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 used 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

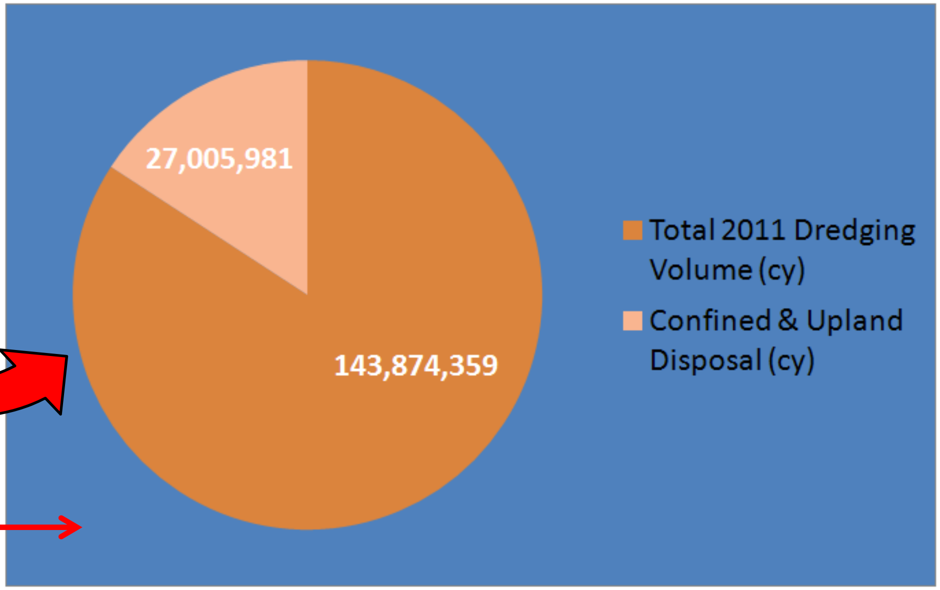
Upland

Island

Nearshore

How "proven" is confined disposal?

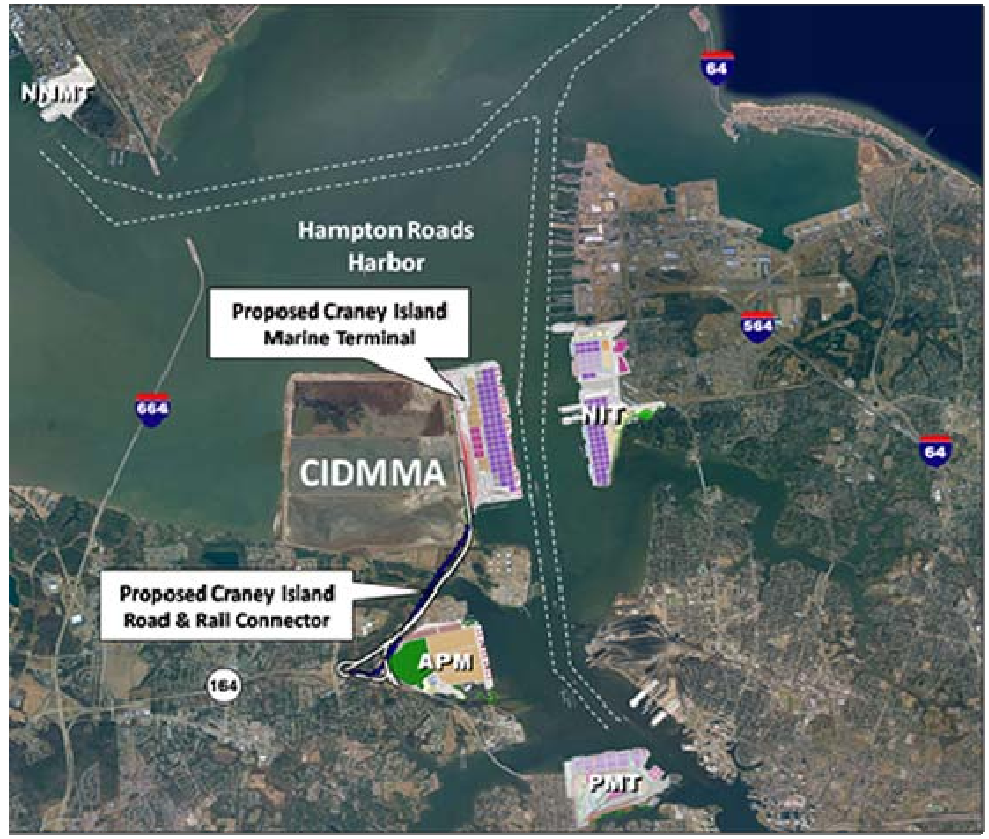
- **Confined disposal is a mature and well established management alternative**
- **Relative volume of upland and confined disposal vs. total volume dredged**



