PRESENTATION TITLE: TVA Kingston Ash Recovery Project Regulatory Overview

AUTHORS: Craig Zeller, US EPA - Region 4 / Environmental Engineer; Leo Francendese**,** US EPA

ABSTRACT BODY: On May 11, 2009, the Tennessee Valley Authority (TVA) entered into an Administrative Order on Consent (AOC) with the Region 4 Office of the United States Environmental Protection Agency (EPA), under the regulatory authority of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), to address the approximate 5.4 million cubic yards (CY) of coal ash released to the environment on December 22, 2008. The Superfund program was selected as the preferred regulatory framework due to 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. The TVA Kingston Ash Recovery Project was divided into 3 distinct phases using Time Critical and Non Time Critical Removal Action authority to address coal ash that was released to area waters including the Emory River and embayments/sloughs of Watts Bar Reservoir. Time Critical removal involved wet excavation, mechanical and hydraulic dredging, rapid materials handling and disposal of an estimated 3.3 million cubic yards of ash from the Emory River to mitigate further downstream transport. Ash removed from the river is dewatered on-site and loaded onto rail cars for disposal at an approved landfill in Perry County, Alabama. Ash removal from the Emory River channel under the Time Critical phase was completed in May 2010 with the reopening of the Emory River for navigation and recreation. Railroad transportation and off-site ash disposal is expected to continue through the end of 2010. Non-Time Critical Removal Actions will be utilized to excavate and place the 2.5 million CY of ash from the embayments/sloughs into a re-constructed cell; and to assess the environmental risks posed to ecological receptors by residual ash in the river system. This presentation provides an overview of the regulatory framework, and short- and long-term removal actions employed by EPA to protect human health and the environment.

PRESENTATION TITLE: Generating Meaningful Environmental Data in the Midst of an Emergency Response

AUTHORS: Dennis Callaghan, Environmental Standards, Inc.; Neil Carriker, Tennessee Valley Authority; William Rogers, Tennessee Valley Authority; Rock Vitale, Environmental Standards, Inc.; Ruth Forman, Environmental Standards, Inc.

ABSTRACT BODY: Environmental data collection involves a series of activities, each having inherent uncertainty, that when propagated across the entire process can result in substantial total uncertainty. Emergency response activities by their nature do not lend to decreasing uncertainty. The challenge is to move from a chaotic emergency response to a mature environmental remediation management process in the shortest period of time. Quick decisions relating to data collection system, processes, and activities made by TVA soon after the Kingston, Tennessee ash release event, resulted in a defensible database that provides meaningful information from which conclusions can be drawn, decisions can be made, and against which regulatory benchmarks can be compared. This presentation will provide insight on the many challenges that faced TVA, the decisions that TVA made with assistance from Environmental Standards, the impacts of these decisions, and the lessons learned.

PRESENTATION TITLE: TVA Kingston Fly Ash Transport and Fate Study

AUTHORS: Steve Scott, ERDCWES

ABSTRACT BODY: In December of 2008 an 84-acre containment berm failed on a fly ash storage facility at the TVA Kingston Fossil Plant, releasing approximately 6 million cubic yards of ash which impacted approximately 300 acres of the surrounding area, including 3 million cubic yards of ash which deposited in the Emory River. The ash completely filled the Emory River channel adjacent to the Swan Pond Embayment, with ash transporting more than 2 miles upstream in the Emory River due to the momentum of the slurry release. After the spill, the channel thalweg was filled with ash (ash depths up to 30 feet), thus the channel capacity was significantly reduced. This in turn resulted in an immediate flood risk for the numerous properties that were located on both sides of the channel. Studies conducted by the TVA indicated that the ash deposits in the river increased the predicted flood elevation for the 100 year flood by 8 feet. To counter the increased flood and sediment transport risk, the TVA and EPA initiated an aggressive dredging operation to restore the Emory River channel capacity within one year of the spill. This effort involved bringing in a number of high capacity dredges that worked 24 hours a day until the channel was restored. However, a number of relatively large flow events occurred in the Emory River before the channel was completely cleared, including a three year return storm event (~70,000 cfs) that occurred in May of 2009. To better understand the impact of fly ash deposits on Emory River hydraulics and sediment transport, the EPA contracted with the Engineering Research and Development Center at Waterways Experiment Station (ERDCWES) to model the Watts Bar reservoir system. A two-dimensional sediment transport model was developed for the Emory, Clinch, and Tennessee Rivers, from Emory River Mile 4.0 to Watts Bar dam at Tennessee River Mile 530 (45 miles) This paper presents the modeling background, procedures, and results. In addition, the concept of long-term natural recovery of Watts Bar reservoir is discussed. The model used to conduct the fly ash transport study will be utilized to evaluate the impact of natural incoming sediment load on fly ash deposits in the reservoir. Natural sediment loads will be routed into Watts Bar reservoir to evaluate the long term deposition and mixing with residual fly ash deposits. Timelines will be estimated for the dilution and burial of fly ash by the natural sediment load from the Emory, Clinch, and Tennessee Rivers.

