Most Efficient and Reliable Activated Sludge Process for Bio P & NH3-N Removal in North America

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Montrose, MI

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Ann Arbor, MI
## NPDES Permit

<table>
<thead>
<tr>
<th></th>
<th>April</th>
<th>May-November</th>
<th>December-March</th>
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<tr>
<td></td>
<td>Daily  Monthly 7-day</td>
<td>Daily Monthly 7-day</td>
<td>Daily Monthly 7-day</td>
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<tr>
<td><strong>BOD 5</strong></td>
<td>15</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td><strong>TSS</strong></td>
<td>30 45</td>
<td>24 36</td>
<td>28 42</td>
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<tr>
<td><strong>Ammonia N</strong></td>
<td>7.2 4.6</td>
<td>2.3 1.9</td>
<td>4.2/5.0</td>
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<tr>
<td><strong>TP</strong></td>
<td>0.75</td>
<td>0.75</td>
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<tr>
<td><strong>pH</strong></td>
<td>6.5 – 9.0</td>
<td>6.5 – 9.0</td>
<td>6.5 – 9.0</td>
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<tr>
<td><strong>DO</strong></td>
<td>5.0</td>
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# Wastewater Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Raw</th>
<th>Primary Effluent</th>
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<tbody>
<tr>
<td>BOD5</td>
<td>176</td>
<td>87</td>
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<tr>
<td>TSS</td>
<td>192</td>
<td>81</td>
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<tr>
<td>Ammonia N</td>
<td>17.5</td>
<td>16.3</td>
</tr>
<tr>
<td>Total P</td>
<td>4.5</td>
<td>3.7</td>
</tr>
<tr>
<td>Volatile fatty acids</td>
<td>-</td>
<td>14-28</td>
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<tr>
<td>BOD/TP ratio</td>
<td>39.1</td>
<td>23.5</td>
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# Effluent TP - No Chemical Addition/No Tertiary Filtration

<table>
<thead>
<tr>
<th>Year, Q, MGD</th>
<th>Annual Ave</th>
<th>Max Month</th>
<th>Max Week</th>
<th>Max Day</th>
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<tr>
<td>2014, Q, MGD</td>
<td>29.96</td>
<td>50.88</td>
<td>73.81</td>
<td>97.55</td>
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<tr>
<td>TP</td>
<td>.40</td>
<td>.57</td>
<td>.67</td>
<td>1.46</td>
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<td>2015, Q, MGD</td>
<td>26.17</td>
<td>33.10</td>
<td>39.60</td>
<td>56.04</td>
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<tr>
<td>TP</td>
<td>.39</td>
<td>.65</td>
<td>.90</td>
<td>1.00</td>
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<tr>
<td>2016, Q, MGD</td>
<td>28.83</td>
<td>49.44</td>
<td>63.23</td>
<td>81.13</td>
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<tr>
<td>TP</td>
<td>.30</td>
<td>.42</td>
<td>.57</td>
<td>1.18</td>
</tr>
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<td>2017, Q, MGD</td>
<td>29.82</td>
<td>53.15</td>
<td>76.05</td>
<td>121.10</td>
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<tr>
<td>TP</td>
<td>.33</td>
<td>.51</td>
<td>.64</td>
<td>1.04</td>
</tr>
<tr>
<td>2018, Q, MGD</td>
<td>29.18</td>
<td>46.70</td>
<td>80.59</td>
<td>135.42</td>
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<tr>
<td>TP</td>
<td>.38</td>
<td>.52</td>
<td>.71</td>
<td>1.59</td>
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Activated Sludge for Bio-P Removal

