Optimization of Biological Nutrient Removal Wastewater Treatment Systems

ACWA Nutrients Permitting Workshop

June 5, 2018

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Ohio EPA

Division of Environmental and Financial Assistance

Compliance Assistance Unit

The Plan

- What goes wrong
- Troubleshooting systems
- Case studies
- Questions and Comments

What goes wrong…

Permit Limits change, and the WWPT doesn't

Land Application of Treated Wastewater Rules Implemented 2014

- WWTPs encouraged to avoid discharging to Waters of the State
- Eased limits since they discharged to impoundments
- WWTPs not designed to meet 10 mg/L TIN in effluent

What goes wrong…

Effluent limits tighten statewide

Tighter TP limits for some dischargers to Ohio River

Nitrate limits on the horizon?

What goes wrong…

Design is important

But often design is by the book (and bacteria can’t read)

Inattention to influent waste streams will create havoc with BNR

Especially influents with weak organic loadings

What goes wrong…

Disconnect between design and operation

Design is important

But when design doesn’t include operational flexibility,

the hands of the operator are tied

(operators don’t get to chose what comes down the pipe)

Troubleshooting Systems

Process Control is a essential

- Check the chemical trails that the biology leaves behind
- Field test equipment
- Grab samples, sometimes lots of grab samples
- Cheap, easy, and effective

Toubleshooting Systems

Toubleshooting Systems

Troubleshooting Systems

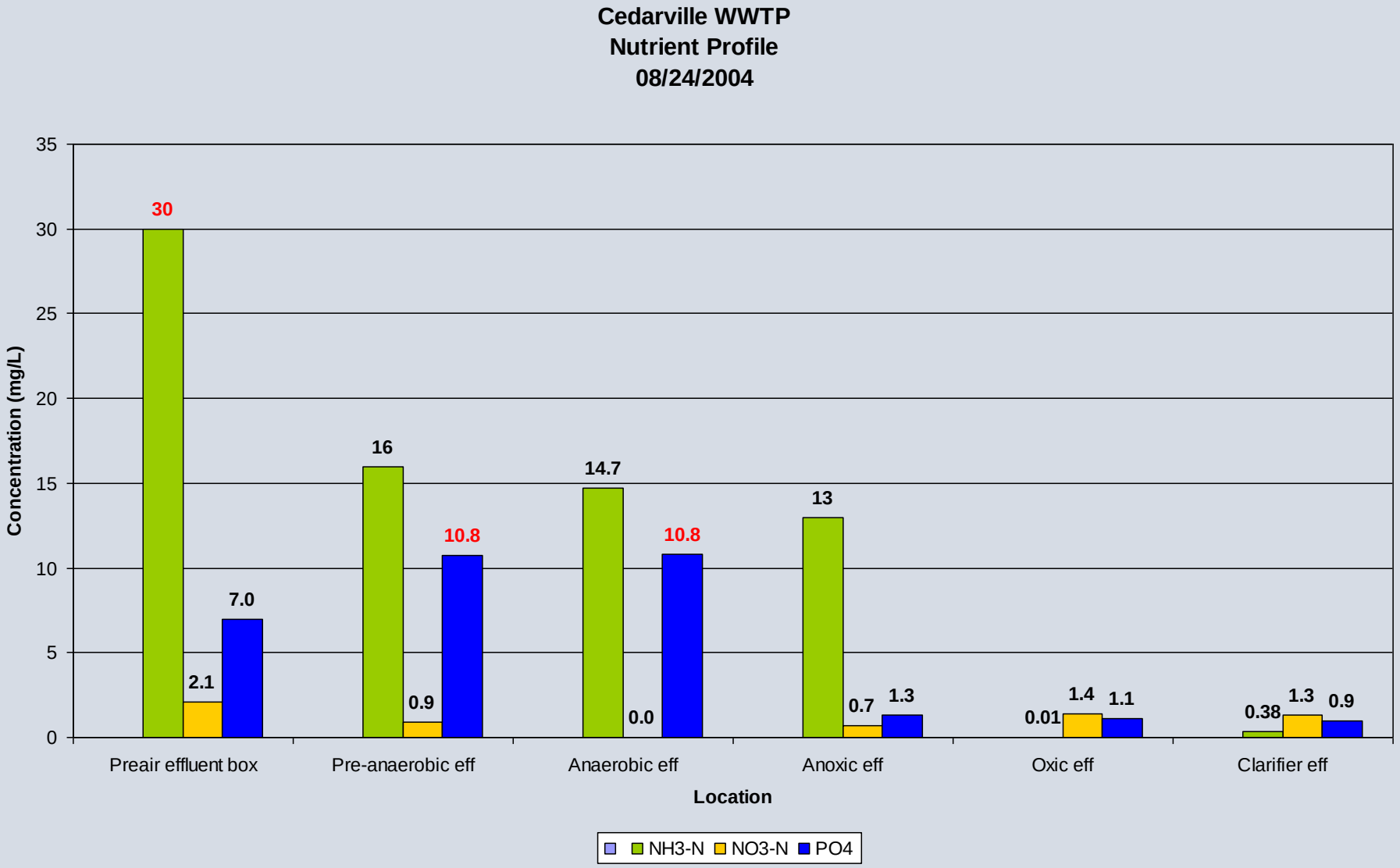
If the conditions are right, the bacteria will perform

Ammonia, nitrate, and orthophosphate in the inputs to the tanks

Ammonia, nitrate, and orthophosphate in the tanks

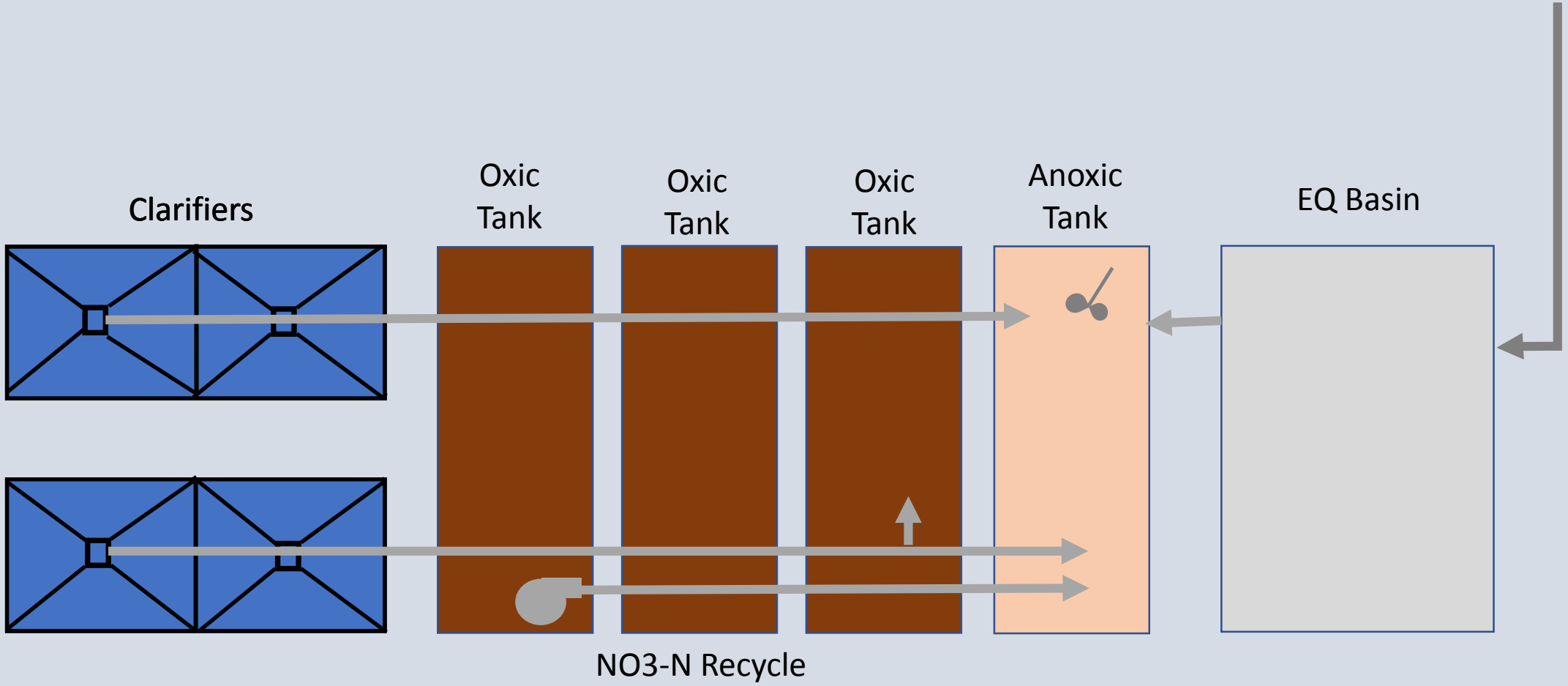
Measure, don’t guess…

Troubleshooting Systems



Case Study: Firestone Trace WWTP

Case Study: Firestone Trace WWTP



Firestone Trace WWTP

We found:

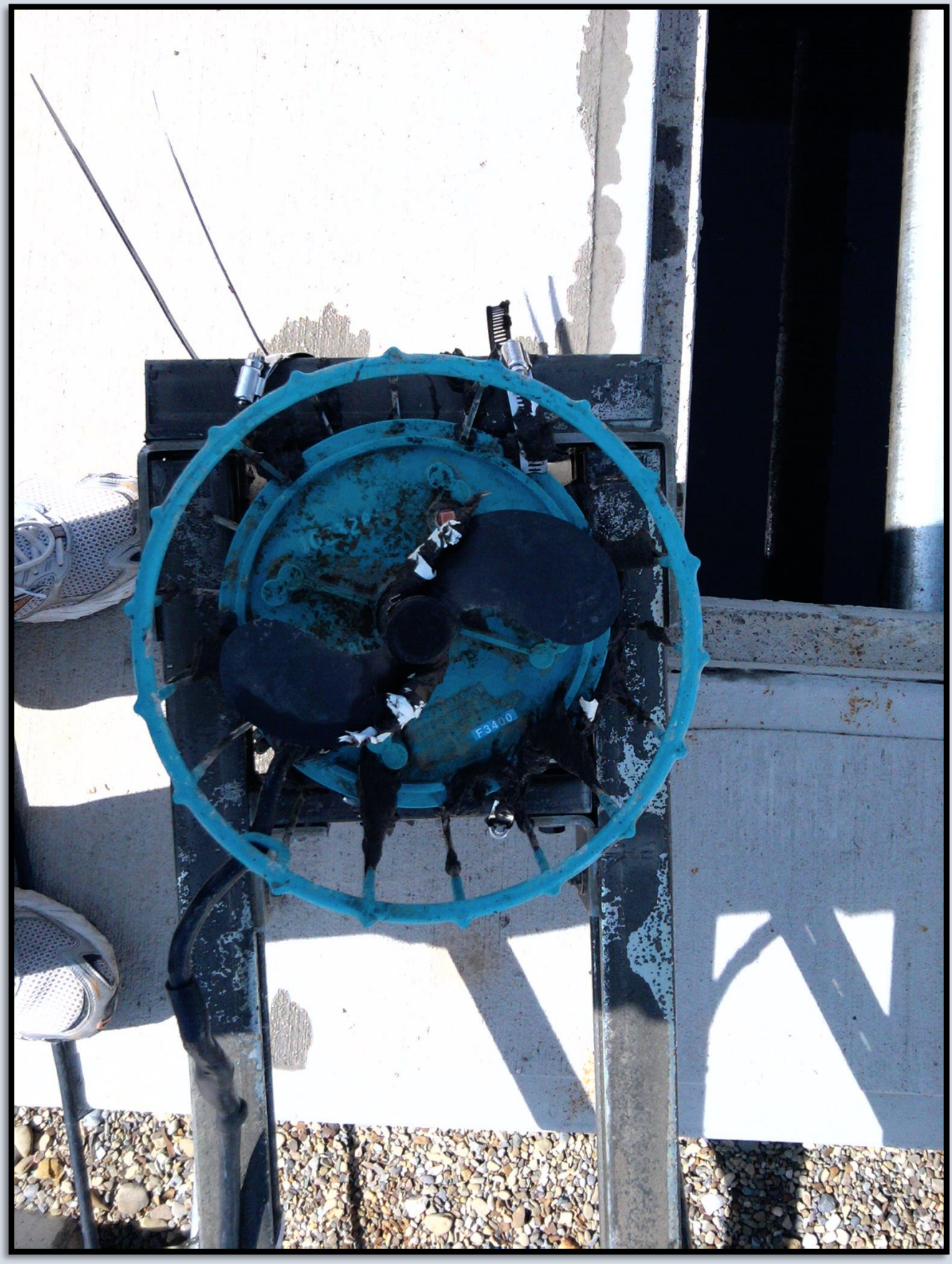
Nitrates are high (anoxic and effluent)

- Turn the Nitrate Recycle Pump down to 15 min ON, 45 min OFF (96 pin timer!)

