Boosting Wastewater Pond Phosphorus and Nitrogen Treatment in Baudette, MN.

Results

Phosphorus:
4.2 mg/L ➡ .4 mg/L

Nitrogen:
2.5 mg/L ➡ 1.2 mg/L

Ferric Chloride:
6,600 gal ➡ 0 gal

$22,000 Annual Savings

Challenge

Achieving cleaner water is the goal of all wastewater treatment professionals. Until recently, the City of Baudette MN was resigned to the idea that chemical treatment for phosphorus was the only option for meeting their effluent phosphorus permit limits. The pond operations team changed in 2019, and the new team decided to look for improvements. The new operators partnered with Frank Stuemke with MRWA and the LCCMR Nutrient Optimization Project Team to look for strategies to improve treatment. As a result, Charlie Cook and Jake Fish implemented several new operational strategies bringing their pond nutrient treatment to the next level, and eliminating the need for chemical treatment.

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Approach

'Flow Through' Pond Operation

The 'Flow Through' operational strategy serves to increase pond hydraulic retention times while maintaining steady treatment conditions in a deep first pond. The project team believes this is the best general operational change to boost pond efficiency. Here's the method:

- Keep Pond 1 as deep as possible.
- Allow water to flow into pond 1, while water continuously flows out to fill pond 2.
    - This is most easily accomplished with a slide gate that will maintain a full depth in pond 1.
- When pond 2 is full, discharge the secondary (pond 3), and transfer water from pond 2 to the secondary.
- Repeat

This method keeps pond 1 and pond 3 full. Influent water flowing into the full pond 1 provides the pond 1 ecosystem with a steady supply of carbon and nutrients which it adapts to treat.

In Baudette specifically, the operations team held their large pond 1 at 4.5' depth using a slide gate. Water was then allowed to cascade over the slide gate to fill pond 2. It is worth noting that this cascade of water provides some additional aeration as it is transferred, which may also have a positive impact on treatment. This method was implemented over the summer of 2020. Prior to this change, the average pre-discharge phosphorus concentration was 4.2 mg/L. The post project pre-discharge phosphorus concentration was .4 mg/L! This meant that the city had no need to add the typical 10-12 totes of ferric chloride prior to discharge in the fall of 2020, saving $11,000, with similar savings expected after spring discharge.

Results

As a result of implementing 'Flow Through' Operation in 2020 and a series of other changes since 2019, the Baudette operations team has seen their nutrient treatment improve dramatically. The results are shown below.

Baudette MN Pond Optimization Project Savings

Category	Amount Before	Amount After	Annual Savings
Phosphorus	4.2 mg/L (pre-ferric) .73 mg/L (post-ferric)	0.4 mg/L (no ferric)	200 lb Phosphorus
Nitrogen	2.5 mg/L	1.2 mg/L	800 lb Nitrogen
Ferric Chloride	6,600 gallons per year	0 gal per year	$22,000 2500 lb Chloride

Approach (continued)

While 'Flow Through' Operation is believed to be the core improvement, the wastewater operators were hard at work optimizing the many optimization opportunities.

Utilizing Full Pond System Volume

Increasing hydraulic retention time within Minnesota pond systems has a positive correlation with phosphorus treatment efficiency. Because of design changes over time in the Baudette pond system, pond 2 is at a much lower elevation than pond 1, and similar elevation to pond 3. This means that to operate in series, water must be pumped from pond 2 to pond 3. In the past, turning on the pump was considered a waste of energy, and pond 2 was often bypassed as water was transferred from pond 1 to pond 3 directly. This bypass reduced the system HRT by 17.4%. The new operational strategy is to use the full series, and to simply pump water from pond 2 to pond 3 when it is time to transfer water, maintaining larger HRTs to achieve better treatment.

Allowing Beneficial Aquatic Plant Growth to Uptake Nutrients

Coontail is an aquatic plant that naturally grows in many Minnesota wastewater pond systems. It is known to uptake nutrients as it grows, and can therefore be a useful tool in achieving better treatment in the pond system. In Baudette, the operators used to use chemical to thin out the coontail growing in the pond system. In 2020, they decided to try not thinning the coontail, and let it grow instead. Letting the coontail grow was another factor contributing to this better nutrient treatment.

