Phytoremediation Case Study
A Growing Solution for Hydraulic Control, Groundwater Treatment and More

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Overview of Presentation

• Project Background
• Treatability Study Phases
• Key Findings
• Recommendations and Options
• Questions and Answers
Project Background

• WRR Environmental Services Co., Inc.
  – Waste solvent recycling and wastewater treatment since 1970

• Historical releases to site soils and groundwater
  – Volatile organic compounds (VOCs) detected in groundwater in 1978

• Multiple phases of investigation and remediation since 1979
  – RCRA Facility Investigation (RFI) process begun in 1988

• Active regulatory agency involvement
Project Background (cont’)

[Diagram with legend: SP = Poorly Graded Sand, SM = Silty Sand, ML = Silt, CL = Clay and Silty Clay, CL-ML = Banded Silt and Clay and Clayey Silts, SANDSTONE = Geologic Contact (Dashed Where Inferred), WATER TABLE, MID DEPTH AQUIFER]
Project Background (cont’)

[Legend]
- Monitoring Well Location and Number
- Pal Exceedance / No ES
- ES Exceedances

[Map showing various markers and regions marked in green and orange]
Project Background (cont’)

• Remediation System Optimization
  – Began in 2002
  – Water balance – increase net groundwater recovery
  – Segregated “hot” well for off-site treatment
  – Used treated groundwater in facility processes
  – Replace shallow pumping wells with trees

➤ Phytoremediation
Phytoremediation Processes

- Hydraulic control
- Uptake of VOCs in root zone
- Metabolism of VOCs within plant
- Evapotranspiration of volatiles
Phytoremediation Processes (cont’)

- Consider Phytoremediation at the site for:
  - Hydraulic uptake and control
  - Water quality improvement
  - Development of beneficial natural resource
    • County Park → Arboretum

- Phased treatability studies from May to December in both 2002 and 2003
Phase I (2002)

Objectives:

- Evaluate use of plants to improve hydraulic control at site
- Evaluate possible VOC removal by using plants
- Evaluate hybrid and naturally occurring species of poplars, willows and grasses
- Select best plant materials
Phase I (2002) (cont’)

Nine Tanks
Poplars

Nine Tanks
Willows

Nine Tanks
Grasses

Three Tanks
No Plants - Soil Only

Native Cottonwood
Hybrid Poplar
Native Black Willow
Hybrid Willow
Switch grass
Big Bluestem

On-Site Soil
Phase I (2002) (cont’)
Phase I (2002) (cont’)

- Operation, Maintenance and Monitoring
  - Plant inspection and spraying
  - Water balance three times per week (uptake)
  - Sampling and analysis (VOC reduction)
    - Feed water each event, drain water monthly

- Plant Measurements and Harvest
  - Height and diameter measurements
  - Mortality
  - Soil samples
Phase I (2002) (cont’)

Average Percent Uptake

Plant Species by Feed Water
Phase I (2002) (cont’)

Final Average Plant Growth

Plant Species by Feed Water

- Hybrid Poplar
- Native Cottonwood
- Hybrid Willow
- Black Willow

Plant Volume (cm³)

- DN 34 - Clean
- DN 34 - Discharge
- DN 34 - Untreated
- EC - Clean
- EC - Discharge
- EC - Untreated
- SX 61 - Clean
- SX 61 - Discharge
- SX 61 - Untreated
- BW - Clean
- BW - Discharge
- BW - Untreated
Phases II and III (2003)

- Objectives
  - Refine design under more representative field conditions
  - Obtain additional performance data on uptake and VOC reduction/removal
  - Perform side by side tank study and in-ground plantation
  - Discharge water only
Phase II Tank Study (2003)

- Design and Construction
  - 14 uncovered tanks
  - Cottonwood, willow, switchgrass, wildflowers and soil
  - Planted 10-inch long cuttings or rooted plugs
Phase II Tank Study (2003) (cont’)

• Operation, Maintenance and Monitoring
  – Plant inspection and spraying
  – Water balance three times per week
  – Sampling and analysis
    • Feed water each event, drain water monthly

• Plant Measurements and Harvest
  – Height and diameter measurements
  – Soil samples
  – Aboveground and belowground biomass samples
Phase II Tank Study (2003) (cont’)

Average Percent Uptake

<table>
<thead>
<tr>
<th>Plant Species</th>
<th>Percent Uptake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willows</td>
<td>80%</td>
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<tr>
<td>Cottonwoods</td>
<td>60%</td>
</tr>
<tr>
<td>Wildflowers</td>
<td>40%</td>
</tr>
<tr>
<td>Switchgrasses</td>
<td>20%</td>
</tr>
<tr>
<td>Soil</td>
<td>0%</td>
</tr>
</tbody>
</table>
## Phase II Tank Study (2003) (cont’)

<table>
<thead>
<tr>
<th>Plant Material</th>
<th>Average Height (cm)</th>
<th>Average Diameter (cm)</th>
<th>Average Volume (cm$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonwoods</td>
<td>167.85</td>
<td>1.42</td>
<td>353.84</td>
</tr>
<tr>
<td>Willows</td>
<td>212.41</td>
<td>1.43</td>
<td>443.24</td>
</tr>
<tr>
<td>Switchgrasses</td>
<td>98.35</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Phase III In-Ground Plantation (2003)

• Design and Construction
  – Two each 7 x 7 plots of cottonwood, willow and switchgrass
  – Trickle (drip) irrigation system
Phase III In-Ground Plantation (2003) (cont’)

• Operation, Maintenance and Monitoring
  – Plant inspection, spraying and weed control
  – Watered three times per week
    • Up to 3,000 gallons per watering event

• Plant Measurements and Harvest
  – Height and diameter measurements
  – No plants harvested
# Phase III In-Ground Plantation (2003)

## (cont’)

<table>
<thead>
<tr>
<th>Plant Material and Plantation Location</th>
<th>Average Height (cm)</th>
<th>Average Diameter (cm)</th>
<th>Average Volume (cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonwoods (NW)</td>
<td>157.72</td>
<td>1.58</td>
<td>460.20</td>
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<tr>
<td>Cottonwoods (SE)</td>
<td>184.10</td>
<td>1.83</td>
<td>763.70</td>
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<tr>
<td>Willows (SC)</td>
<td>160.24</td>
<td>1.30</td>
<td>308.34</td>
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<tr>
<td>Willows (NE)</td>
<td>159.95</td>
<td>1.22</td>
<td>274.18</td>
</tr>
<tr>
<td>Switchgrasses (NC)</td>
<td>102.11</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Switchgrasses (SW)</td>
<td>95.20</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Phytoremediation Treatability Study
Key Findings

- Excellent plant growth
- Low mortality
- Effective hydraulic control
- Effective VOC removal or reduction for plant/soil system
- Improve the environment through use of natural resources
- It’s much more than just “Plant them and they will grow”
Recommendations and Options

• 2004
  – Expanded in-ground treatability study with established plants
  – Partner involvement
    • Objectives, agreements and permits
    • Site locating
  – Plan, prepare and obtain plant materials

• 2005
  – Full-scale implementation
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Thank You!