Design and Management of CDFs

Effluent and Runoff Quality Assessment

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Topics

- Regulatory definition & requirements
- Environmental concerns
- Tiered approach
- Testing & Modeling
- Controls
- Recap
“...the term ‘discharge of dredged material’ ... includes... the runoff or overflow from a contained land or water disposal area...”
CWA Regulatory Provisions

- **Water Quality Standards**
  - Adopted per 40 CFR 131
  - Narrative or numeric criteria
  - Dissolved or total concentrations

- **Initial Mixing**
  - As per 40 CFR 230.3(m)
  - Normally expressed as a distance from point of discharge or area around the discharge
Conceptual Model - Contaminant Pathways

Birds/Wildlife

Precipitation

Volatilization

Surface Runoff

Air Quality

Dike

Plant/Animal Uptake

Unsaturated

Saturated

Seepage

Infiltration

Leachate

Effluent

Ground Water

SURFACE WATER
## Characteristics

### Effluent vs. Runoff

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Effluent</th>
<th>Runoff</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Occurrence / Duration</strong></td>
<td>Continuous discharge during disposal &amp; initial dewatering</td>
<td>Discrete events throughout life of facility</td>
</tr>
<tr>
<td></td>
<td>Weeks to months</td>
<td>Hours to days</td>
</tr>
<tr>
<td><strong>Flow Rate</strong></td>
<td>Dredge discharge rate for hydraulic dredges</td>
<td>Depends on rainfall intensity, duration, CDF area and site management</td>
</tr>
<tr>
<td></td>
<td>Minimal effluent flow rate if mechanically dredged</td>
<td></td>
</tr>
<tr>
<td><strong>Characteristics</strong></td>
<td>TSS &lt; 100 mg/L for estuarine or &lt; a few g/L for freshwater</td>
<td>TSS dependent on holding time, 100 mg/L to a few g/L</td>
</tr>
<tr>
<td></td>
<td>Dissolved contaminants in equilibrium with influent slurry of 70 to 250 g/L unoxidized DM</td>
<td>Dissolved contaminants in equilibrium with runoff slurry of 0.5 to 15 g/L unoxidized DM or 0.05 to 3 g/L oxidized DM</td>
</tr>
<tr>
<td></td>
<td>Total contaminant is a function of TSS and contaminant concentration of fines</td>
<td>Total contaminant is a function of TSS and contaminant concentration of fines</td>
</tr>
</tbody>
</table>
Tiered Approach

- Tier 1 - Existing information
- Tier 2 - Partitioning (screening assessment)
- Tier 3 – Testing

<table>
<thead>
<tr>
<th>Contaminant Evaluations</th>
<th>Effluent</th>
<th>Runoff</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Column Settling Test</td>
<td>SLRP chemistry</td>
</tr>
<tr>
<td></td>
<td>EET chemistry</td>
<td>RSLS chemistry</td>
</tr>
<tr>
<td>Toxicity</td>
<td>EET toxicity</td>
<td>SLRP/RSLS toxicity</td>
</tr>
</tbody>
</table>

- Tier 4 – Case specific studies
CDF Effluent
Supernatant Water Interactions
Basis of Effluent Quality Predictions

• Partitioning
  - Theoretical (screening spreadsheets)

• Testing
  - Contaminant mobilization - Modified Elutriate
  - Sedimentation – Column Settling
  - Total = Dissolved + Particle Associated

• Unoxidized conditions
Modified 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 0.45μm filtration

- Water from dredging site
- Sediment
- Suspended Solids Determination
- Chemical Analysis Total Concentration
- Chemical Analysis Dissolved Concentration
Modified Elutriate Test Setup
Extraction of Elutriate
Column Settling Test

- **Column**
  - 8-in diameter, > 6-ft tall
  - Ports every 6 in.

- **Fill column with slurry at expected influent solids concentration**
  - $C_{sl} = \% Fines + (3 \times \% Coarse)$

- **15 day test**
  - Sample supernatant TSS
  - Record interface height

- **Predict rate of settling and effluent TSS**
  - SETTLE model
Effluent Toxicity Evaluation

- Effluent elutriate used as test medium
- Procedure same as for open water
  - Expose test organisms to dilution series of whole effluent elutriate
    - Must be sufficiently clear for organisms to be visible
  - End result is LC50 or EC50 expressed as percentage of original effluent elutriate concentration
  - Detailed procedures in ITM
- Compare with effluent concentration at the boundary of the allowable mixing zone
  - Must not exceed 0.01 of LC50 or EC50
ADDAMS Effluent Quality Modules

• SETTLE
  - CDF sizing for storage and effluent TSS

• EFQUAL
  - Reduction of modified elutriate data
    - Determine COC
  - Water quality standards compliance
  - Dilution requirements

• LAT-E
  - Analysis of water column bioassay test to determine toxicity (LC50) of CDF effluent

• EFFLUENT
  - Windows version of the above two modules
CDF Surface Runoff Process

Discharge → Ponded → Evaporation → Runoff → Transpiration

Leaching

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Basis of Runoff Water Quality Predictions

- **Partitioning**
  - Theoretical (screening spreadsheets)

- **Testing**
  - SLRP/RSLS

- **Total and Dissolved**

- **Oxidized and Unoxidized Conditions**
  - Unoxidized analysis may not be necessary
Simplified Laboratory Runoff Procedure (SLRP) Wet Sediment

- 3 gal sediment
- Common laboratory equipment
- Dilute to representative TSS
- Agitate for one hour
- Analyze contaminant concentrations
  - Filtered for soluble
  - Unfiltered for total
## Field SS Measurements