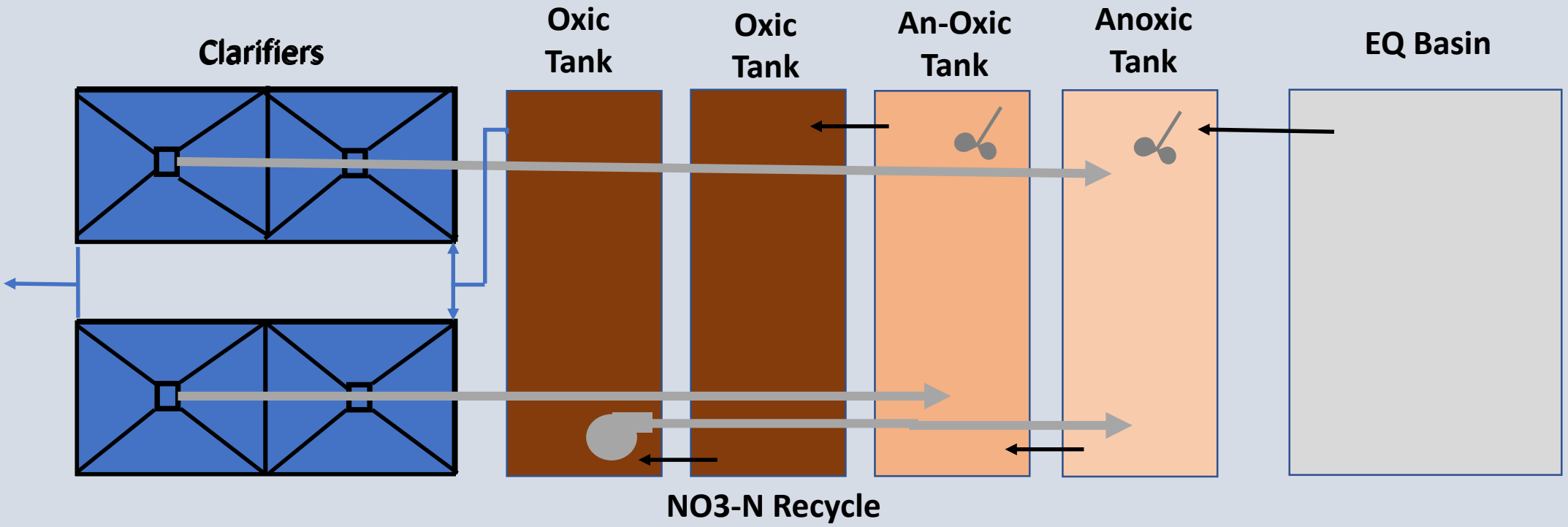
Influent COD is low

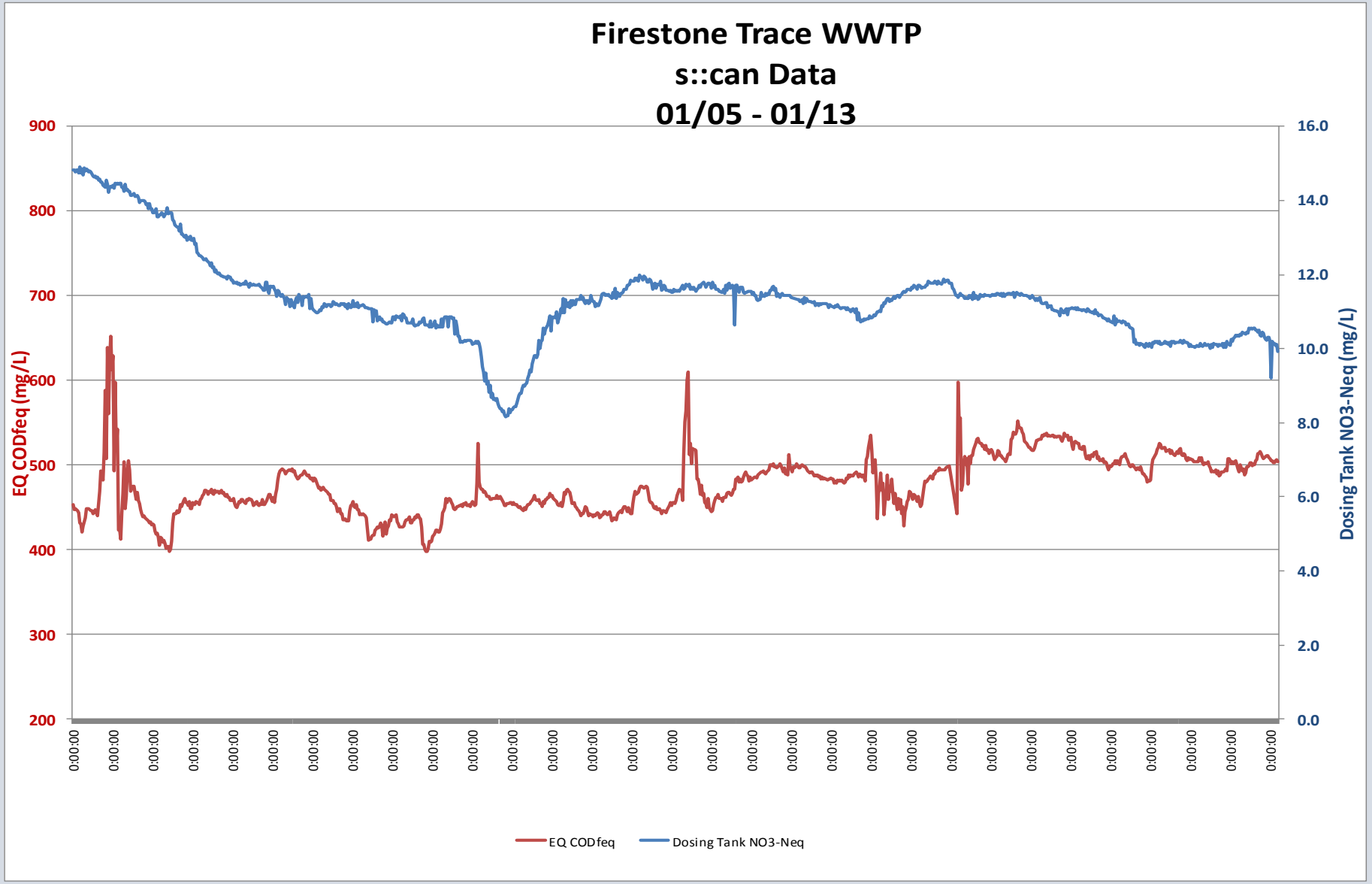
Aeration tanks are very aerobic (NH_3-N ~ 0)

Expand the Anoxic Tank?


F3400

Troubleshooting Systems




Firestone Trace WWTP
s::can Data
01/05 - 01/13
EQ CODfeq (mg/L)
Dosing Tank NO3-Neq (mg/L)
900
800
700
600
500
400
300
200
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0:00:00
EQ CODfeq
Dosing Tank NO3-Neq

Firestone Trace WWTP

Continued to run with two anoxic tanks for through the summer of 2011

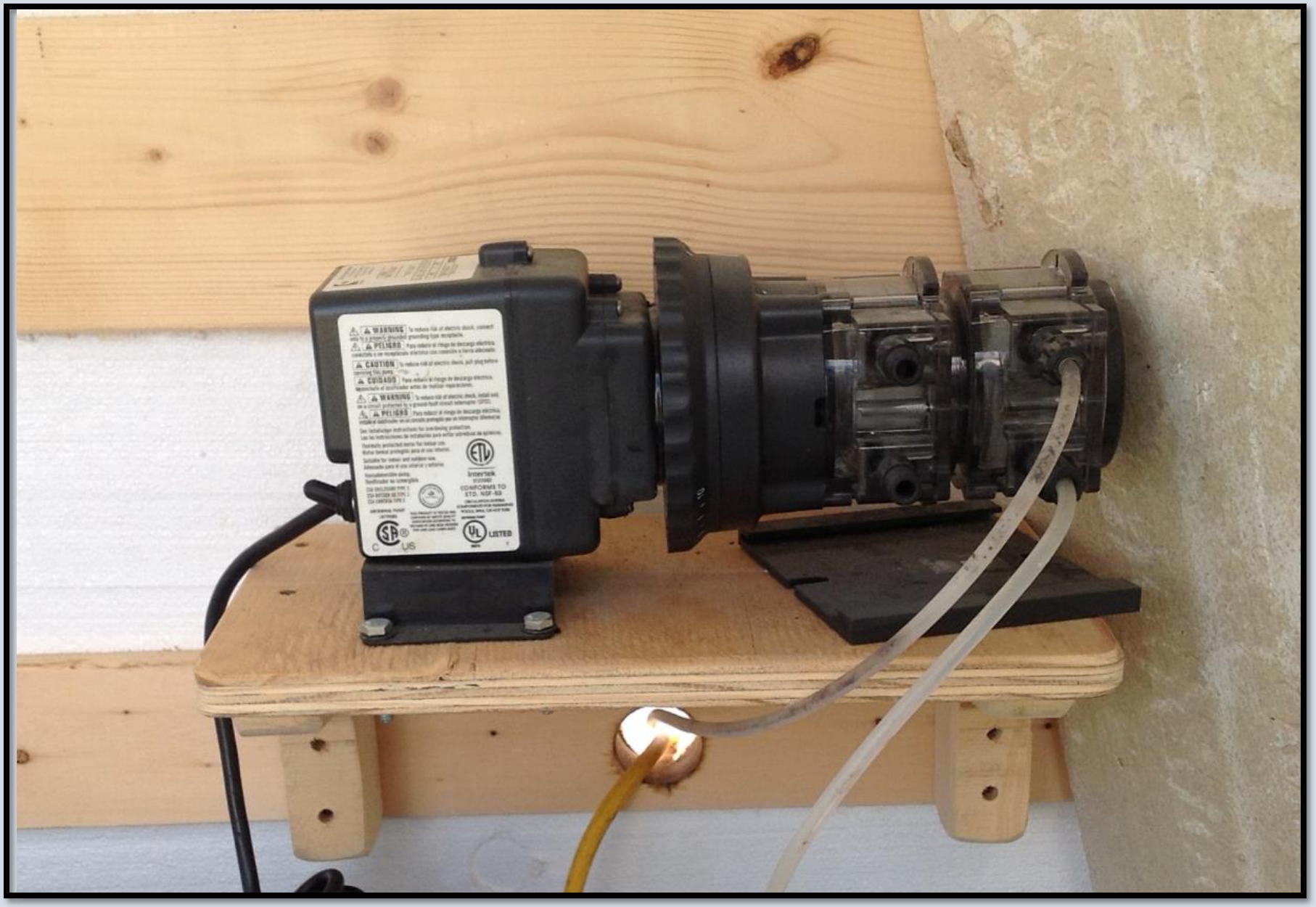
Flirted with Noncompliance for TIN all summer

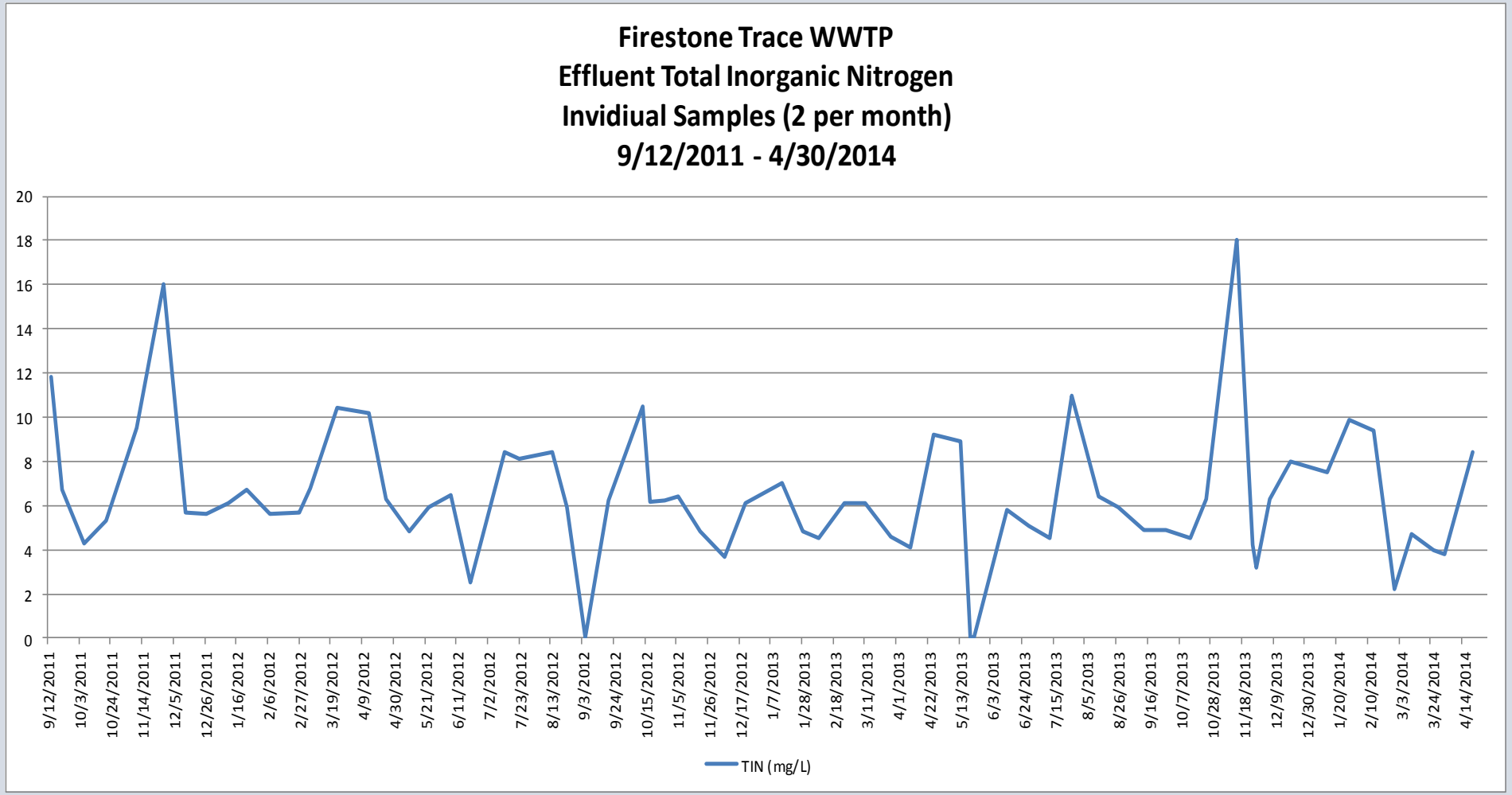
Pretty certain that carbon was the limiting factor

