United States Environmental Protection Agency

TVA Kingston Site Case Study

Revitalization of the Wetlands, Embayments and Emory River

This is the story of ecological revitalization at the Tennessee Valley Authority (TVA) Kingston Fossil Plant Fly Ash site in Roane County, Tennessee. Proactive responses to a catastrophic spill have recovered hundreds of acres of habitat for ecological and recreational use.

On December 22, 2008, a dike containing about 20 million cubic yards of coal ash from TVA's power plant operations failed at the site. The release of material – about 5.4 million cubic yards of bottom ash and fly ash – created a wave of water and ash that choked the adjacent Emory River, disrupted electrical power, ruptured a natural gas line and water line, and covered a railway and local roadways.

The ash spill had significant effects on the community and the environment. Aquatic organisms, shorelines and local utilities were buried in coal ash. Urgent cleanup was needed to reestablish utilities and ensure the protection of human health and the environment. EPA, TVA and the Agency's state and local partners responded immediately. In May 2009, EPA and TVA entered into an Administrative Order on Consent (AOC) requiring TVA to perform cleanup and restoration efforts under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The cleanup process ensured that consideration of the revitalization and reuse of the site and the surrounding area were an integral part of all response activities.

Today, less than a decade later, the site is home to a 240-acre capped landfill, Roane County's Swan Pond Recreation Area and Lakeshore Park, see Figure 1. Natural areas at the site provide an interconnected ecosystem that supports diverse wildlife habitat and recreation opportunities.

Figure 1. Aerial view of the coal ash spill in 2008 (left). Capped landfill and recreation area at the site in 2015 (right). (*Source*: EPA)

This case study is part of a series focused on ecological revitalization as part of contaminated site remediation and reuse; these case studies are being compiled by the U.S. Environmental Protection Agency (EPA) Technology Innovation and Field Services Division (TIFSD). The purpose of these case studies is to provide site managers with ecological reuse information, including principles for implementation, recommendations based on personal experiences, a specific point of contact and a network of sites with an ecological reuse component.

Topics Highlighted in this Case Study:

- Green Cleanups
- Wetland Revitalization
- Shoreline Revitalization
- Use of Native Plants
- Wildlife Habitat

Ecological Revitalization

Ecological revitalization is the process of returning land from a contaminated state to one that supports functioning and sustainable habitat.

Background

The site is located at the headwaters of Watts Bar Reservoir near the confluence of the Clinch and Emory Rivers in Harriman, Roane County, Tennessee, see Figure 2. The TVA Kingston Fossil Plant generates about 10 billion kilowatt-hours of electricity per year, enough to supply more than 670,000 homes in the Tennessee Valley.

The TVA Kingston Fossil Plant started operating in 1955; it provided power for the Department of Energy's Reservation in Oak Ridge, Tennessee. In 1955, TVA's Kingston Fossil Plant was the largest coal-burning power plant in the world; it held this distinction for more than a decade. In the late 1950s, the plant began discharging coal ash directly into the Swan Pond Embayment (bay). Discharge regulations later changed, and TVA created a waste cell in the bay for the coal ash. Over time, the waste cell contents replaced most of the water in the bay.

On December 22, 2008, a containment dike around part of the waste cell failed. Cleanup took place in phases; initial actions focused on clearing waterways for navigation and responding to immediate risks. Longer-term responses included activities to ensure landfill stabilization and ecological revitalization.

