River Systems Investigations Update
TVA Kingston Ash Recovery Project

Presentation 6 of 6

June 7, 2012

EE/CA Workshops

Tonight's focus: Human Health Risk Assessment & EE/CA Alternatives

April 5: Residual ash nature & extent, transport modeling

April 19: Aquatics Results
(toxicity testing, bioaccumulation in invertebrates & fishes)

May 3: Wildlife Results
(birds, turtles, mammals, plants)

May 17: Human Health Risk Assessment
Ecological Risk Assessment Process

**June 7: Human Health Risk Assessment &
Development of General Response Action Alternatives**

Agenda

- Summary of TDH and ORAU studies
- Summary BHHRA & BERA
- Summary nature and extent
- Removal action objectives
- Technology screening
- Alternatives
- Evaluation criteria

TDH and ORAU Studies (2010)

- **TDH Public Health Assessment**
  - By the State of Tennessee Department of Health (TDH) Environmental Epidemiology Program
  - Under a Cooperative Agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR)
- **ORAU Kingston Project Medical Screening**
  - Funded by TVA to assess health of individuals in Roane County
  - ORAU contracted with Vanderbilt University Medical Center in Nashville, Tennessee

Tennessee Department of Health
Public Health Assessment

http://health.state.tn.us/coalashspill.htm

Based on the sampling results by all agencies, TDH is confident that:

- No harm to health should have occurred from touching the coal ash
- Except in the immediate vicinity of the coal ash release, the coal ash or the metals in the coal ash have not affected surface water in the Watts Bar Reservoir
- Municipal drinking water from the Kingston and Rockwood water treatment plants has not shown any contamination

ORAU Medical Screening

http://www.orau.org/occupational-exposure-worker-health-studies/projects/kingstonproject/default.aspx

- 214 people from 112 households participated in the screening program
- Approximately half of the participants lived within two miles of the spill
- No long-term effects on physical health are expected
- Findings compatible with conclusions in TDH's Public Health Assessment

Baseline Human Health Risk Assessment (BHHRA): Receptors and Exposure Scenarios

- **Resident (Adult and Child).** Most conservative scenario that assumes that the resident draws water *directly from the river for household use without filtration or treatment*, by-passing the available public water supply or installation of a groundwater well.

- **Recreator (Adolescent-Adult Swimmer).** The potential receptors are assumed to be adults and adolescents who are old enough to be away from parental supervision for extended periods (assumed to be 9 to 18 years old). Swimming is assumed to occur 45 days a year with an exposure time of 1.4 hours a day.

- **Recreator (Adolescent-Adult Beachcomber).** Adolescent or adult recreators may be exposed to residual ash-impacted sediment during the winter when Watts Bar Reservoir is lowered to winter pool, exposing the sediment. The receptors were assumed to be an adult or adolescent living adjacent to the river. Exposure to near shore sediments is assumed to be two days per week from October through March.

- **Recreator (Fisher).** Recreational fishing is known to occur in the Emory and Clinch Rivers; however, subsistence level fish consumption is not known to occur. Currently, there are fish consumption advisories in place for the Emory River and Watts Bar Reservoir; however, it may be assumed that not all potential receptors adhere to the advisories.

BHHRA: Receptors and Exposure Parameters

- **Adult and Child Residents**
  - Surface water – household use, including consumption
    - 2 L/day ingestion (adult), 1 L/day (child)
    - 350 days/yr exposure frequency
    - 24 yr exposure duration (adult), 6 yr (child)
  - Fish consumption – fillet portion only
    - 54 g/day ingestion rate (equivalent 1 lb. of fish/week)
    - 350 days/yr exposure frequency
    - 24 yr exposure duration (adult), 6 yr (child)
- **Adult and Adolescent Recreators**
  - Surface water – swimming
    - 1.4 hours/day
    - 45 days/year
    - 0.05 L/hr ingestion
    - 24 yr exposure duration (adult), 10 yr (adolescent)
  - Sediment – during winter pool when Watts Bar Reservoir is lowered (e.g., beachcombing)
    - 100 mg/day sediment ingestion rate (adult), 120 mg/day (adolescent)
    - 48 days/year exposure frequency
    - 24 yr exposure duration (adult), 10 yr (adolescent)

