Optimizing POTW Performance for Nutrient Removal

ACWA Annual Meeting
August 15, 2025
Madison, Wisconsin

Grant Weaver
Grant@GrantTechSolutions.com

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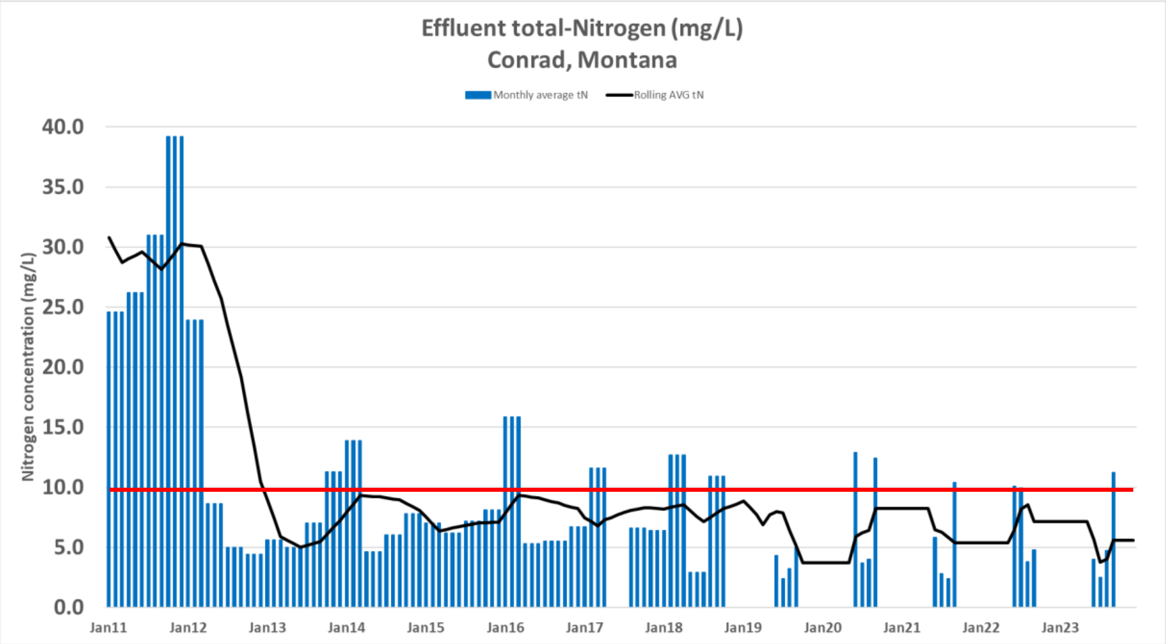
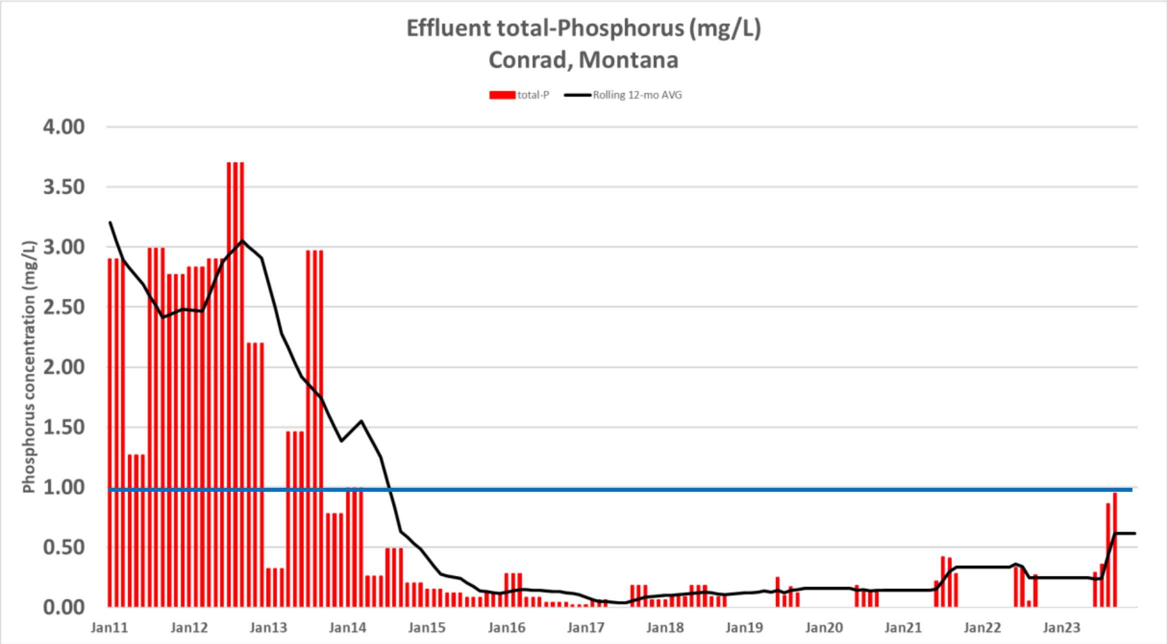
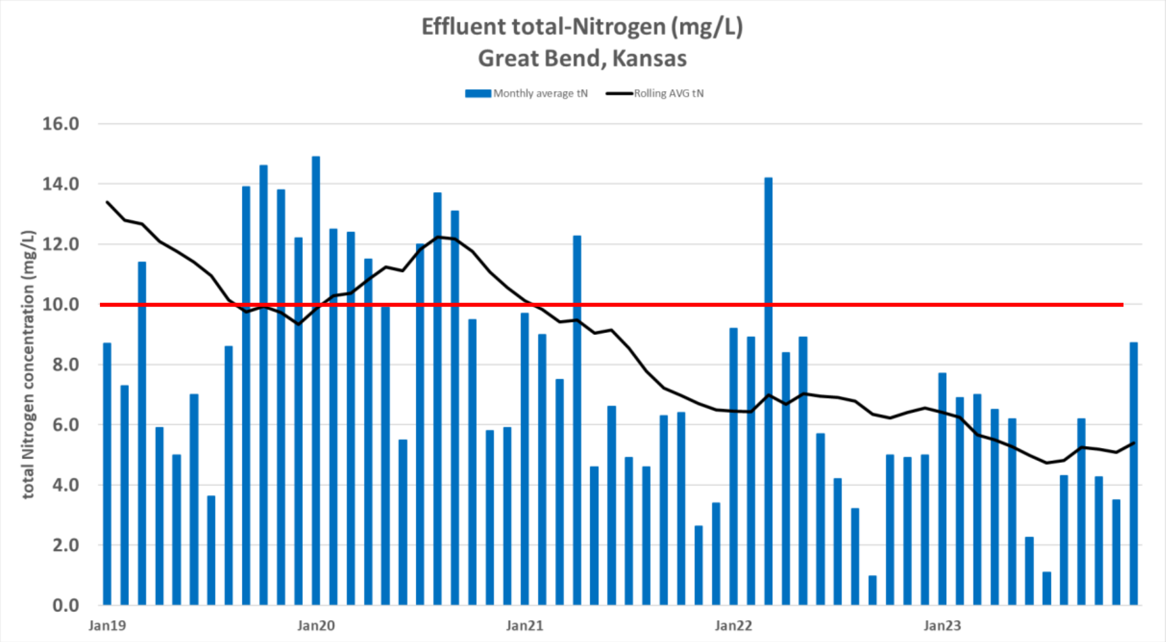
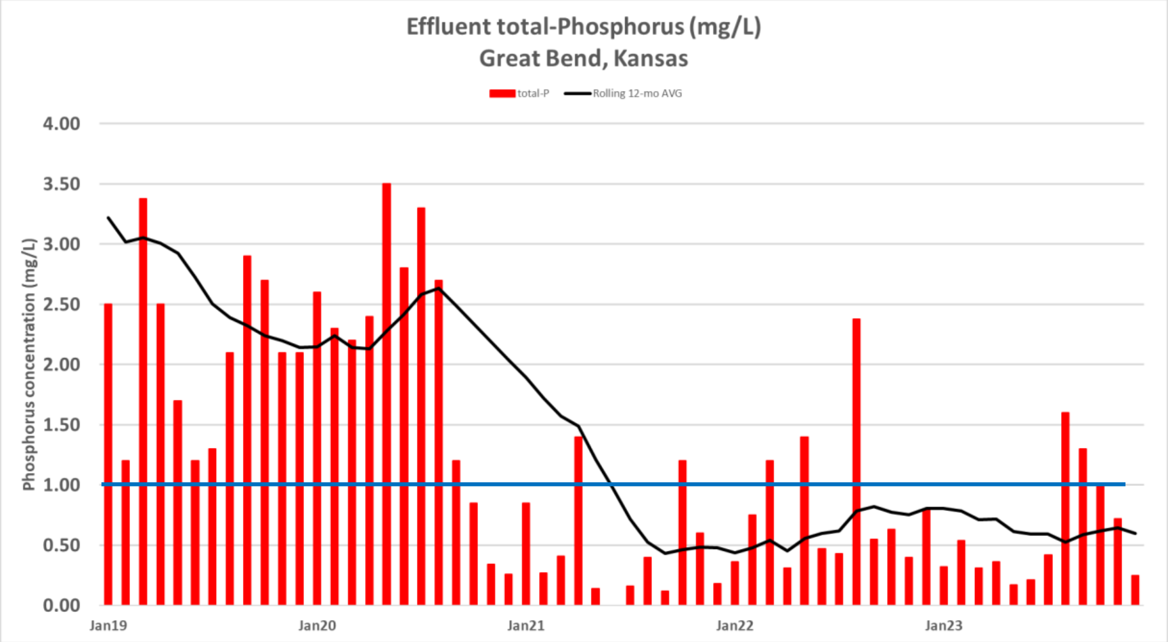
Case Study: Conrad, Montana