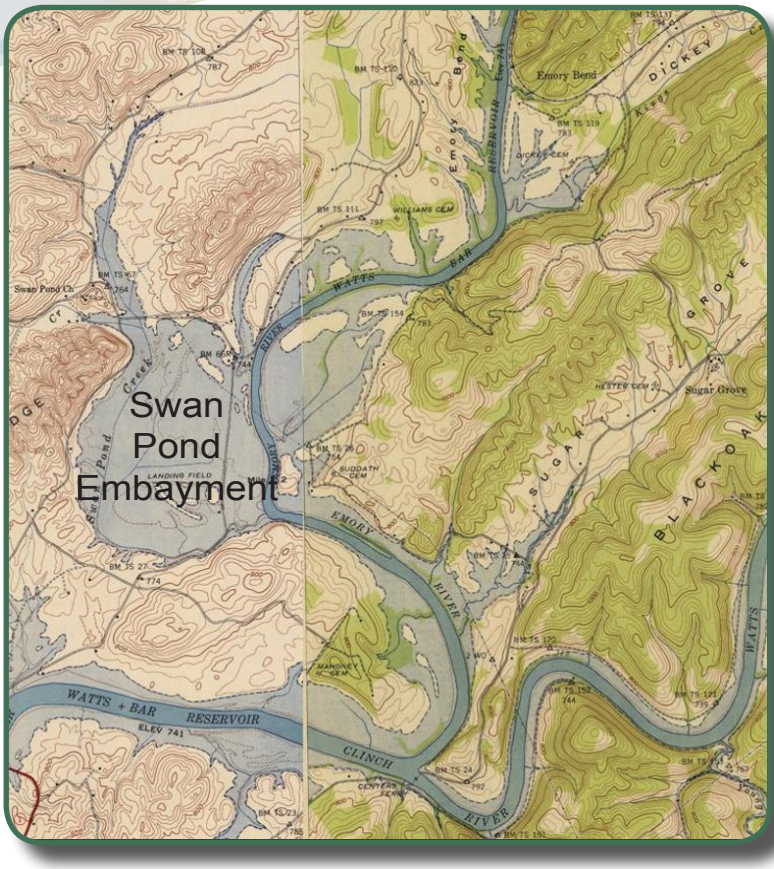


Figure 2. Topography of the area in 1941, before TVA began discharging waste into Swan Pond Embayment. (*Source*: U.S. Geological Survey)

What is Coal Ash?

It is the material left after coal is burned. It can contain fine powdery material, coarse angular ash, molten ash and wet sludge. The material contains naturally occurring metals – arsenic, chromium, copper, lead, mercury, nickel, selenium, thallium, vanadium and zinc – as well as naturally occurring radionuclides.
(*Photo Source*: EPA)

Initial Response

TVA, state and local emergency management agencies helped nearby residents affected by the release and took actions to reduce further contamination, see Figure 3.

River flows were managed by controlling nearby dams. Ash migration was controlled by constructing a weir, or low dam - Weir #1, across the Emory River and Dike #2 across the embayment, see Figure 4. Damaged railroads, roads and utilities, including gas lines and waterlines, were repaired. Floating ash residue (cenospheres) and debris from the river systems were collected. TVA installed stormwater management systems, dust control systems and dike stabilization. Community outreach provided for safety and housing of affected residents.

Figure 3. Remaining ash in cell where the breach occurred in 2008 (left). Flow of ash into the Emory River from the breach (right). (*Source*: EPA)

Cleanup Actions

As required by the AOC, TVA conducted the cleanup in three phases. Site stakeholders worked to maintain a positive relationship with community members and kept them informed throughout the planning and implementation phases of cleanup. Feedback from community meetings and outreach efforts helped guide cleanup decisions and end use considerations.

Phase 1: Time-Critical Cleanup

Phase 1 cleanup began in August 2009, with a time-critical removal action. It involved mechanical excavation, hydraulic dredging, rapid materials handling and disposal of 3.5 million cubic yards of ash from the Emory River. This removal alleviated upstream flooding and mitigated downstream ash transport. TVA dewatered ash removed from the river on site and loaded it onto

1. EPA, 2014. *Project Completion Fact Sheet.* Available at https://semspub.epa.gov/work/04/11015836.pdf.

Why Was the Cleanup Conducted Under Superfund?

The Superfund program was selected as the preferred regulatory framework because of its comprehensive human health and ecological risk assessment process and its proven ability to actively engage and involve multiple stakeholders in large, complex environmental cleanup projects.[1]

Did You Know?