PRESENTATION TITLE: Fly Ash Geochemistry: Current Course of Investigations

AUTHORS: Mark Chappell, U.S. Army Corps of Engineers / Environmental Laboratory

ABSTRACT BODY: As cleanup efforts of the 2008 fly ash spill at the Kingston Fossil Plant continue, questions have emerged regarding the long-term geochemical behavior of the residual fly ash following time-critical dredging period. For this reason, multiple investigations are being pursued from government and university research groups to understand the current state of the fly ash and its potential geochemical fate in the extended outlook. The purpose of this talk is to summarize the different efforts currently underway to geochemically describe the character, leaching potential, and long-term stability of the residual fly ash remaining in the Emory River. For example, specific efforts are designed to determine the speciation and complexation of heavy metals within the fly ash, in order to better understand their geochemical cycling and bioaccumulative potential. Efforts to understand the influence of river water chemistry, seasonally shifting redox, temperature, and conductivity profiles, and continued migration and mixing of ash with river sediments and dissolved humics will be discussed. The implications of these findings with respect to fly ash deposits in the proximate Clinch and Tennessee Rivers will be discussed as well.

PRESENTATION TITLE: Evaluation of Risks to Fish Reproduction from the Kingston Steam Plant Coal Ash Spill

AUTHORS: Mark Greeley, Oak Ridge National Laboratory / Environmental Sciences Division; S. Marshall Adams, Oak Ridge National Laboratory / Environmental Sciences Division

ABSTRACT BODY: On December 22, 2008, a dike at the Tennessee Valley Authority's (TVA) Kingston Steam Plant in Tennessee failed and released a large quantity of coal ash into the adjacent Emory River. Ash deposits extended as much as four miles upstream in the Emory River, and ash was detected as much as four miles downstream of the confluence of the Emory River with the Clinch River. In the spring of 2009, approximately four months after the spill, we initiated an assessment of the reproductive status of sentinel fish populations exposed to the ash spill. Female largemouth bass, white crappie, bluegill sunfish, and a limited number of channel catfish were collected at the beginning of the their respective breeding seasons from sites within the spill zone and from upstream reference sites in both the Emory and Clinch Rivers. Fish were examined for ovarian size and gross appearance and quantitatively scored for oocyte developmental status, including the presence or absence of atresia among vitellogenic or maturing oocytes and the abundance of vitellogenic oocytes. Batch and/or total fecundities were estimated from counts of the leading clutch of maturing oocytes or, in the case of fish that had spawned just prior to collection, the abundance of shed follicles in the ovaries. Samples of ovarian tissue were histologically examined for various lesions including atresia of smaller oocytes, and ovarian and other tissues were analyzed for a suite of metals. Significant reproductive dysfunction was not observed in these fish sampled during the first reproductive season following the coal ash spill, but selenium concentrations in ovaries from exposed fish were approaching levels considered to be capable of triggering reproductive failure through effects on larval fish development. Follow-up investigations being conducted in collaboration with TVA are focused on metal bioaccumulation and reproductive condition in female fish sampled from the Emory and Clinch rivers during the subsequent 2010 breeding season, an assessment of the condition of larval fish sampled at intervals during the 2010 breeding season from both river systems, and complimentary laboratory studies involving experimental coal ash exposures to adult fish and fish embryos and larvae.

PRESENTATION TITLE: An Integrated Health Assessment of Fish Populations Exposed to Fly Ash Releases at the TVA Kingston Facility

AUTHORS: S. Marshall Adams, Oak Ridge National Laboratory / Environmental Sciences Division; Mark Greeley, Oak Ridge National Laboratory / Environmental Science Division; Swee Teh, Oak Ridge National Laboratory / Environmental Science Division

ABSTRACT BODY: As a major component of the comprehensive biological monitoring and assessment project related to the TVA Kingston fly ash release, we conducted an integrated fish health study for the purpose of evaluating possible effects of fly ash exposure on fish health. Three species of fish, representing different trophic levels and home ranges, were sampled at sites in the immediate vicinity of the fly ash release and at multiple reference sites. An integrated fish health assessment using suites of multiple biomarkers and bioindicators was conducted on all fish from each sample site including indicators of physiological function, electrolyte homeostasis, tissue damage (histopathology), bioenergetic status, organ dysfunction, and reproductive integrity. Results of these studies, conducted 9-11 months after the spill, indicate that (1) in general, health of fish is lower downstream of the fly ash release than at reference areas as demonstrated by responses of several tissue pathology and blood chemical parameters, (2) for some measures of fish health, there is a downstream gradient of responses with some variables increasing and others decreasing along the spatial gradient of the river, (3) overall health of catfish downstream of the release is higher than both bass and bluegill with bluegill demonstrating the relatively poorest health possibly due to their restricted movements and high site fidelity, 4) compared to the fish health studies conducted earlier in the year, fish sampled at sites below the ash release show a slight decline in health and condition over a 6 month period possibly due to uptake and bioconcentration of metals via the food chain, and 5) an integrated bioindicator analysis using all measured health indicators in a canonical discriminant analysis procedure demonstrated that bass and bluegill were in the poorest health at the two sites immediately downstream of the release compared to all other sample locations. Current studies are focused on trophic transfer of fly ash-associated metals through the food chain and the importance of selenium in the reproductive integrity of fish populations.

