Acknowledgements
Topics for Today’s Presentation

1. Side Stream Treatment Overview
   • What is side stream treatment?
   • Different types of side stream treatment systems

2. Side Stream Treatment Planning for City’s Bioenergy Recovery Project
   • Bioenergy Recovery Program overview (Quick Recap)
   • Drivers for side stream treatment at NRRRF
   • Process considerations for treating high strength filtrate
   • Side stream treatment systems considered
   • LIFT SEE IT site visit of short-cut nitrogen removal systems
   • Next Steps
Side Stream Treatment Overview
What is Side Stream Treatment?

- Separate treatment of solids handling recycle streams
- Lessen impacts of recycle nutrient loads on main treatment process
  - Small volume, high nutrient load
  - Intermittent solids handling operations can impact peak loads
  - Potential to impact main stream nutrient removal process
    - Ammonia break through
    - Increased air demands
    - Increased chemical demands
    - Variable performance
Different Types of Side Stream Treatment

Equalization

Biological Nitrogen Removal Systems

Chemical Phosphorus Removal or Phosphorus Recovery System
Equalization

- Attenuate flows and/or loads from solids handling operation
- Reduce potential for ammonia break through
- Reduce fluctuations on air demands
- Reduce fluctuations on supplemental carbon demands
Side Stream Short-Cut Nitrogen Removal

- Biologically treat nitrogen in side stream treatment process
- Often use “Short-Cut” nitrogen cycle
  - Reduce air required
  - Reduce / eliminate carbon
  - Several different systems available
Side Stream Phosphorus Removal

• Add coagulant for chemical phosphorus removal

• Or utilize process to recover phosphorus
  • Add chemicals to produce struvite in controlled environment
  • Obtain phosphorus rich product that can be used as fertilizer
  • Several different systems available
Side Stream Treatment Planning for Bioenergy Recovery Project
Neuse River Resource Recovery Facility

- Currently expanding from 60 to 75 mgd
- Planning for expansion to 90 mgd (~2040)
- Centralized biosolids processing
  - Lime stabilization, composting, and some Class B liquid land application
- Converting to advanced digestion (Thermal Hydrolysis)
- Includes side stream nitrogen removal for Phase 1
NRRRF Existing Process Flow Diagram
Proposed Biosolids Process
Visualization of the New Residuals Handling Complex (30-Percent Design Concept)
Side Stream Treatment - Drivers
Drivers for Side Stream Nitrogen Removal

- Improved VSR across digestion increases nutrient mass loadings in the sidestream. (+20%)

- Deammonification offers a reduced energy and reduce carbon pathway for nitrogen removal.
  - ~$600,000 additional O&M costs to treat in main stream process at current flows and loads

✓ No Carbon
✓ 60% less air
Drivers for Side Stream Phosphorus Removal

- Improved VSR across digestion increases nutrient mass loadings in the side stream
  - Increased risk for struvite precipitation
  - Opportunities for P recovery

- Side stream TP loads significantly lower with chemical P vs. biological P removal
  - Plan to stay with chemical P removal for now at NRRRF
  - Provisions for side stream alum addition at multiple locations

- Site layout allows for space for future phosphorus recovery

<table>
<thead>
<tr>
<th>Description</th>
<th>50% Ultimate</th>
<th>Ultimate</th>
<th>Side Stream TP Concentration (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side Stream TP Load with Chemical P Removal (lbs/day)</td>
<td>240</td>
<td>470</td>
<td>94</td>
</tr>
<tr>
<td>Side Stream TP Load with Biological P Removal (lbs/day)</td>
<td>710</td>
<td>1,420</td>
<td>284</td>
</tr>
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</table>
Process Considerations for Treating High Strength Filtrate
NRRRF Projected Side Stream Loads

- TKN and NH\textsubscript{4} loads from BioWin Modeling, mass balance, and literature
- BOD, COD, CODs, Alkalinity values estimated from literature and other facilities
- Ultimate design based on 90 MGD Design Flow (2040)
  - Install 1 train designed to treat 50% of ultimate (90 MGD) load now
- 1x Dilution Water – Necessary for effects of high COD in THP Effluent

