Nutrient Removal in Activated Sludge wastewater treatment plants

US EPA sponsored webinar for
Wastewater Treatment Plant Operators
March 31, 2022

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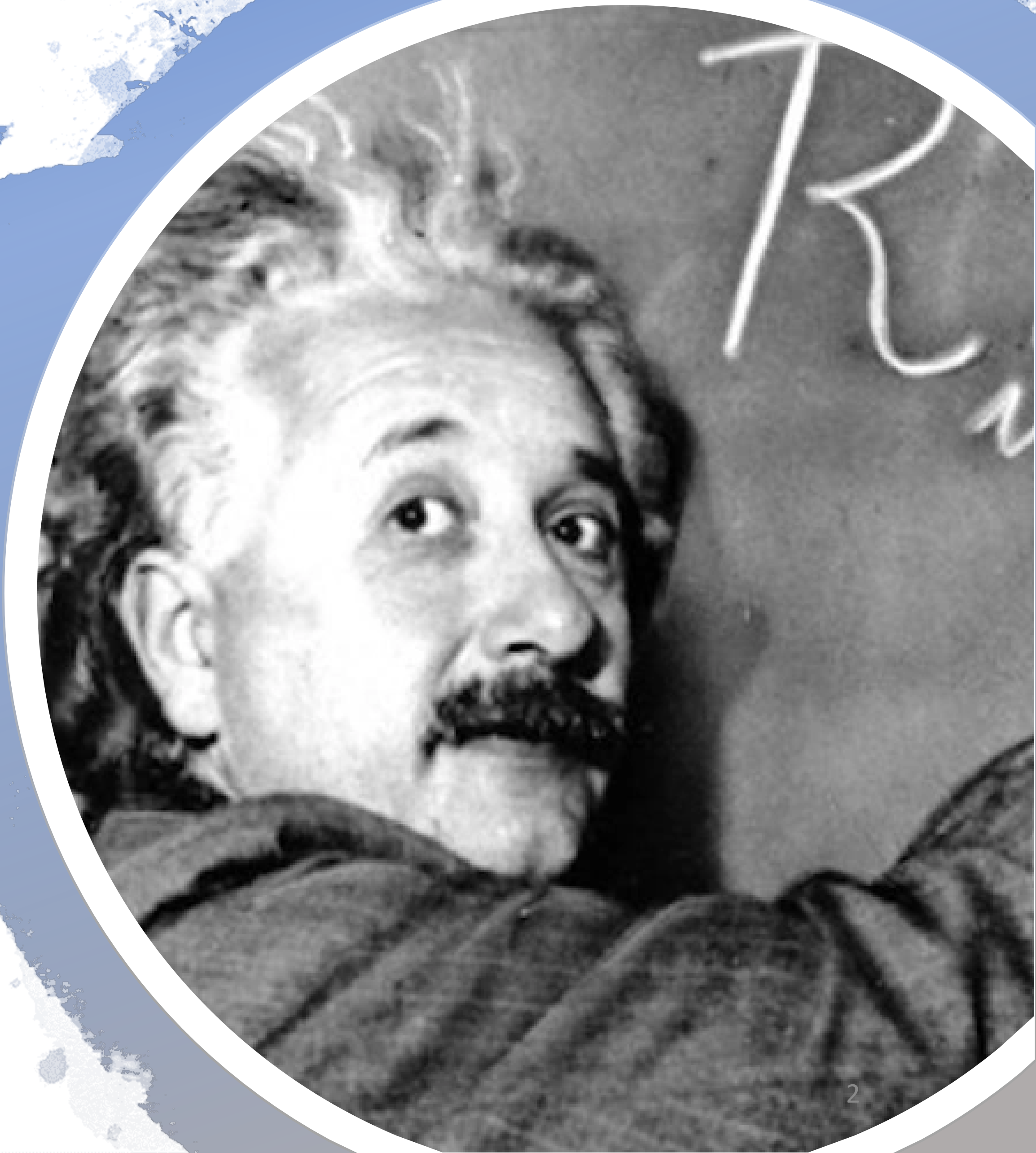
President
Grant Tech, Inc.
Grant@GrantTechSolutions.com

Optimizing Nutrient Removal & Wastewater Excellence

Optimizing Nutrient Removal in:

- **Oxidation Ditches**
  (January)
- **Sequencing Batch Reactors**
  (February)
- **Other Activated Sludge WWTPs**
  (Today)

Transitioning from Permit Compliance to Wastewater Excellence
(April 28, 2022)



KEEP
CALM

AND

BLAME
ME FOR EVERYTHING

Acknowledgements

CONRAD, MONTANA Keith Thaut

HELENA, MONTANA Jeff Brown & staff

KALISPELL, MONTANA Aaron Losing & staff including Curt Konecky (retired)

NASHVILLE, TENNESSEE David Tucker & Johnnie McDonald (retired)

NORRIS, TENNESSEE Tony Wilkerson & Doug Snelson

PARSONS, KANSAS Derek Clevenger

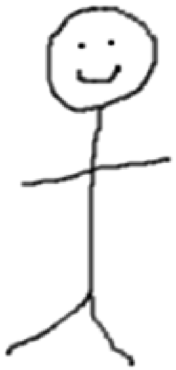
SUNDERLAND, MASSACHUSETTS Bob Gabry

EPA Peter Bahor, Laura Paradise, Paul Shriner & Tony Tripp (**HQ**), Brendon Held & Craig Hesterlee (**R4**), Andrea Schaller & Sydney Weiss (**R5**), Tina Laidlaw (**R8**),

TENNESSEE Karina Bynum, Tim Hill & Mark Valencia (**TDEC**), Brett Ward (**UT-MTAS**), Dewayne Culpepper (**TAUD**)

KANSAS Tom Stiles, Shelly Shores-Miller, Ryan Eldredge & Rod Geisler (retired), (**KDHE**)

MONTANA Paul LaVigne (retired), Pete Boettcher, Josh Viall, Darryl Barton, Bill Bahr (retired), Dave Frickey (retired) & Mike Abrahamson (**DEQ**)



TODAY

Optimizing Nutrient Removal in Activated Sludge wwtps

Nutrient Removal

Nitrogen: Ammonia → Nitrate … and … Nitrate → Nitrogen Gas

Phosphorus: Manufacture the food, feed the bacteria, grow the bacteria, prevent re-release

Case Studies

Wastewater treatment plants operating differently than designed to improve N&P removal

- Sunderland, Massachusetts
- Norris, Tennessee
- Conrad, Montana
- Parsons, Kansas
- Kalispell, Montana
- Nashville, Tennessee
- Helena, Montana

Discussion

7

N

Nitrogen

Ammonia Removal - 1st Step of N Removal

Step 1: Convert Ammonia (NH_4) to Nitrate (NO_3)

Oxygen-rich Aerobic Process

Don’t need BOD for bacteria to grow

Bacteria are sensitive to pH and temperature

Nitrate Removal - 2^{nd} Step of N removal

Step 1: Convert Ammonia (NH_4) to Nitrate (NO_3)

Oxygen-rich Aerobic Process
Don’t need BOD for bacteria to grow
Bacteria are sensitive to pH and temperature

Step 2: Convert Nitrate (NO_3) to Nitrogen Gas (N_2)

Oxygen-poor Anoxic Process
Do need BOD for bacteria to grow
Bacteria are hardy

Phosphorus

15

P

30.974


THREE
steps

Biological Phosphorus Removal

<u>Step 1: prepare "dinner"</u>

VFA (volatile fatty acids) production in septic/fermentive conditions

Biological Phosphorus Removal

Step 1: prepare “dinner”

VFA (volatile fatty acids) production in septic/fermentive conditions

Step 2: “eat”

Bio-P bugs (PAOs, “phosphate accumulating organisms”) eat VFAs in anaerobic/fermentive conditions … temporarily releasing more P into the water

Biological Phosphorus Removal

<u>Step 1: prepare “dinner”</u>

VFA (volatile fatty acids) production in septic/fermentive conditions

<u>Step 2: “eat”</u>

Bio-P bugs (PAOs, “phosphate accumulating organisms”) eat VFAs in anaerobic/fermentive conditions … temporarily releasing more P into the water

<u>Step 3: “breathe” and grow</u>

Bio-P bugs (PAOs) take in almost all of the soluble P in aerobic conditions as they grow and reproduce


Questions?
Comments?


What do you
think?

