

# Use of dynamic process control at a Long Island Sound Water Pollution Control Facility significantly reduces supplemental carbon use while maintaining nitrogen removal permit compliance

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**MARK RODE, GENERAL CONTROL SYSTEMS**

# Overview

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Background on nitrogen trading in Connecticut

Nitrogen removal process at the Stratford WPCF

Use of nitrate analyzers

Process control system case study

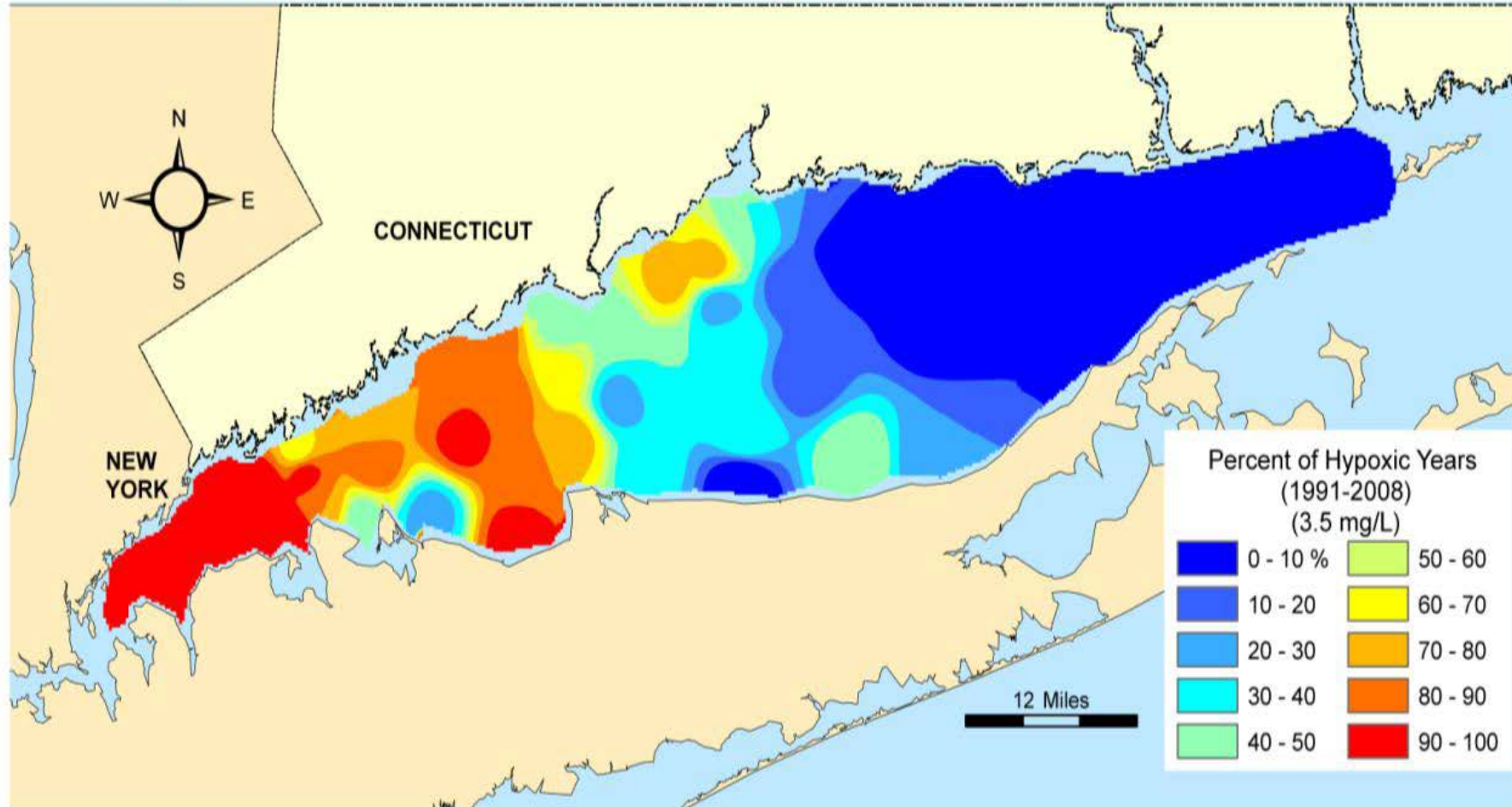
Discussion of results

Conclusions

# Background on nitrogen trading in Connecticut

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## THE FREQUENCY OF HYPOXIA IN LONG ISLAND SOUND BOTTOM WATERS

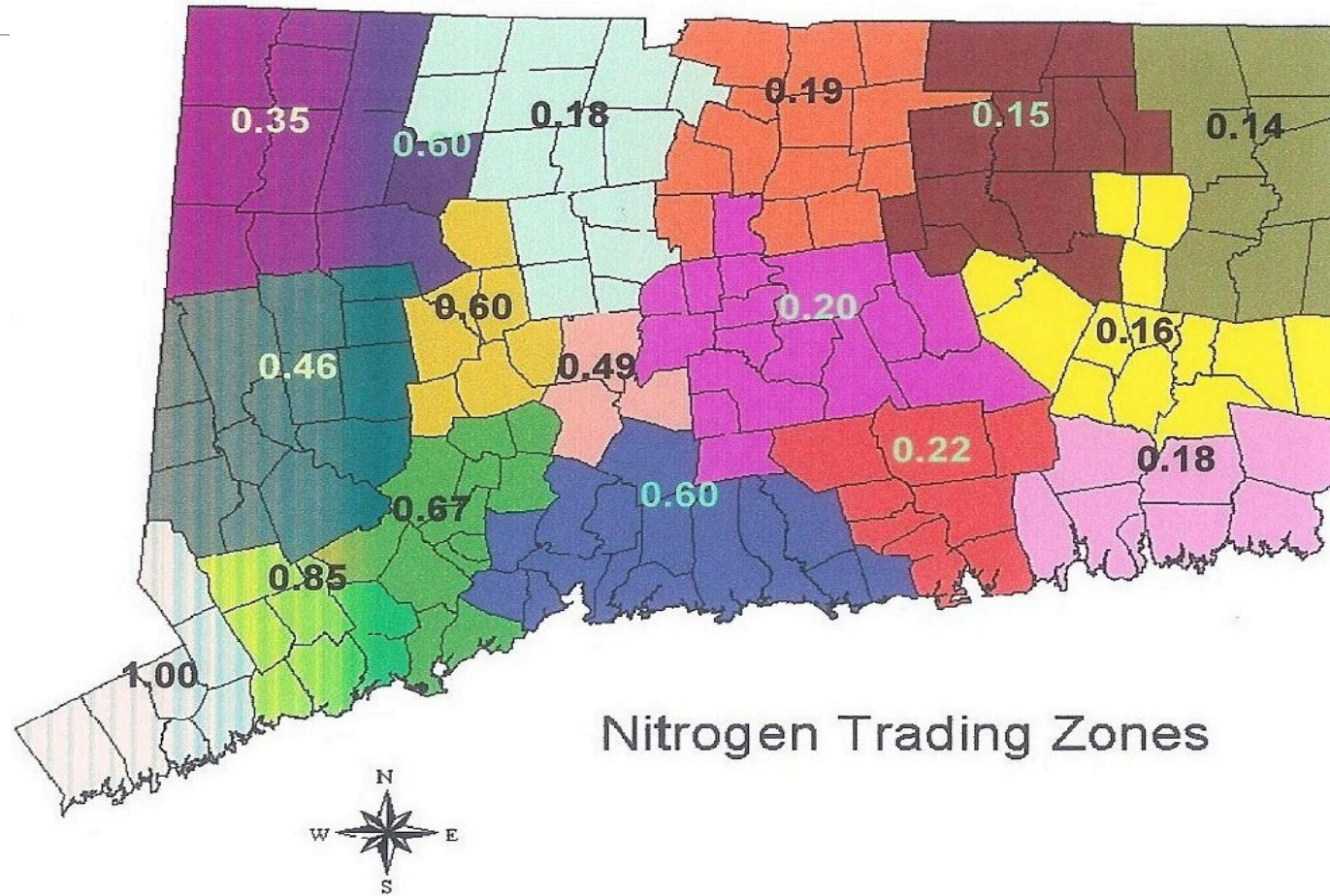


## Connecticut Nitrogen Trading Program and General Permit were initiated in 2002 as a result of the TMDL and WLA for Long Island Sound

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- The General Permit provided annual mass based nitrogen limits for 79 POTWs in Connecticut.
- The annual mass based limits decreased each year from 2002-2014 when the final TMDL limit was achieved.
- POTWs are allowed to trade (buy and sell) credits based on the annual nitrogen mass removal performance.
- Trades are based on geographic trading zones. Stratford is located in zone 4 where the equivalent credit ratio is 0.67.
- The 2014 final limit for Stratford is 356 pounds per day.
