Working with Nature

Managing Contaminants in Dredged Material for Beneficial Use

Trudy J. Estes

US Army ERDC, Vicksburg, MS

trudy.j.estes@usace.army.mil

USACE Beneficial Use of DM

- Increased BU is motivated by
  - Restrictions on open water disposal
  - Diminishing disposal capacity
- DM as a resource not a waste
- Many examples of BU of sand
  - Construction fill
  - Habitat development
- Large volumes of untapped DM
  - Stored in CDFs
  - Fine grained materials
  - Low to moderate levels of contamination

Erie Pier CDF

Wilds Polander

ERDC Engineer Research and Development Center

Obstacles to BU of DM

- **Lack of beneficial use criteria**
  - Sediment specific criteria limited
  - Orders of magnitude variation between states
  - Efforts to motivate a risk based approach to development of criteria
- **Lack of commercially available and economical treatment technologies**
  - Treatment not feasible - cost and logistical constraints
  - Developmental status of available technologies

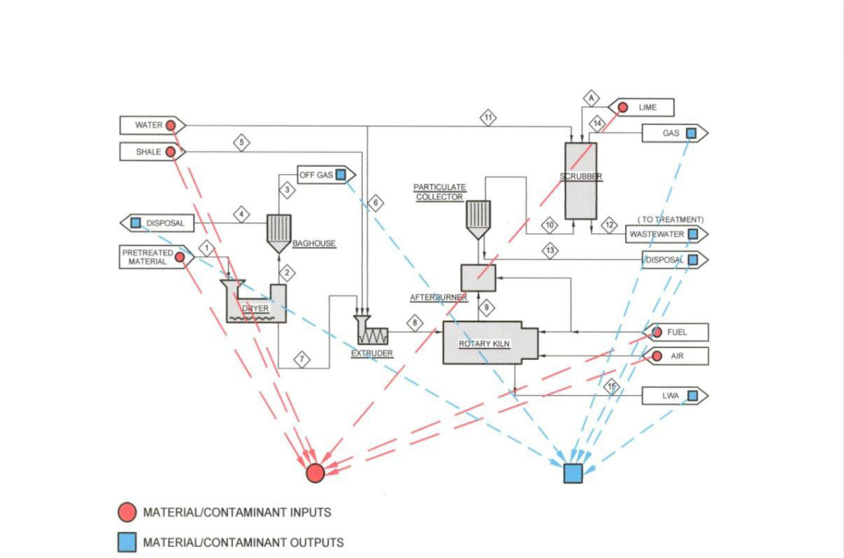
ERDC
Engineer Research and Development Center

Treatment Technology Development

- **Major technology development programs (≈1986-2007)**
  - **ARCS , SITE, CoSTTEP, WRDA**
  - **Thermal, physico-chemical, biological, solidification/stabilization**
  - **Most tested at bench or small pilot scale**
  - **Slow path to commercialization**
- **Four technologies near commercialization**
  - **3 thermal**
  - **1 physico/chemical**

Commercial Technology Review

- **Reconstructed process mass balance**
  - **Effectiveness of unit operations**
  - **Overall efficiency**
  - **Products**
  - **Residuals/waste streams**
- **Cost, relative maturity**
- **Type/value BU products**



Commercial Technology Review

- **Findings**
  - **Complete removal/destruction largely unattainable**
  - **Vitrification effective but costly**
  - **Chemical solidification/stabilization proven but significantly alter matrix**
  - **Chemical oxidation generally ineffective**
  - **Physical separation possible but difficult in some matrices**
  - **Business model requirements vs. physical, funding and locational constraints**


ERDC/EL TR-11-1

Environmental Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

Dredging Operations and Environmental Research Program

Mass Balance, Beneficial Use Products, and Cost Comparisons of Four Sediment Treatment Technologies Near Commercialization

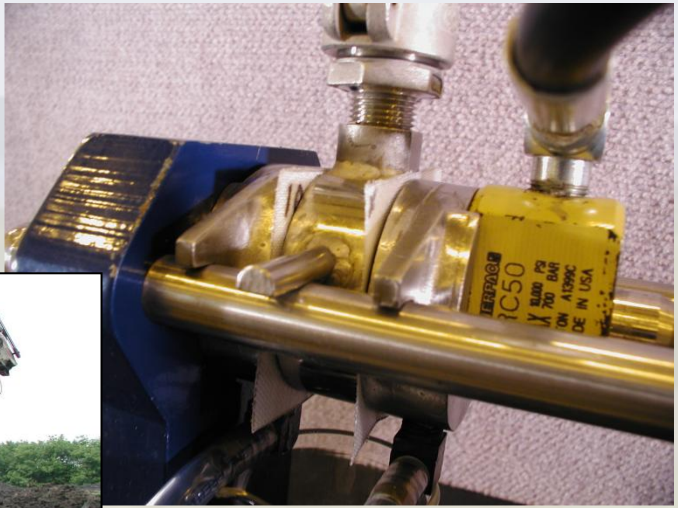
Trudy J. Estes, Victor S. Magar, Daniel E. Averett, Nestor D. Soler, Tommy E. Myers, Eric J. Glisch and Damarys A. Acevedo

