Performance of a Pilot Constructed Treatment Wetland for Membrane Concentrate Produced from Reclaimed Water

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Outline

• Background on Oxnard
• Wetlands for Concentrate Management
• Pilot Study Description
• Key Results
• Conclusions

Advanced Water Purification Facility, Oxnard CA
Oxnard: A Coastal Community in Southern California is Building Needed Future Water Supply Capacity
Oxnard’s GREAT Program: Membrane Treatment of Groundwater and Reclaimed Water

Key Features

• Treat secondary treated effluent from Oxnard WWTP
• Product water (25.5 mgd) will recharge GW; also will be used for irrigation and seawater barrier
• Finished water quality will comply with CADHS criteria for GWR and federal rules
Oxnard AWPF Process Includes Wetlands
Treatment of Concentrate Sidestream

Oxnard WPCF Secondary Effluent → MF/UF → Break Tank

31 mgd

7.8 mgd

To WPCF (Headworks)

To Barrier Injection Wells

6.25 mgd

To Landscape and Agricultural Irrigation

25 mgd

Decarbonation

Ultraviolet Irradiation System

Reverse Osmosis

Hydrogen Peroxide

RO Feed Pump

Phase I Demonstration Wetlands

RO Waste (Ocean Outfall or Marsh Wetlands)
Constructed Brackish Wetlands Create an Opportunity for Treatment and Habitat

- Evapotranspiration
- Volatilization
- Plant Uptake & Storage
- Adsorption
- Nitrification / Denitrification
- Decomposition
- Burial & Soil Storage
- Sedimentation
- Volatile Organics, Selenium
- N, Volatile Organics, Selenium
- Organic C
- NO$_3$, NH$_3$
- TSS, Adsorbed Contaminants
Oxnard Previously Established Feasibility of Treating Groundwater Concentrate Using Wetlands

- 6 types
- 3 years
- Metals, nutrients
- Toxicity reduction
The AWPF Will Treat Higher Strength Concentrate

AWPF Layout

Three Types of Treatment Wetlands

• Subsurface horizontal flow for ammonia removal
• Anaerobic subsurface upflow reactors for metals reduction
• Free water surface wetlands for habitat and nutrient removal
A Pilot Study was Needed to Bridge the Gap between Concentrate Strengths

- Confirm the survival and growth of brackish marsh plants receiving the RO concentrate
- Confirm that the aesthetics of the treatment wetland would be acceptable (i.e., no offensive odors or colors would be generated)
- Assess the pollutant removal performance of wetlands treating the RO concentrate
Trailer-Mounted Pilot Wetland Co-Located with RO Pilot System at WWTP

L = 3.7 m  
W = 2.4 m  
D = 1.3 m  
A = 8.9 m²  
V = 11.9 m³

Portable Subsurface Flow Constructed Wetland

Mobile Environmental Solutions (MES), Tustin, CA

RO Concentrate  
Influent  
Effluent  
Flow control
# Hydraulic Data Summary

<table>
<thead>
<tr>
<th>Dates</th>
<th>Duration (day)</th>
<th>Flows (L/min)</th>
<th>HRT (day)</th>
<th>HLR (cm/day)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/1/2008 - 9/24/2008</td>
<td>23</td>
<td>1.9</td>
<td>1.3</td>
<td>24.5</td>
<td>Initial Acclimation Period</td>
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<tr>
<td>10/1/2008 - 1/19/2009</td>
<td>110</td>
<td>1</td>
<td>2.5</td>
<td>12.9</td>
<td>Sampling 1</td>
</tr>
<tr>
<td>1/20/2009 - 3/5/2009</td>
<td>40</td>
<td>0.5</td>
<td>5</td>
<td>6.5</td>
<td>Sampling 2</td>
</tr>
</tbody>
</table>

HLR = Hydraulic Loading Rate  
HRT = Hydraulic Residence Time
Sampling from Wetlands and RO Concentrate

- **Field Measurements (Influent and Effluent – Bi-weekly):**
  - Temperature
  - Ammonium
  - Conductivity
  - Chlorine (Free and Combined)
  - pH