SHALL WE BEGIN

Connecticut
Colchester-East Hampton
East Haddam
Groton
New Canaan
New Hartford
Plainfield North
Plainfield Village
Suffield
Windham

Kansas
Abilene
Andover
Arkansas City
Baldwin City
Basehor
Beloit
Bonner Springs
Buhler
Caney
Chanute
Chisholm Creek
Coffeyville
Derby
De Soto
Ellinwood
Eudora
Garden Plain

Kansas, cont'd
Gardner
Garnett
Goddard
Great Bend
Halstead
Haysville
Herington
Hiawatha
Holton
Independence
Kansas City #14 & 20
Kingman
Lansing
Lakewood Hills
Lyons
Medicine Lodge
Miami CO - Bucyrus
Miami CO - Walnut Creek
Norton
Osawatomie
Parsons
Phillipsburg
Pratt
Riley CO - University Park
Rose Hill
Shawnee CO - Sherwood
St. Marys
Spring Hill

Kansas, cont'd
Tonganoxie
Topeka North
Wamego
Wellington
Wellsville
Wichita Plants 1&2
Winfield
Yates Center

Kentucky
Hopkinsville

Massachusetts
Amherst
Barnstable
Easthampton
Greenfield
Montague
Newburyport
Northfield
Palmer
South Deerfield
South Hadley
Sunderland
Upton
Westfield

Montana
Bigfork
Big Sky
Billings
Boulder
Bozeman
Butte
Chinook
Choteau
Colstrip
Columbia Falls
Conrad
Craig
Dillon
East Helena
Forsyth
Gallatin Gateway
Glendive
Great Falls
Hamilton
Hardin
Havre
Helena
Kalispell
Laurel
Lewistown
Libby
Lolo
Manhattan

Montana, cont'd
Miles City
Missoula
Stevensville
Wolf Creek

New Hampshire
Keene

North Carolina
Asheboro
Eden - Mebane Bridge
Newton
Reidsville

South Carolina
Greeneville

Tennessee
Athens
Baileyton
Bartlett
Chattanooga
Collierville
Cookeville
Cowan
Crossville
Dickson – White Bluff
Harpeth Valley

Tennessee, cont'd
Harriman
Humboldt
Lafayette
LaFollette
Livingston
McMinnville
Millington
Nashville Dry Creek
Norris
Oak Ridge
Oneida

Virginia
Strasburg

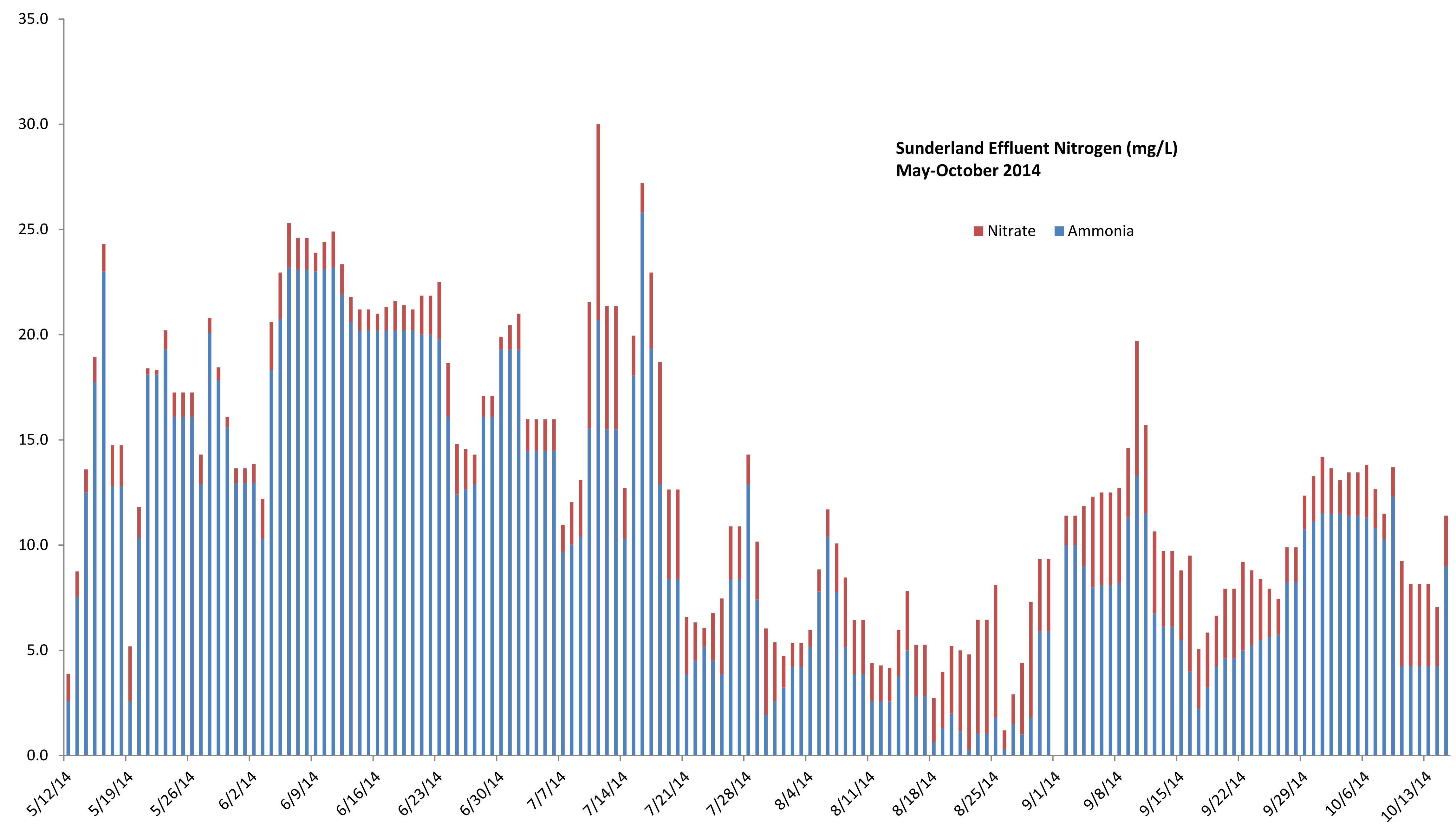
Washington
Alderwood
Everett
King CO Brightwater
Lake Stevens
Marysville
Mukilteo
Sultan

Wyoming
Laramie

Sunderland, Massachusetts Population: 3,700 0.5 MGD design flow

Sunderland, Massachusetts

- Not designed for nitrogen removal
  - Effluent total-nitrogen now 8 mg/L, was 25 mg/L
- Not designed for phosphorus removal
  - No change
- Process changes
  - Raised MLSS
  - Cycle air/off
- Costs
  - Portable ORP probe
  - Aeration timers
- Savings
  - Electricity
  - Sludge disposal
  - Facility upgrade



Sunderland Effluent Nitrogen (mg/L)
May-October 2014
Nitrate
Ammonia
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
5/12/14
5/19/14
5/26/14
6/2/14
6/9/14
6/16/14
6/23/14
6/30/14
7/7/14
7/14/14
7/21/14
7/28/14
8/4/14
8/11/14
8/18/14
8/25/14
9/1/14
9/8/14
9/15/14
9/22/14
9/29/14
10/6/14
10/13/14

https://www.tpomag.com/editorial/2017/04/simple_solutions_for_process_improvement

Norris, Tennessee Population: 1,450 0.2 MGD design flow

Norris, Tennessee

Not designed for nitrogen removal

- Effluent total-nitrogen now 6 mg/L, was ??

