Utilizing Electrocoagulation (EC) & Chitosan Enhanced Sand Filtration (CESF) for Dredge Return Water Treatment on Superfund Sites in Western Washington

WEDA PACIFIC CHAPTER MEETING OCTOBER 21, 2016

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Outline

• Active Water Treatment (What)
• Treatment System Design Considerations (Why)
• Case Studies
  – Lower Duwamish Superfund Early Action Areas
  – Port of Ridgefield
  – Port of Tacoma
Active Treatment - CESF

- Liquid Biopolymer (coagulant/flocculent) made from crab or shrimp shells.
- Used to remove Turbidity/TSS, Total Metals
- Implemented with Sand Filtration
Active Treatment - EC

- Sacrificial ion (coagulant) driven from a metal plate, cleaving of water to make OH+ (dissolved metals) and electron flow between plates (de-emulsification, bacterial membrane lysing).
- Used to remove colloidal particles (Turbidity/TSS), total and dissolved metals, emulsified oils and bacteria
- Implemented with Sand Filtration
- Wavelonics carries GULD approval from WA Dept. of Ecology
## Why Active Treatment

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Particle Diameter (microns)</th>
<th>Time Required to Settle 3ft</th>
<th>TREATMENT OPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>10,000</td>
<td>0.016 sec</td>
<td>Active Treatment, CESF/EC</td>
</tr>
<tr>
<td>Coarse Sand</td>
<td>2000</td>
<td>0.4 sec</td>
<td>Pressurized SF, Bag Filters</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>1.7 sec</td>
<td>Passive Filtration</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>4.6 sec</td>
<td>Silt Fence, Ponds, Vault,</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>19.0 sec</td>
<td>Biological Treatment</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>42.0 sec</td>
<td></td>
</tr>
<tr>
<td>Fine Sand</td>
<td>150</td>
<td>1.25 min</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>2.8 min</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>7.8 min</td>
<td></td>
</tr>
<tr>
<td>Silt</td>
<td>25</td>
<td>2.2 hrs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>6.2 hrs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>14.0 hrs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>56.0 hrs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>155.3 hrs</td>
<td></td>
</tr>
<tr>
<td>Clay</td>
<td>1.5</td>
<td>26.0 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>58.0 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.1</td>
<td>16 yrs</td>
<td></td>
</tr>
<tr>
<td>Colloidal Particles</td>
<td>0.01</td>
<td>1600 yrs</td>
<td></td>
</tr>
</tbody>
</table>

*(not to scale)*
# Building a Treatment Train

## TREATMENT METHODS BY CONTAMINANT OF CONCERN – DREDGE RETURN WATER

<table>
<thead>
<tr>
<th>Method</th>
<th>Suspended Solids (Low Turbidity)</th>
<th>Suspended Solids (High Turbidity)</th>
<th>Total Metals (attached to soil particle)</th>
<th>Dissolved Metals (free ions)</th>
<th>Organics (TPH, PCBs, PAH, TBT)</th>
<th>Pretreatment for Granular Activated Carbon (GAC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scuppers w/Filter Fabric</td>
<td>Possibly¹</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Geotube®</td>
<td>✓</td>
<td>Possibly²</td>
<td>Possibly²</td>
<td>✗</td>
<td>✗</td>
<td>Possibly²</td>
</tr>
<tr>
<td>Geotube® w/Polymer Pretreat</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Possibly²</td>
<td>Possibly²</td>
<td>Possibly²</td>
</tr>
<tr>
<td>Sand Filter</td>
<td>Possibly²</td>
<td>Possibly²</td>
<td>Possibly²</td>
<td>✗</td>
<td>Possibly²</td>
<td>Possibly²</td>
</tr>
<tr>
<td>Chitosan Enhanced Sand Filtration (CESF)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>Possibly²</td>
<td>✓</td>
</tr>
<tr>
<td>Specialized Polymer &amp; Sand Filtration</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Possibly²</td>
<td></td>
<td>Possibly²</td>
</tr>
<tr>
<td>EC</td>
<td>✓</td>
<td>❌</td>
<td>✓</td>
<td>Likely²,³</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>GAC¹</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>❌</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Ion Exchange Resin⁴</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>✓</td>
<td>❌</td>
<td>N/A</td>
</tr>
</tbody>
</table>

¹ If contaminant particle size is large enough to be captured
² If contaminants are attached to soil particles removal can be achieved
³ If organics are attached to soil particles removal can be achieved. EC does destroy/precipitate some hydrophilic organic compounds, the full range of compounds is still under research
⁴ Pretreatment required to remove turbidity and prevent blinding
⁵ Not recommended for salt water application as salts will compete with metal ions and reduce performance
Building a Treatment Train