The subsurface stabilization slurry wall installed in Phase 2 was designed to withstand liquefaction forces caused by a 6.0-magnitude earthquake on the East Tennessee fault line and a 7.6-magnitude earthquake on the New Madrid fault line.

Figure 4: Site Map (*Source*: EPA)

rail cars for disposal at the Arrowhead Landfill in Perry County, Alabama. TVA completed ash removal under the time-critical phase in May 2010, which coincided with re-opening of the Emory River for navigation and recreation. Railroad transportation and off-site ash disposal efforts took place throughout the cleanup and finished in December 2010.

Phase 2 – Non-Time-Critical Removal Action

Phase 2 involved mechanical excavation of about 2.3 million cubic yards of ash in the north and middle Swan Pond Embayments (see Figures 4 and 5). Recovered ash was dried to optimum moisture content, spread into thin lifts and compacted on site in a 240-acre disposal cell. The disposal cell was re-engineered with a 12-mile subsurface stabilization slurry wall. It is the largest slurry wall in the United States. Most Phase 2 activities were finished by December 2014.

Removal Timeline

- **1955: TVA Kingston Fossil Plant built**
- **2008: Largest coal ash spill in U.S. history; initial response follows**
- **2009-2010: Phase 1 cleanup takes place**
- **2010: Emory River reopens for navigation and recreation**
- **2010-2014: Phase 2 cleanup takes place**
- **2013: Long-term monitoring begins (part of Phase 3)**
- **2014: Lakeshore Park opens**

Figure 5. Dredging during cleanup. (*Source*: EPA)

Phase 3 – Non-Time-Critical Removal Action and Assessment

A comprehensive human health and ecological risk assessment was conducted on ash not removed during the initial time-critical dredging work. The ash present was found to be commingled with contamination from the Department of Energy (DOE) Oak Ridge Reservation site. Oak Ridge Associated Universities conducted independent medical screening and concluded that there were no adverse health impacts caused by the coal ash spill.[2] Analysis also included extensive geochemistry

Local Materials and Relations

TVA purchased rock for buttressing, aggregate, weir construction and other activities from a local quarry on Swan Pond Road.

TVA used one million yards of clay and topsoil for the cap from the neighboring Gupton Farm (Berkshire Slough or "Borrow Area") purchased by TVA, reducing the number of truck trips by 10,000.

TVA built an underpass to move ash and dirt so it did not travel on public roads and added rail sidings to reduce closures of local roads.

2. EPA, 2014. *Project Completion Fact Sheet.* Available at https://semspub.epa.gov/work/04/11015836.pdf.

studies, sediment and pore water bioassays, benthic macroinvertebrate assessments, two-dimensional sediment-ash fate and transport modeling, and groundwater modeling.

Long-term monitoring began in 2013. The goal was to determine the need for additional actions to address any residual contamination in the Emory River. Five years after the spill, monitoring data showed that river ecology was already returning to baseline conditions.[3] Annual monitoring of the river system will continue for up to 30 years to confirm that risks associated with the residual ash remains low and that ash-related concentrations of metals decline with time. Groundwater monitoring and maintenance of the on-site coal ash disposal cell will also be conducted over the long term.[4] A local fish advisory is in place in because of contamination from nearby past industrial operations.

Ecological Revitalization

TVA chose to conduct extensive revitalization efforts beyond EPA's cleanup requirements in the AOC. A team of biologists, landscape architects and engineers worked together to integrate plantings and ecological aspects as components of the cleanup activities. The ecosystem in the bay was prepared by planting a mosaic of forested, scrub-shrub and emergent wetland plant communities. Specifics included construction of weirs to control water levels in the North Embayment and additional wetlands in the former borrow area. TVA conducted ecological activities from January 2014 to June 2015. Final steps included planting trees and seeds in disturbed areas. Today, wildlife sightings continue to increase. Reported rare bird sightings have included white ibises, cattle egrets and an abundance of herons (little blue, black-crowned night and green).

