Holistic Approach to Plant Optimization for Biosolids Management

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The F. Wayne Hill WRC is an advanced treatment facility located in Buford, Georgia.
Background – F. Wayne Hill WRC

- Gwinnett County DWR
- 60 mgd capacity – current average flow 33 mgd
  - Also receives PS and WAS from Yellow River (22 mgd)
- Primary Treatment
- Biological Nutrient Removal
- High Level Tertiary Treatment
- Five 1 MG mesophillic anaerobic digesters
  - Primary sludge and TWAS feed

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Monthly Avg. Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>mgd</td>
<td>60</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>3</td>
</tr>
<tr>
<td>COD</td>
<td>mg/L</td>
<td>18</td>
</tr>
<tr>
<td>Ammonia-N</td>
<td>mg/L</td>
<td>0.4</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>mg/L</td>
<td>0.08</td>
</tr>
<tr>
<td>Turbidity</td>
<td>ntu</td>
<td>0.5</td>
</tr>
<tr>
<td>Fecal Coliform</td>
<td>#/100</td>
<td>2</td>
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</table>
FWHWRC Process Flow Diagram
Project Overview – Holistic approach required to address multiple whole plant issues

- **Capacity Issues:**
  - Influent loadings far exceeding design conditions
  - PS and WAS from Yellow River (22 mgd) to be received
- **New CHP system installed**
  - Digester gas was not where expected
- **Poor primary clarifier performance**
- **High P recycle loadings and struvite problems**
Capacity Crisis – Consultant – Your 60 mgd Plant is Really Only a 30 mgd Plant

Individual Unit Process Capacity - Maximum Month With Yellow River Sludge

Influent Sampling Questioned
Primary Clarifiers “Not Working” – why?
Can Optimization regain capacity?

Unit Process / Scenario
- Primary Clarifiers
- Bioreactors
- Secondary Clarifiers
- Blowers
- TWAS
- Centrifuges
- Anaerobic Digesters

Capacity (mgd)
- 70
- 60
- 56.8
- 56.8
- 50
- 40
- 30
- 20
- 10
- 0

- 50% PC Eff.
- 20% PC Eff.
# Annual Average Influent Characteristics

<table>
<thead>
<tr>
<th>Year</th>
<th>BOD$_5$, mg/L</th>
<th>COD, mg/L</th>
<th>TSS, mg/L</th>
<th>NH3-N, mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>182</td>
<td>609</td>
<td>430</td>
<td>24.8</td>
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<tr>
<td>2005</td>
<td>237</td>
<td>1,021</td>
<td>940</td>
<td>25.6</td>
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<tr>
<td>2006</td>
<td>252</td>
<td>715</td>
<td>575</td>
<td>25.6</td>
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<tr>
<td>2007</td>
<td>297</td>
<td>1,170</td>
<td>1,391</td>
<td>28.6</td>
</tr>
<tr>
<td>2008</td>
<td>277</td>
<td>1,211</td>
<td>1,186</td>
<td>30.6</td>
</tr>
</tbody>
</table>
Poor sample location and impacts from FOG/Grease buildup sloughing into sampler
Dynamic BioWin Calibration – MLSS and WAS

Model MLVSS/MLSS = 72.3%
Actual MLVSS/MLSS = 72.4%
Modified sampling and whole plant BioWin calibration verified true influent loadings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Original Design</th>
<th>Historical Avg. (2005 to 2010)</th>
<th>Recommended Values (After Data Reconciliation)</th>
<th>Recommended Values Including YRWRF Sludge</th>
<th>Actual 2014/2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD, mg/L</td>
<td>476</td>
<td>1,030</td>
<td>635</td>
<td>734</td>
<td>737</td>
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<tr>
<td>BOD$_5$, mg/L</td>
<td>200</td>
<td>266</td>
<td>284</td>
<td>318</td>
<td>280</td>
</tr>
<tr>
<td>TSS, mg/L</td>
<td>230</td>
<td>1,023</td>
<td>365</td>
<td>465</td>
<td>490</td>
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</tbody>
</table>

- If primaries work properly (50% TSS removal), liquids capacity maintained at 60 mgd
- Thickening and digestion still had short falls
Energy Recovery - BCE

- New 2,100 kW Combined Heat and Power System
  - Meet 40% of Total Plant Electrical Demand
  - Business Case Evaluation
    - Annual Savings >$600,000 at Full Load (523 SCFM)
    - Without NGS Blending: Break Even at 350 SCFM

Assumptions:
- Power Cost = $0.05 /KWH
- NG Cost = $5.00 /MBTU
- DG Heat Content = 600 BTU/CF
- Electrical Output = 2.147 MW
- Service = 8,000 hours/year
- Maintenance Cost = $22/hour
- REC = $10 / MWH w/ Digester Gas

No NGS Blending

![Graph showing net benefit vs. digester gas flow with and without REC.]
Where’s The Digester Gas?!?