Firestone Trace WWTP

9/12/2011

A 55 gallon drum of Glycerin began to drip into the Anoxic Tank


WARNING
PELIGRO
CAUTION
CUIDADO
WARNING
PELIGRO
ETL
Intertek
COMPONENTS TO
STD. NSF-50
C US
LISTED


Firestone Trace WWTP
Effluent Total Inorganic Nitrogen
Invidiual Samples (2 per month)
9/12/2011 - 4/30/2014
20
18
16
14
12
10
8
6
4
2
0
9/12/2011
10/3/2011
10/24/2011
11/14/2011
12/5/2011
12/26/2011
1/16/2012
2/6/2012
2/27/2012
3/19/2012
4/9/2012
4/30/2012
5/21/2012
6/11/2012
7/2/2012
7/23/2012
8/13/2012
9/3/2012
9/24/2012
10/15/2012
11/5/2012
11/26/2012
12/17/2012
1/7/2013
1/28/2013
2/18/2013
3/11/2013
4/1/2013
4/22/2013
5/13/2013
6/3/2013
6/24/2013
7/15/2013
8/5/2013
8/26/2013
9/16/2013
10/7/2013
10/28/2013
11/18/2013
12/9/2013
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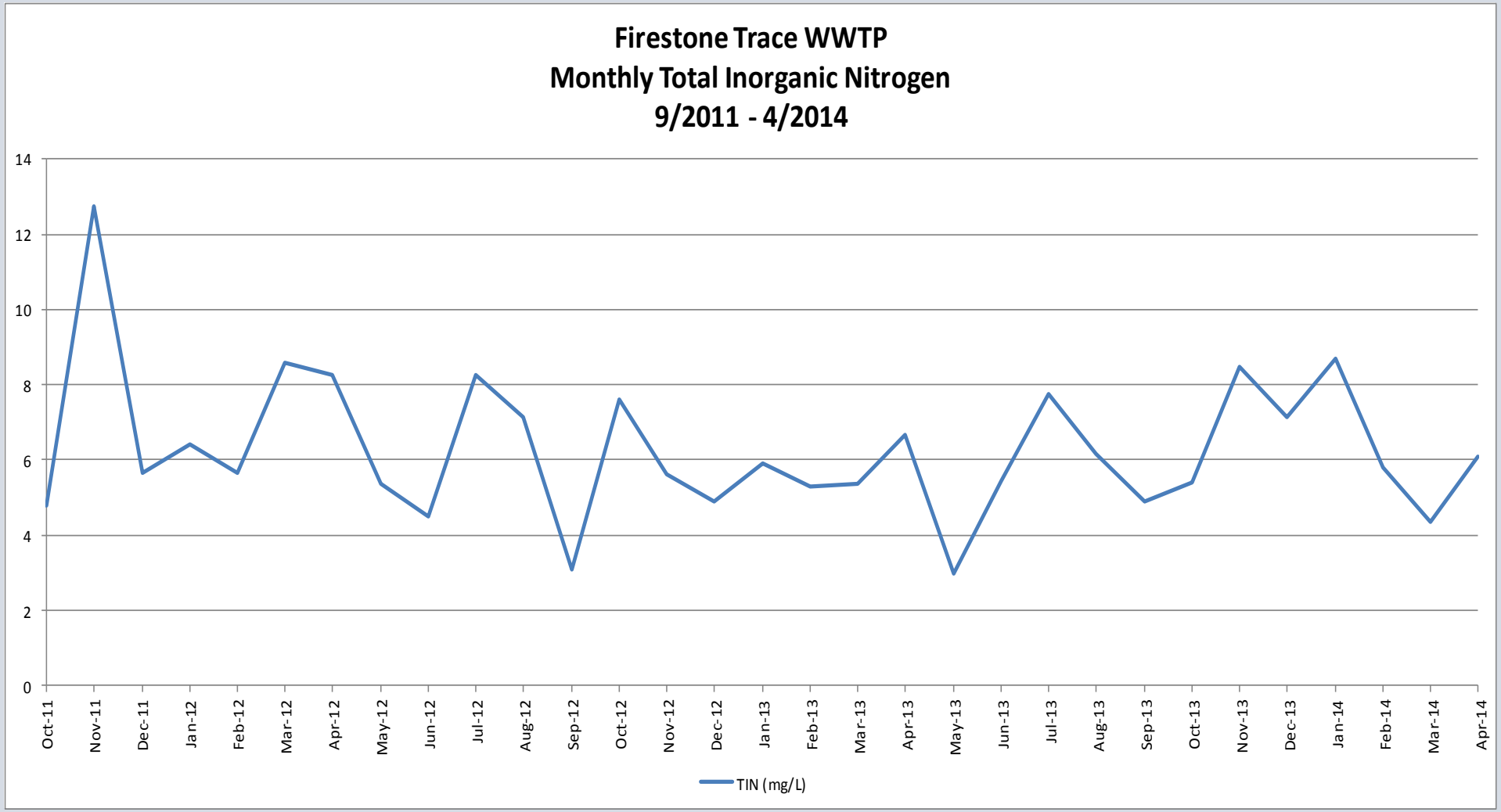
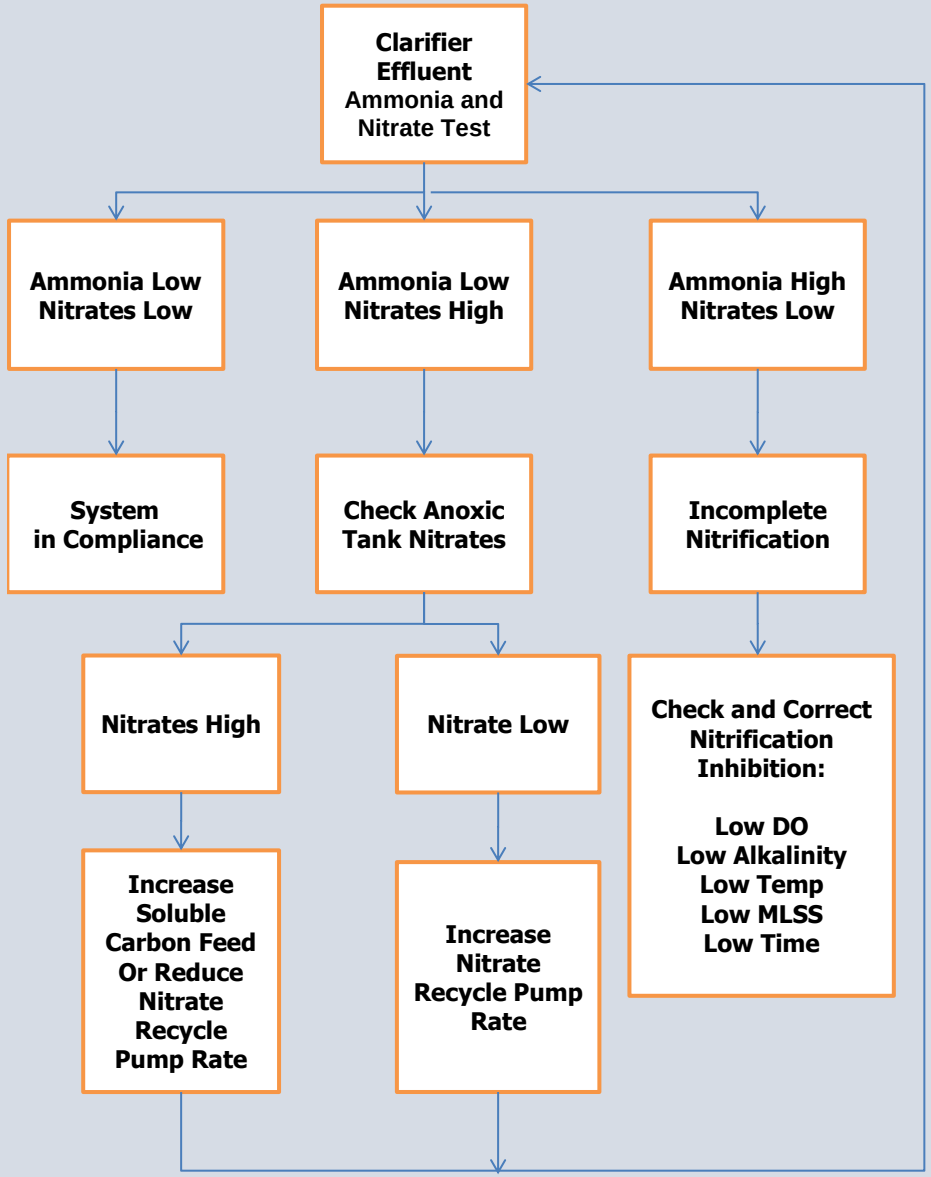
1/20/2014
2/10/2014
3/3/2014
3/24/2014
4/14/2014
TIN (mg/L)


Firestone Trace WWTP
Monthly Total Inorganic Nitrogen
9/2011 - 4/2014
14
12
10
8
6
4
2
0
Oct-11
Nov-11
Dec-11
Jan-12
Feb-12
Mar-12
Apr-12
May-12
Jun-12
Jul-12
Aug-12
Sep-12
Oct-12
Nov-12
Dec-12
Jan-13
Feb-13
Mar-13
Apr-13
May-13
Jun-13
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
Dec-13
Jan-14
Feb-14
Mar-14
Apr-14
TIN (mg/L)

Process Control Flow Chart for Denitrification in Anoxic Tank

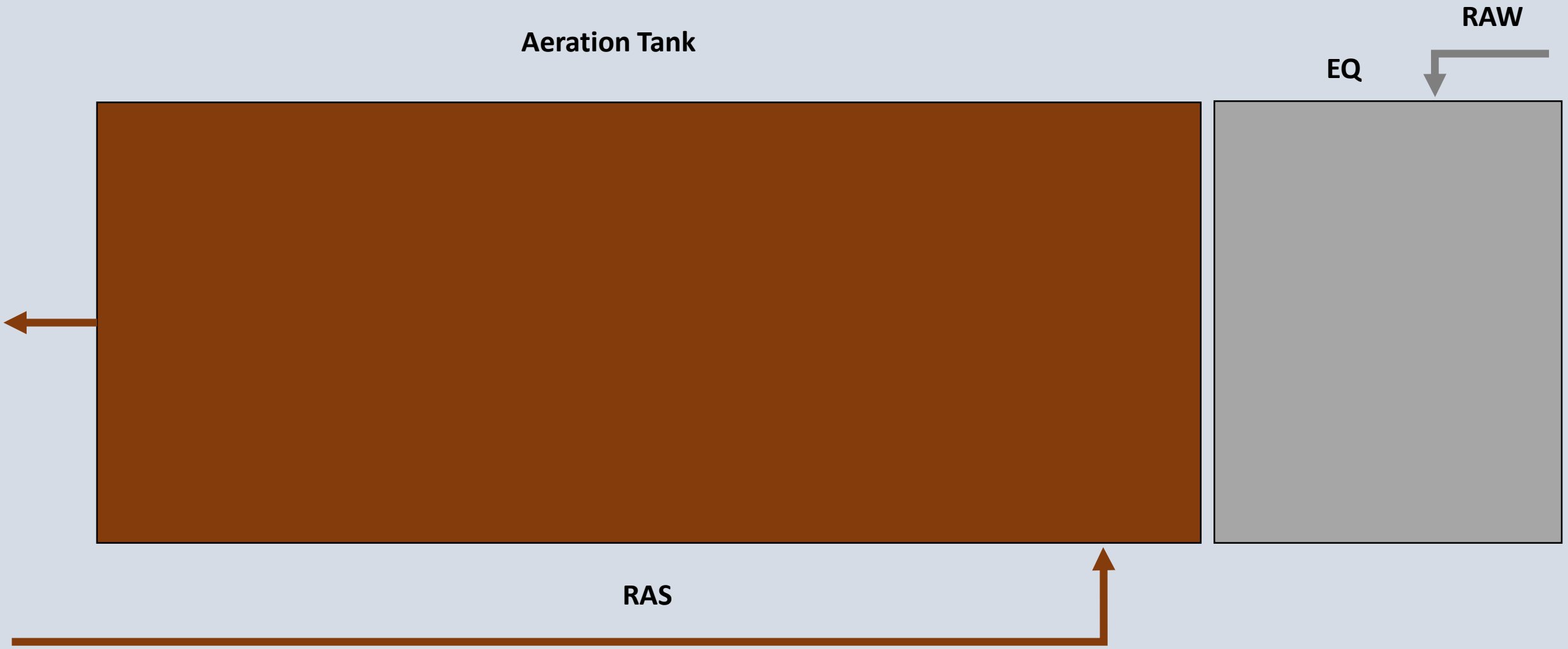


Firestone Trace WWTP

Optimize Anoxic Zone

- Control Nitrate Recycle
- Control Soluble Carbon
- Process Control
  - Anoxic Tank NH3-N and NO3-N
  - Aeration Tank NH3-N and NO3-N

Case Study: Scioto Reserve WWTP



Scioto Reserve WWTP

0.423 MDG Design Flow

Operates at 50 % design flow at 100+% of capacity

Land applies treated wastewater to an impoundment for irrigation of golf course

In 2012, rules for land application change and implementation of tight limits begins
Effluent limits required 10 mg/L TIN by April 2014