- Changes to the program starting this year will limit the value of nitrogen credits sold to the amount of credits purchased in future years. This is estimated to reduce the value of credits sold by up to 70% by 2018.

# Connecticut Nitrogen Trading Zones



Nitrogen Trading Zones

# Nitrogen removal process utilized at Stratford

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# Stratford WPCF

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- **Located on Long Island Sound**
- **Plant design average annual flow: 11.5 mgd**
- **Process: 4 stage BNR facility**
- **Supplemental Carbon- 70% glycerol**
- **Nitrogen Limit is an annual mass based limit in pounds of total nitrogen per day.**
  - **356 #/d in 2014 (Final WLA Limit) or 5.4 mg/l TN at average annual flow of 8 mgd**
- **Stratford utilizes 5 Hach Nitratax online nitrate analyzers to monitor the process.**
- **Control is through a feed forward process control with a feed back effluent NO<sub>x</sub> trim through a PID.**





# BNR Process Tanks

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# Stratford 2nd anoxic zones

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# Supplemental carbon storage and feed system

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# Tote transfer tank

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# Supplemental carbon feed pumps and bulk transfer pump

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# Online analyzers and locations

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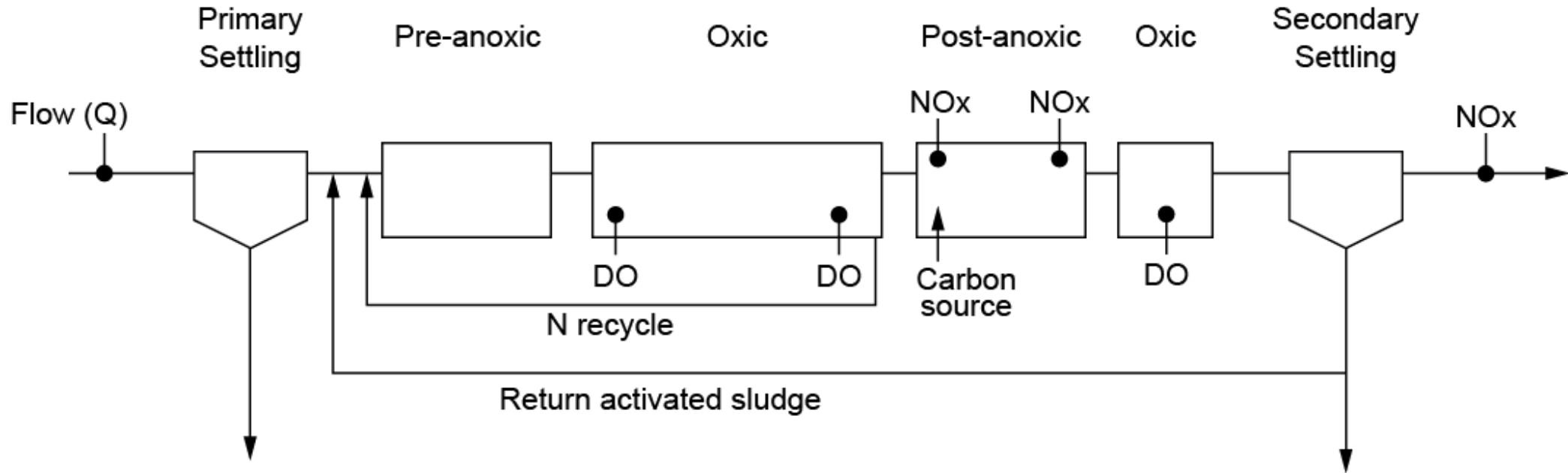
# Stratford online analyzers

