ONSITE TREATMENT

Amphidrome®
Agenda

• System Description
• Installation
• Locations
• Performance
• Questions
• Definition in Oceanography
  – The position in the ocean where the tide vanishes to zero
• Definition in Wastewater
  – A submerged attached-growth bioreactor (SAGB) in which the nitrogen vanishes to nearly zero
Amphidrome® Process Description

• Biological Nutrient Removal (BNR) Process
  – TSS
  – BOD$_5$
  – Total Nitrogen
  – Oil and Grease

• One Reactor
  – A submerged attached growth bioreactor (SAGB) operating in sequencing batch mode
  – SAGB is also commonly referred to as a BAF (biological aerated filter).
System Consists Of 2 Tanks And 1 Reactor

- Anoxic / Equalization Tank
- Amphidrome™ Reactor
- Clear Well Tank
Anoxic/Equalization Tank

- Solids settling
- Sludge storage
- Secondary functions
  - Buffers the dissolved oxygen in the recycled flow
  - Mixes recycle with influent organic carbon to promote de-nitrification
Main Reactor Function

- Media provides the surface area for biofilm growth
- Provides solids separation, eliminating the need for downstream clarification
- Intermittent aeration
  - Typically 3 minutes on 15 minutes off
Clearwell Function

- Stores batch volume
- Stores some fraction of backwash volume
- Contains backwash and effluent pumps (or Plus™ feed pumps)
Controls

Control Panel

- Touch Screen
- Remote Access
- Operator Can ‘tune’ the system
Amphidrome® System Benefits

• Highest Level of Nitrogen Removal of any system available

• Low Visual Impact

• Not affected by air temperature as are trickling filters

• All effluent filtered through deep sand bed to protect SAS
Installation
Three-tank system

Reactor

Clear Well

Anoxic
NANTUCKET, MASSACUSSETTS
SINGLE FAMILY HOME

REACTOR COVERS
Where can you find us?

• New England
• Pennsylvania
• North Carolina
• Maryland
• Minnesota
• Internationally
Performance

- **Plant:** Pleasant Bay Nursing Home
- **Location:** Brewster, MA
- **Design Flow:** 26,500 gpd

<table>
<thead>
<tr>
<th>Date</th>
<th>BOD5 (mg/L)</th>
<th>TSS (mg/L)</th>
<th>Total N (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 18, 12</td>
<td>5.07</td>
<td>6.3</td>
<td>4.79</td>
</tr>
<tr>
<td>Oct 26, 11</td>
<td>6.3</td>
<td>7.7</td>
<td>5.5</td>
</tr>
<tr>
<td>Mar 11, 11</td>
<td>5.07</td>
<td>6.3</td>
<td>4.79</td>
</tr>
<tr>
<td>Apr 11, 11</td>
<td>6.3</td>
<td>7.7</td>
<td>5.5</td>
</tr>
<tr>
<td>Jun 11, 11</td>
<td>5.07</td>
<td>6.3</td>
<td>4.79</td>
</tr>
<tr>
<td>Jul 11, 11</td>
<td>6.3</td>
<td>7.7</td>
<td>5.5</td>
</tr>
<tr>
<td>Aug 11, 11</td>
<td>5.07</td>
<td>6.3</td>
<td>4.79</td>
</tr>
<tr>
<td>Sep 11, 11</td>
<td>6.3</td>
<td>7.7</td>
<td>5.5</td>
</tr>
<tr>
<td>Oct 11, 11</td>
<td>5.07</td>
<td>6.3</td>
<td>4.79</td>
</tr>
<tr>
<td>Nov 11, 11</td>
<td>6.3</td>
<td>7.7</td>
<td>5.5</td>
</tr>
</tbody>
</table>

**Permit Limit:**
- BOD5: 30 mg/L
- TSS: 30 mg/L
- Total N: 10 mg/L

**Average:**
- BOD5: 5.07 mg/L
- TSS: 6.3 mg/L
- Total N: 4.79 mg/L
Performance

- **Plant:** Daniel Hand High School
- **Location:** Madison, CT
- **Design Flow:** 25,000 gpd