• Reliability – Full Compliance; Annual Average TP - below 0.4mg/L
  o Treated Dry and Wet Weather Flows, which Peaked at 135 MGD in 2018
  o Activated Sludge Capacity expanded by 2 added clarifiers (877 g/d/FT² at 62 MGD)
  o Favorable Wastewater & Optimized Operation
    ➢ BOD/TP Ratio; greater than 30 in Raw and over 23 at Primary Effluent
    ➢ VFA above 10 mg/L @ Primary Effluent
    ➢ Process Control Protocols Optimized;
    ❖ Baseline Parameters – F/M, Sludge Age, RAS flow rate for different seasons
    ❖ Profiles of ORP, DO, P Release and Uptake, and
    ❖ Profiling Ammonia N as a Leading Indicator
  o C.O.V.  30% - 40%, the Most Stable for Secondary Plant
  o No chemical addition or tertiary filters
  o No chemical sludge produced to handle
  o No chemical costs
## Activated sludge Process at ARTP

<table>
<thead>
<tr>
<th></th>
<th>Design</th>
<th>Actual</th>
<th>At 62 MGD</th>
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<tr>
<td>HRT, anaerobic zone, hr</td>
<td>1.0</td>
<td>1.21 – 2.0</td>
<td>0.47</td>
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<tr>
<td>HRT, Oxic zone, hrs</td>
<td>7.0</td>
<td>8.0 - 10</td>
<td>3.15</td>
</tr>
<tr>
<td>Sludge Age, days</td>
<td>8-12</td>
<td>11-13</td>
<td>1-5</td>
</tr>
<tr>
<td>F/M, and MCRT</td>
<td>0.2-1.5 &amp; 10-14 days</td>
<td>0.11-0.22 &amp; 17-18 Days</td>
<td>0.01-0.02 &amp; 8-10 Days</td>
</tr>
<tr>
<td>Clarifier overflow rate</td>
<td>600 g/d/Ft²</td>
<td>600 g/d/Ft²</td>
<td>877 g/d/Ft²</td>
</tr>
</tbody>
</table>
Plant Process Diagram – Biosolids Management

• Lime Stabilization - Combined Primary and Secondary Sludge
  • Raise to pH 12 and Maintain for a Minimum of 2 hours +
• Decant 1-2 days per week – to the Head of the Secondary
• Haul from Sludge Storage whenever Conditions Allow
  • (Weather & Crop Dependent).
• During Wet Weather - Decant if Possible – Maintain Soluble BOD
  • Drain Back Primary Sludge to Headworks
GENESEE CO., MI - ARTP PROBABILITY DISTRIBUTION OF TP 2008 COMPARED TO 2018

10/12/2018 ORP as it goes thru the Aeration Basin

- Basin 3
- Basin 4
Activated Sludge for Bio P Removal - Release and Uptake

10/12/2018 AO PHOS as it goes thru the Aeration Basin

- Basin 1
- Basin 2
- Basin 3
- Basin 4
Activated Sludge-Bio P: D.O. 8/19/2016

D.O. as it goes thru the Aeration Basin

--- Basin 2

<table>
<thead>
<tr>
<th>7</th>
<th>6</th>
<th>5</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
</table>
Activated Sludge for Bio NH3-N - Removal - NH3-N Profile

8/19/2016 NH3-N as it goes thru the Aeration Basin

- Basin 1
- Basin 2

Graph showing the concentration of NH3-N over time (0.00 to 10.00) through the aeration basin.
Wet Weather Flow Treatment – Compliance Strategy Optimized

• Anticipate the Wet Weather Event Prepare by:
  • Increasing Plant Set Point – Make Room-in-System as well as in Plant Storage
  • Drawing down Wet well, Run All Influent Pumps to Assure Functional –
    • Not Air-bound and Remove Grit from Passive Areas of the Wet Well.
  • Emptying All Tanks with Water in them, i.e. EQ tanks, etc.
  • Prepare to Capture the Collection System Scour – High Loading
  • Maximize the full treatment – up to 62 MGD
  • Allow Wet Well to Rise for Additional Capture – Fill All Tanks – OSB & OOS
  • Set up Wet Weather for Chlorination
  • Once the Capture Subsides – Flow into EQ is Cl2 and then Wet Weather
Process Control Strategy – Following the Event