Ecological revitalization activities included:

- Replanting of shorelines and upland areas with native species (see Table 1 and Appendix A). Upland areas were planted with seed mixes designed to provide forage for local wildlife, including deer and birds.
- Conservation of existing wetlands by controlling water flow and plantings of native species.
- Establishment of aquatic habitat. For example, trees cut during cleanup were placed in the water for fish habitat (fish attractors). Vernal pools (seasonal shallow ponds) and wetlands were established where ash was excavated.

Native Pollinators

Native pollinators provide Americans with a significant amount of our food supply, contribute to the economy and perform key roles in ecosystems. By helping to keep plant communities healthy and able to reproduce naturally, native pollinators assist plants in providing food and cover for wildlife, preventing erosion and keeping waterways clean.

Source: http://www.plants.usda.gov/pollinators/Native_Pollinators.pdf (*Photo Source:* Pixabay)

3, 4. EPA, 2014. *Project Completion Fact Sheet.* Available at https://semspub.epa.gov/work/04/11015836.pdf.

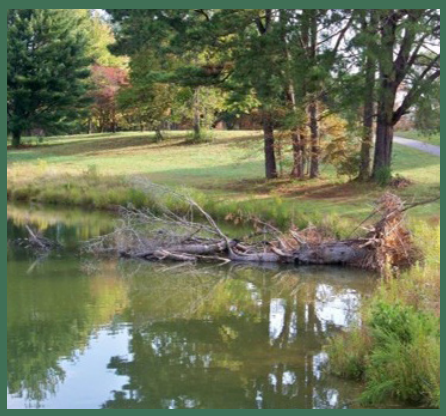
- Planting of nearly 7,000 trees across 15 acres, using over 40 tree types. Planting hardwood trees and understory shrubs promotes natural successional growth of hardwood forest.
- Installation of osprey and heron platforms in strategic locations throughout relevant habitat to fulfill the need for nesting habitat and encourage use of the sufficient feeding opportunities in area streams and rivers.
- Revegetation of five miles of shoreline using native plants and seed mixes. The plants provide much-needed habitat for pollinators. The seed mixes included wildflowers that attract flies, bees, beetles and butterflies. Riparian zones create shading, which cools waterways, provide shelter for birds and protect shorelines from erosion. Table 1 lists planting areas and structural elements. Appendix A provides detailed seed mix listings.
- Construction of a vegetative wall (instead of rip rap) for shoreline stabilization.

Table 1. Planting Quantities and Structures (Acres)[5]

Description	Borrow Area	North Embayment	Middle Embayment	East Embayment	Total Area (Acres) and Structures
Wetland/Shrub Mix	--	0.45	--	--	**0.45**
Subxeric/Xeric	--	7.57	5.56	--	**13.13**
Mesic/Submesic	--	5.54	6.53	0.72	**12.79**
Hydric	10.40	0.58	--	--	**10.98**
Screen	--	--	--	0.61	**0.61**
Reforest	--	2.92	4.05	3.93	**10.90**
Steep Slope Seed Mix	19.10	--	--	--	**19.10**
Live Stakes	--	--	--	0.19	**0.19**
Vernal Pool (Hydric Plant)	--	0.90	0.21	--	**1.11**
Osprey Nesting Platform	--	--	1	--	**1**
Heron Platform	--		2	1	**3**
Mosaic Wetlands Simulated Snag	--	6	5	--	**11**
Simulated Fallen Tree	--	2	5	1	**8**

5. TVA, 2015. *Kingston Ash Recovery Project Natural Resources Damages Assessment Monitoring, Maintenance, and Reporting Plan, Appendix A*. Available at https://www.fws.gov/cookeville/pdfs/TVA%20RCDP_Final_2015_0526.pdf.

Ecological Revitalization Components at the Site



Fish Attractors
Provide preferred fish habitat.

Bird Attractors
Provide optimum osprey and heron nesting areas.

Riparian Zone Plantings
Reduce nutrient runoff and provide shade and habitat for creatures living on land and in water.

Wetlands
Control water flow, help prevent flooding and provide wildlife habitat.

Vernal Pools
Provide areas for amphibians to live and breed.