PRESENTATION TITLE: Bioaccumulation, Maternal Transfer, and Effects of the TVA Kingston Ash Spill

AUTHORS: William Hopkins, Virginia Tech / Dept. of Fisheries and Wildlife Sciences; T. Hill Henry, Tennessee Valley Authority; Suzy Young, ARCADIS

ABSTRACT BODY: On 22 December, 2008 a retaining wall failure at the TVA Kingston Fossil Plant in Roane County, Tennessee released approximately 5.4 million cubic yards of ash from a holding pond into the Emory River. In April 2009 TVA initiated a variety of studies to assess impacts from the ash spill to wildlife resources in the area. The initial objective of the studies was to determine whether a variety of wildlife species in the vicinity of the spill were accumulating trace elements. Target species were selected that encompassed a range of feeding ecologies and life histories. To date, sampling has primarily included piscivorous birds (Osprey and Great Blue Herons), herbivorous birds (Canada Geese), insectivorous birds (Tree Swallows), predatory and benthic feeding turtles (stinkpots, softshell turtles, and snapping turtles), spring breeding amphibians (chorus frogs and toads), and omnivorous mammals (raccoons). Starting next year, effects-based work will be initiated to determine whether the spill is adversely affecting physiological and reproductive attributes of turtles and tree swallows in the area. An overview of monitoring efforts thus far and future effects-based research plans will be presented.

PRESENTATION TITLE: Environmental Assessment and Management Programs for the TVA Kingston Ash Recovery Project

AUTHORS: Daniel Jones, ARCADIS; David Ludwig, ARCADIS; Neil Carriker, Tennessee Valley Authority; Dennis Yankee, Tennessee Valley Authority

ABSTRACT BODY: The Kingston fly ash spill discharged approximately 5.4 million cubic yards of coal ash slurry into the adjacent aquatic and terrestrial systems. Recognizing the potential for adverse environmental effects from both the initial spill and the ash that may remain in the rivers, the Tennessee Valley Authority (TVA) developed an integrated research program to support the environmental management decision-making process for the site. As both responsible party and resource trustee, TVA's environmental management program for the site is comprised of three component programs: remediation, restoration, and natural resource stewardship. Each program has different goals and is governed by different guidance and protocols. For remediation, the decisions are driven by the risk assessment and risk management process with the goal of protecting human health and the environment. For restoration, the Natural Resource Damage Assessment process is used to quantify and replace lost environmental services, both human-use and ecological services. For stewardship, TVA's internal programs and protocols are used to maintain the extensive suite of environmental services that remain following the release. Although the methods and goals are distinct, the data needs for these programs are overlapping and the decisions to be made are interrelated. By taking a holistic view of their environmental management responsibilities, TVA has been able to prioritize the characterization and assessment efforts at the site in order to maximize the return on investment for these efforts. This is critical to the success of the overall environmental management program, because time, money, effort, and technical expertise spent on one issue are not available for other issues. Although the scale of this release is uncommonly large, the zero-sum principle of environmental management is applicable to all cleanup and restoration projects at whatever scale.

POSTER TITLE: Integrated Ecotoxicological Research Program – TVA Kingston Ash Recovery Project

AUTHORS: Neil Carriker, Tennessee Valley Authority; Dennis Yankee, Tennessee Valley Authority; Anda Ray, Tennessee Valley Authority

ABSTRACT BODY: The Kingston fly ash spill deposited several million cubic yards of ash into portions of Watts Bar reservoir. Most of the ash has been removed from the Emory River, but there is about 300,000 cubic yards that may be impossible to remove from the Emory, Clinch, and Tennessee Rivers without causing more environmental damages than benefits. Recognizing the potential for adverse environmental effects from both the initial spill and the ash that may remain in the rivers, TVA has developed an integrated research program that draws on its own technical expertise, nationally-recognized third-party researchers, and academic institutions to assess effects of ash-related contaminants on ecological receptors at multiple trophic levels. Primary objectives of this program are to 1) accurately assess immediate and intermediate-term effects of the spill on the aquatic ecology of the system, 2) develop information necessary to predict long-term system responses to ash that may remain in the river, and 3) identify potential problems for which innovative solutions must be developed. This research spans multiple disciplines (e.g., environmental geochemistry, toxicology, and ecology), and examines ecological effects at cellular, organ, organism, and population levels. For key contaminants such as arsenic and selenium, it includes characterizing chemical speciation, bioaccumulation, and biogeochemical transformation rates, and the effects of environmental conditions on those rates. This poster describes the different components of this research program and the methods being developed to encourage coordination and communication among researchers. It uses results to date for investigations begun soon after the spill to illustrate linkages among the different research components.

POSTER TITLE: Characterization of Coal Ash Associated with a Release of Fly Ash at TVA's Kingston Fossil Plant

AUTHORS: William Rogers, Tennessee Valley Authority; Neil Carriker, Tennessee Valley Authority; Paul Clay, Restoration Services, Inc; Mark Stack, Jacobs

