ARCADIS
Infrastructure, environment, buildings

Imagine the result

Conceptual Restoration Design Report for Swan Pond Embayments

TVA Fly Ash Response

Kingston, Tennessee

October 2009

ARCADIS

Conceptual Restoration Design Report for Swan Pond Embayments

TVA Fly Ash Response
Kingston, Tennessee

Robert Lepsic
Project Manager

Douglas J. Partridge, MS, PWS, CE
Project Ecologist

Prepared for:
Tennessee Valley Authority

Prepared by:
ARCADIS
114 Lovell Road
Suite 202
Knoxville
Tennessee 37934
Tel 865.675.6700
Fax 865.675.6712

Our Ref.:
TNTVA903.RST1.00003

Date:
19 October 2009

This document is intended only for the use of the individual or entity for which it was prepared and may contain information that is privileged, confidential and exempt from disclosure under applicable law. Any dissemination, distribution or copying of this document is strictly prohibited.

Table of Contents

1. Introduction 1-1

1.1 Site Background 1-1

1.2 Ash Migration Management 1-1

1.3 Regulatory Framework 1-2

2. Site Conditions 2-1

2.1 Pre-Impact Condition 2-2

2.1.1 Waters and Wetlands 2-3

2.1.2 Faunal Habitat 2-4

2.1.3 Endangered and Threatened Species 2-5

3. Embayment Restoration Concepts 3-1

3.1 Concept A – Restore Embayment Area to Pre-Existing Condition 3-2

3.1.1 Morphology/Topography 3-2

3.1.2 Hydrology 3-2

3.1.3 Soils and Sediments 3-3

3.1.4 Plant Communities 3-4

3.1.5 Faunal Habitat 3-5

3.1.6 Summary of Actions 3-6

3.1.7 Summary of Data Gaps 3-6

3.2 Concept B – Restore Embayment Area to Pre-Existing Condition with Selected Enhancements 3-6

3.2.1 Morphology/Topography 3-7

3.2.2 Hydrology 3-7

3.2.3 Soils and Sediments 3-8

3.2.4 Plant Communities 3-8

3.2.5 Faunal Habitat 3-9

3.2.6 Summary of Enhancement Opportunities 3-10

3.2.7 Summary of Data Gaps 3-10

4. Costing **4-1**

4.1 Concept A 4-1

4.2 Concept B 4-2

5. Summary **5-1**

6. References **6-1**

Tables

1 Federally Listed as Endangered and Threatened Species that are Currently Present in Roane County, Tennessee

2 Preliminary List of Plant Species to be Included in Final Restoration Design

Figures

1 Area Site/Watershed Map

2 2008 Aerial Photograph – Pre-Event

3 2009 Aerial Photograph – Post-Event

4 Central Embayment Topography

5 Northern Embayment Topography

6 Concept A Conceptual Design

7 Concept B Conceptual Design

8 Conceptual Cross-Section of Restored Embayment Ecosystem

Appendices

A TVA Wetland Reference Data

B NRCS Soils Map

C Typical Construction Details

Acronyms

CA	Cost Analysis
CERCLA	Comprehensive Environmental Response, Compensation & Liability Act
EE	Engineering Evaluation
EPA	U.S. Environmental Protection Agency
KIF	Kingston Fossil Plant
msl	mean sea level
NRCS	National Resources Conservation Service
Order	Administrative Order and Agreement on Consent
TVA	Tennessee Valley Authority
TVARAM	Tennessee Valley Authority Rapid Assessment Model
TWRA	Tennessee Wildlife Resources Agency

1. Introduction

ARCADIS has prepared this Conceptual Restoration Design Report to assist the Tennessee Valley Authority (TVA) with Non-Time Critical Removal Action in response to the ash dike failure at TVA's Kingston Fossil Plant (KIF) in Roane County, Tennessee. Specifically, this report addresses an evaluation of site concepts for restoration of the Swan Pond Embayment, which was filled with ash following the dike failure. Identified concepts will be evaluated in conjunction with the identified alternatives for restoration of the failed dredge cell.

1.1 Site Background

The site is located near the confluence of the Emory and Clinch Rivers on Watts Bar Reservoir near Kingston, Tennessee (Figure 1). On Monday, December 22, 2008, a dike containing the KIF dredge cells failed, releasing about 5.4 million cubic yards of fly ash and bottom ash. Ash was released from about 60 acres of the 84-acre dredge cell complex. The spilled material now covers about 300 acres of adjacent parts of Watts Bar Reservoir, including most of Swan Pond Embayment areas (Northern, Central, and Western Embayments), reservoir shoreline and adjacent floodplain. Figure 2 illustrates the area prior to the dike failure, and Figure 3 shows the area on March 20, 2009, after the dike failure. Specific to this report, the Northern, Central and Western Embayments located to the north of the failed dredge cell were almost completely filled with ash.

TVA responded immediately when the ash was released. A number of emergency response actions and sampling activities, as well as community outreach programs, were initiated promptly. Additional information relative to the emergency response actions can be referenced in the *Initial Emergency Response Actions for the Kingston Fossil Plan Ash Dike Failure* (Tennessee Valley Authority 2009a) and *Corrective Action Plan for the TVA Kingston Fossil Plant Ash Release* (Tennessee Valley Authority 2009b).

1.2 Ash Migration Management

To prevent downstream migration of ash and dike material, TVA constructed two temporary rock structures.

1. Weir #1, completed on January 5, 2009, is built across the Emory River, just north of the existing intake skimmer wall and approximately 0.5-mile downstream of the embayments (not illustrated in Figures). This underwater weir is about 615 feet long. The top of most of this weir is at elevation 730 feet, 11 and 5 feet

below the normal summer and winter reservoir pool elevations, respectively. A 50-foot section of the weir has a top elevation of 728 feet.

2. Dike #2 extends across the Central Embayment a short distance upstream of its mouth (Figure 2). This weir is approximately 1,750 feet long. The top elevation of most of the weir is at 752.0 feet; and a 300-foot-wide spillway section has a top elevation of 745.0 feet. The objective of this dike is to minimize the movement of ash from the embayment into the Emory River.

The scope of this report focuses on the impacted embayment ecosystem west of Dike #2. Specifically, it includes both the Central and Northern Embayments (Figure 2 and 3). The Western Embayment is not included, as it was addressed under a different phase of the response action.

TVA is managing the inflows into the Swan Pond Embayments through the development of a series of ditches and piping. This action precludes further movement of ash from surface water flow in the embayments and will help facilitate recovery of the area in the future. The identified restoration concepts assume hydrology from the Swan Pond Creek, as well as the surrounding landscape, will be restored to the embayment ecosystems and previously constructed clean water ditches removed.

1.3 Regulatory Framework

An Administrative Order and Agreement on Consent (Order) was signed on May 11, 2009, between the U.S. Environmental Protection Agency (EPA) and TVA providing the regulatory framework for the restoration efforts. The EPA Order requires TVA to comply with Clean Water Act Section 404(b)(1) guidelines to restore waters of the U.S. to the functional level occurring prior to the ash release. In order to identify the full extent of response activities necessary to meet this requirement, TVA must conduct a jurisdictional assessment of the site, to the extent not previously evaluated, which will identify all waters of the U.S., including wetlands impacted by the release. Based on the results of this assessment, TVA shall propose, as a part of the Engineering Evaluation (EE)/Cost Analysis (CA) process, final cleanup criteria which address removal of ash from streams/sloughs/river beds, banks, floodplains, adjacent wetlands and the shorelines adjoining open waters, compensatory mitigation for any permanent loss to waters/wetlands, as well as replanting the impacted riparian zone, as approved by EPA in consultation with the Tennessee Department of Environment and Conservation.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) also requires analysis of potentially impacted resources, the formulation of concepts to restore those resources, appropriate protection of public health and the environment, and involvement of the public and other agencies in doing this. CERCLA and its associated processes and methodologies can be used to formulate and test remediation concepts to ensure that they appropriately restore the impacted area, and that the public and the environment are protected in the short- and long-term.

The EE/CA for the dredge cell and embayment documents the site conditions, alternatives evaluated, and the preferred alternative. This report has been prepared to support the EE/CA, with specific emphasis on identification and evaluation of restoration concepts. Once public comments are received, the decision as to the accepted alternative will be documented in an action memorandum.

2. Site Conditions

The site is located near the confluence of the Emory and Clinch Rivers on Watts Bar Reservoir near Kingston, Tennessee (Figure 1). The Emory River at the KIF is impounded by Watts Bar Dam, having a significant influence on the hydrology, and thus the ecology of the embayment ecosystem. The Emory River originates on the Cumberland Plateau and its inflows to Watts Bar Reservoir are not regulated. It drains a watershed area of approximately 865 square miles with average flow rates between 700 and 1300 cubic feet per second. The normal summer and winter pool levels of Watts Bar Reservoir in the vicinity of KIF are 741 and 735 feet mean sea level (msl), respectively.

The affected reach of Watts Bar Reservoir at the KIF transitions from the upstream riverine reaches of the Emory River and the Clinch River, to the more lacustrine conditions found in the impounded portions of the Clinch and Emory River backwaters of Watts Bar Reservoir. The embayments are located in more of a lacustrine habitat, about 2 river miles upstream of the KIF condenser cooling water discharge. The slopes of the overbank areas of the Swan Pond Embayments are very shallow.

The embayments were filled as a result of the dike failure containing the KIF dredge cells. As identified in Figure 2, this report refers to different portions of the Swan Pond Embayments separately as the Central, Northern and Western Embayments. Only the Central and Northern Embayments are addressed in this report, as the Western Embayment was addressed in an earlier phase of work, and the Eastern Embayment will be addressed as part of the EE/CA for the river system. All surrounding riparian/floodplain vegetation associated with the embayments were impacted by the dike failure. Restoration concepts relative to the embayment are discussed in Section 3.

However, to develop the conceptual restoration plans, it is important to characterize the pre-impact condition of these embayments to the Emory River. Pre-impact conditions are summarized based upon data review from the following TVA documents: 1) *Initial Emergency Response Actions for the Kingston Fossil Plan Ash Dike Failure* (Tennessee Valley Authority 2009a); 2) *Corrective Action Plan for the TVA Kingston Fossil Plant Ash Release* (Tennessee Valley Authority 2009b); 3) *TVA Reservoir Operations Study Wetland Monitoring Summary Report* (Tennessee Valley Authority 2006); and 4) *Kingston Fly Ash Recovery Project Non-Time Critical Removal Action Scope and Work Plan* (Tennessee Valley Authority 2009c).

2.1 Pre-Impact Condition

The area surrounding the wide portion of the Central Embayment was a relatively flat, low-lying riparian zone with mid-age forest community. Dominant species included sycamore (*Platanus occidentalis*), green ash (*Fraxinus pennsylvanica*), and silver maple (*Acer saccharinum*) with considerable amounts of fescue (*Festuca* spp.) grasses and some scattered kudzu (*Pueraria montana* var*. lobata*) in places. The peninsula feature that extended into the main reservoir between the Central and Eastern Embayments was comprised of a diversity of riparian tree species characteristic of the area, such as silver maples, sycamore, green ash, and sweetgum (*Liquidambar styraciflua)*, with scrub-shrub and emergent wetland fringe habitats in the shallower shoreline areas.

The area to the northeast end of the embayments and Swan Pond Road is a steep north-facing slope with old age upland hardwood comprised of various oaks (*Quercus* spp.) and hickories (*Carya* spp.), white ash (*Fraxinus americana*), black gum (*Nyssa sylvatica*), yellow poplar (*Liriodendron tulipifera*), black cherry (*Prunus serotina*), red maple (*Acer rubrum*), basswood (*Tilia americana*), American beech (*Fagus grandifolia*), yellow buckeye (*Aesculus octandra*), and flowering dogwood (*Cornus florida*). These areas were used by a variety of terrestrial wildlife species before the spill.

The area at the fringe of the embayments included wetland areas similar in flora, as described above, with younger trees. The shrub layer contained a substantial amount of buttonbush (*Cephalanthus occidentalis*) and silky dogwood (*Cornus amomum*), and the emergent wetland portions had a high diversity of obligate wetland grasses, rushes (*Juncus* spp.), sedges (*Carex* spp.), smartweeds (*Polygonum* spp), jewelweed (*Impatiens* sp.) and marsh mallow (*Althea officinalis*). Hydric soils were found throughout these areas with numerous vernal pools throughout the floodplain. This habitat was particularly important to various amphibian species such as green frog (*Rana clamitans*), gray treefrog *(Hyla chrysoscelis),* upland chorus frog (*Pseudacris triseriata*) and spring peepers (*Pseudacris crucifer*). The rest of the surrounding landscape includes agriculture areas, landscaped lawns and roads.

Site topography of the Central and Northern Embayments, as well as surrounding landscapes, are included as Figure 4 and 5, respectively. The topography of the Central Embayment (Figure 4) is based upon a pre-event survey conducted in 1993, with 2-foot contour intervals. However, this survey did not include measurements in the Northern Embayment areas. Therefore, the topography of the Northern Embayment

(Figure 5) is based upon a post-event survey completed in December 2008, also with 2-foot contour intervals. Both are shown with pre-event aerial imagery taken in 2008.

2.1.1 Waters and Wetlands

As federal and state regulated waters and wetlands were impacted by the spill, TVA utilized land use/land cover data, 2006/2008 aerial imagery, and National Wetlands Inventory wetlands mapping to estimate the acreage of wetlands affected by the ash. Acreage calculations are based on the area of each individual polygon classified in the interpretation process. This analysis determined that there were approximately 2.58 acres of wetlands affected by the ash spill (Tennessee Valley Authority 2009b). A summary of the wetlands identified by TVA using the revised land use/land cover/aerial imagery analysis were classified based upon habitat types as described by Cowardin et al. (1979) and are listed below.

- Palustrine Emergent Wetland = 1.56 acres
- Palustrine Forested Wetland = 0.71 on figure
- Palustrine Scrub-Shrub Wetland = 0.31 on figure

A subsequent analysis of the TVA land-use data conducted by ARCADIS determined that there were approximately 51 acres of waters (including mapped open water habitat and mud flats during winter low water levels) affected by the ash spill.

Wetland habitats in the vicinity of the KIF have also been monitored as part of a larger study associated with the 2004 *TVA Reservoir Operations Study and Environmental Impact Statement* (Tennessee Valley Authority 2004). There are two wetland reference sites near the embayments outside of the ash flow area (Appendix A, Figure A-1). Baseline data have been collected on these sites beginning in 2004, and subsequently in 2005. Collected data, as well as a site location map for each plot location, are included in Appendix A. One scrub-shrub and one forested wetland plot were part of the original study design. The two sampling sites were chosen because they were high quality wetlands (e.g., based upon TVA Rapid Assessment Model [TVARAM]) located on TVA land, which ensured the long-term accessibility of these sites. A summary of the reference data for each habitat type, as well as specific information from each reference plot based upon 2004 data, is provided below. Please note baseline data was not collected in a palustrine emergent wetland habitat near the embayments.

- **Palustrine Forested Wetland:** All sampled forested wetland sites within the Watts Bar Reservoir contained moderate invasive species cover (25 to 75

percent); however, all scored as TVARAM Category 2 or 3 wetlands, indicating moderate to high quality functions. All sites exhibited hydric soil with indicators that included gleyed/low chroma colors, concretions, and reducing conditions. Likewise, all sites exhibited wetland hydrology, with indicators that included inundation and/or saturated soils in the upper 12 inches.

  - Swan Pond (WBF3) – Dominant tree species included river birch (*Betula nigra*), red maple, sweetgum, and black willow (*Salix nigra*), with cover measured at 77 percent crown closure and a basal area of 160 square feet/acre. Dominant shrub species included river birch and red maple, with cover calculated at 62 percent. Groundcover was dominated by blunt broom sedge (*Carex tribuloides*), with a total ocular cover estimate of 99 percent.

