West Point Digestion System
Current Conditions and Assessment

Technology Assessment Program
King County Department of Natural Resources and Parks
Wastewater Treatment Division
Presentation Outline

- Digestion System Configuration
- Digester Operating Conditions
- Digester Upset Conditions
- Digester Assessment
- Recommendations
References

• West Point Treatment Plant Operating Data
• West Point Treatment Plant Digestion System Manual
• University of Washington Fellowship Program Thesis
• Thermophilic Anaerobic Digestion Demonstration Project Report
• Black and Veatch Digestion Survey
West Point Treatment Plant
Digester Physical Attributes

- 5 Primary - 1 Secondary Digester
- 2.4 MG digester volume
- 100ft diameter x 37.5ft side-wall
- Floating cover on primary digesters
- Mesophilic operating temperature
- Gas (diffuser and draft tube) and Pumped Mixing
Digester Configuration

![Diagram of Digester Configuration](image)

**Legend**

- **Feed line**
- **Recirculation line**
- **Transfer line**
- **Closed line**

- Valve, open
- Valve, closed

**Overview of the Digestion Cycle**

- Hot sludge to primary from north digesters (used for manual scum pumping)
Digester Feed Characteristics

- 50% Primary : 50% Secondary (w:w)
- protein, carbohydrate, lipid, VFA fractions
- scum sequentially fed to digesters 1 through 3
- gravity thickened to 6%TS (80%VS)
- grit content in primary fraction

COD basis

- C 28%
- L 14%
- VFA 5%
- P 53%
King County DNRP-WTD Technology Assessment Program

Digester Organic Loading Rate

 lbs VS / cf - day

Monthly Mean
Peak Day
Design Annual Average
Design Peak Week

Jan-00 Apr-00 Jun-00 Aug-00 Oct-00 Jan-01 Mar-01 May-01 Aug-01 Oct-01 Dec-01 Mar-02 May-02 Jul-02 Oct-02 Dec-02 Feb-03 Apr-03 Jul-03
Digester Process Monitoring

- **Analytical** - TS, VS, alkalinity, pH, VFA, CO$_2$, H$_2$S
- **SCADA (control)** - cover height, feed volume, withdrawal volume
- **SCADA (instrumentation)** - gas production, temperature, cover height, feed volume, withdrawal volume
- **Visual** - foam, mixing system gas flow
## Primary Digester Operating Conditions

<table>
<thead>
<tr>
<th></th>
<th>VS Loading (lb VS/cf-day)</th>
<th>TS (%)</th>
<th>VFA (mg HAc/L)</th>
<th>ALK (mg CaCO₃/L)</th>
<th>CO₂ (%)</th>
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<tbody>
<tr>
<td>2000</td>
<td>0.147</td>
<td>2.82</td>
<td>94</td>
<td>6,600</td>
<td>38</td>
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<td>2001</td>
<td>0.136</td>
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<td>2002</td>
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<td>2.86</td>
<td>81</td>
<td>6,800</td>
<td>38</td>
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<td>2003</td>
<td>0.112</td>
<td>2.82</td>
<td>70</td>
<td>6,600</td>
<td>38</td>
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</table>
Primary Digester Performance

<table>
<thead>
<tr>
<th>Year</th>
<th>VSR (%)</th>
<th>SRT (days)</th>
<th>Gas Production (cf/lb VSR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>66</td>
<td>25</td>
<td>21.5</td>
</tr>
<tr>
<td>2001</td>
<td>63</td>
<td>28</td>
<td>20.5</td>
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<td>2002</td>
<td>66</td>
<td>32</td>
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<tr>
<td>2003</td>
<td>67</td>
<td>34</td>
<td>21.8</td>
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</table>

Anaerobic Digestion typically 12 - 16 cf/lb VSR. High values attributed to digester gas flow meter.
Digester # 4 in March 2002

- Increase in VFA concentration
- Increase in %CO$_2$ in gas
- Decrease in gas production
- Decrease in alkalinity
Response to Digester 4 “Upset” Condition