ABSTRACT BODY: The composition and characteristics of fly ash depends on the source of coal and the types of burners and pollution control devices. The Tennessee Valley Authority (TVA) Kingston Fossil Plant (KIF) burns mostly eastern bituminous coal, but has also used coal from Illinois, and blends low-sulfur Western coal to reduce emissions. This results in some heterogeneity of the ash as different sources or combinations of coal were burned. KIF produces about 80% fly ash and 20% bottom ash. For ease of handling, water is used to flush fly ash and bottom ash to an onsite ash pond for settling. Settled ash has been hydraulically dredged to dredge cells for de-watering and long-term storage. TVA has evaluated the characteristics of KIF coal ash following the release that occurred in December, 2008. KIF ash has been tested for chemical, radiological, and physical properties using EPA methods for total metals, TCLP metals, BTEX, radionuclides, polynuclear aromatic hydrocarbons (PAHs), grain size, acid volatile sulfides and simultaneously extractable metals, standard toxicity tests, and polarized light microscopy to evaluate the degree of mixing with native sediment. Analytes considered to be constituents of interest include arsenic, chromium, copper, lead, mercury, nickel, selenium, thallium, vanadium, zinc, and naturally occurring radionuclides. The initial assumption following the ash release was that mixing of the various layers of ash during the release would have resulted in a relatively homogeneous material in the river. Some constituents occur in a fairly narrow range of concentrations, and results for those might seem to support this assumption. However, closer analysis shows that while results do not span very broad ranges, there is a reasonable amount of heterogeneity in the ash deposited in the river. This is due to less mixing of the initially deposited ash than was assumed, particle size sorting that occurs as storm flows re-suspend and transport ash further downstream, and mixing with native sediment.

POSTER TITLE: Evaluation of Impacts on Surface Water Quality Associated with a Release of Fly Ash at TVA's Kingston Fossil Plant

AUTHORS: Paul Clay, Restoration Services, Inc; William Rogers, Tennessee Valley Authority; Neil Carriker, Tennessee Valley Authority; Mark Stack, Jacobs

ABSTRACT BODY: In response to the coal ash spill at the Tennessee Valley Authority's (TVA) Kingston Fossil Plant (KIF), TVA, the Tennessee Department of Environment and Conservation (TDEC) and the Environmental Protection Agency (EPA) have collected surface water samples from the Emory, Clinch, and Tennessee Rivers. The objectives of the surface water monitoring were to determine whether there was any immediate down-river migration of ash-related constituents that posed an imminent public health or environmental threat. TDEC also performed weekly sampling and analysis of the raw and finished water at the Kingston and Rockwood municipal water plants which are downstream of KIF. Both TVA and TDEC performed additional sampling, triggered either by heavy local rainfall or elevated flow on the Emory River to determine the extent to which these events contributed to ash migration. Sampling locations encompassing approximately 14 miles of the river system were selected to bracket the fly ash release area. TVA monitoring stations included five locations on the Emory River, four on the Clinch River, and two on the Tennessee River. TVA collected samples at these locations two days per week; TDEC performed independent sampling at these and other locations two days per week. TVA's samples were analyzed for a suite of 24 total and dissolved metals and total suspended solids (TSS). Field parameters measured at each location included temperature, dissolved oxygen, pH, conductivity, and turbidity. To monitor the effectiveness of best management practices (e.g. turbidity curtains) to reduce ash migration during dredging, TVA performed daily monitoring of dredge plumes in the Emory River. Field measurements were used to guide the collection of samples directly from dredge plumes. TVA has collected more than 2,500 surface water samples since the spill, with TDEC independently collecting over 800 hundred more. Through the middle of April 2010, total arsenic in one surface water sample exceeded the Tennessee Domestic Water Supply Criterion and Tennessee Water Quality Criterion of 0.01 mg/L. This exceedence was in the vicinity of the ash spill at ERM 2.1. Lead also exceeded its Tennessee Domestic Water Supply Criterion in one Emory River sample at ERM 1.75. This is consistent with results reported by TDEC. This poster summarizes the results of TVA water quality monitoring at KIF during the period in which dredging of ash from the river was occurring.

POSTER TITLE: Producing Defensible Environmental Data Using Modified and Non-Standard Methodology

AUTHORS: Rusty Vicinie, TestAmerica Laboratories; Patricia McIsaac, TestAmerica Laboratories; Larry Matko, TestAmerica Laboratories; Mark Matrozza, TestAmerica Laboratories; Tara Martz, TestAmerica Laboratories

ABSTRACT BODY: The coal ash release that occurred in Kingston, TN in December 2008 was unprecedented in scope and unique in many aspects. As such the scientific community does not have significant experience to draw upon to understand all the potential impacts of this event. Many investigations are being conducted to characterize the site to understand both the immediate and potential long term effects of the release. The data being generated by these various investigations are being conducted for specific purposes. The data quality may be sufficient for the intended purposes generated. However, it is likely that as our understanding of the situation evolves, we will be looking to the entire body of available data generated to help us better understand other related aspects of the event for other than its originally intended purpose. We should fully understand the nature of the data, assumptions that may have been used in experimental design, and uncertainty in the data itself to understand how it may or may not be used for other than its intended purpose. Due to the unique nature of the investigation and recovery efforts, both routine and non-routine methodology are being utilized as well as novel investigative techniques. We are presenting here for discussion purpose an example of a study performed that employed the adaptation of a published research investigation combined with routine USEPA methodology to better characterize the metal content of the ash.