- **Palustrine Scrub-shrub Wetland:** All sampled scrub-shrub wetland sites contained nearly absent (<5 percent) to sparse (5 to 25 percent) invasive species cover, and all scored as TVARAM Category 2 or 3 wetlands, indicating moderate to high quality functions. All sites exhibited hydric soil with indicators that included gleyed/low chroma colors, concretions, and reducing conditions. Likewise, all sites exhibited wetland hydrology, with indicators that included inundation and/or saturated soils in the upper 12 inches.

  - Swan Pond (WBS3) – The shrub layer was dominated by buttonbush, with total cover calculated at 81 percent. Groundcover was dominated by tearthumb (*Polygonum sagittatum*) and rice cut grass (*Leersia oryzoides*), with a 100 percent total ocular cover estimate.

Wetlands in the Western Embayment have already been restored under a different phase of the response action. The restored area included the 1.56 acres of palustrine emergent wetland, and 0.71 acres of palustrine forested wetland. The restoration of 0.31 acres of palustrine scrub-shrub wetlands and open waters will be restored to pre-existing condition in both Concepts A and B, discussed below.

2.1.2 Faunal Habitat

The embayment ecosystems were heavily used by shorebirds, waterfowl, amphibians and reptiles. Dominant bird species observed utilizing the embayments included Canada geese (*Branta canadensis*), wood ducks (*Aix sponsa*), great blue (*Ardea herodias*) and green herons (*Butorides* virescens), great egrets (Ardeidae *alba*), belted kingfishers (*Megaceryle alcyon*), and double-crested cormorants (*Phalacrocorax auritis*). Ospreys (*Pandion haliaetus*) are common in the area, often nesting on natural and man-made structures on and around the KIF properties. Heron colonies also occur near the fossil plant; the closest is approximately 0.3-mile upstream and in direct line of sight of the affected area. A second colony including great blue herons and double-crested cormorants occurs 2 miles southeast of the site, approximately 0.5-mile

downstream of the junction of the Emory and Clinch Rivers. In addition, the adjacent wetlands and fringe emergent wetlands were used by semi-aquatic mammals, turtles, water snakes, and a variety of amphibians, including frogs and salamanders.

Within the aquatic environment, existing data from both TVA and Tennessee Wildlife Resources Agency (TWRA) are being compiled to accurately characterize the aquatic communities affected by the spill. These data include TVA fish and benthic surveys used to satisfy National Pollutant Discharge Elimination System permit requirements for the KIF plant and for other TVA projects in the vicinity, and TWRA fish stocking data. TVA historic data indicate a "good" fish assemblage within the reservoir based upon the TVA Reservoir Fish Assemblage Index. Other megafauna aquatic surveys identified six mussel species: giant floater (*Anodonta grandis*), fragile papershell (*Leptodea fragilis*), Pistolgrip (*Tritogonia verrucosa*), pimpleback (*Plethobasus* sp.), wartyback (*Plethobasus cicatricosus*), threehorn wartyback (*Obliquaria reflexa*), and a common aquatic snail (hornsnail) in a recent survey of this area (Yokley 2005). All of these species, except pistolgrip, are generally tolerant of reservoir conditions.

2.1.3 Endangered and Threatened Species

Although several federally-listed plants and animals are known from Roane County (Table 1), only the piping plover (*Charadrius melodus*) is known to occur in the area affected by the ash spill. The piping plover has been reported from KIF ash ponds on five occasions between 1978 and 2002. The species is considered a casual migrant in Tennessee by the Tennessee Ornithological Society; most records at the plant include a single individual observed for a short period of time. It has not been found on systematic shorebird surveys at KIF conducted since 2004. Some suitable habitat for this casually-occurring species has likely been adversely affected by the spill.

The gray bat (*Myotis grisescens*), a second federally-endangered species, also likely occurs proximate to the KIF. The closest cave known to be occupied by gray bats is 16 miles from KIF. However, the species likely forages along the Clinch and Emory Rivers. Suitable habitat for the other federally-listed species does not occur in the vicinity of KIF.

Several other plants and aquatic and terrestrial animals listed as endangered, threatened, or of special concern by the State of Tennessee have been reported from within 2 miles of KIF. Only two plants on the State lists are known from the immediate vicinity of KIF spreading false foxglove (*Aureolaria patula*), a species of special concern, is known to occur along the banks of the Melton Hill, Watts Bar and Norris reservoirs. The closest known populations are found approximately 2 miles

downstream of the spill in Sugar Grove and Rayburn Bridge Habitat Protection areas. Fetterbus (*Leucothoe racemosa*) is the second listed plant. It is listed as threatened and is known to occur from one population within the KIF reservoir along the banks of the Clinch River approximately 1 mile from the ash spill site. This species is a common coastal plain plant with several disjunct populations in Tennessee.

3. Embayment Restoration Concepts

Following the removal of ash from all areas west of Dike #2 (Figure 4), two restoration concepts were identified for the restoration of the embayment ecosystem. The first restoration concept (Concept A) would restore the embayment area to pre-existing conditions as best determined from analysis of existing data, site observations, reference site data, and best professional judgment (Figure 6). The second restoration concept (Concept B) would restore the embayment to pre-existing conditions, but also include a suite of enhancements to both the riparian and aquatic environments (Figure 7). Selected enhancement opportunities would directly target a functional enhancement to the overall ecosystem. Available models to assess or evaluate the functional enhancement include the TVARAM for wetlands, as well as the Shoreline Aquatic Habitat Index. A discussion of each restoration concept is provided below.

It is recognized as part of this conceptual restoration design that significant areas of native soil may have been lost as a result of the ash spill, and potentially the clean-up operation, which may have implications on the final restoration design. For the purposes of this report, it is assumed that all pre-existing terrestrial environments will be able to be restored to an elevation that supports native plant communities. This may require previous riparian forest communities being restored to a wetland emergent community. However, it is possible that significant areas of native soil could have been lost in which the final elevation of native soils is too low to support planting of native plant communities. This situation could result in the restoration of a greater areal extent of open water habitat than the pre-existing condition.

It is also recognized that the northern perimeter of Dike C (Figures 6 and 7) is configured differently in each of the alternative in the EE/CA. The slope, construction materials, and the geographic placement of Dike C varies depending on the final volume and height of the dredge cell. This may require modification of the riparian planting zone along the northern perimeter of Dike C to ensure structural stability of the dike. These variations are not explicitly incorporated in each of the Embayment Restoration Concepts for the EE/CA, but will be accounted for in the final design for the selected alternative.

Concepts presented in this conceptual design report also have applicability to other portions of the embayment ecosystems outside the purview of this report. For example, areas on the peninsula east of Dike #2 could incorporate concepts presented below and be restored as part of the final restoration design.

3.1 Concept A – Restore Embayment Area to Pre-Existing Condition

Restoration Concept A targets the restoration of pre-existing conditions of the embayment ecosystems prior to the ash spill. The pre-existing conditions have been identified based upon analysis of existing data, site observations, reference site data, and best professional judgment. A plan view of the restoration actions proposed under Concept A is presented in Figure 6.

3.1.1 Morphology/Topography

The pre-existing topography of the Central Embayment area is derived from a combination 1993 topographic survey of the KIF and surrounding areas (Figure 4), and a post-event topographic survey collected in December 2008. The scale of both surveys are 2-foot contour intervals. Given low water levels at the time of the survey, the survey covers significant areas of the Central Embayment that would normally be under water during characteristic summer reservoir water levels. Pre-event bathymetry data are not available for either of the Northern or Central Embayments. The final restoration design will require measuring the elevation of the native soil surface throughout the restoration area.

Concept A will not significantly alter the pre-existing topography of the embayment shoreline and surrounding areas. Development of a final grading plan would incorporate the following actions:

- Achieve suitable elevations within the floodplain necessary to support the restoration of complex mosaic of forested, scrub-shrub, and emergent wetland plant communities. This includes the restoration of floodplain microtopography (i.e., constructed vernal pools) that historically provided important off-channel, seasonal, aquatic habitat for amphibians, birds, and other semi-aquatic species. A conceptual cross-section of the restored embayment is included as Figure 8.
- Restore the island that was historically located on the northern perimeter of the Central Embayment. The island was likely an aquatic habitat feature important to fish and other aquatic species.

3.1.2 Hydrology

Hydrology of the Northern and Central Embayments was historically supported by surface and shallow subsurface flow from Swan Pond Creek, backwater from the impounded Emory River, precipitation, as well as storm water run-off from surrounding

impervious surfaces (i.e., Swan Pond Circle Road). Water levels in these embayments fluctuated throughout the year in response to managed water levels at the Watts Bar Dam. The normal summer and winter pool levels of Watts Bar Reservoir in the vicinity of the KIF are 741 and 735 feet msl, respectively. Low winter water levels, as seen in historical aerial photography, expose significant areas of unvegetated mudflats and sand bars around the perimeter of the embayments.

Restoration Concept A will restore flow from Swan Pond Creek, as well as a hydrologic connection to the Emory River, by restoring pre-spill topography to the embayment area. In addition, existing culverts under Swan Pond Road and Swan Pond Circle that provide a hydrologic connection from the Central Embayment to the Northern and Western Embayments will be returned to their pre-existing condition. Reestablishment of microtopography within the floodplain will facilitate restoration of wetland hydrology in areas adjacent to the embayments.

3.1.3 Soils and Sediments

Fine sediments likely characterized the bed or bottom of the Northern and Central Embayments. Analysis of historical aerial photography clearly demonstrates that this reach of the Emory River and the associated embayments are in a highly depositional environment, and characterized by high sediment loads. Sediment bars or bands within the main channel of the Emory River are distinctly observable in Figure 2, as well as other historical aerial photography. While the majority of sediment within the embayments likely comes from backwater of the Emory River, the embayments likely also capture sediment from the Swan Pond Creek. A final restoration design may require hydrologic and sediment modeling.

The U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) soils maps were also reviewed for native soils surrounding the two embayments. Dominant mapped units included: 1) Etowah loam, 2 to 5 percent slopes; 2) Etowah silt loam, 5 to 12 percent slopes; 3) Melvin silt loam, frequently flooded; 4) Montevallo channery silt loam, 12 to 20 percent slopes; and 5) Allen loam, 5 to 12 percent slopes. The soils mapping is included as Appendix B.

Restoration Concept A will excavate all ash within the embayments to at least the native soil surface or historic sediments. Final depth of excavation will be addressed in the final restoration design. In addition, a final restoration design will require characterization of these sediments. Given that the embayment appears subject to

high sediment deposition, Concept A will not attempt to restore complexity to the bottom substrate of the embayments. This is expected to reestablish naturally.

Along the banks of the embayments and surrounding historic floodplain, dredging will attempt to preserve as much of the native soil profile as possible. Hydric soils were identified in the wetland ecosystems surrounding the embayment areas. Restoration of microtopography within the floodplain will attempt to restore wetland hydrology. After determination of a necessary depth of excavation, a final design will evaluate the organic content, as well as moisture retention capacities of the soils to be exposed by excavation to determine if soil amendments will be necessary to support the restoration of native plant communities.

3.1.4 Plant Communities

Plant communities within the embayment area were greatly impacted by the ash spill. Dominant plant communities proximate to the embayments prior to the ash spill included: 1) riparian forest dominated by sycamore, green ash, willow, silver maple, boxelder, and alder surrounding the embayments; 2) scrub-shrub and emergent wetland communities along the fringe of the Central Embayment, dominated by buttonbush and silky dogwood and a high diversity of obligate wetland grasses, rushes, sedges, smartweeds, jewelweed and marsh mallow; 3) landscaped, suburban lawns, and agricultural land; and 4) 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. Analysis of the 2008 aerial photograph taken before the spill indicates that at least 28.4 acres of forest and scrub-shrub vegetation was impacted.

Restoration Concept A will restore a complex mosaic of native wetland and upland plant communities to areas previously dominated by forest and scrub-shrub habitat. This is inclusive of the restoration of the pre-existing 0.31-acre scrub-shrub wetland along the western shoreline of the northern embayment. The proposed planting areas are illustrated in Figure 6. A conceptual cross-section of the embayment with reference to different native plant communities is included as Figure 8. Species composition and densities of restored plant communities will be based upon previously collected data within the embayment area, as well as data collected from surrounding reference communities in a similar geomorphic position. Table 2 includes a preliminary list of native species that could be incorporated into a final planting design.

3.1.5 Faunal Habitat

The embayment areas were historically heavily used by shorebirds, waterfowl, amphibians, reptiles, fish, benthic macroinvertebrates, and mammals. Concept A will address the restoration of faunal communities and assemblages indirectly through the restoration of habitat features important to a wide suite of native faunal species. Specifically, this restoration approach will: 1) restore a complex mosaic of native plant communities with vertical and horizontal structure necessary for a wide suite of faunal species; 2) restore a floodplain microtopography important to amphibian species; and 3) restore a shoreline and in-water structural habitat important to fish, benthic macroinvertebrates, and birds. A summary of the approach specific to the different faunal groups is provided below:

- Fish populations historically used the embayment areas as off-channel habitat necessary for foraging, resting, cover, and potentially spawning. Riparian cover across significant areas of the shoreline provided shade, organic inputs, as well as potential shoreline complexity important to fish. This restoration concept will restore a complex mosaic of forest, scrub-shrub, and emergent wetland plant communities along the embayment shorelines. In addition, this concept will restore the island along the northern perimeter of the embayment that likely provided aquatic structural complexity important to fish, benthic macroinvertebrates, and larger semi-aquatic fauna.
- Semi-aquatic mammals, turtles, water snakes, and a variety of amphibians, including frogs and salamanders, likely utilized the lacustrine fringe emergent wetlands, as well as the floodplain forest and scrub-shrub plant communities. Restoration of a complex mosaic of native plant communities to the embayment ecosystems will provide horizontal and vertical structure important to a suite of terrestrial and semi-aquatic faunal species.
- A wide diversity of bird species utilized the embayment ecosystem. Consistent with the approach discussed above, restoration of a mosaic of native plant communities with horizontal and vertical structure will attract a suite of native bird species that historically utilized the area for foraging, nesting, resting, etc. Artificial snags could be constructed with on-site coarse wood to provide additional roosting habitat proximate to open water habitat. Shoreline restoration with emphasis on restoring the mudflats surrounding the embayments during low water levels can also address habitat restoration for the piping plover.

3.1.6 Summary of Actions

Actions required under Restoration Concept A are as follows, and conceptually illustrated in Figure 6.

- Restore topography to the embayment area to the pre-existing condition. This will require dredging and excavating all ash to the depth of the native soil surface. In addition, the small island habitat proximate to the northern shoreline of the Central Embayment will be restored.
- Restore complex microtopography to areas adjacent to the open water habitat.
- Restore hydrology from Swan Pond Creek and to the Emory River. This will be completed through the removal of Dike #2 and subsequent removal of the clean water channels which were constructed following the ash spill.
- Plant a complex mosaic of native wetland and floodplain plant communities with attributes important to native faunal species.

3.1.7 Summary of Data Gaps

The following is a preliminary list of actions still required to complete a final restoration design for the embayment areas:

- Potential hydrologic and sediment modeling of the embayments.
- Sampling of ash depths throughout the embayments, associated floodplain, as well as characterization of historic substrate/sediment that will be exposed after excavation/dredging.
- Reference sampling of regional plant communities found in a range of sites with a similar geographic position.

3.2 Concept B – Restore Embayment Area to Pre-Existing Condition with Selected Enhancements

Restoration Concept B will restore the embayments to pre-existing condition, but include a number of enhancements strategically selected to enhance both the terrestrial and aquatic environments. A final selection of enhancement opportunities can be evaluated based upon an assessment of functional enhancement to the overall ecosystem functioning, as well as incurred costs. Available models to assess or evaluate the functional enhancement include the TVARAM for wetlands, as well as the

Shoreline Aquatic Habitat Index. A conceptual plan view of Restoration Concept B actions is presented as Figure 7.

