Costs and Other Considerations for Constructed Wetlands

Constructed Wetlands Workshop
Caesar Kleburg Wildlife Center
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Cost Considerations
  - Major Cost Categories & Drivers
  - Costs for Example Projects
- Green Infrastructure Case Study
- “Ownership” of the Project
Before we start...

- Each project is unique...
- One size does *NOT* fit all...
- Basic cost components shared by all wetland systems
General Cost Categories
- Indirect ("soft") costs
- Capital costs
- O & M costs
Indirect Costs

- Planning
- Studies
- Site Evaluations
- Permitting
- Engineering
<table>
<thead>
<tr>
<th>ITEM (CATEGORY)</th>
<th>UNIT</th>
<th>QTY.</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Land</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Earthwork</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Liner</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Plant media</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Plants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Water control structures, pipe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Electrical, instrumentation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Facility appurtenances</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Contractor GCs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Contingency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL CAPITAL COST</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
- Land
  - Site characteristics
  - Location (rural, urban)
  - Land area needed
    - For wetland
    - Total needed
<table>
<thead>
<tr>
<th>Treatment Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Natural Treatment Systems</td>
</tr>
<tr>
<td>Intensified Wetland Systems</td>
</tr>
<tr>
<td>Active Mechanical Treatment Systems</td>
</tr>
</tbody>
</table>

**LAND REQUIREMENTS**

- **MOST**: Passive Natural Treatment Systems
- **LEAST**: Active Mechanical Treatment Systems
Land area requirements by type of system

**WASTEWATER TREATMENT**

Summary of Process Area Requirements
Austin & Nivala, 2008

<table>
<thead>
<tr>
<th>Model</th>
<th>Area Requirements (m² per m³ of flow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activated Sludge</td>
<td>0.2</td>
</tr>
<tr>
<td>Aerated Wetland</td>
<td>10.3</td>
</tr>
<tr>
<td>Tidal Flow Wetland</td>
<td>5.0</td>
</tr>
<tr>
<td>Pulsed Flow System</td>
<td>21.3</td>
</tr>
<tr>
<td>FWS Wetland</td>
<td>40.0</td>
</tr>
</tbody>
</table>

**STORMWATER TREATMENT**

- Retain/treat 90th percentile storm for at least 2 days
- 5% - 10% of watershed area
- Retrofit - land limited

*Source: Texas A&M Agrilife Extension*
Capital Cost Components - Land
Earthwork
Earthwork Cost per Acre vs. Total Water Surface Area for FWS Wetlands (APAI 2014) without clay liner

\[ y = 51065x^{0.299} \]

\[ R^2 = 0.4581 \]
Capital Cost Components - Earthwork

CCWA, Georgia
- Liner
  - TCEQ Chapter 217
  - In-situ
  - Compacted clay
  - Geotextile
Plant Media
- Type of media
- Source

CLAY LINER
SOIL COVER

15
SSF Pilot Wetland, Jefferson Co. TX (APAI 2017):

Comparative cost - SSF \( D_{50} = 10 \) mm
- Pea gravel
- Expanded shale (\( \sim 2 \times \) pea gravel)
- Zeolite (\( \sim 5 \times \) pea gravel)
Capital Cost Components - Plants

- Plants
  - Natural recruitment
  - Seeding
  - Planting
Capital Cost Components - Plants

Harvest & transplant
$3.00 - $5.00 per plant
Capital Cost Components – Water Control Structures, Piping
Capital Cost Components – Water Control Structures, Piping

Inlet – Flow Distribution
Outlet Structures - Passive
Outlet Structures - Active

Tres Rios Wetlands, Phoenix AZ
Capital Cost Components – Electrical & Instrumentation

Passive Natural Treatment Systems
Intensified Wetland Systems
Active Mechanical Treatment Systems

**LEAST ENERGY REQUIREMENTS**
Pumps, actuated gates, blower, recirculation pumps, instrumentation

**MOST**
Capital Cost Components – Facility Appurtenances

- Site security
- Roads, office, lab, shop
- Public use facilities
**EXAMPLE #1: FWS WETLAND, TEXAS**

512 ac. Wetted area
Domestic WW
Q=31.9 MGD
Year built 2007

~$22K/acre

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Water control structures</td>
<td>$2,139,000</td>
<td>19</td>
</tr>
<tr>
<td>2. Earthwork</td>
<td>$4,685,000</td>
<td>42</td>
</tr>
<tr>
<td>3. Aquatic plants/seeding</td>
<td>$1,218,000</td>
<td>11</td>
</tr>
<tr>
<td>4. Roads</td>
<td>$1,905,000</td>
<td>17</td>
</tr>
<tr>
<td>5. Dewatering</td>
<td>$600,000</td>
<td>5</td>
</tr>
<tr>
<td>6. GCs &amp; demo</td>
<td>$660,000</td>
<td>6</td>
</tr>
<tr>
<td>TOTAL WETLAND</td>
<td>$11,207,000</td>
<td>100</td>
</tr>
</tbody>
</table>
EXAMPLE #2: FWS WETLAND, TEXAS
65 ac. Wetted area
Industrial WW
Q=2.9 MGD
Year built 2009

