CASE STUDY

Evaluation of Short-Term Risks Resulting from Dredge-Induced Resuspension and Deposition in the Buffalo River and Buffalo Ship Canal

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The Buffalo River

Background

• Flows from the east and discharges into Lake Erie near the head of the Niagara River

• A Great Lakes Area of Concern
Site Characteristics

- **Buffalo River (lower 5.5 miles)**
  - Slow-moving river (~0.1 m/s)
  - Small watershed with flashy responses
  - High suspended sediment load at high flows

- **Ship Canal**
  - Short (1.5 miles), dead-end, man-made canal
  - Virtually no watershed
  - Water exchange driven by fluctuating Lake Erie water elevation
  - Very low velocity (~0.002 m/s)
  - Low suspended sediment load
Project Background

- Support Remediation of Buffalo AOC under the Great Lakes Restoration Initiative by the USACE Buffalo District
- Dredge the Federal Navigation Channel to Authorized Depth of 22 ft with 2 ft of Overdredging in the delineated AOC
- 337,600 CY in Buffalo River including overdepth
- 62,600 CY in Ship Channel including overdepth
Project Background

• COCs consist mainly of PCBs, PAHs, Lead, Mercury and Copper
• Bucket dredging utilized due to distance to the CDF
• Additional environmental dredging is planned for areas outside and below the channel
16 DMUs Divided into 45 Subunits
Problem

Measured contaminant concentrations in pre-dredging sediment sampling led to concerns over:

- Dissolved concentrations in the water column resulting from release of contaminants during sediment resuspended during dredging
- Particulate associated contaminants settling in channel
- Deposition of sediments with particulate associated contaminants outside the channel
ERDC Study Objective

1. Determine the short-term environmental risks associated with suspended sediment and contaminants resulting from dredging the Buffalo River and Buffalo Ship Canal pursuant to Section 401 of the Clean Water Act.

2. Determine the short-term environmental risk associated with the deposition of the dredge-induced plume outside of dredging areas.

3. Determine controls to mitigate any unacceptable risks from resuspension impacts on water quality and sediment quality.

4. Evaluate the feasibility of barge overflow to improve economic loads in light of risks predicted to result from resuspension.
Risk Evaluation

• Short-term environmental risk in the water column
  ➢ Model sediment resuspension and contaminant concentrations as a function of distance from the dredging operation
  ➢ Compare model results to risk-based water quality criteria
• Short-term risk to sediment–dwelling organisms outside the dredging area
  ➢ Model contaminant concentrations associated with settled solids outside the dredging area
  ➢ Compare to preliminary sediment remediation goals (PRGs)
• Deposition in-channel is considered dredging residuals, modeled using RECOVERY under a parallel effort
• The Buffalo River and Buffalo Ship Canal (Dredging Reach DA-P) were modeled separately due to the significantly different flow regimes
Modeling Approach: Dredging Resuspension Rates

- Choose a conservative, “upper bound” resuspension rate
- Use ERDC tools to calculate a resuspension rate based on available
  - Grain size distribution data
  - In-situ sediment density
  - Assumed dredge operational characteristics
  - Assumed dredge production
- Model both resuspension rates as “user defined input” in DREDGE and carry results through post-processors
- Evaluate results, assess the need for controls
Modeling With DREDGE
Utilizing DREDGE Model Output for Dissolved Phase Concentrations and Deposition Masses

• The DREDGE Model does not
  - Predict dissolved phase contaminant concentrations
  - Compute masses or thicknesses of deposited sediment
  - Account for a channelized waterway

• All of these limitations needed to be addressed for the Buffalo River Project

• A suite of post-processing spreadsheets was written to accept DREDGE Model output and account for the limitations above
DREDGE Model Post-Processor
Deposition Modeling

• A loss rate scenario is run twice
  ➢ Once with no settling \((v_s = 0)\)
  ➢ Once with a settling velocity representative of the dredged material

• Comparison of the two plumes gives the change in suspended sediment mass at a distance (i.e. unit deposition)

• Couple with duration of dredging at a DMU to obtain mass deposited

• Use assumed dry density of deposited sediment to obtain depositional thickness
1. The bulk sediment contaminant concentration, $C_s$ was input into dredge