• Watch Final Blankets and RAS Rates – Keep Organisms in Secondary
• When Wet Weather Flow Ceases:
• Begin Dewatering Sequentially to Recover Treatment Capacity
• Primaries, Finals, Wet Weather, EQ, Containment, Etc.
• Gets you Ready for the next Storm.
• Soluble BOD (sBOD) in the Secondary Influent is Needed –
  • Draining Tanks Captures more Grit and Provides more sBOD
**ANTHONY RAGNONE TREATMENT PLANT**

**GOING INTO OR STAYING OUT OF WET WEATHER**

**IF THERE IS RAIN IN THE FORECAST, PREPARE FOR WET WEATHER**

- Place cookies and close drains on idle final tanks. Close drains on empty primary tanks.
- Empty E.Q. basins and close green gates. Turn on Wet Weather sampler (Line 10) in the old disinfection building basement.
- Stay ahead of the flow, fill idle final tanks to allow maximum capacity flow through secondary system. Start arm and open RAS isolation valves as final tank flows start going over weirs.
- Place both grit vortex in service if one is idle when flows exceed 30 MGD and extend grit timers. 40 MGD and higher use the McMullen procedure. (Procedure on back of page)
- Estimate the flow coming to Brent Run and jog the raw pumps that will most likely be put in service to remove the excess grit at Brent Run before the surge hits.
- Shut off decant if draining to Brent Run. Decant can be left on if utilizing decant pump station.
- Let PE channel rise to back flow into empty primary tanks (Use as E.Q.). Shut off primary scum ejector.
- Open Pass 3’s P.E. bypass valves to East Aeration when flows exceed 20 MGD, if not already in.
- In Group 5.3 Change West MOV to 70%. Write change in green folder.
- Begin filling empty Primary Tanks at a rate to maintain maximum secondary flow. Use empty primary tanks as E.Q. as long as possible. Backup wet well containment basin to 60%.* Put idle Bar Screen in service if over 40 MGD.
- Push maximum capacity flow through final tanks (61 MGD), after primary tanks are filled through the weirs by using back flow. This may help stay out of wet weather with flows at 61 MGD or slightly higher (11° or higher P.E. channel is needed to push 58+ MGD). Start another RAS pump on East side at 48 MGD and cut RAS % in half on the East side.
- Set Screening Belt Conveyor to discharge on Bar Screens when flows start causing high differential alarms.
- If needed and weather conditions allow (rain only: no lightening or strong winds), backup basin to 61°, if possible, to avoid wet weather.
- Prepare to chlorinate flow to Equalization Tanks. Check that the WW Chlorine feed line drains (5) are closed, and that the inducers are down and the valves at the inducers are open. Start the inducers and make sure there is a vacuum on Chlorinator #3. Current feed rate is 4-6 mg/L. Start chlorination only after opening green gates and E.Q. Tanks begin receiving flow. Check WW basin bubblers and blowdown. Target residual is 1.0 mg/L. (See Wet Weather Chlorination Procedures)
- Prepare to de-chlorinate wet weather flows. Close drains on WW flume. The inducer cannot be started if not submerged. Make sure that the inducer is down and the valves at the inducer are open. Make sure there is a vacuum on Sulfonator #3. *Current feed rate is one and a half times the chlorine residual.*

- Start Wet Weather sampler as soon as Wet Weather overflow begins. Make sure sample jug is in place and make a note in the log of when we started sampling. This sampler will need to be restarted after 24hrs of run time (11:00 pm) and the sample placed in sample fridge in the lab. You will need to take an extra sample when there are eight hours or less of a sample so that there is one liter. See instructions by sampler for more detail.
- NOTE: Lab will need at least two liters of sample per day of wet weather overflow.
- Check North Primary Effluent Channel and make sure P.E. scum drains on east & west side are closed.
- Make any other necessary changes to the plant to pump 61 MGD through process.
- Check final tank effluent often during high flow, adjust flow rates and plant split where needed to achieve maximum treatment.
- Before the initial scour arrives and as time permits, pump primary sludge to avoid heavy solids building up in Primary Settling Tanks and to prevent flights crashing. Once too much grit makes into the primaries and the primary pumps start having issues, (lower pumping rates, plugged primary pumps, sheared pins, etc.) stop pumping.
- Watch your air demand and dump primaries back to Brent Run in 10 minute intervals, and wait 10 minutes between tanks to allow drain/bar screen/grit to catch up. Rotate through all primaries in service as much as time allows, but try to dump each primary at least three times per shift. During this time make sure to keep an eye on the grit pumps and classifiers as they will be more prone to plugging.
- Make sure there are enough people here to be able to keep up with the extra work during wet weather. Call someone in if needed.

