So You’ve Removed Your Phosphorus? Now What?

JTAC Luncheon – April 9th, 2014
Agenda

- RWHTF and Upcoming Regulatory Requirements
- Biological Phosphorus Removal Outcomes
- Liquid and Solids Stream Interactions
- Laboratory Requirements for New Processes
- The Emerging Plan: Managing Overlapping Impacts
Robert W. Hite Treatment Facility
RWHTF Current Treatment

Primary Treatment

Secondary Treatment

Sidestream Reactor

RAS

Digester

Centrifuge

Centrate (recycle flow)

TKN = 40
TP = 6.5
TP = 3.35

TN ~ 12
TP ~ 3.0
TP = 2.35

TP = 1.0

TP conc. – mg/L
TP load – tpd
Notes:

(1) – Permits are renewed every 5 years. Compliance schedules to be negotiated during permit renewal.
Biological Phosphorus Removal

- Near-term and long-term drivers.
- Achieve a Total Phosphorus concentration of <1.0 mg-P/L.
- Reduce or eliminate the need for supplemental carbon addition.
- Optimize the District’s effluent phosphorus Coefficient of Reliability (COR) to reduce Tertiary Treatment Facility sizing.
Biological Phosphorus Removal

- Sidestream approach in the North Secondary
- A2O in the South Secondary

TP = 0.58 mg-P/L
OP = 0.10 mg-P/L
Biological Phosphorus Removal

- Full-scale demonstration provided the District with valuable insight into future impacts.

- Several O&M cost centers observed significant budget impacts from EBPR.
Biological Phosphorus Removal

- Management of Phosphorus Recycle Load

TP = 1.8 mg-P/L
OP = 1.8 mg-P/L

TP = 0.58 mg-P/L
OP = 0.16 mg-P/L
Biological Phosphorus Removal

- Degradation of Dewatering Performance
- Impact of changing chemical characteristics in digested sludge.
Biological Phosphorus Removal

- Significant Increase in Struvite Accumulation
- Further impact of changing chemical characteristics in digested sludge.
### Biological Phosphorus Removal

**Increased Phosphorus Load in Biosolids**

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>% Biosolids Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>METROGRO Farm</td>
<td>Wheat 17%</td>
</tr>
<tr>
<td>Private (Dryland)</td>
<td>Wheat 30%</td>
</tr>
<tr>
<td>Private (Irrigated)</td>
<td>Corn/Wheat 54%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Irrigated Site Evaluation</th>
<th>Irrigated Site Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated Sites Scored</td>
<td>11 out of 84</td>
</tr>
<tr>
<td>Avg. COPI Score – Current Operations</td>
<td>9-10</td>
</tr>
<tr>
<td>Avg. COPI Score – with future EBPR operations</td>
<td>12</td>
</tr>
</tbody>
</table>
Liquid/Solids Stream Interactions

- Why is biological phosphorus removal impacting multiple other processes?
  - Increasing phosphorus load in WAS.
  - Release of phosphate in anaerobic digestion.
  - Changing chemical characteristics of solids streams due to biological process requirements.
  - Undetermined interactions between different sludge qualities and dewatering polymers/equipment.
INFLUENT:
TKN = 22.2 tpd (40 mg/L)
TP = 3.6 tpd (6.5 mg/L)

EFFLUENT:
TN ~ 5.5 tpd (10 mg/L)
TP ~ 0.3 tpd (0.6 mg/L)

Primary Treatment

Side stream Reactor

TP ~ 0.4 tpd

Secondary Treatment

PO₄³⁻, K⁺, Na⁺, Mg²⁺, Ca²⁺ Uptake

PO₄³⁻, K⁺, Na⁺, Mg²⁺, Ca²⁺ Release

Digester

TP ~ 1.7 tpd

Centrate (recycle flow)

Ferric Chloride

Centrifuge

SOLIDS:
TP ~ 3.3 tpd
Liquid/Solids Stream Interactions

- $\text{PO}_4^{3-}$ release increases centrate concentration.
- Increasing $\text{PO}_4^{3-}$, $\text{Mg}^{2+}$ ions can combine with available $\text{NH}_4^+$ ions to cause struvite precipitation.
- $\text{PO}_4^{3-}$, Monovalent:Divalent cation ratios may be underlying cause of dewaterability deterioration.
- Under current configurations, metal salt precipitation forces phosphorus into biosolids.
The Future: Understanding the Present

- What do we do to control the multiple impacts?