National dredging volumes IWR database

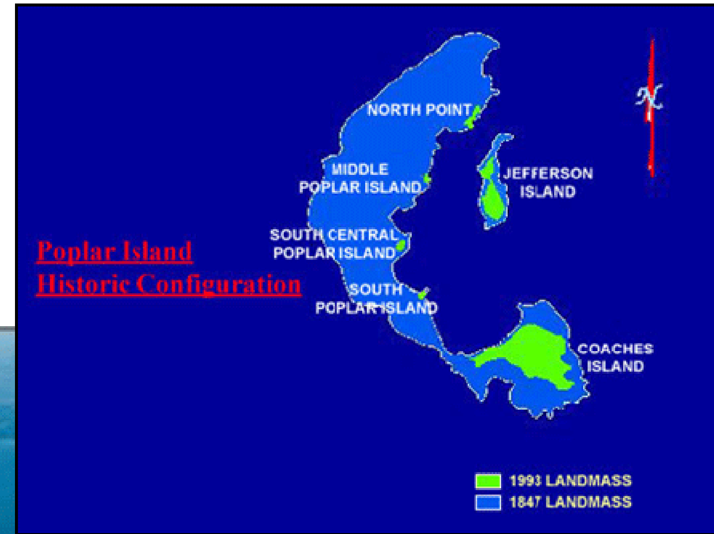
Craney Island

- **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



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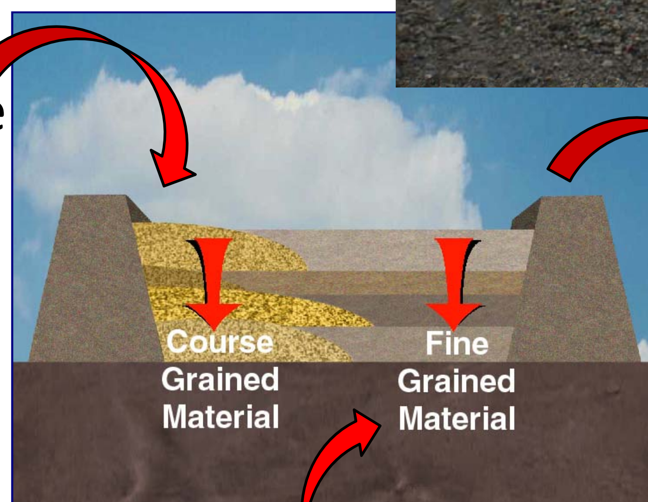
What happens during hydraulic disposal?

Floating discharge pipeline

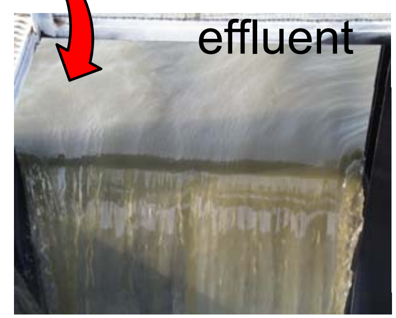
Sediment slurry
≈ 4/1 water/solids

Aerial of CDF

Dredge Discharge



Clarified effluent



Low permeability materials

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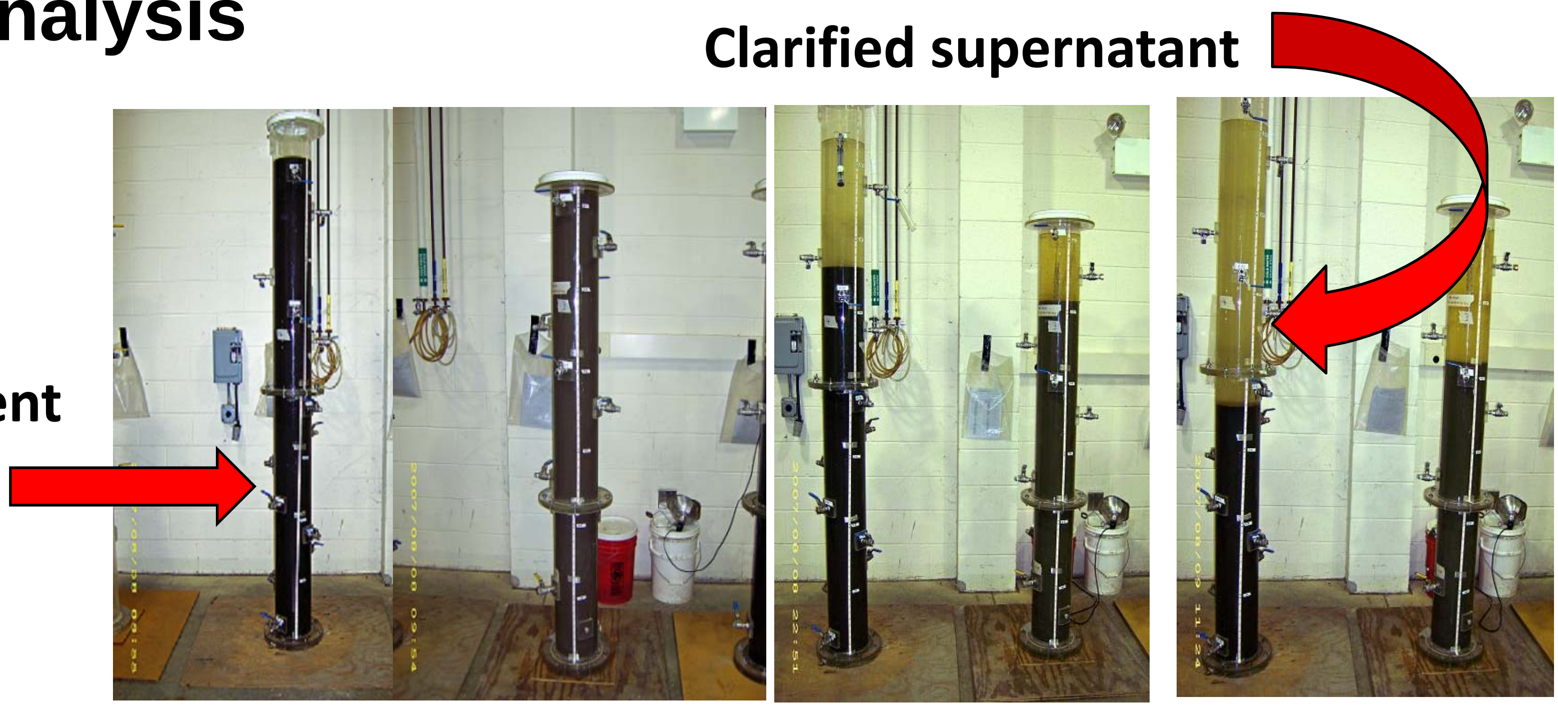
What happens to the material in the CDF?