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	Manufacturer	Model	Locations	Use of Data
<b>DO</b>	HACH	LDO	upstream and downstream ends of oxic zones, reaeration zone	Control of aeration rate
<b>NO<sub>x</sub></b>	HACH	NITRATAX	upstream and downstream ends of post-anoxic zone and at the final effluent sampling well	Real-time control of external carbon dosing rate



# Stratford BNR process with analyzer locations



# Nitrate analyzer locations in the 2<sup>nd</sup> anoxic zone

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# Final effluent sampler

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# Process control system case study

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# Why and what type of control to use

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Control is about adjusting dynamic systems in order to reach a specific goal.

The fundamental components of a control system are:

- Sensors
- Actuators
- Controllers

Feedforward control (use of a specific algorithm which is specific to the process)

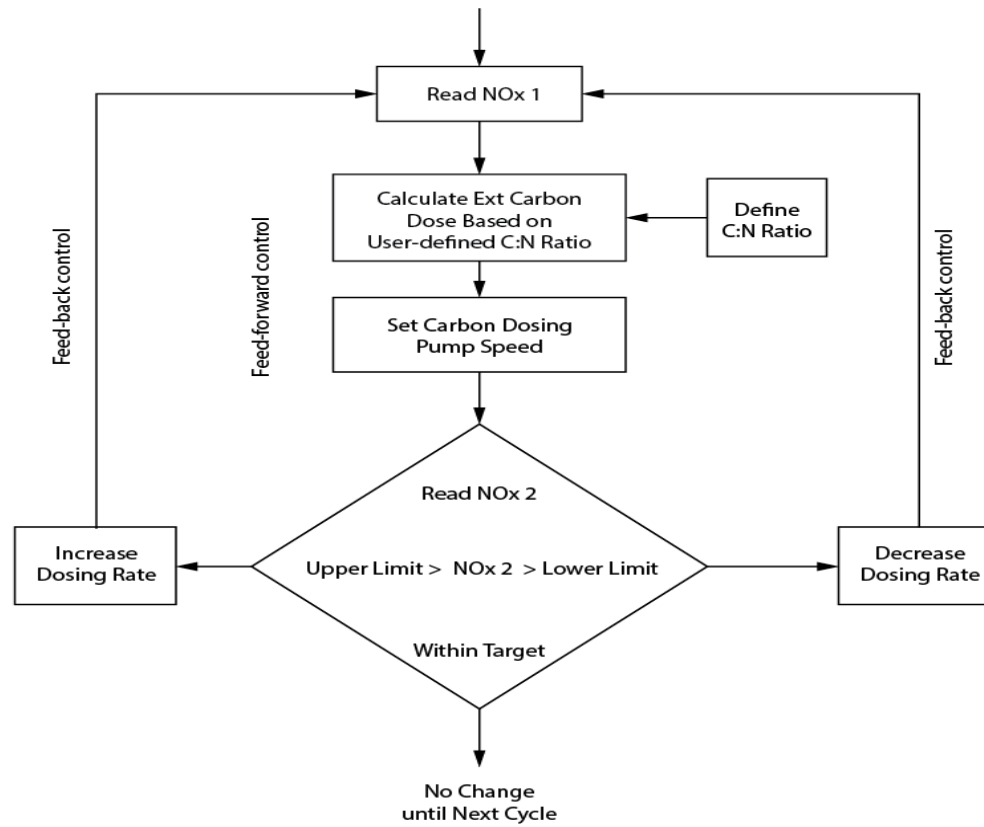
Feedback control

PID controllers

- Proportional term
- Integral term
- Derivative term

# Process control logic

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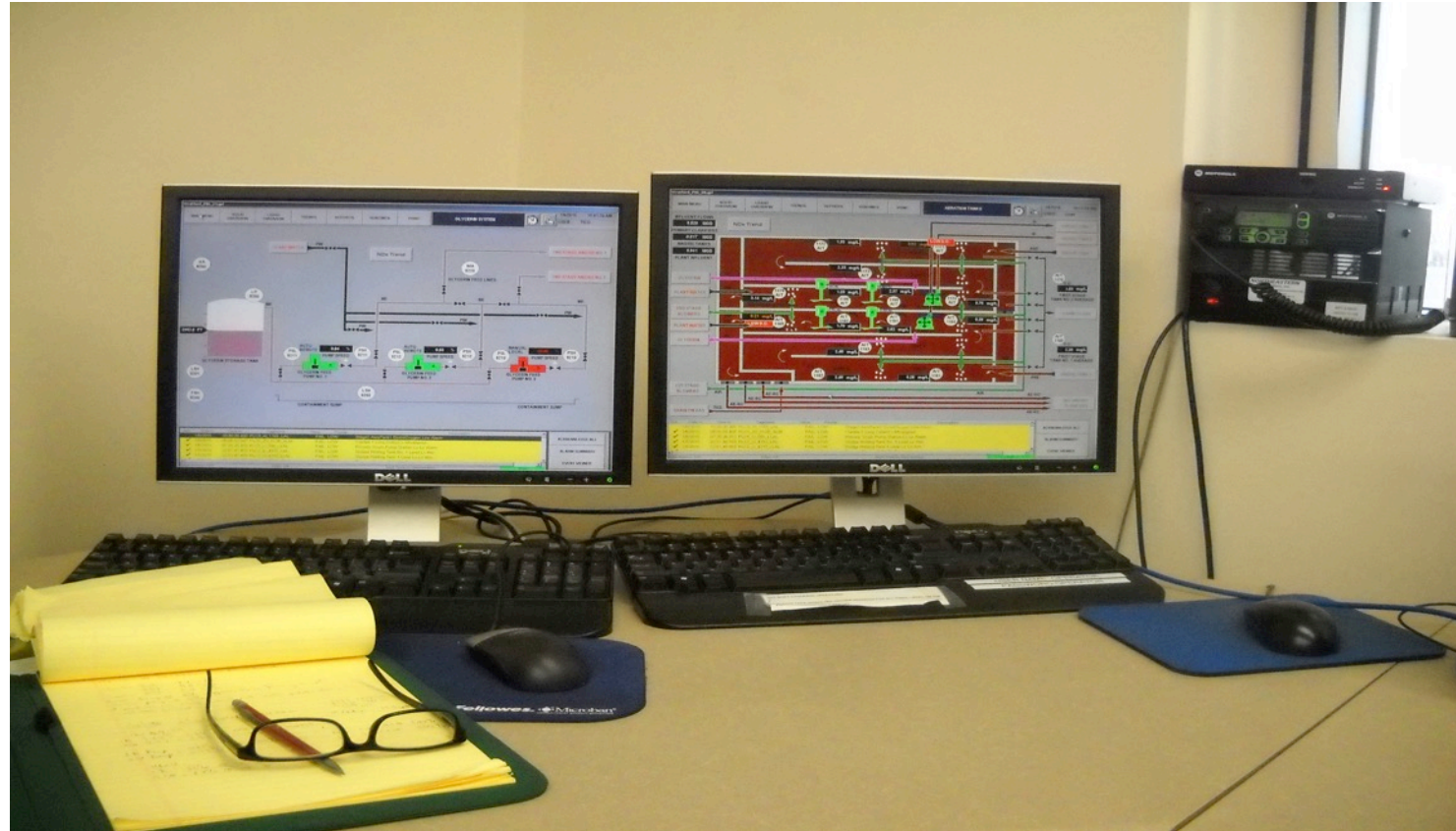
## Nitrate removal control algorithm

