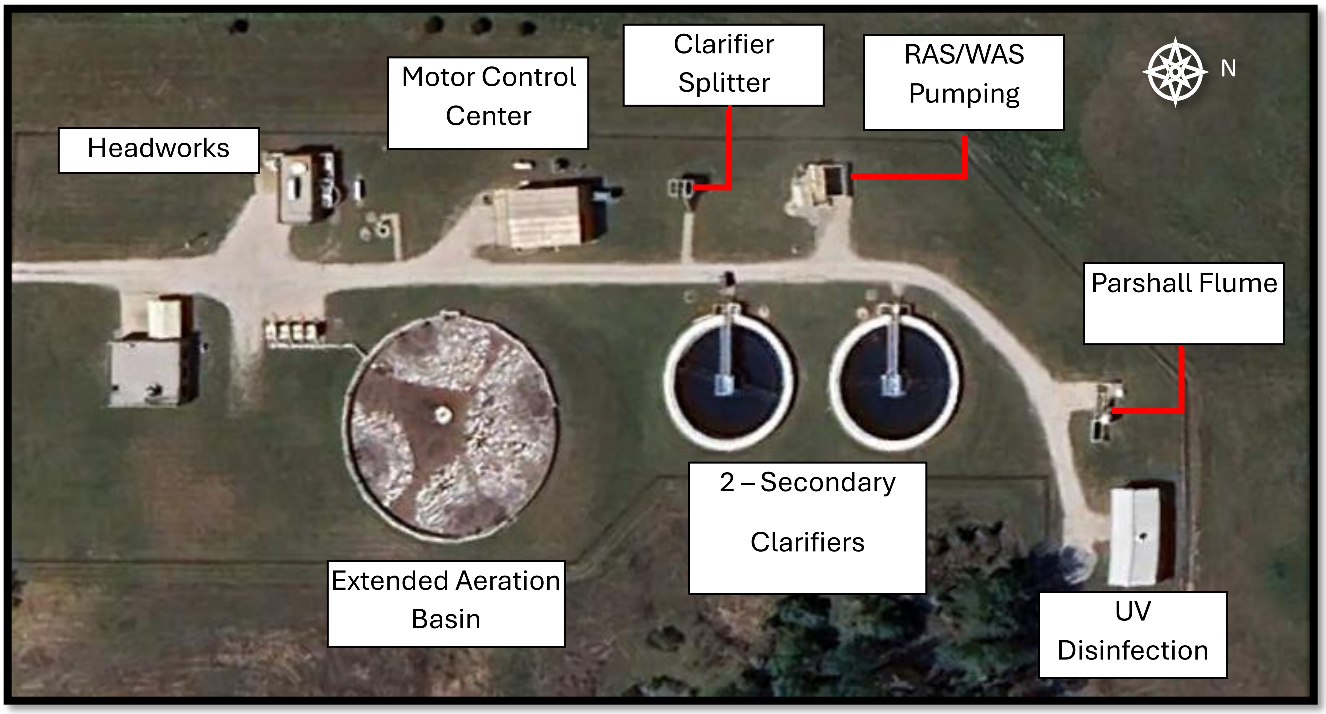
Oak Grove, Missouri

MO0130371
MoDNR Municipal Wastewater Nutrient Optimization Pilot Project
August 2025



Oak Grove Wastewater Treatment Plant (WWTP)

Extended Aeration

Design Flow: 1.3 MGD
Actual Flow: 0.84 MGD

1500 NE Gillespie Rd
Oak Grove, MO 64011
Latitude 39.0275 /Longitude -94.183333

Corey Alford, Director of Public Works
Cobey Dreher, Operator

Summary of Optimization Efforts:

The Oak Grove WWTP historically discharged total nitrogen (TN) close to the Missouri Department of Natural Resource (MoDNR) goal and total phosphorus (TP) at a level significantly above the target value. Initial efforts focused on getting the plant to run consistently and continue to reduce nitrogen. Later in the project, a minimal amount of time was spent on phosphorus reduction with minor success. The optimization effort was hindered by a variety of issues including loss of two separate lead operators during the project, an extremely high initial mixed liquor suspended solids (MLSS) concentration, equipment breakdowns, questionable aeration diffuser performance, and periodic influent slugs that upset the plant.