Not designed for phosphorus removal

- Effluent total-phosphorus now 2-3 mg/L, was 3-4

Process changes

- Raised MLSS
- Cycle air/off
- Created fermentation zone

Costs

- Piping & Fermenters (IBC totes)
- Aeration timers

Savings

- Electricity
- Facility upgrade


Norris, TN

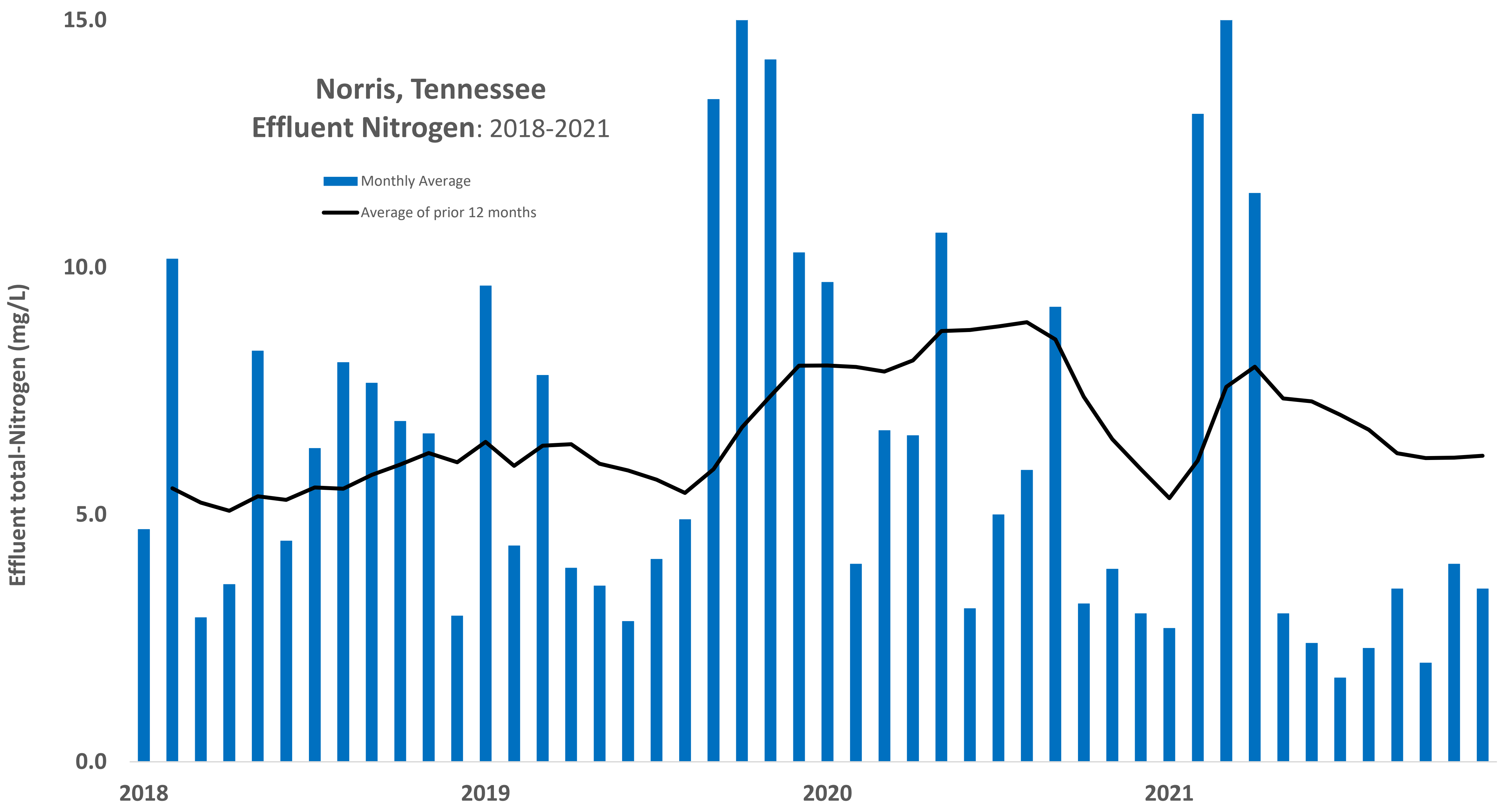
Norris, TN:
Nitrogen Removal

Nitrogen Removal

Raise MLSS concentration

Cycle aeration:

- ON 2-3 hours
- OFF 1½-2 hours



Norris, Tennessee
Effluent Nitrogen: 2018-2021
Monthly Average
Average of prior 12 months
Effluent total-Nitrogen (mg/L)
15.0
10.0
5.0
0.0
2018
2019
2020
2021

Norris, TN: First try at Phosphorus Removal

Phosphorus Removal

Recycle RAS through fermenters

Norris, TN: Second try at Phosphorus Removal

Phosphorus Removal

Create Fermentation Zone in Aeration Tank …

Air off

70% RAS to aeration

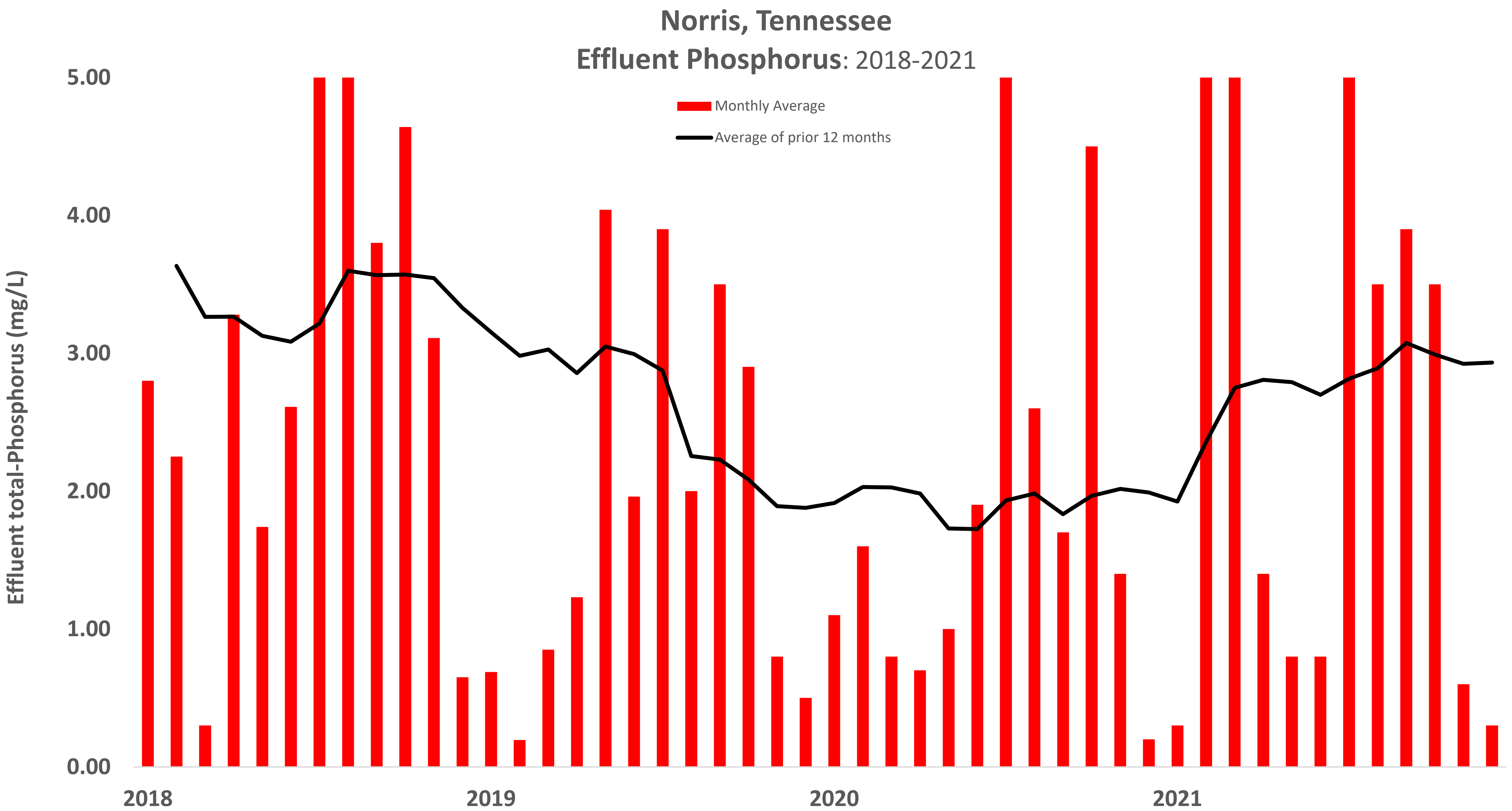
Norris, TN: Third try at Phosphorus Removal

Phosphorus Removal

Hold influent in tote fermenters

- and -

Create Fermentation Zone in Aeration Tank


Norris, Tennessee
Effluent Phosphorus: 2018-2021
Monthly Average
Average of prior 12 months
Effluent total-Phosphorus (mg/L)
5.00
4.00
3.00
2.00
1.00
0.00
2018
2019
2020
2021


Questions?
Comments?


What do you
think?

