Confined Disposal Facilities

Function, Design, Management and Environmental Evaluation Procedures

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Topics

• General processes and procedures
  ➢ Confined Disposal Facilities – Function, Design and Management

• Contaminants
  ➢ Metals vs. organics in the environment
  ➢ Sediment characteristics vs. bioavailability

• Environmental assessment process
  ➢ Evaluating potential environmental impacts of confined disposal
  ➢ Tiered approach
  ➢ Relevant contaminant pathways
  ➢ Physical modeling and testing
  ➢ Interpretation of test data
What is confined disposal?

- Any placement of dredged material (DM) in a containment area

- When do we use confined disposal?
  - Open water disposal site unavailable
  - Material is unsuitable for open water disposal

- Confined disposal facilities are engineered structures
  - Design to contain sediment solids
  - Procedures set forth in engineering manuals
Types of Confined Disposal Facilities

- Upland
- Island
- Nearshore
How “proven” is confined disposal?

- Confined disposal is a mature and well-established management alternative.
- Relative volume of upland and confined disposal vs. total volume dredged.

National dredging volumes IWR database

- Total 2011 Dredging Volume (cy)
- Confined & Upland Disposal (cy)
Craney Island

- Craney Island
  - Norfolk, VA
  - Constructed 1956
  - ~2500 acre CDF
  - Eastward expansion - future marine terminal (2017)
Poplar Island – Chesapeake Bay

- Early 1600’s
  - ~1000 acres
- By 1990
  - Main island <10 acres
- Restoration effort
  - 1998-2027
  - 68M cy DM
  - Baltimore Harbor and channels
What happens during hydraulic disposal?

- Floating discharge pipeline
- Sediment slurry ≈ 4/1 water/solids
- Dredge discharge
- Clarified effluent
- Coarser Finer
- Course Grained Material
- Fine Grained Material
- Low permeability materials
What happens to the material in the CDF?

- Estuarine and saline sediments more rapid than freshwater sediments
- Informs CDF design and environmental analysis
Planning & Design of Confined Disposal Facilities

• Design objectives
  ➢ Retain solids
  ➢ Manage water
  ➢ Material recovery

• Structured process
  ➢ Siting
  ➢ Capacity evaluation
  ➢ Conceptual design
  ➢ Detailed engineered design
Environmental Evaluation of Confined Disposal

- **Structured evaluation process**
  - Tiered approach - detailed in the UTM
  - Estimate magnitude of contaminant releases
  - Assess potential environmental impact

- **Multiple lines of evidence support decision-making**
  - Will water quality criteria be exceeded?
  - Is off-site exposure a concern?
  - Is plant and animal uptake acceptable?

- **Evaluation of risk informs**
  - Need for engineering controls – risk management
## UTM – Tiered Approach

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Tier I – Existing Information

• “Reason to believe”
  - Need for “Pathway” Evaluations
• Compile
  - Available sediment and water chemistry
  - Sediment physical characterization
  - Municipal, industrial, surface water inputs
  - Available data from other agencies
• Establish relevant “Exposure Pathways” and “Contaminants of Concern” (COCs)

Proceed to Tier II for relevant pathways
6 Potential Contaminant Pathways

- Volatilization
  - Losses to air from DM surface and ponded water
- Plant and animal uptake
  - From sediment as well as site and pore water
- Effluent
  - Water discharged during disposal operations
- Runoff
  - Water discharged following precipitation
- Leachate
  - Water (precipitation) filtering through the DM and into the underlying soils
Exposure Pathway Concepts

• Risk considers
  - Exposure concentrations
  - Likelihood of exposure
  - Manner of exposure
  - Frequency/duration of exposure
  - Demonstrated “effects”

• Exposure requires a “complete” pathway
  - e.g. no volatile compounds = no inhalation pathway
Sediment Characterization

• Objectives
  ➢ Determine physical (geotechnical) characteristics
  ➢ Identify contaminants of concern
  ➢ Evaluate variability

• Sediment sampling plan
  ➢ Anecdotal data
  ➢ Industry/outfalls

• Obtain representative samples
  ➢ All sediment types in project area
  ➢ All contaminants and contaminant levels
Tier II – Screening Analysis

- Desktop analysis
- Predict effluent, runoff, leachate concentrations and volatile losses
  - Contaminant properties and behavior
- Predict plant and animal uptake
  - Theoretical bioaccumulation (TBP)
  - Plant uptake (PUP and DTPA)
- Determine need for further testing (Tier III)
- Refine Contaminants of Concern (COC’s)
Contaminant Partitioning

Partitioning coefficient ($K_d$)