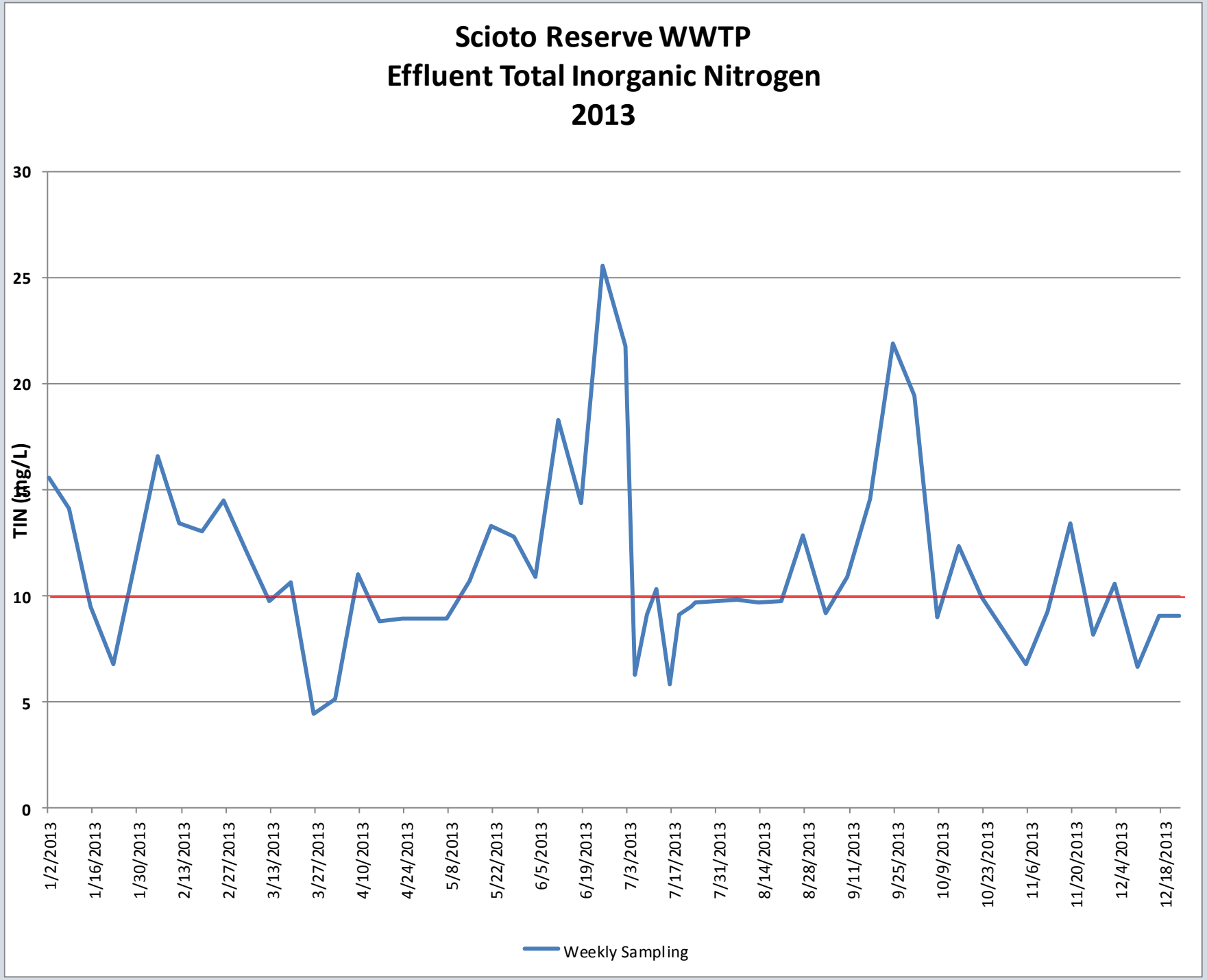
Scioto Reserve WWTP original design does not provide for denitrification

Scioto Reserve WWTP

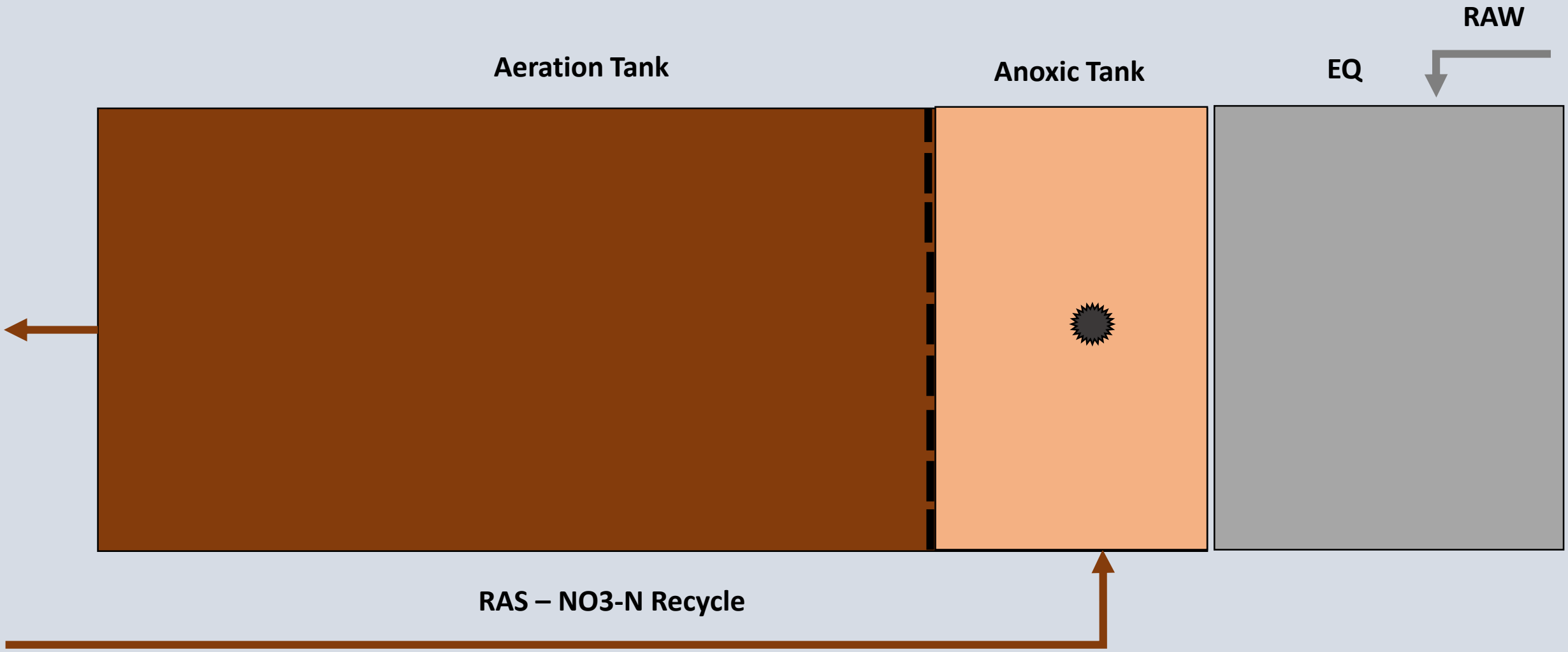
Initially, tried to ON/OFF blower operation to denitrify in the aeration tanks

Occasionally TIN would be within permit, but no consistency, no room for safety

December 2013: Drastic measures

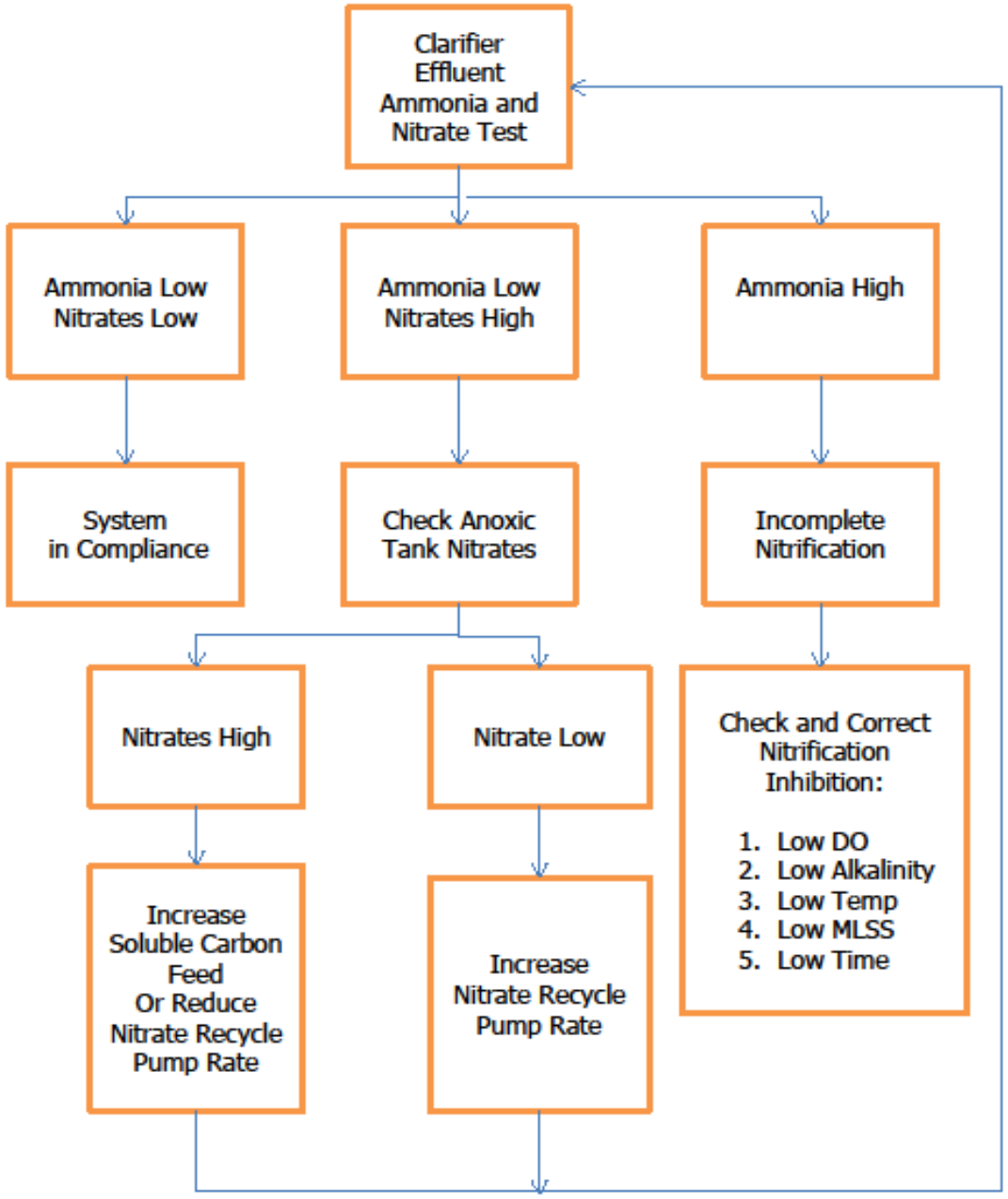

Scioto Reserve WWTP
Effluent Total Inorganic Nitrogen
2013
TIN (mg/L)
30
25
20
10
5
0
1/2/2013
1/16/2013
1/30/2013
2/13/2013
2/27/2013
3/13/2013
3/27/2013
4/10/2013
4/24/2013
5/8/2013
5/22/2013
6/5/2013
6/19/2013
7/3/2013
7/17/2013
7/31/2013
8/14/2013
8/28/2013
9/11/2013
9/25/2013
10/9/2013
10/23/2013
11/6/2013
11/20/2013
12/4/2013
12/18/2013
Weekly Sampling