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- Calculates loading based on forward nitrate analyzers
- Creates a ratio using set point error
- Adds chemical based on flow and loading
- When the optimal feed forward ratio is achieved the final process trimming function is accomplished with a PI controller from final nitrate analyzer.

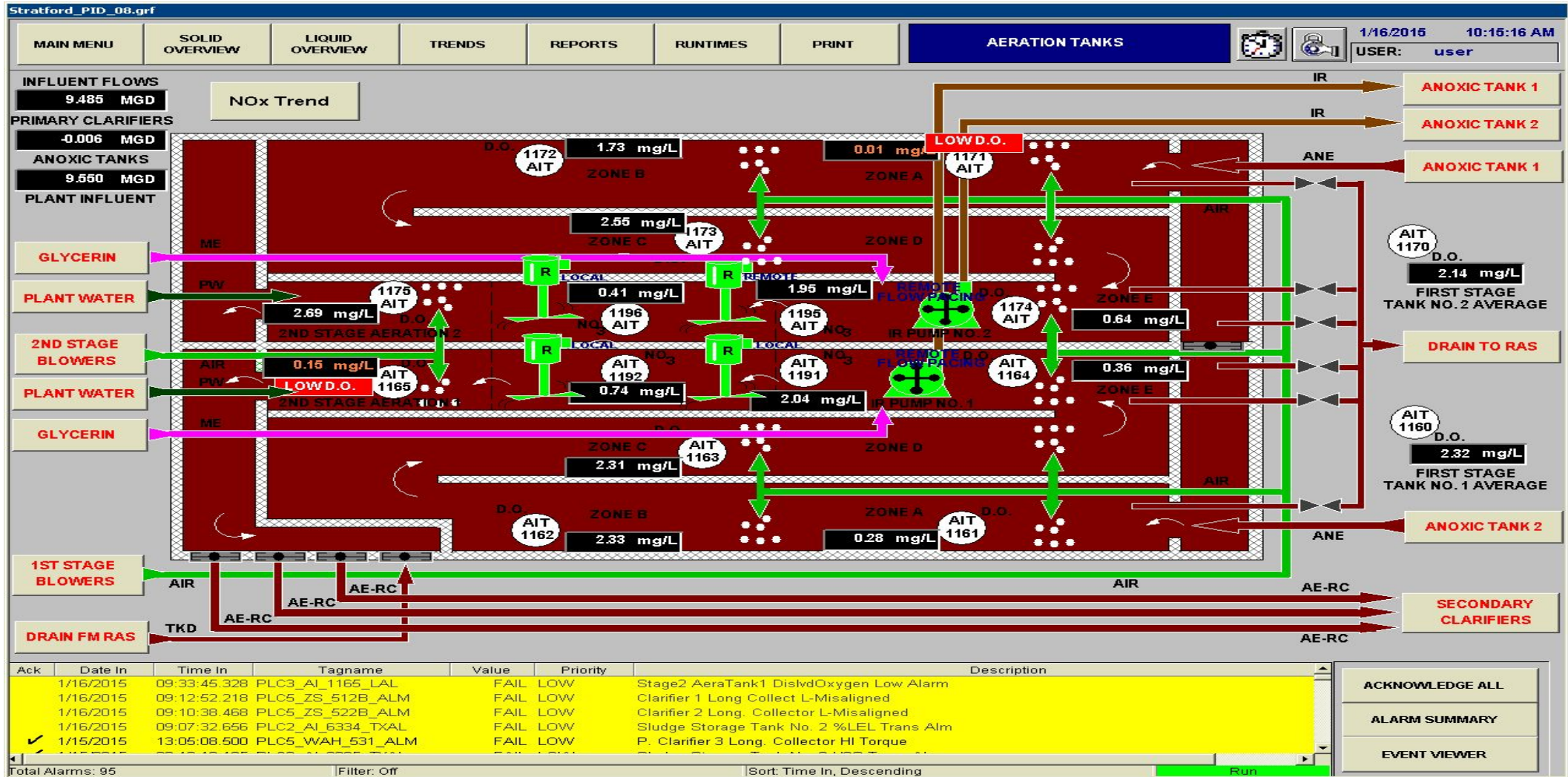
# SCADA control display

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# BNR Process SCADA screen



# Glycerol feed pump control

Stratford\_PID\_27.grf
Stratford\_P5211.grf

GLYCERIN FEED PUMP NO. 1

*The operator shall Start/Stop the pump by using the pushbuttons hereunder. There is no automatic control to Start and/or Stop the pumps.*