BHHRA: Process

- **All detected constituents carried through quantitative calculations**
- **Toxicity Values from EPA**
- **Cancer Risk**
  - Using EPA target cancer risk range of 1.E -6 to 1.E -4 (also stated 10^{-6} to 10^{-4})
  - Target risk range allows 1 in 1 million to 1 in 10,000 exposed persons developing cancer above background cancer rate
  - Expressed in terms of *Incremental Lifetime Cancer Risk (ILCR)*
- **Non-Cancer Hazards**
  - Health effects other than cancer
  - Expressed in terms of *Hazard Quotients (HQ)* and *Hazard Indices (HI)*
  - HI > 1 defines the level of concern for potential non-cancer health effects

BHHRA: Draft Results

Receptor	Medium	Max ILCR	Max HI[1]	Notes
Resident - Adult	Surface Water	**2.E-04**	0.7	Single Detection of Ra-228
Resident - Child	Surface Water	4.E-05	1	
Recreational - Adult	Seasonally Exposed Sediment	3.E-05	0.2	
	Surface Water	9.E-07	0.01	
Recreational - Adolescent	Seasonally Exposed Sediment	1.E-05	0.3	
	Surface Water	4.E-07	0.02	
Recreational - Adult	Bass	**6.E-04**	**9**	PCBs, Hg, As*
	Sunfish	9.E-05	1	
	Catfish	**8.E-04**	**8**	PCBs, Hg, As*
	Crappie	**2.E-04**	**2**	PCBs, Hg, As*
Recreational - Child	Bass	**6.E-04**	**44**	PCBs, Hg, As*
	Sunfish	8.E-05	**5**	PCBs, Hg, As*
	Catfish	**7.E-04**	**37**	PCBs, Hg, As*
	Crappie	**2.E-04**	**7**	PCBs, Hg, As*

BOLD text indicates exceeds EPA risk range

*Arsenic was assumed to be inorganic for calculations. Speciation data demonstrates arsenic to be predominantly in the non-toxic, organic form.

BHHRA: Summary of Results

- Pre-existing risks for fish consumption due to legacy contamination (Hg, PCBs) remain
- No unacceptable human health risks associated with residual ash

BERA

- Moderate risk to benthic invertebrate community in Emory River due to arsenic and selenium in ash-contaminated sediment
- Low risk to tree swallows & killdeer due to arsenic and selenium in prey (benthic invertebrates)
- Low risk to fish-eating birds & mammals due to legacy constituents (PCBs, non-ash-related metals) in fish (no remediation warranted due to ash release)
- Negligible/low risk in other species (no remediation warranted)

BERA

Receptor	Potential Risk	Risk Mgmt	COECs	Weight of Evidence
Fish	Ø			Surveys, Bioassays, Reproductive Studies, Tissue, Biomarkers, Surface Water
Benthic Invertebrates	**Θ** (ER) **O** (CR)	√	As, Se	Surveys, Bioassays, Tissue, Porewater, Sediment
Birds Piscivore – Heron, Osprey Omnivore – Mallard Herbivore – Wood Duck Invertivore – Killdeer Aerial Insectivore – Tree Swallow	 Ø Ø Ø **O** **O**	 √ √	 As, Se Se	Clutch size, Egg Weight/Concentration, Dietary Exposure Models (Fish, Plants, Invertebrates, Insects, Eggs),
Mammals Piscivore – Mink Omnivore – Raccoon Herbivores – Muskrat Aerial Insectivore – Gray Bat	 O O Ø O			Tissue, Dietary Exposure Models (Fish, Eggs, Plants, Insects)
Reptiles	Ø			Community, Tissue, Surface Water, Sediment
Amphibians	Ø			Tissue, Surface Water, Sediment
Aquatic Plants	O			Tissue, Surface Water, Sediment