<table>
<thead>
<tr>
<th>Sediment (mg/L)</th>
<th>SS, Wet</th>
<th>SS, Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indiana</td>
<td>6600</td>
<td>56</td>
</tr>
<tr>
<td>Black Rock</td>
<td>10326</td>
<td>167</td>
</tr>
<tr>
<td>Everett</td>
<td>6900</td>
<td>1000</td>
</tr>
<tr>
<td>New Bedford</td>
<td>7730</td>
<td>268</td>
</tr>
<tr>
<td>Oakland Inner</td>
<td>4447</td>
<td>1686</td>
</tr>
<tr>
<td>Oakland Outer</td>
<td>9140</td>
<td>970</td>
</tr>
<tr>
<td>Pinole Shoal</td>
<td>1500</td>
<td>618</td>
</tr>
<tr>
<td>West Richmond</td>
<td>3290</td>
<td>2340</td>
</tr>
<tr>
<td>Santa Fe</td>
<td>6240</td>
<td>2130</td>
</tr>
</tbody>
</table>
SLRP SS Concentrations

SLRP-Wet Concentrations

- 50, 500, 5000 mg/L

SLRP-Dry Concentrations

- 500 mg l\(^{-1}\), 5000 mg l\(^{-1}\), 50,000 mg l\(^{-1}\)
SLRP - Dry Sediment

- Air dry to < 5% moisture and grind
- Oxidize with $\text{H}_2\text{O}_2$, dry and regrind
- Re-slurry at TSS 50, 500, 5,000 mg/l, agitate and extract
- Analyze for total and dissolved contaminants
SLRP Procedures

Unoxidized (Wet)

Sediment

DI Water

50 mg/L
500 mg/L
5000 mg/L
50,000 mg/L

Agitate 1 hr

Filter

Dissolved
Chemical Analysis

Total Chemical
Analysis

TSS Analysis

Oxidized (Dry)

Sediment

Air dry
Grind

Dried Sediment

Add H₂O₂
Dry, Regrind

Oxidized Sediment

Dried Sediment

50 mg/L
500 mg/L
5000 mg/L

Agitate 1 hr

Split
Sample

Filter

Dissolved
Chemical Analysis

Total Chemical
Analysis

TSS Analysis

1For Nutrients/Organics; 2For Metals

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SLRP Predicted Copper

![Graph showing concentration of copper versus suspended solids](image-url)
Rainfall Simulator/Lysimeter System (RSLS)

- 600 gal sediment from dredging site
- Specialized equipment
- Conduct test on wet sediment (unoxidized) first
- Allow sediment to dry 6 months, then repeat test on oxidized sediment
RSLS Test Equipment

SYSTEMS FOR EVALUATING CONTAMINANT LOADINGS DURING STORM RUNOFF
RSLS Test Specifics

• **Rainfall**
  - 5.08 cm/hr (2 in/hr)
  - 30 min event
  - 3 events on consecutive days

• **Sample**
  - Runoff rate - every minute
  - pH, TSS, EC
    - Every minute up to 15 min, then every 5 min
  - Chemical analysis
    - composite of 5, 15 and 25 min after runoff begins
    - dissolved and total

• **Can modify test to match site-specific conditions**
Runoff Toxicity Evaluation

- Simulated runoff from SLRP or RSLS used as medium
  - Whole water (not filtered)
  - Sufficiently clear for organisms to be visible

- Procedure same as for open water
  - Expose organisms to dilution series of test medium
  - End result is LC50 or EC50, expressed as percentage of original simulated runoff concentration
  - Detailed procedures in ITM

- Compare with runoff concentration at boundary of allowable mixing zone
  - Must not exceed 0.01 of LC50/EC50 (or NOEL/LOEL)
ADDAMS Runoff Quality Programs

• RUNQUAL
  - Compares predicted runoff WQ with standards
  - Determines COC
  - Dilution requirements

• LAT-R
  - Analysis of water column bioassay test to determine toxicity (LC50) of CDF runoff

• RUNOFF
  - Windows version of the above two modules
Schematic of a Mixing Zone for a Single Effluent Source
# CDF Effluent Mixing Models

<table>
<thead>
<tr>
<th>Model/Technique</th>
<th>Hydrodynamics</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dilution Volume</td>
<td>Steady Uniform</td>
<td>General</td>
</tr>
<tr>
<td>MacIntyre</td>
<td>Steady Uniform</td>
<td>Riverine</td>
</tr>
<tr>
<td>CDFATE (CORMIX)</td>
<td>Steady Uniform</td>
<td></td>
</tr>
<tr>
<td>TABS</td>
<td>Unsteady Nonuniform</td>
<td>Tidally influenced Rivers &amp; Estuaries</td>
</tr>
</tbody>
</table>
Contaminant Controls

• TSS & Particulate Associated Contaminants
  - Operational modifications – retention time
  - Filtration
  - Chemical flocculants
  - Engineered controls – vegetation, capping

• Dissolved
  - Treatment
    - Carbon adsorption
    - Ion exchange
    - Chemical or UV oxidation
    - Biological
Polymer Addition
Filter Cell
Runoff SS Controls

Suspended Solids, mg/l

Time, minutes

Veg
Detritus
Bare

ERDC

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**Summary**

- **EFFLUENT**
  - Tier II Screening
  - Column settling
  - Modified elutriate
    - Accurate
    - Relatively inexpensive
    - Generally conservative
  - Controls
    - Operational
    - Treatment

- **RUNOFF**
  - Tier II Screening
  - RSLS
    - Time and material intensive
  - SLRP
    - Rapid
    - Conservative

- **Controls**
  - Operational
  - Treatment
  - Engineered