**START**

**STOP**

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Pump Status

**Command**

Start     Stop

**Status**

Local     Remote

Stopped     Running

Speed Control

*In manual, the operator shall adjust the pump speed manually by entering a speed setpoint hereunder (0-100%)*

    **AUTO**

Click below to change or adjust pump speed

-0.2 %    -0.2 %

SPEED FEEDBACK    SPEED SETPOINT

*In auto, the pump will change its speed to maintain the ratio of pump speed to wastewater flow at an adjustable ratio below. This ratio can be changed if*

0.10    **RATIO**     $\times$      $\left( \frac{\text{P. CLARIFIERS } 7.496 \text{ MGD} + \text{ANOXIC TANKS } 0.003 \text{ MGD}}{2} \right)$     0.4 %

AUTO SPEED CALCULATION 1

*The operator can adjust the ratio manually or compensate for loading by automatically by using the upstream nitrate analyzer if "Auto Ratio" is selected below.*

0.4 %    **AUTO RATIO**     $\times$     2.09 mg/L    0.8 %

AUTO SPEED CALCULATION 1    AIT-1191    AUTO SPEED CALCULATION 2

*if the operator select a nitrate analyzer to adjust the ratio. Furthermore, the speed of the pump can be trimmed by using downstream nitrate analyzer.*

    **AUTO RATIO**

SCADA will trim the speed calculated above by adding    or subtracting this % to meet the setpoint entered based on the downstream Analyzer

    **PID TRIM**

AUTO SPEED CALCULATION 3

*The operator can add a trim to the above calculation using the downstream nitrate analyzer if "Trim Bias" pushbutton is selected below.*

    **TRIM BIAS**

AUTO SPEED CALCULATION 2

0.0 %    **BIAS SET POINT**

**Exit**

PUMP STATUS

-25.00 %    **PUMP SPEED**

PSL 5213    MANUAL LOCAL    PSH 5213

GLYCERIN FEED PUMP NO. 3

**Speed** 0-100%

0.5 %    -0.2 %

Setpoint    Feedback

PID TRIM SP'S

0.5 %    **AUTO SPEED CALCULATION 3**

0.5 %    **AUTO SPEED CALCULATION 2**

CONTAINMENT SUMP

SYSTEM    1/16/2015 10:34:08 AM    USER: GCSADMIN

Ack	Date	Time	Tagname	Value	Priority	Description
	1/16/2015	10:31:49.640	PLC5_ZS_522A_ALM	FAIL	LOW	Clarifier 2 Long. Collector R-Misaligned
	1/16/2015	10:26:11.718	PLC5_FI_4030_LAL	FAIL	LOW	Thickened Primary Sludge Pumps Low Flow
	1/16/2015	09:33:45.328	PLC3_AI_1165_LAL	FAIL	LOW	Stage2 AeraTank1 DislvdOxygen Low Alarm
	1/16/2015	09:12:52.218	PLC5_ZS_512B_ALM	FAIL	LOW	Clarifier 1 Long Collect L-Misaligned
	1/16/2015	09:18:38.458	PLC5_ZS_522B_ALM	FAIL	LOW	Clarifier 2 Long. Collector L-Misaligned

**ACKNOWLEDGE ALL**

**ALARM SUMMARY**

# Effluent feedback trim PI

**GLYCERIN FEED PUMP NO. 1**

The operator shall Start/Stop the pump by using the pushbuttons hereunder. There is no automatic control to Start and/or Stop the pumps.