Case Study: Great Bend, Kansas





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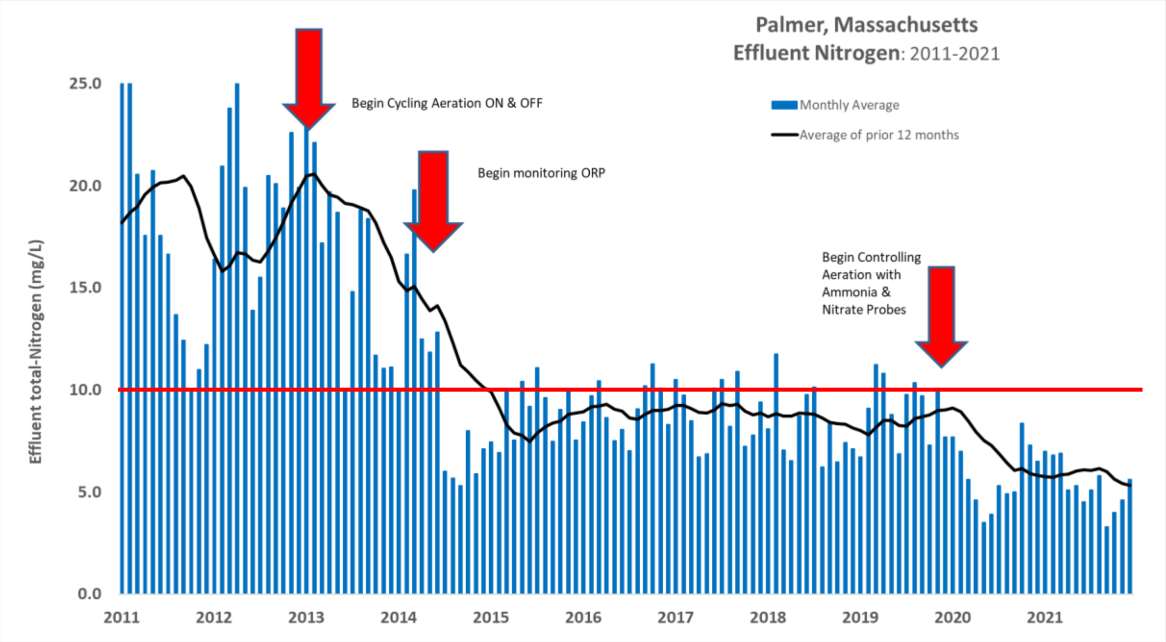
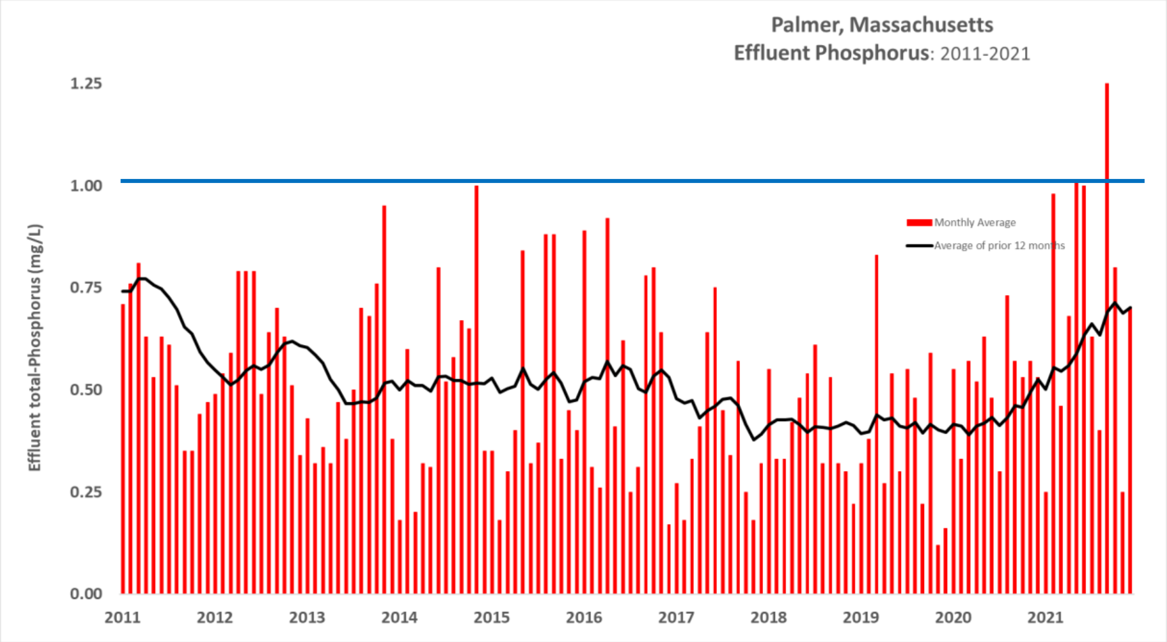
Case Study: Palmer, Massachusetts





Lessons Learned

with apologies to Cy Twombly

Lessons Learned: Nitrogen Removal

Most Activated Sludge plants can be optimized to produce a 10 mg/L tN effluent

75%+ with one-year of support produce a 10 mg/L tN effluent

5-10% visited once and provided with written plans get to 10 mg/L

Less than 1% of Activated Sludge plants left on their own achieve 10 mg/L tN

....

