ROANE	SPCO	
Carex oxylepis var. pubescens	Hairy sharp-scaled Sedge	H	ROANE	SPCO	
Cimicifuga rubifolia	Appalachian Bugbane	E	ROANE	THR	
Cypripedium acaule	Pink Lady-slipper	E	ROANE	S-CE	
Delphinium exaltatum	Tall Larkspur	E	ROANE	END	
Diervilla lonicera	Northern Bush-honeysuckle	E	ROANE	THR	
Diervilla sessilifolia var. rivularis	Mountain Bush-honeysuckle	E	ROANE	THR	
Draba ramosissima	Branching Whitlow-wort	E	ROANE	SPCO	
Elodea nuttallii	Waterweed	E	ROANE	SPCO	
Helianthus occidentalis	Mcdowell Sunflower	E	ROANE	SPCO	
Hydrastis canadensis	Goldenseal	E	ROANE	S-CE	
Juglans cinerea	Butternut	E	ROANE	THR	
Juncus brachycephalus	Short-head Rush	E	ROANE	SPCO	
Leucothoe racemosa	Fetter-bush	E	ROANE	THR	
Liatris cylindracea	Slender Blazing-star	E	ROANE	THR	
Lilium canadense	Canada Lily	E	ROANE	THR	
Liparis loeselii	Loesel's Twayblade	E	ROANE	THR	
Lonicera dioica	Mountain Honeysuckle	E	ROANE	SPCO	
Marshallia grandiflora	Large-flowered Barbara's-buttons	H	ROANE	END	
Myurella julacea	Myurella moss	H	ROANE	S-P	
Panax quinquefolius	American Ginseng	E	ROANE	S-CE	
Pedicularis lanceolata	Swamp Lousewort	E	ROANE	SPCO	
Platanthera flava var. herbiola	Pale Green Orchid	E	ROANE	THR	
Platanthera integrilabia	Monkey-face Orchid	X?	ROANE	END	C
Preissia quadrata	Blister ribbon	E	ROANE	THR	
Pseudognaphalium helleri	Heller's Catfoot	E	ROANE	SPCO	
Ruellia purshiana	Pursh's Wild-petunia	E	ROANE	SPCO	
Solidago ptarmicoides	Prairie Goldenrod	E	ROANE	END	
Spiraea virginiana	Virginia Spiraea	E	MORGAN	END	LT
Spiranthes lucida	Shining Ladies'-tresses	E	ROANE	THR	

Table 14. Continued

Scientific Name	Common Name	EO Ranks	County	State Status	Federal Status
Symphyotrichum pratense	Barrens Silky Aster	E	ROANE	END	
Thuja occidentalis	Northern White Cedar	H	ROANE	SPCO	
Villosa perpurpurea	Purple Bean	H	ROANE	END	LE
Viola tripartita var. tripartita	Three-parted Violet	E	ROANE	SPCO	
Invertebrates					
Caecidotea incurva	Incurved Cave Isopod	H	ROANE	TRKD	
Cumberlandia monodonta	Spectaclecase	H	ROANE	TRKD	C
Epioblasma turgidula	Turgid Blossom Pearlymussel	X	ROANE	EXTI	LE
Fusconaia cor	Shiny Pigtoe Pearlymussel	X	ROANE	END	LE
Fusconaia cuneolus	Fine-rayed Pigtoe	H, X	ROANE	END	LE
Io fluvialis	Spiny Riversnail	E	ROANE	TRKD	
Lampsilis abrupta	Pink Mucket	E	ROANE	END	LE
Lampsilis virescens	Alabama Lampmussel	H	ROANE	END	LE
Lithasia geniculata	Ornate Rocksnail	H	ROANE	TRKD	
Plethobasus cooperianus	Orange-foot Pimpleback	H	ROANE	END	LE
Pleurobema rubrum	Pyramid Pigtoe	E	ROANE	TRKD	
Amphibians					
Cryptobranchus alleganiensis	Hellbender	E, H	ROANE	NMGT	
Gyrinophilus palleucus	Tennessee Cave Salamander	E	ROANE	THR	
Hemidactylium scutatum	Four-toed Salamander	E	ROANE	NMGT	
Reptiles					
Ophisaurus attenuatus longicaudus	Eastern Slender Glass Lizard	H	ROANE	NMGT	
Fish					
Cycleptus elongatus	Blue Sucker	E	ROANE	THR	
Cyprinella monacha	Spotfin Chub	X?	ROANE	THR	LT
Hemitremia flammea	Flame Chub	H	ROANE	NMGT	
Percina aurantiaca	Tangerine Darter	E	MORGAN	NMGT	
Phoxinus tennesseensis	Tennessee Dace	E	ROANE	NMGT	
Birds					
Accipiter striatus	Sharp-shinned Hawk	H	ROANE	NMGT	
Aimophila aestivalis	Bachman's Sparrow	E	ROANE	END	
Haliaeetus leucocephalus	Bald Eagle	AC, BC	ROANE	NMGT	
Pandion haliaetus	Osprey	E, X	ROANE		
Colonial Wading Bird Colony		AC, E	ROANE		