POSTER TITLE: Ash Migration Investigation Using Sub-Bottom Profiler near the Kingston Ash Spill

AUTHORS: John Lane, Tennessee Valley Authority; Katie Gassaway, Tennessee Valley Authority

ABSTRACT BODY: Ash migration has been a major concern following the Kingston Fossil Plant ash spill. Efforts to characterize the extent and amount of submerged ash have been marginally successful due to the logistical constraints in surveying large areas of waterway. TVA purchased a Sub-Bottom Profiling System (SBP), a device that differentiates between sediment types based on density, to overcome these constraints. Three phases of the SBP investigation were: 1) Identifying the areal extent of ash migration from the spill area, 2) Characterizing the depth of ash throughout the deposition area, and 3) Mapping to depict the extent and depth of ash deposition. Using sampling devices, measurable ash was identified upstream to approximately Emory River Mile 6, Clinch River Mile 5, and Tennessee River Mile 568.7, and downstream to Tennessee River Mile 562. During Phase 1, SBP cross-sectional profiles were collected in immediate proximity to the spill site. The profiles were used to target locations of recent sediment deposition. Sediment samples were collected, described, and used to create maps of sediment types (ash or native sediments) and depths. During Phase 2 (in progress), SBP data is being collected in a grid pattern from the spill site to the downstream extent defined earlier. Coring devices also are used to determine ash depth and correlate with the reflective imagery. Where profiles distinguish between ash and native sediment layers, ash will be digitized and mapped. Sediment sampling shows the ash is being mixed with or covered by native sediments. This causes difficulty in differentiating the two using SBP reflective imagery. Ash deposits predating the 2008 spill also have been confirmed by microscopy below the recent ash deposits near Clinch River Mile 1. Using SBP technology TVA is able to survey large areas of waterway in a time-efficient manner and target sediment coring locations. Sediment core data are used to create maps depicting the depth and extent of ash migration. Differentiating between ash and native sediment by SBP techniques is a difficult problem that has not yet been adequately resolved (sediment cores have not matched profile interpretations for the Clinch and Tennessee Rivers). Data acquisition parameters must be fine-tuned based on subsurface properties to obtain data that matches core samples. Depending on future high-flow events, portions of this investigation may be repeated.

POSTER TITLE: Characterization of Survival and Growth Effects Observed in *Hyalella azteca* Exposures to Fly Ash

AUTHORS: Rick Sherrard, Tennessee Valley Authority; Neil Carriker, Tennessee Valley Authority; William Rogers, Tennessee Valley Authority

ABSTRACT BODY: Sediment toxicity studies by 3 separate laboratories with ash from the TVA Kingston Fly Ash Release resulted in measurable effects (survival, growth) by *Hyalella azteca*. TVA conducted a follow-up study using methods employed in bioavailability studies (porewater separation) and sediment Toxicity Identification Evaluations (anionic exchange resin) to elucidate reasons for those effects. The objectives of this study were to (1) discern effects caused by physical properties of ash and metals/metalloids, and (2) characterize bioavailability of metals/metalloids in ash and porewater. Ash was carried through a series of porewater separation and resin treatment steps to provide 6 distinct exposure media: untreated ash (UA), untreated porewater (UPW), untreated porewater with subsequent resin treatment (PWR), resin-treated ash (RTA), resin-treated ash porewater (RTAPW), and resin-treated ash porewater with subsequent resin treatment (RTAPWR). Total metals were measured in solids and overlying Emory River water (ERW) while dissolved metals were measured in porewaters and filtered ERW (FERW). Exposures to the 6 media included *Hyalella azteca* (10-d) and *Ceriodaphnia dubia* (7-d). Concentrations decreased slightly for most metals with 15-d resin treatment of ash but continued loss of Sb, As, and Se during the 10-d *H. azteca* exposure was greater (22, 18, 34%) in RTA than in UA. Partitioning of Al, As, Mo, Se, and V to overlying water in twice-daily ERW renewals in the H. azteca exposure to UA was >90% of RTA as determined from Day 0-1 and Day 9-10 analyses, yet no measured concentrations of metals in overlying water clearly exceeded published 7-d LC50 values for this species. All 3 resin treatments for porewater resulted in removal (mostly 96-100%) of Al, Sb, As, Mo, Se, and V; however, RTAPW and RTAPWR increased (136-584%) Ba, Ca, Mg, Mn, K, and Na while PWR did not. None of the porewater metal concentrations exceeded 7-d LC50 values for *H. azteca*. Survival effects were observed for *H. azteca* exposed to UA (78%) and RTA (82%), while growth effects were measured in UA and UPW. RTA elicited the only significant effect on *C. dubia* survival (0%). Ion toxicity from a resin treatment artifact is suspected. Reproductive effects on *C. dubia* were observed for UA and UPW. Comparisons of treatment results indicate physical effects for survival of H. azteca, and porewater metal/metalloid effects on growth.

POSTER TITLE: Assessment of Bioaccumulation of Fly-Ash Associated Metals by Fish in the Area of the TVA Kingston Fly Ash Release

AUTHORS: Allison Fortner, ARCADIS; A. Marshall Adams, Oak Ridge National Laboratory; Tyler Baker, Tennessee Valley Authority

ABSTRACT BODY: As a major component of the comprehensive biological monitoring and assessment project related to the TVA Kingston fly ash release, we conducted a fish bioaccumulation study for the purpose of determining if fly ash-associated metals were being incorporated through the food chain into upper level consumers. Three species of fish, representing different trophic levels and home ranges, were sampled at sites in the immediate vicinity of the fly ash release and at multiple reference sites upstream and downstream of the release. Muscle, liver, and ovarian tissue from individual fish were analyzed for 25 metals typically associated with fly ash including selenium and mercury. Results of these studies, conducted 4-10 months after the spill, indicate that (1) selenium is the only metal that appears to be consistently bioconcentrated above background levels in muscle tissue, (2) levels of selenium in muscle tissue is highest in fish downstream of the spill displaying a spatial downstream gradient, (3) selenium levels in catfish are lower than bluegill and largemouth bass, possibly indicating a larger home range movement and lower site fidelity of this species, (4) concentrations of selenium in liver and ovarian tissue are generally higher than in muscle tissue in all three species, and (5) based on EPA's three- tiered approach for assessing reproductive effects of selenium on fish and birds, future studies will be focused at the Tier 2 level because of slightly elevated levels of selenium muscle and ovarian tissue in fish downstream of the fly ash release. Current studies are focused on assessing the relationship between reproductive competence of fish and levels of selenium in target organs such as liver and ovary.