2. The non-settling plume generated by DREDGE give the total contaminant concentration at distance, $C_t$

3. Results for the settling plume generated by DREDGE are exported to the post-processor, where a fraction dissolved, $f_d$, if computed

4. $f_d$ is multiplied by $C_t$ in the non-settling plume (2.) to obtain the dissolved contaminant concentration throughout the waterbody, $C_d$
DREDGE Model Post-Processor Contaminant Modeling

5. It is assumed that the total contaminant concentrations, $C_t$, reported by DREDGE at distance are particulate associated, $C_p$

6. These conservative $C_d$ and $C_p$ concentrations were added together to compute a new, conservative total contaminant concentrations, $C_t$

7. $f_d$ was then reapplied to the repartition and compute the final $C_d$ and $C_p$ distributions that were used in water quality and deposition evaluations
Contaminant Modeling

• Dissolved contaminant concentrations are exported and compared to screening criteria

• The mass of sediment deposited at a given distance and the mass of contaminant deposited at the same distance are exported to compute the contaminant concentration of deposited sediment in mg/kg, then compared to screening criteria
Modeling Flowchart

Site Data and Operational Characteristics

Resuspension Factor Approach

Resuspension Rate (g/s)

DREDGE MODEL

Bulk Sediment Conc., K_d, site characteristics

Settling Plume

Non-settling Plume

Dredging Duration at Location

Sediment Mass Deposited

Thickness of Deposition

Conservative Dissolved Concentration, c_d

Conservative Particulate Assoc Conc, c_p

Contaminant Conc. of Deposited Sediment

Conservative Total Concentration, c_t

Initial Particulate Assoc. Conc, c_p

Fraction Dissolved, f_d

Initial Total Contam. Conc, c_{ti}

Initial Dissolved Conc, c_{di}
Model Inputs: Resuspension Rates

- 1% loss rate chosen for upper bound resuspension rate, based on typical assumptions regarding all parameters that are thought to influence resuspension for mechanical dredges in the absence of site-specific information.
- 0.08% loss rate was calculated using the Hayes et al. (2007) Resuspension Factor Method. The lower calculated value is a result of the low liquidity/high compaction/high cohesion of Buffalo River sediments.
- For both loss rates, a conservative production rate of 6000 cy/day was assumed.
- Modeling of a sediment loss rate that incorporates barge overflow was to be performed if evaluation of the upper bound of dredging resuspension did not pose unacceptable risk.
Model Inputs: Organics Partitioning

- Partitioning coefficients developed from elutriate testing
  - More conservative than using pore water due to inclusion of colloidal fraction
  - More representative of monitoring protocols
- Release of dissolved organic carbon (DOC) included in the sediment resuspension and contaminant plume modeling
Model Inputs: Metals Partitioning

• The site-specific partitioning coefficients for the metallic constituents were developed from modified elutriate test results
  ➢ Coefficients assumed that the metals will be released in an oxic environment, increasing the metal solubility and availability.
  ➢ This produced conservative predictions for metal concentrations in the water column, while limiting the concentrations predicted in the residuals.

• Metals assumptions are justified by
  ➢ dissolved contaminants in the water column driving short-term risk due to bioavailability
  ➢ risk associated with dredging residuals was performed as a separate task using RECOVERY Model analysis using conservative sediment concentrations
Buffalo River Water Quality Analysis

- Based on the screening of contaminants performed for disposal of the sediment in a CDF, eight COCs were identified for further modeling:
  - Copper
  - Lead
  - Mercury
  - Benzo(a)anthracene
  - Fluorene
  - Phenanthrene
  - Total PAHs
  - Total PCBs

- Modified elutriate results for the eight constituents exceeded the National Recommended Water Quality Criteria Criterion Maximum Concentrations (CMCs) or NYS Water Quality Standards & Guidance for Fish Survival
Buffalo River Water Quality Analysis: Approach