Table 14. Continued

Scientific Name	Common Name	EO Ranks	County	State Status	Federal Status
Mammals					
Myotis grisescens	Gray Bat	AC, E	ROANE	END	LE
Sorex longirostris	Southeastern Shrew	E, H	ROANE	NMGT	

Source : Tennessee Valley Authority Regional Natural Heritage Program
Element Occurrence (EO) Ranks are summarized for species with multiple occurrences

Element Occurrence (EO) Rank
AC - Excellent; good; or fair estimated viability
BC - Good or fair estimated viability
E - Verified extant (viability not assessed)
H - Historical
X - Extirpated
X? - Possibly extirpated

State Status
END - Endangered
EXTI - Extirpated
NMGT - In Need of Management
S-CE - Special Concern, Commercially Exploited
S-P - Special Concern, Possibly Extirpated
THR - Threatened
TRKD - Tracked by TN natural Heritage Program

Federal Status
C - Candidate
LE - Listed Endangered
TE - Listed Threatened

Table 15. Soil Ecological Screening Values for Use in the Preliminary SLERA

Chemical Name	Region 4 Ecological Screening Values [a] (mg/kg)	USEPA EcoSSL [b] (mg/kg)
Aluminum	50	NA
Antimony	3.5	0.27
Arsenic	10	18
Barium	165	330
Beryllium	1.1	21
Boron	0.5	NA
Cadmium	1.6	0.36
Chromium	0.4	26
Cobalt	20	13
Copper	40	28
Iron	200	NA
Lead	50	11
Magnesium	NA	
Manganese	100	220
Mercury	0.1	NA
Molybdenum	2	NA
Nickel	30	38
Selenium	0.81	0.52
Silver	2	4.2
Thallium	1	NA
Tin	53	NA
Titanium	1000	NA
Vanadium	2	7.8
Zinc	50	46

Notes:
[a] Region 4 Ecological Screening Values (USEPA, 2001c).
[b] USEPA Ecological Soil Screening Levels (USEPA, 2005, 2008; EcoSSL).

mg/kg = Milligrams per kilogram.
NA = Not available.
SLERA = Screening-level ecological risk assessment.
USEPA = United States Environmental Protection Agency.

Table 16. Sediment Ecological Screening Values for Use in the Preliminary SLERA

	Region 4 Ecological Screening Values (mg/kg)
Chemical Name	**Effect Value**
Aluminum	NA
Antimony	2
Arsenic	7.24
Barium	NA
Beryllium	NA
Boron	NA
Cadmium	0.676
Chromium	52.3
Cobalt	NA
Copper	18.7
Iron	NA
Lead	30.2
Magnesium	NA
Manganese	NA
Mercury	0.13
Molybdenum	NA
Nickel	15.9
Selenium	NA
Silver	0.733
Thallium	NA
Tin	NA
Titanium	NA
Vanadium	NA
Zinc	124

Notes:
[a] Region 4 Ecological Screening Values (USEPA, 2001c).

mg/kg = Milligrams per kilogram.
NA = Not available.
SLERA = Screening-level ecological risk assessment.
USEPA = United States Environmental Protection Agency.

Table 17. Surface Water Ecological Screening Values for use in the Preliminary SLERA

	Ambient Water Quality Criteria [a]			Region 4 Ecological Screening Values [b]	
Chemical Name	**CMC**	**CCC**		**CSV**	
Aluminum	0.75	0.087	1	0.087	8
Antimony	NA	NA		0.16	
Arsenic	0.34	0.15	2	0.19	9
Beryllium	NA	NA		0.00053	
Boron	NA	NA		0.75	
Cadmium	0.00042	0.00008	2,3	0.00066	9,10
Chromium	0.016	0.011	4	0.011	
Chromium (III)	0.15	0.02	2,3	0.11732	9,10
Chromium (VI)	0.016	0.011	2	0.011	
Copper	0.003	0.0023	2,3	0.00654	9,10
Iron	NA	1	5	1	
Lead	0.01	0.00041	2,3	0.00132	9,10
Mercury	0.0014	0.00077	6	0.000012	
Nickel	0.12	0.013	2,3	0.08771	9,10
Selenium	20	0.005	7	0.005	
Silver	0.0002	NA	2,3	0.000012	
Thallium	NA	NA		0.004	
Zinc	0.03	0.03	2,3	0.05891	9,10
Alkalinity, Total as CaCO3	NA	20	5	NA	

Notes:

[a] National Ambient Water Quality Criteria (USEPA, 2006; AWQC) and Tennessee Water Quality Criteria (TDEC, 2008). Tennessee has adopted the National Water Quality Criteria for the following constituents: arsenic, cadmium, chromium (III), chromium (VI), copper, lead, mercury, nickel, silver, zinc, and the CCC for selenium. The CMC for selenium is a Tennessee Water Quality Criteria (TDEC, 2008).

[b] Region 4 Ecological Screening Values (USEPA, 2001c).

* Footnotes for AWQC and Region 4 ESVs

1 Based on pH 6.5-9.0; total recoverable concentration.
2 Dissolved concentration.
3 Based on 20 mg/L total hardness.
4 Chromium VI used as surrogate, dissolved concentration.
5 Non-priority pollutant (USEPA Red Book, 1976).
6 Dissolved concentration, based on inorganic mercury.
7 The CMC = 1/[(f1/185.9 µg/L)=(f2/12.83 µg/L)], where f1 and f2 are fractions of selenium that are treated as selenite, and selenate, respectively.
8 Based on pH 6.5-9.0.
9 Criterion.
10 Based on 50 mg/L total hardness.