3.2.1 Morphology/Topography

Restoration Concept B will only alter the pre-existing topography of the embayments when there is an opportunity for increasing the complexity of the shoreline habitat, or increasing the aerial extent of adjacent wetland communities. A conceptual plan view of proposed restoration actions under Concept B is included as Figure 7. A conceptual cross-section of the restored embayment is included as Figure 8. A final restoration design will incorporate the following actions:

- Grading banks along the shoreline to enhance the hydrologic connection and increasing the potential aerial extent of restored wetland communities adjacent to the embayments.
- Increase the number and size of microdepressions throughout the floodplain. Microdepressions could also incorporate coarse wood to mimic tree windfalls, and provide additional structural complexity important to wildlife. Large coarse wood could potentially be harvested from impacted plant communities within the project site, and incorporated into the final construction.
- Construction of one or more islands within the Central embayment. These islands provide structure important to birds and other terrestrial animals, while also providing additional structure important to fish and other aquatic species. Depending upon the proposed final grading, the potential exists for using on-site soil, coarse wood, and potential rock or boulders for construction of the islands. However, importing fill and other structural materials may be necessary.

3.2.2 Hydrology

Restoration Concept B would principally incorporate the actions described above under restoration of topography/morphology to the Northern and Central Embayments. Enhancement opportunities as they pertain to hydrology would focus on construction of floodplain microdepressions, or grading the banks along the shoreline of the embayments to achieve a greater area suitable to support native wetland plant communities.

Concept B could evaluate the potential construction of weirs within the Northern and Central Embayments to reduce the significant (i.e., 4 feet) seasonal water fluctuations.

Currently, large unvegetated mudflat areas characterize the perimeter of the embayments during winter low water levels, as emergent vegetation is not tolerant of these fluctuating water levels. By increasing the aerial extent of permanent open water within the Central and Northern Embayments, this concept could facilitate the restoration of a greater area of emergent wetland communities around the perimeter of the embayments. The engineered weirs would need to allow fish movement between the Emory River and the embayments.

3.2.3 Soils and Sediments

Given the embayments are depositional environments, enhancement opportunities relative to bottom substrates are limited, if not impractical. However, a final design could evaluate the addition of cobble and boulders along the shoreline of the embayments. The addition of cobbles and boulders would enhance structural complexity important to fish and benthic macroinvertebrates during summer high water levels. Depending upon the final restoration design, there may be portions of the embayment not susceptible to significant sediment accumulation and allow for the enhancement of bed materials. Please refer to Section 3.2.6 for a discussion of additional enhancements that could provide important structure to fish and benthic macroinvertebrates.

Consistent with Concept A, a final design will evaluate the need for importing additional soil amendments into the restored riparian and floodplain communities. Soil amendments would address appropriate carbon to nitrogen ratios, as well as water retention capacities, and thus the long term survival of specified restoration plantings.

3.2.4 Plant Communities

Restoration Concept B can achieve one of the most significant functional enhancements by increasing the areal extent of restored native plant communities. Specifically, this concept can address 1) restoration of portions of the embayment shorelines that were maintained as landscaped lawns, and 2) increase width of the riparian zone and floodplain forests. By restoring native plant communities around the entire perimeter of both embayments, while also increasing the width and subsequent complexity of plant communities, this concept will provide a significant enhancement to both biogeochemical and faunal habitat ecosystem functions.

Figure 7 illustrates the potential restoration opportunities for restored native plant communities in the central and northern embayment. This concept identifies a

maximum of 50 acres to be restored proximate to the embayments. Along the Central Embayment, the southern boundary will be limited by reconstruction of the dredge cell and the northern and western boundaries limited by Swan Pond Road and Swan Pond Circle. Along the Northern Embayment, the extent of restored plant communities will be limited by Swan Pond Road to the west and decisions as to future land uses along the eastern boundary. The eastern boundary was historically maintained as open fields and/or managed agricultural fields, but has since been purchased by TVA subsequent to the spill. This restoration concept has assumed a minimum riparian width of 300 feet, but can be easily adjusted based upon final restoration evaluations.

Consistent with Concept A, this concept will require additional data collection at multiple regional reference sites. A preliminary list of native species to be incorporated in the final design is included as Table 2.

3.2.5 Faunal Habitat

In addition to restoration of floodplain microtopography and native wetland and floodplain plant communities, a number of additional enhancement opportunities exist to increase the faunal habitat within the embayment ecosystem. Specifically, these enhancements include: 1) structural complexity of shoreline and floodplain, 2) in-water structural habitat, and 3) artificial osprey platforms.

Similar to the inclusion of coarse wood into the graded floodplain microdepressions as discussed above, coarse wood structures could be constructed within the restored shoreline. These structures could extend into open water habitat, and provide both aquatic and terrestrial habitat for a suite of faunal species. In addition, they would provide additional long-term stability to the shoreline. In addition, coarse wood could also be used to construct artificial snags within the restored floodplain and provide valuable roosting habitat to a suite of native bird species.

A concept to the artificial snags would be construction of osprey platforms within the open water habitat or restored floodplain. Ospreys are common in the area, and known to nest on natural and man-made structures on and around the KIF properties. Osprey platforms have been successful across the country, and could provide additional habitat that normally would require the development of a mature riparian forest.

The final restoration design could also include restoration or creation of in water artificial reef habitats within the Central Embayment. The artificial reefs are commonly used in aquatic environments, and shown to provide significant habitat functions

important to fish and benthic macroinvertebrates. Artificial reefs could be addressed by construction of boulder and coarse wood structures within the open water habitat, or placement of concrete Reef Balls. Reef Balls are made by pouring concrete into a fiberglass mold containing a central polyform buoy surrounded by various sized inflatable balls to make holes. There are over a dozen different standard mold sizes, and custom sizes are possible. Molds are obtained from the Reef Ball Foundation. The critical variable to these artificial reefs are placement in a position of the embayment that will have water levels covering all of the reefs during critical times of fish spawning.

3.2.6 Summary of Enhancement Opportunities

Restoration enhancement opportunities under Restoration Concept B include, but are potentially not limited to:

- Restoration of embayment shoreline to include additional structural complexity through coarse wood structures, while also grading portions of bank to increase aerial extend of adjacent wetlands.
- Restore complex microtopography to the historic floodplain greater than pre-existing condition (Concept A). Microtopography could include construction of windfalls and other floodplain coarse wood structures, and provide important wildlife habitat.
- Restore a complex mosaic of native wetland and floodplain plant communities to an area up to 50 acres.
- Create multiple islands within the embayments that will provide additional forested and scrub-shrub wetland area, as well as provide additional in-water aquatic structural complexity.
- Construction of in-water artificial reefs to provide additional habitat important to fish and benthic macroinvertebrates.
- Construction of weir(s) within the embayments to increase the areal extent of permanent open water.

3.2.7 Summary of Data Gaps

No additional actions will be required beyond those identified for Concept A.

4. Costing

Given the number of assumptions included in this report, costing has been summarized based upon per unit price for many of the identified actions. Costs provided below are provisional estimates and only intended to support preliminary evaluation of a preferred concept for restoration of the embayment ecosystems. Consistent with the report organization above, each of the concepts is addressed separately below.

4.1 Concept A

Restoration Concept A targets the restoration of pre-existing conditions of the embayment ecosystems prior to the ash spill. A plan view of the restoration actions proposed under Concept A is presented as Figure 6. The preliminary cost estimates are provided in the following table:

Proposed Action	Estimated Per Unit Cost	Estimated Total Cost
Coarse and fine grading to restore pre-existing topography to embayment and surrounding terrestrial areas. Includes construction of multiple small microdepressions. Assume restoration area of 28 acres, including 0.43 acres of microtopography.	$6000/acre (Coarse) $58,600/acre (Fine)	$168,000 (Coarse) $25,200 (Fine)
Construction of single small island in central embayment. Assume 6,500 square feet, and 8 to 10 feet in elevation above embayment bottom.	Lump Sum	$50,000
Potential soil amendments to surrounding terrestrial areas to address appropriate carbon to nitrogen ratios. These may not be necessary, depending upon subsequent data collection. Assume 28 acres of restoration, 260 cubic yards/acre. Assumes 2-inch amendments of compost or top soil.	$25/cubic yard	$182,000
Planting of a complex mosaic of native wetland and floodplain plant communities with attributes important to native faunal species. Assume 28 acres of restoration. Density of trees and shrubs both 700 stems per acre, with 1 gallon nursery stock.	$15,000/acre	$420,000.00
Estimated Total		**$845,200**

4.2 Concept B

Restoration Concept B will restore the embayments to pre-existing condition, but include a number of enhancements strategically selected to enhance both the terrestrial and aquatic environments. A conceptual plan view of Concept B actions is presented as Figure 7. The preliminary cost estimates are provided in the following table:

Proposed Action	Per Unit Cost	Estimated Total Cost
Coarse and fine grading to restore pre-existing topography to embayment and surrounding terrestrial areas. Includes construction of microdepressions (without coarse wood). Assumes restoration of 50 acres, including 1.26 acres of microtopography.	$6000/acre (Coarse) $58,600/acre (Fine)	$300,000 (Coarse) $73,836 (Fine)
Construction of coarse wood structure within shoreline of embayments. Assume 20 structures.	$200/structure	$4,000
Construction of multiple islands in embayments. Assume three islands.	$50,000/island	$150,000
Construction of floodplain coarse wood structures. Assume 50 structures.	$200/structure	$10,000
Placement of large boulders and cobbles along portions of the embayment shoreline. Assume 25 units.	$1,200/Ea	$30,000
Potential amendments (i.e., organic material) to surrounding terrestrial areas. Assume 50 acres of restoration, 260 cubic yards/acre. Assume 2-inch top soil amendment.	$25cubic yard	$325,000
Planting of a complex mosaic of native wetland and floodplain plant communities with attributes important to native faunal species. Assume 50 acres of restoration. Density of trees and shrubs both 700 stems per acre, with one gallon nursery stock.	$20,000/acre	$1,000,000
Construction of osprey platform. Assume construction of 3 platforms.	$2,500/platform	$7,500
Construction of artificial reefs.	Lump Sum	$25,000
Construction of weir(s) within the embayments to increase the areal extent of permanent open water habitat.	Lump Sum	$ 65,000
Estimated Total		**$1,990,336**

5. Summary

This *Conceptual Restoration Design Report* is intended to support the preparation of the Non-Time Critical Removal Action EE/CA for the dredge cell and embayment, with emphasis on an evaluation of site concepts for restoration of the Swan Pond embayment, which was filled with ash following the dike failure. The EE/CA identifies four overall site concepts for restoration of the dredge cell area. Specific to the embayments, the concepts analysis identifies two general approaches: leave ash in place (Concept 1), or remove ash from embayments (Concepts 2 through 4) and restore the ecosystem. TVA has committed to removing ash from the embayment areas; therefore, the "No Action Concept" (i.e., Concept 1) was not evaluated as part of this report.

This report identifies two restoration design concepts for the embayment ecosystem. The first concept (Concept A) would restore the embayment area to pre-existing conditions as best determined from analysis of existing data, site observations, reference site data, and best professional judgment. The second restoration concept (Concept B) would restore to pre-existing condition, but also include a suite of enhancements to both the riparian and aquatic environments. Selected enhancement opportunities would directly target enhancement to the overall ecosystem functioning. Available models to assess or evaluate the functional enhancement include the TVARAM for wetlands, as well as the Shoreline Aquatic Habitat Index.

This report summarizes pre-existing conditions and potential restoration actions for each concept based upon: 1) topography/morphology, 2) hydrology, 3) sediments/soils, 4) plant communities, and 5) faunal habitat. To assist in the evaluation of concepts, a cost analysis of the proposed actions is summarized in Section 4. It is important to note that concepts presented in this conceptual design report also have applicability to other portions of the embayment ecosystems outside the purview of this report. For example, areas on the peninsula east of Dike #2 could incorporate concepts presented below and be restored as part of the final restoration design.

6. References

Cowardin, L. M., V. Carter, F. C. Golet, E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 131pp.

Tennessee Valley Authority. 2004. *TVA Reservoir Operations Study and Environmental Impact Statement*. Prepared in cooperation with the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

Tennessee Valley Authority. 2006. *TVA Reservoir Operations Study Wetland Monitoring Summary Report*.

Tennessee Valley Authority. 2009a. *Initial Emergency Response Actions for the Kingston Fossil Plan Ash Dike Failure*. February 2009.

Tennessee Valley Authority. 2009b. *Corrective Action Plan for the TVA Kingston Fossil Plant Ash Release*. March 2009.

Tennessee Valley Authority. 2009c. *Kingston Fly Ash Recovery Project Non-Time Critical Removal Action Scope and Work Plan*.

Yokley, P., Jr. 2005. *Freshwater Mussel Survey of Impounded Area of the Clinch River Adjacent to the Power Plant, TVA, Kingston, Tennessee*. A Report Submitted to TVA by Yokley Environmental Consulting Service, Florence, Alabama.

Table 1. Federally Listed as Endangered and Threatened Species that are Currently Present in Roane County, Tennessee

Common Name	Scientific Name	Federal Status
Plants		
American hart's-tongue fern	*Asplenium scolopendrium var. americanum*	Threatened
Cumberland rosemary	*Conradina verticillata*	Threatened
Virginia spiraea	*Spiraea virginiana*	Threatened
Mussel		
Pink mucket	*Lampsilis abrupta*	Endangered
Fish		
Spotfin chub	*Cyprinella monacha*	Threatened
Bird		
Piping plover	*Charadrius melodus*	Endangered
Mammal		
Gray bat	*Myotis grisescens*	Endangered

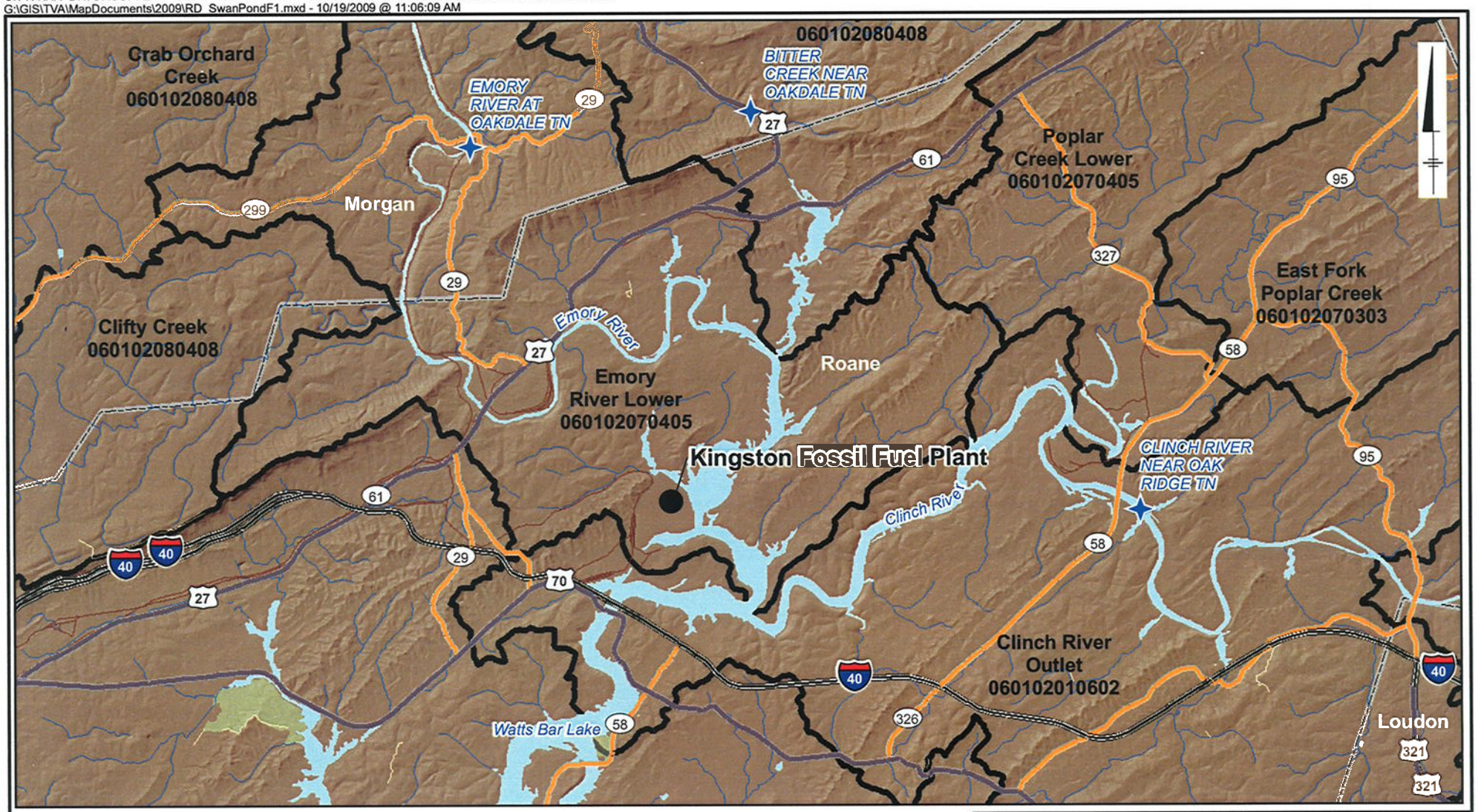
Table 2. Preliminary List of Plant Species to be Included in Final Restoration Design