- For short term risk worst case estimate, maximum area average concentrations measured for dredge units in the Buffalo River and Buffalo Ship Canal were used at both resuspension rates.
- These dissolved concentration results were used to predict dissolved concentrations resulting from the dredging of each individual dredging area by linearly scaling the area average sediment concentrations.
- The contaminant contribution from dissolved organic carbon in the sediment pore water was added to the results of the water quality analysis to determine a total dissolved concentration.
- Two distances were considered for exceedances of CMCs, 150 m and 500 m.
## Parameters for DREDGE Model and Post-Processor

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<thead>
<tr>
<th>Model: Parameter</th>
<th>Assumption</th>
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<tr>
<td>1</td>
<td>Steady State, Depth Averaged, Line Source for Sediment Release</td>
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<td>2</td>
<td>Ambient Current = 0.1 m/s Buffalo River, 0.002 m/s Buffalo Ship Channel</td>
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<td>Water Depth = 7 m</td>
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<td>River Width = 80 m</td>
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<td>15 cy Dredge Bucket</td>
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<td>Bucket 80% full after sediment capture</td>
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<td>7</td>
<td>6000 cy/day Dredge Production</td>
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<td>8</td>
<td>70 second Dredge Cycle Time</td>
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<td>9</td>
<td>Worst Case Sediment Contaminant Concentrations for the River and Side Channel (DA-P) were used to calculate Concentrations at the Mixing Zone Boundry</td>
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<td>Characteristic Particle Size of 10um used to calculate Stokes settling (0.000079 m/s), based on aggregate (floc) size in fine-grained sediment beds comprised of approximately 25% clay</td>
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<tr>
<td>11</td>
<td>Equilibrium Contaminant Partitioning</td>
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<td>Sediment In-Situ Dry Density = 1337 kg/m³</td>
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<td>Sediment percent fines = 95%</td>
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<td>Waterway Lateral Diffusivity = 42 cm²/s for Buffalo River, 0.84 cm²/s for Buffalo Ship Channel</td>
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<td>15</td>
<td>For 1% Loss (1.641 kg/s), assume liquidity index =1.82, open navigation bucket, and bucket ascent and descent velocities of 1.6 and 1.2 m/s, respectively</td>
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<td>For 0.08% Loss (0.131 kg/s), calculated a liquidity index of 1.37, assumed bucket ascent and descent velocities of 0.7 and 0.6 m/s, respectively</td>
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<td>Pore Water DOC Concentration = 60 mg/L</td>
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<td>Sediment volume lost @ 1% loss rate = 2 L/s; @ 0.08% loss rate, 0.13 L/s</td>
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Buffalo Ship Canal Water Quality Analysis: Approach

A similar analysis was conducted for the Buffalo Ship Canal except that

• The analysis was done on a daily basis due to the extremely low velocities in the canal

• The ambient velocity was estimated to be 0.002 m/sec and bidirectional, leading to a calculated lateral diffusivity of 0.84 cm$^2$/sec

• The mass release rates were different due to a different ambient velocity (0.673 kg/sec and 0.054 kg/sec for loss rates of 1% and 0.08%, respectively)
### Buffalo River Post Processor Dissolved Contaminant Results: Copper

<table>
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- **1% Loss**
- **Results from centerline concentration used for screening**
- **Copper Criteria 18 ug/L**
Dissolved Contaminant Results: Copper

- Copper Criteria
- 18 ug/L

Dredged Material Assessment and Management Seminar
24-26 May 2011, Jacksonville, FL
### Table: Dissolved Contaminant Results: Copper

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- **0.08% Loss**
- **Copper Criteria**

18 ug/L
## Water Quality Results at 150 m from Dredging

**Buffalo River Maximum Sediment Concentration (BR-MAX C)**

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<th>Parameter</th>
<th>Units</th>
<th>River</th>
<th>Canal</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1% Loss Rate</td>
<td>kg/s</td>
<td>1.64</td>
<td>0.67</td>
</tr>
<tr>
<td>0.08% Loss Rate</td>
<td>kg/s</td>
<td>0.13</td>
<td>0.054</td>
</tr>
</tbody>
</table>

### Concentrations in mg/L

**Criteria or Screening Value**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>River</th>
<th>Canal</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS @ 150 m</td>
<td>mg/L</td>
<td>263.47</td>
<td>2316</td>
</tr>
<tr>
<td>TSS @ 150 m 0.08% loss</td>
<td>mg/L</td>
<td>20.80</td>
<td>184.95</td>
</tr>
</tbody>
</table>