CCC = Criterion Continuous Concentration.
CMC = Criteria Maximum Concentration.
CSV = Chronic screening value.
ESV = Ecological screening value.
mg/L = Milligrams per liter.
µg/L = Micrograms per liter.

Table 18. Preliminary[1] Summary Statistics and Comparison with Soil Ecological Screening Values for Ash as Soil

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Location for Maximum Detection	Mean[2]	Ecological Soil Screen[3]	Hazard Quotient	Number of Detections > Screen
Aluminum, Total	mg/kg	84	84	0	100.0%	**1730**	**46000**	RA	20184	50	**920**	**84**
Arsenic, Total	mg/kg	88	79	9	89.8%	1.84	**166**	GP 44-46	50	18	**9**	**67**
Barium, Total	mg/kg	88	88	0	100%	18.3	**1410**	S-2	501	330	**4**	**52**
Beryllium, Total	mg/kg	84	58	26	69.0%	1.36	9.6	S-4	3.95	21	0.5	0
Boron, Total	mg/kg	84	59	25	70.2%	**13**	**262**	RA	66.7	0.5	**524**	**59**
Calcium, Total	mg/kg	84	82	2	97.6%	292	31800	RA	8694	NA	NT	0
Chromium, Total	mg/kg	88	87	1	98.9%	3.19	**68**	RA	33.3	26	**3**	**59**
Cobalt, Total	mg/kg	84	48	36	57.1%	11.4	**29.7**	S-4	14.6	13	**2**	**47**
Copper, Total	mg/kg	88	85	3	96.6%	3.68	**102**	GP 46-48	47.9	28	**4**	**64**
Iron, Total	mg/kg	84	84	0	100%	**3650**	**39700**	GP 26-28	16856	200	**199**	**84**
Lead, Total	mg/kg	88	88	0	100%	2.12	**60.5**	ERM2.1GRID12	22.2	11	**6**	**69**
Magnesium, Total	mg/kg	84	81	3	96.4%	274	7020	RA	2178	NA	NT	0
Manganese, Total	mg/kg	84	84	0	100%	38.8	**698**	AFA19	149	220	**3**	**10**
Mercury, Total	mg/kg	12	6	6	50.0%	0.064	**0.2**	ERM.VB.2	0.0915	0.1	**2**	**4**
Nickel, Total	mg/kg	88	87	1	98.9%	4.39	**64.4**	AFA05	30.2	38	**2**	**35**
Potassium, Total	mg/kg	84	81	3	96.4%	302	7040	GP 46-48	2783	NA	NT	0
Selenium, Total	mg/kg	88	59	29	67.0%	**2.21**	**17.8**	GP 48-50	4.61	0.52	**34**	**59**
Sodium, Total	mg/kg	84	53	31	63.1%	283	1790	GP 02-04	587	NA	NT	0
Thallium, Total	mg/kg	84	4	80	4.8%	**2.65**	**3.8**	GP 30-32	1.47	1	**4**	**4**
Vanadium, Total	mg/kg	84	74	10	88.1%	**15.6**	**175**	RA	79.4	7.8	**22**	**74**
Zinc, Total	mg/kg	88	88	0	100%	15	**94.7**	189 LAKESHORE DR	50.2	46	**2**	**50**

Notes:
Matrix: Released Ash
For duplicate samples, the highest detected value or the lowest detection limit were used.

mg/kg = Milligrams per kilogram.
NA = Not available/ not applicable.
NT = Non-toxic.

[1] Summary statistics are provided for screening purposes only pending validation of all data.
[2] MEAN is calculated using one half of the reporting limit as the value for samples that did not have a detectable concentration.
[3] See Table 15 for presentation of soil screening values.

Table 19. Preliminary[1] Summary Statistics and Comparison with Sediment Ecological Screening Values for Ash as Sediment

