Fond du Lac Low Level Phosphorus Efforts & SNRP Overview
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CSWEA Resource Recovery Seminar
November 10, 2016

Presented By:
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Co-Author:
Jeremy Cramer, Wastewater Superintendent  Fond du Lac WWTP
Presentation Outline

- Facility Background
- P Reduction Efforts/Optimization
- Phosphorus Speciation
- Next Steps
Fond du Lac Plant Details - Liquid Flow

Influent → Primary Clarification → Nitrification/Denitrification Aeration Basins → Secondary Clarification → UV Disinfection

Fine Screening & Grit Removal → Ferric Chloride
Fond du Lac Plant Details - Solids Flow

- Primary Sludge & WAS
- Primary Solids & WAS
- Thermophilic Digesters 1
- Thermophilic Digesters 2
- HSW Addition
- Mesophilic Digesters (3 & 4)
- Centrifuge
- Cake – land application
- Centrate – to Primary Clarifiers
Fond du Lac WWTP Service Area
# Problems With This Schedule

<table>
<thead>
<tr>
<th>Item</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permit Effective</td>
<td>1/1/13</td>
</tr>
<tr>
<td>Operational Evaluation Report</td>
<td>12/31/13</td>
</tr>
<tr>
<td>Study of Feasible Alternatives:</td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td>12/31/13</td>
</tr>
<tr>
<td>Status Report</td>
<td>12/31/14</td>
</tr>
<tr>
<td>Preliminary Compliance Plan</td>
<td>12/31/15</td>
</tr>
<tr>
<td>Final Compliance Plan</td>
<td>12/31/16</td>
</tr>
<tr>
<td>Statewide Multidischarger Variance</td>
<td>2016-17?</td>
</tr>
<tr>
<td>Upper Fox/Wolf Total Maximum Daily Load for P</td>
<td>2017?</td>
</tr>
<tr>
<td>Design Treatment Improvements</td>
<td>2017-2018</td>
</tr>
<tr>
<td>Achieve Compliance with 0.04 mg/L</td>
<td>1/1/2022</td>
</tr>
</tbody>
</table>
# WQBEL Phosphorus Limit

<table>
<thead>
<tr>
<th>Limit</th>
<th>Total Phosphorus Concentration (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current/Interim Limit</td>
<td>1.0</td>
</tr>
<tr>
<td>Future WQBELs</td>
<td></td>
</tr>
<tr>
<td>Six-Month Average(^1)</td>
<td>0.04 (3.3 lb/day)</td>
</tr>
<tr>
<td>Monthly Average</td>
<td>0.12</td>
</tr>
</tbody>
</table>

\(^1\)Averaging periods are May to October and November to April.
I/I Effects

Peak Flow: 48 MGD
Average Flow: 8 MGD

MGD

3/30/16 4/1/16 4/2/16 4/3/16 4/4/16 4/5/16

11 MGD
AF3

5/30 13.76 MGD 0.99” rain
5/31 9.77 MGD 0.32” rain
6/1 8.96 MGD
6/2 8.31 MGD

6/11 15.81 MGD
6/12 18.22 MGD 2.47”
6/13 12.14 MGD
6/14 11.41 MGD
6/15 11.06 MGD 0.18”
6/16 10.26 MGD 0.26”
6/17 9.22 MGD

Autumn Fisher, 5/9/2016
P Reduction Efforts/Optimization

- User education
- Eliminate Poly P from drinking water
- Jar Testing (SorbX, Alum, Ferric, PACl)
- Optimize full scale P removal chemical (SorbX, Alum, Ferric)
- Promote BPR
- Pilot studies
Fond du Lac P Trend

Average Total Phos Load (lbs/Day)

Influent P Load (lbs/day)

Effluent P Load (lbs/day)
Watershed Efforts

- Opportunity for a TMDL established waste load allocation in lieu of 0.04 mg/L WQBEL
FDL County Sampling Sites
Watershed Sampling Results 2015-2016
Jar Testing Results

- Ferric
- Alum
- PAC
- SorbX

Chemical Dose ppmV vs. TP Concentration mg/L
Full Scale SorbX

Dec 2-Dec 29
421 gpd SorbX (62 ppmv)
0.14 mg/L TP
COMAG® Ballasted Settling System

- September 16, 2013 - October 15, 2013
- Avg operating pilot flow = 50 gpm
- Range of coagulant dosages used to generate dose-response curves
## COMAG® Ballasted Settling System