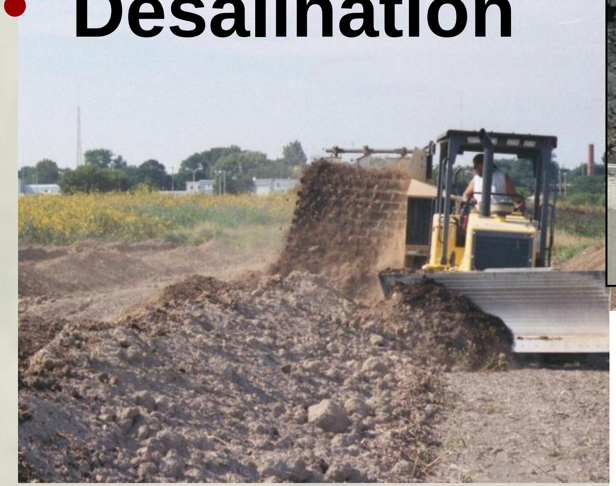
March 2011

Approved for public release; distribution is unlimited.

Related ERDC Research

- Composting
- Mechanical dewatering
- Physical separation/ volume reduction
- Desalination





ERDC TN-DOER-T7
October 2004

Mechanical Dewatering of Navigation Sediments: Equipment, Bench-Scale Testing, and Fact Sheets

ERDC TN-DOER-T10
September 2011

Physical Separation Process Demonstrations-- A Review of Three Dredging Projects

by Daniel E. Averett and Trudy J. Estes

Physical Separation and Dewatering

- **Contaminant distribution, phase associations**
  - **Inform physical separation processes**
- **Field demonstration - dry screening and self contained hydrocyclone**

Physical Separation and Dewatering

- **Findings**
  - **Contaminants not always correlated to grain size**
  - **Targeted phase removal potentially effective**
    - **O&G, condensed carbon, natural organic carbon**
  - **Multiple unit processes - $$**
- **Full scale projects**
  - **Miami River**
  - **Fox River**

Photograph of Boskalis-Dolman vibrating screens, hydrocyclones, & washingsystem, MiamiRiver,FL (CourtesyBastiaanLammers, BoskalisDolman)

Sediment Composting

- Field demonstrations
  - Bayport CDF, Green Bay, WI
  - Jones Island CDF, Milwaukee, WI
  - Limited/no degradation of PCBs or PAHs

- Issues identified
  - Maintaining target moisture content and temperature
  - Heap size
  - Level and frequency of biosolids addition
  - Contaminants in amendments
  - Microbial preference for amendments over contaminants
  - Limited contaminant bioavailability?

Activated Carbon Stabilization

- In-situ treatment
- Multiple bench and pilot scale tests to date
- Some full scale demonstrations
- Effective contaminant sequestration demonstrated
  - Pore water concentrations
  - Reduced GW facilitated transport in sediment caps
- Limited effectiveness for metals
- Uncertain longevity and ecosystem effects

Engineer Research and Development Center

Shifting Focus

- **Removal/destruction vs. in-situ management**
  - **Beyond sorption**
- **Geochemical controls preserving sediment matrix character**
  - **Heavy metals focus**
  - **H_2S**
- **Biological treatment**
  - **PCBs, PAHs focus**
  - **Other organic contaminants if promising**
  - **Leveraging lessons learned**

In-Situ Amendments for Remediation

- Current guidance
  - EPA 2013 "Use of Amendments for In Situ Remediation at Superfund Sediment Sites"
- Sediment-specific demonstrations
  - HOCs - Activated carbon, coal, and coke breeze
  - NAPL, HOCs, Metals - Organoclays™
- Other amendments
  - Zero valent iron
  - Phosphate additives
  - Biopolymers
  - Zeolites