Electrical savings are often realized; many times, enough to pay for optimization!

Lessons Learned: Phosphorus Removal

33% of Activated Sludge plants can be optimized to produce 1.0 mg/L effluent tP

10% with one-year of support generate effluent with 1.0 mg/L tP

2-3% plants visited once and provided with written plans get down to 1.0 mg/L tP

<1% of Activated Sludge plants left on their own achieve 1.0 mg/L effluent tP

Yearlong Nutrient Optimization Strategy

Approach:

Volunteers are selected
Preliminary meetings / training / discussion
Initial site visit

Written Optimization Plan / Enforcement Discretion

Plants implement recommended changes / ops team provides support

- Monitor, review, discuss
  - Quarterly (or more frequent) in-plant visits
  - Monthly (or more frequent) video calls
- Frequent changes ... "tweak"
- Repeat until nutrient goals achieved

Funding source:

EPA Hypoxia grants and more

Missouri Optimization Project
April 2024 - August 2025

Outputs:

Four in-plant visits x 8 POTWs

Written plant optimization strategies x 8 POTWs

“Safe Harbor” enforcement discretion letters from MoDNR

Average of 10 video calls with plant staff and consultants x 8 POTWs

Monthly, Quarterly, Final Reports presented to MoDNR with follow-up video calls

August 2025 in-person “debriefing” with MoDNR staff

Outcomes:

616,000 additional pounds Nitrogen removed

35,000 additional pounds of Phosphorus removed

360,000 fewer KWH (annualized)

Tennessee Optimization Project
2025 - 2029

Outputs:

Four in-plant visits by consultant and full-time assigned staff (year 1: 15 POTWs)
Written plant optimization strategies
TDEC enforcement discretion

Video calls, emails & telephone calls with plant staff and consultants

Quarterly & Final Reports

Outcomes:

6 of 10 POTWs meeting 10 mg/L total-Nitrogen goal

6 of 10 POTWs meeting 1.0 mg/L total-Phosphorus goal

Savings:

Year one facilities: anticipated ongoing electrical savings of almost $500,000 per year

Missouri Optimization Project
April 2024 - August 2025

Tennessee Optimization Project
2025 - 2029

Iowa Optimization Project
... to begin in 2026

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Lessons Learned, continued

with apologies to Cy Twombly

Lessons Learned, Continued

Many (most) Activated Sludge POTWs can be operated differently to:

- Remove Nitrogen
- Remove Phosphorus
- Reduce Chemical Usage
- Save Electricity

Optimization removes nutrients at a ***fraction of the cost*** of facility upgrades

Few POTWs will Optimize without regulatory encouragement and support

Lessons Learned, Continued

Technology matters ... but not that much

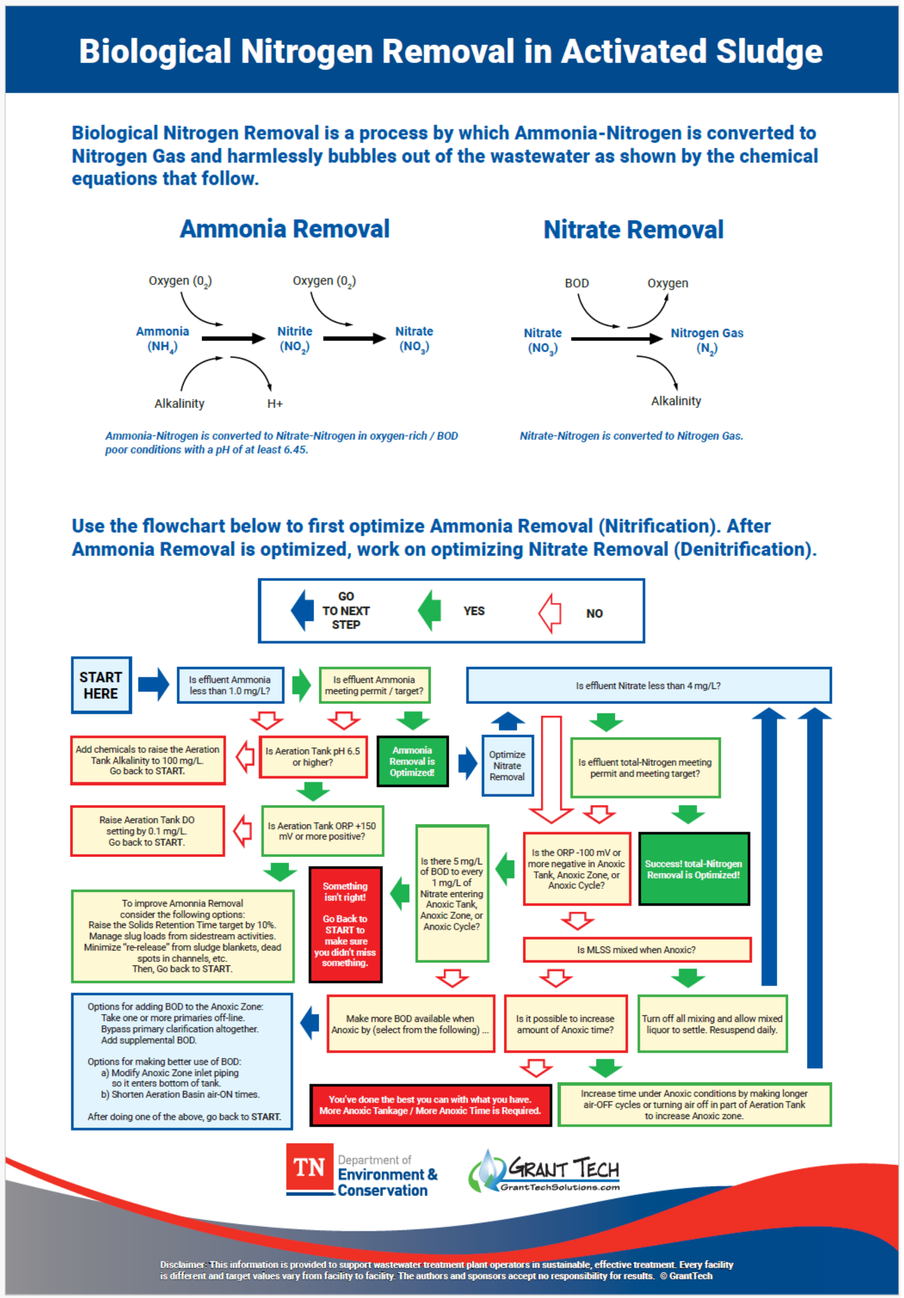
Biggest factors affecting optimization:

- #1: Regulatory encouragement & support
- #2: POTW engagement
- #3: “We have your back” ongoing technical support
- #4: Technology, a distant fourth

....

Success requires making the effort rewarding to all involved!

Thank You!


Biological Nitrogen Removal in Activated Sludge
Biological Nitrogen Removal is a process by which Ammonia-Nitrogen is converted to Nitrogen Gas and harmlessly bubbles out of the wastewater as shown by the chemical equations that follow.
Ammonia Removal
Oxygen (O_2)
Oxygen (O_2)
Ammonia (NH_4)
Nitrite (NO_2)
Nitrate (NO_3)
Alkalinity
H+
Ammonia-Nitrogen is converted to Nitrate-Nitrogen in oxygen-rich / BOD poor conditions with a pH of at least 6.45.
Nitrate Removal
BOD
Oxygen
Nitrate (NO_3)
Nitrogen Gas (N_2)
Alkalinity
Nitrate-Nitrogen is converted to Nitrogen Gas.
Use the flowchart below to first optimize Ammonia Removal (Nitrification). After Ammonia Removal is optimized, work on optimizing Nitrate Removal (Denitrification).
GO TO NEXT STEP
YES
NO
START HERE
Is effluent Ammonia less than 1.0 mg/L?
Is effluent Ammonia meeting permit / target?
Is effluent Nitrate less than 4 mg/L?
Add chemicals to raise the Aeration Tank Alkalinity to 100 mg/L. Go back to START.
Is Aeration Tank pH 6.5 or higher?
Ammonia Removal is Optimized!
Optimize Nitrate Removal
Is effluent total-Nitrogen meeting permit and meeting target?
Raise Aeration Tank DO setting by 0.1 mg/L. Go back to START.
Is Aeration Tank ORP +150 mV or more positive?
Is there 5 mg/L of BOD to every 1 mg/L of Nitrate entering Anoxic Tank, Anoxic Zone, or Anoxic Cycle?
Is the ORP -100 mV or more negative in Anoxic Tank, Anoxic Zone, or Anoxic Cycle?
Success! total-Nitrogen Removal is Optimized!
To improve Amonnia Removal consider the following options: Raise the Solids Retention Time target by 10%. Manage slug loads from sidestream activities. Minimize "re-release" from sludge blankets, dead spots in channels, etc. Then, Go back to START.
Something isn't right! Go Back to START to make sure you didn't miss something.
Is MLSS mixed when Anoxic?
Options for adding BOD to the Anoxic Zone: Take one or more primaries off-line. Bypass primary clarification altogether. Add supplemental BOD.
Options for making better use of BOD: a) Modify Anoxic Zone inlet piping so it enters bottom of tank. b) Shorten Aeration Basin air-ON times.
After doing one of the above, go back to START.
Make more BOD available when Anoxic by (select from the following) ...
Is it possible to increase amount of Anoxic time?
Turn off all mixing and allow mixed liquor to settle. Resuspend daily.
You've done the best you can with what you have. More Anoxic Tankage / More Anoxic Time is Required.
Increase time under Anoxic conditions by making longer air-OFF cycles or turning air off in part of Aeration Tank to increase Anoxic zone.
TN Department of Environment & Conservation
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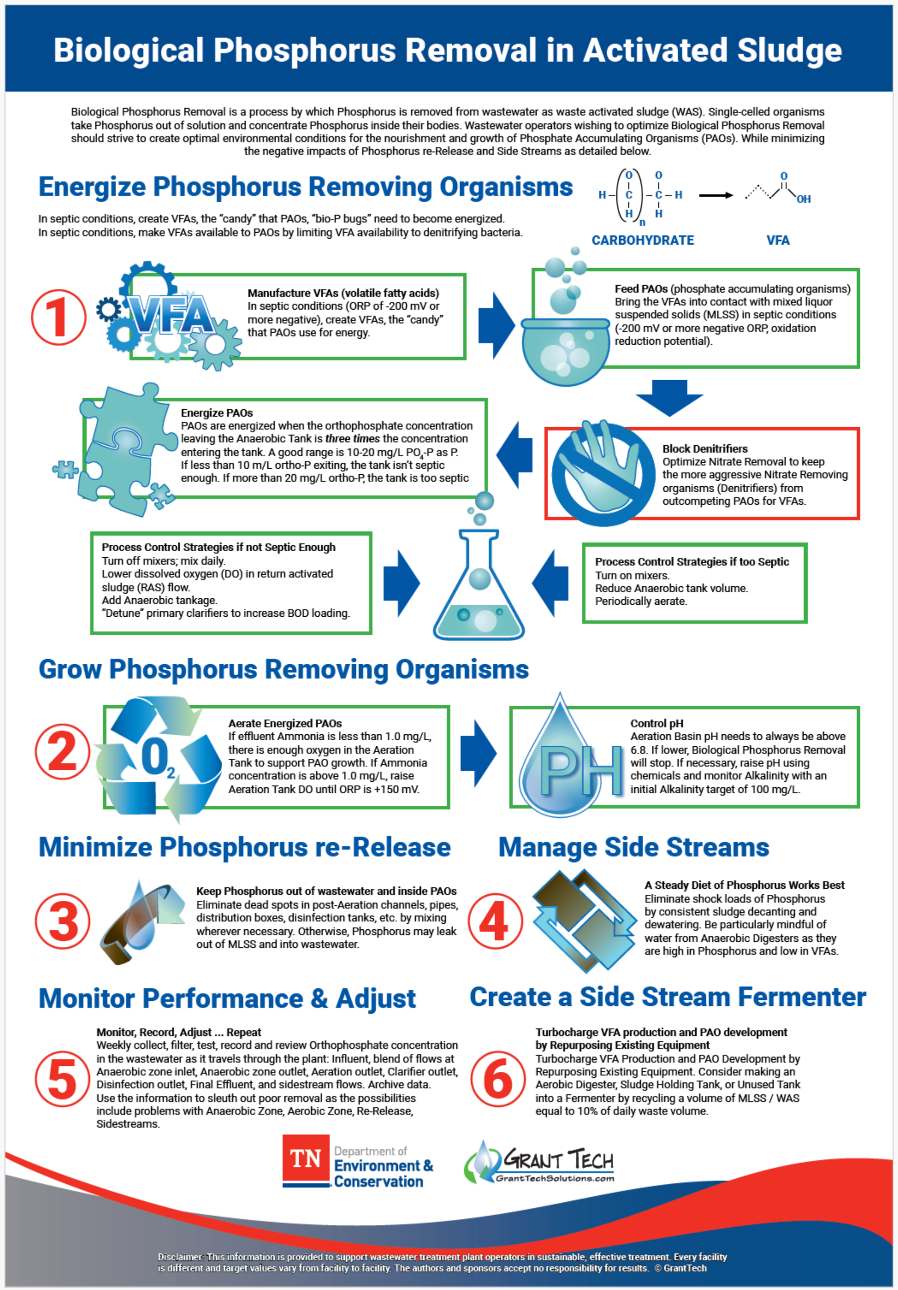
Disclaimer: This information is provided to support wastewater treatment plant operators in sustainable, effective treatment. Every facility is different and target values vary from facility to facility. The authors and sponsors accept no responsibility for results. © GrantTech