- Estuarine and saline sediments more rapid than freshwater sediments
- Informs CDF design and environmental analysis



2 hours 12 hours 26 hours

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

Conservative Estimates → Refined Estimates

Tier I	Existing Info
Tier II	Screening Evaluations
Tier III	Effects-Based Testing and Evaluations
Tier IV	Case Specific Studies/ Risk Assessment

Complexity

Data/Effort Required

Cost

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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

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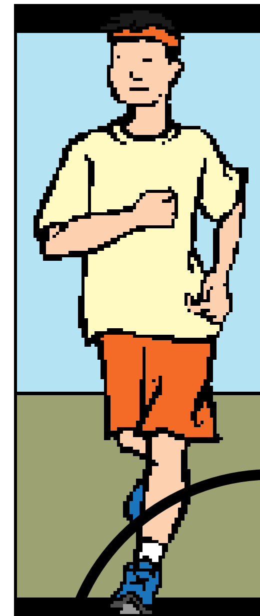
6 Potential Contaminant Pathways

- 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

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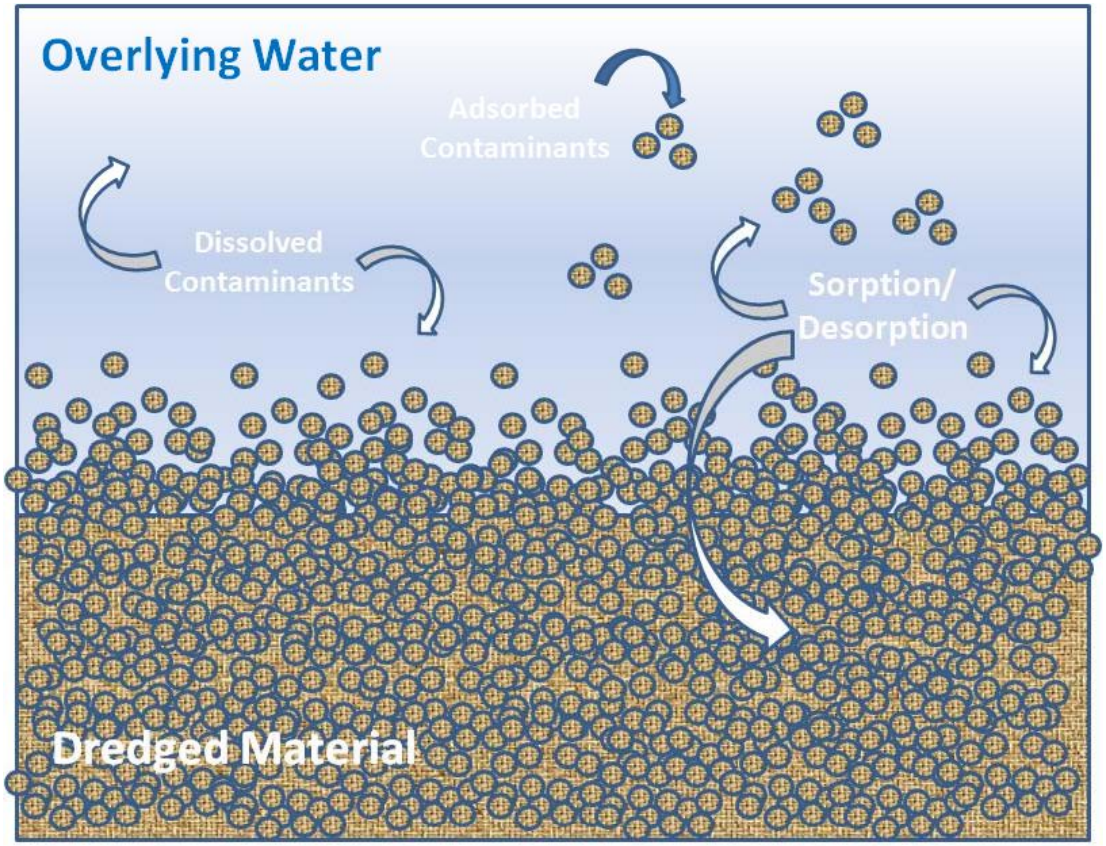
Tier II – Screening Analysis