**START**  **STOP**

**Pump Status**

Command  Start  Stop

Status  Local  Remote  Stopped  Running

Speed 0-100%

0.5 %  -0.2 %

Setpoint  Feedback

**Post Analyzer Set Points**

FLOW P. CLARIFIERS ANOXIC TANKS  
7.568 MGD + 0.010 MGD

PRE NOx  
AIT-1191 2.09 mg/L + AIT-1195 1.93 mg/L = PRE NOx AVERAGE 2.01 mg/L

POST NOx  
AIT-1192 0.84 mg/L + AIT-1196 0.41 mg/L = POST NOx AVERAGE 0.63 mg/L

USE POST NOx AVG

USE AIT2602

1.55 mg/L AIT-2602 1.6 mg/L

SELECTED VALUE 2.2 mg/L UV EFFLUENT

NITRATE SETPOINT 35.0 % PCT AUTHORITY

Exit

2ND STAGE ANOXIC NO. 1

2ND STAGE ANOXIC NO. 2

ME

PW

MANUAL LOCAL -25.00 % PSH 5213

GLYCERIN FEED PUMP NO. 3

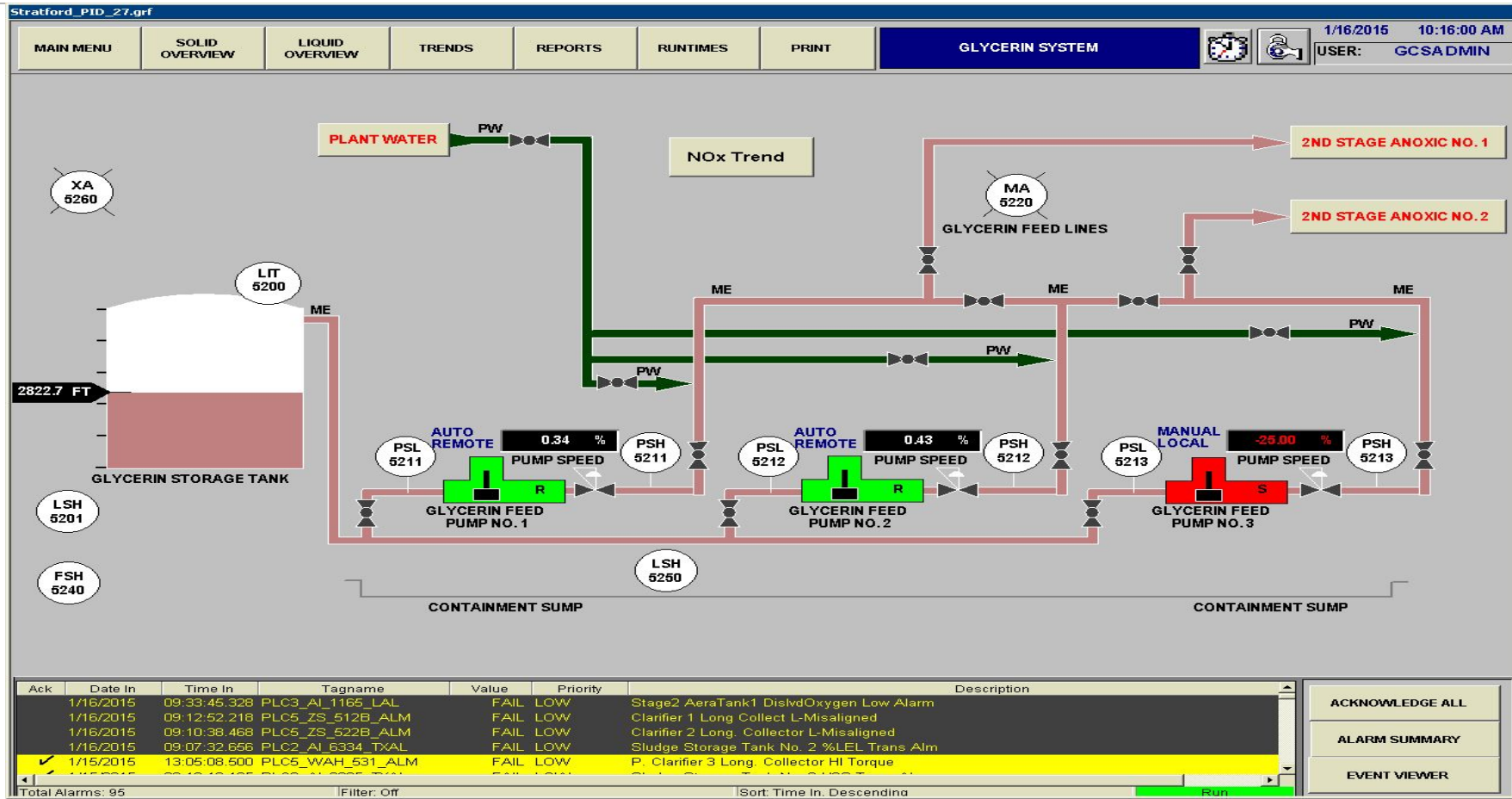
CONTAINMENT SUMP

ACK	DATE/TIME	DESCRIPTION	VALUE	UNIT	DESTINATION
	1/16/2015 10:31:49.540	PLC5_ZS_522A_ALM	FAIL	LOW	Clarifier 2 Long Collector R-Misaligned
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	1/16/2015 09:33:45.328	PLC3_AI_1165_LAL	FAIL	LOW	Stage2 AeraTank1 DissolvedOxygen Low Alarm
	1/16/2015 09:12:52.218	PLC5_ZS_512B_ALM	FAIL	LOW	Clarifier 1 Long Collect L-Misaligned
	1/16/2015 09:10:28.155	PLC5_ZS_522A_ALM	FAIL	LOW	Clarifier 2 Long Collector L-Misaligned