Species	
Common Name	**Scientific Name**
Trees	
Silver maple	*Acer saccharinum*
Yellow buckeye	*Aesculus octandra*
Yellow birch	*Betula alleghaniensis*
River birch	*Betula nigra*
Pignut hickory	*Carya glabra*
Pecan	*Carya illinoensis*
Shagbark hickory	*Carya ovata*
Mockernut hickory	*Carya tomentosa*
Flowering dogwood	*Cornus florida*
American beech	*Fagus grandifolia*
White ash	*Fraxinus americana*
Green ash	*Fraxinus pennsylvanica*
Black walnut	*Juglans nigra*
Black gum	*Nyssa sylvatica*
Sycamore	*Platanus occidentalis*
Cottonwood	*Populus deltoides*
Black cherry	*Prunus serotina*
White oak	*Quercus alba*
Chestnut oak	*Quercus montana*
Willow oak	*Quercus phellos*
Northern red oak	*Quercus rubra*
Black oak	*Quercus velutina*
Black willow	*Salix nigra*
Basswood	*Tilia americana*
American elm	*Ulmus americana*
Cedar elm	*Ulmus crassifolia*
Winged elm	*Ulmus elata*
Slippery elm	*Ulmus rubra*
Shrubs/Understory	
Smooth alder	*Alnus serrulata*
Serviceberry	*Amelanchier spp.*

Species	
Common Name	**Scientific Name**
Shrubs/Understory, continued	
American hornbeam	*Carpinus caroliniana*
Sugarberry	*Celtis laevigata*
Buttonbush	*Cephalanthus occidentalis*
Silky dogwood	*Cornus amomum*
Huckleberry	*Galussacia ursina*
Crimsoneyed rosemallow	*Hibiscus moscheutos*
Holly	*Ilex spp.*
Mountain laurel	*Kalmia latifolia*
Spicebush	*Lindera benzoin*
Magnolia species	*Magnolia spp.*
Hophornbeam	*Ostrya virginiana*
Sourwood	*Oxydendrum arboreum*
Flame azalea	*Rhododendron calendulaceum*
Rosebay rhododendron	*Rhododendron maxiumum*
Elderberry	*Sambucus canadensis*
Steeplebush	*Spirea tomentosa*
Herbaceous	
Marsh mallow	*Althea officinalis*
False foxglove	*Aureolaria laevigata*
Small spike falsenettle	*Boehmeria cylindrical*
Sedge species	*Carex spp.*
Spikerush species	*Eleocharis spp.*
Virginia wildrye	*Elymus virginicus*
Joe-pye-weed	*Eupatorium purpureum*
Galax	*Galax aphylla*
Downy rattlesnake plantain	*Goodyera pubescens*
Fowl mannagrass	*Gylceria striata*
Rush species	*Juncus spp.*
Rice cutgrass	*Leersia oryzoides*
Smartweeds	*Polygonum spp.*
Christmas fern	*Polypodium virginianum*
Bullrushes	*Scirpus spp.*

Species	
Common Name	**Scientific Name**
Herbaceous, continued	
Blue-eyed grass	*Sisyrinchium angustifolia*
Goldenrods	*Solidago spp.*
Bellwort	*Uvularia perfoliata*

CITY: KNX DIV/GROUP: ENV DB: R.MCKINNEY LD: D.PARTIRDGE PIC: PM: D.JONES TM: R.LEPSICK TR:
G:\GIS\TVA\MapDocuments\2009\RD_SwanPondF1.mxd - 10/19/2009 @ 11:06:09 AM



Legend

- USGS Stream Gages
- Stream
- Interstate
- Highway
- Lake
- County
- HUC 12 Watersheds

0 2 4 Miles

GRAPHIC SCALE

Tennessee Valley Authority
Kingston, Tennessee
Conceptual Restoration Design Report
Swan Pond Embayments

Area Watershed Map

ARCADIS

FIGURE
1

0 1,000 2,000 Feet

Legend

Culvert

Dike

NOTES:

1. 2008 aerial photograph provided by Tennessee Valley Authority, and prior to ash slide event.

Tennessee Valley Authority
Kingston, Tennessee

Conceptual Restoration Design Report
Swan Pond Embayments

2008 Aerial Photograph - Pre Event

ARCADIS

FIGURE 2

CITY: KNX DIV/GROUP: ENV DB: R.MCKINNEY LD: D.PARTIRDGE PIC: PM: D.JONES TM: R.LEPSICK TR: G:\GIS\TVA\MapDocuments\2009\RD_SwanPondF2.mxd

Legend

- Culvert
- Dike
- Pre-Existing Wetlands
- Pre-Existing Waters at Summer Pool Level

NOTES:

1. March 20, 2009 post-event aerial photograph provided by Tennessee Valley Authority.
2. Wetlands were identified by TVA as part of the Corrective Action Plan (2009) assessment by integrating Land Use/Land Cover (2003) data with aerial imagery from 2006 and/or 2008.

Tennessee Valley Authority
Kingston, Tennessee

Conceptual Restoration Design Report
Swan Pond Embayments

2009 Aerial Photograph - Post Event

ARCADIS

FIGURE 3

CITY:(Cranbury) DIV/GROUP:(ENV) DB: LD: PIC: PM: TM: TR:
G:\GIS\TVA\MapDocuments\2009\RD_SwanPondF3.mxd

CITY: KNX DIV/GROUP: ENV DB: R.MCKINNEY LD: D.PARTIRDGE PIC: PM: D.JONES TM: R.LEPSICK TR:
G:\GIS\TVA\MapDocuments\2009\RD_SwanPondF4.mxd

Legend

- Culvert
- Dike
- Pre-Existing Wetlands

NOTES:

1. 2008 base aerial photograph (pre-event) provided by Tennessee Valley Authority.

2. Topography surveyd by Tennessee Valley Authority in 1993. Contour interval = 2 feet.

3. Blue identifies geographic extent of water at time of survey. Green identifes approximate extent of vegetation at time of survey.

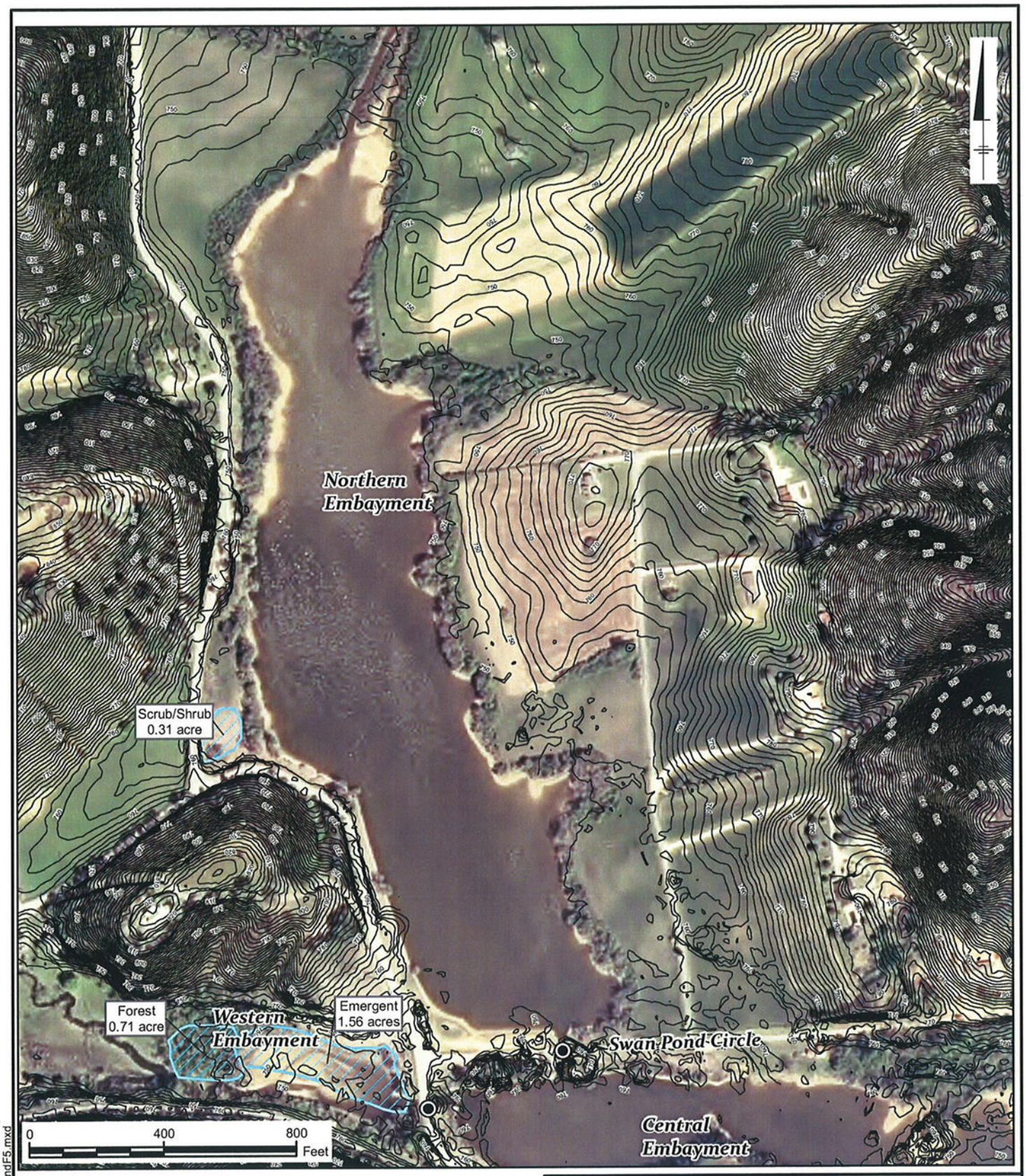
4. Wetlands were identified by TVA as part of the Corrective Action Plan (2009) assessment by integrating Land Use/Land Cover (2003) data with aerial imagery from 2006 and/or 2008.

Tennessee Valley Authority
Kingston, Tennessee
Conceptual Restoration Design Report
Swan Pond Embayments

Central Embayment Topography

ARCADIS

FIGURE
4



Legend

- Culvert
- Pre-Existing Wetlands

NOTES:

1. 2008 base aerial photograph (pre-event) provided by Tennessee Valley Authority.
2. Wetlands were identified by TVA as part of the Corrective Action Plan (2009) assessment by integrating Land Use/Land Cover (2003) data with aerial imagery from 2006 and/or 2008.
3. Post-event topography for un-impacted areas surveyd by Tennessee Valley Authority on December 28, 2008. Contour Interval = 2 feet.

Tennessee Valley Authority
Kingston, Tennessee

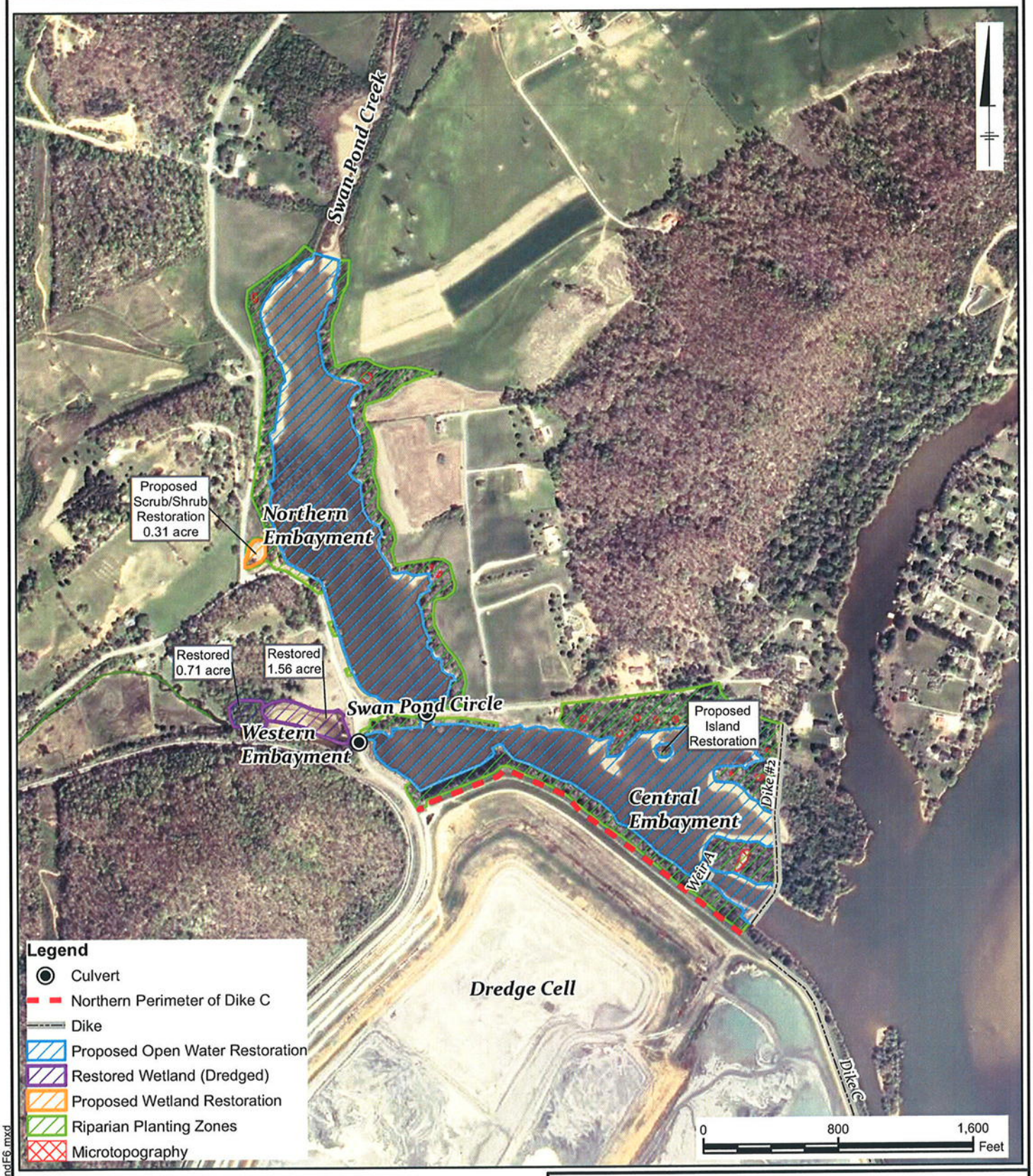
Conceptual Restoration Design Report
Swan Pond Embayments

Northern Embayment Topography

ARCADIS

FIGURE
5

CITY: KNX DIV/GROUP: ENV DB: R.MCKINNEY LD: D.PARTIRDGE PIC: PM: D.JONES TM: R.LEPSICK TR:
G:\GIS\TVA\MapDocuments\2009\RD_SwanPondF5.mxd



RESTORATION ACTIONS:

1. Restoration of embayment area topography to approximate pre-existing condition.
2. Construction of microtopography within riparian zone / floodplain.
3. Re-establishment of complex mosaic of native wetland and floodplain plant communities to a geographic area equivalent to the pre-existing condition (i.e., approximate 28 acres).
4. Restoration of island within the central embayment.