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**Dosage formula for SO2: Sulfonator SP in lbs/day = 8.34 lbs/gal x Flow MGD x 1.5 **

**HIGH FLOW GRIT SYSTEM PROCEDURE**

Open all intakes on grit pumps and pipe valves from both vortexes. Cross connection pipe installed between pumps 2 and 3.
- Open all discharge valves on grit pumps.
- Open cross valve along with both feed pipe lines to classifier in the basement.
- Turn on both classifiers by placing in manual on PWC.
- Turn on grit pumps 1-3 by placing in manual on.

By doing this the system will draw higher flow through the grit system from the Vortexes, allowing a higher rate of grit removal and help keep the pipes from plugging up.
Seasonal Strategy -

• Winter – Longer MCRT - Target 18-22 Days
• Summer – Normal MCRT - Target 14-18 Days
• Spring – Begin Reducing MCRT to Normal
• Fall – Begin Gradual rise in MCRT
Costs of Treatment 2018

- Overall, $773.47/MG Treated - Year
- Energy - 1251 KWH/MG Treated or $101/MG Treated KWH/MG
Total Cost of Phosphorus Removal

• US EPA Model for Typical Plant—Allocation of Costs for Pollutant Parameters is 10% for Phosphorus
  ❑ $2.147 per pound of Phosphorus Removed.

• Total cost of TP removal at ARTP - negative
  ❑ No chemical addition,
  ❑ No chemical sludge to process,
  ❑ Removes some BOD and Reduces the Aeration Demand in the Basin,
  ❑ RAS is Thicker Sludge to Process (RAS Averages 2.2% (22000 mg/L)
2018 ARTP Total Budget Breakdown

- Salaries/wages: 23%
- Operating Supplies: 18%
- Fringe Benefits: 18%
- Professional and Contractual Services: 12%
- Sludge Disposal: 8%
- Repairs and Maintenance: 12%
- Utilities: 15%
- Vehicle Fuel: 0%
- Miscellaneous: 5%
- Non-capitalized outlay: 2%
- Capital Outlay: 12%
Current Issues

• Draft NPDES Permit Requires
  • Additional I/I removal from Collection System
  • Maximize Biological Treatment >62 MGD - Peak Wet Weather Flows
  • 25 Year/24 Hour Storm Transported to the Plant – Demonstrated in 2018
    • Essentially doubling the size of the plant for once in 25 years.
    • No Net Benefit to the Receiving Stream or Environment


• MI has Water Quality Standards during the Drought Condition in the Receiving Water, but not for Wet Weather Conditions. A New set of Criteria is Recommended (WEFTEC 2019 paper)
Summary and Conclusions

- Unparalleled Performance for Bio P and NH3-N Removal at ARTP
  - Favorable Wastewater Characteristics with good BOD/TP Ratio and High VFA
  - Optimized Operating Strategies for Wastewater, Sludge, and Controls
  - Established (SOP) Practices for Wet Weather Flow Treatment Management
  - Expanded Sampling and Testing Supporting these Strategies

- Costs of Treatment are Reasonably Low for an Advanced Secondary Plant
  - Reasonably Low at $0.77/1000 gallon Treated
  - Power use is Low at 1250 KWH/MG Treated
  - Zero Cost for Chemicals and Chemical Sludge Handling

- Compliance with the NPDES permit
- Annual County Fishing Competitions are held in the Flint River