Biological Phosphorus Removal in Activated Sludge
Biological Phosphorus Removal is a process by which Phosphorus is removed from wastewater as waste activated sludge (WAS). Single-celled organisms take Phosphorus out of solution and concentrate Phosphorus inside their bodies. Wastewater operators wishing to optimize Biological Phosphorus Removal should strive to create optimal environmental conditions for the nourishment and growth of Phosphate Accumulating Organisms (PAOs). While minimizing the negative impacts of Phosphorus re-Release and Side Streams as detailed below.
Energize Phosphorus Removing Organisms
In septic conditions, create VFAs, the "candy" that PAOs, "bio-P bugs" need to become energized.
In septic conditions, make VFAs available to PAOs by limiting VFA availability to denitrifying bacteria.
CARBOHYDRATE
VFA
1
VFA
Manufacture VFAs (volatile fatty acids) In septic conditions (ORP of -200 mV or more negative), create VFAs, the "candy" that PAOs use for energy.
Feed PAOs (phosphate accumulating organisms) Bring the VFAs into contact with mixed liquor suspended solids (MLSS) in septic conditions (-200 mV or more negative ORP, oxidation reduction potential).
Energize PAOs PAOs are energized when the orthophosphate concentration leaving the Anaerobic Tank is three times the concentration entering the tank. A good range is 10-20 mg/L PO_4-P as P. If less than 10 m/L ortho-P exiting, the tank isn't septic enough. If more than 20 mg/L ortho-P, the tank is too septic
Block Denitrifiers Optimize Nitrate Removal to keep the more aggressive Nitrate Removing organisms (Denitrifiers) from outcompeting PAOs for VFAs.
Process Control Strategies if not Septic Enough Turn off mixers; mix daily. Lower dissolved oxygen (DO) in return activated sludge (RAS) flow. Add Anaerobic tankage. "Detune" primary clarifiers to increase BOD loading.
Process Control Strategies if too Septic Turn on mixers. Reduce Anaerobic tank volume. Periodically aerate.