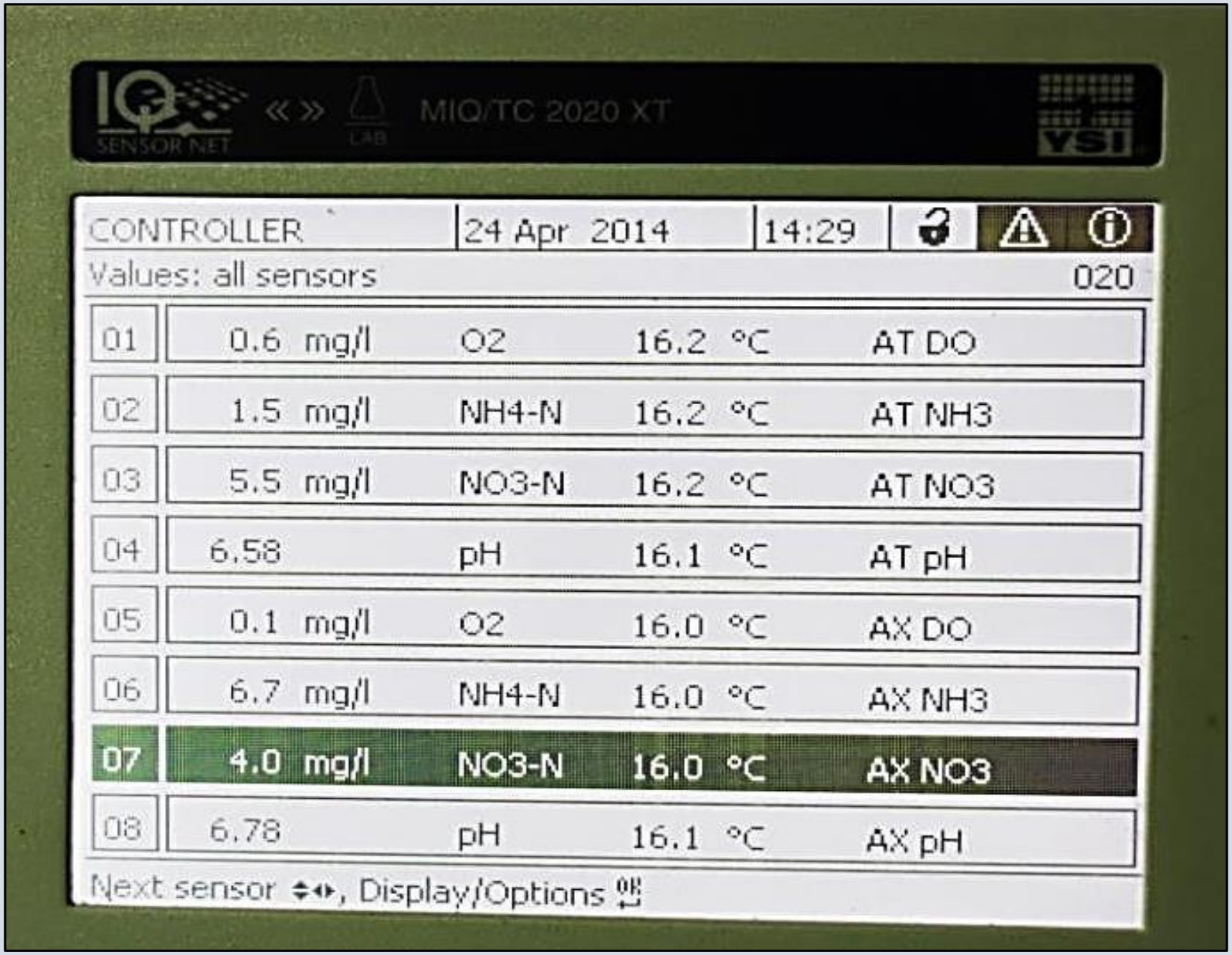
Troubleshooting Systems

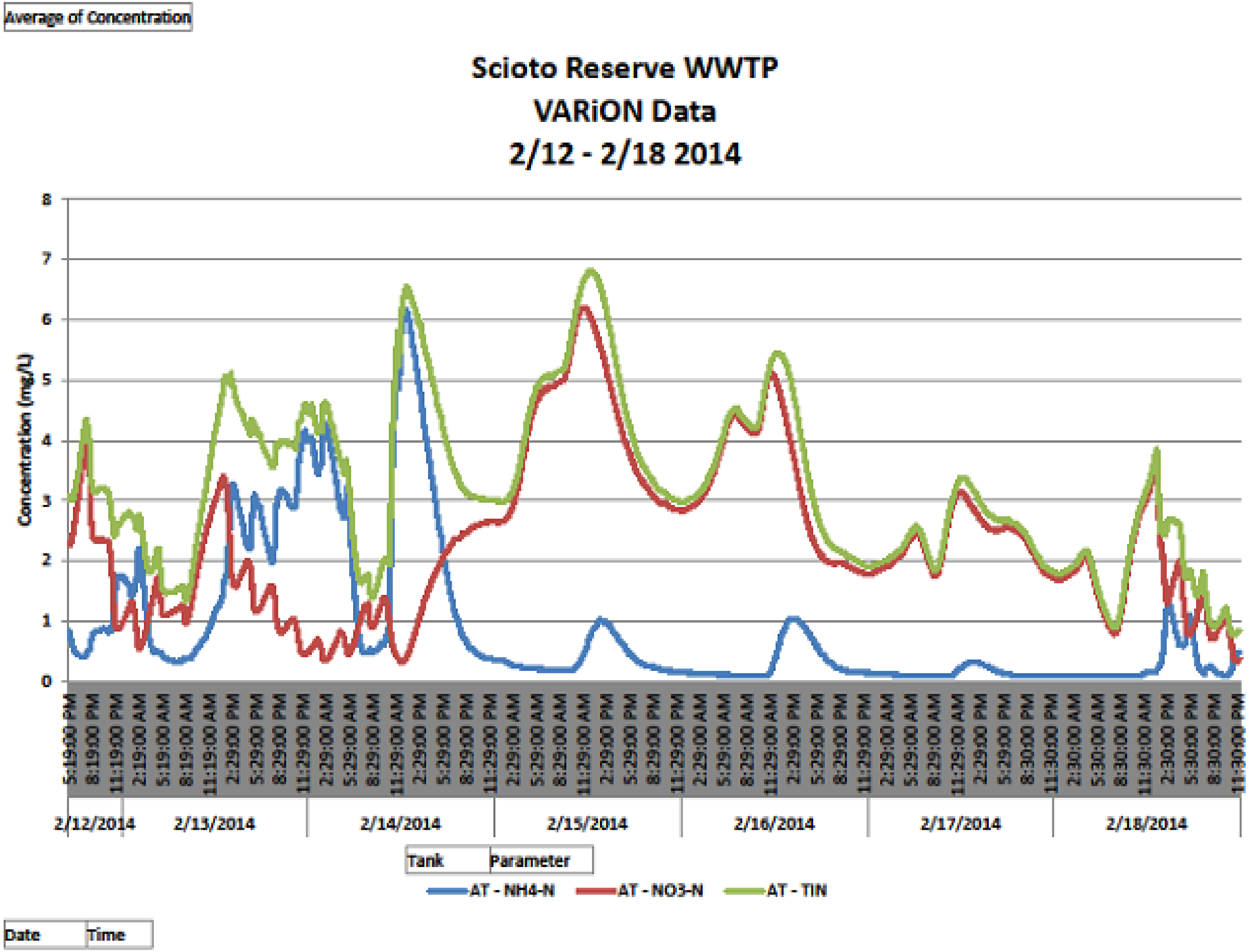



SKIMMER
SKIMMER
SLUDGE RETURN

Process Control Flow Chart for Denitrification in Anoxic Tank

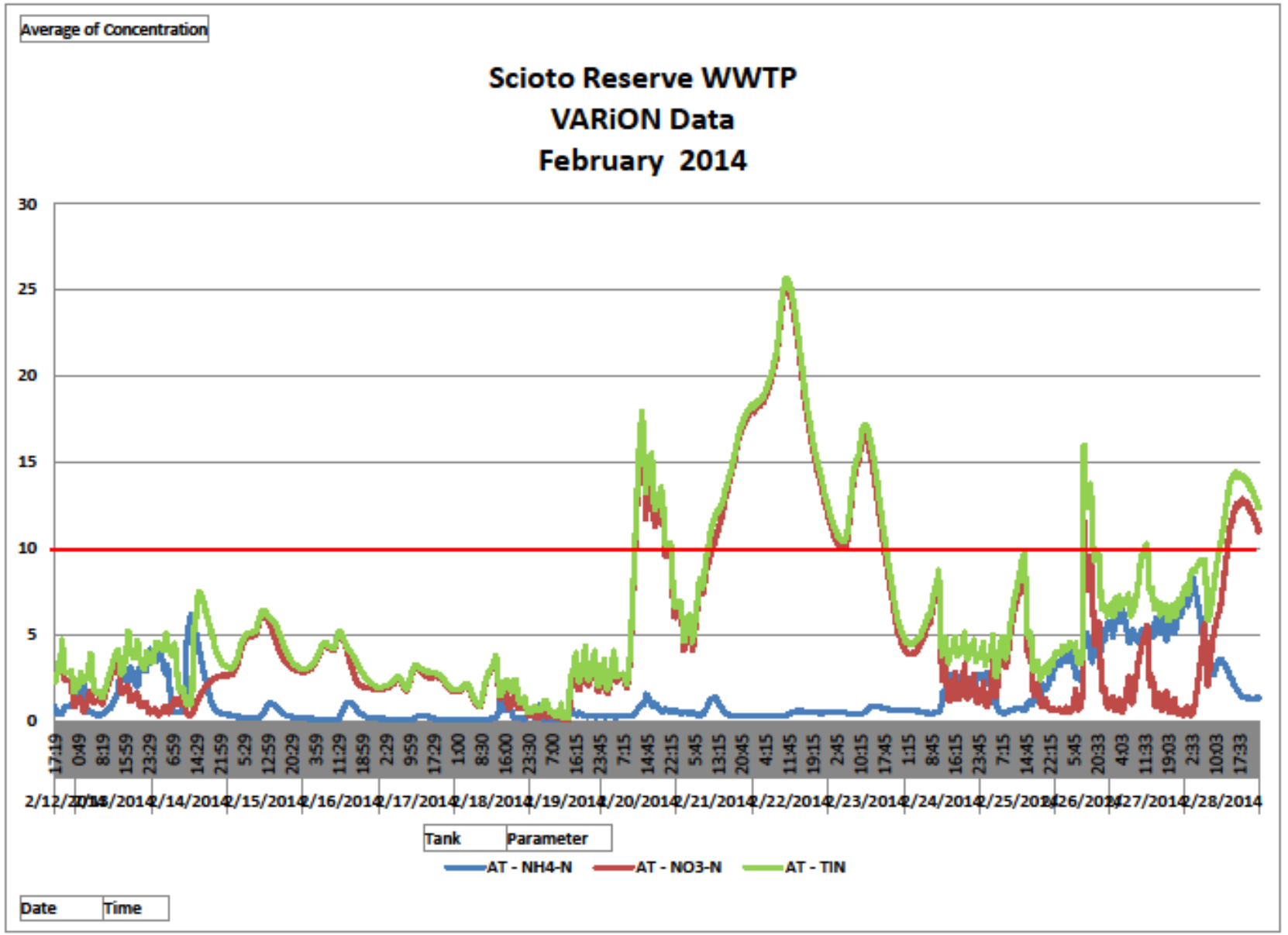


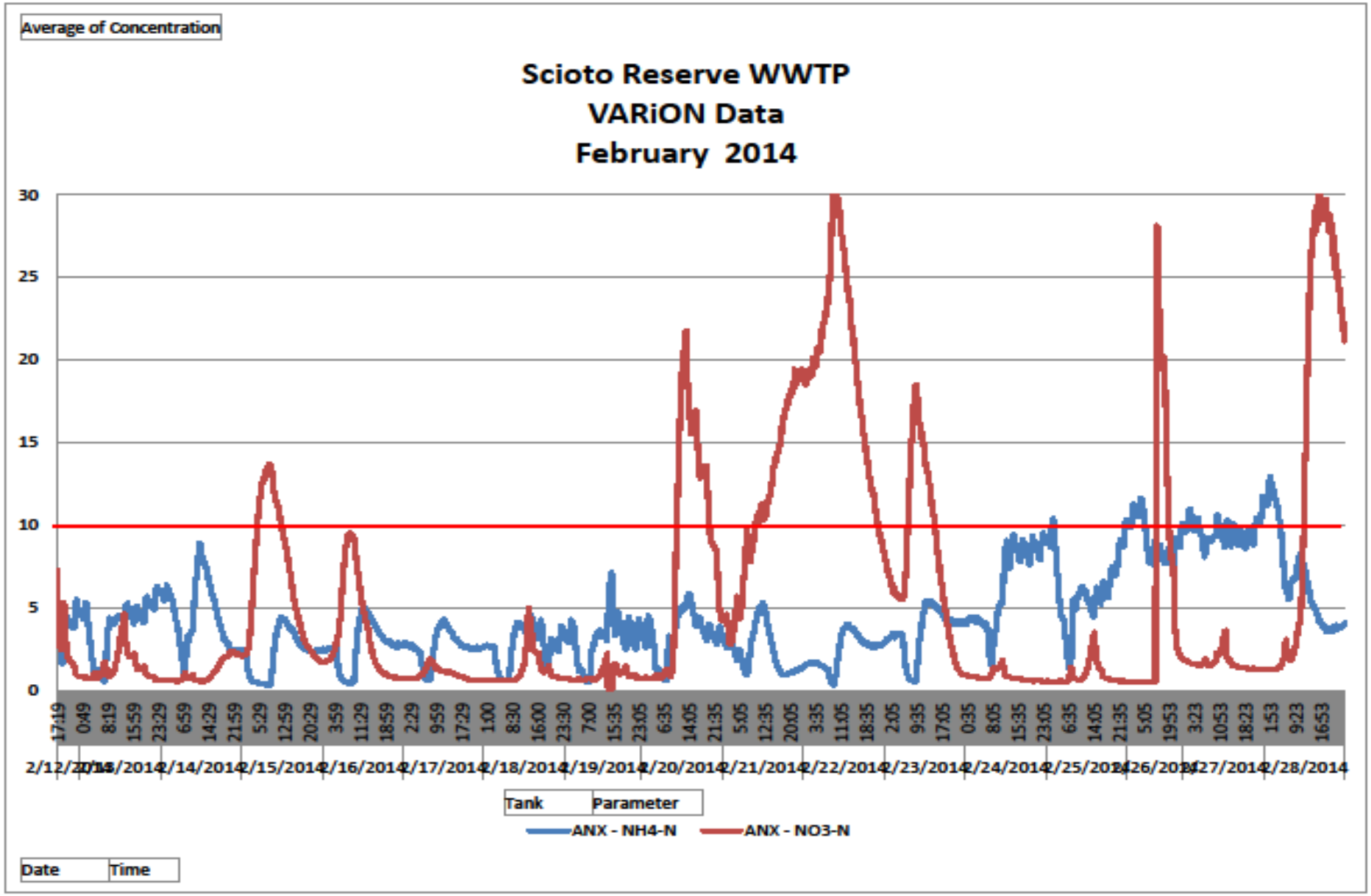

IQ SENSOR NET
LAB
MIQ/TC 2020 XT
YSI
CONTROLLER
24 Apr 2014
14:29
Values: all sensors
020
01 0.6 mg/l O2 16.2 °C AT DO
02 1.5 mg/l NH4-N 16.2 °C AT NH3
03 5.5 mg/l NO3-N 16.2 °C AT NO3
04 6.58 pH 16.1 °C AT pH
05 0.1 mg/l O2 16.0 °C AX DO
06 6.7 mg/l NH4-N 16.0 °C AX NH3
07 4.0 mg/l NO3-N 16.0 °C AX NO3
08 6.78 pH 16.1 °C AX pH
Next sensor, Display/Options

