Planning for the Future
Battle Creek’s Approach to Upgrading its Secondary Treatment Processes

Michigan Water Environment Association
Annual Conference
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Richard Beardslee, City of Battle Creek
Nathan Cassity, Donohue & Associates
# Outline and Acknowledgements

## Outline
- Background
- Energy Evaluation
- Nutrient Evaluation
- Planned Upgrades

## Acknowledgements

**Battle Creek**
- Marvin Krause
- Bryan Crawford

**Donohue**
- Mike Harvey
- Kendra Sveum
Battle Creek Background
Background: Battle Creek

- Design capacity 27 mgd
- Currently operating at 9 mgd
- Flows have decreased over the years
- Significant loadings from food processors and paper
  - Influent BOD
    - 580 mg/L (2013-2014)
    - 650 mg/L (2015)
Process Type: Single-Stage Activated Sludge with Nitrification

Background: Battle Creek
Background: Battle Creek, MI

- Project Drivers
  - Energy conservation
  - Aged facilities: Blowers cannot be repaired
  - Aged facilities: Outdated aeration control
  - Process Improvements: Nutrient deficiency issues
  - Chemical Savings: Phosphorus control
Energy Evaluation
40-55% of total energy use with peak use in summer months
Energy Use

Start with the “Low-Hanging Fruit” for Significant Reductions and Returns on Investment

Percent of Plant Energy Use

Aeration system is the “low-hanging fruit”

Multiple uses and equipment systems

50%

45%

4%

1%

Aeration
Settled Sewage Pumps
RAS Pumps
Other Misc. Loads

Aeration system is the “low-hanging fruit”
Existing Blower Systems

(3) Multi-Stage Centrifugal Blowers
Turndown: Manual Inlet Throttling
Max Flow: 21,000 scfm
Min Flow: 13,000 scfm
Age: > 30 years, motor replaced recently

(4) Positive Displacement Blowers
No Turndown Capability
Flow: 7,000 scfm
Age: > 40 years, parts not available
Existing Aeration Control

- All adjustments are manual
- Handheld DO profile each shift
- SCADA monitoring
  - Blower airflow
  - DO at end of basins
- Operator periodically adjusts blowers and butterfly valves
Energy Evaluation Approach

Comprehensive Aeration System Study Approach

1. Provide the air more efficiently
   a. More efficient blower system

2. Reduce the amount of air Provided
   a. Improved automation and controls
   b. Increased oxygen transfer efficiency
   c. Biological nutrient removal
Provide Air More Efficiently
Provide Air More Efficiently

High Efficiency Blowers Will Reduce Aeration Energy
Provide Air More Efficiently

Opportunity: Improve Blower Reliability, Operating Efficiency and Turndown

Replacement of Aging Equipment

25% Reduction In Blower Energy Use
Turndown to Lowest Operating Requirement
Existing Blowers

Probability Distribution Curve

Airflow (scfm)

Percent of Time Equal or Less Than

Existing blower capacity

Turndown to 20\textsuperscript{th} percentile requirements
Propose Blower Upgrades

- Improved Turndown
- Greater Energy Efficiency Over Operating Range
- New equipment sized to meet majority of demand
Estimated Blower Savings

Anticipated Savings:

- 25% Reduction in Blower Energy Use
- $121,000 in annual electricity cost savings
- $139,000 incentive rebate from utility
- 10-Year Payback (no control upgrades)
Reduce Amount of Air Provided
Diffuser Efficiency

SOTE Per Foot of Submergence
Based on Air Flow and Basins in Service

As airflow per diffuser increases, oxygen transfer efficiency decreases.