Reforestation
Reduces erosion, provides valuable habitat and reduces nutrient runoff.

(Photos Source: TVA)

Recreational Components

In addition to the AOC's cleanup requirements, TVA elected to develop detailed plans that created significant recreational amenities for the community (see Figures 4 and 6). Heavy machinery brought in for the cleanup was used to grade land for trails, parking areas and ball fields. Today, the public enjoys access to these park resources as well as extensive green space, wildlife habitat and environmental education opportunities.

Lakeshore Park includes:

- Two miles of paved walking trails.
- Two docks and four fishing piers.
- Boat ramp, canoe and kayak launches.
- Pedestrian bridge (used often for fishing).
- Picnic areas.
- Parking and restroom facilities.

Did You Know?

TVA donated $500,000 of surplus material to Roane County and volunteered $350,000 to repave Swan Pond Road/Circle.

Roane County is constructing a sports complex on 60 acres of land designated as part of the Swan Pond Recreation Area. When completed, the complex will house a festival field, soccer and softball fields, and playground areas.

Region 4 Excellence in Site Reuse Award

EPA awarded its Excellence in Site Reuse award to TVA in June 2015 for community revitalization and ecological revitalization efforts that went above and beyond cleanup requirements. (*Photo Source*: EPA)

Figure 6: Recreation Area Map (*Source*: TVA)

Lessons Learned

1. **Integrate cleanup and reuse.**
   Coordinating ecological revitalization efforts with site cleanup maximized efficiencies and reuse. For example, the coordinated use of heavy machinery for cleanup, restoration and revitalization efforts saved time and money.

2. **Rely on diverse expertise for complex cleanups.**
   Having a project team of biologists, landscape architects and engineers working together at the site helped optimize cleanup and revitalization efforts.

3. **Community input is invaluable.**
   Sustained input from the community helped guide cleanup decision-making and made sure that restoration and reuse efforts reflected local priorities.

4. **Consider potential community impacts of cleanup activities and adjust plans accordingly.**
   At the site, separating cleanup-related traffic from local traffic by creating dedicated cleanup related roads reduced road impacts and the chance of accidents. It also helped build trust with the community and minimized disruptions in people's lives.

Communication and Community Support

Throughout cleanup efforts, the public was kept informed of activities through over 400 community updates, more than 50 public meetings, over 100 site tours, a Community Outreach Center and dedicated websites on TVA, Tennessee Department of Environment & Conservation and EPA web pages.

Appendix A: Seed Plantings[6]

Area Planted	*Scientific Name* - Common Name
Trees and Shrubs Planted in Reforested Areas and Used as Screens	*Acer rubrum* - Red Maple *Acer saccharinum* - Silver Maple *Amelanchier arborea* - Serviceberry *Amorpha fruticosa* - False Indigo Bush *Asimina triloba* - Pawpaw *Callicarpa Americana* - American Beautyberry *Calycanthus floridus* - Eastern Sweetshrub *Carpinus caroliniana* - American Hornbeam *Carya glabra* - Pignut Hickory *Carya ovata* - Shagbark Hickory *Celtis laevigata* - Sugarberry *Cercis Canadensis* - Eastern Redbud *Cornus amomum* - Silky Dogwood *Cornus florida* - Flowering Dogwood *Crataegus phaenopyrum* - Washington Hawthorn *Diospyros virginiana* - Common Persimmon *Fagus grandifolia* - American Beech *Halesia carolina* - Carolina Silverbell *Hamamelis virginiana* - American Witchhazel *Ilex opaca* - American Holly *Itea virginica* - Virginia Sweetspire *Juglans nigra* - Black Walnut *Lindera benzoin* - Northern Spicebush *Liriodendron tulipifera* - Tuliptree *Magnolia acuminata* - Cucumber Tree *Nyssa sylvatica* - Blackgum *Ostrya virginiana* - Hophornbeam *Oxydendrum arboreum* - Sourwood *Photinia pyrifolia* - Red Chokeberry *Physocarpus opulifolius* - Common Ninebark *Pinus strobus* - Eastern White Pine *Pinus taeda* - Loblolly Pine *Pinus virginiana* - Virginia Pine *Platanus occidentalis* - American Sycamore *Prunus americana* - American Plum *Quercus alba* - White Oak *Quercus falcata* - Southern Red Oak