### Table 3a: Dredging Resuspension Losses, Predicted TSS and Contaminant Concentrations in Water at a 150-m Distance from the Dredge

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Copper, mg/kg</th>
<th>Lead, mg/kg</th>
<th>Mercury, mg/kg</th>
<th>PCB, Total, mg/kg O.C.</th>
<th>PAH, Total, mg/kg O.C.</th>
<th>Fluorine, mg/kg O.C.</th>
<th>D.C. mg/kg O.C.</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>BR-MAX C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% Loss</td>
<td>4.24</td>
<td>57.50</td>
<td>5.16</td>
<td>0.91</td>
<td>8.19E-02</td>
<td>2.64E-04</td>
<td>2.18E-03</td>
<td>151.12</td>
</tr>
<tr>
<td>0.08% Loss</td>
<td>4.24</td>
<td>57.50</td>
<td>5.16</td>
<td>0.91</td>
<td>8.19E-02</td>
<td>2.64E-04</td>
<td>2.18E-03</td>
<td>151.12</td>
</tr>
<tr>
<td>0.06% Loss</td>
<td>4.24</td>
<td>57.50</td>
<td>5.16</td>
<td>0.91</td>
<td>8.19E-02</td>
<td>2.64E-04</td>
<td>2.18E-03</td>
<td>151.12</td>
</tr>
</tbody>
</table>

**Highlighted cells exceed Criterion Maximum Concentrations, Acute Toxicity Screening Values, or NYS Standards for Fish Survival**

---

**Dredging Material Assessment and Management Seminar**

24-26 May, 2011, Jacksonville, FL
### Water Quality Results at 500 m from Dredging

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Buffalo River Sediment</th>
<th>Buffalo Ship Canal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffalo River Maximum Concentration</td>
<td>BR-MAX C</td>
<td></td>
</tr>
<tr>
<td>Buffalo Ship Channel (DA-P)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sediment Concentration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentrations in ug/L</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3b: Dredging Resuspension Losses, Predicted TSS and Contaminant Concentrations in Water at a 500-m Distance from the Dredge**

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Units</th>
<th>Parameter</th>
<th>Buffalo River Sediment</th>
<th>Buffalo Ship Canal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1% Loss</td>
<td>0.08% Loss</td>
</tr>
<tr>
<td>Copper, mg/kg</td>
<td></td>
<td></td>
<td>0.45</td>
<td>0.29</td>
</tr>
<tr>
<td>Lead, mg/kg</td>
<td></td>
<td></td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>Mercury, mg/kg</td>
<td></td>
<td></td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Arsenic, mg/kg</td>
<td></td>
<td></td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Sulfide, mg/kg</td>
<td></td>
<td></td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Phenanthrene, mg/kg</td>
<td></td>
<td></td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Fluorine, mg/kg O.C.</td>
<td></td>
<td></td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

**Highlighted cells exceed Criterion Maximum Concentrations, Acute Toxicity Screening Values, or NYS Standards for Fish Survival.**

---

**Table 3a: TSS @ 500 m Loss Rate**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>1% Loss Rate</th>
<th>0.08% Loss Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS @ 500 m</td>
<td>Loss Rate</td>
<td>kg/s</td>
<td>1.64</td>
</tr>
<tr>
<td></td>
<td>kg/s</td>
<td>0.13</td>
<td>0.054</td>
</tr>
<tr>
<td></td>
<td>mg/L</td>
<td>136.40</td>
<td>176.08</td>
</tr>
<tr>
<td></td>
<td>mg/L</td>
<td>10.89</td>
<td>14.06</td>
</tr>
</tbody>
</table>

---

**Table 1: Drilled Material Assessment and Management Seminar (Jacksonville, FL)**

**Date:** 24-26 May 2011

**Location:** Jacksonville, FL
Water Quality Analysis

• Buffalo River
  - Exceedances were predicted only for copper at the higher resuspension loss rate of 1%.
  - No exceedances of the CMCs or NYS fish survival standards for fluorene, phenanthrene, benz(a)anthracene, or Total PCBs at either resuspension loss rate.