Nitrogen Removal

The biological treatment at the Oak Grove WWTP is an extended aeration process. The WWTP has one circular aeration tank aerated by eight diffuser racks each fed by a flexible drop hose. The diffusers extend from the wall of the tank toward the center of the tank. Air is supplied by four fixed-speed blowers. A slow-speed mixer mounted to a floating platform is in the middle of the basin and is tethered in place by cables extending from the wall. With the blowers being fixed speed instead of variable frequency (VFDs) drives, plant staff experimented with only running one blower, then cycling the blowers on and off to establish an anoxic zone. Turning the mixer on and off when the blowers were turned off was also tried to create a more anoxic zone.

Phosphorus Removal

Having never achieved consistent operation, it was difficult to take additional action to enhance phosphorus reduction. It was believed a septic or anaerobic zone might be created in the middle of the basin since the aerators did not extend to the middle and the mixer could be turned off, which would allow solids to settle in the bottom of the basin. This was the same operation scheme as was practiced for TN reduction, and some initial TP reduction was seen. The basins were initially carrying an extremely high MLSS concentration – 8,000 to 10,000 mg/L. So, when the aeration and mixing were turned off, solids settled quickly and likely became anaerobic quickly, generating volatile fatty acids (VFAs) and causing phosphorus accumulating organisms (PAOs) to release phosphorus that was taken up when aeration was restarted.

Nutrient Reductions

As shown in Table 1, the Oak Grove WWTP data are somewhat confounding. TN concentration worsened by 2% while the TN mass reduced improved by 34%. Conversely, TP concentration improved by 15% while TP mass worsened by 34%.

Table 1 – Nutrient and Energy Reductions

	Pre-Optimization	**Post-Optimization**	**% Improvement**
TN – mg/L	8.5	8.7	-2
TP – mg/L	5.7	4.8	15
TN – lb/day Reduced	184	248	34
TP – lb/day Reduced	30.4	20.2	-34
Energy Use – kWh/MG	3,343	3,164	7
Energy Cost - $/MG	278	266	3

The explanation lies mostly in influent concentration reported by Oak Grove pre- and post-optimization. As shown in Figure 1, TN influent concentration is highly variable and rose by nearly 30%, thus with the effluent TN concentration pre- and post-optimization about equal, there was much more TN to remove post-optimization accounting for the large increase in the mass of TN reduced.

The pre- and post-optimization influent TP went in the opposite direction with the post-optimization influent concentration being 34% less than the pre-optimization influent. Therefore, there was significantly more TP mass to remove pre-optimization which accounts for the large decrease in TP removed post-optimization.

A second more minor factor was that in April of 2024 (pre-optimization) Oak Grove reported "no discharge" for the month. That is possible since they can route their effluent to their old lagoon system that is permitted for both extraneous flow holding and sludge storage.

The contractors brought up the uncommonly wild swings in data with Oak Grove staff and staff believed the data were accurate.

The TN effluent concentration of 8.7 mg/L is below the MoDNR target. The post-optimization TP concentration is 4.8 mg/L – significantly above the 1 mg/L target. Due to numerous plant issues throughout the Pilot Project, the contractors and plant staff were never able to devote significant time to optimizing phosphorus removal.

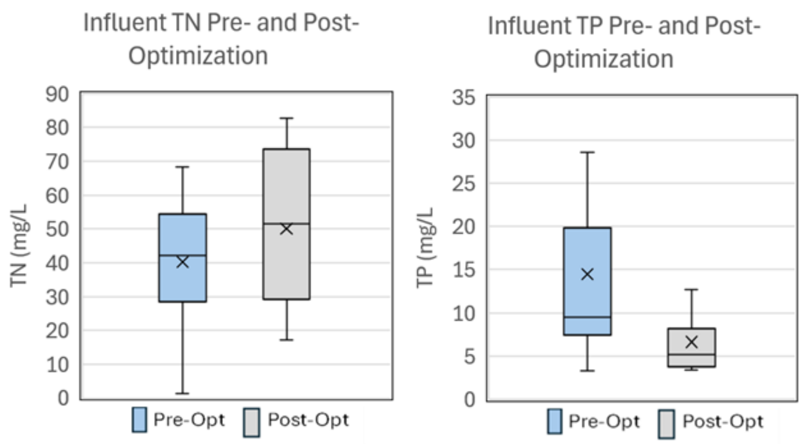


Figure 1 - Influent TN and TP at Oak Grove

For all mass-based calculations, the results were normalized for flow to fairly compare pre- and post-optimization since flows during the pilot period were 3% higher than previous flows. Without normalizing for flow, discharging the same concentration (mg/L) pre- and post-optimization would yield more mass reduced post-optimization simply because of higher flows. Normalization involved reducing the mass removed by the increase in flow – 3%.