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Location for Maximum Detection	Mean[2]	Ecological Sediment Screen[3]	Hazard Quotient	Number of Detections > Screen
Aluminum, Total	mg/kg	84	84	0	100%	1730	46000	RA	20184	NA	**NA**	0
Arsenic, Total	mg/kg	88	79	9	89.8%	1.84	**166**	GP 44-46	50	7.24	**23**	**69**
Barium, Total	mg/kg	88	88	0	100%	18.3	1410	S-2	501	NA	**NA**	0
Beryllium, Total	mg/kg	84	58	26	69.0%	1.36	9.6	S-4	3.95	NA	**NA**	0
Boron, Total	mg/kg	84	59	25	70.2%	13	262	RA	66.7	NA	**NA**	0
Calcium, Total	mg/kg	84	82	2	97.6%	292	31800	RA	8694	NA	NT	0
Chromium, Total	mg/kg	88	87	1	98.9%	3.19	**68**	RA	33.3	52.3	1	**12**
Cobalt, Total	mg/kg	84	48	36	57.1%	11.4	29.7	S-4	14.6	NA	**NA**	0
Copper, Total	mg/kg	88	85	3	96.6%	3.68	**102**	GP 46-48	47.9	18.7	**5**	**65**
Iron, Total	mg/kg	84	84	0	100%	3650	39700	GP 26-28	16856	NA	**NA**	0
Lead, Total	mg/kg	88	88	0	100%	2.12	**60.5**	ERM2.1GRID12	22.2	30.2	**2**	**22**
Magnesium, Total	mg/kg	84	81	3	96.4%	274	7020	RA	2178	NA	NT	0
Manganese, Total	mg/kg	84	84	0	100%	38.8	698	AFA19	149	NA	**NA**	0
Mercury, Total	mg/kg	12	6	6	50.0%	0.064	**0.2**	ERM.VB.2	0.0915	0.13	**2**	**2**
Nickel, Total	mg/kg	88	87	1	98.9%	4.39	**64.4**	AFA05	30.2	15.9	**4**	**65**
Potassium, Total	mg/kg	84	81	3	96.4%	302	7040	GP 46-48	2783	NA	NT	0
Selenium, Total	mg/kg	88	59	29	67.0%	2.21	17.8	GP 48-50	4.61	NA	**NA**	0
Sodium, Total	mg/kg	84	53	31	63.1%	283	1790	GP 02-04	587	NA	NT	0
Thallium, Total	mg/kg	84	4	80	4.8%	2.65	3.8	GP 30-32	1.47	NA	**NA**	0
Vanadium, Total	mg/kg	84	74	10	88.1%	15.6	175	RA	79.4	NA	**NA**	0
Zinc, Total	mg/kg	88	88	0	100%	15	94.7	189 LAKESHORE DR	50.2	124	0.8	0

Notes:
Matrix: Released Ash
For duplicate samples, the highest detected value or the lowest detection limit were used.

mg/kg = Milligrams per kilogram.
NA = Not available/ not applicable.
NT = Non-toxic.

[1] Summary statistics are provided for screening purposes only pending validation of all data.
[2] MEAN is calculated using one half of the reporting limit as the value for samples that did not have a detectable concentration.
[3] See Table 16 for presentation of sediment screening values.

Table 20. Preliminary[1] Summary Statistics and Comparison with Ecological Screening Values for Emory River Surface Water, (Excluding Upstream Locations)

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Location for Maximum Detection	Mean[2]	Ecological Surface Water Screen[3]	Hazard Quotient	Number of Detections > Screen
Aluminum	mg/L	318	5	313	1.6	0.125	0.702	ERM4.0	0.055	0.087	**8**	5
Aluminum, Total	mg/L	320	287	33	89.7	0.101	96	ERM1.75	1.21	0.087	**1103**	287
Antimony, Total	mg/L	320	5	315	1.6	0.00225	0.00364	ERM0.1	0.00103	0.16	0.02	0
Arsenic	mg/L	318	29	289	9.1	0.00215	0.0281	ERM1.75	0.0015	0.15	0.2	0
Arsenic, Total	mg/L	320	44	276	13.8	0.00206	0.189	ERM1.75	0.00315	0.15	1	0
Barium	mg/L	318	316	2	99.4	0.0128	0.11	ERM1.75	0.0287	NA	**NA**	0
Barium, Total	mg/L	320	320	0	100	0.0215	1.91	ERM1.75	0.0486	NA	**NA**	0
Beryllium, Total	mg/L	320	3	317	0.9	0.00208	0.00878	ERM0.1	0.00112	0.00053	**17**	3
Boron	mg/L	318	7	311	2.2	0.0561	0.113	ERM1.0	0.0264	0.75	0.2	0
Boron, Total	mg/L	320	8	312	2.5	0.061	0.227	ERM1.75	0.0277	0.75	0.3	0
Calcium	mg/L	278	278	0	100	4.45	40.7	ERM1.75	13.7	NA	NT	0
Calcium, Total	mg/L	312	312	0	100	4.61	38.7	ERM1.75	14.5	NA	NT	0
Chromium, Total	mg/L	320	10	310	3.1	0.00268	0.0829	ERM1.75	0.0017	0.011	**8**	**5**
Cobalt	mg/L	317	1	316	0.3	0.0014	0.0014	ERM4.0	0.00214	NA	**NA**	0
Cobalt, Total	mg/L	320	9	311	2.8	0.0022	0.0546	ERM1.75	0.0026	NA	NA	0
Copper	mg/L	319	6	313	1.9	0.0016	**0.0157**	ERM0.1	0.00257	0.0023	**7**	**5**
Copper, Total	mg/L	320	11	309	3.4	0.001	**0.223**	ERM1.75	0.00427	0.0023	**97**	**10**
Iron	mg/L	318	62	256	19.5	0.0508	0.287	ERM4.0	0.0344	1	0.3	0
Iron, Total	mg/L	320	320	0	100	0.0905	**37.5**	ERM1.75	0.674	1	**38**	**14**
Lead, Total	mg/L	285	10	275	3.5	**0.00323**	**0.104**	ERM1.75	0.00211	0.00041	**254**	**10**
Magnesium	mg/L	318	318	0	100	1.02	13.6	ERM1.75	4.2	NA	NT	0
Magnesium, Total	mg/L	320	320	0	100	1.1	12.9	ERM1.75	4.25	NA	NT	0
Manganese	mg/L	318	157	161	49.4	0.00517	0.519	ERM4.0	0.0174	NA	NA	0
Manganese, Total	mg/L	320	318	2	99.4	0.0213	0.666	ERM4.0	0.0543	NA	NA	0
Mercury, Total	mg/L	194	2	192	1	**0.000245**	**0.00027**	ERM4.0	0.000102	0.000012	**23**	**2**
Molybdenum	mg/L	318	2	316	0.6	0.00515	0.00549	ERM1.0	0.00534	NA	NA	0
Molybdenum, Total	mg/L	320	1	319	0.3	0.00585	0.00585	ERM1.0	0.00555	NA	NA	0
Nickel, Total	mg/L	320	9	311	2.8	0.0011	**0.126**	ERM1.75	0.00368	0.013	**10**	**5**
Potassium	mg/L	278	131	147	47.1	0.93	2.11	ERM0.1	0.945	NA	NT	0
Potassium, Total	mg/L	280	135	145	48.2	0.93	17.6	ERM1.75	1.14	NA	NT	0
Selenium	mg/L	318	3	315	0.9	0.00233	**0.00512**	ERM1.75	0.00102	0.005	1	**1**
Silica	mg/L	40	34	6	85	1.01	5.05	ERM2.1	2.61	NA	NA	0
Sodium	mg/L	278	278	0	100	1.02	10.7	ERM1.75	3.53	NA	NT	0
Sodium, Total	mg/L	280	280	0	100	1.04	10.1	ERM1.75	3.55	NA	NT	0
Thallium, Total	mg/L	320	3	317	0.9	0.0033	**0.00491**	ERM1.75	0.00103	0.004	1	**2**
Vanadium	mg/L	278	6	272	2.2	0.00604	0.0265	ERM1.75	0.00227	NA	NA	0
Vanadium, Total	mg/L	280	14	266	5	0.0044	0.339	ERM1.75	0.00521	NA	NA	0
Zinc	mg/L	318	1	317	0.3	**0.151**	**0.151**		0.0253	0.03	**5**	**2**
Zinc, Total	mg/L	320	2	318	0.6	**0.0527**	**0.104**	ERM0.1	0.0269	0.03	**3**	**2**