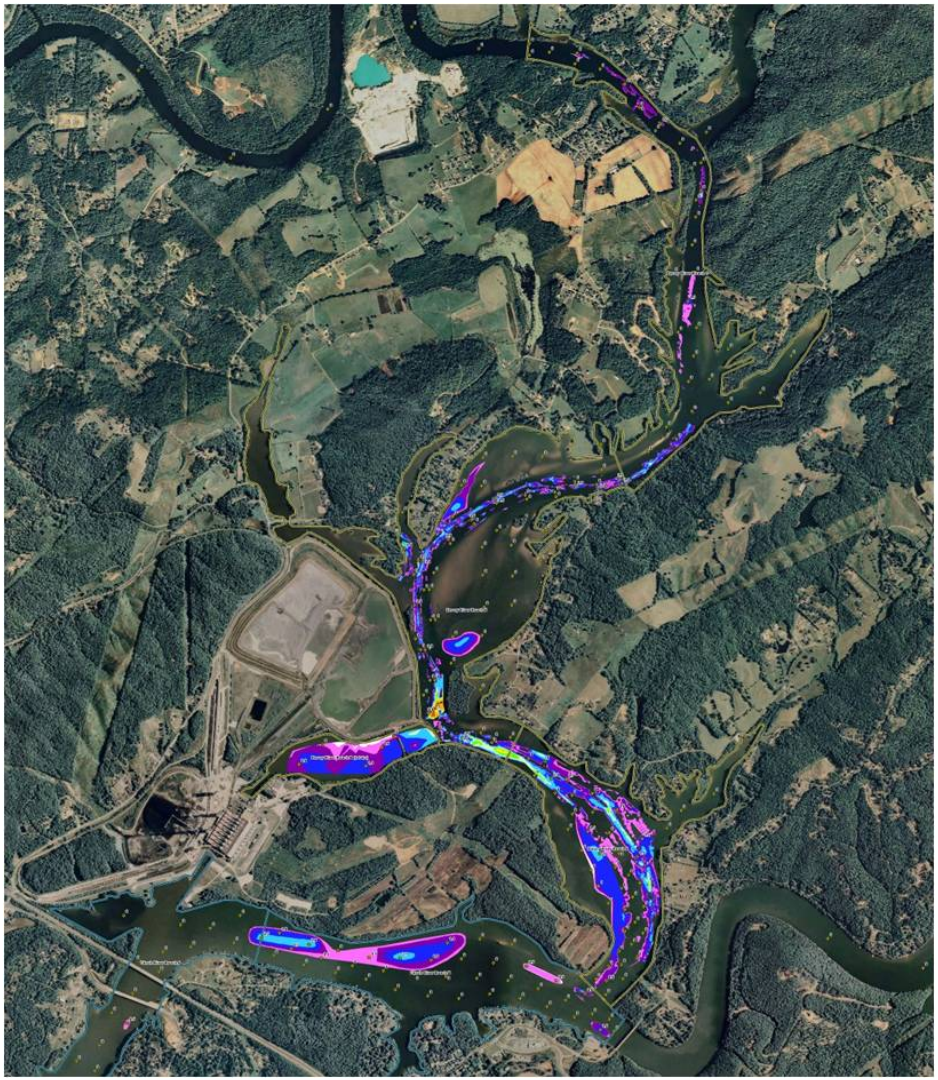
Ø = risks are negligible **O**= risks are low **Θ**= risks are moderate ●= risks are high √ = risk management is recommended
COECs = constituents of ecological concern; ER = Emory River; CR = Clinch River

