IT’S ALL IN THE MIX – DESIGN OF NEW MIXERS FOR ANAEROBIC SLUDGE DIGESTION FACILITIES AT ST. JOHNSBURY WWTF

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NEBRA ANNUAL CONFERENCE
OCTOBER 26, 2017

Image Source: Google Maps, 2012
1 - Introduction to St. Johnsbury WWTF
2 – Existing Digester Facilities
3 – 2013 Digester Mixer Evaluation Study
4 – Energy Evaluation of Digestion Process
5 – Digester Mixer Design Considerations
6 – Current Status
1 - INTRODUCTION TO ST. JOHNSBURY WWTF
TOWN OF ST. JOHNSBURY, VT
Pop. 7,600 2010 Census

Image Sources: Google Maps, 2017
PLANT CHARACTERISTICS

- Secondary Treatment Plant
- Owned by Town of St. Johnsbury
- Operated by Utility Partners
- Treats St. Johnsbury, VT Wastewater
- Handles Water Trt. Plant Residuals
- Last Major Upgrade 1988-1990
- Discharges to Passumpsic River
TREATMENT PROCESS COMPONENTS – LIQUID TRAIN

1. Influent Lift Pumps
2. Preliminary Treatment
3. Primary Settling
4. Rotating Biological Contactors
5. Final Settling
6. Chlorination / Dechlorination

Image Source: Google Maps, 2017
TREATMENT PROCESS COMPONENTS
– SOLIDS TRAIN

1. Primary and Secondary Sludge, Scum, and Septage
2. Primary Digester
   • Anaerobic Digestion
3. Secondary Digester
   • Settling
   • Gas Holder Tank
4. Sludge Storage Tank
5. Land Application

Image Source: Google Maps, 2017
## INFLUENT PARAMETERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>2008 Design</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Daily Flow (MGD)</td>
<td>1.6</td>
<td>0.74</td>
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<tr>
<td>Peak Daily Flow (MGD)</td>
<td>6.9</td>
<td>6.9</td>
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<tr>
<td>BOD (mg/L)</td>
<td>251</td>
<td>271</td>
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<tr>
<td>TSS (mg/L)</td>
<td>296</td>
<td>298</td>
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</tbody>
</table>
2 – EXISTING DIGESTER FACILITIES
PRIMARY DIGESTER

- 45' Diameter Dual-Deck Steel Structure
- Dome Surface Fixed to Concrete Tank Walls
- Gas Mixing System Converts Volatile Organic Solids to Methane Gas
- Gas Mixing System in Constant Use
SECONDARY DIGESTER

- 45' Diameter Floating Steel Cover
- Cover Rides Up & Down on Gas Bubble
- Steel Rollers & Spiral Guides Align Cover
- Digester Serves as Settling and Gas Holding Tank
- Gas Mixing System Used Infrequently
EXISTING GAS MIXING/HEATING SYSTEM
EXISTING GAS MIXING/HEATING SYSTEM

- Large Gas Bubble Mixing System
- Gas Drawn Off Center Well of Secondary Digester
- Gas Cleaned, Compressed, & Returned to Three, 24" Diameter Open-Ended Heating/Mixing Tubes
- Heat Exchanger Mounted on Inside of Tubes
### DIGESTER SIZE & OPERATION

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Digester Tank Dimensions, Diam X Ht</td>
<td>45’ x 21’</td>
</tr>
<tr>
<td>Tank Volume, Each, cf</td>
<td>31,620</td>
</tr>
<tr>
<td>Type of Operation</td>
<td>Mesophilic</td>
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<tr>
<td>Internal Temperature, °F</td>
<td>95</td>
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</table>
### DIGESTER OPERATING CONDITIONS

<table>
<thead>
<tr>
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<th>Design</th>
<th>2014 Avg.</th>
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<tr>
<td>Sludge Loading, lbs/day</td>
<td>3,846</td>
<td>1,874</td>
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<tr>
<td>Volatile Solids (VS) In, %</td>
<td>70</td>
<td>62</td>
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<tr>
<td>VS Loading to Primary Digester, lbs VS/1000 cf/day</td>
<td>85</td>
<td>38</td>
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<tr>
<td>Tank Detention Time, Days</td>
<td>16</td>
<td>37</td>
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<tr>
<td>Estimated VS Reduction, %</td>
<td>55</td>
<td>60</td>
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</tbody>
</table>
Reasons for Evaluation Study

• Mixing Equipment >22 Years Old
• Poor Mixing Characteristics
• Solids Build-up in Tank
• Water Residuals Impact
• Tanks Taken Out of Service Frequently
• Gas Mixing Not Comparable to Current Mixing Systems
Mixers Evaluated