POSTER TITLE: Fly Ash and Mercury: Does Selenium in Fly Ash Inhibit Methylmercury Bioaccumulation?

AUTHORS: S. Marshall Adams, Oak Ridge National Laboratory / Environmental Sciences Division; George Southworth, Oak Ridge National Laboratory / Environmental Sciences Division; Mark Peterson, Oak Ridge National Laboratory / Environmental Sciences Division

ABSTRACT BODY: Selenium is known to have an antagonistic effect on the mammalian toxicity of inorganic mercury, and it also appears to play a role in reducing the accumulation of methylmercury in fish in some aquatic ecosystems. Oak Ridge National Laboratory (ORNL) has measured mercury and selenium concentrations in largemouth bass over a 20 year period in a quarry that once received direct discharges of slurried fly ash. When monitoring was initiated in 1990, a year after ash disposal in the quarry was discontinued, mercury concentrations in fish averaged less than 0.02 ppm, and selenium exceeded concentrations in fish from regional reference sites by five-fold. Over the next 10 years, mercury concentrations in bass steadily increased to over 1 ppm before reaching an apparent steady-state, and selenium concentrations decreased but never returned to background levels. In the mid 2000's, selenium concentrations in bass began to increase rising from 1 to over 2 ppm between 2005 and 2009. Over this same period, mean mercury concentration in fish decreased from 1.1 ppm to nearly 0.5 ppm. Similar relationships between mercury and selenium were also observed in fish sampled from an ash stilling pond at the Kingston fossil plant where average mercury and selenium concentrations were 0.01 ppm and 2.4 ppm, respectively. Thus, studies from both of these aquatic systems show that there is an inverse relationship between levels of selenium and mercury in fish with high levels of selenium resulting in reduced bioconcentration of mercury and vice versa.

POSTER TITLE: Accumulation of Potential Fly Ash Contaminants by Aquatic Invertebrates Downstream of the Tennessee Valley Authority Kingston Fossil Plant

AUTHORS: John Smith, Oak Ridge National Laboratory / UT-Battelle / Environmental Sciences Division; Tyler Baker, Tennessee Valley Authority

ABSTRACT BODY: On December 22, 2008, a dike failure at the Tennessee Valley Authority's (TVA) Kingston Fossil Plant (KIF) released an estimated 5.4 million yd^3 of fly ash into the Emory River, and a comprehensive assessment of the consequences of the spill to the aquatic ecosystem soon followed. Included in this assessment was a study of contaminant (i.e., metals) exposures to aquatic invertebrates. Two widespread and abundant aquatic macroinvertebrate species present throughout the affected watershed were chosen for study: the silty horn snail, *Pleurocera canaliculatum,* and the burrowing mayfly, *Hexagenia bilineata* (nymphs and adults). Five core sites were assessed, but additional sites were used as needed for improved spatial coverage. The core sites included three on the Emory River (ERM 6.0 upstream of KIF; ERM 2.5 adjacent to KIF, and ERM 1.0 downstream of KIF) and two on the Clinch River (CRM 6.0 and CRM 1.5, upstream and downstream of the Emory River respectively). Snails were collected by hand and held for 72 hr in a laboratory for depuration before analysis. *Hexagenia* nymphs were collected with a Peterson dredge; samples from all sites were analyzed without depuration, but additional samples were collected at two sites and depurated for 48 hr before analysis. *Hexagenia* adults were collected opportunistically by sweep net or hand and separated by sex and adult stage (i.e., imago and subimago) before analysis. Samples were analyzed by ICP-AES for a suite of 25 metals. Results revealed slight to moderate elevations in some contaminants downstream of the ash spill. Except for selenium (Se), concentrations of most metals generally varied by species, developmental stage (adult *vs*. nymph), and in some cases sex (i.e., adult mayflies). For all test groups, maximum concentrations of Se (maximum = 7.7 µg/g dry wt, adult mayflies) were found ~1.5 miles downstream of the KIF (ERM 1.0). Depuration had no discernable affect on Se concentrations in mayfly nymphs, nor did transformation to adult stage. For other metals, lowest concentrations were found in adult mayflies, and highest concentrations were generally found in undepurated nymphs; depuration reduced concentrations of most contaminants by ~45 to 75%. Arsenic (As) was not elevated in snails and only slightly elevated in adult mayflies, but at ERM 1.0 and ~6 miles downstream of KIF (CRM 1.5), As was elevated ~11-fold and 4-fold, respectively, in undepurated nymphs, while concentrations in purged nymphs were similar to reference sites. Future studies will focus on better understanding the spatial extent of contaminant transport, clarification of sex differences in uptake, and the effect of depuration on estimates of contaminant burdens.

