Flow Capacity vs. Treatment Capacity: Changing one without the other?
Background
City of Wyoming Clean Water Plant (CWP)

- Flow & Treatment Capacity
  - 42 mgd Peak
  - 24 mgd Design Max Month
  - 22 mgd 24-hour Average
- Biochemical Oxygen Demand (BOD) Design Capacity
  - 57,250 lb/day Annual Average
  - 68,050 lb/day Max Month
- Relatively Constant Influent Flowrate
  - 14 mgd Average Day
- Increasing Influent Organic Loading / Biochemical Oxygen Demand (BOD)
- Goal: Cost-effectively increase treatment capacity to attract industrial users
CWP Liquid Treatment System

• 3 Aeration Basins
• Recent Aeration Improvements
• 4 Final Clarifiers
Process Modeling

- EnviroSim BioWin Wastewater Treatment Process Simulator
- Modeled 3-years Operating Data
- Calibrated Model

Two modeling scenarios evaluated:

- Increasing influent flowrate at the design BOD concentration, such that the influent BOD load exceeds the design value
- Increasing influent BOD concentration at design flowrate, such that the influent BOD load exceeds the design value
Process Modeling

BioWin Model Diagram for the CWP
Process Modeling Results

• Results:

  Good News: Aeration facilities capable of treating approximately 30% additional organic loading

  Bad News: Additional final clarifier capacity required to match potential of aeration facilities

• 30% increase to BOD load (increased MLSS concentration and respective solids loading rate) significantly exceeds the 10 States Standards recommended Final Clarifier maximum solids loading rate (SLR) of 25 ppd/sf
## Process Modeling

<table>
<thead>
<tr>
<th>SCENARIO</th>
<th>FLOW</th>
<th>BOD</th>
<th>MLSS(^1)</th>
<th>ADDITIONAL CLARIFIERS (95 X 95 X 12 FT)</th>
<th>EFFLUENT TN</th>
<th>EFFLUENT TP</th>
<th>TOTAL AIRFLOW(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>24</td>
<td>68,100</td>
<td>2,700</td>
<td>-</td>
<td>6.6</td>
<td>0.39</td>
<td>14,600</td>
</tr>
<tr>
<td>Scenario 1 (increased flow)</td>
<td>32</td>
<td>91,540</td>
<td>5,050</td>
<td>13</td>
<td>7.0</td>
<td>0.36</td>
<td>22,490</td>
</tr>
<tr>
<td>Scenario 2 (increased BOD)</td>
<td>24</td>
<td>91,300</td>
<td>4,000</td>
<td>9</td>
<td>4.4</td>
<td>0.3</td>
<td>21,900</td>
</tr>
</tbody>
</table>

Notes:
1 MLSS concentration corresponding to a nitrifying sludge age
2 Blower firm capacity = 26,800 SCFM
3 Peak Day summer OUR = 66 mg/L/hr
Develop Final Clarifier Stress Testing Protocol

• Next Steps:
  • Before planning for additional final clarifier infrastructure, validate model results with final clarifier stress testing
  • Obtain MDEQ buy-in for conducting stress testing with the intent to re-rate organic treatment capacity of the CWP
  • Referenced standard protocols for the evaluation of clarifier performance and capacity
  • Developed site-specific stress testing protocol
  • Met with MDEQ
Stress Testing Protocol

• Test 1 Final Clarifier
• Operate 2 Aeration Basins & 2 Final Clarifiers
• Test Condition 1: Final Clarifier Maximum Flow Capacity
• Test Condition 2: Final Clarifier Maximum Loading Capacity

Valve/Gate Legend
Red = Open
Pink = Throttle
Green = Closed

RAS to AB-3 = 50% of total RAS

Operate AB-4 and FC-10 (or FC-9)

Stress test FC-8, using RAS pumps Pa-12 Pa-14
FC Q = 5.0 mgd, RAS Q = 1.50 mgd
FC Q = 5.5 mgd, RAS Q = 1.62 mgd
FC Q = 6.0 mgd, RAS Q = 1.75 mgd
FC Q = 6.5 mgd, RAS Q = 2.00 mgd

Throttle AB-4 influent as required to maintain target flow to AB-3.
Stress Testing Results

• Test No. 1 (increase flow to clarifier):
  • Testing neared the design condition of 25 ppd/sf SLR at an SOR of 900 gpd/sf
  • Limited flow control from the aeration basins to the test clarifier may not allow testing a higher SLR
  • BOD and TSS concentration remained within allowable limits (15 and 30 mg/L, respectively)
  • Consistently low nitrite concentrations
  • Sludge blanket remained stable, increasing with diurnal peaks and decreased with reduced flow