ACKNOWLEDGE ALL

ALARM SUMMARY

# Tank and pump information



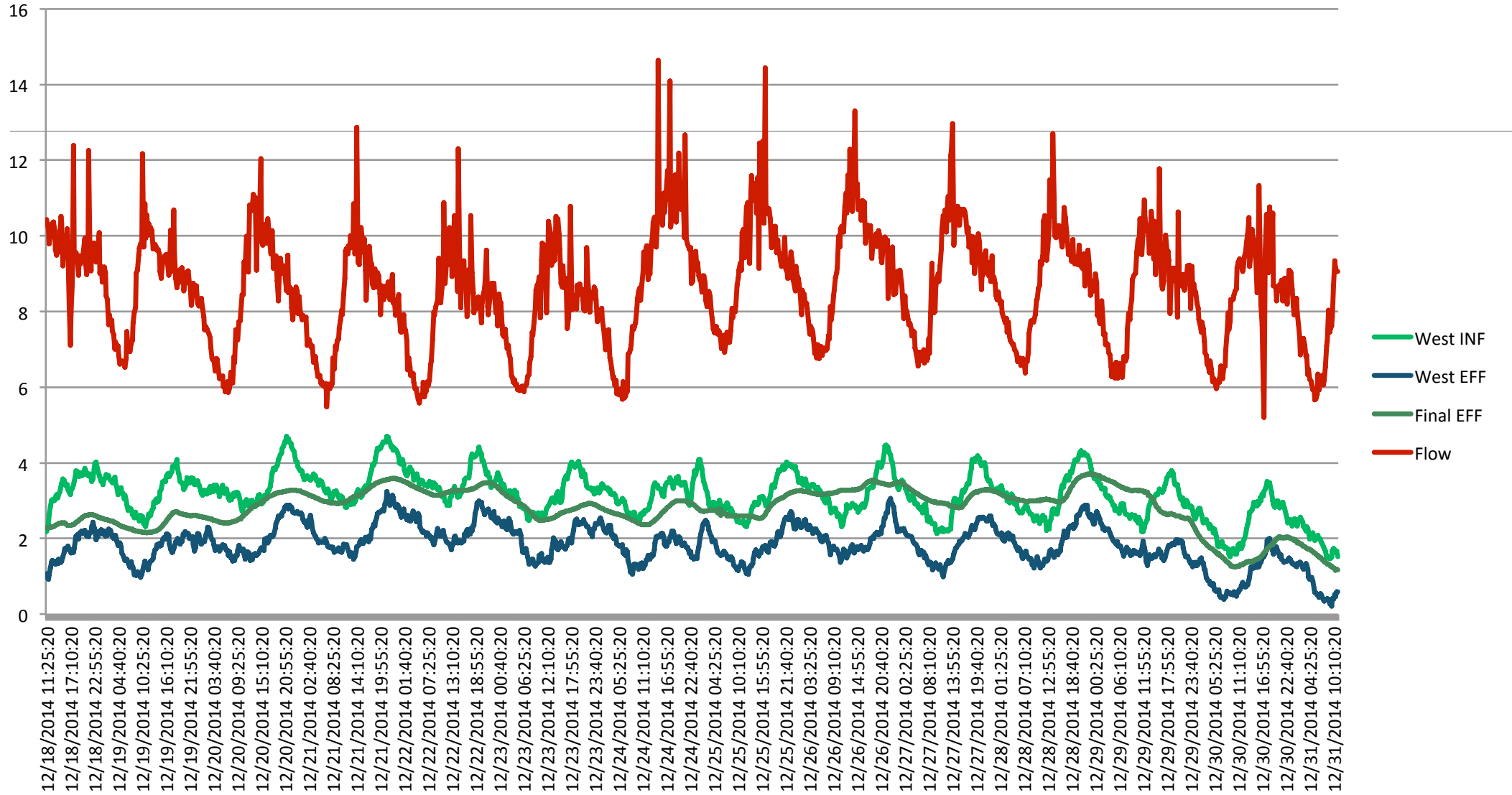
# Evaluation and Optimization Period

## June 2014-December 2014

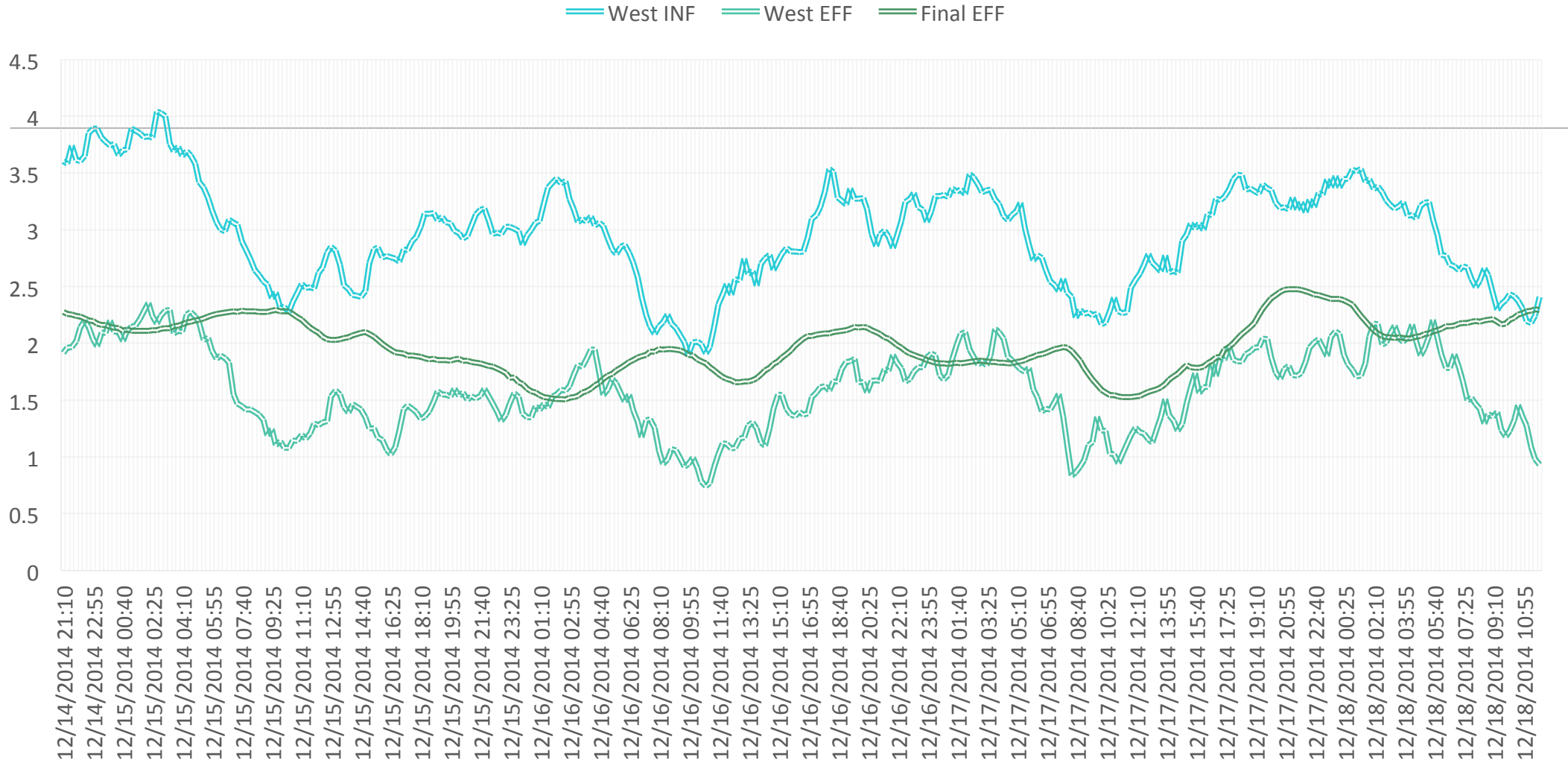
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- Supplemental Carbon Use was 10,800 gallons for all 2014
- Supplemental carbon use in 2011 was 150 gpd without control and <30 gpd in 2014 with process control.
- Previous Supplemental Carbon use in 2011 before optimization was 54,000 gallons and 43,000 gallons in 2012
- Average use reduction from the 2011 year to 2014 was 43,200 gallons per year or an 80% overall reduction in chemical use for an annual savings of \$75,600
- Average mass based total nitrogen discharged June - December 2014 was 206 pounds per day with optimized supplemental carbon use.
- Average mass based total nitrogen discharged June – December 2011 was 219 pounds per day with high supplemental carbon use and little control.
- 2014 mass permit = 356 pounds per day
- A net savings of 150 pounds per day or 31,500 pounds for the evaluation period below the permit limit was achieved.
- Average total nitrogen discharged was 3.96 mg/l for the evaluation period