POSTER TITLE: The Effects of Fly Ash Release from the TVA Kingston Steam Plant on Fish and Benthic Macroinvertebrate Communities

AUTHORS: Tyler Baker, Tennessee Valley Authority; Kurt Lakin, Tennessee Valley Authority; Donny Lowery, Tennessee Valley Authority; John Smith, Oak Ridge National Laboratory / UT-Battelle / Environmental Sciences Division

ABSTRACT BODY: The comprehensive assessment of the ecological consequences of the TVA Kingston fly ash release includes studies of fish and benthic macroinvertebrate assemblages. Fish were sampled in the Clinch and Emory Rivers using TVA's Reservoir Fish Assemblage Index (RFAI) and Spring Sport Fish Survey (SSS) methodologies. The RFAI methodology uses boat electrofishing and gill netting to collect fish from a variety of habitat types. Twelve metrics from four general categories: Species Richness and Composition; Trophic Composition; Abundance; and Fish Health are used to evaluate the integrity of the fish community. Fish are collected with the SSS methodology using boat electrofishing; this method specifically focuses on monitoring long-term trends in black bass (largemouth, smallmouth and spotted bass) populations. Historical RFAI and SSS surveys in the Clinch and Emory Rivers provided baseline data for comparison. The autumn 2009 RFAI results and spring 2009 and 2010 SSS results indicate that the fish assemblage and sport fish population (i.e., largemouth bass) were similar to those observed prior to ash release. Assessments of the benthic macroinvertebrate assemblage were conducted in January and December 2009, with quantitative collections at up to 14 locations in the Emory, Clinch, and Tennessee Rivers; at least one upstream site served as a reference for each river. Benthic invertebrate samples are collected with a Ponar grab sampler and analyzed in the laboratory for taxonomic identification and enumeration. The benthic macroinvertebrate assemblage was clearly different between reference and downstream sites in the Clinch River and Emory River; there appeared to be little difference between Tennessee River sites. For example, two reference sites on Clinch River had significantly higher densities than other sites due to high numbers of tubificid worms and/or chironomids. The mayfly *Hexagenia* and the fingernail clam *Musculium* were most abundant in the Clinch River downstream of the Emory River and generally less abundant at reference sites. Nonmetric multidimensional scaling ordination (Bray-Curtis similarity) showed that sites within the same river and with the most similar channel morphology generally had the most similar invertebrate communities. Future monitoring should help determine whether community differences are due to natural factors, effects associated with the ash spill, or a combination of these factors.

POSTER TITLE: Initial Assessment of Trace Element Exposure in Insectivorous Birds Nesting Near the Kingston Ash Spill

AUTHORS: Elizabeth Burton, Restoration Services, Inc.; Suzy Young, ARCADIS; Jesse Morris, Restoration Services, Inc.; William Hopkins, Virginia Polytechnic Institute and State University, Wildlife Ecotoxicology and Physiological Ecology Laboratory; T. Hill Henry, Tennessee Valley Authority

ABSTRACT BODY: In April, 2009, TVA initiated a study using tree swallows (*Tachycineta bicolor*) to examine potential impacts of the Kingston ash spill to insectivorous birds in the vicinity of the release. The initial study design consisted of three sites near the ash spill and two reference sites. A tree swallow colony was established at each site and a total of 76 nests (30 at the spill, 46 at reference sites) were monitored during the breeding season. In the spring of 2010 the study design was expanded substantially to better characterize potential exposures in the river system downstream of the release. The number of nest boxes was increased to a total of 530 boxes distributed along the shores of the river system and at two reference locations. The colonies sampled in the spring of 2009 were re-sampled in 2010 for the same suite of metals and metalloids. New colonies were also sampled if occupancy and clutch size met minimum requirements. As in 2009, approximately 15 eggs and 15 nestlings were targeted for sampling from each colony. Eggs were measured, weighed, and sent for content analysis of metals and metalloids. Nestlings were collected from the colonies established in 2009 by removing 15-17 days-old birds from the same nests from which eggs were collected earlier in the season. Nestlings were weighed, the 3rd primary feather and tarsus were measured, and the nestling was sent for content analysis of metals and metalloids. All 530 boxes are monitored four times throughout the season for occupancy, clutch size, and hatching success. Year 2 results are compared with Year 1 results for the five colonies in the initial study design. This provides the first year-on-year trend analysis for metals and metalloid exposures for insectivorous birds near the site. Locations added to the study design in 2010 will serve as the foundation for planned annual surveys, providing data for analysis of temporal trends and improving the likelihood of adequate occupancy rates in the next breeding season. Together, these and future studies will examine potential bioaccumulation of ash-related trace elements to avian receptors and their prey.

POSTER TITLE: An Overview of Ecological Studies of Wildlife Potentially Impacted by the Kingston Ash Spill

AUTHORS: Suzy Young, ARCADIS; Elizabeth Burton, Restoration Services, Inc.; Jesse Morris, Restoration Services, Inc.; William Hopkins, Virginia Polytechnic Institute and State University, Wildlife Ecotoxicology and Physiological Ecology Laboratory; T. Hill Henry, Tennessee Valley Authority