NOTE:

Wetlands were identified by TVA as part of the Corrective Action Plan (2009) assessment by integrating Land Use/Land Cover (2003) data with aerial imagery from 2006 and/or 2008.

Tennessee Valley Authority
Kingston, Tennessee

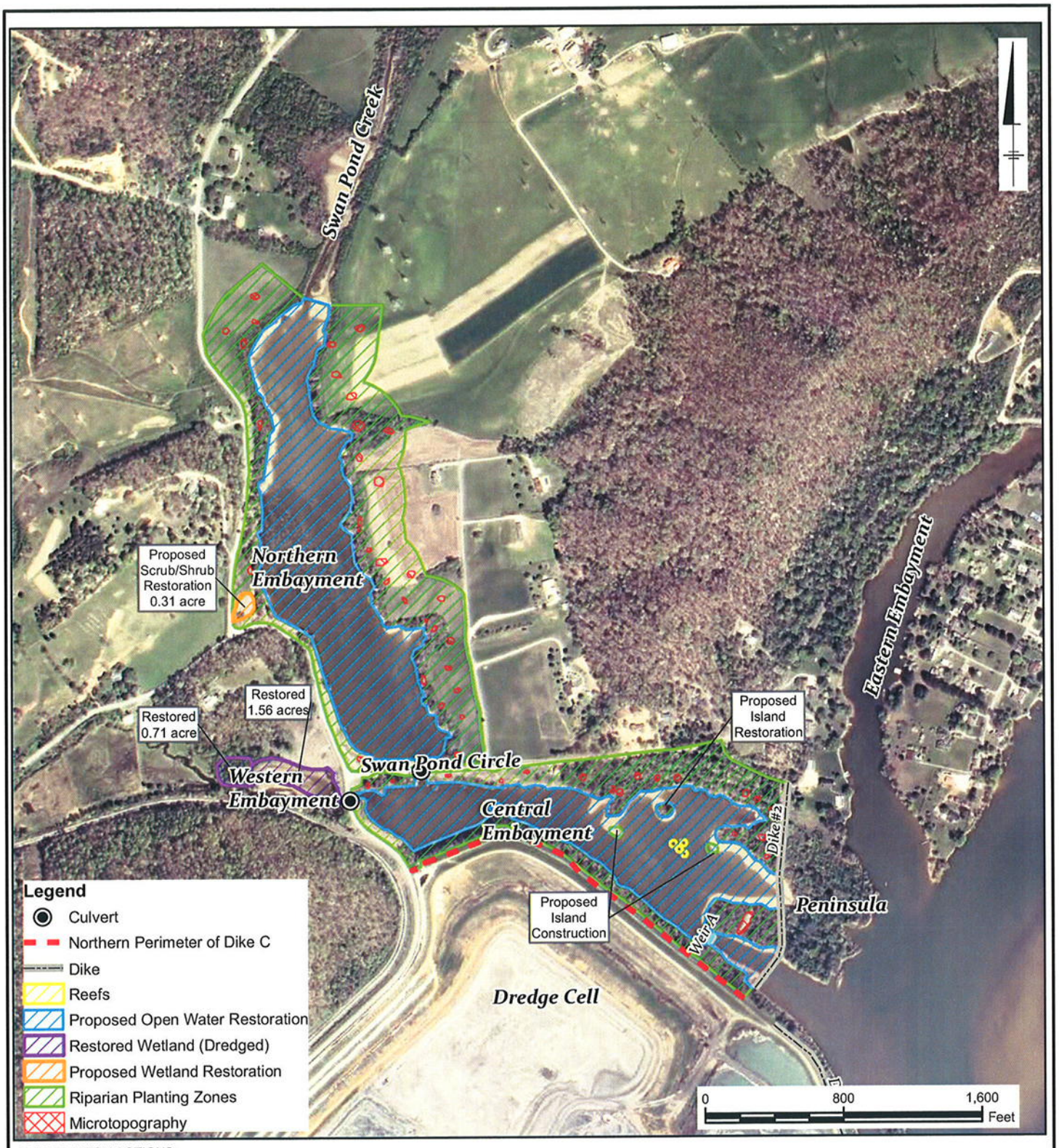
Conceptual Restoration Design Report
Swan Pond Embayments

Concept A Conceptual Design Swan Pond Embayments

ARCADIS

FIGURE
6

CITY: KNX DIV/GROUP: ENV DB: R.MCKINNEY LD: D.PARTIRDGE PIC: PM: D.JONES TM: R.LEPSICK TR:
G:\GIS\TVA\MapDocuments\2009\RD_SwanPondF6.mxd



RESTORATION ACTIONS:

1. Enhance structural complexity of embayment shorelines through construction of coarse wood structures, addition of boulders, and grading banks to increase surface area of wetlands.
2. Construction of microtopography within the riparian zone / floodplain.
3. Re-establishment of complex mosaic of native wetland and floodplain plant communities to a geographic area exceeding the pre-existing condition (approximate minimum of 28 acres - maximum of 50 acreas).
4. Restoration of multiple islands within the embayments which will provide additional forested and scrub shrub wetland area, as well as provide additional in-water aquatic structural complexity.
5. Construction of in-water artificial reefs to provide additional habitat for fish and benthic macroinvertebrates.
6. Construction of a weir within the Central Embayment to increase the areal extent of permanent open water.

NOTES:

Wetlands were identified by TVA as part of the Corrective Action Plan (2009) assessment by integrating Land Use/Land Cover (2003) data with aerial imagery from 2006 and/or 2008.

Tennessee Valley Authority
Kingston, Tennessee

Conceptual Restoration Design Report
Swan Pond Embayments

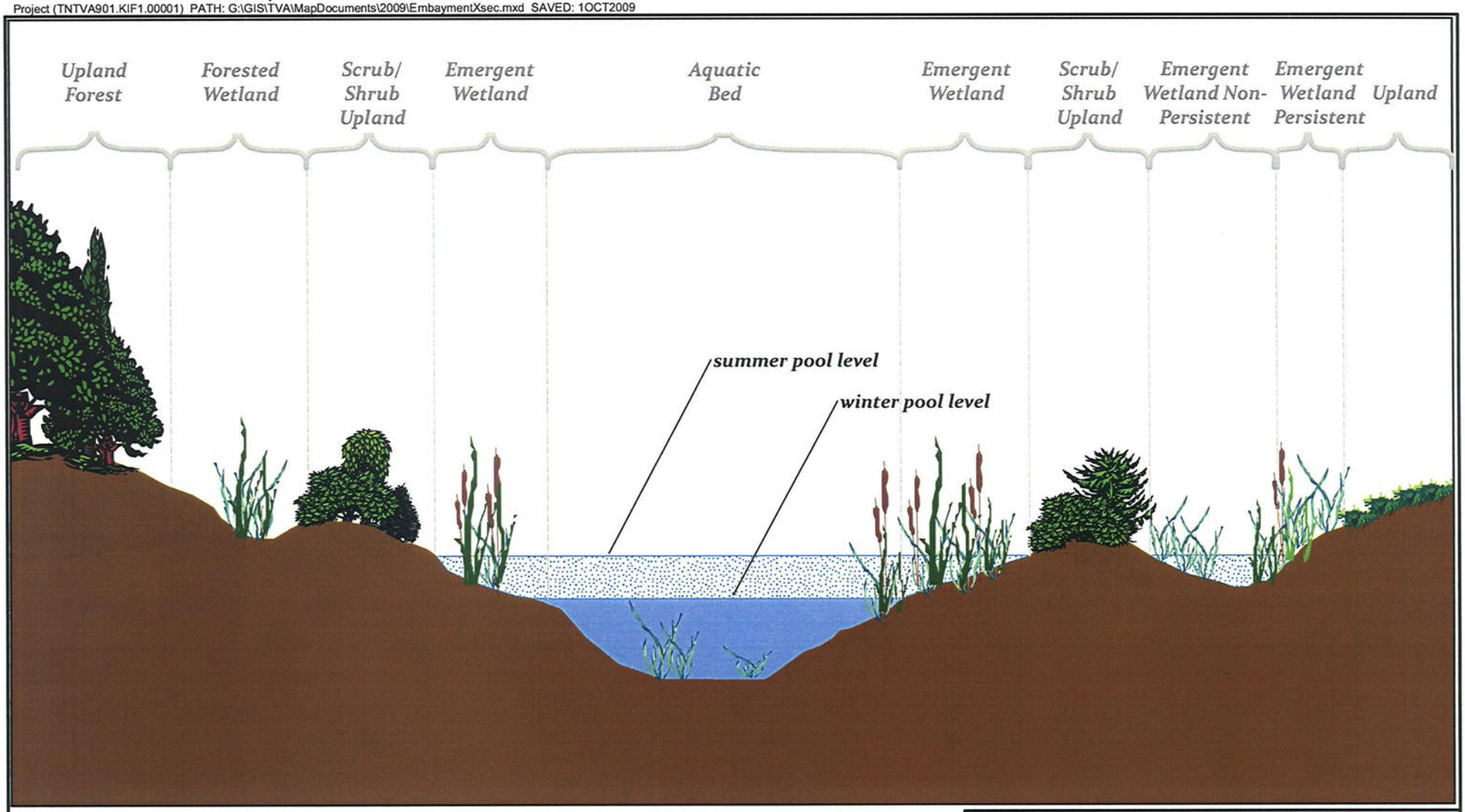
Concept B Conceptual Design Swan Pond Embayments

ARCADIS

FIGURE 7

CITY: KNX DIV/GROUP: ENV DB: R.MCKINNEY LD: D.PARTIRDGE PIC: PM: D.JONES TM: R.LEPSICK TR:
G:\GIS\TVA\MapDocuments\2009\RD_SwanPondF7.mxd

CITY: KNX DIV/GROUP: ENV DB: R.McKinney LD: PIC: PM: D. Jones TM:
Project (TNTVA901.KIF1.00001) PATH: G:\GIS\TVA\MapDocuments\2009\EmbaymentXsec.mxd SAVED: 1OCT2009



NOTES:

1. Example of complex mosaic of native plant communities proximate to the restored embayments. Note the microdepression on the left and right side of the aquatic bed that facilitates the restoration of forested and emergent wetland communities in the floodplain.

2. Not to scale.

TENNESSEE VALLEY AUTHORITY
KINGSTON, TENNESSEE
CONCEPTUAL RESTORATION DESIGN REPORT
SWAN POND EMBAYMENT

Conceptual Cross Section of Restored Embayment Ecosystem

ARCADIS

FIGURE
8

ARCADIS

Appendix A

TVA Wetland Reference Data

TVA Natural Heritage ROS Wetland Determination Form

Project: ROS Wetland Monitoring – Year 1	Investigator: Groton/Hixson/Pilarski	Normal Circumstances:	X	Sample ID (Reservoir, Transect & Plot #):	WBF3
County: Roane	TVA Reservoir: Watts Bar	Atypical Situation:		TVA Parcel ID/Zone	Swan Pond
State: TN	Date: 7/5/05	Problem Area:		Cowardin Code:	

Vegetation

	Plant Species	Stratum	Indicator		Plant Species	Stratum	Indicator
1.	*Liquidambar styraciflua*	H/S/T	FAC+	12.	*Juncus effuses*	H	FACW+
2.	*Quercus phellos*	S/T	FACW-	13.	*Betula nigra*	S/T	FACW
3.	*Acer rubrum*	S/T	FAC	14.	*Lycopus sp.*	H	OBL
4.	*Fraxinus pennsylvanica*	T	FACW	15.	*Glyceria striata*	H	OBL
5.	*Ulmus americana*	T	FACW	16.	*Eulalia viminea*	H	FAC+
6.	*Salix nigra*	T	OBL	17.	*Polygonum sagittatum*	H	OBL
7.	*Carex intumescens*	H	FACW	18.	*Leersia oryzoides*	H	OBL
8.	*Cephalanthus occidentalis*	S	OBL	19.	*Moss sp.*	H	
9.	*Carex tribuloides*	H	FACW+	**20.**	*Galium sp.*	**H**	
10.	*Boehmeria cylindrical*	H	FACW+	**21.**	*Aster sp.*	**H**	
11.	*Carex frankii*	H	OBL	**22.**	*Privet*	**S**	

Percent of Dominant Species That are OBL, FACW, or FAC: %

Hydrology

Field Observations:

Depth of Surface Water:	0	(in.)
Depth to Free Water in Pit:	0	(in.)
Depth to Saturated Soil:	0	(in.)

Wetland Hydrology Indicators:

Primary Indicators				**Secondary Indicators**	
X	Inundated	X	Drift Lines	X	Oxidized Root Channels
X	Saturated in Upper 12 in.	X	Water Marks	X	Water Stained Leaves
	Sediment Deposits	X	Drainage Patterns		

Remarks:

Soils *Soil Pit Center: 35.92344N -84.49985W*

Soil Unit:		**Drainage class:**		**Listed hydric soil?**	**Yes**		**No**	

Profile Description:

Depth (Inches)	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance	Texture
0-5”	10YR 5/1	----	----	----
5-8”	10YR 6/1	----	----	----
8-13”+	2.5Y 7/1	----	----	----

Hydric Soil Indicators:

X	Gleyed or Low Chroma Colors		Histic Epipedon	X	Aquic Moisture Regime
X	Sulfidic Odor		High Organic Cont. Surf. Layer Sandy Soils	X	Reducing Conditions
X	Concretions		Organic Streaking in Sandy Soils		Other (Explain in Remarks)

Remarks: Organic surface Oa to 2-3”

Wetland Determination

Hydrophytic Vegetation Present?	Yes	X	No		Is this Sampling Point Within a USACE Wetland?	Yes	X	No
Wetland Hydrology Present?	Yes	X	No		Does area only meet USFWS wetland definition?	Yes		No	X
Hydric Soils Present?	Yes	X	No		Is wetland mapped on NWI?	Yes	X	No

Estimated size:

Wetland Descriptors

Sample ID: WBF3

Photo ID(s):

Flagging Description:

Drawing

Please Include: North Arrow, Project Centerline, Survey Corridor Boundaries, Length of Wetland Feature, Distances from Centerline, Photo Locations

Obvious Connections to Waters of the US/State?	X	Yes		No	Waterbody/Watershed: Tennessee River							
Primary Water Source (If other, note in comments)		Cap. Fringe		Overbanking		Sheet Flow	X	Groundwater		Precipitation	X	Other
TVARAM SCORE:	67	**TVARAM CATEGORY:**										

Description of Wetland and Other Comments: (i.e. forest age class; habitat features; hydrologic regime; description of the wetland outside of or adjacent to ROW; erosion potential, existing disturbances, adjacent land use, wildlife observations, station numbers, lat-long, etc)

- Tree frogs
- Yellow-billed cuckoo
- Beaver activity in area (not affecting site)

Reservoir Operation System (ROS) Supplemental Wetland Monitoring Data Form
Tree Plot (0.1 acre: 37.2 ft radius)

Reservoir:	Watts Bar	**County:**	Roane	**Transect:**	
Investigator:	Groton/Hixson/Pilarski	**State:**	TN	**Plot ID:**	**WBF3**
Date:	7/5/05	**TVA Parcel ID/Zone:**	Swan Pond	**Cowardin Code:**	**PFO**

Tree ID #	**Species**	**Distance**	**Bearing**			**Comment**
1	Betula nigra					13
2	Acer rubrum					2
3	Fraxinus pennsylvanica					1
4	Quercus phellos					1
5	Ulmus americana					1
6	Salix nigra					2
7	Liquidambar styraciflua					2
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						