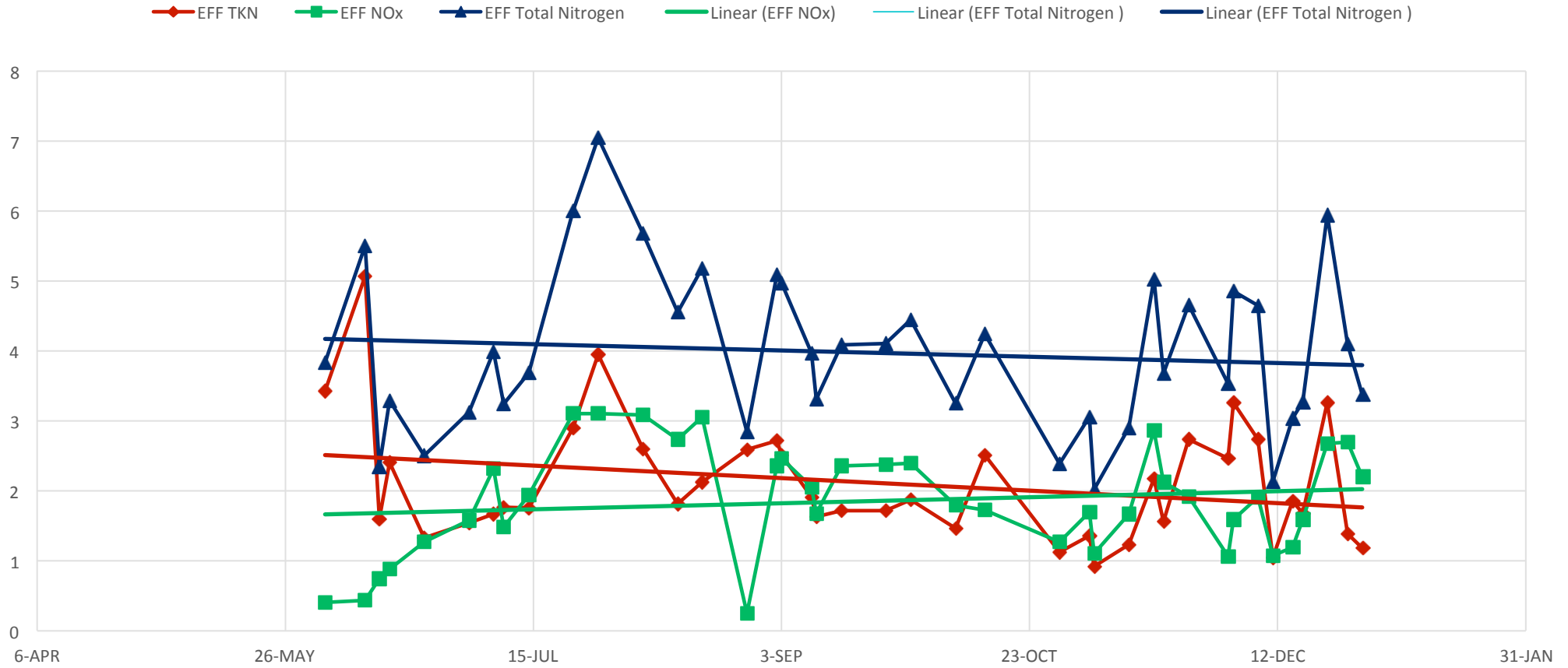
# West process train nitrogen data and plant flow: December 18-31, 2014



# West process train nitrogen data: December 14-18, 2014



# STRATFORD EFF NITROGEN JUNE-DEC 2014 DAILY COMPOSITE DATA





# GENERAL CONTROL SYSTEMS - SYSTEM HIGHLIGHTS

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- System can be self-contained or part of a plant SCADA system
- System can be monitored or adjusted remotely
- System has data logging and alarming
- Data can be extracted or hosted on a web page
- Sensors can be wired or wireless



## Lessons learned and things to consider

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- Assume the flow balance between process trains will **not** be equal and adjustment to either the influent gates or the process control will be necessary to balance the system performance.
- Adjustment of the internal recycle is necessary to maximize the overall process performance.
- Adjustment to the DO control system will be needed to reduce DO levels into the post anoxic zone but high enough to completely nitrify in the oxic zone.
- Understand that each wastewater treatment plant is unique with respect to flow and loading patterns and trends.
- Observe the process to check and calibrate your analyzers.
- Have a high flow wet weather plan to allow operation of the process without washout of nitrifiers

## Conclusions

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- Installation of the Nitratax online nitrate analyzers provided a better understanding of the daily fluctuations in nitrogen loading to the post anoxic zone which allowed for better nitrogen control.
- Utilization of an automatic flow proportioned feed forward control system utilizing online nitrate analyzers provided the optimal nitrogen removal and most efficient use of supplemental carbon.
- Overall supplemental carbon use was reduced by >75% from the 2011-2012 operating years without online control from 150 gpd down to <30 gpd.
- This resulted in an average annual chemical savings of >\$66,000/year over the 2011-2012 operating years without full process control.
- Nitrogen removal at Stratford was excellent with total nitrogen discharged at <4 mg/ for the June – December evaluation period.
- Optimization of supplemental carbon use through process control enhancements will help to offset the reduced value of nitrogen credits sold with the Connecticut nitrogen trading program changes taking effect in 2015.

Optimize the system but beware that under the most rigorously controlled conditions of temperature, pH, volume, loading, and other variables, the microorganisms will do as they damn well please!!

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**Questions?**

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