~$30K/acre

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Influent Splitter Box</td>
<td>$137,000</td>
<td>7</td>
</tr>
<tr>
<td>2. Earthwork/liner</td>
<td>$1,000,500</td>
<td>51</td>
</tr>
<tr>
<td>3. Aquatic plants/seeding</td>
<td>$314,500</td>
<td>16</td>
</tr>
<tr>
<td>4. Water control structures</td>
<td>$41,500</td>
<td>2</td>
</tr>
<tr>
<td>5. Yard piping</td>
<td>$357,000</td>
<td>19</td>
</tr>
<tr>
<td>6. Electrical/Instrumentation</td>
<td>$40,000</td>
<td>2</td>
</tr>
<tr>
<td>7. GCs (wetland portion)</td>
<td>$60,500</td>
<td>3</td>
</tr>
</tbody>
</table>

TOTAL WETLAND ONLY $1,951,000 100
EXAMPLE #3: FWS WETLAND, TEXAS

5.9 ac. Wetted area
Domestic WWQ=0.12 MGD
Year built 2002

~$50K/acre

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Site prep</td>
<td>$11,500</td>
<td>4</td>
</tr>
<tr>
<td>2. Earthwork</td>
<td>$104,500</td>
<td>35</td>
</tr>
<tr>
<td>3. Aquatic plants/seeding</td>
<td>$50,000</td>
<td>17</td>
</tr>
<tr>
<td>4. Re-lift pump station</td>
<td>$63,900</td>
<td>22</td>
</tr>
<tr>
<td>5. Pipes, structures</td>
<td>$34,400</td>
<td>12</td>
</tr>
<tr>
<td>6. GCs, misc.</td>
<td>$30,000</td>
<td>10</td>
</tr>
<tr>
<td>TOTAL WETLAND ONLY</td>
<td>$294,300</td>
<td>100</td>
</tr>
</tbody>
</table>
Capital Costs – FWS systems

FWS Wetland Capital Cost as Function of Size, 2006 USD (N=84 wetlands)

Kadlec & Wallace, 2009

\[ C = 194 \ A^{0.690} \]
\[ R^2 = 0.79 \]

\( C = 1,000s \ of \ dollars \)
\( A = ha \)

• APAI FWS Wetlands, 2014 USD (N=14 wetlands)
Capital Costs – Stormwater Wetland

Stormwater Treatment Wetland Costs
to build or retrofit into a stormwater detention basin
(Ref: *Stormwater Wetlands for the Texas Gulf Coast, Sea Grant Texas ESP-385*)

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost ($/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Design, engineering</td>
<td>$8,000 - $15,000</td>
</tr>
<tr>
<td>2. Retrofit grading</td>
<td>$5,000 - $15,000</td>
</tr>
<tr>
<td>3. Aquatic plants</td>
<td>$10,000-$20,000</td>
</tr>
<tr>
<td>4. Spillway/drawdown structure</td>
<td>$10,000 - $15,000</td>
</tr>
<tr>
<td><strong>TOTAL (w/o engineering)</strong></td>
<td><strong>$25,000 - $50,000</strong></td>
</tr>
</tbody>
</table>

*APAI project (60 ac wetland restoration + 8.5 acres stormwater wetland retrofit into existing basin) = $33,837/acre*
O&M Costs

Passive Natural Treatment Systems

Intensified Wetland Systems

Active Mechanical Treatment Systems

LEAST O&M, ENERGY REQUIREMENTS MOST
O&M Costs

- **O&M Input Costs**
  - **Personnel**
    - Mowing, nuisance animal/plant control, maintain/repair structures & equipment, regulatory duties, etc.
  - **Electricity, telephone, etc.**
  - **Monitoring (analytical)**
  - **Equipment parts, materials, etc.**
  - **Outside consulting/contracting**
    - Permit renewal, dredging stormwater wetland
O&M Costs - Examples

- **Prado Wetlands (CA)**
  - $800K/yr O&M ~$2,000/ac-yr
  - Plus $400K/yr budget – 3 biologists

- **Arcata Wetlands (CA)**
  - ~$4,000/ac-yr

- **East Fork Wetland (TX)**
  - ~$1,400/ac-yr
Financial Analysis

Replacement Cost Methodology (RCM)

Environmental Analysis

Life Cycle Assessment (LCA)
Financial Assessment

- Used capital costs + O&M, other costs
- Assumed 30-yr lifetime for the projects
- NPV saved was $282 million (2012 USD)

Case Study for Green Infrastructure

$1.5 million

$40 million (est.)
Variation of financial analysis

- Assumed SBR was built in 1995.
- Break-even at 3 years, continued savings after that.
- Conclusion: wetlands for wastewater treatment may be as cost effective as replacement technology for existing capital assets.

$3M capital reinvestment
OR
50 acre constr. wetland
Environmental Assessment

- SBR impacts > wetland impacts
- Land use/land transformation
  - “Upstream” or “embedded” land burdens for SBR *not negligible* compared to land use of the constructed wetland.
- Important to consider in gray-green infrastructure decisions.

Ref: A Financial and Environmental Analysis of Constructed Wetlands for Industrial Wastewater Treatment
Final Thoughts – “Ownership”
Thank you!

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