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EPA United States Environmental Protection Agency

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Technical Assistance Webinar Series: Improving CWA-NPDES Permit Compliance

On this page:

- Upcoming Webinars
- Recorded Webinars

This technical assistance webinar series supports the joint EPA and Authorized State Significant Noncompliance (SNC) Rate Reduction National Compliance Initiative (NCI). The SNC NCI is aimed at improving surface water quality and reducing potential impacts on drinking water by assuring that all Clean Water Act (CWA) – National Pollutant Discharge Elimination System (NDPES) permittees are complying with their wastewater discharge permits.

This page includes registration information for upcoming webinars as well as recordings and supplemental materials for past webinars.

Intended Audience: The webinars are intended for plant operators, municipal leaders, technical assistance providers, and compliance inspection staff from federal, state, tribal and local governments. Every plant is unique and plant operators should discuss any major operational change with their NDPES permiting authority.

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For additional information, contact: Laura Paradise (paradise.laura@epa.gov) or Peter Bahor (bahor.peter@epa.gov)

Upcoming Webinars

- Thursday March 31, 2022 (1:00 – 2:30pm Eastern)
  Optimizing Nutrient Removal in Activated Sludge WWTPs EXIT
  Presenter: Grant Weaver, PE, President Grant Tech, Inc
- Thursday April 28, 2022 (1:00 – 2:30pm Eastern)
  Transitioning from Permit Compliance to Wastewater Excellence EXIT
  Presenter: Grant Weaver, PE, President Grant Tech, Inc

Recorded Webinars

Recorded Webinars

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Alkalinity Testing for Better Process Control in Small Wastewater Treatment Plants	2020-01-29
Asset Management 101 – Finding Financial Assistance for Infrastructure Upgrades	2020-04-15
Best Management Practices for POTW Compliance Part 1	2020-08-18
Best Management Practices for POTW Compliance Part 2	2020-09-15
Biosolids Part 1: Overview of Wastewater Treatment Sludge and Clean Water Act Regulatory Structure	2021-04-29
Biosolids Part 2: Wastewater Treatment Sludge Disposal Methods	2021-05-27
Build Resilience & Adapt to Climate Change Impacts for Drinking Water & Wastewater Utilities Part 2	2021-07-29
CWA – NPDES Compliance Assistance for Public Drinking Water Systems	2020-05-13
Discharge Monitoring Reports - Avoiding Common Mistakes	2020-07-15
Do's and Don'ts in Operating an NPDES Laboratory: Common Mistakes and Ways to Improve Results	2021-02-24

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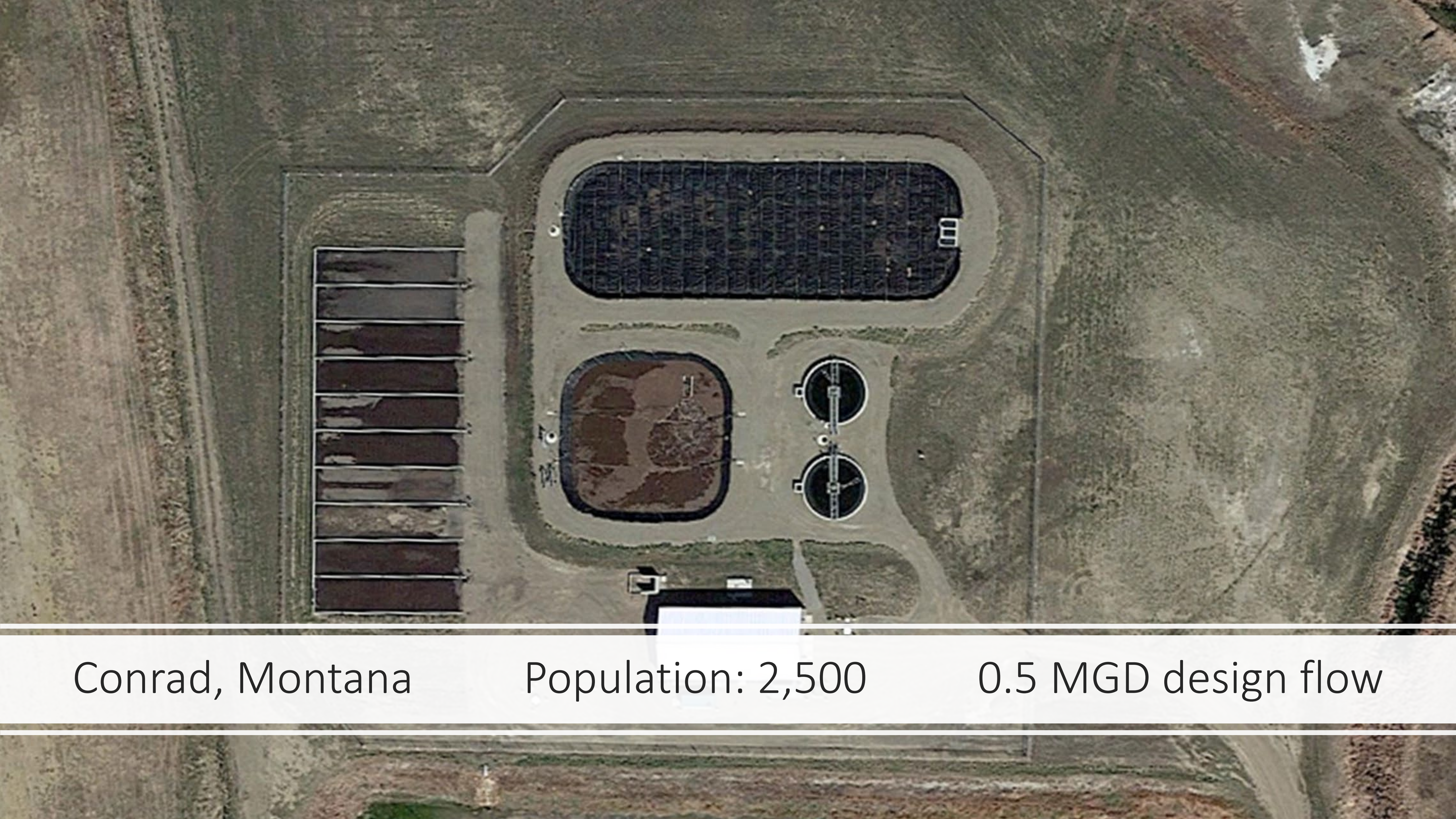
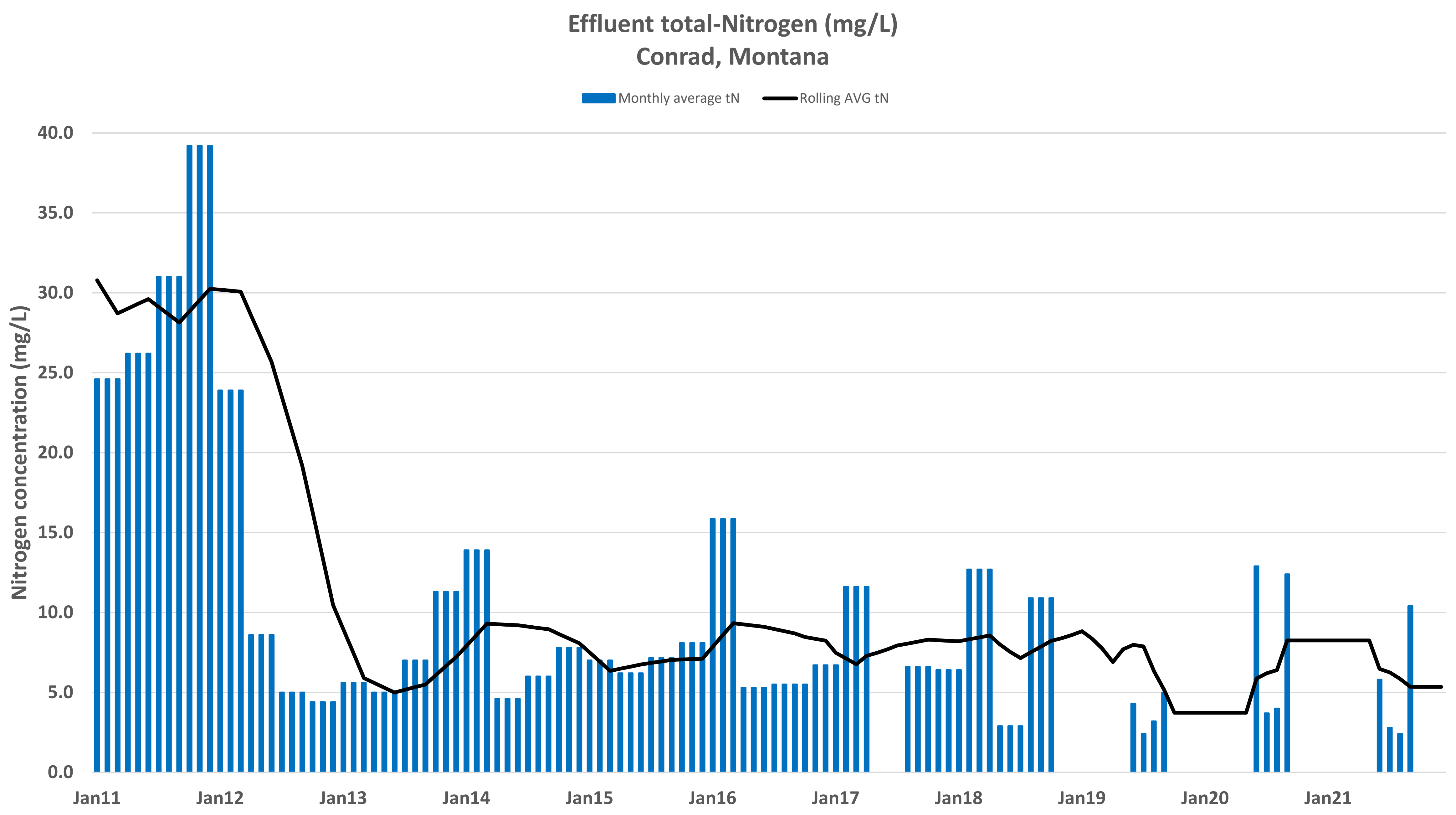
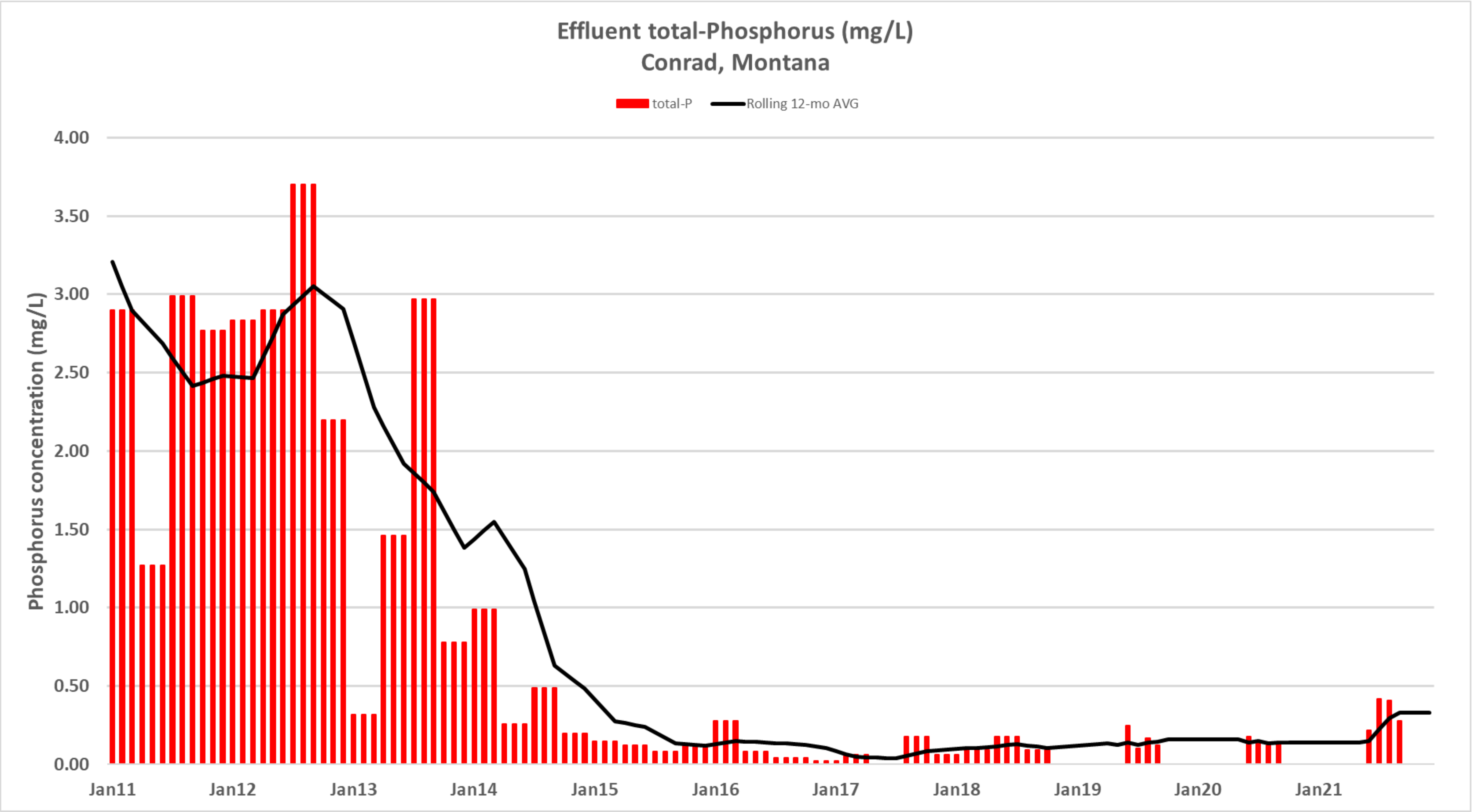