Crown Closure	**N**	**E**	**S**	**W**	**Mean**
	88	80	64	76	80%
Basal Area	**Total # of stems**	**BAF of prism**	**Sum BA**		
	16	**10**	160 sq. ft.		
Total number of species		6			

Crown Condition

Tree ID	**Distance**	**Bearing**	**Species**	**DBH**	**Crown Class**	**Condition**
A	20’	115°	Betula nigra	24.6 cm	2	Co-Dominant
B	30.3’	152°	Liquidambar styraciflua	21.3 cm	2	Co-Dominant
C	29.1’	279°	Acer rubrum	38.1 cm	2	Co-Dominant
D	36.2’	100°	Salix nigra	47 cm	2	Dominant

Reservoir Operation System (ROS) Supplemental Wetland Monitoring Data Form
Shrub Plot (0.01 acre: 11.8 ft radius)

Reservoir:	Watts Bar	**County:**	Roane	**Transect:**	
Investigator:	Groton/Hixson/Pilarski	**State:**	TN	**Plot ID:**	**WBF3**
Date:	7/5/05	**TVA Parcel ID:**	Swan Pond	**Plot Type:**	

Shrub ID #	Species	Distance	Bearing	Diameter (long axis)	Diameter (minor axis)	Comment
1	Alnus serrulata					2
2	Betula nigra					1
3	Liquidambar styraciflua					1
4	Acer rubrum					2
5	Quercus phellos					1
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Reservoir Operation System (ROS) Supplemental Wetland Monitoring Data Form
Forb Plot (0.0002 acre: 1.6 ft radius)

Reservoir:	Watts Bar	**County:**	Roane	**Transect:**	
Investigator:	Groton/Hixson/Pilarski	**State:**	TN	**Plot ID:**	**WBF3**
Date:	7/5/05	**TVA Parcel ID:**	Swan Pond	**Plot Type:**	

Center of Forb Plot: 35.92342N -84.50003W

Forb ID #	**Species**	**% cover**				**Comment**
1	Carex tribuloides	85				
2	Carex frankii	10				
3	Moss	5				
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
27						
29						
30						

ORAM v.TVA Field Form Quantitative Rating

Site: WBF3	Rater(s): Groton/Hixson/Pilarski	Date: 7/5/05

6	6
max 6 pts.	subtotal

Metric 1. Wetland Area (size)

Notes: BR/CM = adjusted points for Blue Ridge and Cumberland Mountains. If an open water body (excluding aquatic beds and seasonal mudflats) is >20 acres (8 ha), then add only 0.5 acre (0.2 ha) of it to the wetland size for Metric 1.

Select one size class and assign score.
- ☒ >50 acres (>20.2 ha) (6 pts)
- ☐ 25 to <50 acres (10.1 to <20.2 ha) (5) [BR/CM (6)]
- ☐ 10 to <25 acres (4 to <10.1 ha) (4) [BR/CM (6)]
- ☐ 3 to <10 acres (1.2 to <4 ha) (3) [BR/CM (5)]
- ☐ 0.3 to <3 acres (0.1 to <1.2 ha) (2) [BR/CM (3)]
- ☐ 0.1 to <0.3 acre (0.4 to <0.1 ha) (1) [BR/CM (2)]
- ☐ >0.1 acre (0.4 ha) (0)

Sources/assumptions for size estimate (list):

NWI maps and field observation

7	13
max 14 pts.	subtotal

Metric 2. Upland Buffers and Surrounding Land Use

2a. Calculate average buffer width. Select only one and assign score. Do not double check.
- ☐ WIDE. Buffers average 50 m (164 ft) or more around wetland perimeter (7)
- ☒ MEDIUM. Buffers average 25 m to <50 m (82 to <164 ft) around wetland perimeter (4)
- ☐ NARROW. Buffers average 10 m to <25 m (32 ft to <82 ft) around wetland perimeter (1)
- ☐ VERY NARROW. Buffers average <10 m (<32 ft) around wetland perimeter (0)

2b. Intensity of surrounding land use. Select one or double check and average.
- ☐ VERY LOW. 2nd growth or older forest, prairie, savannah, wildlife area, etc. (7)
- ☐ LOW. Old field (>10 years), shrubland, young 2nd growth forest (5)
- ☒ MODERATELY HIGH. Residential, fenced pasture, park, conservation tillage, new fallow field (3)
- ☐ High. Urban, industrial, open pasture, row cropping, mining, construction (1)

19	32
max 30 pts.	subtotal

Metric 3. Hydrology

3a. Sources of water. Score all that apply.
- ☐ High pH groundwater (5)
- ☐ Other groundwater (3) [BR/CM (5)]
- ☐ Precipitation (1) [unless BR/CM primary source (5)]
- ☒ Seasonal/intermittent surface water (3)
- ☐ Perennial surface water (lake or stream) (5)

3b. Connectivity. Score all that apply.
- ☒ 100-year floodplain (1)
- ☒ Between stream/lake and other human use (1)
- ☒ Part of wetland/upland (e.g., forest), complex (1)
- ☒ Part of riparian or upland corridor (1)

3c. Maximum water depth. Select only one and assign score.
- ☒ >7 m (27.6 in.) (3)
- ☐ 0.4 to 0.7 m (16 to 27.6 in.) (2) [BR/CM (3)]
- ☐ <0.4 m (<16 in.) (1) [BR/CM 0.15 to 0.4 m (6 to <16 in.) (2)]

3d. Duration inundation/saturation. Score one or dbl. check & avg.
- ☐ Semi- to permanently inundated/saturated (4)
- ☐ Regularly inundated/saturated (3) [BR/CM (4)]
- ☒ Seasonally inundated (2) [BR/CM (4)]
- ☐ Seasonally saturated in upper 30 cm (12 in.) (1) [BR/CM (2)]

3e. Modifications to natural hydrologic regime. Score one or double check and average.
- ☐ None or none apparent (12)
- ☒ Recovered (7)
- ☐ Recovering (3)
- ☐ Recent or no recovery (1)

Check all disturbances observed

☐ ditch	☐ point source (nonstormwater)
☐ tile (including culvert)	☐ filling/grading
☐ dike	☐ road bed/RR track
☐ weir	☐ dredging
☐ stormwater input	☐ other _____

19	51
max 20 pts.	subtotal

Metric 4. Habitat Alteration and Development

4a. Substrate disturbance. Score one or double check and average.
- ☒ None or none apparent (4)
- ☐ Recovered (3)
- ☐ Recovering (2)
- ☐ Recent or no recovery (1)

4b. Habitat development. Select only one and assign score.
- ☐ Excellent (7)
- ☒ Very good (6)
- ☐ Good (5)
- ☐ Moderately good (4)
- ☐ Fair (3)
- ☐ Poor to fair (2)
- ☐ Poor (1)

4c. Habitat alteration. Score one or double check and average.
- ☒ None or none apparent (9)
- ☐ Recovered (6)
- ☐ Recovering (3)
- ☐ Recent or no recovery (1)

Check all disturbances observed

☐ mowing	☐ shrub/sapling removal
☐ grazing	☐ herbaceous/aquatic bed removal
☐ clearcutting	☐ sedimentation
☐ selective cutting	☐ dredging
☐ woody debris removal	☐ farming
☐ toxic pollutants	☐ nutrient enrichment

51
subtotal this page

Site: WBF3	Rater(s): Groton/Hixson/Pilarski	Date: 7/5/05

51
subtotal this page

0	51
max 10 pts.	subtotal

Metric 5. Special Wetlands

Select all that apply. Where multiple values apply in row, score row as single feature with highest point value. Attach documentation for each.

- ☐ Bog, fen, wet prairie (10); acidophilic veg., mossy substrate >10 sq.m, sphagnum or other moss (5); muck, organic soil layer (3)
- ☐ Assoc. forest (wetl. &/or adj. upland) incl. >0.25 acre (0.1 ha); old growth (10); mature >18 in. (45 cm) dbh (5) [exclude pine plantation]
- ☐ Sensitive geologic feature such as spring/seep, sink, losing/underground stream, cave, waterfall, rock outcrop/cliff (5)
- ☐ Vernal pool (5); isolated, perched, or slope wetland (4); headwater wetland [1st order perennial or above] (3)
- ☐ Island wetland >0.1 acre (0.04 ha) in reservoir, river, or perennial water >6 ft (2 m) deep (5)
- ☐ Braided channel or floodplain/terrace depressions (floodplain pool, slough, oxbow, meander scar, etc.) (3)
- ☐ Gross morph. adapt. in >5 trees >10 in. (25 cm) dbh: buttress, multitrunk/stool, stilted, shallow roots/tip-up, or pneumatophores (3)
- ☐ Ecological community with global rank (NatureServe): G1*(10), G2*(5), G3* (3) [*use higher rank where mixed rank or qualifier]
- ☐ Known occurrence of state or federally listed species (10)
- ☐ Superior/enhanced habitat/usage: migratory songbird/water fowl (5); in-reservoir buttonbush (4); other managed fish/wildlife (3)
- ☐ Cat. 1 (very low quality): <1 acre (0.04 ha) AND EITHER >80% cover of invasives OR nonvegetated on mined/excavated land (-10)

	raw score*

*If the documented raw score for Metric 5 is 30 points or higher, the site is automatically considered a Category 3 wetland regardless of overall score.

16	67
max 20 pts.	subtotal

Metric 6. Plant Communities, Interspersion, Microtopography

6a. Wetland vegetation communities.
Score all present using 0 to 3 scale.

- 1 Aquatic bed
- 2 Emergent
- 1 Shrub
- 3 Forest
- 1 Mudflats
- 1 Open water <20 acres (8 ha)
- 1 Moss/lichen. Other _____

Vegetation Community Cover Scale

0 =	Absent or <0.1 ha (0.25 acre) contiguous acre [For BR/CM <0.04 ha (0.1 acre)]
1 =	Present and either comprises a small part of wetland's vegetation and is of moderate quality, or comprises a significant part but is of low quality
2 =	Present and either comprises a significant part of wetland's vegetation and is of moderate quality, or comprises a small part and is of high quality
3 =	Present and comprises a significant part or more of wetland's vegetation and is of high quality

6b. Horizontal (plan view) interspersion.
Select only one.

- ☐ High (5)
- ☐ Moderately high (4) [BR/CM (5)]
- ☒ Moderate (3)[BR/CM (5)]
- ☐ Moderately low (2) [BR/CM (3)]
- ☐ Low (1) [BR/CM (2)]
- ☐ None (0)

Narrative Description of Vegetation Quality

low =	Low sp diversity &/or dominance of nonnative or disturbance tolerant native sp
mod =	Native sp are dominant component of the vegetation, although nonnative &/or disturbance tolerant native sp can also be present, and species diversity moderate to moderately high, but generally w/o presence of rare, threatened or endangered sp
high =	A predominance of native species with nonnative sp &/or disturbance tolerant native sp absent or virtually absent, and high sp diversity and often but not always, the presence of rate, threatened, or endangered sp

6c. Coverage of invasive plants.
Refer to Table 1 ORAM long form for list.
Add or deduct points for coverage

- ☐ Extensive >75% cover (-5)
- ☐ Moderate 25-75% cover (-3)
- ☒ Sparse 5-25% cover (-1)
- ☐ Nearly absent <5% cover (0)
- ☐ Absent (1)

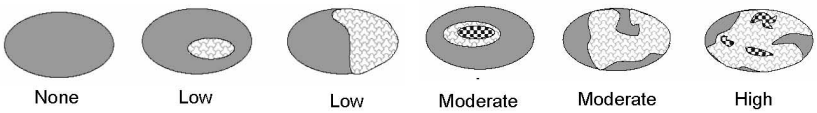
Mudflat and Open Water Class Quality

0 =	Absent <0.1 ha (0.25 acres) [For BR/CM <0.04 ha (0.1 acre)]
1 =	Low 0.1 to <1 ha (0.25 to 2.5 acres) [BR/CM 0.04 to <0.2 ha (0.1 to 0.5 acre)]
2 =	Moderate 1 to <4 ha (2.5 to 9.9 acres) [BR/CM 0.2 to <02 ha (0.5 to 5 acre)]
3 =	High 4 ha (9.9 acres) or more [BR/CM 2 ha (5 acres) or more]

6d. Microtopography.
Score all present using 0 to 3 scale.

- 1 Vegetated hummocks/tussocks
- 1 Coarse woody debris >15 cm (6 in.)
- 1 Standing dead >25 cm (10 in.) dbh
- 1 Amphibian breeding pools

Hypothetical Wetland for Estimating Degree of Interspersion



Microtopography Cover Scale

0 =	Absent
1 =	Present in very small amounts or if more common of marginal quality
2 =	Present in moderate amounts, but not of highest quality or in small amounts of highest quality
3 =	Present in moderate or greater amounts and of highest quality

67 **GRAND TOTAL (max 100 pts)**

Refer to the most recent ORAM Score Calibration Report for the scoring breakpoints between wetland categories at the following address:
http://www.epa.state.oh.us/dsw/401/401.html

TVA Natural Heritage ROS Wetland Determination Form

Project: ROS Wetland Monitoring – Year 1	Investigator: Groton/Hixson/Pilarski	Normal Circumstances:		Sample ID (Reservoir, Transect & Plot #):	WBS3
County: Roane	TVA Reservoir: Watts Bar	Atypical Situation:		TVA Parcel ID/Zone	Swan Pond
State: TN	Date: 7/5/05	Problem Area:		Cowardin Code:	PSS1E

Vegetation

	Plant Species	Stratum	Indicator		Plant Species	Stratum	Indicator
1.	*Acer rubrum*	S/T	FAC	11.	*Polygonum sagittatum*	H	OBL
2.	*Fraxinus pennsylvanica*	T	FACW	12.	*Leersia oryzoides*	H	OBL
3.	*Quercus phellos*	S/T	FACW-	13.	*Elymus virginicus*	H	FAC
4.	*Ulmus rubra*	T	FAC	14.	*Scirpus cyperinus*	H	OBL
5.	*Salix nigra*	S/T	OBL	15.	*Boehmeria cylindrical*	H	FACW+
6.	*Cephalanthus occidentalis*	S	OBL	16.	*Carex tribuloides*	H	FACW+
7.	*Rosa multiflora*	S	UPL	17.	*Carex intumescens*	H	FACW
8.	*Alnus serrulata*	S	FACW+	18.	*Juncus effusus*	H	FACW+
9.	*Acer saccharinum*	S	FACW	19.	Platanus occidentalis	T	FACW-
10.	*Hibiscus moscheutos*	S	OBL	20.	Ludwigia palustris	H	OBL

Percent of Dominant Species That are OBL, FACW, or FAC: 95%

Hydrology

Field Observations:

Depth of Surface Water:	4”	(in.)
Depth to Free Water in Pit:	8”	(in.)
Depth to Saturated Soil:	0	(in.)