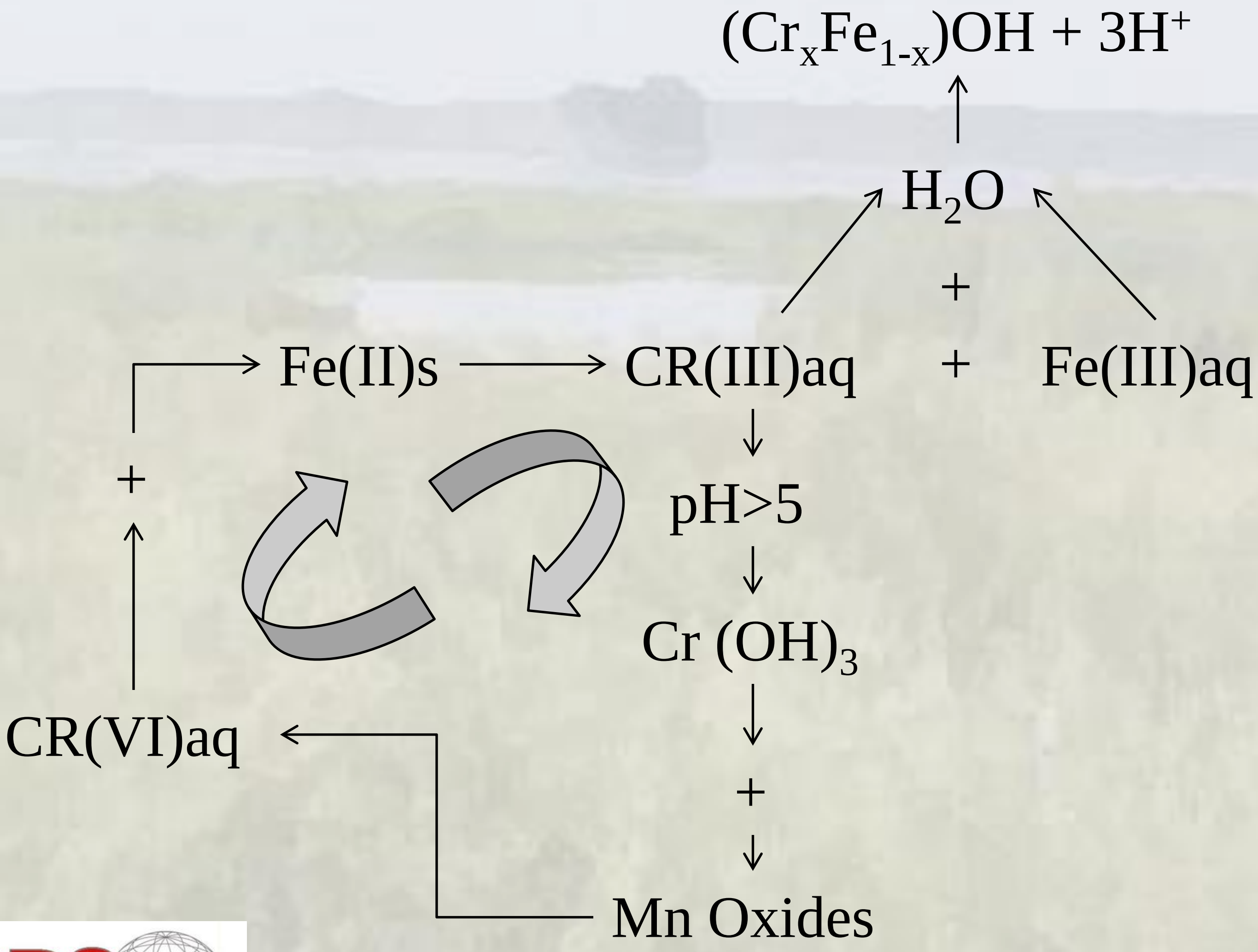
Limited number of field demonstrated amendments in sediments

Currently bench or pilot scale only in sediments

Geochemical Management of Metals

- **Challenges**
  - Biogeochemistry is complex
  - Limited ability to accurately predict system response
  - Intermittent inundation may cause redox and pH changes mobilizing stabilized contaminants
- **Approach**
  - Semi-empirical
  - Modeling to determine a target Eh/pH “zone” for solution chemistry controls
  - Amend to support formation of desired phases (complexes, precipitates)
  - Amend to prevent formation of undesirable phases (Hg methylation, H_2S)
  - pH buffering
  - Multiple amendments/mechanisms as needed

Cr(VI) Reduction and Oxidation



H_2S Controls

- H_2S generation at CDFs
  - Nuisance factor in populated areas
  - Preferred organic degradation pathway is aerobic bacterial oxidation

$$Carbon\ matter + O_2 \rightarrow CO_2 + H_2O$$

  - Next is:

$$Carbon\ matter + NO_3^{2-} \rightarrow CO_2 + N_2$$

  - And finally:

$$Carbon\ matter + SO_4^{2-} \rightarrow CO_2 + H_2S$$

- Existing USACE guidance – operational focus
- CaNO3 provides an alternate pathway and stimulates bio-oxidation of hydrogen sulfide as per:

$$HS^- + Ca(NO_3)_2 \rightarrow CO_2 + H_2O + N_2$$

Goals for Geochemical Testing

- **Develop sediment characterization procedures informing geochemical controls**
  - **Contaminant profile, mobility and speciation under changing conditions**
  - **Natural buffering capacity**
  - **Constituents important to metals stabilization, e.g.**
    - **FeOH**
    - **MnOH**
- **Demonstrate a semi-empirical approach**
  - **Targeting multiple low solubility phases expected to form under environmental conditions**
  - **Monitor Eh and pH**
  - **Measure dissolved metals – initial and final**
  - **Monitor relative H_2S generation, water quality impacts**