Conrad, Montana   Population: 2,500   0.5 MGD design flow

Conrad, Montana

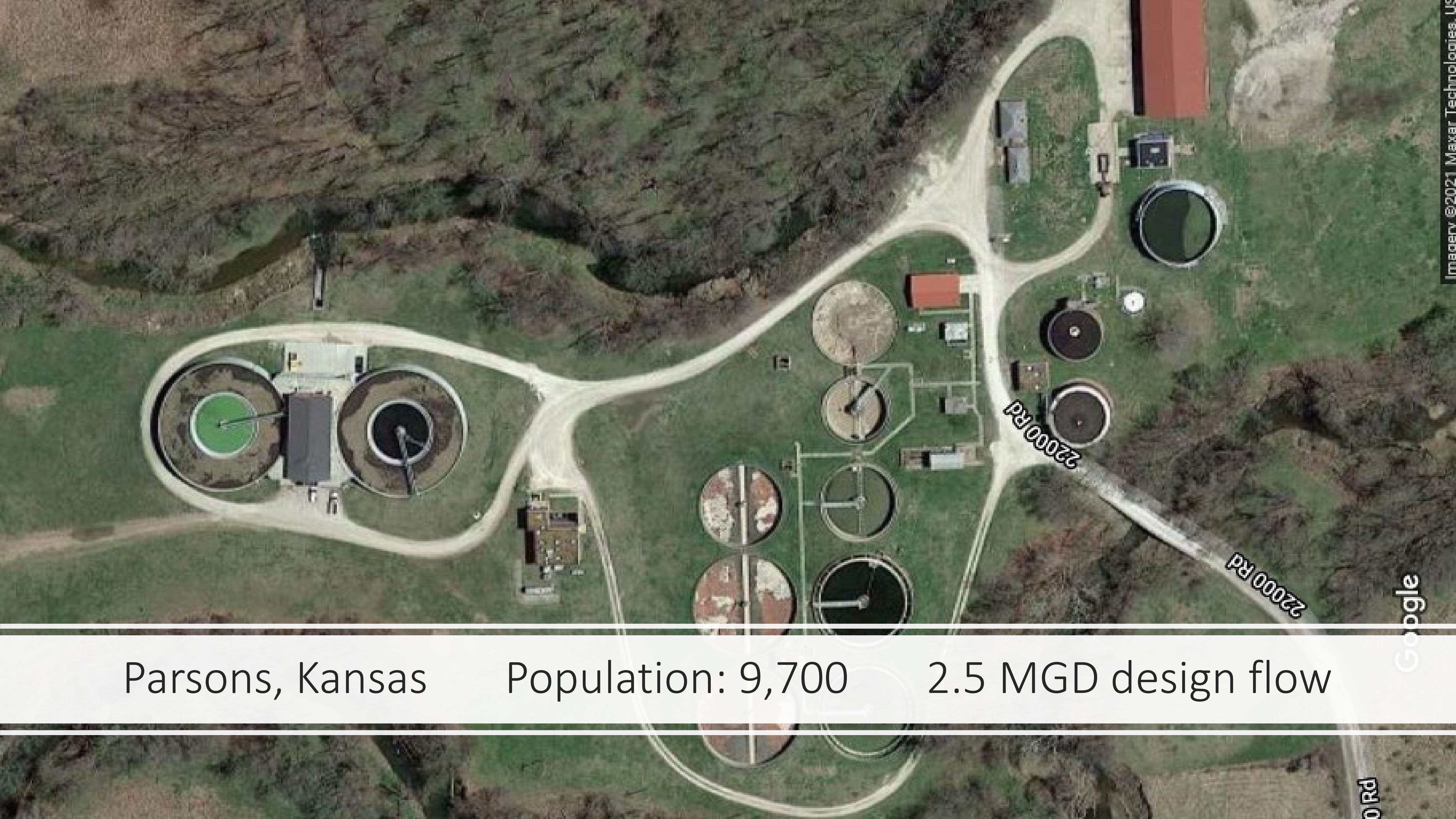
- Not designed for nitrogen removal
  - Effluent total-nitrogen now 4-8 mg/L, was 30
- Not designed for phosphorus removal
  - Effluent total-phosphorus now 0.2-0.4 mg/L, was 2.5-3.0
- Process changes
  - Raised MLSS
  - Cycle air/off in both aeration and digester
  - Returned fermented MLSS to aeration
- Costs
  - Lab testing equipment
- Savings
  - Electricity
  - Facility upgrade