Wetland Hydrology Indicators:

Primary Indicators					**Secondary Indicators**
X	Inundated	X	Drift Lines	X	Oxidized Root Channels
X	Saturated in Upper 12 in.	X	Water Marks	X	Water Stained Leaves
	Sediment Deposits	X	Drainage Patterns		

Remarks:

Soils *Soil Pit: 35.92653N -84.51570W*

Soil Unit:		**Drainage class:**		**Listed hydric soil?**	**Yes**		**No**	

Profile Description:

Depth (Inches)	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance	Texture
0-3”	10YR 5/2	7.5YR 4/6	Common	SIL
3-8”	10YR 6/1	7.5YR 4/6	Common	Sil
8-16”+	10YR 6/2	7.5YR 4/4	Many	SiL

Hydric Soil Indicators:

X	Gleyed or Low Chroma Colors		Histic Epipedon	X	Aquic Moisture Regime
X	Sulfidic Odor		High Organic Cont. Surf. Layer Sandy Soils	X	Reducing Conditions
X	Concretions		Organic Streaking in Sandy Soils		Other (Explain in Remarks)

Remarks:

Wetland Determination

Hydrophytic Vegetation Present?	Yes	X	No		Is this Sampling Point Within a USACE Wetland?	Yes	X	No
Wetland Hydrology Present?	Yes	X	No		Does area only meet USFWS wetland definition?	Yes		No X
Hydric Soils Present?	Yes	X	No		Is wetland mapped on NWI?	Yes	X	No

Estimated size:

Wetland Descriptors

Sample ID: WBS3	**Photo ID(s):** 1-4 (N,E,S,W)
Flagging Description:	

Drawing

Please Include: North Arrow, Project Centerline, Survey Corridor Boundaries, Length of Wetland Feature, Distances from Centerline, Photo Locations

Obvious Connections to Waters of the US/State?	X	Yes		No	Waterbody/Watershed: Tennessee River/Watts Bar Reservoir									
Primary Water Source (If other, note in comments)		Cap. Fringe		Overbanking		Sheet Flow		Groundwater		Precipitation	X	Other		
TVARAM SCORE:	71	**TVARAM CATEGORY:**												

Description of Wetland and Other Comments: (i.e. forest age class; habitat features; hydrologic regime; description of the wetland outside of or adjacent to ROW; erosion potential, existing disturbances, adjacent land use, wildlife observations, station numbers, lat-long, etc)

- Tree Frogs
- Red-wing Black Birds
- Frackles

Reservoir Operation System (ROS) Supplemental Wetland Monitoring Data Form
Tree Plot (0.1 acre: 37.2 ft radius)

Reservoir:	Watts Bar	**County:**	Roane	**Transect:**	
Investigator:	Groton/Hixson/Pilarski	**State:**	TN	**Plot ID:**	**WBS3**
Date:	7/5/05	**TVA Parcel ID/Zone:**	Swan Pond	**Cowardin Code:**	**PSS1E**

Tree ID #	**Species**	**Distance**	**Bearing**			**Comment**
1	Acer rubrum					
2	Fraxinus pennsylvanica					
3	Quercus phellos					
4	Ulmus rubra					
5	Salix nigra					
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						

Crown Closure	**N**	**E**	**S**	**W**	**Mean**
Basal Area	**Total # of stems**	**BAF of prism**	**Sum BA**		
		10			
Total number of species					

Crown Condition						
Tree ID	**Distance**	**Bearing**	**Total Height**	**DBH**	**Crown Class**	**Condition**

Reservoir Operation System (ROS) Supplemental Wetland Monitoring Data Form
Shrub Plot (0.01 acre: 11.8 ft radius)

Reservoir:	Watts Bar	**County:**	Roane	**Transect:**	
Investigator:	Groton/Hixson/Pilarski	**State:**	TN	**Plot ID:**	**WBS3**
Date:	7/5/05	**TVA Parcel ID:**	Swan Pond	**Plot Type:**	**PSS1E**

Shrub ID #	Species	Distance	Bearing	Diameter (long axis)	Diameter (minor axis)	Comment
1	Cephalanthus occidentalis					35
2	Rosa multiflora					1
3	Alnus serrulata					1
4	Acer rubrum					1
5	Acer saccharinum					1
6	Quercus phellos					1
7	Hibiscus moscheutos					1
8	Salix nigra					1
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Reservoir Operation System (ROS) Supplemental Wetland Monitoring Data Form
Forb Plot (0.0002 acre: 1.6 ft radius)

Reservoir:	Watts Bar	**County:**	Roane	**Transect:**	
Investigator:	Groton/Hixson/Pilarski	**State:**	TN	**Plot ID:**	**WBS3**
Date:	7/5/05	**TVA Parcel ID:**	Swan Pond	**Plot Type:**	**PSS1E**

Forb Plot: 35.92653N -84.51568W

Forb ID #	**Species**	**% cover**				**Comment**
1	Polygonum sagittatum	60				
2	Leerzia oryzoides	12				
3	Galium sp.	1				
4	Polygonum sp.	2				
5	Elymus virgincus	10				
6	Scirpus cyperinus	10				
7	Boehmeria cylindrical	1				
8	Carex tribuloides	1				
9	Juncus effusus	2				
10	Carex intumescens	1				
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
27						
29						
30						

Site: WBS3	Rater(s): Groton/Hixson/Pilarski	Date: 7/5/05

6	6
max 6 pts.	subtotal

Metric 1. Wetland Area (size)

Notes: BR/CM = adjusted points for Blue Ridge and Cumberland Mountains. If an open water body (excluding aquatic beds and seasonal mudflats) is >20 acres (8 ha), then add only 0.5 acre (0.2 ha) of it to the wetland size for Metric 1.

Select one size class and assign score.
- ☒ >50 acres (>20.2 ha) (6 pts)
- ☐ 25 to <50 acres (10.1 to <20.2 ha) (5) [BR/CM (6)]
- ☐ 10 to <25 acres (4 to <10.1 ha) (4) [BR/CM (6)]
- ☐ 3 to <10 acres (1.2 to <4 ha) (3) [BR/CM (5)]
- ☐ 0.3 to <3 acres (0.1 to <1.2 ha) (2) [BR/CM (3)]
- ☐ 0.1 to <0.3 acre (0.4 to <0.1 ha) (1) [BR/CM (2)]
- ☐ >0.1 acre (0.4 ha) (0)

Sources/assumptions for size estimate (list):

NWI Maps and field observations

7	13
max 14 pts.	subtotal

Metric 2. Upland Buffers and Surrounding Land Use

2a. Calculate average buffer width. Select only one and assign score. Do not double check.
- ☐ WIDE. Buffers average 50 m (164 ft) or more around wetland perimeter (7)
- ☒ MEDIUM. Buffers average 25 m to <50 m (82 to <164 ft) around wetland perimeter (4)
- ☐ NARROW. Buffers average 10 m to <25 m (32 ft to <82 ft) around wetland perimeter (1)
- ☐ VERY NARROW. Buffers average <10 m (<32 ft) around wetland perimeter (0)

2b. Intensity of surrounding land use. Select one or double check and average.
- ☐ VERY LOW. 2nd growth or older forest, prairie, savannah, wildlife area, etc. (7)
- ☐ LOW. Old field (>10 years), shrubland, young 2nd growth forest (5)
- ☒ MODERATELY HIGH. Residential, fenced pasture, park, conservation tillage, new fallow field (3)
- ☐ High. Urban, industrial, open pasture, row cropping, mining, construction (1)

19	32
max 30 pts.	subtotal

Metric 3. Hydrology

3a. Sources of water. Score all that apply.
- ☐ High pH groundwater (5)
- ☐ Other groundwater (3) [BR/CM (5)]
- ☐ Precipitation (1) [unless BR/CM primary source (5)]
- ☒ Seasonal/intermittent surface water (3)
- ☐ Perennial surface water (lake or stream) (5)

3b. Connectivity. Score all that apply.
- ☒ 100-year floodplain (1)
- ☒ Between stream/lake and other human use (1)
- ☒ Part of wetland/upland (e.g., forest), complex (1)
- ☒ Part of riparian or upland corridor (1)

3c. Maximum water depth. Select only one and assign score.
- ☐ >7 m (27.6 in.) (3)
- ☒ 0.4 to 0.7 m (16 to 27.6 in.) (2) [BR/CM (3)]
- ☐ <0.4 m (<16 in.) (1) [BR/CM 0.15 to 0.4 m (6 to <16 in.) (2)]

3d. Duration inundation/saturation. Score one or dbl. check & avg.
- ☐ Semi- to permanently inundated/saturated (4)
- ☒ Regularly inundated/saturated (3) [BR/CM (4)]
- ☐ Seasonally inundated (2) [BR/CM (4)]
- ☐ Seasonally saturated in upper 30 cm (12 in.) (1) [BR/CM (2)]

3e. Modifications to natural hydrologic regime. Score one or double check and average.
- ☐ None or none apparent (12)
- ☒ Recovered (7)
- ☐ Recovering (3)
- ☐ Recent or no recovery (1)

Check all disturbances observed

☐ ditch	☐ point source (nonstormwater)
☐ tile (including culvert)	☐ filling/grading
☐ dike	☐ road bed/RR track
☐ weir	☐ dredging
☐ stormwater input	☐ other _____

16	48
max 20 pts.	subtotal

Metric 4. Habitat Alteration and Development

4a. Substrate disturbance. Score one or double check and average.
- ☒ None or none apparent (4)
- ☐ Recovered (3)
- ☐ Recovering (2)
- ☐ Recent or no recovery (1)

4b. Habitat development. Select only one and assign score.
- ☐ Excellent (7)
- ☒ Very good (6)
- ☐ Good (5)
- ☐ Moderately good (4)
- ☐ Fair (3)
- ☐ Poor to fair (2)
- ☐ Poor (1)

4c. Habitat alteration. Score one or double check and average.
- ☐ None or none apparent (9)
- ☒ Recovered (6)
- ☐ Recovering (3)
- ☐ Recent or no recovery (1)

Check all disturbances observed

☐ mowing	☐ shrub/sapling removal
☐ grazing	☐ herbaceous/aquatic bed removal
☐ clearcutting	☐ sedimentation
☐ selective cutting	☐ dredging
☐ woody debris removal	☐ farming
☐ toxic pollutants	☐ nutrient enrichment

48
subtotal this page

Site: WBS3	Rater(s): Groton/Hixson/Pilarski	Date: 7/5/05

48
subtotal this page

4	52
max 10 pts.	subtotal

Metric 5. Special Wetlands

Select all that apply. Where multiple values apply in row, score row as single feature with highest point value. Attach documentation for each.

- ☐ Bog, fen, wet prairie (10); acidophilic veg., mossy substrate >10 sq.m, sphagnum or other moss (5); muck, organic soil layer (3)
- ☐ Assoc. forest (wetl. &/or adj. upland) incl. >0.25 acre (0.1 ha); old growth (10); mature >18 in. (45 cm) dbh (5) [exclude pine plantation]
- ☐ Sensitive geologic feature such as spring/seep, sink, losing/underground stream, cave, waterfall, rock outcrop/cliff (5)
- ☐ Vernal pool (5); isolated, perched, or slope wetland (4); headwater wetland [1st order perennial or above] (3)
- ☐ Island wetland >0.1 acre (0.04 ha) in reservoir, river, or perennial water >6 ft (2 m) deep (5)
- ☐ Braided channel or floodplain/terrace depressions (floodplain pool, slough, oxbow, meander scar, etc.) (3)
- ☐ Gross morph. adapt. in >5 trees >10 in. (25 cm) dbh: buttress, multitrunk/stool, stilted, shallow roots/tip-up, or pneumatophores (3)
- ☐ Ecological community with global rank (NatureServe): G1*(10), G2*(5), G3* (3) [*use higher rank where mixed rank or qualifier]
- ☐ Known occurrence of state or federally listed species (10)
- ☒ Superior/enhanced habitat/usage: migratory songbird/water fowl (5); in-reservoir buttonbush (4); other managed fish/wildlife (3)
- ☐ Cat. 1 (very low quality): <1 acre (0.04 ha) AND EITHER >80% cover of invasives OR nonvegetated on mined/excavated land (-10)

4	raw score*

*If the documented raw score for Metric 5 is 30 points or higher, the site is automatically considered a Category 3 wetland regardless of overall score.

19	71
max 20 pts.	subtotal

Metric 6. Plant Communities, Interspersion, Microtopography

6a. Wetland vegetation communities.
Score all present using 0 to 3 scale.

- 1 Aquatic bed
- 2 Emergent
- 2 Shrub
- 1 Forest
- 1 Mudflats
- 1 Open water <20 acres (8 ha)
- 1 Moss/lichen. Other _____

Vegetation Community Cover Scale

0 =	Absent or <0.1 ha (0.25 acre) contiguous acre [For BR/CM <0.04 ha (0.1 acre)]
1 =	Present and either comprises a small part of wetland's vegetation and is of moderate quality, or comprises a significant part but is of low quality
2 =	Present and either comprises a significant part of wetland's vegetation and is of moderate quality, or comprises a small part and is of high quality
3 =	Present and comprises a significant part or more of wetland's vegetation and is of high quality

6b. Horizontal (plan view) interspersion.
Select only one.

- ☐ High (5)
- ☒ Moderately high (4) [BR/CM (5)]
- ☐ Moderate (3)[BR/CM (5)]
- ☐ Moderately low (2) [BR/CM (3)]
- ☐ Low (1) [BR/CM (2)]
- ☐ None (0)

Narrative Description of Vegetation Quality

low =	Low sp diversity &/or dominance of nonnative or disturbance tolerant native sp
mod =	Native sp are dominant component of the vegetation, although nonnative &/or disturbance tolerant native sp can also be present, and species diversity moderate to moderately high, but generally w/o presence of rare, threatened or endangered sp
high =	A predominance of native species with nonnative sp &/or disturbance tolerant native sp absent or virtually absent, and high sp diversity and often but not always, the presence of rate, threatened, or endangered sp

6c. Coverage of invasive plants.
Refer to Table 1 ORAM long form for list.
Add or deduct points for coverage

- ☐ Extensive >75% cover (-5)
- ☐ Moderate 25-75% cover (-3)
- ☐ Sparse 5-25% cover (-1)
- ☒ Nearly absent <5% cover (0)
- ☐ Absent (1)

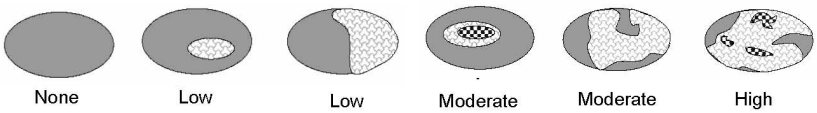
Mudflat and Open Water Class Quality

0 =	Absent <0.1 ha (0.25 acres) [For BR/CM <0.04 ha (0.1 acre)]
1 =	Low 0.1 to <1 ha (0.25 to 2.5 acres) [BR/CM 0.04 to <0.2 ha (0.1 to 0.5 acre)]
2 =	Moderate 1 to <4 ha (2.5 to 9.9 acres) [BR/CM 0.2 to <02 ha (0.5 to 5 acre)]
3 =	High 4 ha (9.9 acres) or more [BR/CM 2 ha (5 acres) or more]

6d. Microtopography.
Score all present using 0 to 3 scale.

- 3 Vegetated hummocks/tussocks
- 2 Coarse woody debris >15 cm (6 in.)
- 1 Standing dead >25 cm (10 in.) dbh
- 0 Amphibian breeding pools

Hypothetical Wetland for Estimating Degree of Interspersion



Microtopography Cover Scale

0 =	Absent
1 =	Present in very small amounts or if more common of marginal quality
2 =	Present in moderate amounts, but not of highest quality or in small amounts of highest quality
3 =	Present in moderate or greater amounts and of highest quality

71 **GRAND TOTAL (max 100 pts)**

Refer to the most recent ORAM Score Calibration Report for the scoring breakpoints between wetland categories at the following address:
http://www.epa.state.oh.us/dsw/401/401.html

Legend

- Culvert
- Dike
- Pre-Existing Wetlands
- Pre-Existing Waters at Summer Pool Level
- 2005 Wetland Sampling Point

NOTES:

1. March 20, 2009 post-event aerial photograph provided by Tennessee Valley Authority.
2. Wetlands were identified by TVA as part of the Corrective Action Plan (2009) assessment by integrating Land Use/Land Cover (2003) data with aerial imagery from 2006 and/or 2008.
3. Coordinates for Wetland Study Areas from Appendix A - TVA Natural Heritage ROS Wetland Determination Form.