6. TVA, 2015. *Kingston Ash Recovery Project Natural Resources Damages Assessment Monitoring, Maintenance, and Reporting Plan, Appendix A*. Available at https://www.fws.gov/cookeville/pdfs/TVA%20RCDP_Final_2015_0526.pdf.

Area Planted	*Scientific Name* - Common Name
Trees and Shrubs Planted in Reforested Areas and Used as Screens *(continued)*	*Quercus lyrata* - Overcup Oak *Quercus michauxii* - Swamp Chestnut Oak *Quercus nigra* - Water Oak *Quercus phellos* - Willow Oak *Quercus rubra* - Northern Red Oak *Quercus shumardii* - Shumard's Oak *Quercus stellata* - Post Oak *Quercus velutina* - Black Oak *Rhus copallinum* - Winged Sumac *Rhus typhina* - Staghorn Sumac *Sambucus nigra* - American Black Elderberry *Sassafras albidum* - Sassafras *Tilia americana* - American Basswood *Viburnum dentatum* - Southern Arrowwood *Viburnum nudum* - Possumhaw *Viburnum prunifolium* - Blackhaw
Steep Slope Mix – Roundstone Mix 199	*Panicum anceps* - Fall Panicum *Sorghastrum nutans* - Indiangrass *Schizachrium scoparium* - Little Bluestem *Bouteloua curtipendula* - Sideoats Grama *Panicum virgatum* - Switchgrass *Elymus virginicus* - Virginia Wild Rye *Andropogon gerardii* - Big Bluestem *Cassia fasciculata* - Partridge Pea *Festuca rubra* - Creeping Red Fescue *Heliopsis helianthoides* - False Sunflower *Coreopsis lanceolata* - Lanceleaf Tickseed; Lance Leaved Coreopsis *Helianthus maximiliani* - Maximilian Sunflower *Bidens aristosa* - Showy Tickseed *Desmanthus illinoensis* - Illinois Bundleflower *Tridens flavus* - Purple Top *Lotus corniculatus* - Bird's Foot Trefoil *Vernonia altissima* - Iron Weed *Solidago nemoralis* - Gray Goldenrod *Rudbeckia hirta* - Blackeyed Susan *Pycnanthemum pilosum* - Hairy Mountain Mint

Area Planted	*Scientific Name* - Common Name
Mesic/Subxeric Retention Basin Mix – Roundstone Mix 133	*Elymus virginicus* - Virginia Wildrye *Andropogon glomeratus* - Bushy Bluestem *Cassia marilandica* - Wild Senna *Verbesina alternifolia* - Yellow Wingstem *Iris virginica* - Blue Flag; Virginia Iris *Bidens aristosa* - Showy tickseed; Bearded Beggarticks *Panicum virgatum* - Switchgrass *Vernonia altissima* - Iron Weed *Carex vulpinoidea* - Fox Sedge *Carex lurida* - Lurid (Shallow) Sedge *Tradescantia ohiensis* - Bluejacket; Ohio Spiderwort *Asclepias incarnata* - Swamp Milkweed *Carex scoparia* - Broom Sedge *Carex crinita* - Fringed Sedge *Glyceria striata* - Fowl Mannagrass *Scirpus atrovirens* - Green Bulrush *Scirpus cyperinus* - Woolgrass *Eupatorium coelestinum* - Mistflower; Blue Mistflower *Verbena hastata* - Swamp Verbena; Blue Vervain *Penstemon digitalis* - Smooth Beardtongue; Foxglove Beardtongue *Eupatorium fistulosum* - Joe Pye Weed *Helenium autumnale* - Common Sneezeweed *Ludwigia alternifolia* - Seed Box *Juncus tenuis* - Path Rush; Poverty Rush *Juncus effusus* - Soft Rush *Mimulus rigens* - Allegheny Monkey Flower
Subxeric/Xeric Deer and Turkey Habitat Mix – Roundstone Mix 147	*Cassia fasciculata* - Partridge Pea *Heliopsis helianthoides* - False Sunflower; Smooth Oxeye *Schizachyrium scoparium* - Little Bluestem *Lespedeza capitata* - Roundhead Lespedeza *Elymus virginicus* - Virginia Wildrye *Desmanthus illinoensis* - Illinois Bundleflower *Helianthus maximiliani* - Maximilian Sunflower *Andropogon gerardii* - Big Bluestem *Sorghastrum nutans* - Indiangrass *Panicum virgatum* - Switchgrass *Sporobolus compositus* - Tall Dropseed; Composite Dropseed *Dalea purpurea* - Purple Prairie Clover *Tradescantia ohiensis* - Bluejacket; Ohio Spiderwort *Rudbeckia triloba* - Browneyed Susan *Rudbeckia hirta* - Blackeyed Susan *Chasmanthium latifolium* - Indian Woodoats; River Oats

