Sub-surface Flow Wetlands –
Constructed Wastewater Treatment System

Village of Avoca - St. Clair County, Michigan

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Robert Wiley - St. Clair County Drain Commissioner
Dave Flowers, P.E. – Natural Water Solutions, Inc.

9th INTECOL International Wetlands Conference
June, 2012
The Village of Avoca had no sanitary system

- Wastewater (raw or semi treated) discharges into drain system
- Approximately 15,000 gpd
- E. coli detected in County Drain
- E. coli levels from >24,000 to > 240,000
The Project Solution

Standard Collection with Subsurface Wetland Wastewater Treatment System with a capacity of 20,000 gallons per day

- Funding Secured through a Clean Michigan Initiative (CMI) grant, United States Department of Agriculture (USDA) grant, and USDA low interest loans
- September 2009- Construction Began
- July 2010- System Start Up
The Collection System

#211 Drain
The Treatment System

- Lined Wetland Cells
- Septic Tanks
- Unlined Wetland Cells
- Main Pump Station
Why the Treatment Works

**Septic Tanks**
Provides Pre-Treatment (Settling of Solids & Removal of fats, oils and greases)

**Lined Wetland Cells**
Provide Nitrogen, BOD₅ (organic matter), and TSS Reduction

**Unlined Wetland Cells**
Provides added Polishing, then Dispersal

**Dispersal into the Soil Horizon**
Provides Phosphorus Reduction

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(cont.) Why it Works

- **Lined Wetland Cell**
  - BOD5 Reduction
  - Ammonia conv. - NO2
  - NO2 conv. – NO3
  - NO3 denitrification to N gas
    - Recycled Effluent -
    - Carbon addition from Septic Tank Discharge and Benthos!

- **Unlined Wetland Cell**
  - Cont. BOD5 reduction
  - Excellent TSS reduction from physical filtration in sand
  - Continued polishing and nutrient reduction through soil horizon
  - Phosphorous adsorption - soil horizon
Lined Wetland Cell

- PVC liner sandwiched between engineered fabric
- 18” of gravel and 6” of topsoil
- Leveling Structure to regulate water levels
- Entrance and exit plumbing
- Regional Native Wetland Plants

Aerial Photography courtesy of Frank Frisk, Photographer
Lined Wetland

Aerial Photography courtesy of Frank Frisk, Photographer
Unlined Wetland Cell

Aerial Photography courtesy of Frank Frisk, Photographer

- 4” Observation Tube
- 6” Pea Gravel
- 12” Sand
- Break in unlined wetland for surface flow to Drain #211
- Native Soil Surface (Plowed into Furrows)
Unlined Wetland Construction
Recycle Pump Stations

Other Unique Features

Leveling Structures

Distribution Valves

Patented
Natural System Treatment

Aerial Photography courtesy of Frank Frisk, Photographer

(c) Frank Frisk
**Effective Results**

Avoca, Michigan  
St. Clair County  
Subsurface Flow Wetland

Design Capacity  20,000 gal./day

Connections (lateral)  77 units

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Raw Influent</th>
<th>Final Effluent Permitted Monitoring Well</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Measured at Wet Well</td>
<td>Measured at MW Wells</td>
</tr>
<tr>
<td>BOD5 (mg/L)</td>
<td>210.98</td>
<td>3.40</td>
</tr>
<tr>
<td>TIN-N (mg/L)</td>
<td>25.62</td>
<td>0.65</td>
</tr>
<tr>
<td>NH3-N (mg/L)</td>
<td>24.66</td>
<td>0.14</td>
</tr>
<tr>
<td>NO2-N (mg/L)</td>
<td>0.08</td>
<td>0.02</td>
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<tr>
<td>NO3-N (mg/L)</td>
<td>0.88</td>
<td>0.50</td>
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<tr>
<td>Total-P (mg/L)</td>
<td>5.02</td>
<td>0.56</td>
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<tr>
<td>DO (mg/L)</td>
<td>2.83</td>
<td>4.91</td>
</tr>
<tr>
<td>Fecal Coli (CFU/100 mL)</td>
<td>10,000,000*</td>
<td>4.43</td>
</tr>
<tr>
<td>Chloride (mg/L)</td>
<td>416.70</td>
<td>157.48</td>
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<tr>
<td>pH</td>
<td>7.52</td>
<td>6.74</td>
</tr>
<tr>
<td>Sodium (mg/L)</td>
<td>290.00</td>
<td>38.89</td>
</tr>
<tr>
<td>Sulfate (mg/L)</td>
<td>92.50</td>
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* From Water Environment Literature
Avoca, Michigan  
St. Clair County  
Subsurface Flow Wetland

Design Capacity: 20,000 gal./day  
Connections (laterals): 77 units

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<tr>
<th>Parameter</th>
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<th>Lined Cell Outlet 1/2 way through System</th>
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<tr>
<td></td>
<td>Measured at Wet Well</td>
<td>Measured at Pump Tanks</td>
<td>Measured at Berm Toe</td>
<td>Measured at MW Wells Near Ditch</td>
</tr>
<tr>
<td>BOD5 (mg/L)</td>
<td>210.98</td>
<td>10.68</td>
<td>3.29</td>
<td>3.40</td>
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<td>NH3-N (mg/L)</td>
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<td>NO2-N (mg/L)</td>
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<td>Total-P (mg/L)</td>
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<td>416.70</td>
<td>400.19</td>
<td>336.58</td>
<td>157.48</td>
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<tr>
<td>pH</td>
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<td>6.97</td>
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<td>Sodium (mg/L)</td>
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<td>237.86</td>
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<tr>
<td>Sulfate (mg/L)</td>
<td>92.50</td>
<td>10.85</td>
<td>Not Measured</td>
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* From Water Environment Literature

* Measured at Wet Well

** Measured at Pump Tanks

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Other Systems

Town of Oakfield, Wisconsin
Sanitary District - 6,500 gpd

- Kettle Moraine Lutheran High School – 4,100 gpd