2.1 MW Generator – 523 SCFM

Current Gas Production 175 scfm
Plant-Wide Optimization

- Focus Areas:
  - Primary Clarifier Performance
    - Solids from Yellow River WRF
    - Primary sludge drives digester gas production
  - Anaerobic Digesters
    - Increase SRT for greater volatile solids destruction
  - Co-Digestion
    - FOG and high strength wastes
Primary Clarifier Performance was poor and highly variable.

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Pri TSS % Removal</th>
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<tbody>
<tr>
<td>2006</td>
<td>-24%</td>
</tr>
<tr>
<td>2007</td>
<td>20%</td>
</tr>
<tr>
<td>2008</td>
<td>19%</td>
</tr>
<tr>
<td>2009</td>
<td>-27%</td>
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</table>

### Primary TSS Removal

- Pri TSS Removal from Pri Inf (Load)
- 30 per. Mov. Avg. (Pri TSS Removal from Pri Inf (Load))
Poor primary clarifier performance was major concern for capacity and gas production

- Poor removals led to much higher loadings to the secondary system
  - Major reduction in secondary treatment capacity
- Poor removals led to low digester gas production
  - Major issue for new 2.1 MW CHP system for energy recovery
Reasons for PC Poor Performance

- Scum collectors had been reversed.
- Septic conditions
- Inlet hydraulics
Requirement for in-tank thickening also led to non-optimal performance

- No separate thickening of primary sludge before digestion
- Design called for 4.5 to 5% primary sludge
- Attempts to achieve this led to high blankets, septic conditions and poor removal efficiencies
- Modified operations to limit thickness to < 3%
Canopy Baffle Further Improves PC Performance

<table>
<thead>
<tr>
<th>Primary Clarifier</th>
<th>% TSS Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary 9 – Baffle Installed</td>
<td>48%</td>
</tr>
<tr>
<td>Primary 10 – As Is</td>
<td>31%</td>
</tr>
</tbody>
</table>
New baffling and operational modifications resulted in substantial improvements.
Increased Digester Gas

Current Production ~ 300 to 400 scfm

- Digester Gas Flow
- Primary Sludge Loading

Current Production ~ 300 to 400 scfm.
Co-thickening of primary sludge and WAS recommended to resolve short falls

- Co-thickening of primary sludge and WAS on rotary drum thickeners (RDTs) to 5.5%-6.5%
- Replaced high energy WAS only thickening centrifuges
- Synergy with optimizing primary clarifiers
  - No more in tank thickening - dilute primary sludge
  - Reduces septicity in primary clarifiers
- Deferred new digesters for 10+ yrs
- Increased Digester SRT > 15 Days
FOG and Food Waste for additional gas

- Bench Scale Digestion Performance Testing
  - Teamed with Georgia Tech to assess critical elements of the proposed co-digestion
    - Optimum FOG/high strength waste source
    - Ultimate digestability
    - Digestion rate
    - Optimum wastewater VS:FOG VS ratio
    - Gas production potential
FOG/HSW receiving was added to allow co-digestion of select streams for gas production.
Co-Digestion with FOG and High Strength Organic Wastes

- Increase Digester Gas Production
  - TPS and TWAS: 1.4 CF CH₄/Gallon
  - FOG: 2 CF CH₄/Gallon
  - HSW: 2 – 11 CF CH₄/Gallon

- Tipping fee revenues
  - Up to $500,000/yr
  - Most recent
    - 30kgal/d, $300,000/yr
Increased Digester Gas Pays

**Assumptions:**
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- Electrical Output = 2.147 MW
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- Maintenance Cost = $22/hour
- REC = $10 / MWH w/ Digester Gas
Actual Savings: 4 X BCE

5,552,745 kWhr  Self Generated Power

$2,000,000  Savings in Purchased Power with Real Time Power Structure and Engine Generator

Average Power Cost:

- F. Wayne Hill WRC: $0.038 / kWh
- Yellow River WRF: $0.071 / kWhr
- Crooked Creek WRF: $0.069 / kWhr
Plant also struggled with struvite problems and high dewatering P recycle loads

- Enhanced biological P removal providing most of P removal
  - Influent TP ~ 9 mg/L; effluent TP limit = 0.08 mg/L
  - 5 mg/L alum dose, 10 mg/L tertiary ferric dose
- P released in anaerobic digestion
  - Struvite and High P recycle
Background Struvite & Phosphorus Issues

- 2009 – Replaced Bioxide with Mg(OH)₂ in collection system
  - Resulted in struvite formation in centrate lines, centrifuges, digester complex

- Accepting sludge from 22 mgd Yellow River Bio-P plant
  - Substantial increase in P load
  - Substantial risk for increased struvite formation
Phosphorus in solids handling is the key issue

- Phosphorus outlets:
  - Effluent (Limit TP = 0.08 mg/L)
  - Sludge cake (precipitated complex, biomass, struvite)

- ~ 40% of Influent P in sludge cake as struvite now

- If struvite formation stopped (stop Mg), significant consequence from P recycle load; YR sludge

- Can Nutrient Recovery provide equivalent, controlled outlet for P? Alternative is metal salt

- Study goal: determine best solution for struvite issue (Mg continues) or P recycle issue (Mg stops)
  - Nutrient Recovery OR metal salts
Six options were considered for sidestream P removal/struvite control

- Do Nothing
- Ferric addition with and without Mag addition in collection system
- Struvite recovery with and without WASStrip™ with and without Mag in collection system
Implementation of WASSTRIP™ concept at FWH takes advantage of co-thickening.

Release P and Mg from sludge using VFA rich stream.

Low P and Mg content of sludge minimizes nuisance struvite formation from digester onwards.

Send P, Mg rich sidestream to recovery process.

Send NH3 rich sidestream to recovery process.
Bench scale testing of the WASSTRIP™ process was performed

- Determine levels and rates of PO$_4$ release from WAS
- Optimize parameters to maximize PO$_4$ release in pilot studies
  - Anaerobic retention time and WAS:PS blend ratio

![Graph showing mg PO$_4$-P/mg WAS VSS over time for different blends and WAS ACE60, ACE400, BLEND25, BLEND50, BLEND100]
Ostara WASSTRIP Pilot

50/50 mass ratio

WAS P-Release Reactor

Solids Separation

Polymer

P-Release Filtrate

Dewatered Centrate

Blend

Pearl® Pilot

Crystal Green

Effluent

80/20 filtrate/centrate volume ratio

P-release reactor

Centrate mix tank

Screen filter

Pearl Influent storage tank
Ostara vs. Multiform product

Ostara Pearl

Multiform Harvest
Using the pilot data, Biowin™ process modeling was used to simulate each alternative

1. Use calibrated whole plant model to simulate alternatives at each flow scenario
2. “Do Nothing” scenario is modeled for comparison of struvite formation
3. The modeling results were used to assess effectiveness of the nutrient control strategy and also to estimate costs for the BCE.
P recovery provides equivalent struvite reduction compared with the ferric addition option.
## Nutrient Recovery + WASSTTRIP – Best option from BCE with < 8 year payback

<table>
<thead>
<tr>
<th></th>
<th>OSTARA Struvite Recovery Alternatives</th>
<th>Chemical Addition Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alternative 1a WASSTTRIP Mg Addition</td>
<td>Alternative 1b WASSTTRIP No Mg Addition</td>
</tr>
<tr>
<td>Total Capital Costs</td>
<td>$13.75M</td>
<td>$13.08M</td>
</tr>
<tr>
<td>Year 1 Capital Costs</td>
<td>$9.75M</td>
<td>$11.41M</td>
</tr>
<tr>
<td>Year 1 O&amp;M</td>
<td>$(200,000)</td>
<td>$(94,700)</td>
</tr>
<tr>
<td>Total Net Present Cost</td>
<td>$7.04M</td>
<td>$10.86M</td>
</tr>
</tbody>
</table>

2,200 gpd Ferric (39 lbFe/ Dry Ton sludge) = $1.1M/YR  
Sludge Savings = $160K/YR  
Blower Power Savings = $20K/YR  
Net revenue from sales = $147K/YR
FWH Nutrient Recovery Facilities – Startup June 2015
Questions?

Thank You!

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