<table>
<thead>
<tr>
<th>Description</th>
<th>50% Ultimate</th>
<th>Ultimate</th>
<th>Diluted Conc (mg/L)</th>
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<tbody>
<tr>
<td>Sidestream Flow (mgd)</td>
<td>0.15</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Dilution Water Flow (mgd)</td>
<td>0.15</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>TKN (lb N/day)</td>
<td>3,375</td>
<td>6,750</td>
<td>1,350</td>
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<tr>
<td>NH\textsubscript{3} (lb N/day) (85% of TKN)</td>
<td>2,869</td>
<td>5,738</td>
<td>1,150</td>
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<tr>
<td>BOD (lb/day)</td>
<td>125-1,000</td>
<td>250-2,000</td>
<td>50 – 400</td>
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<tr>
<td>COD (lb/day)</td>
<td>7,874</td>
<td>15,748</td>
<td>3,150</td>
</tr>
<tr>
<td>CODs (lb/day)</td>
<td>6,750</td>
<td>13,500</td>
<td>2,700</td>
</tr>
<tr>
<td>TSS (lb/day)</td>
<td>1,751</td>
<td>3,503</td>
<td>700</td>
</tr>
<tr>
<td>Alkalinity (lb/day)</td>
<td>10,125</td>
<td>20,250</td>
<td>4,050</td>
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## THP Digestate Challenges

<table>
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<tr>
<th>Challenge</th>
<th>Issues</th>
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<tr>
<td>High TKN</td>
<td>• Potential to inhibit AOBs</td>
</tr>
<tr>
<td></td>
<td>• Alkalinity and NH$_3$-N balance</td>
</tr>
<tr>
<td>High COD</td>
<td>• Potential to Inhibit AOBs</td>
</tr>
<tr>
<td></td>
<td>• Increased competition between anamox and heterotrophs</td>
</tr>
<tr>
<td>High TP</td>
<td>• Increased risk for struvite formation</td>
</tr>
<tr>
<td>Other</td>
<td>• Elevated TSS</td>
</tr>
<tr>
<td></td>
<td>• Elevated Polymer</td>
</tr>
<tr>
<td></td>
<td>• Diffusion Limitations</td>
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## Example Short-Cut Nitrogen Removal “Process Enhancement” Strategies

<table>
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<tr>
<th>Strategy</th>
<th>Benefits</th>
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<tbody>
<tr>
<td>Dilute filtrate (≥1:1)</td>
<td>• Reduce AOB inhibition to high ammonia and COD (Figdore et al, 2011)</td>
</tr>
<tr>
<td>AOB in suspension; annamox on media (ANITA™ Mox IFAS configuration)</td>
<td>• Improve substrate diffusion (Zhao et al)</td>
</tr>
<tr>
<td>Higher operating DO</td>
<td>• Reduce oxygen diffusion limitation (Zhang et al, 2016)</td>
</tr>
<tr>
<td>Better annamox selection</td>
<td>• Increase annamox retention (Zhang et al, 2016)</td>
</tr>
<tr>
<td>Pretreat filtrate</td>
<td>• Reduces struvite potential; reduces annamox competition (Remy et al, 2016)</td>
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Proposed Side Stream Treatment Systems for NRRRF
General Process Flow Diagram – Side Stream Nitrogen Removal

1. **Anaerobic Digester**
   - Heated Dilution Water for Dewatering (approximately 1X) (Solids)
   - Dewatering

2. **Side Stream Equalization Pump Station**

3. **Equalization Tank**
   - Heated Dilution Water (if necessary)

4. **Sidestream Bioreactor**
   - To RAS Channel

5. **Side Stream Influent Pump Station**
Side Stream will use Deammonification

- **Short-Cut Nitrogen Removal**
- **Ammonia Oxidizing Bacteria (AOB)**
  - Aerobically convert $\frac{1}{2}$ of ammonia to nitrite
- **Anaerobic Ammonia Oxidizing Bacteria (annamox)**
  - Oxidize ammonia under anoxic conditions
  - Utilize nitrite as oxygen source
- **No carbon needed**
- **Some residual NO$_3$-N**
Deammonification Technologies Considered

- Two Recommended from PER
  - World Water Works conDEA™
  - Kruger ANITA™ Mox IFAS

<table>
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<tr>
<th>Reactor configuration</th>
<th>WWW conDEA™</th>
<th>Kruger ANITA™ Mox IFAS</th>
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<tbody>
<tr>
<td>Flow Through</td>
<td>Flow Through</td>
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<table>
<thead>
<tr>
<th>Biomass characteristic</th>
<th>WWW conDEA™</th>
<th>Kruger ANITA™ Mox IFAS</th>
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<tbody>
<tr>
<td>Flocs and granules</td>
<td></td>
<td>Biofilm on media and flocs (IFAS)</td>
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<tr>
<th>Proprietary retention strategy</th>
<th>WWW conDEA™</th>
<th>Kruger ANITA™ Mox IFAS</th>
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<tbody>
<tr>
<td>Micro-Screen and Lamella Plate Settlers</td>
<td></td>
<td>Plastic carriers, screens, and clarifier</td>
</tr>
</tbody>
</table>