- Contaminants “distribute” between dissolved phases and solid phases
- Ratio sorbed to dissolved contaminant
  - $K_d = \frac{C_{sorbed}}{C_{dissolved}}$
- Literature or direct measurement
- Contaminant specific
- Function of sediment characteristics
Sediment Characteristics – Grain Size

Fine fraction
<75µm

Coarse fraction
75µm – 4.75mm

>4.75mm gravel and cobbles
Coarse Fraction Characteristics

• Contains
  - Large fragments of primary minerals such as quartz
  - Natural organic materials – detritus
  - Coatings of fine materials – e.g. organic matter, soot, clay
  - Possibly coarse carbon containing materials – e.g. coal fragments

• Coarse minerals
  - Lower surface area
  - Non-reactive surfaces

High contaminant sorption potential
Low contaminant sorption potential
Fine Fraction Characteristics

- Contains
  - Fine fragments of same minerals as coarse fraction
  - Very fine natural organic materials, and condensed carbon e.g. soot
  - Clay minerals

- Clay minerals
  - Interlayers (some forms)
  - High surface area
  - Negatively charged surfaces
  - High contaminant sorption potential
  - High ion exchange potential
Metal Contaminants

- Most are cationic (positive charge)
  - E.g. Lead, copper, zinc, etc.
- Attracted to negatively charged clays
- Some sorption to carbon (e.g. soot, coal)
- Form precipitates (insoluble solids)
  - Metal sulfides – reducing conditions
  - Metal hydroxides – oxidizing conditions
- Wetting and drying cycles promote release
  - Metals release from runoff > from effluent
- Not biodegradable
Organic Contaminants

• Most non-polar, highly hydrophobic
  - Low solubility
  - High affinity for organic sediment fractions, esp. condensed carbon phases

• Strongly held by solids
  - $K_d$ dioxins - 1 to 2 orders of magnitude higher than common metals
  - Slow desorption or irreversible sorption

• Some biodegradable

• Generally not very mobile in the environment
  - Solids containment generally effective in limiting mobility
Tier II Outcomes

• Definitive
  ➢ WQC met with attainable dilutions/attenuation
  ➢ Volatilization exposures acceptable
  ➢ Plant and animal uptake levels acceptable

• Not definitive
  ➢ Contaminants present have no WQC
  ➢ Predicted exposures potentially unacceptable
  ➢ Data or model inconsistency

Resolve specific issues with Tier III Testing and Evaluations
Tier III Testing

- Effects Based Testing and Evaluations
  - Physical/chemical testing to evaluate contaminant releases
  - Biological testing to evaluate exposure effects
- Models for Mixing, Attenuation, Dispersion
  - Refine exposure predictions
  - Extrapolate to site specific conditions
Column Settling Tests

- 15-day procedure
  - Slurry sediment

- At intervals
  - Monitor interface
  - Measure TSS in supernatant

- Informs
  - Ponding req.
  - Predicted effluent TSS and total COC concentrations
Effluent Elutriate Test

1. Mix sediment and water to expected influent concentration
2. Aerate in 4L cylinder for 1 hr
3. Settle for expected mean field retention time up to 24 hr maximum
4. Extract sample and split
5. Centrifugation or 0.45um filtration

- Suspended Solids Determination
- Chemical Analysis Total Concentration
- Chemical Analysis Dissolved Concentration
Modified Elutriate Test Setup
Runoff Physical Testing (Lab)

• **Simplified Laboratory Runoff Procedure (SLRP)**
  - Models runoff from wet and dry sediment

• **Conducted at representative TSS**
  - Wet: 500, 5,000, 50,000 mg/L
  - Dry: 50, 500, 5,000 mg/L

• **Total and dissolved contaminants measured**
SLRP Procedures

**Unoxidized (Wet)**

- Sediment
- DI Water

1. Air dry
2. Grind

**Dried Sediment**

1. Add $\text{H}_2\text{O}_2$
2. Dry, Regrind

**Oxidized Sediment**

1. Agitate 1 hr
2. Filter
3. Split Sample

**Dissolved Chemical Analysis**

**Total Chemical Analysis**

**TSS Analysis**

**Dissolved Chemical Analysis**

**Total Chemical Analysis**

**TSS Analysis**

1For Nutrients/Organics; 2For Metals
Mixing/Dilution – Effluent/Runoff

- Estimate dilution required to meet WQC outside the mixing zone
  
  Relative flow and background concentrations

\[ D = \frac{V_{\text{RecWater}}}{V_{\text{Eff}}} = \frac{\left( C_{\text{Eff}} - C_{\text{WQC}} \right)}{\left( C_{\text{WQC}} - C_{\text{RecWater}} \right)} \]