The Baudette wastewater operators have started doing their fall discharge in September instead of October. This idea behind this change is to discharge water before coontail starts to die off, ensuring that when water is being discharged it is as clean as possible.

Keep Wastewater Flowing and Avoid Holdup in Pipes

In the past, operators allowed the wet well to build to a depth of 8' before pumping it to the pond system. In doing so, wastewater would submerge the influent pipe, and backup for 7 structures, allowing them all to fill before the structures would all be pumped out at once. The main treatment concern with this operational choice is that holding raw wastewater underground and in pipes for long periods of time may cause it to turn septic, making it more difficult to aerate and treat later.

The new operational strategy is to discharge the wet well as it approaches the influent pipe depth, and to pump it down to 2' under the influent pipe depth. This results in much more

frequent transfers to pond 1, allowing it to reach the aerobic conditions in the wastewater pond more quickly.

The Baudette Wastewater Pond System accepts wastewater from a school which was in reduced operations in 2020 due to COVID-19. This school has a very large, 6000', 6'' force main. The operators calculated that wastewater takes three days to pass through the large pipe system. It is possible that after three days of sitting in the pipes, this waste stream turns septic and adds additional loading burden on the pond system. The operators are investigating possible long term solutions to this issue. For 2020, accepting reduced loading from this source may have also contributed to better pond treatment.

Reduced Inflow and Infiltration and Less Flow

Baudette Average Influent Flow

Year	Average Flow (MGD)
2017	0.20
2018	0.20
2019	0.25
2020	0.17

Reducing inflow and infiltration effectively increases the hydraulic retention time of the wastewater we are trying to treat. Sure, incoming clean rainwater does dilute the waste stream, but it hurts the overall treatment by reducing the treatment time available to clean the water that is dirty. Even if I&I has an immediate impact of slightly reducing nutrient concentrations, it does not reduce the total mass of phosphorus in the system. The operators with Baudette were able to address some I&I issues like replacing some leaky clay tile pipes and replacing leaky manholes in order to better keep the storm water and wastewater separated. This along with a dryer year helped to reduce their average flow to .17 MGD, helping them to increase their hydraulic retention times and overall phosphorus treatment.

Winter Bioaugmentation

While the Baudette pond system has historically added microorganisms during warm weather operation, the winter of 2020 was the first year they also added microbes over the winter. Specifically, they added TeamLabs T195 Mega Bugs Plus Powder. The product is specifically marketed for pond sludge reduction. Sludge depth data collected by Frank Stuemke with MRWA suggests that between 2009 and 2011, the warm weather bio augmentation microbes were able to bring sludge depths from roughly 11'' down to 5''. Reducing sludge depth serves to increase hydraulic retention time within the pond systems, as the volume previously displaced by the sludge is now available to be utilized to treat the wastewater.

Technical Clarifications

The nutrient reductions highlighted are based on data from one discharge in the fall of 2020. Because the 'flow through' strategy was implemented over the spring and summer of 2020, this is the only discharge so far following that implementation. Future discharges will serve to solidify these findings. Pre-ferric refers to the testing value before adding ferric chloride for phosphorus treatment, while post-ferric refers to the testing value after adding ferric chloride for phosphorus treatment. The pre-ferric 'before' value for phosphorus was calculated from test values provided by Wastewater Pond Operator Charlie Cook, in turn provided to him by his chemical supplier. The values were 4.6 mg/L in October 2018 and 3.8 mg/L in June of 2019.

The post-ferric ‘before’ value is an average of the recorded DMR phosphorus data from the spring of 2014 through the spring of 2020. Prior to spring 2014, values were much higher and it appears that the spring of 2014 is when ferric addition began. The ‘before’ nitrogen value is an average of the sum of TKN and Nitrate + Nitrite values recorded in the DMR from spring 2014 through spring 2020. The ferric chloride amount before was calculated based on an operator estimate of requiring 22 totes of ferric chloride per year on average, and a confirmed tote size of 330 gallons each.