- The first step is to obtain background information.
Laboratory Requirements

- Increased workload for existing analyses
  - *TP, OP, Cations*
    - Background data → Process Control Monitoring
- Development of new methods
  - *WEP, LDT*
- Preventative monitoring
  - *Struvite*
Lab Sample Count Breakdown for Phosphorus Analyses

- Water Quality: 2053, 1847, 1548
- Pretreatment: 5, 3, 8
- Contract: 457, 323, 241
- Biosolids: 136, 132, 235
- Process Control: 916, 1326, 2467
- Quality Control: 68, 42, 67

- Pre-EBPR (2/1/2011 - 10/31/2011)
- EBPR (11/1/2011 - 7/31/2012)
- Post-EBPR (8/1/2012 - 4/30/2013)
New Method Development: WEP

- Water Extractable Phosphorus
  - Used in P-Indexing for land application of biosolids
    - Suggested method: *Universal Water Extractable P Test for Manure and Biosolids* (Kleinman et al., 2007)
  - Undefined parameter testing
    - Holding time
    - Spike recovery
    - ICP vs. colorimetry

![Graph showing water extractable phosphorus levels over time](image-url)
New Method Development: LDT

- Limit Dryness Testing
  - Self-referencing metric for sludge dewaterability
  - Method Development → Parameter Experimentation → Long-term Monitoring

![Graph showing changes in moisture content over time for different sludge samples.]
Preventative Monitoring: Struvite

- Monitor key analytes through grab sampling locations through centrate lines

- **pH**
  - Process Building
  - Holding Tank
  - CaRRB feed

- **NH₃**

- **Mg, soluble**
The Emerging Plan

- Multiple impacts must be managed simultaneously
  - Optimize the Coefficient of Reliability to reduce capital and O&M costs.
  - Perform in-depth phosphorus studies and demonstrations to reduce uncertainty.
  - Construct necessary processes for long-term cost optimization and perform piloting work for tertiary facilities.
Coefficient of Reliability

- Tertiary Treatment Facility represents $380 million capital expense.
- Opportunities to reduce flocculation/sedimentation/filtration sizing by reducing conservatism.
- Consistently low effluent soluble phosphorus concentrations can create significant savings.
Coefficient of Reliability

- Optimize carbon use throughout the secondary processes to simultaneously remove phosphorus and nitrogen.
Coefficient of Reliability

- Reducing the centrate phosphorus recycle load is critical.
- Ferric chloride addition is the baseline.
- Pilot study completed on centrate struvite precipitation.
Phosphorus Recovery

**INFLUENT:**
- TKN = 22.2 tpd (40 mg/L)
- TP = 3.6 tpd (6.5 mg/L)

**EFFLUENT:**
- TN ~ 5.5 tpd (10 mg/L)
- TP ~ 0.3 tpd (0.6 mg/L)

**SOLIDS:**
- TP ~ 2.0 tpd

---

**Diagram:**
- Primary Treatment
- Secondary Treatment
- Side stream Reactor
- RAS
- Centrifuge
- Digester
- Phosphorus Recovery

**Flow:**
- INFLUENT: TKN = 22.2 tpd (40 mg/L) TP = 3.6 tpd (6.5 mg/L) → Secondary Treatment → Side stream Reactor → RAS → Digester → Centrifuge → Phosphorus Recovery → SOLIDS: TP ~ 2.0 tpd
Phosphorus Recovery

- Centrate phosphorus recovery option achieves the phosphorus recycle load control objective.
- Alternative locations for phosphorus recovery may meet additional objectives for:
  - Dewatering
  - Struvite Control
  - Digester Capacity
  - Land Application
  - Sustainability
Phosphorus Recovery

- Post-digestion phosphorus recovery option.
- CO2 stripping to increase pH allows struvite precipitation.
- Magnesium addition can improve precipitation of phosphate.
Phosphorus Recovery

- Post-digestion phosphorus recovery option:
  - Dewaterability improvements shown in Europe.
  - Mineral precipitation reduces dissolved ion concentrations.
  - Magnesium is precipitated, reducing struvite downstream.
  - Lower recovered phosphorus load.
Phosphorus Recovery

- Pre-digestion phosphorus recovery option:

Benefits are possible for multiple other processes.
Phosphorus Recovery

Pre-digestion phosphorus recovery option considerations:

- Concentration of $\text{PO}_4^{3-}$, $\text{Mg}^{2+}$ and $\text{NH}_4^+$
- Pre-thickening of WAS and pH adjustments may be required.
- Benefits to dewatering, potential phosphate recovery.
Phosphorus Recovery

- Develop a results-based plan to recover phosphorus at one or more locations.
- Focus on the best overall value.
- 3-year evaluation program to cost-effectively achieve goals in the next 10 years.
Metrics for Success

- Accurate representation of effluent phosphorus and nitrogen concentrations.
- Lowest cost implementation of reliable processes.
- Reduction and control of O&M costs to sustainably meet treatment goals.
- Cost-effective and efficient transition into tertiary treatment.
Discussion