Oak Grove used 7% less energy per MG treated, and cost per MG went down slightly also – 3%.

Costs and Return on Investment

Three factors contribute to the cost of optimization: (a) MoDNR's investment in consulting support, (b) Oak Grove's investment in equipment and instrumentation, and (c) ongoing operational expenses relating to energy (i.e., electricity), chemicals, lab supplies and personnel.

The Oak Grove WWTP had modest energy savings in cost and kWh, while the efficiency of energy dropped by 17%. This means that for every kWh used in treatment, fewer pollutants are now being removed. As discussed previously, the extremely large differences in influent TN and TP pre- and post-optimization drove the reduction in efficiency.

MoDNR's cost for optimizing the Oak Grove plant was $30,596, one-eighth of the $244,765 pilot project contract fee awarded to Grant Tech, Inc. and T8 Environmental LLC. One-eighth because there were eight municipal wastewater treatment plants in the pilot study. Oak Grove's costs (as estimated by facility staff) total $1,849 but are offset by $1,075 in energy savings - Table 2.

The total cost of optimization therefore was $31,370 ($30,596 + $774), less than $24,150 per MGD of treatment capacity. Conventional facility upgrades for nutrient removal typically cost millions of dollars per MGD of plant capacity.

Table 2 – Facility Reported Costs

Item	(Cost) / Savings
Instrumentation	($980)
Lab Supplies	($869)
Added Personnel Time	0
Other	0
Energy Savings	$1,075
Total	($774)

As shown in Table 1, the year-long optimization effort resulted in an increased TN removal of 64 lbs/day (23,360 pounds per year) and an increased TP 10.2 lb/day (3,723 pounds per year). Dividing the cost of the project by the sum of the additional annual mass of TN minus the TP increase results in pilot project cost of $1.60 per pound per year ($31,370 ÷ (23,360 lb/yr - 3,723 lb/yr)).

Initial Optimization Strategy:

A key part of the initial optimization strategy called for the operators to begin reducing the MLSS concentration in the basin by around 500 mg/L per week. A typical extended aeration plant would carry around 3,000 mg/L while the Oak Grove plant routinely carried around 8,000 to 10,000 mg/L. Slowly lowering the MLSS to an acceptable level could take three to four months. Frequent meetings with the project consultants and the reduction in MLSS would determine when to begin experimenting with turning one or more blowers off for several hours per day to try and drive nutrient reduction. The operators began wasting more sludge in August 2024; however in a matter of four days' time at the first week of September 2024, MLSS went from over 5,000 mg/L to 3,300 mg/L. The operators stated that the sludge in the plant had become "sick", and they wasted most of it to their sludge storage lagoon. Since the MLSS concentration was down, the contractors began working with the operators on an air-ON/air-OFF scheme to create an anoxic zone.

Modifications to Initial Strategy:

The initial strategy progressed until a series of incidents happened to set optimization back. Over a weekend in October 2024 when the plant was unmanned, effluent ammonia spiked to 15 mg/L by the following Monday. That required going back to full aeration. MLSS had also climbed again. At around the same time, the lead operator retired and a new lead operator from outside of Oak Grove was hired. The new operator wanted to run the plant with an MLSS of 2,000 to 2,500 mg/L and dropped the MLSS over a short period of time beginning in November 2024. The plant was operating more consistently initially but developed a large population of filamentous bacteria. Minimal optimization effort took place for several months while the plant recovered. Additionally, the mixer had broken free of its tethers and was out of service for several days.

By January 2025, the plant was operating well at around 1,800 mg/L, so the contractors suggested running with only one blower during the day and shutting off one air drop near the influent entrance. That brought TN down, but TP rose, suggesting that a more septic zone needed to be created in the plant, so the mixer was turned off 8 hrs/day. About the time the plant began recovering in February and producing TN around 5 mg/L, a very high BOD (>300 mg/L) and ammonia (41 mg/L) load hit the plant which caused the operators to run the aerators and mixers continuously. In March 2025, a green colored influent was observed at the plant with elevated strength. Shortly after the green influent incident, the plant lost two of its four blowers. However, the plant was able to re-start reduced aeration operations by running one blower during the week and two on the weekends in April 2025 and maintained TN reduction below 10 mg/L. Again, however it was noted that the plant seemed to experience high strength influent flows over the weekend. It took the plant several days to recover. The contractors recommended running two aerators and the mixer throughout the weekend to see if that would lessen the impact on the plant.