Grow Phosphorus Removing Organisms
2
O_2
Aerate Energized PAOs If effluent Ammonia is less than 1.0 mg/L, there is enough oxygen in the Aeration Tank to support PAO growth. If Ammonia concentration is above 1.0 mg/L, raise Aeration Tank DO until ORP is +150 mV.
PH
Control pH Aeration Basin pH needs to always be above 6.8. If lower, Biological Phosphorus Removal will stop. If necessary, raise pH using chemicals and monitor Alkalinity with an initial Alkalinity target of 100 mg/L.
Minimize Phosphorus re-Release
3
Keep Phosphorus out of wastewater and inside PAOs Eliminate dead spots in post-Aeration channels, pipes, distribution boxes, disinfection tanks, etc. by mixing wherever necessary. Otherwise, Phosphorus may leak out of MLSS and into wastewater.
Manage Side Streams
4
A Steady Diet of Phosphorus Works Best Eliminate shock loads of Phosphorus by consistent sludge decanting and dewatering. Be particularly mindful of water from Anaerobic Digesters as they are high in Phosphorus and low in VFAs.
Monitor Performance & Adjust
5
Monitor, Record, Adjust ... Repeat Weekly collect, filter, test, record and review Orthophosphate concentration in the wastewater as it travels through the plant: Influent, blend of flows at Anaerobic zone inlet, Anaerobic zone outlet, Aeration outlet, Clarifier outlet, Disinfection outlet, Final Effluent, and sidestream flows. Archive data. Use the information to sleuth out poor removal as the possibilities include problems with Anaerobic Zone, Aerobic Zone, Re-Release, Sidestreams.
Create a Side Stream Fermenter
6
Turbocharge VFA production and PAO development by Repurposing Existing Equipment Turbocharge VFA Production and PAO Development by Repurposing Existing Equipment. Consider making an Aerobic Digester, Sludge Holding Tank, or Unused Tank into a Fermenter by recycling a volume of MLSS / WAS equal to 10% of daily waste volume.
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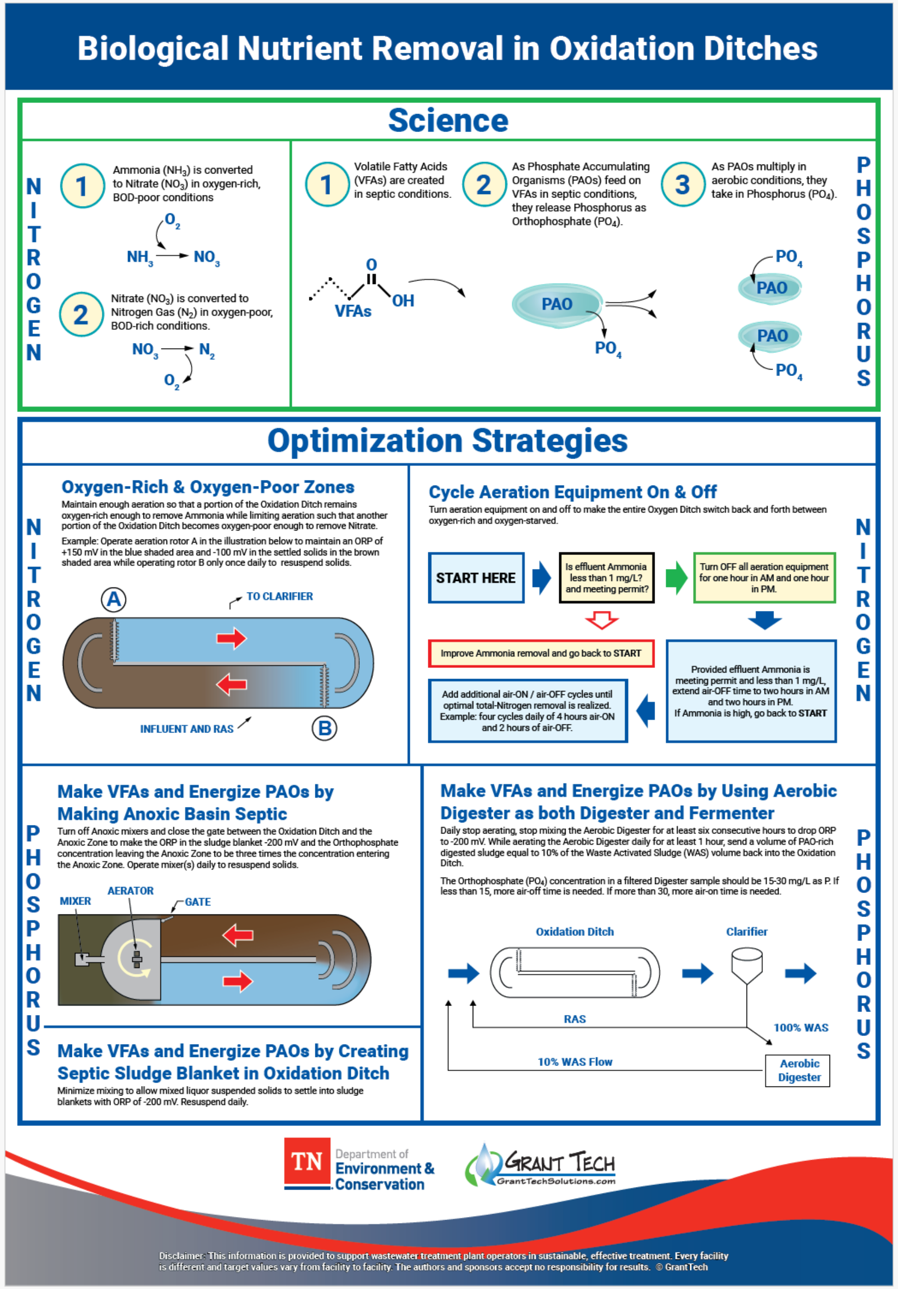

