Considerations for Environmental Dredging of Contaminated Sediments

Michael R. Palermo, PhD, PE
Outline

4 Objectives, Definitions
4 Site/ Sediment Characterization
4 Removal Requirements
4 Equipment Characteristics and Selection Factors
4 Production and Duration
4 Resuspension, Release, and Residual
4 Control Measures
4 Operational Considerations
4 Monitoring and Management
4 Conclusions
Contaminated Sediment Remediation
What are the Options?

4 Monitored Natural Recovery
   - Part of all remedies
   - May be an integral part of active remediation

4 Dredging
   - Need to recognize impacts and limitations
   - Triggers a variety of onshore activities

4 Capping
   - Can be rapidly implemented with minimal impact
   - Need to assess long-term protectiveness

4 Combinations
Navigation versus Environmental Dredging

4 Navigation to maintain depth
   - Economy/Efficiency
   - Effectiveness
   - Environmental Impact

4 Environmental for Remediation
   - Environmental Impact
   - Effectiveness
   - Economy/Efficiency
Dredging and Disposal

4 Advantages
   - Mass removal
   - Proven technology
   - Easily implemented

4 Disadvantages
   - Effectiveness reduced by resuspension and release
   - Effectiveness reduced by residual
   - Disposal is expensive
Objectives of Environmental Dredging

1. Achieve Remediation Goals
2. Remove Targeted Sediments within Horizontal and Vertical Tolerances
3. Control Sediment Resuspension, Contaminant Release, and Residual Sediment
4. Maintain Production/ Efficiency of Removal
5. Assure Compatibility with Treatment and/or Disposal
“Technical Guidelines for Environmental Dredging of Contaminated Sediments”

- Developed for EPA by USACE
- Detailed technical evaluation procedures for Env Dred
- Supports EPA 2005 Superfund Sediment Guidance
- Audience: Project managers, designers, contractors, and other stakeholders
- Published September 2008
Dredging is only one part of a remedy
Site Conditions and Sediment Characterization

4 Site Conditions (Field Investigations)
   - Hydrodynamics; Geotech; Bathy; SS Sonar; Sediment Profiling; Infrastructure; etc.;

4 Sediment Characteristics (Sampling)
   - Physical – density, GSD, etc.;
   - Chemical – Conc of COCs to full depth;

4 Define Dredgeability and Removal Requirements
   - Debris removal; Dredging depths; volumes and volume increases
Equipment Capabilities and Selection

4 Comparative Evaluations, e.g.:
   η Mechanical vs. Hydraulic
   η Conventional vs. Specialty
   η Operational approaches

4 Wide range of suitable equipment is available for environmental dredging

4 No single dredge type is best for all projects

4 Evaluate/select based on field experience, predictive tools, and field trials as needed
<table>
<thead>
<tr>
<th>Equipment Characteristics and Selection Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Production</td>
</tr>
<tr>
<td>4 Percent solids – need for dewatering</td>
</tr>
<tr>
<td>4 Vertical Accuracy</td>
</tr>
<tr>
<td>4 Horizontal Accuracy</td>
</tr>
<tr>
<td>4 Max Dredging Depth</td>
</tr>
<tr>
<td>4 Min Dredging Depth</td>
</tr>
<tr>
<td>4 Sediment Resuspension</td>
</tr>
<tr>
<td>4 Contaminant release control</td>
</tr>
<tr>
<td>4 Residual/ Cleanup Level</td>
</tr>
<tr>
<td>4 Transport by pipeline</td>
</tr>
<tr>
<td>4 Transport by barge</td>
</tr>
<tr>
<td>4 Positioning Control</td>
</tr>
<tr>
<td>4 Maneuverability</td>
</tr>
<tr>
<td>4 Portability/Access</td>
</tr>
<tr>
<td>4 Availability</td>
</tr>
<tr>
<td>4 Debris/ Loose Rock/ Vegetation</td>
</tr>
<tr>
<td>4 Hardpan/ Rock Bottom</td>
</tr>
<tr>
<td>4 Sloping Bottom</td>
</tr>
<tr>
<td>4 Flexibility for Varying Conditions</td>
</tr>
<tr>
<td>4 Thin Lift/ Residual Removal</td>
</tr>
</tbody>
</table>
Wire-Supported Mechanical Clamshell Or Bucket Dredge
Clamshells
Conventional
Bucket Operation
Environmental Bucket
Level Cut
Fixed – Arm Excavators

e.g., Horizontal Profiling Grab
Buckets are Interchangeable for Size and Purpose
Backhoes