Plant staff began experimenting with turning a single air drop off nearest the influent during the day when the plant was manned. Shutting the air drop off was abandoned when it was discovered that the gaskets at the connection of the air hose and the diffuser leaked and the operators were having trouble locating replacement gaskets. By April and May 2025 staff had to run the aerators and mixers continuously due to infiltration and inflow.

During an on-site visit in May, the contractors noted the mixing and aeration did not appear to be even across the basin. The operators noted they periodically changed diffusers and showed a replacement to the contractors. The contractors noted the manufacturer was located in Columbia, MO and suggested the operators see if the company would visit on-site and provide an opinion on the effectiveness of the aeration and diffusers. The diffusers were stated to be fine-bubble; however, the top of the basin did not look like aeration fine-bubble diffusers – it had a very coarse appearance and was not even. This likely led to very poor oxygen transfer which made the option of turning aeration on and off risky. The lead operator noted that he was switching jobs but would contact the manufacturer before he left. The manufacturer did visit the site in June 2025 and agreed the aeration did not appear normal and would have an engineer evaluate the system. The project ended prior to any resolution between the City and the manufacturer.

Ongoing Optimization Strategies for Oak Grove:

- Continue to pursue a resolution to the diffuser and blower issues. If blower replacement is sought, variable frequency drive (VFD) controls should be a priority. They will allow better control over aeration at a lower cost. If new VFD-driven blowers are purchased, DO control via the plant system control and data acquisition (SCADA) system should be a strong consideration. Again, it would allow better control of aeration and save on electricity usage.
- Continue to control the MLSS – somewhere around 3,000 mg/L.
- Continue to monitor weekend influent flow to determine if a high strength waste was directed to the plant over the weekend. The plant experiences extremely wide swings in influent concentrations which make conventional operations difficult, let alone for nutrient reduction.
- Once the diffuser issue is resolved and MLSS is maintained around 3,000 mg/L, the operators should be able to develop anoxic zones and consistently reduce TN. Additional operational tweaking would be needed to see if TP could be reduced.

The operators indicated they were looking at a chemical feed system (metal salt) for TP reduction in the future. At current levels of TP, the cost of the chemical alone would significantly impact the WWTP budget. Any TP that can be reduced biologically will come at essentially no cost and reduce the amount of chemical needing to be fed, which could result in savings of hundreds of thousands of dollars.

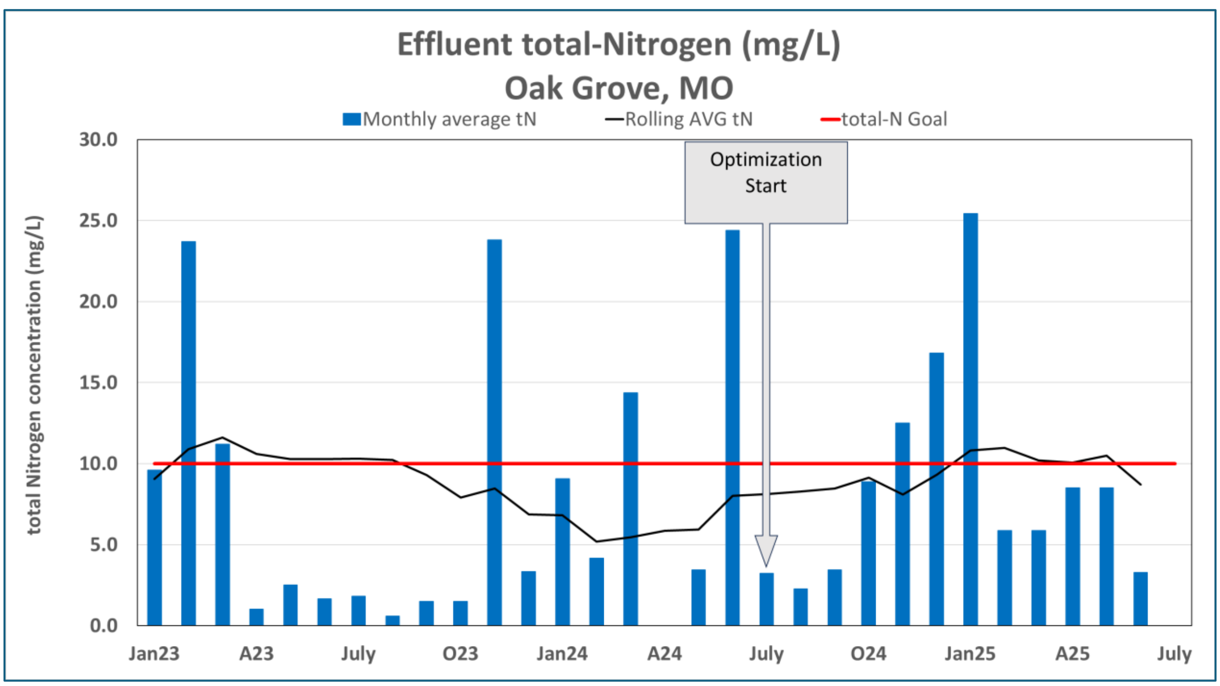
Additional Plant Information:

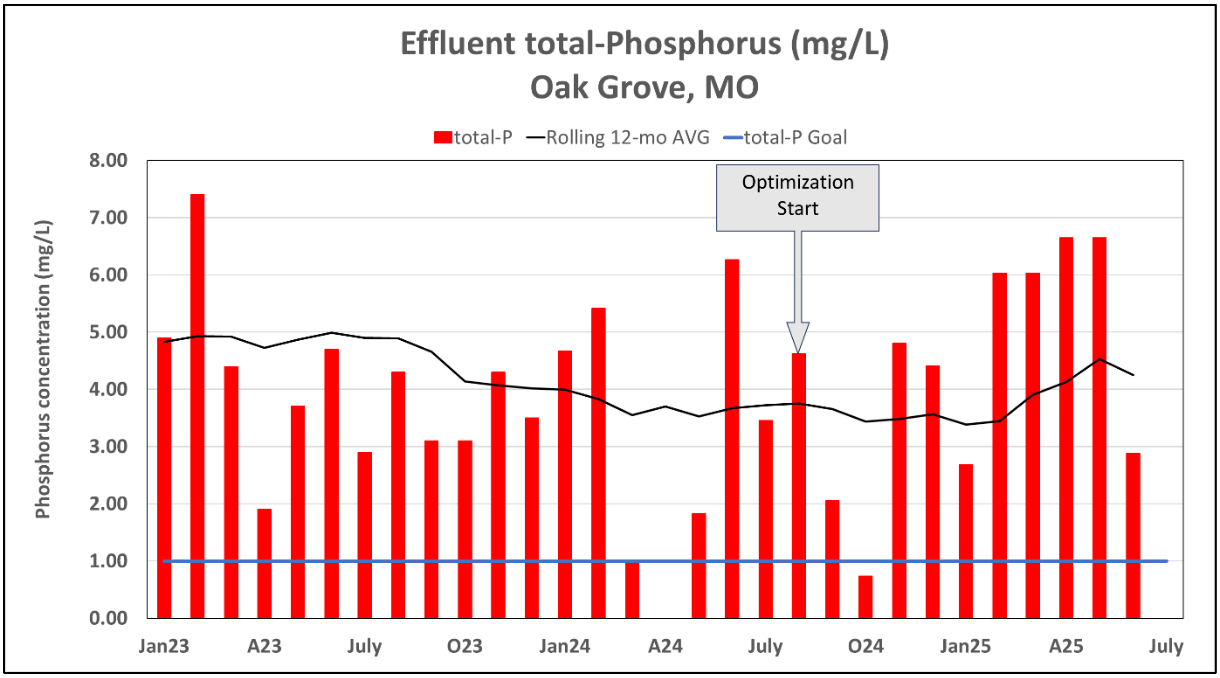
The Oak Grove Wastewater Treatment Plant operates with a daily average flow of 0.84 MGD versus a design flow of 1.3 MGD. The treatment facility includes flow equalization, a mechanical bar screen and grit removal followed by a single extended aeration basin, and two secondary clarifiers. Disinfection is provided by ultraviolet (UV) lamps. The plant sends waste sludge to a holding lagoon. Biosolids are land applied by a contractor.