Nature & Extent - Ash

- Sampling locations from TRM 550.0 to ERM 10.5

River Reach	No. of Samples	No. of Samples with > 0.5 ft Ash	Maximum Thickness of Ash (ft)	Mean Thickness of Ash (ft)	Area of Deposits with >0.5 ft Ash (sq ft)	Volume of Deposits with >0.5 ft Ash (cy)
Emory River						
Reach ER-R	11	0	<0.5	<0.5	0	0
Reach ER-C	35	3	1.3	1.0	374,000	18,600
Reach ER-B	69	20	4.2	1.9	3,633,000	148,700
Reach ER-A	45	10	2.9	1.4	2,753,000	186,000
Clinch River						
Reach CR-R	3	0	<0.5	<0.5	0	0
Reach CR-B	40	13	2.6	1.5	1,519,000	78,900
Reach CR-A	36	1	0.5	<0.5	89,000	5,400
Tennessee River						
Reach TR-R	3	0	<0.5	<0.5	0	0
Reach TR-B	14	0	<0.5	<0.5	0	0
Reach TR-A	12	0	<0.5	<0.5	0	0
TOTAL	**268**	**47**	**4.2**	**--**	**8,368,000**	**437,600**

Nature & Extent - Ash

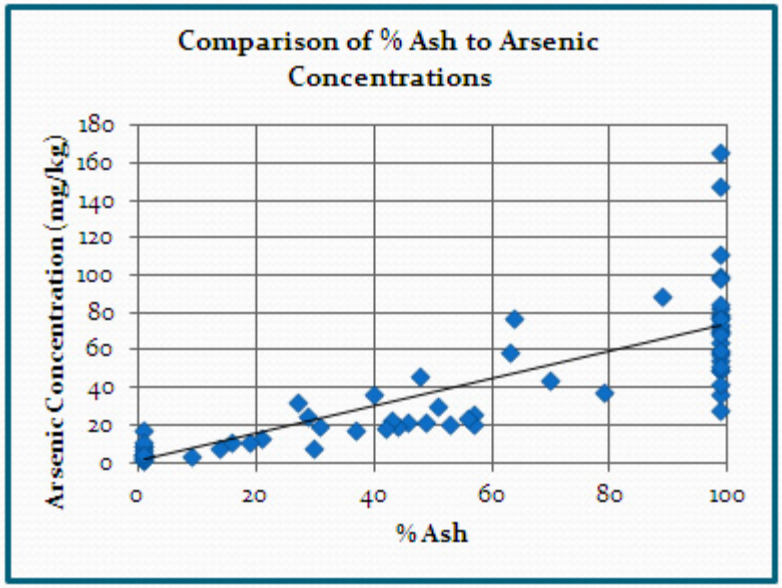


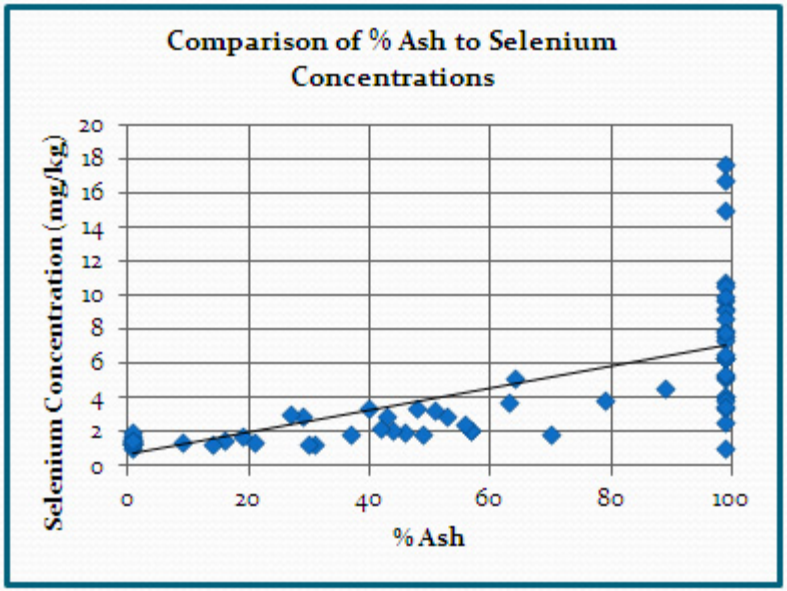
Thickness of Ash in Vibracores > 50% Ash