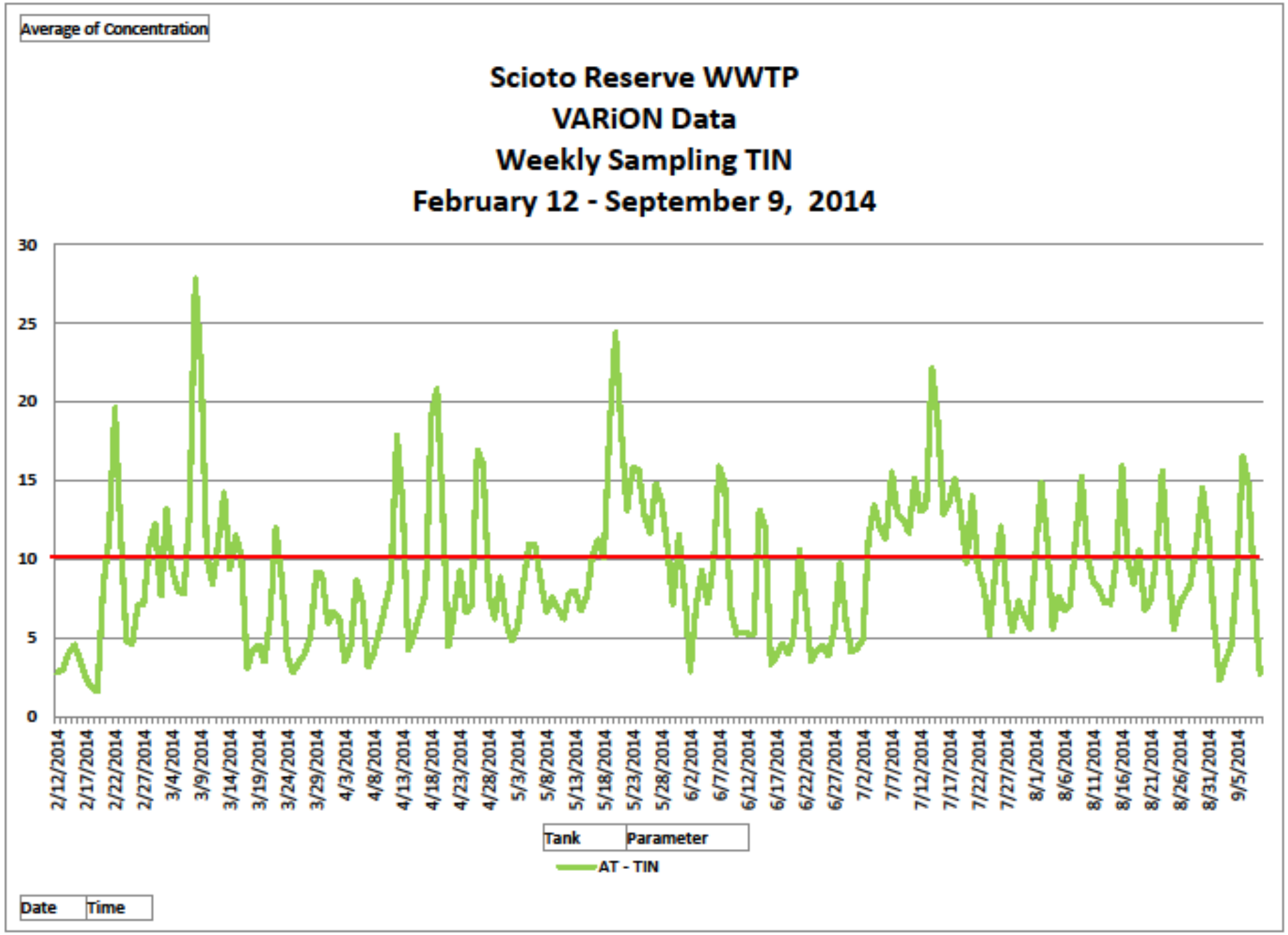

Average of Concentration
Scioto Reserve WWTP
VARiON Data
2/12 - 2/18 2014
Concentration (mg/L)
8
7
6
5
4
3
2
1
0
2/12/2014
2/13/2014
2/14/2014
2/15/2014
2/16/2014
2/17/2014
2/18/2014
Tank
Parameter
AT - NH4-N
AT - NO3-N
AT - TIN
Date
Time

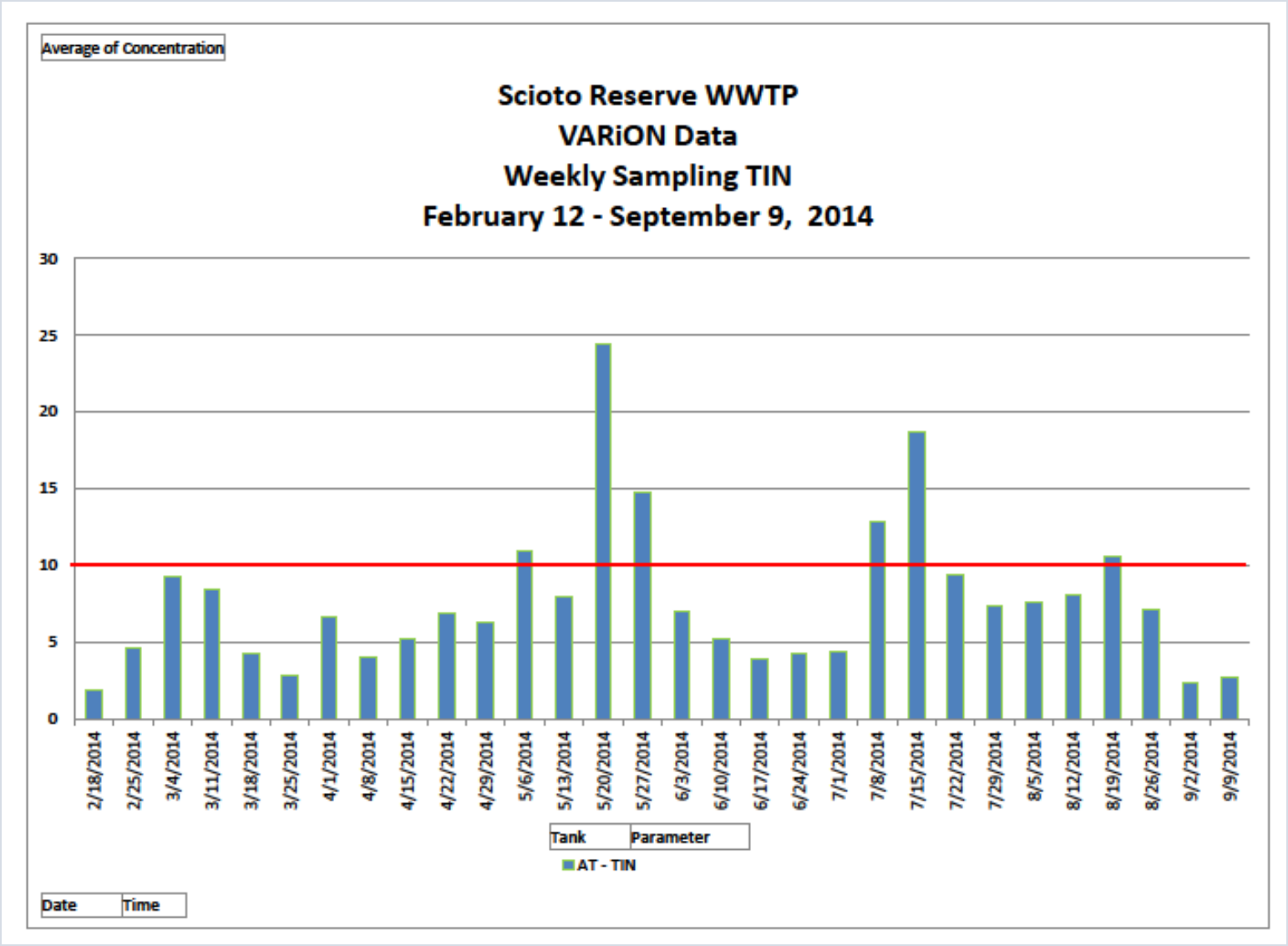
Scioto Reserve WWTP

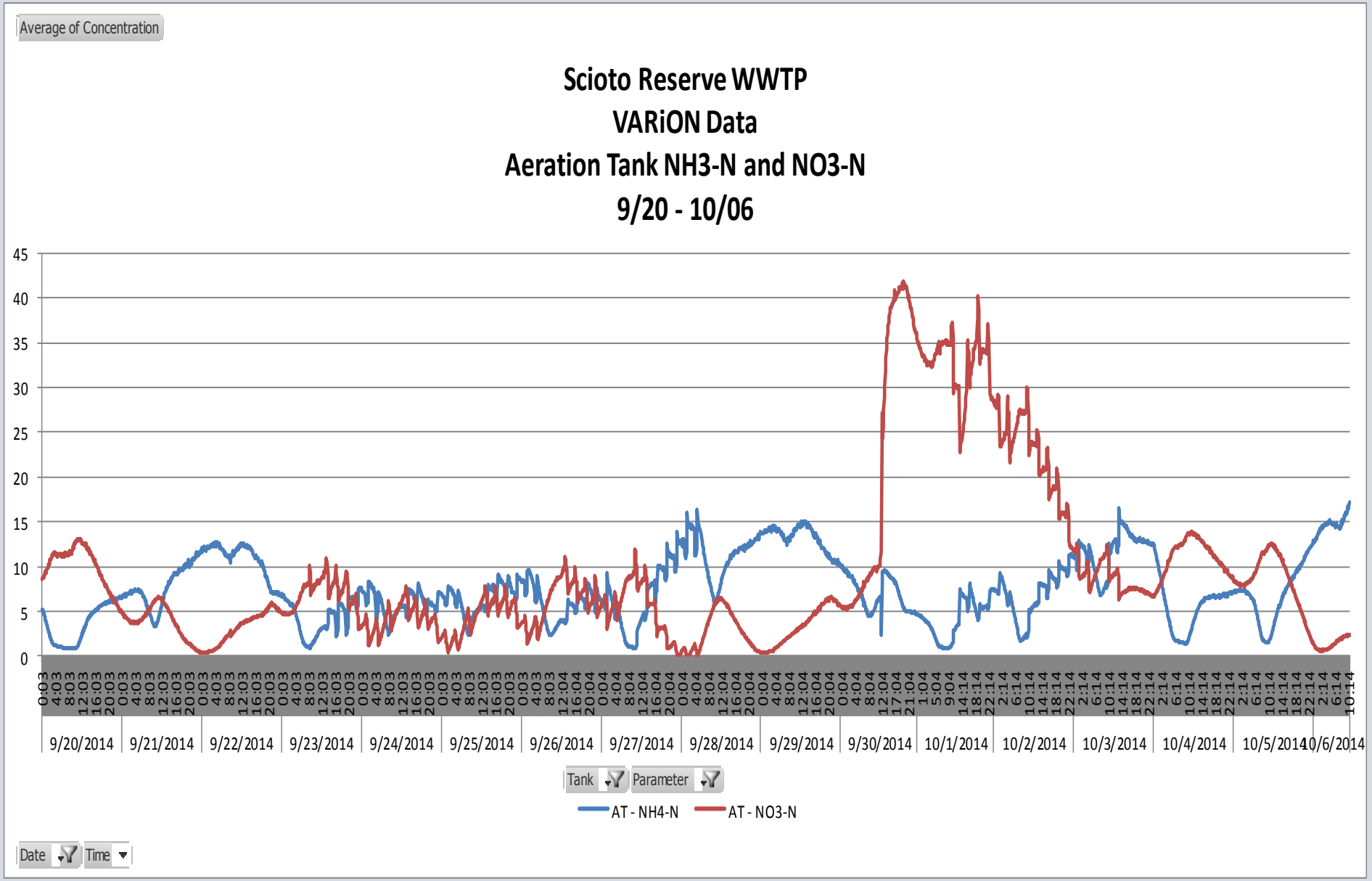
- 1) created a mixed Anoxic Zone
- 2) relied on RAS for nitrate recycle
- 3) relied on raw wastewater for carbon source
- 4) Ran blowers ON/OFF during the week
- 5) Ran full aeration during the weekend
- **TIN < 10 mg/L**