• Decreased organic loading rate

• Increased monitoring of operating conditions

• Inspection of digester operating system
  – check of digester feed valve
  – feed and withdrawal sequence control
  – gas mixing

• With recovery, slowly increased organic feed rate
Digester # 4 in April 2002

- Increase in VFA concentration
- Increase in %CO₂ in gas
- Decrease in gas production
- Decrease in alkalinity
Potential Causes of Digester 4 Upset

- **Organic Shock Loading**
  - feed & transfer control system failure
  - thickening process control

- **Inadequate Mixing Energy**
  - failure of mixing compressor
  - clogging of draft tube gas lances

- **Toxicity**
  - inhibitory compound introduced into system
  - accumulation of inhibitory compound in digester
Digester Assessment Process

- System Review (West Point Process Staff)
- Digester Health Monitoring (TAP Staff)
- Digestion Survey (TAP Staff)
- Modeling (TAP Staff)
Digester System Review
Feeding and Withdrawal Cycle

- Feeding Frequency
- Feed Valving
- Feed Flowmeter
Digester 4-5 Mixing System

- Main Pump
  - 700 gpm

- Auxiliary Pump
  - 350 gpm

- Gas draft tube
Digester 4 Temperature Profile

Peak Temperature of each Sampling Port
Digestion Process Monitoring

- Current process parameters associated with stability
  - operating temperature
  - pH
  - volatile fatty acids
  - alkalinity
  - volatile solids loading
  - volatile solids reduction
  - gas production and composition
Digestion Process Monitoring

- Current process parameters associated with stability
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- Development of additional monitoring tools
  - acetate utilization rate (University of Washington)
Acetate Utilization Rate Test Development (University of Washington)

- Test method used by King County Fellowship Program Graduate students in on-going anaerobic digestion research
  - digester sample collected and transported to university with analysis within 24-hours
  - 55mL serum bottles filled with digested sludge (triplicates)
  - bottles spiked with acetate with corresponding unfed bottles
  - methane production monitored for 8-10 hours using GC-TCD
  - data plotted as $\text{CH}_4$ (L/L sludge) over time
Acetate Utilization Rate Test Development (University of Washington)

- Comparison of slope between fed and unfed samples
- Process Lab VFA analysis: dig #5 = 47 mg/L, dig #4 = 1,207 mg/L
Acetate Utilization Rate Test Development (University of Washington)

- Comparison of slope between fed and unfed samples
- Process Lab VFA analysis: dig #5 = 68 mg/L, dig #4 = 93 mg/L
Digestion Survey Development

- Full-scale Digester Comparison
  - configuration
  - stability
  - performance

- Posted on King County website
  http://dnr.metrokc.gov/wtd/survey-1
## Existing Digestion Survey Data

<table>
<thead>
<tr>
<th></th>
<th>VS Loading (lb VS/cf-day)</th>
<th>SRT (days)</th>
<th>VSR (%)</th>
<th>Mixing Energy (Hp/kcf)</th>
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<tbody>
<tr>
<td>West Point Digester 4 (2003)</td>
<td>0.101</td>
<td>34</td>
<td>67</td>
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<td>Facility Survey</td>
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<td>24</td>
<td>59</td>
<td>0.28</td>
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Survey Source: Black and Veatch (50 facilities)
Assessment Recommendations - Present

- Monitor feeding and withdrawal system
- Perform periodic acetate utilization rate testing of digesters
- Investigate potential application of on-line instrumentation
- Conduct lithium tracer testing of digesters
- Continue collecting data from Digestion Survey
Assessment Recommendations - Future

- Upgrade existing primary digesters to enhance monitoring capabilities
- Investigate digester mixing system modifications
- Investigate modification of Digester 6 to operate as primary digester as a contingency plan
- Evaluate potential for digestion system modeling
West Point Digestion System
Current Conditions and Assessment

Questions

Digestion Survey
http://dnr.metrokc.gov/wtd/survey-1