Effluent total-Nitrogen (mg/L)
Conrad, Montana
Monthly average tN
Rolling AVG tN
Nitrogen concentration (mg/L)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Jan11
Jan12
Jan13
Jan14
Jan15
Jan16
Jan17
Jan18
Jan19
Jan20
Jan21



Effluent total-Phosphorus (mg/L)
Conrad, Montana
total-P
Rolling 12-mo AVG
Phosphorus concentration (mg/L)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Jan11
Jan12
Jan13
Jan14
Jan15
Jan16
Jan17
Jan18
Jan19
Jan20
Jan21


Questions?
Comments?



Parsons, Kansas Population: 9,700 2.5 MGD design flow


22000 Rd
22000 Rd
Google
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Parsons, Kansas

"Continuously Sequencing Reactor" Process

Designed for nitrogen removal

- Air cycles ON for ammonia removal
- Air cycles OFF for nitrate removal

ATMs
Google
TeamViewer
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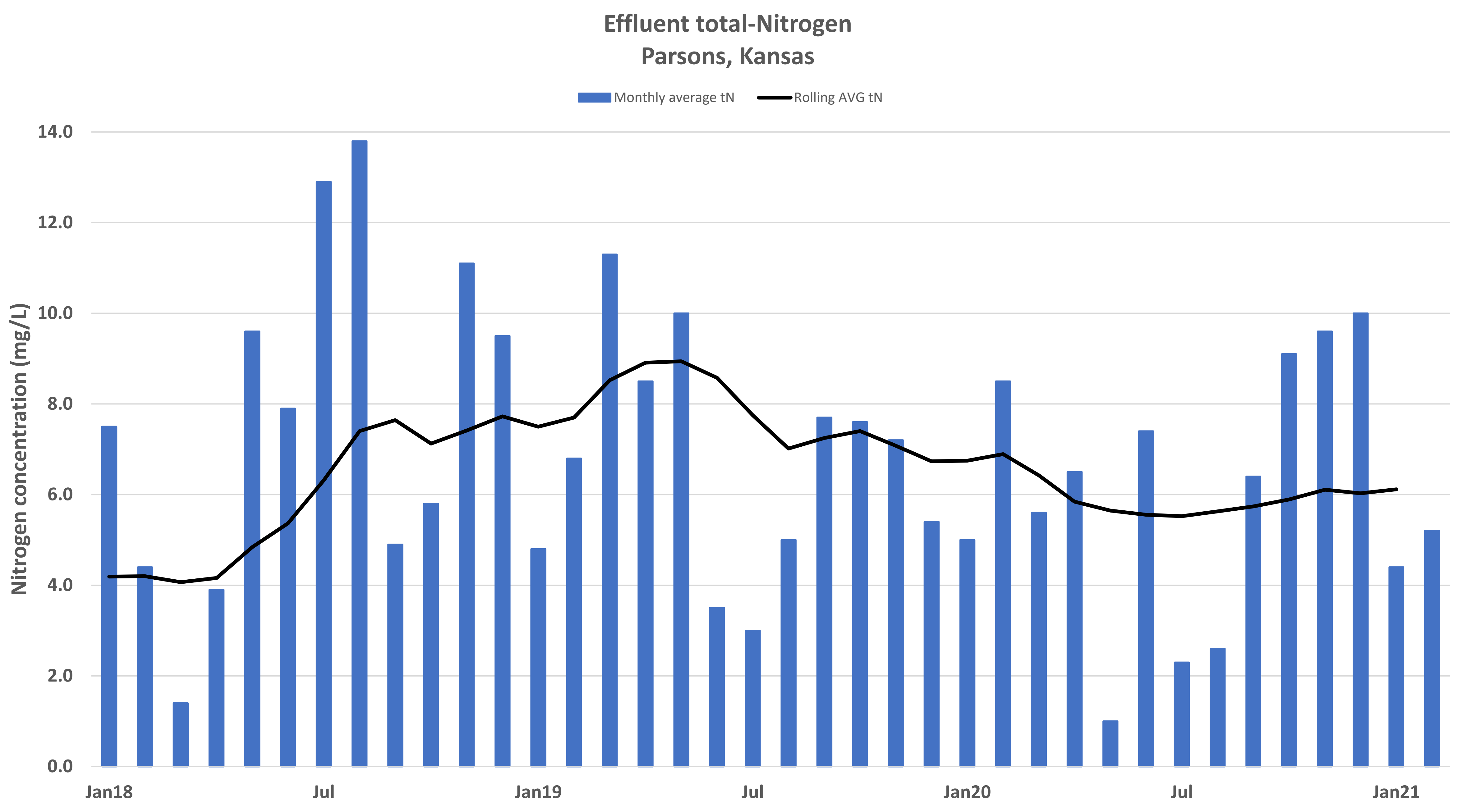


Effluent total-Nitrogen
Parsons, Kansas
Monthly average tN
Rolling AVG tN
Nitrogen concentration (mg/L)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Jan18
Jul
Jan19
Jul
Jan20
Jul
Jan21