**DETENTION TANKS**
Gravity settling of large soil particles

**400GPM EC**
Coagulation of soil particles, precipitation of dissolved metals, De-emulsion of oils

**SETTLING TANKS**
Flocculation and settling of coagulated/precipitated material

**SAND FILTER**
Removal of any unsettled particles
pH Neutralization (as needed)

**GRANULAR ACTIVATED CARBON**
Removal of any remaining TPH, VOCs, cPAH, or organo-metal complexes

Discharge
THE GOAL
Traditional Management

- May require treatment for organics (PCBs/PAHs)
- Per gallon discharge fee
Lower Duwamish Water Way

- 5.5 Mile Superfund Site
- Contaminants of Concern: PCBs, PAHs, Dioxins, Furans, Metals & Phthalates
- An estimated 177 acres will be actively cleaned up. Time frame to complete the entire cleanup is estimated to be 17 years: 7 years of active cleanup and 10 years of monitored natural recovery. 105 acres of dredging or partial dredging and capping
- Early Action Areas: Slip 4, Terminal 117, Boeing Plant 2, Jorgensen Forge
Boeing Plant 2 EAA CS1
Boeing Plant 2 EAA CS1

- Specified treatment approach not approved by Agencies
- Chemicals/Polymers not allowed
- Small Laydown Area
- Discharge to SS not allowed/cost prohibitive
- Considered “pilot season” for larger CS2/CS3
- Wavelonics EC technology selected as considered by Ecology as non-chemical, and carries GULD (TAPE Approval)
After the sandfilter treated water is returned through the WaveIonics Unit where water quality (turbidity & pH) is verified prior to discharge through the GAC. This prevents off spec discharges and protects the carbon from excessive loading and subsequent blinding. Any off spec water is recirculated to the Detention Tanks.
HIGHLY VARIABLE INFLUENT

Over the project duration the following breakdown of turbidity was generally observed:

- 50% of the time turbidity was >1000 ntu
- 14% of the time turbidity was 500 – 1000 ntu
- 26% of the time turbidity was 300 – 500 ntu
- 10% of the time turbidity was <300 ntu

Influent Sample collected 2/11/13:

TSS = 58,000mg/L (measured by ALS)
NTU = 16,200 (measured with volumetric dilutions in laboratory setting)

Wide variations in turbidity and TSS were observed on a daily and even hourly basis. Factors included both the type of cut and type of material being dredged. Lower turbidity was observed when dredging in sandy areas which occurred during the first week and last couple weeks of CS1.
### Boeing Plant 2 EAA CS1

36,000 cubic yards of dredging

Operated for 48 days meeting all water quality discharge parameters

6,300,000 gallons treated and discharged back to the Duwamish Waterway

<table>
<thead>
<tr>
<th>WQ Parameter</th>
<th>Acute Criteria</th>
<th>Chronic Criteria</th>
<th>DRWTS Effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium</td>
<td>40</td>
<td>8.8</td>
<td>0.027</td>
</tr>
<tr>
<td>Chromium</td>
<td>1100</td>
<td>50</td>
<td>0.22</td>
</tr>
<tr>
<td>Copper</td>
<td>4.8</td>
<td>3.1</td>
<td>0.44</td>
</tr>
<tr>
<td>Lead</td>
<td>210</td>
<td>8.1</td>
<td>0.05</td>
</tr>
<tr>
<td>Mercury</td>
<td>1.8</td>
<td>0.025</td>
<td>0.02</td>
</tr>
<tr>
<td>Silver</td>
<td>1.9</td>
<td>1.9</td>
<td>0.016</td>
</tr>
<tr>
<td>Zinc</td>
<td>90</td>
<td>81</td>
<td>5.78</td>
</tr>
<tr>
<td>Mercury</td>
<td>1.8</td>
<td>0.025</td>
<td>0.02</td>
</tr>
<tr>
<td>PCBs</td>
<td>10</td>
<td>0.03</td>
<td>0.010</td>
</tr>
<tr>
<td>Turbidity</td>
<td>5 ntu above background</td>
<td>≤5 ntu</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>6.5-8.5s.u.</td>
<td>6.5-7.5</td>
<td></td>
</tr>
</tbody>
</table>
Boeing Plant 2 EAA CS1

Lessons Learned:

• Operational dewatering strategy from sediment barge to DRWTS is critical
• Having a reliable way to remove solids is also critical
• Plan for redundancy

These challenges were remedied in later CS2/CS3 by replacing detention tanks with large pre settling pond (~2M gallons) and large post treatment clarifier.