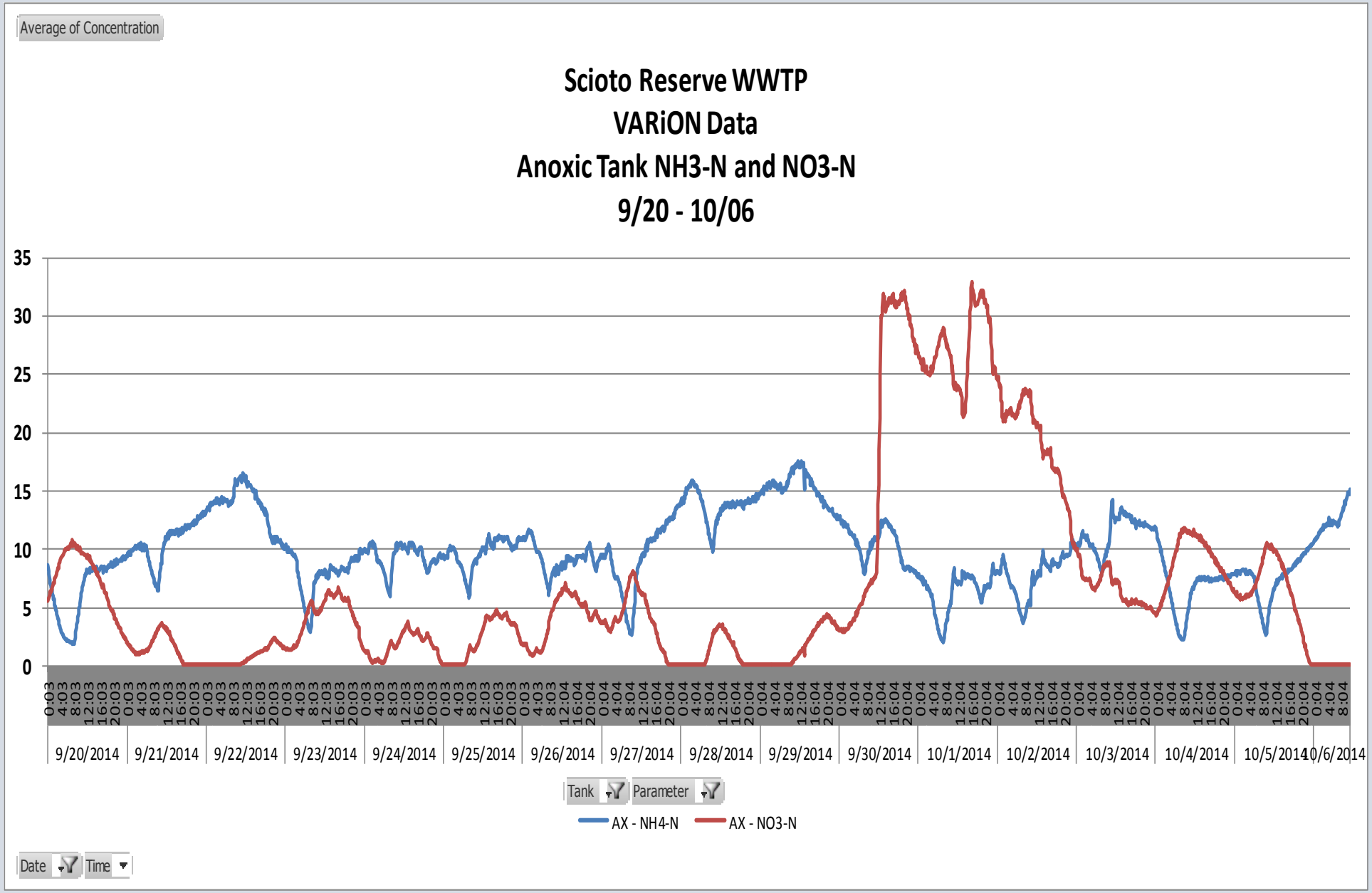

Average of Concentration
Scioto Reserve WWTP
VARiON Data
February 2014
30
25
20
15
10
5
0
2/12/2014
2/13/2014
2/14/2014
2/15/2014
2/16/2014
2/17/2014
2/18/2014
2/19/2014
2/20/2014
2/21/2014
2/22/2014
2/23/2014
2/24/2014
2/25/2014
2/26/2014
2/27/2014
2/28/2014
Tank
Parameter
AT - NH4-N
AT - NO3-N
AT - TIN
Date
Time

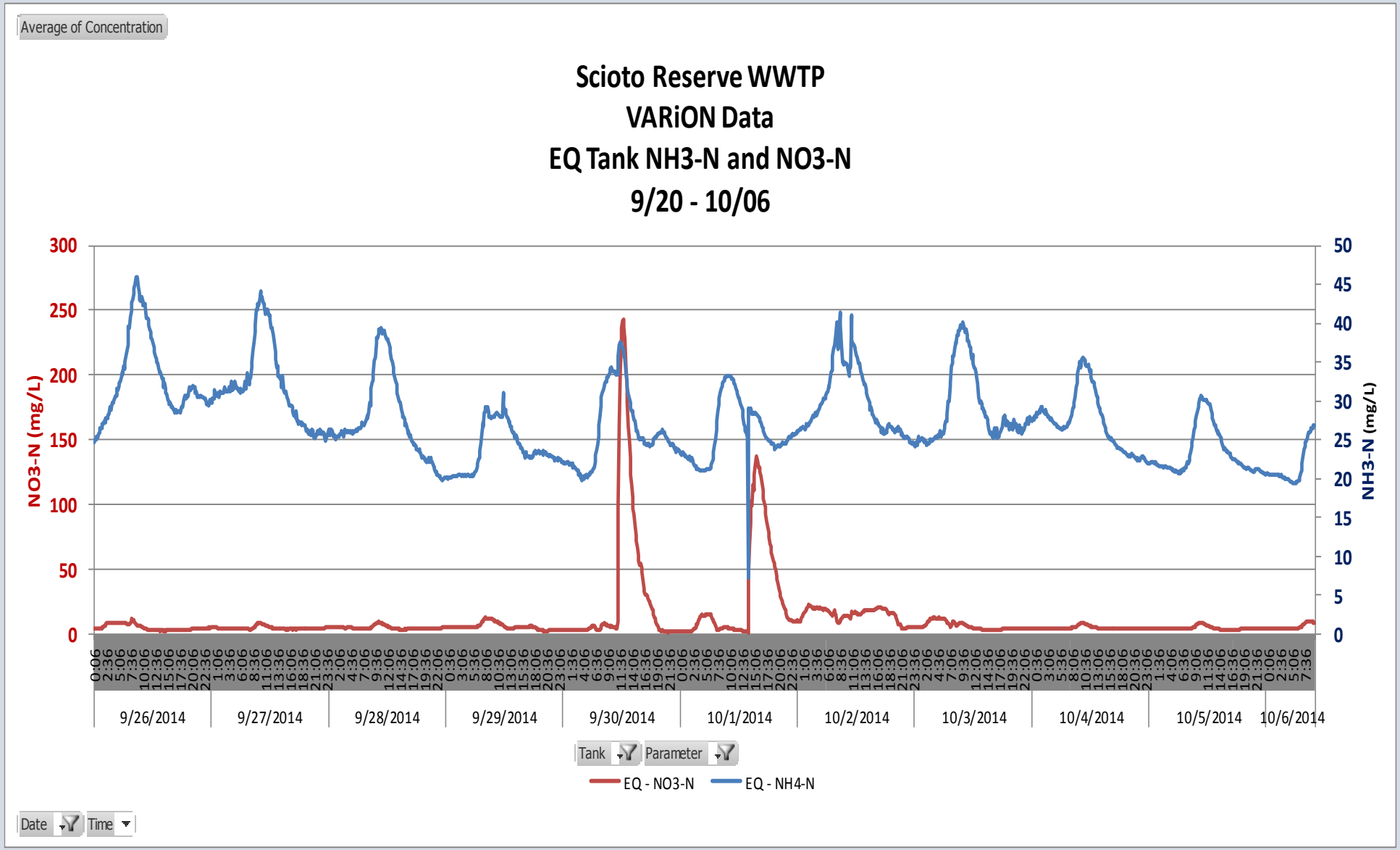

Average of Concentration
Scioto Reserve WWTP
VARiON Data
February 2014
30
25
20
15
10
5
0
17:19
0:49
8:19
15:59
23:29
6:59
14:29
21:59
5:29
12:59
20:29
3:59
11:29
18:59
2:29
9:59
17:29
1:00
8:30
16:00
23:30
7:00
15:35
23:05
6:35
14:05
21:35
5:05
12:35
20:05
3:35
11:05
18:35
2:05
9:35
17:05
0:35
8:05
15:35
23:05
6:35
14:05
21:35
5:05
19:53
3:23
10:53
18:23
1:53
9:23
16:53
2/12/2014
2/13/2014
2/14/2014
2/15/2014
2/16/2014
2/17/2014
2/18/2014
2/19/2014
2/20/2014
2/21/2014
2/22/2014
2/23/2014
2/24/2014
2/25/2014
2/26/2014
2/27/2014
2/28/2014
Tank
Parameter
ANX - NH4-N
ANX - NO3-N
Date
Time


Average of Concentration
Scioto Reserve WWTP
VARiON Data
Weekly Sampling TIN
February 12 - September 9, 2014
30
25
20
15
10
5
0
2/12/2014
2/17/2014
2/22/2014
2/27/2014
3/4/2014
3/9/2014
3/14/2014
3/19/2014
3/24/2014
3/29/2014
4/3/2014
4/8/2014
4/13/2014
4/18/2014
4/23/2014
4/28/2014
5/3/2014
5/8/2014
5/13/2014
5/18/2014
5/23/2014
5/28/2014
6/2/2014
6/7/2014
6/12/2014
6/17/2014
6/22/2014
6/27/2014
7/2/2014
7/7/2014
7/12/2014
7/17/2014
7/22/2014
7/27/2014
8/1/2014
8/6/2014
8/11/2014
8/16/2014
8/21/2014
8/26/2014
8/31/2014
9/5/2014
Tank
Parameter
AT - TIN
Date
Time


Average of Concentration
Scioto Reserve WWTP
VARiON Data
Weekly Sampling TIN
February 12 - September 9, 2014
30
25
20
15
10
5
0
2/18/2014
2/25/2014
3/4/2014
3/11/2014
3/18/2014
3/25/2014
4/1/2014
4/8/2014
4/15/2014
4/22/2014
4/29/2014
5/6/2014
5/13/2014
5/20/2014
5/27/2014
6/3/2014
6/10/2014
6/17/2014
6/24/2014
7/1/2014
7/8/2014
7/15/2014
7/22/2014
7/29/2014
8/5/2014
8/12/2014
8/19/2014
8/26/2014
9/2/2014
9/9/2014
Tank
Parameter
AT - TIN
Date
Time


Average of Concentration
Scioto Reserve WWTP
VARiON Data
Aeration Tank NH3-N and NO3-N
9/20 - 10/06
45
40
35
30
25
20
15
10
5
0
9/20/2014
9/21/2014
9/22/2014
9/23/2014
9/24/2014
9/25/2014
9/26/2014
9/27/2014
9/28/2014
9/29/2014
9/30/2014
10/1/2014
10/2/2014
10/3/2014
10/4/2014
10/5/2014
10/6/2014
Tank
Parameter
AT - NH4-N
AT - NO3-N
Date
Time


Average of Concentration
Scioto Reserve WWTP
VARiON Data
Anoxic Tank NH3-N and NO3-N
9/20 - 10/06
35
30
25
20
15
10
5
0
9/20/2014
9/21/2014
9/22/2014
9/23/2014
9/24/2014
9/25/2014
9/26/2014
9/27/2014
9/28/2014
9/29/2014
9/30/2014
10/1/2014
10/2/2014
10/3/2014
10/4/2014
10/5/2014
10/6/2014
Tank
Parameter
AX - NH4-N
AX - NO3-N
Date
Time


Average of Concentration
Scioto Reserve WWTP
VARiON Data
EQ Tank NH3-N and NO3-N
9/20 - 10/06
NO3-N (mg/L)
NH3-N (mg/L)
300
250
200
150
100
50
0
50
45
40
35
30
25
20
15
10
5
0
9/26/2014
9/27/2014
9/28/2014
9/29/2014
9/30/2014
10/1/2014
10/2/2014
10/3/2014
10/4/2014
10/5/2014
10/6/2014
Tank
Parameter
EQ - NO3-N
EQ - NH4-N
Date
Time