Table 20. Continued

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Location for Maximum Detection	Mean[2]	Ecological Surface Water Screen[3]	Hazard Quotient	Number of Detections > Screen
Hardness (As CaCO3)	mg/L	79	79	0	100	16	135	ERM0.1	72	NA	NA	0

Notes:
Matrix: Surface Water
For duplicate samples, the highest detected value or the lowest detection limit were used.
Included locations: ERM0.1, ERM0.5, ERM1.0, ERM1.7, ERM1.75, ERM1.75L, ERM1.75R, ERM2.0, ERM2.1, ERM2.1GRID11, ERM2.1GRID12, ERM2.1GRID13, ERM2.1GRID14, ERM2.1GRID15, ERM2.1GRID16, ERM2.1GRID17, ERM2.1GRID18, ERM2.1GRID19, ERM2.1GRID22, ERM2.1GRID23, ERM2.1GRID24, ERM2.1GRID26, ERM2.1GRID27, ERM2.1GRID28, ERM2.1GRID32, ERM2.1GRID34, ERM2.1GRID36, ERM2.1GRID4, ERM2.1GRID5, ERM2.1GRID6, ERM2.1GRID7, ERM2.7.OS.08, ERM3.0.BH.05, ERM3.0.BH.06, ERM3.0.BH.07, ERM3.0.BH.08, ERM3.0.BH.09, ERM3.0.CG.01, ERM3.0.CG.02, ERM3.0.CG.03A, ERM3.0.CG.03B, ERM4.0

mg/L = Milligrams per liter.
NA = Not available/ not applicable.
NT = Non-toxic.

[1] Summary statistics are provided for screening purposes only pending validation of all data.
[2] MEAN is calculated using one half of the reporting limit as the value for samples that did not have a detectable concentration.
[3] See Table 17 for presentation of surface water screening values.

Table 21. Preliminary[1] Summary Statistics and Comparison with Ecological Screening Values for Clinch River Surface Water, (Excluding Upstream Locations)