### Coagulant Performance

<table>
<thead>
<tr>
<th>Coagulant</th>
<th>Pilot Influent TP Average</th>
<th>Pilot Effluent TP Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alum</td>
<td>1.0 mg/L</td>
<td>0.039 mg/L</td>
</tr>
<tr>
<td>Ferric Chloride</td>
<td>0.99 mg/L</td>
<td>0.025 mg/L</td>
</tr>
<tr>
<td>PACl</td>
<td>0.93 mg/L</td>
<td>0.036 mg/L</td>
</tr>
</tbody>
</table>
Ovivo TriSep Membranes

March 18, 2015 – April 23, 2015

- iSep™ 500-PVDF UF membrane
- 6 gpm pilot unit
### Ovivo TriSep Membranes

<table>
<thead>
<tr>
<th>Coagulant</th>
<th>Influent TP Average</th>
<th>Effluent TP Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alum</td>
<td>0.70 mg/L</td>
<td>0.06 mg/L</td>
</tr>
<tr>
<td>SorbX-100</td>
<td>0.23 mg/L</td>
<td>0.07 mg/L</td>
</tr>
</tbody>
</table>

- SorbX found to be incompatible with UF membrane
ACTIFLO® Ballasted Settling System

- June 1st – June 19th 2015

<table>
<thead>
<tr>
<th>Coagulant</th>
<th>Influent TP Average</th>
<th>Effluent TP Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferric Chloride</td>
<td>0.40 mg/L</td>
<td>0.038 mg/L</td>
</tr>
<tr>
<td>Alum</td>
<td>1.08 mg/L</td>
<td>0.105 mg/L</td>
</tr>
<tr>
<td>SorbX-100</td>
<td>1.23 mg/L</td>
<td>0.062 mg/L</td>
</tr>
</tbody>
</table>

Source: Veolia
Aqua-Aerobic Systems AquaDisk® CMF and UF

- September 29 – October 27, 2015
- Cloth media filter and ultrafiltration filter
- SorbX used for secondary phosphorus removal for most of pilot – switched to alum toward end of pilot

Source: Aqua-Aerobic Systems Inc.
Aqua-Aerobic Systems AquaDisk® CMF and UF

<table>
<thead>
<tr>
<th>Coagulant</th>
<th>Influent TP Average</th>
<th>Cloth TP Average</th>
<th>Membrane TP Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferric</td>
<td>0.76 mg/L</td>
<td>0.20 mg/L</td>
<td>0.028 mg/L</td>
</tr>
<tr>
<td>Alum</td>
<td>0.67 mg/L</td>
<td>0.17 mg/L</td>
<td>0.022 mg/L</td>
</tr>
<tr>
<td>SorbX</td>
<td>0.52 mg/L</td>
<td>0.07 mg/L</td>
<td>0.022 mg/L</td>
</tr>
</tbody>
</table>
Clearas Water Recovery

- August 9, 2016 to November 10, 2016
- Advanced Biological Nutrient Recovery (ABNR™) System
- Tertiary treatment system using suspended algae
- Removes phosphorus and nitrogen
- Increases dissolved oxygen
- Produces potentially marketable product
Clearas Water Recovery Results

<table>
<thead>
<tr>
<th>Influent TP Average</th>
<th>Effluent TP Average *</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.56 mg/L</td>
<td>0.031 mg/L</td>
</tr>
</tbody>
</table>

* Excludes data from pilot leak and electrical malfunction
## Alternatives Cost Summary

<table>
<thead>
<tr>
<th>Alternative</th>
<th>20-Year Present Worth Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advance TP Removal</td>
<td></td>
</tr>
<tr>
<td>CoMag</td>
<td>$37,000,000</td>
</tr>
<tr>
<td>Blue PRO</td>
<td>$70,300,000</td>
</tr>
<tr>
<td>Ovivo TFS</td>
<td>$131,000,000</td>
</tr>
<tr>
<td>ACTIFLO</td>
<td>$32,800,000</td>
</tr>
<tr>
<td>Aqua Aerobic DF</td>
<td>$23,100,000</td>
</tr>
<tr>
<td>Aqua Aerobic DF + UF</td>
<td>$50,100,000</td>
</tr>
<tr>
<td>Clearas</td>
<td>$19,000,000</td>
</tr>
<tr>
<td>Watershed AM</td>
<td>$19,100,000</td>
</tr>
<tr>
<td>WQT</td>
<td>$16,700,000</td>
</tr>
<tr>
<td>Statewide Variance</td>
<td>$8,000,000</td>
</tr>
</tbody>
</table>
Phosphorus Speciation

- Phosphorus fractions/species
  - Organic
  - Inorganic
  - Broken down further
    - Insoluble, polymerized, organically bound, soluble non-reactive (SNRP), and more

- Fond du Lac’s typical phosphorus fractions
  - Pre-dominantly soluble reactive but some soluble non-reactive (SNRP)
    - Average SNRP: 0.069 mg/L
  - Varies from plant to plant depending on type of P removal (chem, bio or filtration) and industrial contributors
Phosphorus Speciation