• Buffalo Ship Canal
  - Exceedances for metals at higher loss rate
  - No exceedances of the CMCs or NYS standards for fish survival for fluorene, phenanthrene, benz(a)anthracene, or Total PCBs were predicted in the at either resuspension loss rate.
Buffalo River Water Quality Results: Discussion of Copper Exceedances

- Predicted dissolved copper concentrations
  - met the CMC for both distances at all dredging subunits in the Buffalo River at a loss rate of 0.08%
  - exceeded the CMC for a number of subunits for both distances at a loss rate of 1%.
- The maximum loss rate without an exceedance of the copper criteria in the Buffalo River is
  - about 0.25% for a distance of 150 m
  - about 0.45% for a distance of 500 m.
Buffalo Ship Canal Water Quality Results: Discussion of Copper Exceedances

• Predicted dissolved copper concentrations exceeded the water quality criteria at all dredging subunits for a 1% loss rate for both distances.

• At a loss rate of 0.08%,
  ➢ Exceedance at all five subunits at 150-m
  ➢ Exceedance at two of the five subunits at 500-m

• At a loss rate of 0.08% the productivity rate would need to be reduced to
  ➢ Below 3700 cy/day for a 500-m distance
  ➢ Below 2200 cy/day for a 150-m distance
Water Quality Results
Discussion of Lead Exceedances

- In the Buffalo River, no exceedances of the CMC were predicted.
- In the Buffalo Ship Canal, no exceedances of the CMC were predicted at a loss rate of 0.08%, but exceedances were predicted from all subunits at a loss rate of 1%.
Water Quality Results
Discussion of Mercury Exceedances

- In the Buffalo River, no exceedances of the CMC were predicted at either loss rate.
- In the Buffalo Ship Canal, an exceedance of the CMC was predicted from one of the five subunits at a 1% loss rate.
Water Quality Results
Discussion of Total PAH Exceedances

- Exceedances of the acute toxicity screening value for total PAHs were similar in frequency and magnitude as the exceedances for copper.

- In the Buffalo River predicted dissolved total PAHs concentrations
  - met the screening value for acute toxicity at the 500-m distance for all dredging subunits at a loss rate of 0.08%.
  - exceeded the 150-m distance for two dredging subunits.
  - acute toxicity screening values at the
Water Quality Results
Discussion of Total PAH Exceedances

• In the Buffalo Ship Canal the predicted dissolved total PAHs concentrations
  
  ➢ Exceeded the screening value for acute toxicity at the 150-m distance for two of the five dredging subunits at a loss rate of 0.08%
  
  ➢ Exceeded the acute toxicity screening value at the 500-m distance for only one dredging subunit

• At 1% Loss, predicted dissolved total PAHs concentrations exceeded the acute toxicity screening value for a number of subunits in both Buffalo River and Buffalo Ship Canal
Prediction of Thickness and Contaminant Concentration of Deposition: Approach

• An area downstream of the longest contiguous stretch of dredging reaches was chosen to evaluate resuspension generated residuals outside the dredging units

• The site selected for deposition evaluation was a turning basin directly downstream of dredging reach DA-F

  ➢ This location is expected to receive significant deposition from the dredging of reaches DA-D, DA-E, and DA-F

  ➢ This analysis provides a worst case estimate for the amount of solids deposited at a location outside the dredging area
Prediction of Thickness and Contaminant Concentration of Deposition: Approach

Long, Nearly Contiguous Dredging Reaches DA-F, DA-E, and DA-D

Turning Basin
Volume-weighted average for contaminant throughout Buffalo River dredging reaches was used

- Maximum sediment contaminant concentrations is of interest to water quality analyses due to the short-term risks posed by the dredge plume, but
- Sediments deposited downstream can have a different contaminant concentration than the resuspended sediment due to stripping by the water column during transport
Prediction of Thickness and Contaminant Concentration of Deposition: Approach

• To model residuals due to upstream dredging operations
  
  ➢ the river was “straightened” from dredging reach DA-D to the end of DA-F (the location of interest for deposition) so that it could be incorporated into the DREDGE model and its post-processors.
  