- Mixing & transport models
  
  Cornell Mixing Zone Expert System (CORMIX) et al
  
  Determine “where in the receiving water” criteria will be met
Mixing/Dilution – Effluent & Runoff

• Mixing zone
  ➢ The area contiguous to a discharge where mixing with receiving waters takes place and where specified criteria, as listed in §307.8(b)(1) of this title (relating to Application of Standards), can be exceeded.
  ➢ Mixing zone allowance and dimensions codified
  ➢ Zone of Initial Dilution
    – Acute criteria may be exceeded
  ➢ Mixing zone
    – Chronic criteria may be exceeded
Mixing/Dilution – Effluent/Runoff

Zone of Initial Dilution

Mixing Zone

Receiving Water

Effluent

Current
Effluent and/or Runoff Toxicity Testing

• May be needed if
  ➢ Contaminants without WQC present
  ➢ Anticipated WQC exceedances

• **Effluent elutriate & SLRP used as test mediums**
  ➢ Expose test organisms to dilution series of whole effluent elutriate
  ➢ End result is LC50 or EC50 expressed as percentage of original effluent elutriate concentration

• **Compare with effluent & runoff concentrations at the boundary of the allowable mixing zone**
  ➢ Must not exceed 0.01 of LC50 or EC50
Leachate Physical Testing

- Sequential Batch Leach Test (SBLT)
  - Freshwater sediments

- Procedure
  - Load sediment in a 4:1 water-to-sediment ratio under anaerobic (nitrogen atmosphere) conditions.
  - Shake for 24 hours, centrifuge, and filter leachate.
  - Add water to sediment to make up that removed.
  - Repeat steps 1 and 2.
  - Repeat for at least four cycles.
Physical Modeling - Leachate

- Model transport and attenuation of contaminants in subsurface
  - Sorption and degradation
  - Mixing and dilution
  - Transport – diffusion, advection
- Compare predicted concentrations at point of compliance to:
  - Applicable GW standards
  - Applicable SW standards if appropriate
Volatilization Physical Testing (Lab)

- Flux chamber
  - Carrier air passes over the sediment
  - Contaminant traps capture contaminants in the offgases
Example Sampling Protocol

- **Sampling times / intervals:**
  - 6, 24, 48, 72 hours, 5, 7, 10, and 14 days
  - Sample continuously (replace trap at each sample interval)

- **Experimental conditions:**
  - Initiate with field moist sediment and dry air over sediment surface (14-day experiment)
  - Apply humid air over sediment surface for 7 days
  - Rework sediment and repeat with dry air
Physical Modeling - Volatilization

• Calculate flux (contaminant mass release rate)
  - Input parameter to model contaminant concentration at a point of exposure
  - Considering dispersion (transport) of the contaminants

• Compare predicted exposure concentrations to end points
  - OSHA Human Exposure Standards after factoring in dispersion
  - Health-Based Air Concentrations for acceptable level of risk after factoring in dispersion
Animal Uptake Testing

• Earthworm Bioaccumulation Test
  ➢ Based on ASTM Method E-1676-04
  ➢ Approximately 30g biomass
  ➢ 28-day exposure to reference soil & dredge materials
Animal Uptake Modeling

• Compare results between reference soil & dredging material
  - Survival, growth, reproduction
  - COC bioaccumulation
  - Accounts for bioavailability of contaminants

• Extrapolate to conceptual site model
  - Evaluate risk to receptors of concern
Plant Uptake Testing

• **Cyperus** plant bioaccumulation test
  - Saltwater terrestrial, freshwater wetland, and freshwater terrestrial habitat
  - 45-day exposure to reference soil & dredge material

• **Spartina** plant bioaccumulation test
  - Saltwater wetland habitat
  - 90-day exposure to reference soil and dredged material
Plant Uptake Modeling

- Compare results between reference soil & dredge material
  - Survival & growth
  - COC bioaccumulation
- Extrapolate to site conceptual model
  - Evaluate risk to receptors of concern
Tier IV Case Specific Studies

• Formal quantitative risk assessment
• Addresses specific, well-defined questions
• Rarely necessary for navigation dredging
• Useful if
  ➢ Contamination is substantial
  ➢ Decision-making information not otherwise available
  ➢ The evaluation will provide essential information
• Unnecessary use of resources when
  ➢ Merely a refinement of Tier III
  ➢ Definitive determination unchanged
Summary

• Overview
  - Confined disposal process
  - Contaminant partitioning
  - Environmental evaluation processes

• Corps wide procedures
  - Relevant pathways and COCs will be site specific

• Modeling assumptions and test conditions
  - Conservative, but representative
  - Protective

• Risk assessment
  - May be used for final resolution where necessary
  - Resource intensive
  - Useful only if it informs the final decision
References