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Location for Maximum Detection	Mean[2]	Ecological Surface Water Screen[3]	Hazard Quotient	Number of Detections > Screen
Aluminum	mg/L	249	4	245	1.6	0.155	0.378	CRM2.0	0.0558	0.087	**4**	4
Aluminum, Total	mg/L	250	232	18	92.8	0.118	57.8	CRM4.0	0.776	0.087	**664**	232
Antimony, Total	mg/L	249	2	247	0.8	0.00347	0.00347	CRM4.0	0.00101	0.16	0.02	0
Arsenic	mg/L	249	14	235	5.6	0.00207	0.0242	CRM2.0	0.00127	0.15	0.2	0
Arsenic, Total	mg/L	250	33	217	13.2	0.0013	0.109	CRM4.0	0.00216	0.15	0.7	0
Barium	mg/L	249	245	4	98.4	0.0101	0.0923	CRM2.0	0.0302	NA	**NA**	0
Barium, Total	mg/L	250	250	0	100%	0.0189	1.04	CRM4.0	0.0441	NA	NA	0
Beryllium, Total	mg/L	250	2	248	0.8%	**0.00614**	**0.0076**	CRM4.0	0.00108	0.00053	**14**	**2**
Boron	mg/L	249	1	248	0.4%	0.0509	0.0509	CRM2.0	0.0254	0.75	0.07	0
Boron, Total	mg/L	250	2	248	0.8%	0.114	0.143	CRM4.0	0.0261	0.75	0.2	0
Calcium	mg/L	219	219	0	100%	6.89	40.4	CRM4.0	25	NA	NT	0
Calcium, Total	mg/L	244	244	0	100%	6.97	38.6	CRM4.0	26.9	NA	NT	0
Chromium, Total	mg/L	250	9	241	3.6%	0.001	**0.0352**	CRM4.0	0.0013	0.011	**3**	**2**
Cobalt, Total	mg/L	250	4	246	1.6%	0.00274	0.0321	CRM4.0	0.00231	NA	NA	0
Copper	mg/L	249	10	239	4.0%	0.0015	**0.00918**	CRM4.0	0.00266	0.0023	**4**	**9**
Copper, Total	mg/L	250	9	241	3.6%	0.0011	**0.0938**	CRM4.0	0.00326	0.0023	**41**	**6**
Iron	mg/L	249	6	243	2.4%	0.0817	0.35	CRM0.0	0.0285	1	0.4	0
Iron, Total	mg/L	250	249	1	99.6%	0.0882	**20.9**	CRM4.0	0.451	1	**21**	**9**
Lead, Total	mg/L	203	7	196	3.4%	**0.00214**	**0.0648**	CRM4.0	0.00164	0.00041	**158**	**7**
Magnesium	mg/L	249	249	0	100%	1.71	13.5	CRM2.0	8.09	NA	NT	0
Magnesium, Total	mg/L	250	250	0	100%	1.78	12.6	CRM4.0	8.06	NA	NT	0
Manganese	mg/L	249	57	192	22.9%	0.00546	0.0347	CRM0.0	0.00553	NA	NA	0
Manganese, Total	mg/L	250	246	4	98.4%	0.00956	0.175	CRM4.0	0.0403	NA	NA	0
Molybdenum, Total	mg/L	250	1	249	0.4%	0.001	0.001	CRM2.0	0.00536	NA	NA	0
Nickel, Total	mg/L	250	7	243	2.8%	0.0014	**0.053**	CRM4.0	0.0031	0.013	**4**	**2**
Potassium	mg/L	219	207	12	94.5%	1.01	2.1	CRM0.0	1.5	NA	NT	0
Potassium, Total	mg/L	220	215	5	97.7%	1.04	11.6	CRM4.0	1.64	NA	NT	0
Selenium	mg/L	249	2	247	0.8%	0.00264	0.00302	CRM2.0	0.00101	0.005	0.6	0
Silica	mg/L	30	26	4	86.7%	1.21	7.78	CRM0.0	2.57	NA	NA	0
Sodium	mg/L	219	219	0	100%	1.34	11.1	CRM0.0	6.48	NA	NT	0
Sodium, Total	mg/L	220	220	0	100%	1.42	10.1	CRM4.0	6.4	NA	NT	0
Thallium, Total	mg/L	250	2	248	0.8%	0.00277	0.00316	CRM4.0	0.00101	0.004	0.8	0
Vanadium	mg/L	219	3	216	1.4%	0.00434	0.0231	CRM2.0	0.00217	NA	NA	0
Vanadium, Total	mg/L	220	17	203	7.7%	0.0012	0.143	CRM4.0	0.00348	NA	NA	0
Zinc, Total	mg/L	250	2	248	0.8%	**0.077**	**0.0942**	CRM4.0	0.0252	0.03	**3**	**2**

Table 21. Continued

Analyte	Units	Number of Samples	Number of Detects	Number of Non Detects	Percent of Detects	Minimum Detected Result	Maximum Detected Result	Location for Maximum Detection	Mean[2]	Ecological Surface Water Screen[3]	Hazard Quotient	Number of Detections > Screen
Hardness (As CaCO3)	mg/L	63	63	0	100	24.7	134	CRM4.0	92	NA	NA	0

Notes:
Matrix: Surface Water
For duplicate samples, the highest detected value or the lowest detection limit were used.
Included locations: CRM0.0, CRM2.0, CRM4.0

mg/L = Milligrams per liter.
NA = Not available/ not applicable.
NT = Non-toxic.

[1] Summary statistics are provided for screening purposes only pending validation of all data.
[2] MEAN is calculated using one half of the reporting limit as the value for samples that did not have a detectable concentration.
[3] See Table 17 for presentation of surface water screening values.