Tennessee Valley Authority
Kingston, Tennessee

Conceptual Restoration Design Report
Swan Pond Embayments

2005 ROS Wetland Sampling with Post Event Imagery

ARCADIS

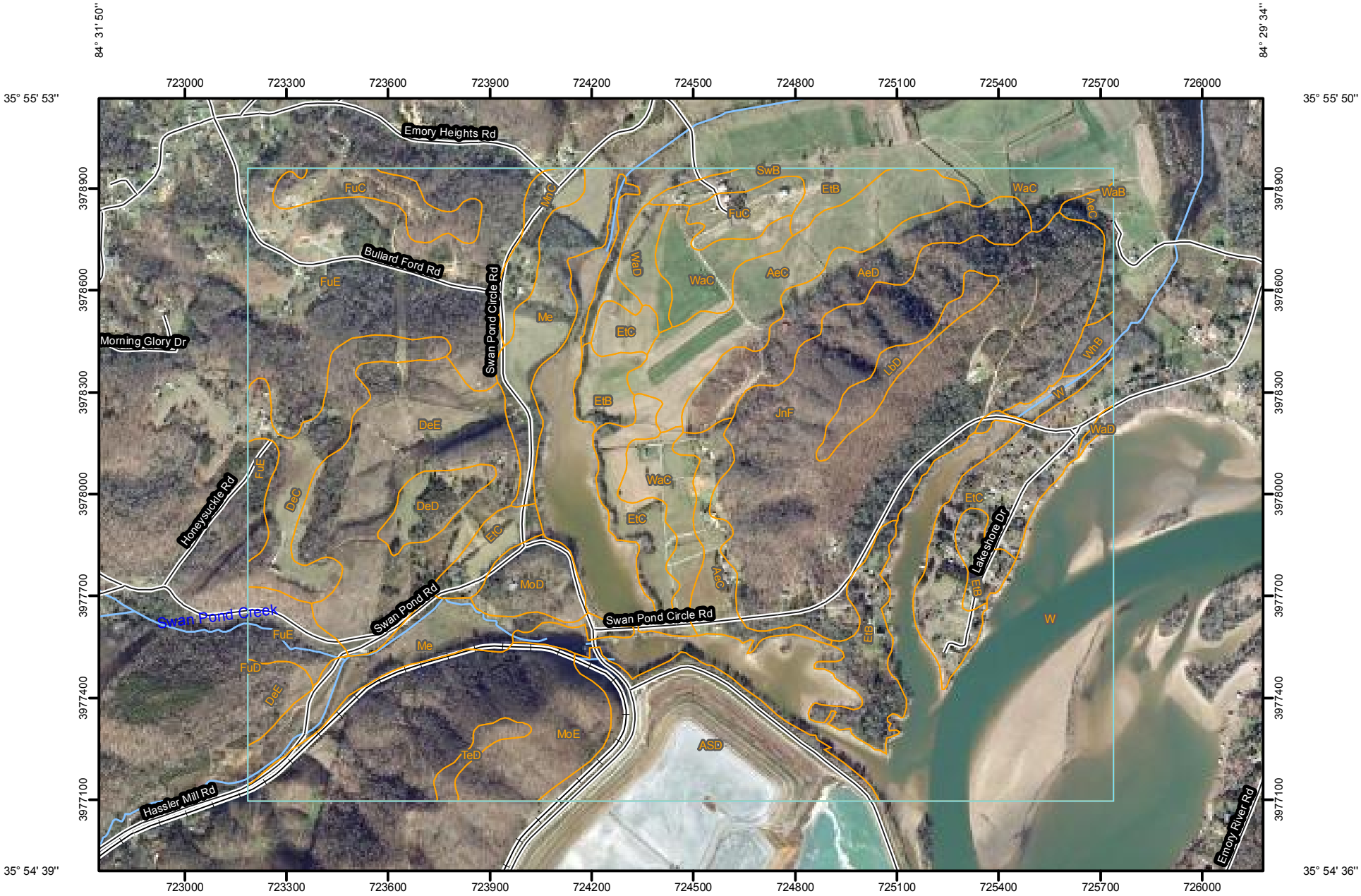
FIGURE
A-1

CITY:(Cranbury) DIV/GROUP:(ENV) DB: LD: PIC: PM: TM: TR:
G:\GIS\TVA\MapDocuments\2009\RD_AppendixA-1.mxd

ARCADIS

Appendix B

NRCS Soils Map



Map Scale: 1:16,300 if printed on A size (8.5" x 11") sheet.

N

Meters: 0 200 400 800 1,200

Feet: 0 500 1,000 2,000 3,000

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Gully

Short Steep Slope

Other

Political Features

Cities

Water Features

Oceans

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

MAP INFORMATION

Map Scale: 1:16,300 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 16N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Roane County, Tennessee
Survey Area Data: Version 6, Jun 22, 2009

Date(s) aerial images were photographed: 12/5/2006

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

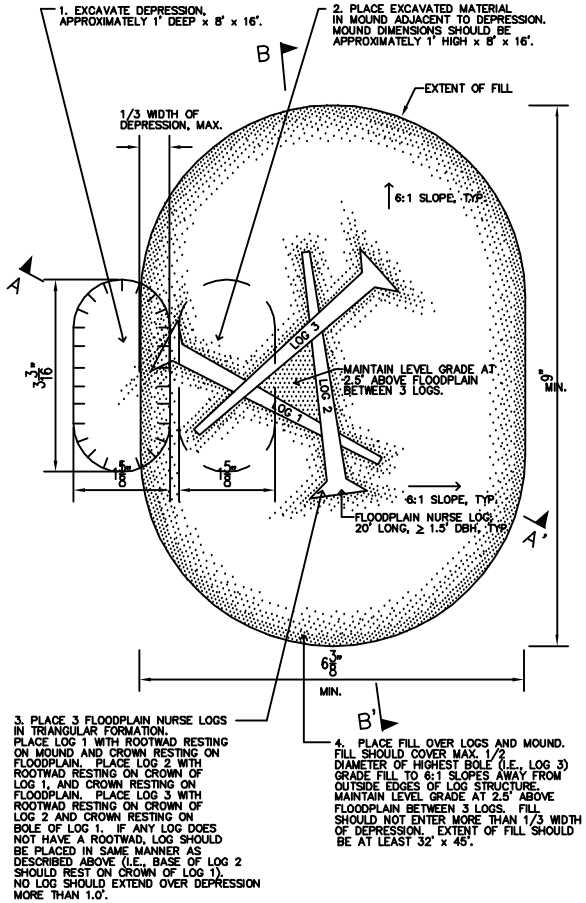
Map Unit Legend

Roane County, Tennessee (TN145)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
AeC	Allen loam, 5 to 12 percent slopes	65.9	5.6%
AeD	Allen loam, 12 to 20 percent slopes	36.5	3.1%
ASD	Ash disposal area	63.2	5.4%
DeC	Dewey silt loam, 5 to 12 percent slopes	32.5	2.8%
DeD	Dewey silt loam, 12 to 20 percent slopes	11.3	1.0%
DeE	Dewey silt loam, 20 to 45 percent slopes	85.1	7.2%
EtB	Etowah loam, 2 to 5 percent slopes	48.1	4.1%
EtC	Etowah silt loam, 5 to 12 percent slopes	74.8	6.4%
FuC	Fullerton-Pailo complex, 5 to 12 percent slopes	25.2	2.1%
FuD	Fullerton-Pailo complex, 12 to 20 percent slopes	0.1	0.0%
FuE	Fullerton-Pailo complex, 20 to 35 percent slopes	117.0	10.0%
JnF	Jefferson cobbly loam, 20 to 50 percent slopes	162.4	13.8%
LbD	Lily loam, 12 to 20 percent slopes	11.3	1.0%
Me	Melvin silt loam, frequently flooded	66.3	5.6%
MnC	Minvale gravelly silt loam, 5 to 12 percent slopes	11.3	1.0%
MoD	Montevallo channery silt loam, 12 to 20 percent slopes	14.6	1.2%
MoE	Montevallo channery silt loam, 20 to 35 percent slopes	81.3	6.9%
SwB	Swafford loam, 2 to 5 percent slopes	0.0	0.0%
TeD	Townley silt loam, 12 to 20 percent slopes	4.5	0.4%
W	Water	206.3	17.6%
WaB	Waynesboro loam, 2 to 5 percent slopes	0.2	0.0%
WaC	Waynesboro loam, 5 to 12 percent slopes	43.5	3.7%
WaD	Waynesboro loam, 12 to 20 percent slopes	9.7	0.8%
WhB	Whitwell loam, 1 to 4 percent slopes, occasionally flooded	3.6	0.3%
Totals for Area of Interest		**1,174.7**	**100.0%**

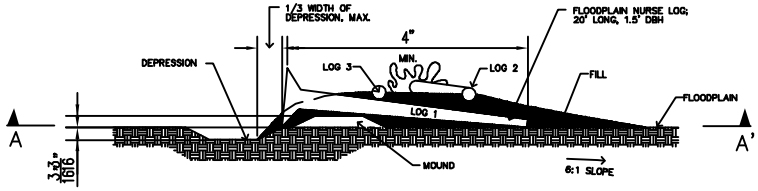
ARCADIS

Appendix C

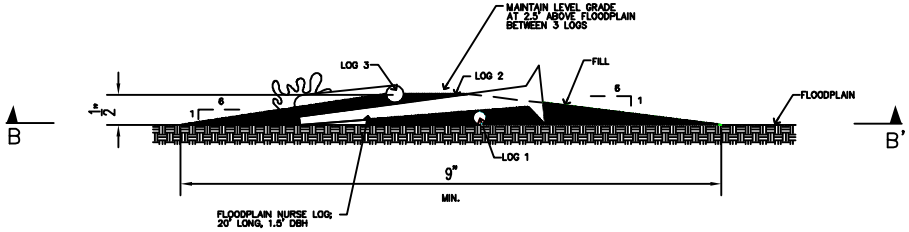
Typical Construction Details



3 JACKSTRAW FLOODPLAIN LOG JAM, PLAN VIEW
SCALE: NTS



3 JACKSTRAW FLOODPLAIN LOG JAM, SECTION A, A'
SCALE: NTS



3 JACKSTRAW FLOODPLAIN LOG JAM, SECTION B, B'
SCALE: NTS

NOT FOR CONSTRUCTION

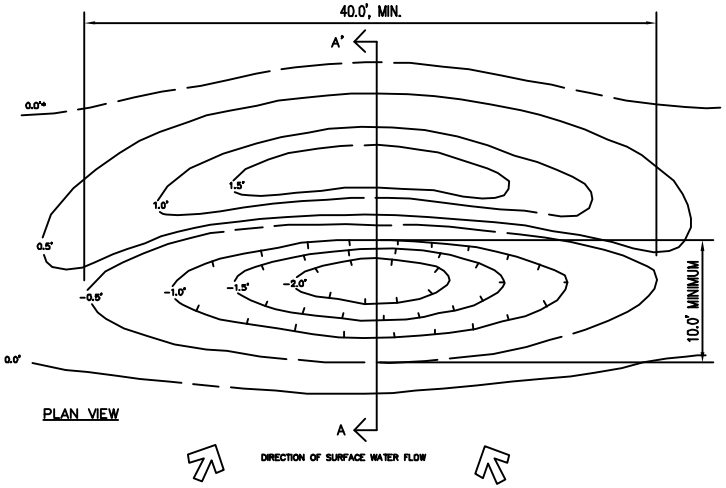
Tennessee Valley Authority
Kingston, Tennessee
Conceptual Restoration Design Report
Swan Pond Embayment

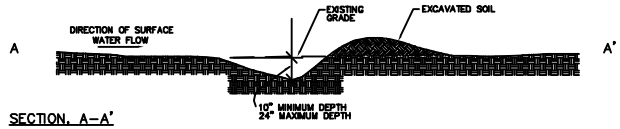
EXAMPLE JACKSTRAW FLOODPLAIN LOG JAM DETAIL

ARCADIS

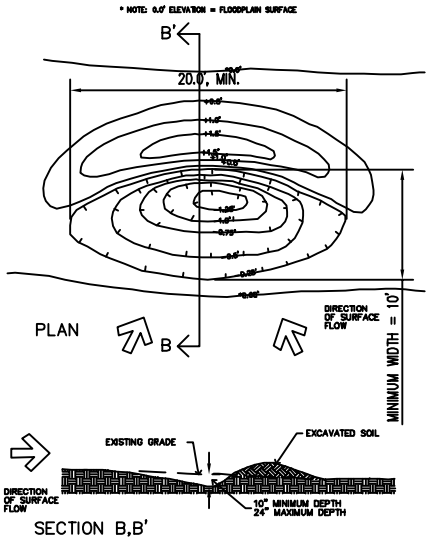
Appendix
C-1

*NOTE: 0.0' ELEVATION = FLOODPLAIN SURFACE





10 LARGE MICRODEPRESSION
SCALE: NTS



9 SMALL MICRODEPRESSION
SCALE: NTS

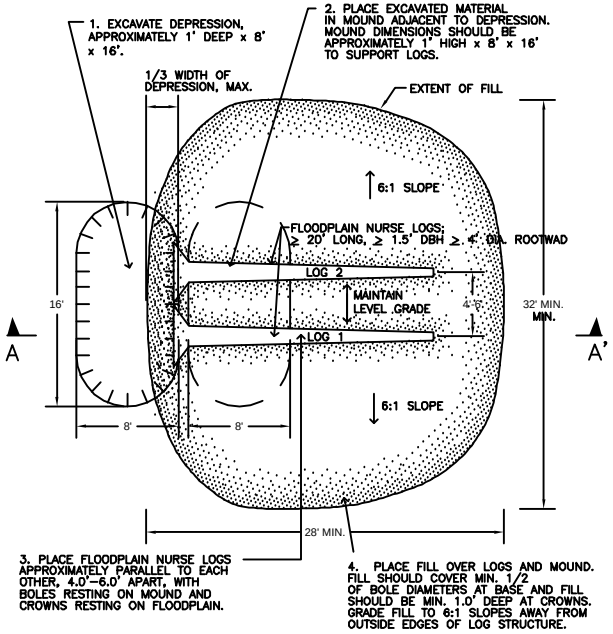
NOT FOR CONSTRUCTION

Tennessee Valley Authority
Kingston, Tennessee
Conceptual Restoration Design Report
Swan Pond Embayment

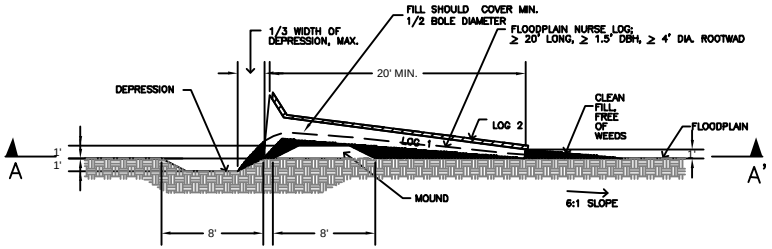
EXAMPLE MICRODEPRESSION DETAIL

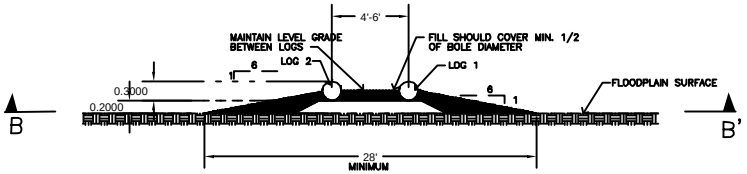
ARCADIS

Appendix
C-2



NOTE: 50% OF ALL FLOODPLAIN NURSE LOGS MUST HAVE ROOTWADS. FLOODPLAIN NURSE LOGS WITH ROOTWADS SHOULD BE RANDOMLY DISTRIBUTED THROUGHOUT ALL FLOODPLAIN LOG JAMS (i.e., ALL SINGLE, DOUBLE AND JACKSTRAW FLOODPLAIN LOG JAMS SHOULD BE CONSTRUCTED USING BOTH FLOODPLAIN NURSE LOGS WITH AND WITHOUT ROOTWADS.)





2 DOUBLE FLOODPLAIN LOG JAM, SECTION B, B'
SCALE: 1"=5'

NOT FOR CONSTRUCTION

Tennessee Valley Authority
Kingston, Tennessee
Conceptual Restoration Design Report
Swan Pond Embayment

EXAMPLE DOUBLE FLOODPLAIN LOG JAM DETAIL

ARCADIS

Appendix
C-3