- 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)

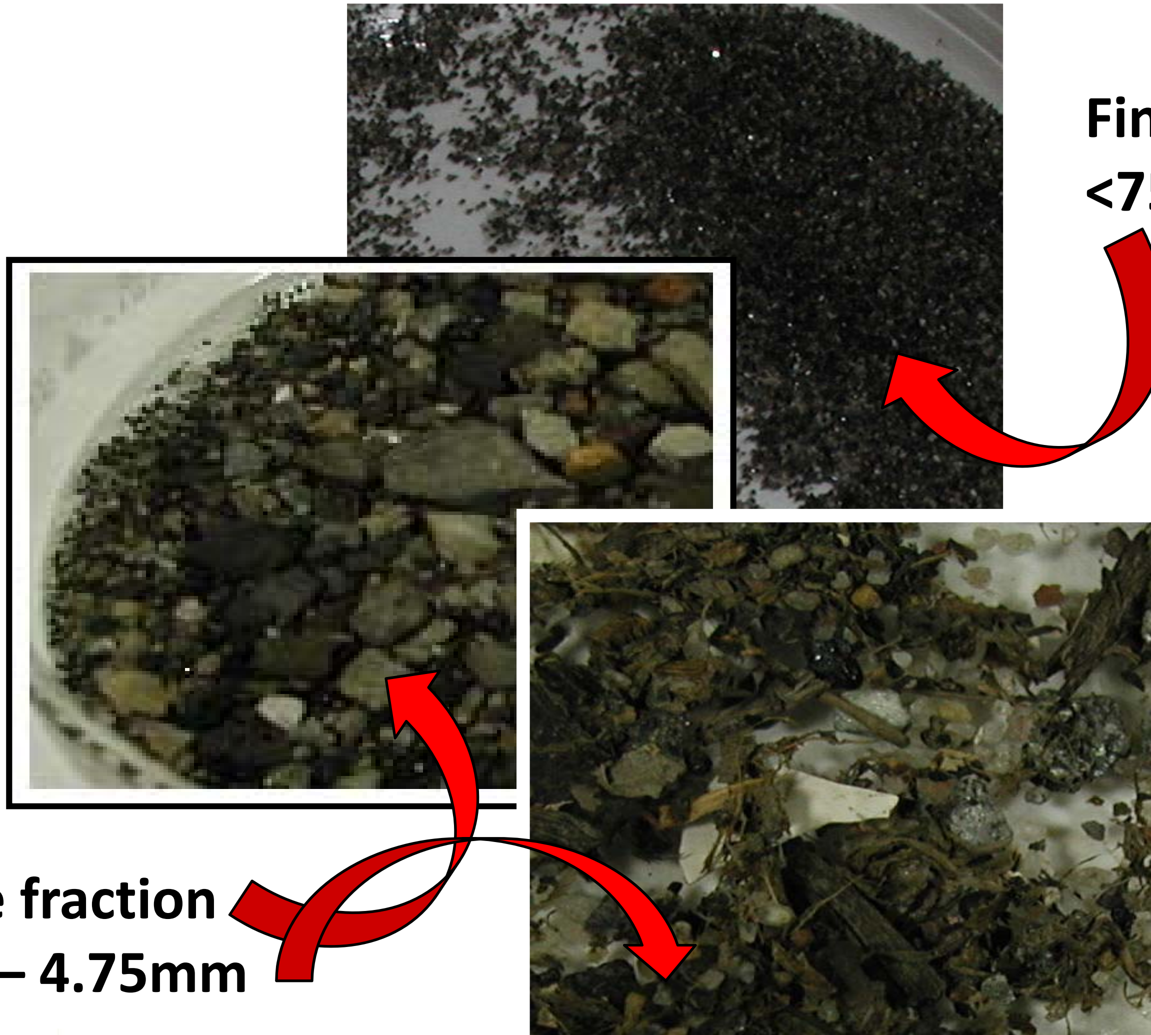
Contaminant Partitioning

Partitioning coefficient (K_d)



- Contaminants "distribute" between dissolved phases and solid phases
- Ratio sorbed to dissolved contaminant
  - $K_d = C_{sorbed}/C_{dissolved}$
- 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

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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

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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

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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**