  ➢ The midpoints of the dredging sub-units were determined along the longitudinal axis of the river relative to the upstream extent of DA-D1.
  
  ➢ Since dredging is to occur from bank to bank throughout this section of the river, deposition was laterally distributed

• For sake of conservative screening, a 1% loss rate and production of 6000 cy/day were assumed for modeling.
Prediction of Thickness and Contaminant Concentration of Deposition

• The production assumption averaged to approximately two dredging days (22.8 hrs) per dredging sub-unit.

• The Dredge model source was placed in the upstream-most sub-unit, DA-D1, and simulated 22.8 hours of resuspension, transport, and deposition of TSS and associated contaminants.

• The source of the model was then repositioned downstream around the midpoint of the next dredging sub-unit, and again simulated the effects of 22.8 hrs of dredging.
Prediction of Thickness and Contaminant Concentration of Deposition

• This process was conducted a total of 25 times as the dredging source moved from DA-D1 to DA-F17

• The sediment and contaminant mass at every location in this modeling sub-domain was stored to calculate an overall average contaminant concentration in the dredging residuals
Prediction of Thickness and Contaminant Concentration of Deposition

- The mass of deposition was converted to a thickness by using an assumed dry bulk density of 300 kg/m³, characteristic of recently settled fine-grained solids.

- A similar analysis was performed in the Buffalo Ship Canal adjacent to dredging reach DA-P. Five sub-units were used for modeling with an average dredging duration of 25 hours.
### Plume Movement Through Buffalo River

#### Coordinates in meters
- \( X_{\text{inc}} = 30 \text{ m} \)
- \( Y_{\text{inc}} = 3 \text{ m} \)

#### Table

| Paste Anchor | 30 | 60 | 90 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | 360 | 390 | 420 | 450 | 480 | 510 | 540 | 570 | 600 | 630 | 660 | 690 | 720 | 750 | 780 | 810 | 840 | 870 |
|--------------|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Coordinate 1 | 100.48 | 4.96503 | 808.71 | 637.95 | 451.05 | 46.70 | 14.65 | 70.24 | 2.84 | 3.70 | 6.00 | 3.00 | 5.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| Coordinate 2 | 169.15 | 3.00622 | 810.68 | 4.94702 | 4.3473 | 3.4527 | 1.2494 | 1.5437 | 3.70 | 6.00 | 3.00 | 5.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |

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**Dredged Material Assessment and Management Seminar**  
24-26 May 2011, Jacksonville, FL
## Plume Movement Through Buffalo River

### Dredged Material Assessment and Management Seminar
24-26 May 2011, Jacksonville, FL
Plume Movement Through Buffalo River

DepositionPlumes.exe
Deposition Modeling Results

• In the Buffalo River
  ➢ Approximately 1.4 cm of deposition was evenly distributed across a width of 80 meters adjacent to the longest stretch of dredging for a loss rate of 1%
  ➢ only 0.11 cm of deposition would be expected at a loss rate of 0.08%.

• In the Buffalo Ship Canal,
  ➢ the maximum depth of deposition outside of the dredging unit was 0.70 cm at a loss rate of 1% and
  ➢ 0.06 cm at a loss rate of 0.08%.
Deposition Modeling Results

• No predicted exceedance of available sediment PRGs for Lead, Mercury, Total PAHs and Total PCBs (PRGs do not exist for the other CoCs) in either waterway

• Probable Effect Concentrations (PECs) used to screen the other four COCs, no exceedances were predicted in either waterway
## Buffalo River Residuals at 1% Loss