22000 Rd
22000 Rd
Google
Imagery ©2021 Maxar Technologies


22000 Rd
22000 Rd
22000 Rd

Parsons, Kansas

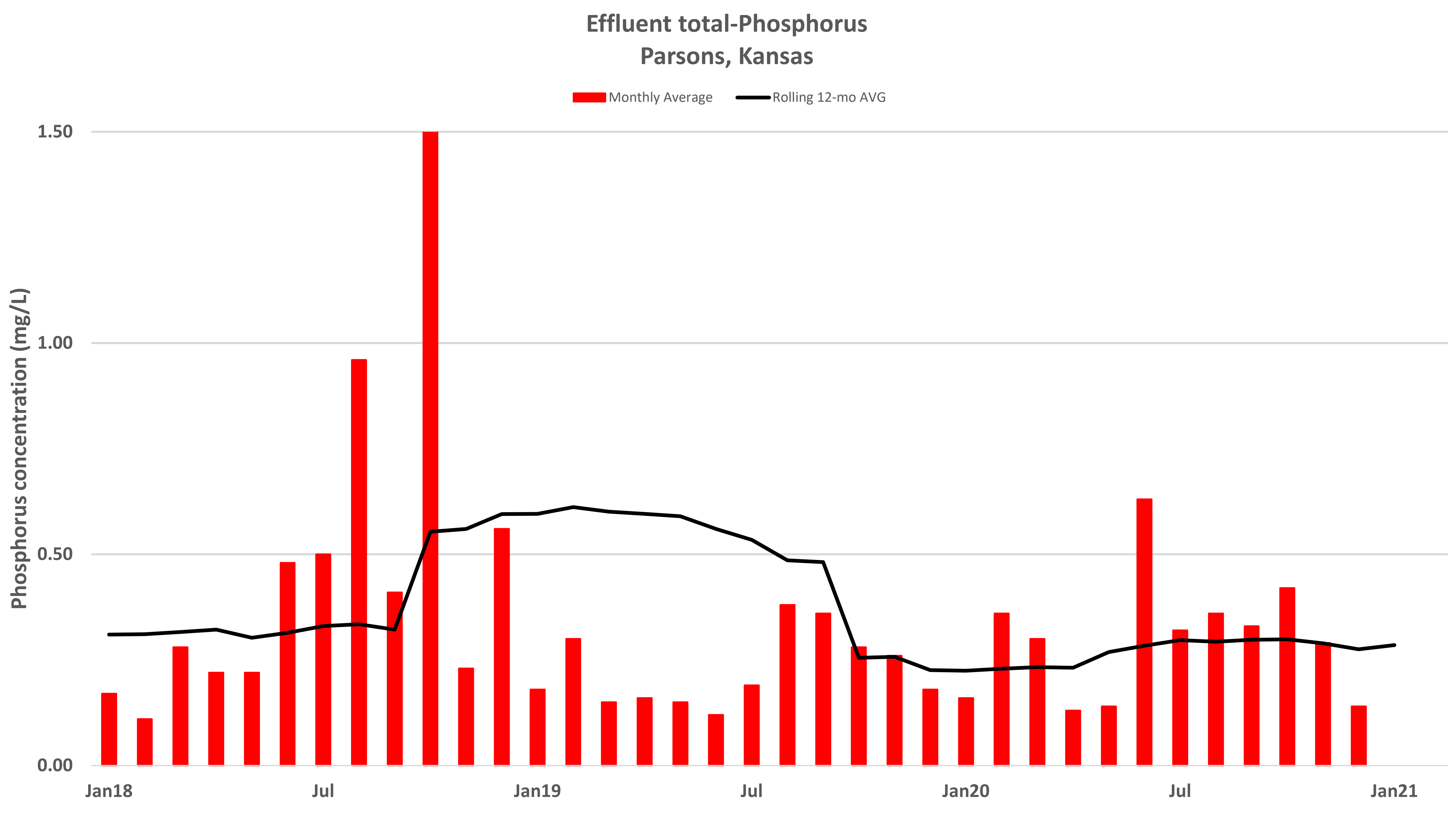
"Continuously Sequencing Reactor" Process

Designed for nitrogen removal

- Air cycles ON for ammonia removal
- Air cycles OFF for nitrate removal

Not designed for phosphorus removal

- NO CHEMICALS
- WAS (waste sludge) sent to digesters
- Digester air is OFF long enough for VFA production and consumption by bio-P bugs
- When sludge is wasted into digesters during air-ON cycles, energized bio-P bugs are sent back to the aeration basin for Phosphorus removal


Effluent total-Phosphorus
Parsons, Kansas
Monthly Average
Rolling 12-mo AVG
Phosphorus concentration (mg/L)
1.50
1.00
0.50
0.00
Jan18
Jul
Jan19
Jul
Jan20
Jul
Jan21


Questions?
Comments?


What do you
think?

Kalispell, Montana Population: 23,200 5.4 MGD design flow

Kalispell, Kansas

Modified Johannesburg Process with final effluent filtration

Designed for nitrogen removal

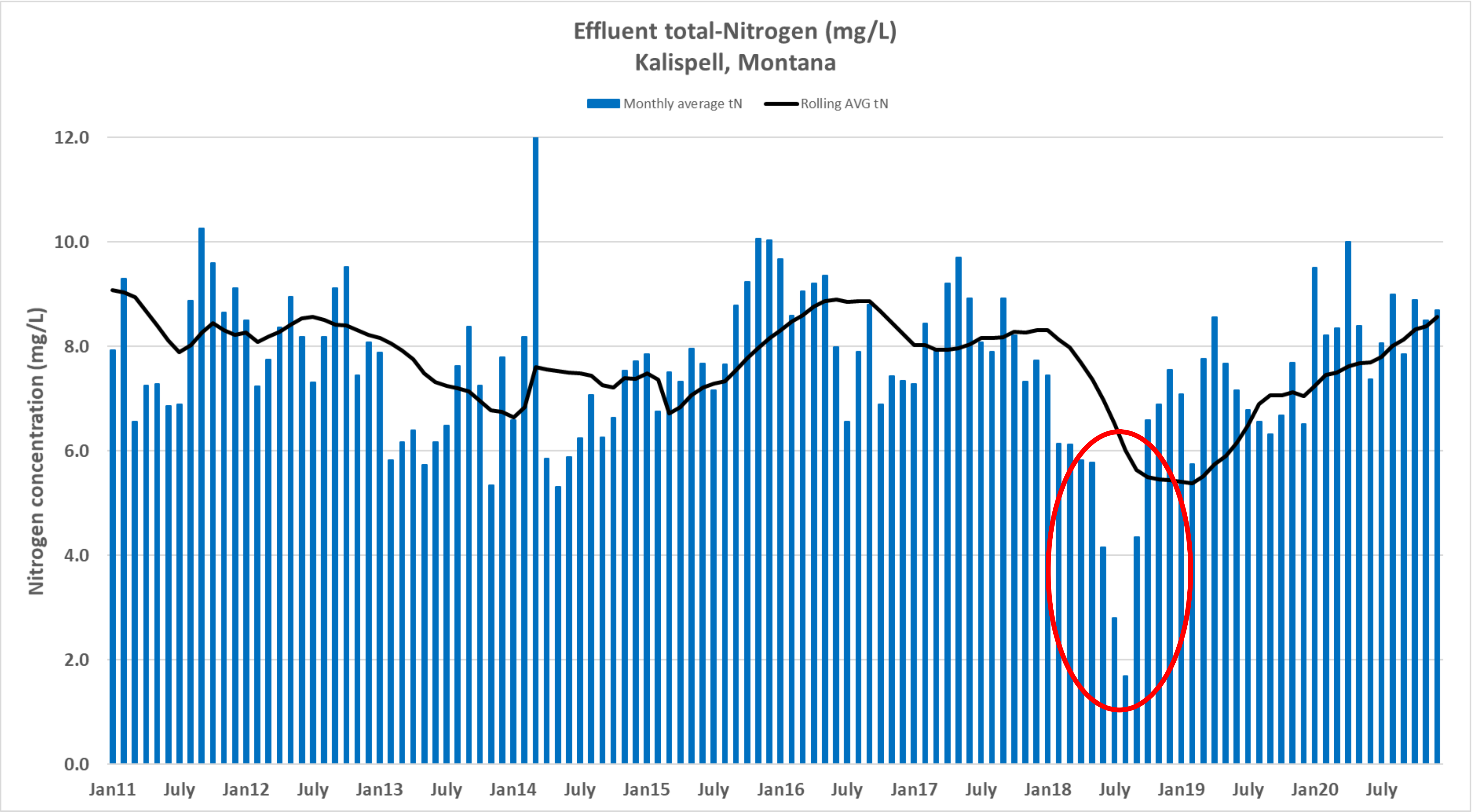
- Air-on zones for ammonia removal
- Air-off zones for nitrate removal