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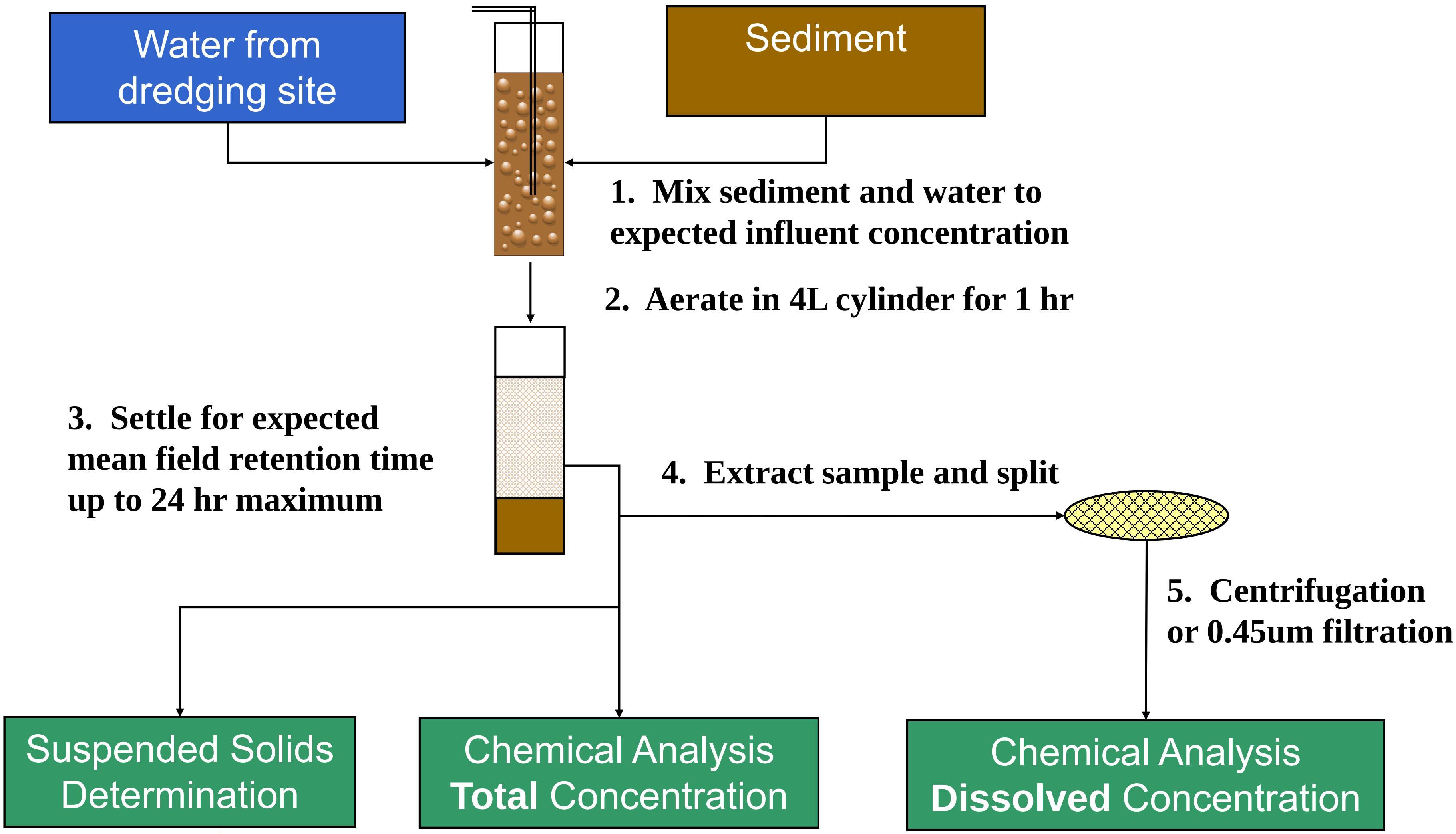
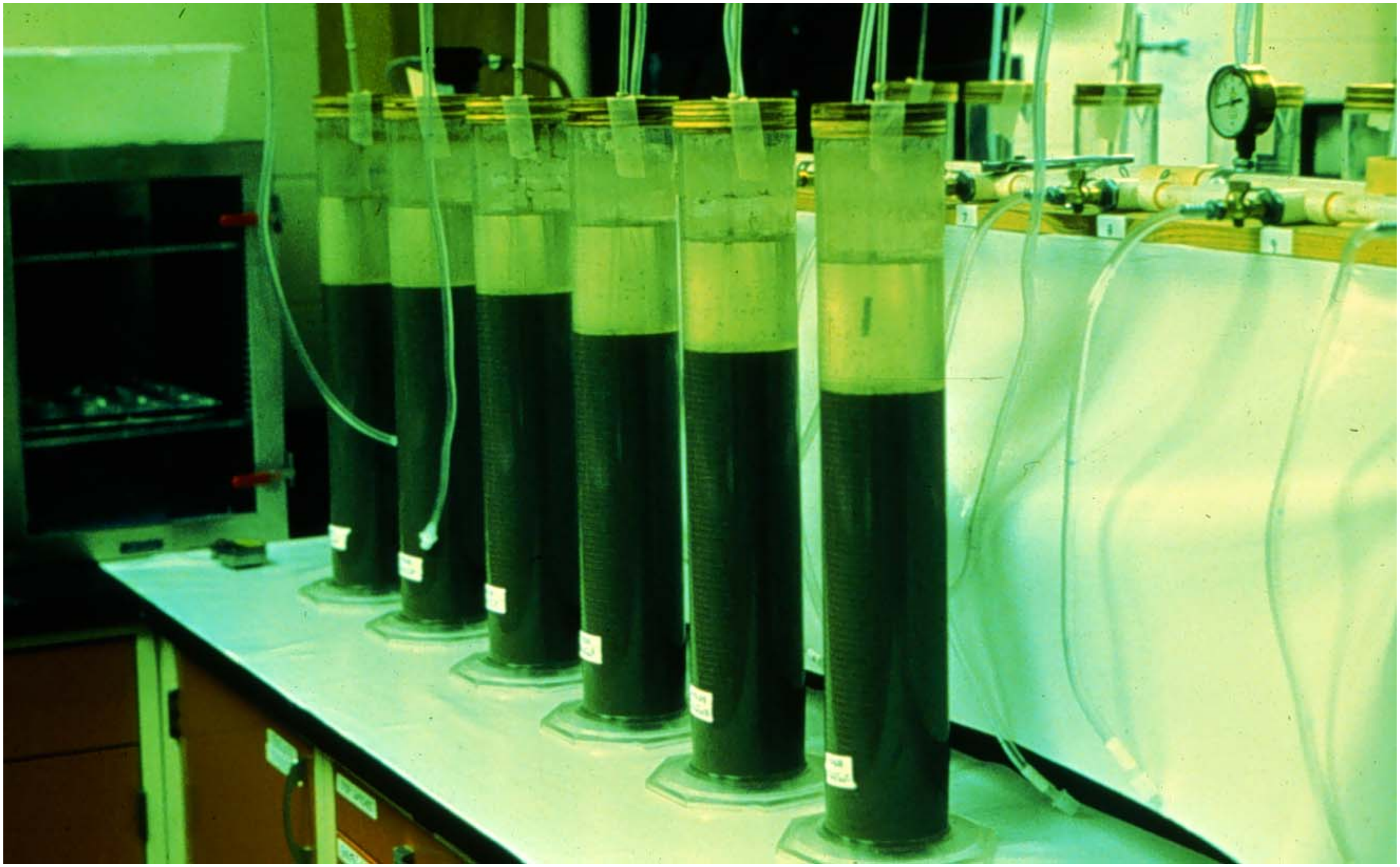
Effluent Elutriate Test