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Screening Value</th>
<th>Avg. Bulk Sediment Conc</th>
<th>Residual Conc Outside Dredging Reach DA-F</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS Deposition for 1% Loss @ 300 g/L Residual Density</td>
<td>cm</td>
<td>149.0</td>
<td>75.70</td>
<td>1.37</td>
</tr>
<tr>
<td>Concentration of Copper in Residuals</td>
<td>mg/kg sed</td>
<td>149.0</td>
<td>75.70</td>
<td>1.49</td>
</tr>
<tr>
<td>Concentration of Lead in Residuals</td>
<td>mg/kg sed</td>
<td>90.0</td>
<td>73.76</td>
<td>2.74</td>
</tr>
<tr>
<td>Concentration of Mercury in Residuals</td>
<td>mg/kg sed</td>
<td>0.44</td>
<td>0.28</td>
<td>0.01</td>
</tr>
<tr>
<td>Concentration of Benz(a)anthracene in Residuals</td>
<td>mg/kg sed</td>
<td>1.05</td>
<td>0.627</td>
<td>0.626</td>
</tr>
<tr>
<td>Concentration of Fluorene in Residuals</td>
<td>mg/kg sed</td>
<td>0.54</td>
<td>0.299</td>
<td>0.263</td>
</tr>
<tr>
<td>Concentration of Phenanthrene in Residuals</td>
<td>mg/kg sed</td>
<td>1.17</td>
<td>1.115</td>
<td>1.052</td>
</tr>
<tr>
<td>Concentration of Total PAHs in Residuals</td>
<td>mg/kg sed</td>
<td>16.00</td>
<td>10.708</td>
<td>3.995</td>
</tr>
<tr>
<td>Concentration of PCBs in Residuals</td>
<td>mg/kg sed</td>
<td>0.20</td>
<td>0.036</td>
<td>0.036</td>
</tr>
</tbody>
</table>
### Buffalo Ship Canal at 0.08% Loss (adjusted for downtime)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Screening Value</th>
<th>Avg. Bulk Sediment Conc</th>
<th>Residual Conc Outside Dredging Reach DA-P</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS Deposition for 0.08% Loss Averaged over 1 Dredging Day @ 300 g/L Residual Density</td>
<td>cm</td>
<td></td>
<td></td>
<td>.056</td>
</tr>
<tr>
<td>Concentration of Copper in Residuals</td>
<td>mg/kg sed</td>
<td>149.0</td>
<td>65.10</td>
<td>4.7</td>
</tr>
<tr>
<td>Concentration of Lead in Residuals</td>
<td>mg/kg sed</td>
<td>90.0</td>
<td>86.86</td>
<td>10.25</td>
</tr>
<tr>
<td>Concentration of Mercury in Residuals</td>
<td>mg/kg sed</td>
<td>0.44</td>
<td>0.66</td>
<td>0.078</td>
</tr>
<tr>
<td>Concentration of Benz(a)anthracene in Residuals</td>
<td>mg/kg sed</td>
<td>1.05</td>
<td>1.07</td>
<td>1.07</td>
</tr>
<tr>
<td>Concentration of Fluorene in Residuals</td>
<td>mg/kg sed</td>
<td>0.54</td>
<td>0.25</td>
<td>0.23</td>
</tr>
<tr>
<td>Concentration of Phenanthrene in Residuals</td>
<td>mg/kg sed</td>
<td>1.17</td>
<td>1.15</td>
<td>1.09</td>
</tr>
<tr>
<td>Concentration of Total PAHs in Residuals</td>
<td>mg/kg sed</td>
<td>16.00</td>
<td>12.75</td>
<td>9.09</td>
</tr>
<tr>
<td>Concentration of PCBs in Residuals</td>
<td>mg/kg sed</td>
<td>0.20</td>
<td>0.04</td>
<td>0.04</td>
</tr>
</tbody>
</table>
# Buffalo Ship Canal at 1.0% Loss (adjusted for downtime)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Screening Value</th>
<th>Avg. Bulk Sediment Conc</th>
<th>Residual Conc Outside Dredging Reach DA-P</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS Deposition for 1% Loss Averaged over 1 Dredging Day @ 300 g/L Residual Density</td>
<td>cm</td>
<td>149.0</td>
<td>65.10</td>
<td>.70</td>
</tr>
<tr>
<td>Concentration of Copper in Residuals</td>
<td>mg/kg sed</td>
<td>149.0</td>
<td>65.10</td>
<td>27.7</td>
</tr>
<tr>
<td>Concentration of Lead in Residuals</td>
<td>mg/kg sed</td>
<td>90.0</td>
<td>86.86</td>
<td>46.3</td>
</tr>
<tr>
<td>Concentration of Mercury in Residuals</td>
<td>mg/kg sed</td>
<td>0.44</td>
<td>0.66</td>
<td>.035</td>
</tr>
<tr>
<td>Concentration of Benz(a)anthracene in Residuals</td>
<td>mg/kg sed</td>
<td>1.05</td>
<td>1.07</td>
<td>1.07</td>
</tr>
<tr>
<td>Concentration of Fluorene in Residuals</td>
<td>mg/kg sed</td>
<td>0.54</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Concentration of Phenanthrene in Residuals</td>
<td>mg/kg sed</td>
<td>1.17</td>
<td>1.15</td>
<td>1.14</td>
</tr>
<tr>
<td>Concentration of Total PAHs in Residuals</td>
<td>mg/kg sed</td>
<td>16.00</td>
<td>12.75</td>
<td>11.78</td>
</tr>
<tr>
<td>Concentration of PCBs in Residuals</td>
<td>mg/kg sed</td>
<td>0.20</td>
<td>0.04</td>
<td>0.04</td>
</tr>
</tbody>
</table>
Need for Controls: Buffalo River