- Linear Motion Mixer
- Low Speed Mechanical Mixer
- Rooftop Mounted Internal Draft Tube Mixer, With and Without Sludge Heat Exchanger
- External Draft Tube Mixer, With and Without Sludge Heat Exchanger
## Mixer Cost Summary

<table>
<thead>
<tr>
<th>ALTERNATIVE</th>
<th>CONSTRUCTION COST</th>
<th>ANNUAL O &amp; M COST</th>
<th>PRESENT WORTH COST</th>
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<tr>
<td>LINEAR MOTION MIXER</td>
<td>$1,344,800</td>
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<td>$1,598,000</td>
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<td>LOW SPEED MIXER</td>
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<tr>
<td>INTERNAL DRAFT TUBE MIXER</td>
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<tr>
<td>INTERNAL ROOFTOP DRAFT TUBE MIXER WITH INTEGRAL HEAT EXCHANGER</td>
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<td>EXTERNAL DRAFT TUBE MIXER</td>
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4 – Energy Evaluation of Digestion Process
2015 Digestion Energy Evaluation Report

Investigated

• Digester Gas Production/Use
• Increased Digester Gas Production Alternatives
• Additional Energy Efficiency Improvement Alternatives
• Digester Gas Use for Energy Production
<table>
<thead>
<tr>
<th></th>
<th>%TS (in)</th>
<th>%VS (in)</th>
<th>%VS (out)</th>
<th>%VSR</th>
<th>Sludge Loading (in gal)</th>
<th>SRT (days)</th>
<th>VS Destroyed (lbs)</th>
<th>VS Loading (lbs/10³ ft³)</th>
<th>Gas Production (ft³/day)</th>
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<tr>
<td>January</td>
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<td>43</td>
<td>50</td>
<td>5849</td>
<td>1196</td>
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<td>37</td>
<td>67</td>
<td>4533</td>
<td>1721</td>
<td>52</td>
<td>760</td>
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<td>April</td>
<td>1.9</td>
<td>54</td>
<td>39</td>
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<td>Average</td>
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<td>62</td>
<td>39</td>
<td>60</td>
<td>6740</td>
<td>1874</td>
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<td>Minimum</td>
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<td>Maximum</td>
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<td>43</td>
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<td>3044</td>
<td>56</td>
<td>1517</td>
<td>67</td>
<td>23513</td>
</tr>
</tbody>
</table>
Increased Gas Production Alternatives

- Improve Mixing
- Add More Septage, Food Waste, Oil & Grease
- Maintain 4 – 6% TS Feed Daily
- Add/Withdraw Daily Similar Amount of Sludge
Energy Efficiency Improvements

• Improve Digester Insulation
• Replace Digester Boiler
• Install Dual-Fuel Burner in Boiler for Domestic Heating/Hot Water
Digester Gas Use for Energy Production

- Use Digester Gas to Generate Electricity via Combined Heat & Power System
- Essex Junction, VT, & Fairhaven, MA
- Possible Future Option for St. Johnsbury
5 – Digester Mixer Design Considerations
Digester Mixer Design Considerations

- Mixer Components
- Mixer Design Criteria
- Structural Analysis of Covers
- Heat Exchanger Size on Mixer
- Digester Cover Modifications
- Internal Piping/Piping Support Modifications
- Taking Digesters Offline
Mixer Components

[Diagram of Mixer Components]
Mixer Design Criteria

- Propeller Diameter: 24”
- Motor Size: 7.5 hp
- Pumping Capacity: 9,000 gpm
- Draft Tube Diameters: 27” & 28.5”
- Digester Turnover Time: 30 minutes
- Heat Exchange Transfer: 360,000 BTU/hr
- Warranty: 5 yrs.
Structural Analysis of Covers

- Support Added Weight of Mixer
- Complete Structural Analysis of Covers for Added Load
Heat Exchanger Size

- Larger Heat Exchanger
- More Capital Cost
- More Efficient Heat Transfer
Cover Modifications

- New Pipe Penetrations
- New Cover Mounting Plates for Mixers
- Attic Insulation
- Floating Cover Ballast Adjustment
Piping Changes

- Hot Water Piping & Pipe Supports
- Gas Piping, Including Flexible Piping
Taking Digesters Off-Line

- Work Plan to Take Down 1 Digester at a Time
- Clean Digester
- Remove Equipment
- Install Equipment
- Start Up Digester
- Repeat Sequence for 2nd Digester
6 – Current Status

• Design/Bidding Complete
• Construction Start Date – 9/5/17
• Construction End Date – 9/30/18
• Engineer’s Estimate for Digester Mixer-Related Improvements - $1,290,000
QUESTIONS?