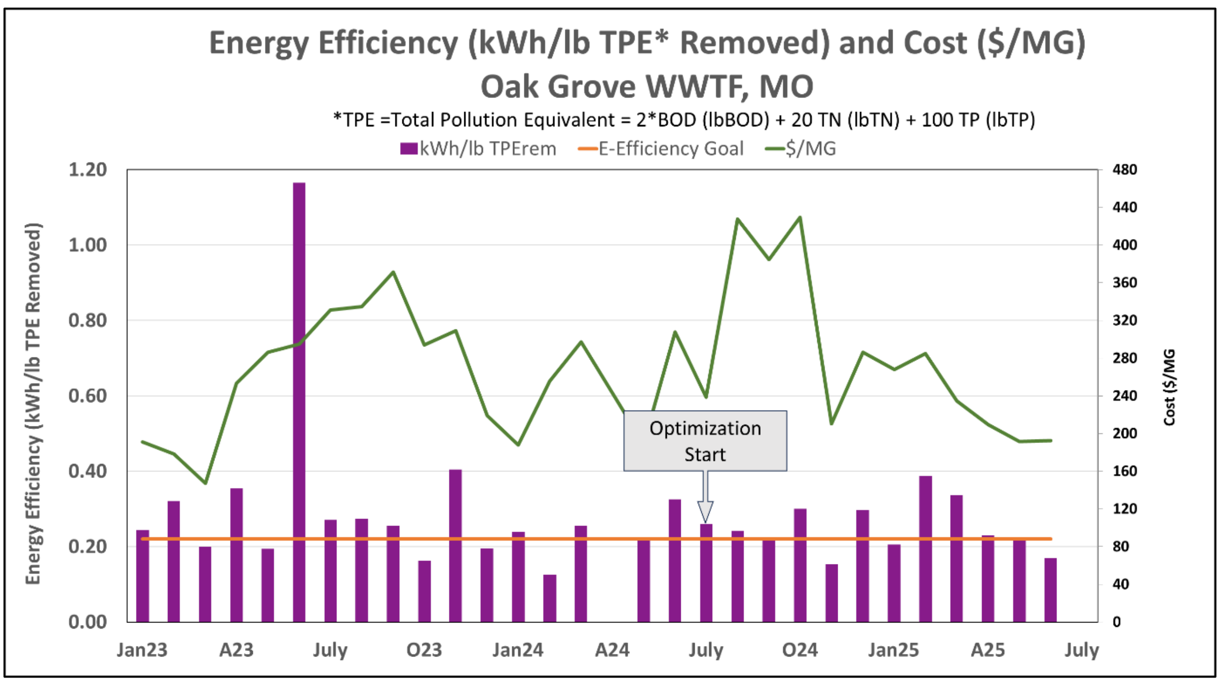
Contractor Information:

The year-long MoDNR funded nutrient optimization study was initiated in May 2024 by Grant Weaver of Grant Tech, Inc. and Mike Tate of T8 Environmental LLC and completed July 2025. The contractors made four site visits and held 22 video call meetings with Oak Grove plant staff.

Nutrient Removal & Energy Efficiency Graphs:







Lessons Learned / Guidance for Others Considering Optimization:

Facilities not designed for nutrient removal must be operated differently than those designed to achieve nutrient removal. Data beyond that required to meet permit conditions need to be collected and compared against targets. This is also true for most facilities designed for nutrient removal as well.

The Oak Grove WWTP experienced numerous equipment breakdowns, unexplained spikes in both the influent concentrations of nutrients and conventional pollutants, and changes in MLSS during the Pilot Project making it difficult to establish a consistent optimization approach. Once the City can resolve their aeration issues and identify the source of influent spikes, their extended aeration WWTP should be able to consistently meet the MoDNR TN goal and allow more experimentation with TP reduction.

An empirical approach to optimization is greatly enhanced with regulatory encouragement and support as was the case in Missouri. Offers of enforcement discretion are a strong motivator for highly regulated and therefore risk-adverse municipalities to seek optimization opportunities.

Given that Nitrogen and Phosphorus are chronic pollutants, permitting discharges as rolling average mass loadings accommodates day-to-day and month-to-month variability with minimal environmental consequence while accommodating the impacts of infiltration and inflow (I/I), seasonality, and day of week variability in flows and loadings.