Area Planted	*Scientific Name* - Common Name
Hydric/Wetland Pond Edge Mix – Roundstone Mix 131	*Iris virginica* - Virginia Iris; Blue Flag *Eupatorium perfoliatum* - Common Boneset *Andropogon glomeratus* - Bushy Bluestem *Cephalanthus occidentalis* - Common Buttonbush *Lobelia cardinalis* - Cardinalflower *Eleocharis palustris* - Creeping Spike Rush *Tripsacum dactyloides* - Eastern Gamagrass *Glyceria striata* - Fowl Manna Grass *Carex vulpinoidea* - Fox Sedge *Carex frankii* - Frank's Sedge *Lobelia siphilitica* - Great Blue Lobelia *Scirpus atrovirens* - Green Bulrush *Eupatorium fistulosum* - Joe-Pye Weed; Trumpetweed *Mimulus rigens* - Allegheny Monkey Flower *Carex crinita* - Fringed Sedge *Carex gynandra* - Nodding Sedge *Tradescantia ohiensis* - Ohio Spiderwort *Leersia oryzoides* - Rice Cut Grass *Hibiscus moscheutos* - Rosemallow; Crimsoneyed Rosemallow *Ludwigia alternifolia* - Seed Box *Helenium autumnale* - Common Sneezeweed *Juncus effusus* - Soft Rush *Asclepias incarnata* - Swamp Milkweed *Elymus virginicus* - Virginia Wild Rye *Verbesina alternifolia* - Wingstem; Yellow Wingstem

Additional Resources and References

December 2014 EPA and TVA Kingston Coal Ash Release Site Project Completion Fact Sheet
https://semspub.epa.gov/work/04/11015836.pdf

EPA's EcoTools
https://clu-in.org/ecotools/default.cfm

Frequently Asked Questions About Ecological Revitalization of Superfund Sites
https://clu-in.org/download/remed/542f06002.pdf

June 2015 Kingston Recovery Site Aerials
http://www.bing.com/videos/search?q=tva+kingston+june+2015&qpvt=tva+kingston+june+2015&view=detail&mid=905ACCC1E1FDFAE8DEE6905ACCC1E1FDFAE8DEE6&FORM=VRDGAR

March 2016 SRI Webinar: Ecological Revitalization and Contaminated Sites
https://clu-in.org/conf/tio/sri_031716

May 2015 TVA Kingston Fossil Plant Coal Ash Release Natural Resource Damage Assessment: Restoration and Compensation Determination Plan
https://www.fws.gov/cookeville/pdfs/TVA%20RCDP_Final_2015_0526.pdf

Region 4 Profile Page
https://cumulis.epa.gov/supercpad/CurSites/csitinfo.cfm?id=0404167&msspp=

Sites in Reuse – TVA Kingston Site
https://semspub.epa.gov/work/04/11015034.pdf

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