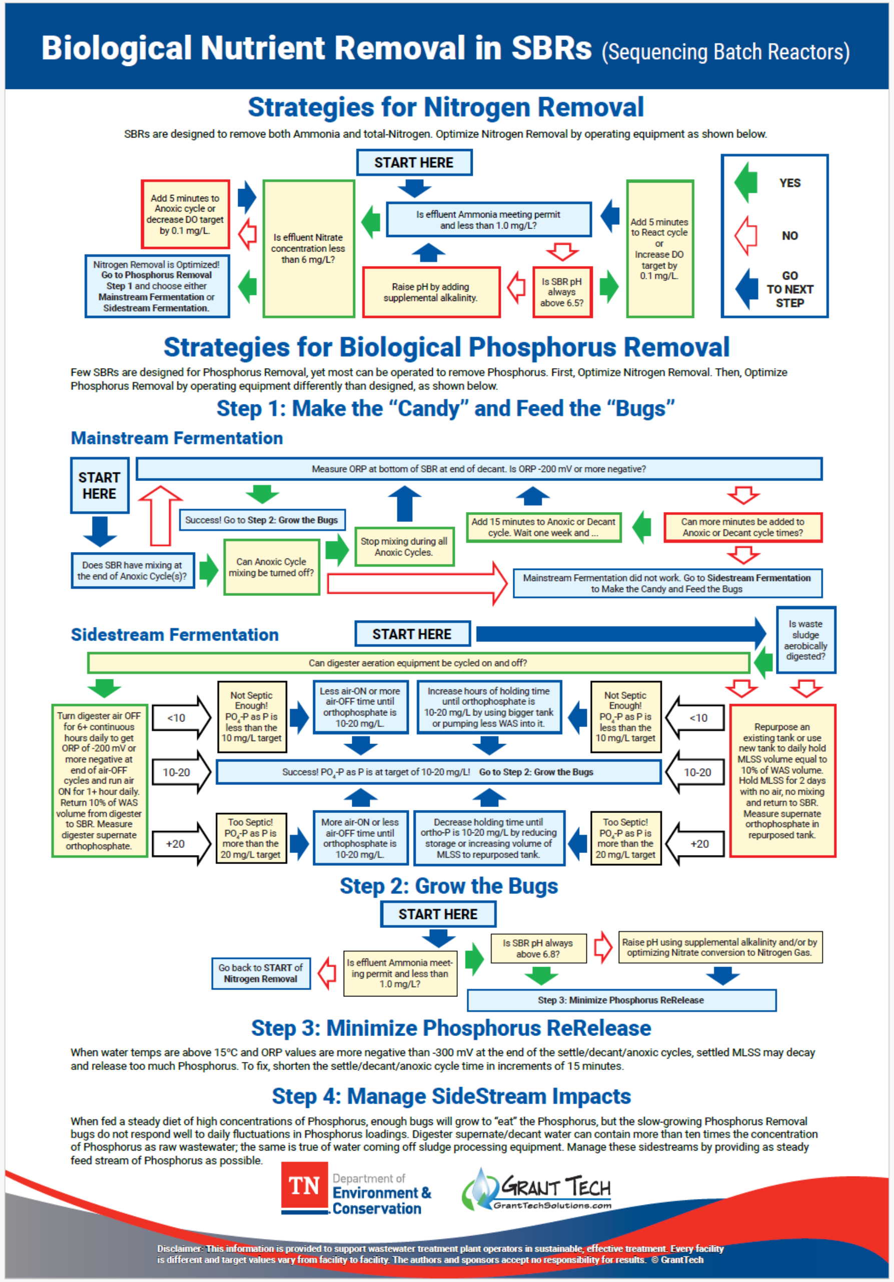

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