ABSTRACT BODY: The release of fly ash at the Tennessee Valley Authority (TVA) Kingston Fossil Plant (KIF) on December 22, 2008 discharged approximately 5.4 million cubic yards of coal slurry, which contains metals and metalloids that might pose a risk to ecological receptors within the adjacent aquatic and terrestrial systems. TVA and cooperators have continued and expanded the studies initiated in the aftermath of the release in order to assess impacts of the spill to wildlife resources in the area and to document whether the ash spill has exposed wildlife in the region to trace elements. Groups of wildlife included in these studies include piscivorous, insectivorous, and herbivorous birds; spring breeding amphibians; aquatic reptiles; and terrestrial mammals. Wildlife species selected include Osprey (*Pandion haliaetus*), Great Blue Heron (*Ardea herodias*), Canada Goose (*Branta canadensis*), Tree Swallow (*Tachycineta bicolor*), Upland Chorus Frog (*Pseudacris feriarum*), Spring Peeper (*P. crucifer*), American Toad (*Bufo americanus*), Snapping Turtle (*Chelydra serpentina*), Common Musk Turtle (*Sternotherous ordoratus*), and Raccoon (*Procyon lotor*). Tissues tested include contents of eggs (birds), whole body (amphibian and bird nestlings), blood (turtles and mammals), hair and organs (mammals). While bioaccumulation was not noted or expected in the first year of studies for higher trophic levels, the continued studies are the first results indicating whether these receptors are accumulating constituents of concern. Trends for constituents and species are presented.

POSTER TITLE: Baseline Ecological Risk Assessment Strategy for the TVA Kingston Fly Ash Recovery Project

AUTHORS: Suzy Young, ARCADIS; Daniel Jones, ARCADIS; Neil Carriker, Tennessee Valley Authority; Mark Stack, Jacobs

ABSTRACT BODY: The release of fly ash at the Tennessee Valley Authority (TVA) Kingston Fossil Plant (KIF) on December 22, 2008 discharged approximately 5.4 million cubic yards of coal ash slurry into the adjacent aquatic and terrestrial systems. The initial response focused on public protection and stabilization of the released ash, but rapidly evolved to include comprehensive monitoring of ambient media and ecological receptors. Metals and metalloids including arsenic and selenium are the primary constituents of potential concern for fly ash. KIF is located on the Emory River near the confluence of the Clinch and Tennessee Rivers. This portion of the Tennessee River Valley is bounded by ridges and impounded by Watts Bar Dam, a multiuse reservoir that supports a diversity of aquatic and terrestrial wildlife. A Conceptual Site Model (CSM) was developed to summarize and illustrate the ecological receptors and potential exposure pathways associated with the Kingston fly ash release. The size and complexity of the potentially affected ecosystems necessitates a comprehensive environmental monitoring program, which TVA is performing in cooperation with numerous federal, state, and academic organizations. The Screening Level Ecological Risk Assessment (SLERA) indicated that a Baseline Ecological Risk Assessment (BERA) is warranted for the River System into which the ash was released. The direct exposure pathways being evaluated for the River System include exposures to ash as ash sediment, sediment pore water, groundwater discharging to surface water, surface water, and seasonally exposed sediment. Dietary exposures are also a concern for some ash-related contaminants, including arsenic and selenium. The ecological receptors for which bioaccumulation and food web pathways are being studied at this site include fish, benthos, emergent insects, piscivorous birds and mammals, aerial-feeding insectivores, herbivorous birds, omnivorous mammals, amphibians, reptiles, and others. The BERA strategy presented in this poster was used to develop data quality objectives for the River System Investigation and identify additional data needs. The CSM and BERA Strategy were then used to refine the numerous field and laboratory studies being performed or supported by TVA, many of which are presented in this poster session.

POSTER TITLE: Evaluation of Human Health Risk from Potential Exposures to Fly Ash at the TVA Kingston Fly Ash Recovery Project

AUTHORS: Mark Stack, Jacobs; Suzy Young, ARCADIS; Daniel Jones, ARCADIS; Neil Carriker, Tennessee Valley Authority

ABSTRACT BODY: The release of fly ash at the Tennessee Valley Authority (TVA) Kingston Fossil Plant (KIF) on December 22, 2008 discharged approximately 5.4 million cubic yards of coal ash slurry into the adjacent terrestrial and aquatic systems. The initial response focused on public protection and stabilization of the released ash, but rapidly evolved to include comprehensive monitoring of ambient media and ecological receptors. The KIF is located on the Emory River near the confluence of the Clinch and Tennessee Rivers. This portion of the Tennessee River Valley is bounded by ridges and impounded by Watts Bar Dam. The 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 River and Emory River backwaters of Watts Bar Reservoir. This multi-use reservoir supports a diversity of aquatic and terrestrial wildlife. The size and complexity of the potentially affected ecosystems necessitates a comprehensive environmental sampling and monitoring program, which TVA has implemented in cooperation with numerous federal, state, and academic organizations. The objective of the human health risk assessment for the TVA Kingston Fly Ash Recovery Project was to develop quantitative and qualitative estimates of potential cancer risks and non cancer hazards for human receptors potentially exposed to the ash. These estimates were developed to support remediation decision making. Risks to both current (or near-term) and potential future receptors were evaluated. Potential receptors were distinguished as on-site and off-site. Onsite receptors are those who reside, work, or play on the ash, whereas, offsite receptors are those whose activities occur in areas where ash is not present. The risk analysis was based on analytical data collected from ash in the failed dredge cell and surrounding land, surface water from the Swan Pond Embayment, and shallow and bedrock groundwater beneath the dredge cell. Metals including arsenic and selenium are the primary constituents of potential concern for human exposures to fly ash.