Modified Elutriate Test Setup



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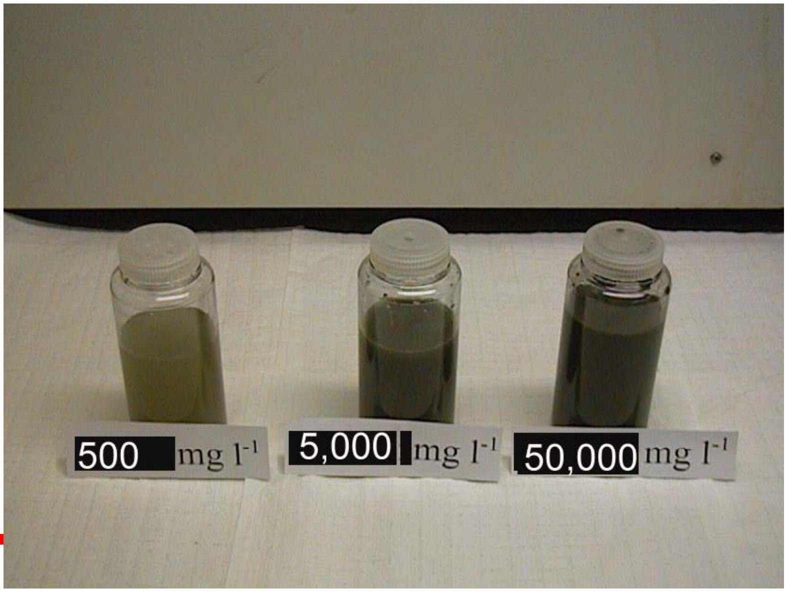
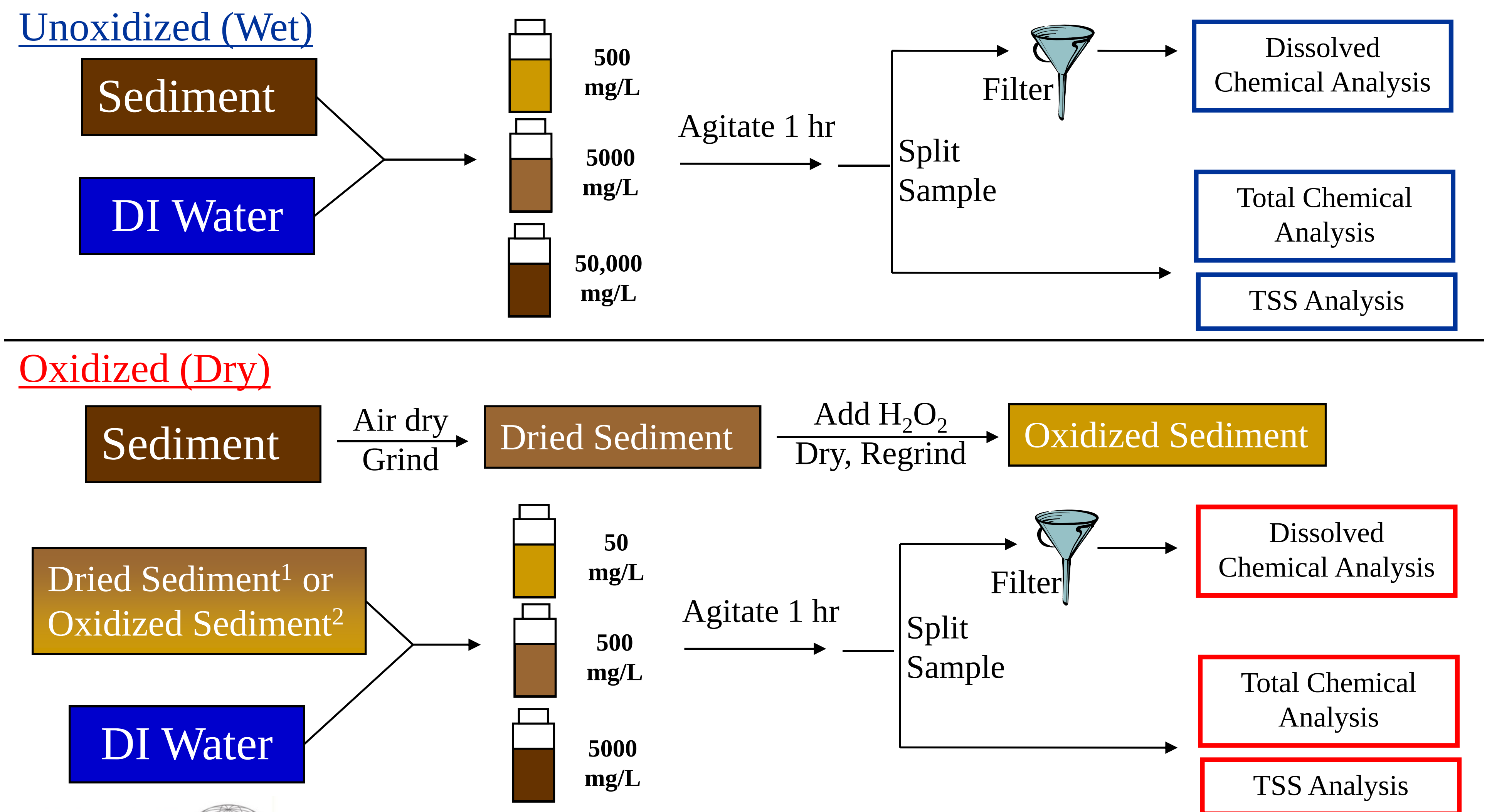
Runoff Physical Testing (Lab)