Smalley Dredge

Dipper Backhoe
Advantages of Mechanical Dredges

4 Can remove hard packed materials
4 Can remove debris and debris-laden sediments
4 Can work tight areas
4 Can operate in deep water
4 Can remove sediments with little excess water
4 Efficient for transport by barge at long haul distances
4 Available in variety of bucket sizes/types
4 Can switch from box cut buckets, to toothed buckets, to smaller buckets, etc.
Issue – Debris
Debris/Boulders/Hardpan/Etc.

4 Buried obstructions such as debris, boulders, underlying hardpan, etc. will adversely affect dredging performance
   • Slower production, more breakdowns
   • More resuspension losses – bucket fill/closure issues
   • Higher post-dredging residuals

4 Mechanical dredges are generally capable of removing sediments if debris and obstructions are abundant

4 Dedicated debris-removal operations may be required, especially for large debris

4 MAJOR ISSUE!
Issue – Accuracy/Precision

4 Accuracy/Precision ~ removal of CS without removing clean material
  η Positioning only locates the dredgehead
  η Attainable positioning accuracy now at +/- several inches

4 Accuracy of positioning may outstrip that for sediment characterization
Issue - Production

4 Consider both Operating Production Rate – while dredge is actively operating and Sustained Production – over a season

4 Allowable weeks/ year, days/week, hours/day, and other Quality of Life Issues will determine project duration/ number of dredging seasons for a given dredge;

4 Dredging system design; numbers of barges, rehandling requirements; other “bottlenecks” may control;

4 Must determine number and sizes of dredges required;
Issues – Resuspension, Releases and Residuals
Conceptual Illustration of Environmental Dredging and Processes
Sediment Resuspension/ Releases

1. All dredges resuspend sediment
2. Contaminant releases closely tied to resuspension
3. Field measurement methods are not consistent
4. Resuspension at dredgehead generally less than 1%
5. Increased resuspension for debris removal
6. Place resuspension in context with other sources
7. Resuspension is near field and can be controlled (at least partially)
Residuals Characteristics

4 Generated residuals - generally accumulate above the dredging cutline in thin layers at relatively low density;
4 Undisturbed residuals - remain below the cutline as higher density sediment that may exist as relatively thick layers;
4 Multiple residual layers are possible;
4 Differing residuals characteristics may require different management approaches;
Control Measures

4 3Rs evaluations determine need
4 Operational controls (timing, sequencing, operating speeds, etc.)
4 Engineered controls (silt curtains, sheet pile enclosures, etc.)
4 Management actions for residuals (backfill, caps, re-dredging, etc.)
4 Evaluate potential effectiveness and impact on costs, project duration, etc.
Silt Curtains
Mechanical Grab & Barge Operating Inside Hanging Curtin
Sheet Pile Enclosure
Residuals Management
Thin Cap, Eco Layer, or Engineered Cap
Cleanup Dredging for Residuals Management

- Applicable for removal of thin layers of residuals;
- More effective with soft underlying sediments;
- Multiple cleanup passes generally inefficient; so passes should be limited, with option for residuals cap.
Operating Methods and Strategies

4 Definition of dredging prisms
4 Sequencing of the work (horizontal and vertical)
4 Production cuts, box cuts, layback slopes, cleanup passes
4 Overdredging allowances
4 Methods of operation
4 Written Operations Plan
Monitoring and Management

- **Removal**
  - Interim and final bathy

- **Resuspension/Release**
  - ADCP; Turbidity; TSS/COC samples;
  - Fixed air monitoring stations; etc.;

- **Residuals**
  - Grabs or Cores

- **Post Construction Monitoring**

- **Written plan with pre-determined management actions**
Environmental Dredging Conclusions

1. Environmental Dredging is complex, and a technically sound design requires an efficient and comprehensive evaluation.
2. Implementability, Effectiveness, and Cost should be considered in determining acceptability of an environmental dredging design.
3. Environmental dredging design should be project-specific, sediment-specific, and site-specific; and
4. Dredging design should focus on project goals.
QUESTIONS?