- **Laboratory Measurements (RO Concentrate - Weekly, Influent and Effluent – Weekly/Monthly):**
  - TDS
  - Nitrate, Nitrite, TN, TKN and Ammonium
  - Orthophosphate
  - TOC
  - BOD5
  - Chloride
  - Calcium
  - Selenium
Relative Changes in Inorganic Concentration Indicate Effects of Evaporation and Chemical Precipitation

<table>
<thead>
<tr>
<th>Process</th>
<th>CI</th>
<th>TDS</th>
<th>SO\textsubscript{4}</th>
<th>Alkalinity</th>
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<tbody>
<tr>
<td>Inflow (mg/L)</td>
<td>2,848</td>
<td>11,729</td>
<td>3,761</td>
<td>1,487</td>
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<tr>
<td>Outflow (mg/L)</td>
<td>3,575</td>
<td>13,450</td>
<td>4,446</td>
<td>1,660</td>
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<tr>
<td>$\Delta$ Conc</td>
<td>26%</td>
<td>15%</td>
<td>18%</td>
<td>12%</td>
</tr>
<tr>
<td>Process</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Evapoconcentration</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Precipitation</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Biological Reduction</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
26% Increase in Cl through Evapoconcentration

2.5-d HRT
5-d HRT

mg Cl/L

Date


In
Out

27%
26%
Normal, Vigorous Plant Growth and Survival

Before (T = 0, August 2008)  After (T = 7 Months, March 2009)
Concentration Reduction Summary

- **20% CR**
- **60% CR**
Ammonium Concentration Reduction: 23%

Date

Influent

Effluent

2.5-d HRT

5-d HRT

NH4-N (mg/L)

9/9/08  10/9/08  11/8/08  12/8/08  1/7/09  2/6/09  3/8/09

23%

24%
Consistent Loading Response Position of the Oxnard AWPF Pilot Indicates Similarity to Global Data Set: Ammonia N

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Mean</th>
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<tbody>
<tr>
<td>$C_i$</td>
<td>mg/L</td>
<td>157</td>
</tr>
<tr>
<td>$C_o$</td>
<td>mg/L</td>
<td>120</td>
</tr>
<tr>
<td>Load</td>
<td>g/m²*yr</td>
<td>5441</td>
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</table>
Oxidized Nitrogen (NOx-N) Concentration Reduction: 63%

Date

9/9/08 10/29/08 12/18/08 2/6/09 3/28/09

mg NOx-N/L

NOXin

NOXout

2.5-d HRT

5-d HRT

Reduction: 63%

63%

63%
Oxidized Nitrogen (NOx-N) Mass Reduction: 75%

![Graph showing the reduction of NOx-N mass over time. The graph compares inflow and outflow on a date scale from 9/9/08 to 3/28/09, with the 2.5-d HRT and 5-d HRT periods highlighted. The graph indicates a mass reduction of 76% in the 2.5-d HRT period and 72% in the 5-d HRT period.](image)
Consistent Loading Response Position of the Oxnard AWPF Pilot Indicates Similarity to Global Data Set: Nitrate+Nitrite-N

<table>
<thead>
<tr>
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<th>Units</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_i$</td>
<td>mg/L</td>
<td>15.8</td>
</tr>
<tr>
<td>$C_o$</td>
<td>mg/L</td>
<td>6.3</td>
</tr>
<tr>
<td>Load</td>
<td>g/m²*yr</td>
<td>454</td>
</tr>
</tbody>
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TOC Concentration Reduction: 15%

The diagram shows the total organic carbon (TOC) concentration reduction over time. The reduction is indicated by the colors and markers on the graph, with 2.5-d HRT and 5-d HRT periods highlighted. The concentration reduction is marked as 10% and 20%.
Selenium Concentration Reduction: 36%
AWPF Construction Progress

Visitor center and wetlands

Wetlands earthwork

Wetlands channels
Conclusions

• Plants tolerated the high levels of salts and nutrients within the expected range of the full-scale projects

• No odor detectable from the RO concentrate influent

• Reduction in nitrogen concentration and mass consistent with general experience

• Wetlands technology can support healthy ecosystems, reduce concentrate volume, and polish effluent and reduce concentration of pollutants
Acknowledgements

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- Dr. Stephen Lyon – Mobile Environmental Solutions (MES)
- Mainstreet Architects and Planners
Questions?

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