- **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



[1]For Nutrients/Organics; [2]For Metals

Mixing/Dilution – Effluent/Runoff

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

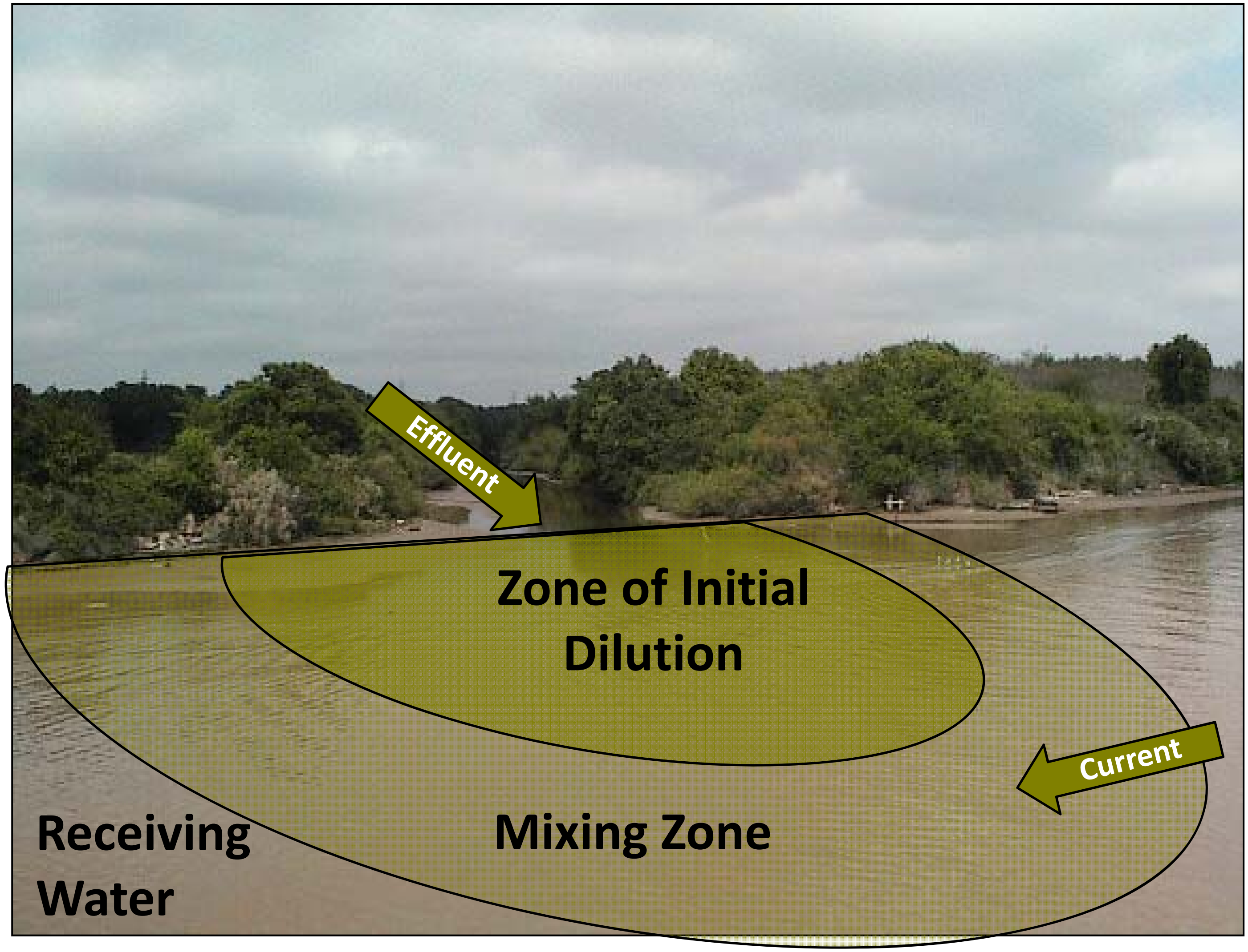
$$D = \frac{V_{RecWater}}{V_{Eff}} = \frac{(C_{Eff} - C_{WQC})}{(C_{WQC} - C_{RecWater})}$$