- **What is soluble non-reactive phosphorus (SNRP)**
  - Soluble TP – Soluble RP = SNRP
  - Majority soluble organic
  - Remainder soluble polymerized

- **Why is SNRP concentration important**
  - Not readily treatable in low levels
    - Some removal with sufficient chemical dosing and ultra filtration and/or a ballasted settling process
  - SNRP may affect our ultimate decision on how we try to meet our 0.04 mg/L limit
Fond du Lac’s Method

- **Terminology**
  - **Particulate**
    - Species retained by a 0.45 µm filter
  - **Soluble/dissolved/filterable**
    - Passes through a 0.45 µm filter
    - Appears to contain some colloidal fractions as well
  - **Ortho/reactive**
Fond du Lac’s Method

- **Difference in methods/options**
  - Vacuum filtration
  - Syringe filtration

- **Difficulties in sampling**
  - Dirtier the sample, longer the filtration takes
  - Coarse filter and then fine filter to make it easier
  - Centrifuge and then filter
Fond du Lac’s Method

- WSLH study for method confirmation
  - At lower concentrations the relative percent differences (RPDs) between labs tends to increase
  - The WiDNR generally recommends 10% RPD but at lower concentrations says a RPD of as much as 25% may be acceptable
WSLH vs FDL Soluble Phosphorus Results

Soluble Phosphorus Concentration (mg/L)

Sample Date

- WSLH
- FDL
Average SNRP: 0.069 mg/L

Proposed Limit: 0.04 mg/L
Influent vs Effluent SNRP Removal

Average SNRP Removal
76%

SNRP (mg/L)

Influent SNRP
Effluent SNRP
Average SNRP By Day of the Week

Day of the Week

SNRP mg/L

Sunday 0.054
Monday 0.053
Tuesday 0.080
Wednesday 0.080
Thursday 0.074
Friday 0.074
Saturday 0.062
<table>
<thead>
<tr>
<th>Coagulant</th>
<th>TP Average</th>
<th>SNRP Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>SorbX (11/1/14 – 10/1/15)</td>
<td>0.64 mg/L</td>
<td>0.085 mg/L</td>
</tr>
<tr>
<td>Alum (10/5/15 – 7/4/16)</td>
<td>0.74 mg/L</td>
<td>0.064 mg/L</td>
</tr>
<tr>
<td>Ferric (7/5/16 – Present)</td>
<td>0.63 mg/L</td>
<td>0.037 mg/L</td>
</tr>
</tbody>
</table>

SNRP By Chemical... or Bio P?
Pilot Phosphorus Results - SNRP

**Ovivo Ultrafiltration**

- Influent 0.56 mg/L TP
- Effluent 0.076 mg/L TP

**Kruger Actiflo**

- Influent 0.95 mg/L TP
- Effluent 0.064 mg/L TP
Pilot Phosphorus Results - SNRP

**Aqua**
- Influent 0.69 mg/L TP
- Effluent 0.167 / 0.025 mg/L TP

**Clearas**
- Influent 0.56 mg/L TP
- Effluent 0.031 mg/L TP
Next Steps

• SNRP Reduction
  ▫ Why – chemical or biological?

• Continue to promote BPR
  ▫ Install deammonification system in 2017

• Nutrient Harvesting

• Survey other facilities

• Monitor TMDL progress/waste load allocations

• WiDNR recommendations/comments
Acknowledgements

• Fond du Lac WWTP Staff
• Strand Associates, Inc.
• Donohue & Associates, Inc. – Eric Lynne
• CH2M, Inc.
• Pilot Manufacturers
• Manufacturer Reps (Mulcahy Shaw Water)
Permit Effective: 1/1/2013
Operational Evaluation Report Due: 12/31/2013
Status Report: 12/31/2014
Preliminary Alternatives Compliance Plan: 12/31/2015
Final Compliance Alternatives Plan: 12/31/2016

Lake/River Sampling: 5/1/2013
Watershed Sampling: 5/1/2015

Alum: 1/1/2013 - 10/31/2014
SorbX: 11/1/2014 - 10/1/2015
Operational Evaluation Report: 12/31/2013
Status Report: 12/31/2014
Preliminary Alternatives Compliance Plan: 12/31/2015
Actiflo: 6/1/2015 - 6/19/2015
CoMag: 9/16/2013 - 10/15/2013

Sampling:
Lake/River: 5/1/2013
Watershed: 5/1/2015

Timeline:
Jan, May, Sep, 2014, May, Sep, 2015, May, Sep, 2016, May, Sep
Questions

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