**Process Diagram**

- WWW conDEA™: Flow Through process with Micro-Screen and Lamella Plate Settlers.
- Kruger ANITA™ Mox IFAS: Flow Through process with Biofilm on media and flocs (IFAS) and plastic carriers, screens, and clarifier.
World Water Works conDEA™

- Continuous flow through process
- Annamox bacteria suspended in granular form
  - MicroScreen is used to retain anammox and waste NOB
    - Selects for large anammox granules
    - 100% of flow can best through screen if clarifier upset
- Messner Panel Aeration (Fine bubble)
- New Lamella clarifier for solids separation
- Strass is running with MicroScreen configuration
- No US installations yet using revised configuration
Kruger ANITA™ Mox IFAS

- Continuous flow through process
- Anammox bacteria colonized on plastic media carriers
- Medium Bubble Aeration System
- Majority of AOBs are in the suspended phase (Zhao et al)
- Clarifier used for solids return, waste from RAS line to maintain design liquid phase SRT
- No US installations of sidestream IFAS system
ANITA™ Mox – MBBR vs. IFAS Configuration

MBBR

- Biofilm
- Media
- Liquid
- Nitritation
- AOB
- Anammox
- Aerobic
- Anaerobic
- $O_2 = 0.5-1.5$ mg/L
- $N_2$

IFAS

- Flocs (~3 g/L)
- Media
- Liquid
- Nitritation
- AOB
- Anammox
- Anaerobic
- $O_2$ 0.2-0.5 mg/L
- $N_2$

Figures courtesy of Veolia (with permission)
New to US Marketplace: Ovivo-Paques AnammoPAQ™

<table>
<thead>
<tr>
<th>Design Info</th>
<th>AnammoPAQ</th>
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<tr>
<td>Reactor configuration</td>
<td>Flow Through</td>
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<tr>
<td>Biomass characteristic</td>
<td>Granules</td>
</tr>
<tr>
<td>Proprietary retention strategy</td>
<td>Inclined Plate Settlers – weight-based selection</td>
</tr>
</tbody>
</table>

Figures courtesy of PAQUES / Ovivo
New to US Marketplace: Ovivo-Paques AnammoPAQ™

• Continuous flow through process
• Completely granular system
• Anammox and AOB bacteria co-exist on granules
• No RAS; Single pass operation
• Granules retained in system through separator
• Occasional “sluicing” of excess granules
• 35 references (0 in USA/1 downstream of THP)
  • Largest unit 10 metric tons of nitrogen/day
  • Install at Olburgen in service for 10 years
• Purportedly higher loading rate
WWW conDEA Layout for NRRRF

- Equalization Tanks
- Submersible Sidestream EQ Pumps (below)
- conDEA Tank
- Blowers
- Electrical Building and RAS Pumping
- Microscreen
- Lamella Clarifier
- Sidestream EQ Pumps (below)
- Submersible Blowers
Messner Panels

Effluent weir to clarifier

EQ Mixing with Invent Mixers

Concrete supports for cover and Microscreen

Submersible Mixers

RAS Pumps & Piping

Submersible Mixers
EQ Mixing with STAMO Mixers

Medium Bubble Diffusers

Media Retention Screens (4)

Concrete supports for cover and mixers

STAMO Mixer

Effluent weir to clarifier

RAS Pumps & Piping
“The LIFT Scholarship Exchange Experience for Innovation & Technology Program (SEE IT) is an initiative spearheaded by WE&RF, WEF, and NACWA to provide scholarships for utility personnel to visit other utilities with innovations of interest and to share experiences with their peers”

http://www.werf.org/lift/LIFTSEE_IT.aspx
World Water Works conDEA™, Amersfoort, NL

conDEA reactor  Cyclone separation device  Process Flow diagram  MLSS from Reactor  Clarifier wet well in center of reactor
Ovivo-Paques AnammoPAQ™, Olburgen, NL
Veolia ANITA™ Mox IFAS, Boras, Sweden

- IFAS System
- Media retention screens
- Stamo Mixer
- Foam Air Lift Pump
- IFAS Clarifier
Next Steps

• Regroup on LIFT SEE IT Site Visit Findings with Design Team

• Finalize selection criteria (cost and non-cost)

• Develop weighted scoring system

• Obtain updated proposals

• Evaluate using selection criteria and weighted scoring system

• Finalize selection and move forward with final design of side stream treatment system
Thank You!