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

Nature & Extent - % ash

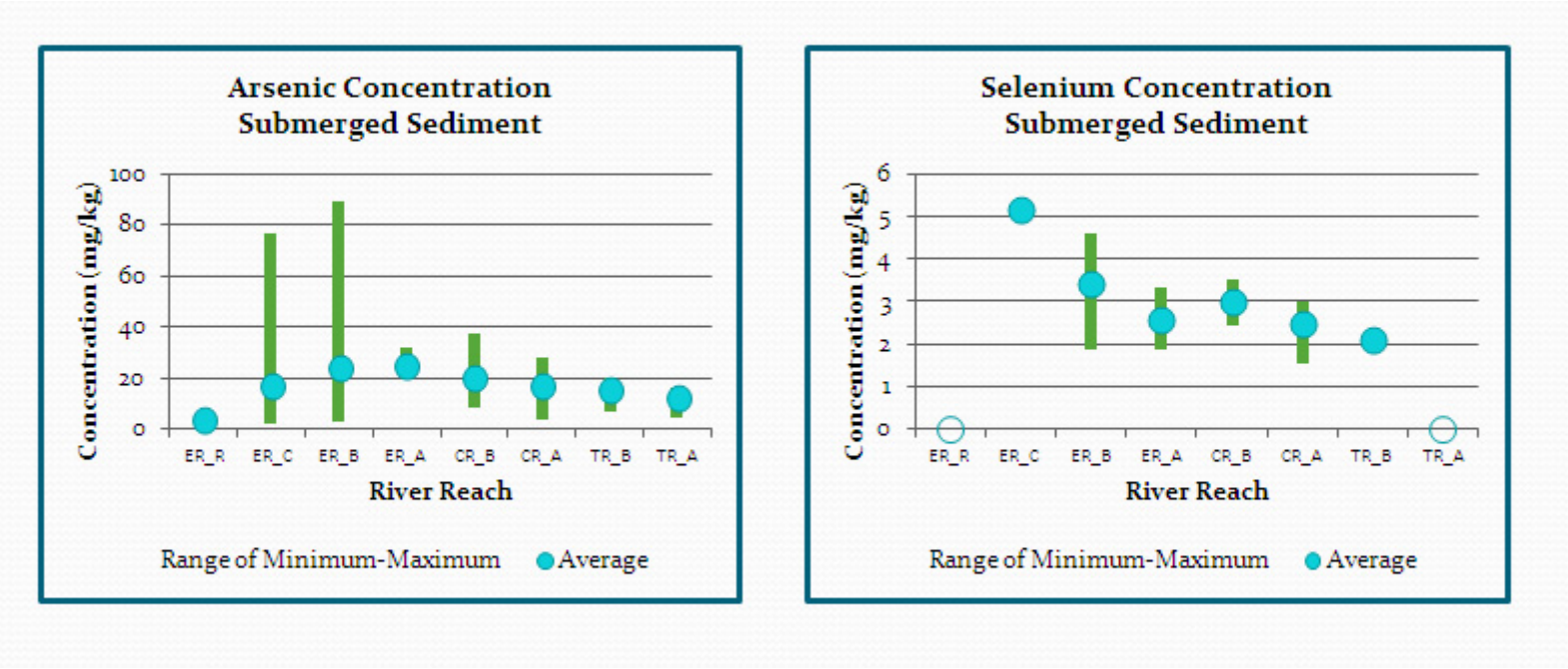
- Fair correlation between ash content and arsenic
- Selenium concentrations are lower than would be expected





Nature & Extent - Sediment

- Arsenic - some locations average approximately 6 times background
- Selenium - infrequently detected and only near detection limit (1.1-2.8 mg/kg)