• Test No. 2 (increase BOD to clarifier):
  • Flow limited to 6 mgd through the test clarifier
  • RAS flow rate increased to the test clarifier
  • Favorable BOD, TSS, nitrite, and sludge blanket conditions
  • SLR maxed out at 18 ppd/sf, or ~2,000 mg/L MLSS concentration w/30% RAS
  • Modeling suggested up to 4,000 mg/L MLSS was possible
Stress Testing Results

• Discussions with the plant personnel indicated that because of the limitations in the influent and RAS flow splitting, stress testing the clarifiers at a solids loading rate higher than 20 ppd/sf is not practical

• Black & Veatch proposed to confirm the clarifier capacity using a State Point Analysis (SPA)
State Point Analysis

- The SPA considers:
  - Physical dimensions of the clarifiers
  - Average and maximum influent flow
  - Target MLSS concentration
  - RAS flow
  - Measured Sludge Volume Index (SVI)

- SVI using 30 minute sludge settling data demonstrated favorable results, with only 1% exceeding 120 mL/g
Standard Solid Flux Curves in comparison to Facility Operating Curves

1. Line 1 is the settling flux curve. While Line 2 is the design flux curve that has a safety factor derating from ideal conditions.
2. Line 3 the thick blue line is the peak or in our case the MM flow conditions flux line. The slope of the blue line is affected by the system RAS rate while the height of Line 2 is set by the system SVI. The lower the SVI the higher the peak hump in line 2. So the goal is to keep the blue dot under the line 2 and not have any part of the blue line to the right touch Line 2.
3. Line 4 is a dashed blue line and it represents average operation. So we design for Max month at the safety factor curve Line 2. Basically be under the thick brown curve line 2.
State Point Analysis

- Process Model predicted existing blowers can handle 91,300 ppd max influent BOD (4,000 mg/L MLSS & 42 ppd/sf BOD Loading)
- 15% Safety Factor results in 85,000 ppd influent BOD (3,700 mg/L MLSS ~39 ppd/sf BOD Loading)

BioWin Projections of MLSS Concentration at Various Influent BOD Loading
State Point Analysis

Historical SVI & % Probability

- 90% of the time, SIV < 93 mL/g
- 95% of the time, SIV < 112 mL/g
- < 1% Chance of SVI > 120 mL/g
## State Point Analysis

| SCENARIO | SLR (ppd/sf) | SVI (mL/g) | RAS (mgd) | RESULTS
<table>
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<tr>
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</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
<td>39</td>
<td>93</td>
<td>3.0</td>
<td>Design underflow and peak underflow rate to the right of the SP is under the settling curve, indicating that the RAS recycling rates are adequate to maintain a healthy sludge blanket at a solids loading rate of 39 ppd/sf.</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>39</td>
<td>112</td>
<td>3.0</td>
<td>Peak SP fell between the flux curve and the safety factor curve. This indicates additional operator attention would be required at higher flow conditions.</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>39</td>
<td>120</td>
<td>3.0</td>
<td>Peak SP fell between the flux curve and the safety factor curve. Peak underflow rate crosses the solids flux line with increased solids concentration, indicating that the RAS rate at this loading is not adequate to return solids fast enough to keep pace with the solids entering the clarifier.</td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>39</td>
<td>120</td>
<td>3.5</td>
<td>Peak SP fell between the flux curve and the safety factor curve. Peak underflow rate does <strong>not</strong> cross the solids flux line with increased solids concentration. This indicates increasing RAS will reduce clarifier blanket thickness. However, the activated sludge system is still stressed.</td>
</tr>
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1. The Annual average SP for each Scenario fell under the flux curve with a 15% safety factor, allowing flexibility in operation of the activated sludge system.
SPA Plot with SLR = 39 ppd/sf & SVI = 93 mL/g
State Point under flux curve - but above safety factor curve

Average State Point

SPA Plot with SLR = 39 ppd/sf & SVI = 112 mL/g
State Point Analysis

SPA Plot with SLR = 39 ppd/sf & SVI = 120 mL/g
State Point Analysis

SPA Plot with SLR = 39 ppd/sf & SVI = 120 mL/g & Increased RAS
State Point Analysis

- Black & Veatch has commonly observed 35 ppd/sf SLR at well-operated plants.

SPA Plot with SLR = 35 ppd/sf & SVI = 93 mL/g (3,290 mg/L MLSS)
Results

• SPA results at 35 ppd/sf & SVI = 93 mL/g (3,290 mg/L MLSS) submitted to MDEQ for acceptance with application for new NPDES permit with ~30% increased organic treatment capacity.

• MDEQ approved increased organic treatment capacity as requested and issued a new NPDES permit.

• Next Steps:
  • Follow-on settling column testing and additional SPA when loading rates increase to within 25% of the new BOD load rating, to better define the clarifier capacity.
Questions

• Ben Whitehead, Project Manager
  • WhiteheadBC@bv.com
  • (616) 710-3443

• Ed Kobylinski, Process Specialist
  • KobylinskiEA@bv.com
  • (913) 458-3370

Thank you for attending!
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