- The principal concern for contaminant release in the Buffalo River is the release of copper and total PAHs associated with resuspension at a rate above about 0.2%.
- Additional concern from release of total PAHs above 0.1%, predominantly from dredging subunits E-4 and L where exceedances of the screening value were observed at the 150-m distance.
- Slower production rates should be considered in these two dredging subunits.
Need for Controls: Buffalo River

- The anticipated loss is about 0.1% without residual losses based on the cohesiveness and liquidity of the sediments, thus there is some margin of safety for nearly all of the dredging subunits in the Buffalo River.

- Consequently, no need for controls in the dredging if care is taken to minimize the disturbance of the sediment bed by
  - Minimizing the number of lifts used to achieve the desired channel depth
  - Limiting traffic over the site and upstream units during active dredging

- Barge overflow should be avoided, but the bucket could be drained at the surface to reduce the water transferred to the barge.

- Draining would increase the contaminant release slightly, but this increase would be offset by the reduction of productivity (increase in cycle time), which would serve to reduce the resuspension rate in kg/sec and the deterioration of the water quality
Need for Controls: Buffalo Ship Canal

- The principal concern is also the release of copper and total PAHs associated with resuspension
- Based on the partitioning information from the modified elutriate tests
  - Unlikely that the CMC for copper can be met without controls within a 500-m distance
  - To a lesser degree, unlikely that total PAHs screening value can be met without controls within a 500-m distance
- Under the best of conditions, productivity should be restricted to about 3000 cy per day
- Minimize the disturbance of the sediment bed by
  - Minimizing the number of lifts used to achieve the desired channel depth
  - Limiting traffic over the site and upstream units during active dredging
Need for Controls: Buffalo Ship Canal

• Barge overflow and bucket draining should be avoided because limited flow does not provide transport or dilution
• A dredging elutriate test could be performed to verify the copper partitioning characteristics
• Use of silt curtains would reduce the spread of suspended solids, but would not significantly reduce the release of dissolved copper or total PAHs because both contaminants are expected to be more than 90% dissolved
• Control of TSS spreading is not needed because the expected residuals outside of the dredging areas are expected to be less than a few millimeters thick and have a contaminant concentration below the PRGs and the PECs.
Summary and Conclusions

• Three tools developed under DOER program used to
  ➢ Resuspension Factor Approach to estimate suspended sediment loss rates resulting from dredging operations
  ➢ Input of loss rates into the DREDGE Model for passive plume transport and decay
  ➢ Manipulation of DREDGE Model outputs using post-processors to estimate
    – Dissolved contaminant concentrations at distance
    – Thickness and contaminant concentration of residuals

• Residuals output can be coupled with the USACE Recovery model, however RECOVERY modeling was done in parallel with short-term assessments due to time constraints on this project
Results of ERDC Study

- Water Quality and NEPA Certification were successfully secured by Buffalo District
- Dredging to initiate this summer
- Monitoring will be conducted to verify our analysis during dredging and placement
- The same analysis is currently being applied to contaminated sediments outside the navigation channel that are to be dredged for remediation under GLLA
- As with previous work, our analysis will be used for CWA and NEPA Permitting, and evaluation of controls