- **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



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 Repeat steps 1 and 2.**
  - **Repeat for at least four cycles.**

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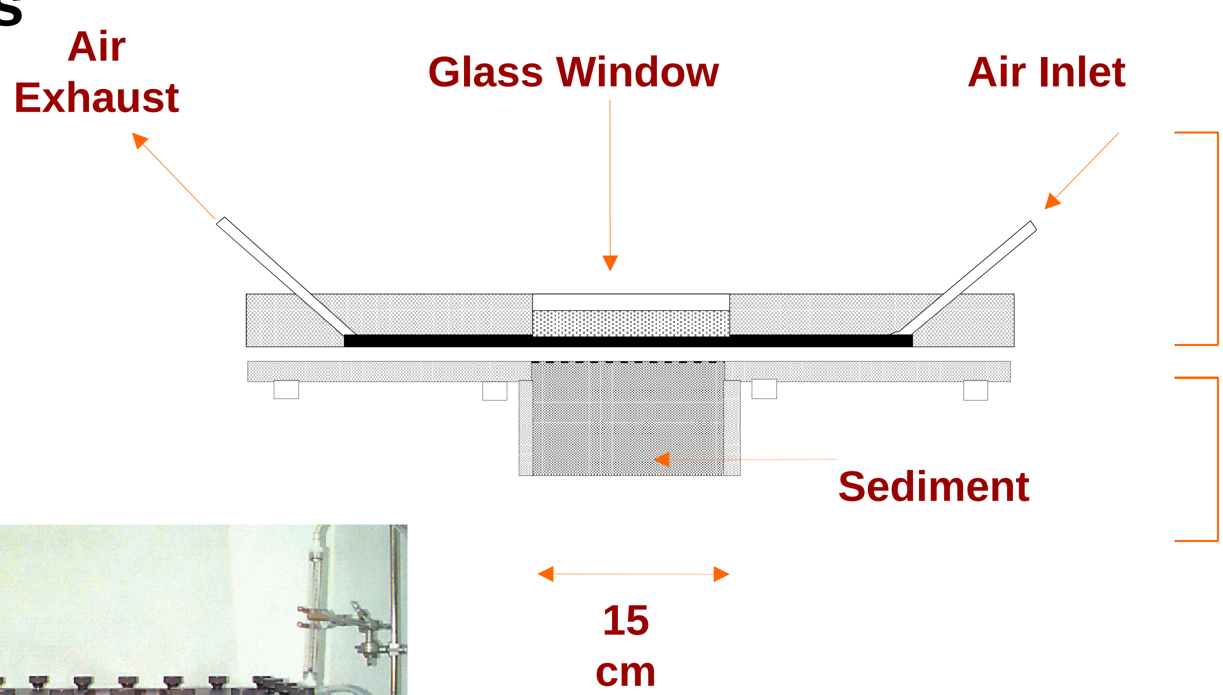
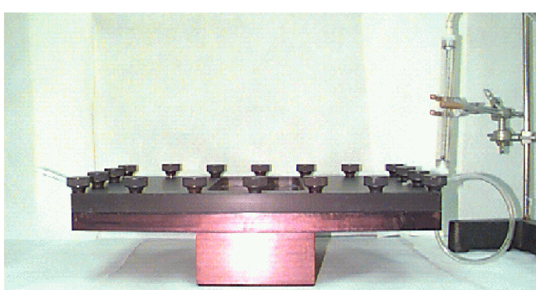
Physical Modeling - Leachate

- **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

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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-dayexposure 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

- US Army Corps of Engineers 2003. "Evaluation of Dredged Material Proposed for Disposal at Island, Nearshore, or Upland Confined Disposal Facilities — Testing Manual", ERDC/EL TR-03-1, Engineer Research and Development Center, Vicksburg, MS.
- Deliman, P. N., Ruiz, C. E., and Schroeder, P. R. (2001). Implementation of dredging risk assessment modeling. Applications for evaluation of the no-action scenario and dredging impacts. DOER Technical Notes Collection (ERDC TN-DOR-R2), US Army Engineering Research and Development Center, Vicksburg, MS.