<table>
<thead>
<tr>
<th>Date</th>
<th>Total Nitrogen (mg/L)</th>
<th>BIOCHEMICAL OXYGEN DEMAND</th>
<th>TOTAL SUSPENDED SOLIDS</th>
<th>TOTAL NITROGEN</th>
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</thead>
<tbody>
<tr>
<td>5/13/2006</td>
<td></td>
<td>174 mg./L.</td>
<td>137 mg./L.</td>
<td>90 mg./L.</td>
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<tr>
<td>10/10/2006</td>
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<td>9.5 mg./L.</td>
<td>8.2 mg./L.</td>
<td>6.8 mg./L.</td>
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<tr>
<td>3/9/2007</td>
<td></td>
<td>9.5 mg./L.</td>
<td>8.2 mg./L.</td>
<td>6.8 mg./L.</td>
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<tr>
<td>8/6/2007</td>
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<td>9.5 mg./L.</td>
<td>8.2 mg./L.</td>
<td>6.8 mg./L.</td>
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<tr>
<td>1/3/2008</td>
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<td>9.5 mg./L.</td>
<td>8.2 mg./L.</td>
<td>6.8 mg./L.</td>
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<td>6/1/2008</td>
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<td>9.5 mg./L.</td>
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<td>10/29/2008</td>
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<td>9.5 mg./L.</td>
<td>8.2 mg./L.</td>
<td>6.8 mg./L.</td>
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</tbody>
</table>

*Effluent Influent Limit*
Performance

- Plant: Chili’s Resturant
- Location: Hingham, MA
- Design Flow: 7,670 gpd

<table>
<thead>
<tr>
<th>Date</th>
<th>BOD5</th>
<th>TSS</th>
<th>Total N</th>
</tr>
</thead>
<tbody>
<tr>
<td>07/21/08</td>
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<td>0</td>
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<tr>
<td>02/06/09</td>
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<td>08/25/09</td>
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<tr>
<td>03/13/10</td>
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<td>0</td>
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<tr>
<td>09/29/10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Limit (25 mg/L) Average (5.4 mg/L)
Performance

- **Plant:** Traditions Condos
- **Location:** Wayland, MA
- **Design Flow:** 10,320 gpd

<table>
<thead>
<tr>
<th>Date of Sample</th>
<th>Effluent Total N (mg/l)</th>
<th>Discharge Limit</th>
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</thead>
<tbody>
<tr>
<td>Nov-01</td>
<td>10.22 mg./L.</td>
<td>30 mg./L.</td>
</tr>
<tr>
<td>May-02</td>
<td>15.34 mg./L.</td>
<td>30 mg./L.</td>
</tr>
<tr>
<td>Dec-02</td>
<td>7.04 mg./L.</td>
<td>19 mg./L.</td>
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<tr>
<td>Jun-03</td>
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<td></td>
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<tr>
<td>Jan-04</td>
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<td></td>
</tr>
<tr>
<td>Aug-04</td>
<td></td>
<td></td>
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<td>Feb-05</td>
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<td>Sep-05</td>
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<tr>
<td>Mar-06</td>
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### Table

<table>
<thead>
<tr>
<th></th>
<th>BIOCHEMICAL OXYGEN DEMAND</th>
<th>TOTAL SUSPENDED SOLIDS</th>
<th>TOTAL NITROGEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERMIT LIMIT</td>
<td>30 mg./L.</td>
<td>30 mg./L.</td>
<td>19 mg./L.</td>
</tr>
<tr>
<td>EFFLUENT</td>
<td>10.22 mg./L.</td>
<td>15.34 mg./L.</td>
<td>7.04 mg./L.</td>
</tr>
</tbody>
</table>
Questions
Biochemical Transformations