Troubleshooting Systems: Bradford WWTP

New WWTP came online November 2013

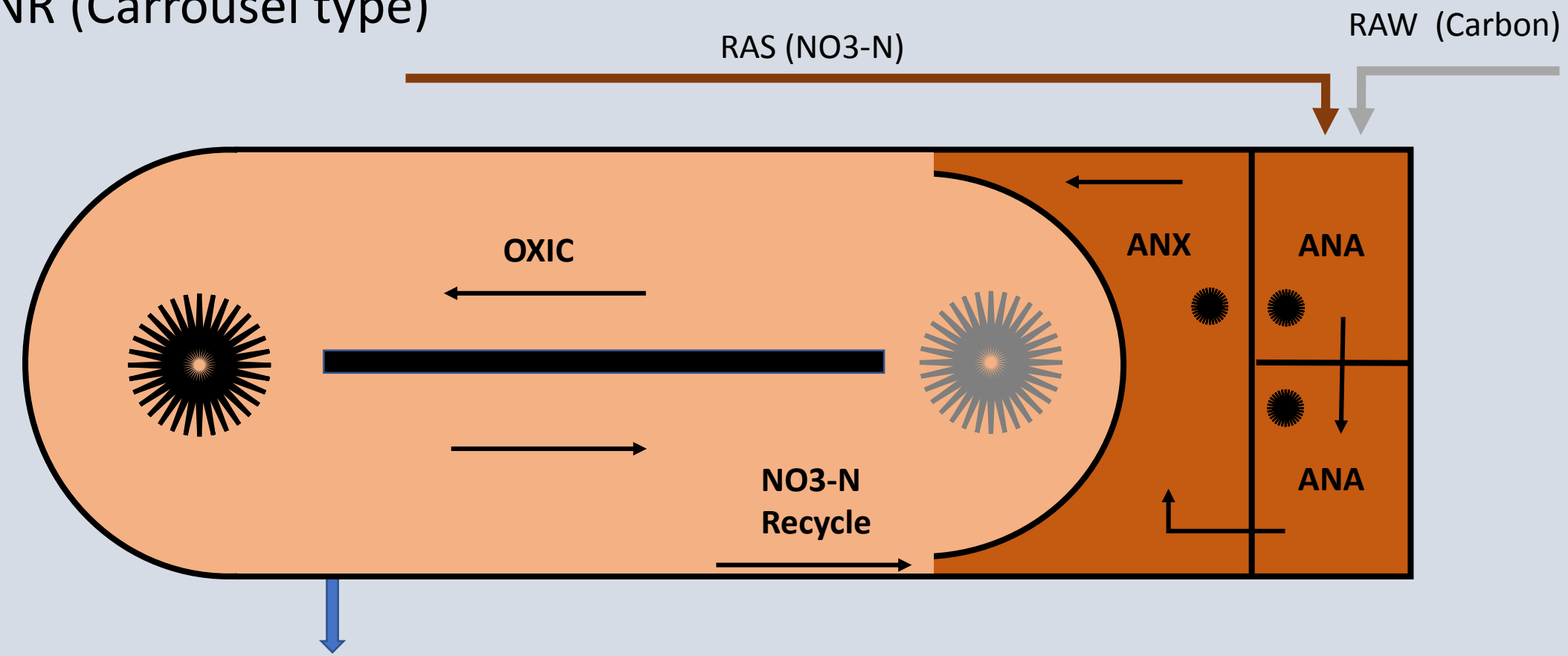
Constructed a Carrousel Type BNR System

Designed for 0.480 MGD

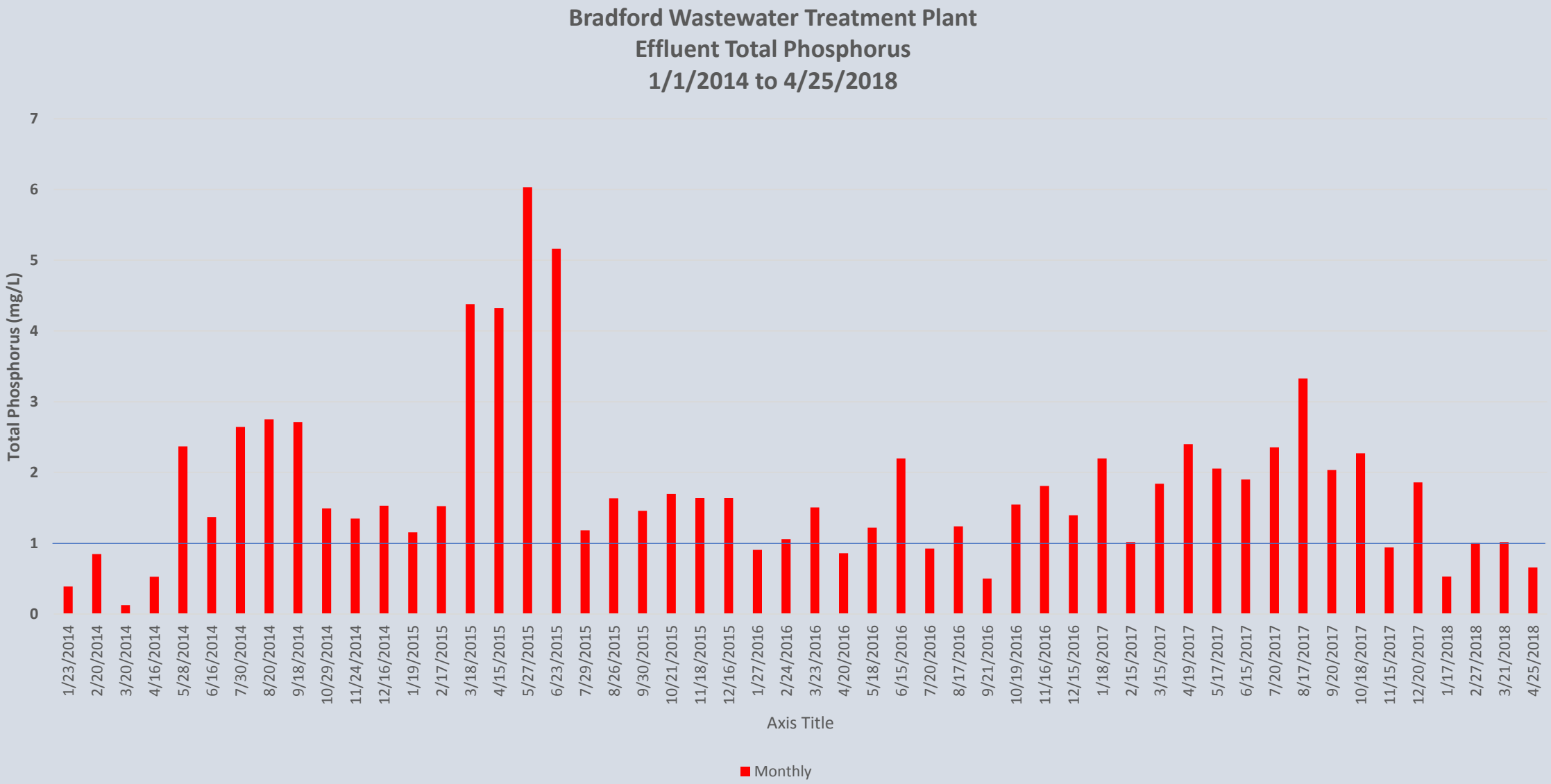
2017 average flow: ~0.550 MGD (big clarifiers!)

Troubleshooting Systems: Bradford WWTP

BNR (Carrousel type)




WesTech


Bradford Wastewater Treatment Plant
Effluent Total Phosphorus
1/1/2014 to 4/25/2018
Total Phosphorus (mg/L)
0
1
2
3
4
5
6
7
1/23/2014
2/20/2014
3/20/2014
4/16/2014
5/28/2014
6/16/2014
7/30/2014
8/20/2014
9/18/2014
10/29/2014
11/24/2014
12/16/2014
1/19/2015
2/17/2015
3/18/2015
4/15/2015
5/27/2015
6/23/2015
7/29/2015
8/26/2015
9/30/2015
10/21/2015
11/18/2015
12/16/2015
1/27/2016
2/24/2016
3/23/2016
4/20/2016
5/18/2016
6/15/2016
7/20/2016
8/17/2016
9/21/2016
10/19/2016
11/16/2016
12/15/2016
1/18/2017
2/15/2017
3/15/2017
4/19/2017
5/17/2017
6/15/2017
7/20/2017
8/17/2017
9/20/2017
10/18/2017
11/15/2017
12/20/2017
1/17/2018
2/27/2018
3/21/2018
4/25/2018
Axis Title
Monthly

Nitrate Analysis

Nitrate (mg/L)				
	RAS	Anaerobic	Anoxic	Digester
3/15/2018	14.3	11.9	14.6	
3/19/2018	8.7	12.5	11.9	
3/20/2018	11.6	7.9	11.8	55.9
3/21/2018	11.5	7.5	12.0	
3/22/2018	8.6	8.2	11.1	131.5

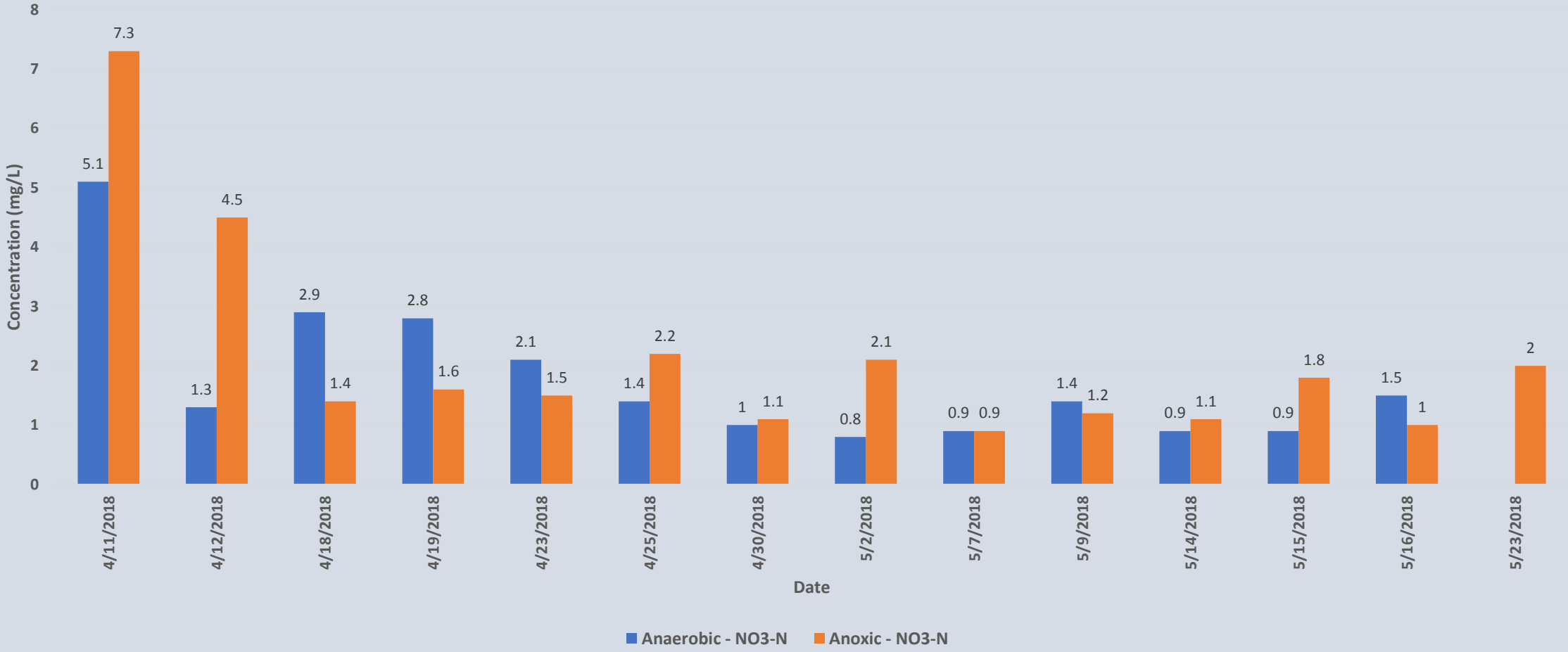
Case Study: Bradford WWTP

Too much Nitrate everywhere

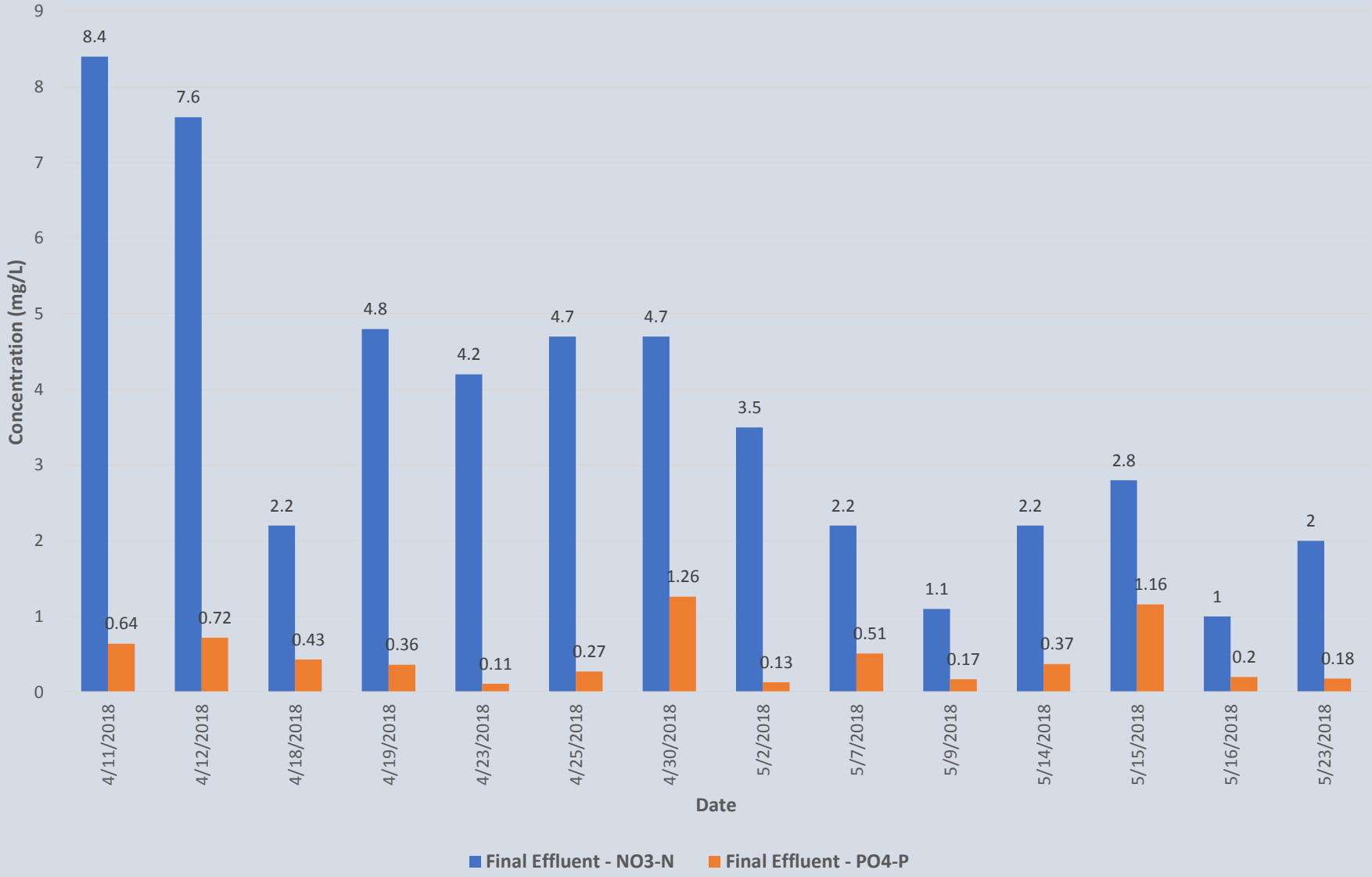
Solution:

1) Close the nitrate recycle gate
2) Run vertical rotor at 30 hertz
3) Turn Anaerobic Zone Mixer OFF for 3 hours, ON for 15 minutes
4) Turn Anoxic Zone Mixer OFF for 3 hours, ON for 15 minutes
5) Profile Ammonia, Nitrate, and Orthophosphate in each zone

Bradford WWTP
Nutrient Profile
Nitrate Grab Sampling
4/11/2018 - 5/23/2018



Bradford WWTP
Nutrient Profile Grab Sampling
4/11/2018 - 5/23/2018




BLUE INFRA TECHNOLOGIES
NEW CASTLE, INDIANA

Case Study: Bradford WWTP

First April sample was high (1.25 mg/L), but the rest of the samples brought the monthly down to 0.66 mg/L

Alum feed was shut down 5/2

May 2018 another consecutive month of compliance for TP

In addition, the village was spending $1200/month for alum previously.

Electricity demand should also be reduced due to mixer turndown

Case Study: Bradford WWTP

Keys to BPR:

Process Control!

1) Monitor the nutrients in the Inputs to each zone
2) Monitor the nutrients in Internal Recycles (Digester Supernatant)
3) If the Chemistry is correct in the zones, the bacterial response will be compliant.
4) **Know the chemical environment in each zone of the WWTP.**

Questions?

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