Designed for biological phosphorus removal … no chemicals

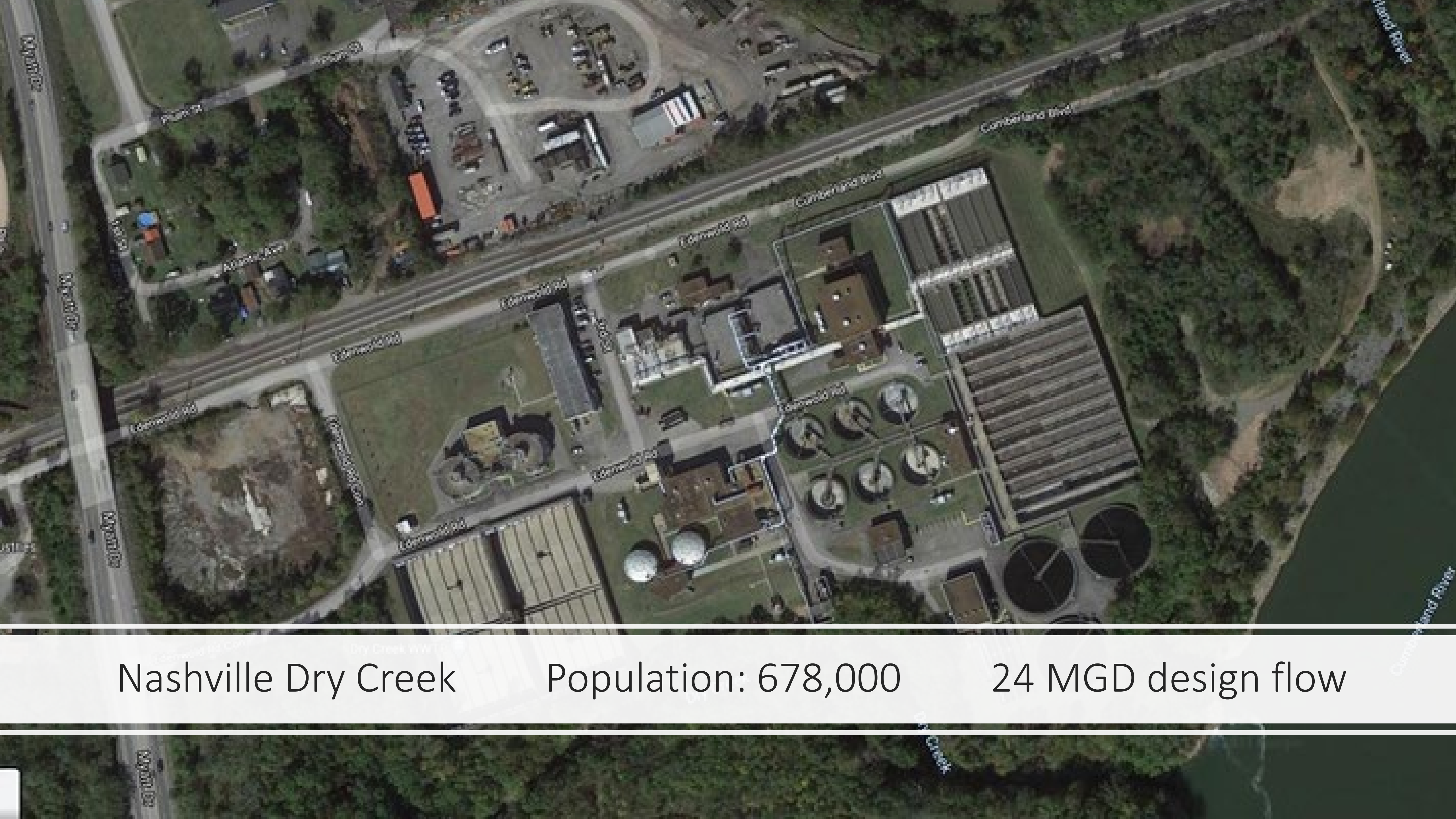
- Sidestream fermenter for VFA (volatile fatty acid) production
- Anaerobic zones for energizing bio-P bugs
- Aerobic zones for bio-P bug growth

4-month trial

- Air turned off in large air-on zone
- Primary effluent bypassed treatment units to trial “post-anoxic” zone for nitrate removal



Effluent total-Nitrogen (mg/L)
Kalispell, Montana
Monthly average tN
Rolling AVG tN
Nitrogen concentration (mg/L)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Jan11
July
Jan12
July
Jan13
July
Jan14
July
Jan15
July
Jan16
July
Jan17
July
Jan18
July
Jan19
July
Jan20
July



Nashville Dry Creek Population: 678,000 24 MGD design flow

Dry Creek wwtp
Nashville, Tennessee

Conventional plug-flow aeration with anaerobic selector

Not designed for nitrogen removal

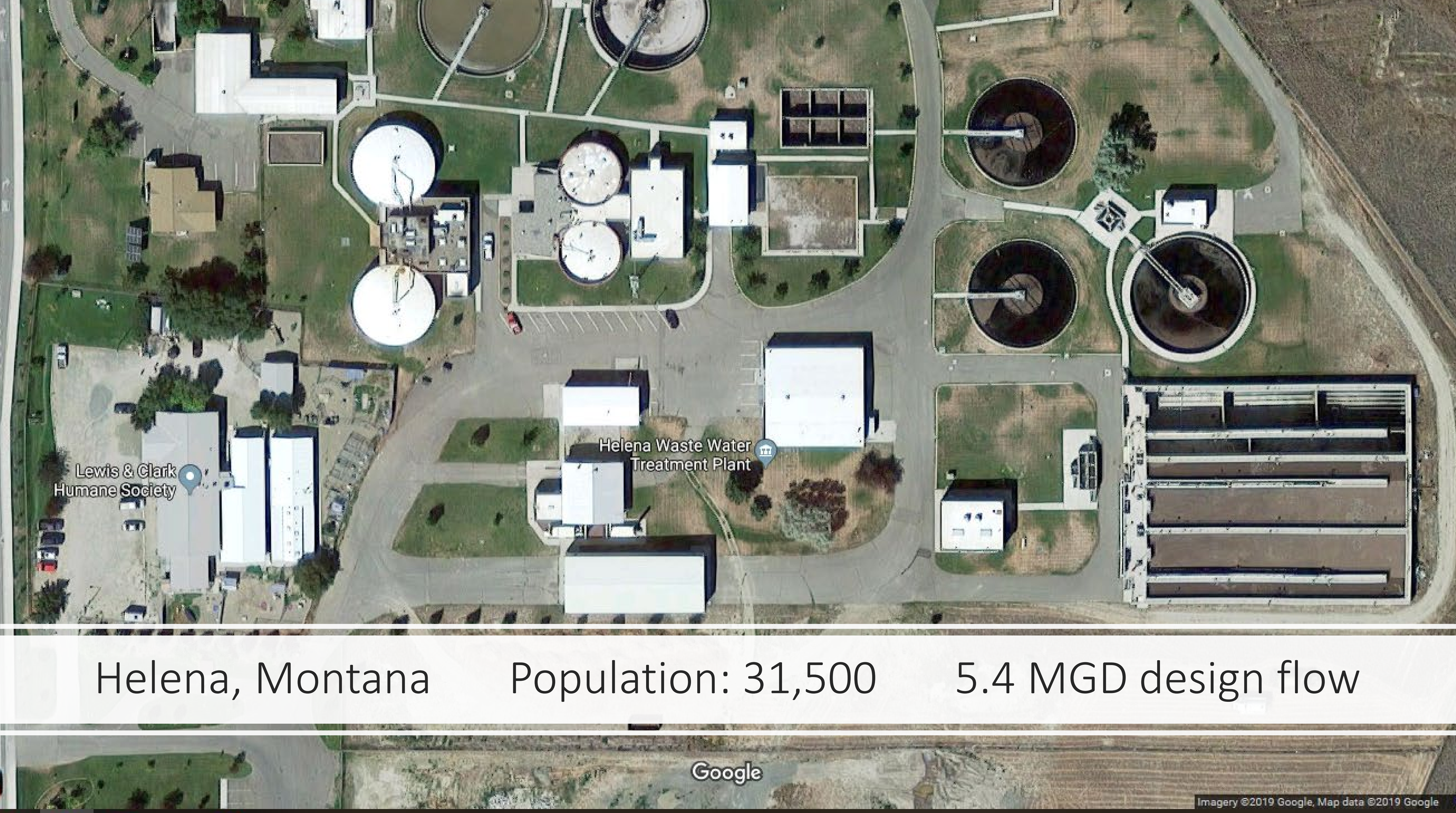
- Nitrate removal during 6-month trial by step-feed flow to air-ON / air-OFF aeration zone

Not designed for phosphorus removal … but …

- Anaerobic selector provides habitat for VFA production & “eating” by bio-P bugs
- Phosphorus removal during aeration as bio-P bugs multiply

Benefits

- Potentially significant electrical savings
- Potential money savings design strategy for Metro’s Dry Creek and White Creek wwtps



Helena, Montana Population: 31,500 5.4 MGD design flow

Helena, Montana

Modified Ludzack-Ettinger (MLE) Biological Nutrient Removal (BNR) Process

Designed for nitrogen removal … yet 2 mg/L improvement to 4 mg/L total-N

- 3 aeration zones
- 2 anoxic zones with internal recycle from 2 aeration zones

Not designed for phosphorus removal … 25% improvement to 1.5 mg/L

- Short-term: “De-tune” primary clarifiers
- Long-term: repurpose first anoxic zone by relocating internal recycle outlet

Monetary expenses / savings

- Field testing equipment
- More staff time spent on process control
- Now operating with 3 bio-reactors vs. 2
- Potential change to contemplated \$50 million$^{+/-}$ upgrade

Optimizing Nutrient Removal & Wastewater Excellence

Wastewater Excellence

April 28: Transitioning from Permit Compliance to Wastewater Excellence

Comments & Questions

Grant Weaver
Grant@GrantTechSolutions.com