Table 22. Preliminary[1] Summary Statistics and Comparison with Ecological Screening Values for Tennessee River Surface Water

Analyte	Units	Number of Samples	Number of Detects	Number of Nondetects	Percent Detect	Minimum Detected Result	Maximum Detected Result	Location for Maximum Detection	Mean[2]	Ecological Surface Water Screen[3]	Hazard Quotient (unitless)	Number of Detections > Screen
Aluminum, Total	mg/L	91	72	19	79.1%	**0.101**	**0.826**	TRM568.5	0.191	0.087	**9**	**72**
Antimony	mg/L	91	1	90	1.1%	0.0025	0.0025	TRM568.5	0.00101	0.16	0.02	0
Antimony, Total	mg/L	90	2	88	2.2%	0.00206	0.00307	TRM568.5	0.00103	0.16	0.02	0
Barium	mg/L	91	91	0	100%	0.0119	0.0311	TRM563.5	0.0215	NA	NA	0
Barium, Total	mg/L	91	91	0	100%	0.0181	0.035	TRM563.5	0.0246	NA	NA	0
Calcium	mg/L	81	81	0	100%	13.8	26	TRM563.5	19.3	NA	NT	0
Calcium, Total	mg/L	89	89	0	100%	14.1	25.9	TRM563.5	19.4	NA	NT	0
Copper	mg/L	90	2	88	2.2%	**0.00578**	**0.0133**	TRM568.5	0.00263	0.0023	**6**	**2**
Iron, Total	mg/L	91	91	0	100%	0.0626	**1.21**	TRM568.5	0.265	1	1	**3**
Magnesium	mg/L	91	91	0	100%	3.7	7.89	TRM563.5	4.92	NA	NT	0
Magnesium, Total	mg/L	91	91	0	100%	3.6	7.82	TRM563.5	4.89	NA	NT	0
Manganese	mg/L	91	2	89	2.2%	0.00533	0.00767	TRM568.5	0.00312	NA	NA	0
Manganese, Total	mg/L	91	90	1	98.9%	0.0164	0.14	TRM568.5	0.0435	NA	NA	0
Mercury	mg/L	58	1	57	1.7%	**0.000245**	**0.000245**	TRM568.5	0.000103	0.000012	**20**	**1**
Potassium	mg/L	81	80	1	98.8%	1.06	2.12	TRM568.5	1.56	NA	NT	0
Potassium, Total	mg/L	81	80	1	98.8%	1.09	2.2	TRM568.5	1.56	NA	NT	0
Silica	mg/L	10	10	0	100%	1.56	5.3	TRM568.5	3.56	NA	NA	0
Sodium	mg/L	81	81	0	100%	3.03	10.9	TRM568.5	7.4	NA	NT	0
Sodium, Total	mg/L	81	81	0	100%	3.11	10.4	TRM568.5	7.25	NA	NT	0
Hardness (As CaCO3)	mg/L	21	21	0	100%	53.7	84.7	TRM568.5	66.1	NA	NA	0

Notes:
Matrix: Surface Water
For duplicate samples, the highest detected value or the lowest detection limit were used.
Included locations: TRM563.5, TRM564.5.OS.06, TRM568.5, TRM569.0.OS.07

mg/L = Milligrams per liter.
NA = Not available/ not applicable.
NT = Non-toxic.

[1] Summary statistics are provided for screening purposes only pending validation of all data.
[2] MEAN is calculated using one half of the reporting limit as the value for samples that did not have a detectable concentration.
[3] See Table 17 for presentation of surface water screening values.

Table 23. Summary of Constituents of Potential Ecological Concern

Analyte	Ash as Soil	Ash as Sediment	Surface Water		
			Emory River	Clinch River	Tennessee River
Aluminum	**YES**	**YES**	**YES**	**YES**	**YES**
Antimony	no	no	no	no	no
Arsenic	**YES**	**YES**	**YES**[1]	**YES**[1]	**YES**[1]
Barium	**YES**	**YES**	**YES**	**YES**	**YES**
Beryllium	no	**YES**	**YES**	**YES**	no
Boron	**YES**	**YES**	no	no	no
Calcium	no	no	no	no	no
Chromium	**YES**	**YES**[1]	**YES**	**YES**	**YES**[1]
Cobalt	**YES**	**YES**	**YES**	**YES**	no
Copper	**YES**	**YES**	**YES**	**YES**	**YES**
Iron	**YES**	**YES**	no[2]	no[2]	no
Lead	**YES**	**YES**	**YES**	**YES**	**YES**[1]
Magnesium	no	no	no	no	no
Manganese	**YES**	**YES**	**YES**	**YES**	**YES**
Mercury	**YES**	**YES**	**YES**	**YES**[1]	**YES**
Molybdenum	no	no	**YES**	**YES**	no
Nickel	**YES**	**YES**	**YES**	**YES**	**YES**[1]
Potassium	no	no	no	no	no
Selenium	**YES**	**YES**	**YES**[1]	**YES**[1]	**YES**[1]
Silica	no	no	**YES**	**YES**	**YES**
Sodium	no	no	no	no	no
Thallium	**YES**	**YES**	**YES**[1]	**YES**[1]	**YES**[1]
Vanadium	**YES**	**YES**	**YES**	**YES**	**YES**[1]
Zinc	**YES**	**YES**[1]	**YES**	**YES**	**YES**[1]

Notes:

[1] Constituent was not detected above appropriate screening value but was identified as a COPEC because it is considered a COI related to fly ash.
[2] Constituent not identified as a COPEC because dissolved concentrations were below the ecological screening value.

COPEC = Constituent of Potential Ecological Concern.
COI = Constituent of Interest.