- \( \text{CH}_2\text{O} + 0.309 \text{ O}_2 + 0.085 \text{ NH}_4^+ + 0.289 \text{ HCO}_3^- \Rightarrow 0.535 \text{ C}_5\text{H}_7\text{O}_2\text{N} + 0.633 \text{ CO}_2 + 0.515 \text{ H}_2\text{O} \) (aerobic)

- \( \text{NH}_4^+ + 3.30 \text{ O}_2 + 6.708 \text{ HCO}_3^- \Rightarrow 0.129 \text{ C}_5\text{H}_7\text{O}_2\text{N} + 3.373 \text{ NO}_3^- + 1.041 \text{ H}_2\text{O} + 6.463 \text{ H}_2\text{CO}_3 \) (aerobic)

- \( \text{NO}_3^- + 0.324 \text{ C}_{10}\text{H}_{19}\text{O}_3\text{N} \Rightarrow 0.226 \text{ N}_2 + 0.710 \text{ CO}_2 + 0.087 \text{ H}_2\text{O} + 0.027 \text{ NH}_3 + 0.274 \text{ OH}^- \) (anoxic)
BNR - Process Chemistry

• Oxidation of Carbonaceous BOD:

Oxidation:
COH + O₂ + Bacteria \Rightarrow CO₂ + other end products + energy
organic matter

Cell Synthesis:
COHNS + O₂ + Bacteria + energy \Rightarrow C₅H₇NO₂
organic matter new bacterial cells

Endogenous Respiration
C₅H₇NO₂ + 5 O₂ \Rightarrow 5 CO₂ + NH₃ + 2 H₂O + energy

Process Chemistry

• Oxidation of Nitrogen Based Compounds

\[ \text{NH}_4^+ + \frac{3}{2} \text{O}_2 \Rightarrow \text{NO}_2^- + 2\text{H}^+ + \text{H}_2\text{O} \]

Nitrosomonas Bacteria

ammonium nitrite

\[ \text{NO}_2^- + \frac{1}{2} \text{O}_2 \Rightarrow \text{NO}_3^- \]
nitrite nitrate

Nitrobacter

Overall Energy Reaction:

\[ \text{NH}_4^+ + 2 \text{O}_2 \Rightarrow \text{NO}_3^- + 2\text{H}^+ + \text{H}_2\text{O} \]

ammonium nitrate
Reduction of Nitrite & Nitrate:

The nitrate reducing bacteria are facultative anaerobic heterotrophs. Therefore, an organic carbon source is required. For the following equations methanol has been used as the carbon source.

First Energy Reaction:

\[ 6 \text{NO}_3^- + 2 \text{CH}_3\text{OH} \Rightarrow 6 \text{NO}_2^- + 2 \text{CO}_2 + 4 \text{H}_2\text{O} \]

<table>
<thead>
<tr>
<th>Nitrate</th>
<th>Methanol</th>
<th>Nitrite</th>
</tr>
</thead>
</table>

Second Energy Reaction:

\[ 6 \text{NO}_2^- + 3 \text{CH}_3\text{OH} \Rightarrow 3 \text{N}_2 + 3 \text{CO}_2 + 3 \text{H}_2\text{O} + 6 \text{OH}^- \]

<table>
<thead>
<tr>
<th>Nitrite</th>
<th>Methanol</th>
<th>Nitrogen Gas</th>
</tr>
</thead>
</table>
Heterotrophic Cell Synthesis:

\[ 3 \text{NO}_3^- + 14 \text{CH}_3\text{OH} + \text{CO}_2 + 3 \text{H}^+ \rightarrow 3 \text{C}_5\text{H}_7\text{O}_2\text{N} + \text{H}_2\text{O} \]

nitrate + methanol \rightarrow Biomass

Overall Nitrate Removal

\[ \text{NO}_3^- + 1.08 \text{CH}_3\text{OH} + 3 \text{H}^+ \rightarrow 0.065 \text{C}_5\text{H}_7\text{O}_2\text{N} + 0.47 \text{N}_2 + 0.76 \text{CO}_2 + \text{H}_2\text{O} \]

nitrate + methanol \rightarrow Biomass