As a result, Influent turbidities prior to the EC system were very low – with the highest reading at 110ntu.
CS1: 90% of time <300 ntu
Jorgensen Forge EAA

- No Laydown Area
- Discharge to SS not allowed/cost prohibitive as full treatment required
- Barge Mounted System Desired
- Turbidity, Total Metals & PCBs
Barge-Mounted Chitosan Enhanced Sand Filtration (CESF) system implemented...
Jorgensen Forge EAA
Jorgensen Forge EAA

From Barge

Primary Treatment

- Settling/Flow Equalization Tank (~20K Gal)
- Settling/Flow Equalization Tank (~20K Gal)
- Settling/Flow Equalization Tank (~20K Gal)
- Recirculation & Media Filter Backwash

Secondary Treatment

- Pretreatment Tank (Wier) Settling Tank (~20K Gal)
- Pretreatment Tank (Wier) Settling Tank (~20K Gal)
- Media Filters
- CESF BOX 8'x10'
- Discharge

Granular Activated Carbon Polishing for TSCA work

P1

P3 – spare pump
Jorgensen Forge EAA

12,500 cubic yards of dredging

Operated for 45 days meeting all water quality discharge parameters

5,183,000 gallons treated and discharged back to the Duwamish Waterway
Other Challenges

Courtesy Dalton, Olmsted & Fuglevand (DOF)
Port of Ridgefield

- Ridgefield National Wildlife Refuge
- Old Wood Processing & Treatment Site
- Dioxins, PCP, heavy metals, PAH, Creosols
**Port of Ridgefield**

**PROCESS FLOW DIAGRAM**

1. **Detention Tanks**
2. **CESF BOX**
   - 500GPM
3. **Detention Tanks**

- **Gravity settling of large soil particles**
- **Coagulation of soil particles**
  - Removal of Total Metals/PCBs
- **Flocculation and settling of Coagulated material**

- **Sand Filter**
  - Housed in CESF Box
  - Probes: NTU, pH & Flow
- **Granular Activated Carbon**
  - Discharge
  - Removal of any unsettled particles
  - Removal of any TPH/PCBs
## Port of Ridgefield

<table>
<thead>
<tr>
<th><strong>Final phase of nearly 20 year - $90M clean-up</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operated for 50 days meeting all water quality discharge parameters</td>
</tr>
<tr>
<td>5,000,000 gallons treated and discharged back to the Columbia River</td>
</tr>
</tbody>
</table>

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![Image of Port of Ridgefield water treatment facility](image-url)
Port of Tacoma Pier 4

- Discharge to SS not allowed/cost prohibitive as full treatment required
- Tributyltin (TBT)
- Laydown Area provided on neighboring property
Port of Tacoma Pier 4

**Detention/Settling Pond**  
(Contractor Provided – Not to Scale)

**INPUTS:**  
Return water from barge  
Stockpile dewatering/run-off  
Stormwater run-off

Temporary recirculation line will be installed to facilitate initial sample collection to prove system performance post GAC. The standard recirculation line will remain in place to ensure that the GAC will not be blinded by any potentially turbid water. This line will have manual valves and will be place in the recirculation orientation upon system commissioning and through WQ verification.

Recirculation line if treated effluent does not meet discharge limits for pH and turbidity.

After the sandfilter treated water is returned through the Waveionics Unit where water quality (turbidity & pH) is verified prior to discharge through the GAC. This prevents off spec discharges and protects the carbon from excessive loading and subsequent blinding. Any off spec water is recirculated to the Detention Pond. (THIS IS THE LOCATION OF THE AUTOMATED RECIRC/DISCHARGE VALVE WHICH IS ACTUATED BASED ON THE INLINE TURBIDITY & pH READINGS)

**ACUTE SAMPLE LOCATION**  
Sample Collection Port (hose bib)

Two (qty. 2) 300 gpm EC units will be mobilized to meet the 600 gpm flow requirement. They system will be plumbed so that one 300 gpm system can be functional at all times – meaning that one side of the system can be maintained while the other continues to process water.
### Port of Tacoma Pier 4

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>49,000 cubic yards of dredging</td>
<td></td>
</tr>
<tr>
<td>Treated Dredge Return Water, site stormwater &amp; transload facility</td>
<td></td>
</tr>
<tr>
<td>11,000,000 gallons treated and discharged back to the Commencement Bay</td>
<td>meeting water quality limits</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Summary

#### Site Characteristics Impacting Design:

- **Schedule – Time Constraints**
- **Contaminants of Concern**
  - Sediment Particle Size
  - Total vs Dissolved Metals
  - Organics
- **WQ Discharge Standards**
- **Agency Approval**
- **Available Laydown Area**
- **Operational Concerns - Barge Off Loading Practices & Solids Management**

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Four Projects Completed with Active Treatment Technologies (WA GULD)
2 CESF & 2 EC

Cost started at $0.07/gallon, 3 years later $0.02/gallon
Thank You!

For more information please contact:

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