Table 24. Uncertainties in the Screening-Level Ecological Risk Assessment

Assumptions	Description And Discussion Related To Uncertainties in ERA	Uncertainty in SLERA
Analytical Sampling and Data Analysis		
Limited number of samples	At the time of this assessment, surface water samples from west of Dike 2 that are representative of potential current and near-term aquatic exposures had not yet been validated.	Underestimate of exposure and risk
Use of maximum concentrations	Maximum concentrations are used to represent the upper estimate exposures. This practice compensates for uncertainty contributed by any situations with limited numbers of samples, but overestimates exposure and risk.	Overestimate of exposure and risk
Detection limits	Some detection limits may exceed ESVs or thresholds for adverse impacts. Constituents with detection limits above these values will be evaluated qualitatively in the uncertainty section of the ERA.	May underestimate risk or effect on risk estimate unknown
Degradation of chemicals not considered	The stability of constituents in ash is currently unknown. This ERA will be based on concentrations of target compounds, and little if any attention is given to degradation constituents that could be more toxic than the original constituent. Conversely, constituent concentrations may decrease over time due to natural physical processes.	Effect on risk estimate unknown
Selection of COPECs		
Coal Combustion Byproducts	Constituents identified as common coal combustion byproducts (i.e., vanadium, zinc, copper, chromium, nickel, lead, arsenic, mercury, selenium, and thallium) were identified as Constituents of Interest (COIs) and were retained in the risk assessment regardless of screening results.	Overestimate of risk
Toxicology and ESVs		
Toxicity and exposure data for a limited number of species	Uncertainties exist in many aspects of the toxicology relied upon for conducting ERAs (Newman, 1998; Lovett Doust et al., 1993). Toxicity and wildlife exposure data are only available for a limited number of species (most of them laboratory test species) under a strictly defined set of test conditions that deviate from natural conditions (Sample et al., 1996; Suter, 1996; Sample et al., 1997).	Effect on risk estimate unknown
Laboratory testing	In current practice, more than 95 percent of the resources in toxicology are focused toward the study of single chemicals (Cassee et al., 1998), while wildlife exposures rarely occur on a chemical-specific basis. Simplistic extrapolations from laboratory species to wildlife species and testing conditions to field conditions are not likely accurate, and are rarely, if ever, validated against natural conditions (Power, 1996; Tannenbaum, 2003).	Effect on risk estimate unknown
Adaptation and tolerance	There is little consistency and no quantitative methodology for the consideration of the diminished bioavailability (and, thereby, diminished toxicity) even though this process is well documented (e.g., Alexander and Alexander, 1999; Alexander, 2000). Similarly, tolerance and adaptation are not considered directly (Millward and Klerks, 2002; Grant, 2002). Furthermore, the white rat often used in toxicological testing is bred to minimize differences between lab animals, thereby diminishing the genetic variability that gives wildlife some capability for adaptation and tolerance (Tannenbaum, 2003).	Overestimate of risk
Predator-prey interactions	There are relatively few studies that actually evaluate the effects of toxicity on predator-prey interactions, or on competition for scarce resources (Atchison et al., 1996), the very conditions within which all wildlife exists (Kapustka and Landis, 1998).	Effect on risk estimate unknown

Table 24. Continued

Assumptions	Description And Discussion Related To Uncertainties in ERA	Uncertainty in SLERA
HQs		
HQs based on maximum	The SLERA HQs are based on the maximum detected concentrations and the most conservative ESVs available (EPA, 1997c; 2000b).	Overestimate of risk
Elevated HQs for background concentrations	HQs may exceed a value of 1 for background concentrations of naturally occurring metals (Tannenbaum, 2003). Background concentrations of metals at the site were used for comparison only and as a result, elevated HQs could in part be attributed to these background concentrations.	Overestimate of risk
Interpretation of HQs	An HQ less than or equal to a value of 1 indicates that adverse impacts to wildlife are considered unlikely (EPA, 2001c). However, there is no clear guidance for interpreting the HQs that exceed a value of 1, except that this point of departure indicates that adverse effects of some kind may have occurred or may occur in the future.	Effect on risk estimate unknown
HQs for individual used to evaluate risks to populations	HQs are based on the types of impacts that could occur to individuals (i.e., those individuals exposed to maximum concentrations) and they completely fail to address ecological exposure and risk at spatial scale of populations (Tannenbaum, 2003; Durda and Preziosi, 1999).	Overestimate of risk to wildlife populations
HQs with unrealistic magnitudes	Some HQs are seen at magnitudes that suggest that every animal should die upon acute exposure (i.e., in the hundreds or thousands) (Tannenbaum et al., 2003). Often, physical conditions at a site demonstrate that this is not the case.	Overestimate of risk
No evaluation of dermal or inhalation pathways	The dermal and inhalation exposure pathways are generally considered “insignificant” due to protective fur and feathers. Under certain conditions, these exposure pathways may occur, but adequate information is rarely available by which to evaluate them (EPA, 2005b).	Underestimate of risk

Notes:

COPEC	Constituent of potential ecological concern.
ERA	Ecological risk assessment.
ESV	Ecological screening value.
HQ	Hazard quotient.
SLERA	Screening level ecological risk assessment.