Removal Action Objectives

- Protect benthic invertebrate populations in Watts Bar Reservoir from adverse affects due to arsenic and selenium in ash-contaminated sediment

- Protect aerial-feeding bird (tree swallow) and riparian-feeding bird (killdeer) populations from adverse affects due to uptake of arsenic and selenium in ash-contaminated sediment through their diet (benthic invertebrates)

- Restore the ecological function and recreational use of the river system to pre-release conditions

- Dispose of waste streams from the removal action in accordance with Applicable or Relevant and Appropriate Requirements (ARARs)

Technology Screening

Technology	Effectiveness	Implementability	Cost	Retained for Evaluation
Institutional Controls Fish advisory, signs, dredging restrictions	Not effective as stand-alone technology; not effective for ecological receptors.	Readily implemented onsite; not implementable offsite.	Low	**Yes**
Monitored Natural Recovery Monitoring of active attenuation processes in sediment and biota for reduction in effects	Effective over the long-term as natural processes of scour, sedimentation, and mixing occur in-stream.	Readily implemented, proven at the site.	Low	**Yes**
Containment Soil, clay, membrane cap/cover	Effective for direct contact; effective for infiltration depending on cover type.	Readily implemented, proven.	Medium	**Yes**
Excavation / Disposal Dredge, excavate, haul, dispose onsite or offsite	Effective for removing contaminants from site; offsite protectiveness depends on proper disposal.	Readily implemented, proven. Offsite disposal availability depends on quantities and nature of waste material, transportation availability.	Medium – High; Costly with large volumes	**Yes**
Phytoremediation Plant uptake of constituents	Innovative; potentially effective for removing contaminants from seasonally-exposed sediment. Not effective for submerged sediment.	Not proven, demonstration pilot test likely needed. Implementable depending on plant stock availability.	Medium	No
Separation Screen/sieve large soil fractions	Not effective since material is relatively homogenous in size; removal of large fraction would not change volume/mass.	Readily implementable, requires greater material handling and dust control.	Medium	No
Soil Washing/Soil Flushing Wash/flush constituents out of soil	Innovative; not effective for homogenous material with low contaminant mass; removal of large fraction would not change volume/mass.	Not proven, demonstration pilot test likely needed. Requires specialty equipment/vendor with lower availability.	High; high energy demand and water treatment	No
Immobilization / Stabilization Mix chemical with soil to make constituents less mobile	Not cost-effective for fly ash material with low contaminant mass.	Readily implementable, requires greater material handling and dust control; adds extensive volume/mass of stabilization agent.	Medium – High	No

Alternative 1: Monitored Natural Recovery (MNR)

- Natural processes will develop mixed ash/sediment cover protective of ecological receptors
- Fate and transport modeling shows 6” mixed cover will develop in side-channel areas
- Severe storm flow events will remove residual deposits in main channel
- Arsenic and selenium gradually will decline to below remedial goals in mixed ash/sediment

Alternative 1: Monitored Natural Recovery (MNR)

Action	Summary
Monitoring of Sediment	Sample sediment and analyze samples for ash content and concentrations of arsenic and selenium in the sediment.
Monitoring of Biota	Sample benthic invertebrates (mayflies and mayfly larvae) and analyze samples for arsenic and selenium.
Monitoring of Effects	Survey benthic populations for abundance and diversity and evaluate results for benthic community health.
Modeling of Sediment Transport	Evaluate monitoring results against predicted rates of natural recovery. Update modeling to evaluate mixing and recovery rates.