Biological Treatment

- **Can we make this work by addressing previously identified testing issues?**
  - **Optimizing conditions**
  - **Supporting indigenous or “designer” microbes**
  - **Testing multiple nutrient/microbe delivery systems**
  - **Amendments to manage metals toxicity**
- **Goals**
  - **Promote in-CDF degradation of organic contaminants**
  - **Feasible and effective for large sediment volumes**

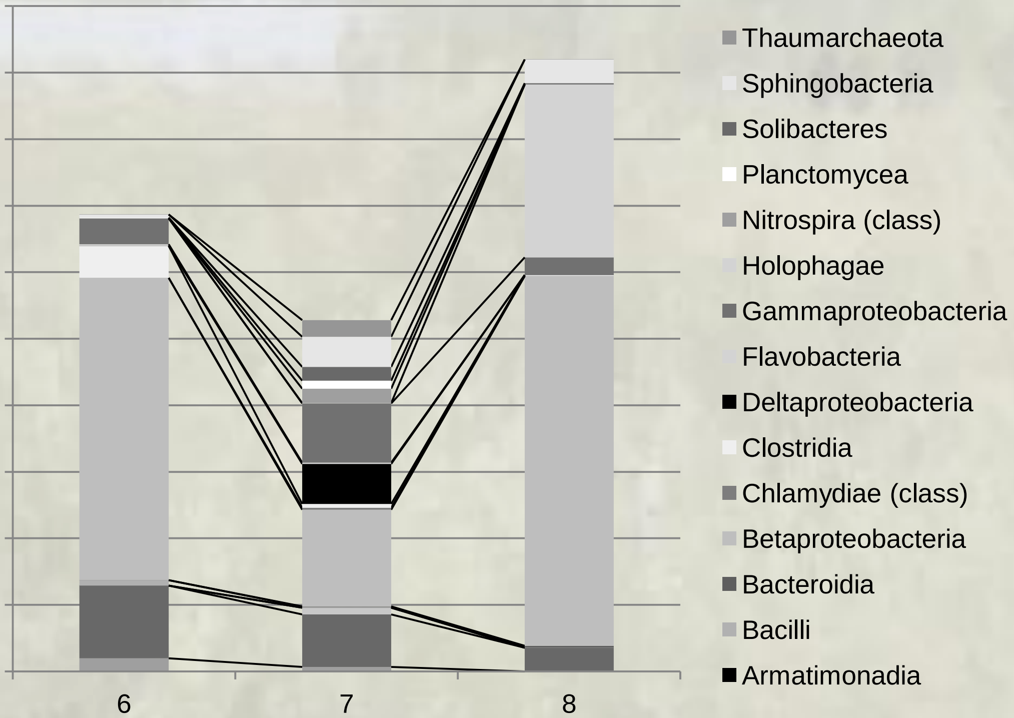
ERDC
Engineer Research and Development Center

Preliminary Testing

- **Literature**
  - ➢ **Improved system controls needed**
  - ➢ **Aerobic/anaerobic cycling potentially beneficial**
  - ➢ **Microbe specific temperatures important**
- **Bench testing**
  - ➢ **PCB, PAH contaminated sediment - estuarine**
  - ➢ **Serum vials with crimped tops**
  - ➢ **Varied temperatures**
  - ➢ **Different carbon sources**

Microbial Characterization

- **Microbe identification**
  - **DNA sequencing**
  - **Any known degraders of chlorinated compounds?**



Evaluating Efficiency

- **Process objectives**
  - **Effective decontamination of process feed**
  - **Efficient overall process**
  - **Balancing efficiency vs. cost**
- **How should we define efficiency?**
  - **Typically concentration of mass reduction of contaminants**
  - **Discriminating between treatment failure and limited bioavailability**
    - **Composting examples**
  - **Reduced toxicity and bioaccumulation?**

Summary

- **Challenges to managing contaminants in DM for BU**
  - ➢ **Matrix complexity**
  - ➢ **Competition for reagents/amendments**
  - ➢ **Modeling limitations**
  - ➢ **Treatment costs**
  - ➢ **Lack of uniform criteria**
- **New direction**
  - ➢ **Toxicity reduction plus contaminant reduction as a performance standard for treatment**
  - ➢ **Focus on controlling solution chemistry rather than contaminant destruction or removal**