Estimated annual savings of $30,000 by placing a 5th basin in service.
Air Required Versus Air Supplied

Goal is to save energy by more closely matching air supply to air requirements:

Estimated Annual Savings Potential: $100K

Observed Periods of Potential Over-Aeration -> Energy Reduction Opportunity
### Improved Control Strategies

#### Several Options to Consider:

<table>
<thead>
<tr>
<th>Control Alternative</th>
<th>Aeration Reduction Potential Achieved (%)</th>
<th>Estimated Energy Savings (kWh/yr)</th>
<th>Estimated Cost Savings ($/yr)</th>
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<tbody>
<tr>
<td>Basic</td>
<td>40</td>
<td>569,000</td>
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<tr>
<td>Intermediate</td>
<td>60</td>
<td>1,138,000</td>
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<td>Advanced</td>
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<td>1,423,000</td>
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</table>

- **Basic Control**: Low capital cost, minimal energy savings.
- **Intermediate Control**: Moderate capital cost, moderate energy savings.
- **Advanced Control**: High capital cost, significant energy savings.
Aeration Control Strategy

• DO Control Loops
  – Every pass
  – Airflow meter + control valve
  – Most-open-valve

• Blower Control
  – Pressure and Airflow based
Aeration Control Strategy

DO Control with Direct Blower Air Flow Control

Eliminating Pressure Setpoint Can Provide Additional Energy Savings
Combined Blower and Control Savings

Anticipated Savings: 45% Total Reduction in Aeration Energy Use

Total estimated savings of $220,000 annually

Additional 1,420,000 kWh per year
Nutrient Evaluation
Battle Creek Nutrient Balance

• Phosphorus removal
  – Ferric chloride used for chemical phosphorus removal
  – Winter effluent limit 1 mg/L
  – Summer TMDL limit of 0.5 mg/L

• Nutrient deficiency
  – Nutrient addition required
    • high food processor BOD loadings
  – Nitrogen feed, urea: 25 tons annually
  – Phosphorus feed, phosphoric acid: 823 tons annually
High Calcium Quicklime, $98,758.40
Polymer (K275FLX), $208,845.00
Ferric Chloride, $119,400.00
Sodium Bisulfite, $25,976.00
Chlorine, $68,220.00
Phosphoric Acid, $88,007.50
UAN-28, $8,125.00
Bioxide, $50,055.00

Annual Total: $667,000

More than one third of current chemical use is related to nutrients
• Nutrient Deficiency
  – BOD:N:P Ratio of 100:5:1 is Good Target
  – Nutrient Addition

<table>
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<tr>
<th>Date</th>
<th>BOD</th>
<th>TKN</th>
<th>Tot-P</th>
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Nutrient Deficiency

– BOD:N:P Ratio of 100:5:1 is Good Target
– Nutrient Addition – UAN-28 and Phosphoric Acid

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Battle Creek Nutrient Balance

- Nitrogen Deficiency

Conceptual Profile – Excess Nitrogen

mgN/L

- PE
- Pass 1
- Pass 2
- Pass 3

NH3-N
NOX-N
• Nutrient Deficiency
  – Battle Creek: 3 of 6 days showed similar numbers

07/15/15 Nitrogen Profile

- mgN/L
- 000
- 050
- 100
- 150
- 200
- 250
- 300

- Pass 1
- Pass 2
- Pass 3

- NH3-N
- NOX-N
• Improve nutrient monitoring and control
  – Effluent analyzers for ammonia, nitrate, and phosphorus
  – Chemical feed based on maintaining minimum effluent concentrations
• Implement biological phosphorus removal
  – Modify aeration basins to incorporate selectors
  – Utilized BioWin modeling to estimate nutrient requirements and effluent P results
Nutrient Profile Predicted in BioWin Model of Bio-P Configuration
Model Results – chemical cost savings

Estimated Annual Spending

- $34,000 Increase for Nitrogen Dosing
- $11,000 Savings on RAS Chlorination

Net Savings: $178,000

- RAS Chlorine
- Ferric Chloride
- Phos. Acid
- UAN-28

Current Operation | Improved Nitrogen | Bio-P
Summary of Planned Improvements
## Summary of Planned Improvements

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<tr>
<th>Improvement</th>
<th>Estimated Construction</th>
<th>Estimated Annual Savings</th>
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<tr>
<td>Aeration Blowers</td>
<td>$2.55M</td>
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<tr>
<td>Aeration Controls</td>
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<td>BPR Modifications</td>
<td>$1.58M</td>
<td>$110,000</td>
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<tr>
<td>Nutrient Feed Controls</td>
<td>0.365M</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$6.04M</strong></td>
<td><strong>$398,000</strong></td>
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