Alternative 2: In-Situ Capping with MNR

- Granular cap
  - Six inches thick
  - Over ash deposits
    - Greater than 6” thick,
    - And greater than 50% ash
- Options:
  - Alternative 2A – Full cap
  - Alternative 2B – Targeted cap (only areas subject to scour)
- Bed shear modeling results show cap needs to resist 25-year storm:
  - Some areas need 1-inch diameter material (large gravel)
  - Other areas only need ¼-inch diameter material (pea gravel)

Alternative 2: In-Situ Capping with MNR

Action	Summary
Infrastructure	Upgrade a two-acre temporary dock area to stage, process, and load the cap materials.
Cap Placement	Cover the ash deposits with 6 inches of gravel. Two sub-alternatives, 2a and 2b have been developed: • Alternative 2a would fully cap all ash deposits • Alternative 2b would optimize capping by capping only ash deposits subject to scour
Cap Maintenance	Maintain cap thickness in areas where scour exposes underlying ash deposits.
Monitoring of Capping Operations	Sample surface water upstream and downstream of active capping operations. Sample imported materials for grain size distribution.
Monitoring of Sediment	Sample cap and/or sediment and analyze samples for sediment deposition and cap thickness.
Monitoring of Biota	Sample benthic invertebrates (mayflies and mayfly larvae) and analyze samples for arsenic and selenium.
Monitoring of Effects	Survey benthic populations for abundance and diversity and evaluate results for benthic community health.
Modeling of Sediment Transport	Evaluate cap scour and deposition relative to predicted modeling results. Evaluate monitoring results against predicted rates of natural recovery.
Institutional Controls	Restrict river traffic around active capping operations. Restrict dredging activities in capped areas.
Operations and Maintenance	Conduct routine inspection, repair, and replacement of cap materials; conduct annual bathymetric survey of capped areas.

Alternative 3: Dredging with MNR

- Dredge ash deposits
  - More than one foot thick,
  - And more than 50% ash
- Need on shore dewatering facility
- Need off-site disposal facility to handle dredged material containing legacy constituents (esp. cesium-137)
- Options:
  - Alternative 3A: Full dredging
  - Alternative 3B: Targeted dredging
    - areas of “ecological significance”
    - Benthic habitat waters less than15 ft deep

Alternative 3: Dredging with MNR

Action	Summary
Infrastructure	Construct or install areas for drying ash, for offloading barges, and for loading of trucks.
Dredging	Remove ash deposits in the river system using hydraulic and/or mechanical dredges. Two sub-alternatives, 3a and 3b have been developed. • Alternative 3a would dredge virtually all areas of ash deposits • Alternative 3b would dredge only targeted shallower water areas of particular ecological significance
Dewatering	Separate solids from the dredge spoils using gravity settling ponds. Dry the solids suitable for offsite shipment using windrows.
Disposal	Load and haul dried ash/sediment to permitted solid waste landfills. Disposal of spoils containing any legacy constituents (radioactive cesium-137) would require special disposal facilities.
Monitoring of Dredging Operations	Sample air quality around land-based facilities. Sample surface water upstream and downstream of active dredging operations. Sample waste material prior to waste shipment offsite.
Monitoring of Sediment	Sample sediment and analyze samples for ash content and concentrations of arsenic and selenium in the sediment.
Monitoring of Biota	Sample benthic invertebrates (mayflies and mayfly larvae) and analyze samples for arsenic and selenium.
Monitoring of Toxic Effects	Survey benthic populations for abundance and diversity and evaluate results for benthic community health.
Modeling of Sediment Transport	Evaluate monitoring results against predicted rates of natural recovery. Update modeling to evaluate mixing and recovery rates.
Institutional Controls	Restrict river traffic around active dredging operations.

Alternatives Evaluation Criteria

- **Effectiveness**
  - Overall protectiveness of human health and environment
  - Compliance with ARARs
  - Long-term effectiveness and reliability
  - Short-term effectiveness and impacts
- **Implementability**
  - Time to achieve Removal Action Objectives
  - Technical and administrative feasibility or difficulty
- **Cost**
  - Capital cost of construction
  - Long-term operation, maintenance, and monitoring cost
  - Present worth cost

Tentative Schedule

Objective	Date
EE/CA issued for public comment	Early August
EE/CA public meeting	Late August

- The EE/CA preferred alternative will be selected following the comment period. Selection will consider input received from the public.