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Optimization of Supplemental Carbon Feed through Automation

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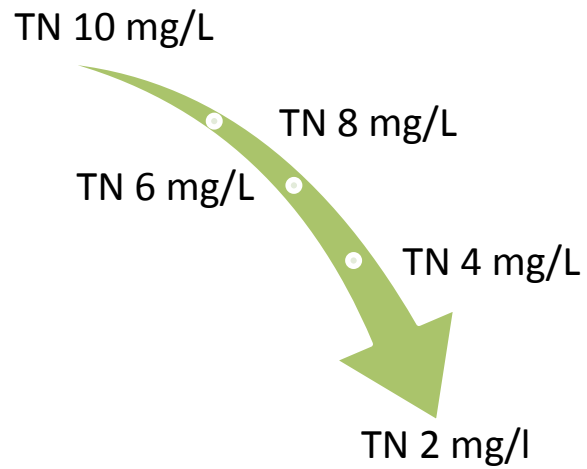
Presentation Overview

- Drivers for Automated Control System
- Performance Metrics
- Nitrack® Control System: General Review
- Case Study: Upper Blackstone WPAD
- Lessons Learned

Drivers for Automated Control Systems

- Consistent Performance/Maintain Compliance
  - Smooth out diurnal patterns
  - Trim peak loads
  - Total nitrogen compliance via denitrification
- Process Efficiency
  - Optimize chemical feed rate
  - Reduce chemical costs
  - Save money!!!
  - Sustainability



Drivers for Automated Control Systems

- Reduce Risk and Redundancy
  - Operator peace of mind
  - Alert operators to problem situation (i.e. power outage, pump problems etc.)
  - Eliminate repetitive tasks (i.e. manual pump speed adjustments)
- Data Collection/Process Diagnostics
  - Central hub for data collection
  - Use control system performance as a means of diagnosing process challenges

Performance Metrics

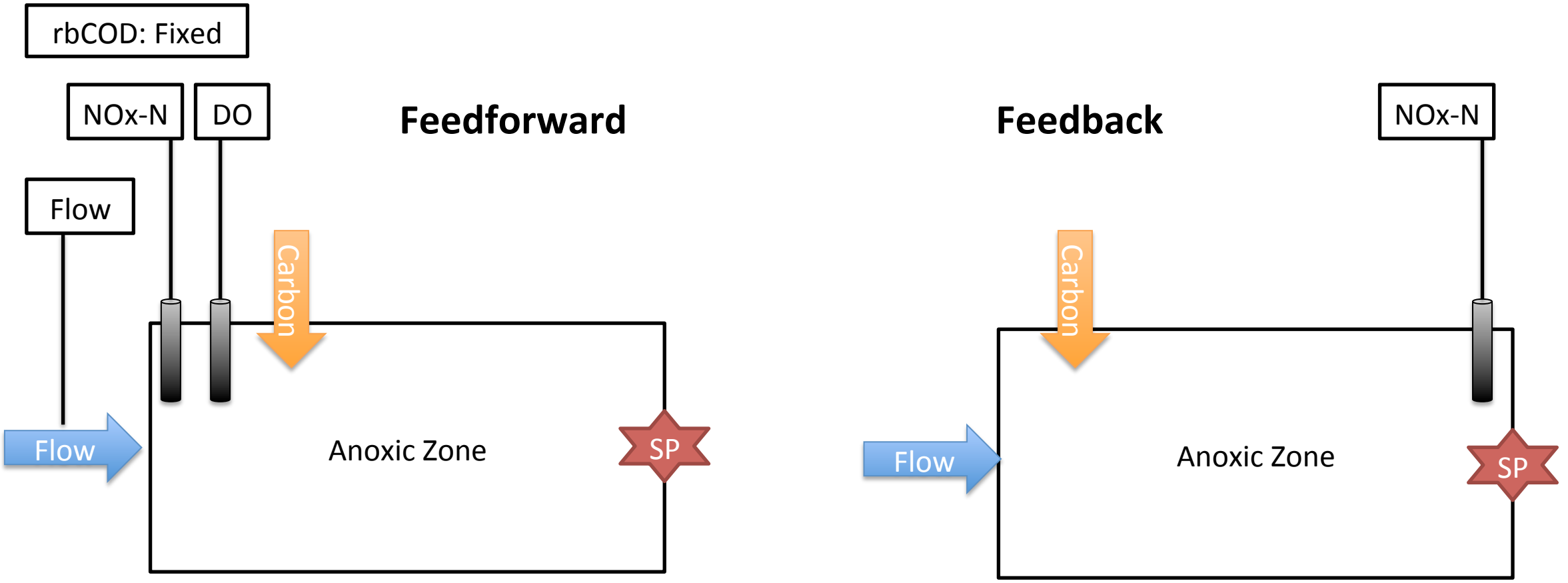
- Performance Consistency
  - Consistently meeting Permit?
  - Able to smooth out diurnal loading pattern?
- Process Efficiency
  - Lower chemical feed with automation?
  - Observed COD:N MicroC 2000™

Observed COD/N	Rating	Description
< 5.5	Excellent	Utilizing internal/primary effluent carbon as well
5.5 to 7	Good	Majority of carbon going to denitrification
7 to 10	Okay	Significant portion of carbon is unused or going to other process (i.e. aerobic respiration)
>10	Poor	Something is wrong! Check pumps, check analytical equipment, etc.

Nitrack® Control System:

- Single or Multi Basin Continuous flow-through applications, regardless of configuration;
- Allen-Bradley Programmable Logic Controller (PLC) and Human Machine Interface (HMI);
- Designed to accept up to 32 input signals tagged to specific parameters via analogue (wired), WiSi (transmitters included), or EtherNet/IP options;
- 4-20 mA pump output signal
- Alarm auto-dialer for critical alarms;
- Uninterruptible power source (UPS) with an estimated 25 minutes of battery back-up power;
- Firewall-protected **remote internet access**;

Nitrack® Control System: Auto Control Modes



Case Study: Upper Blackstone WPAD

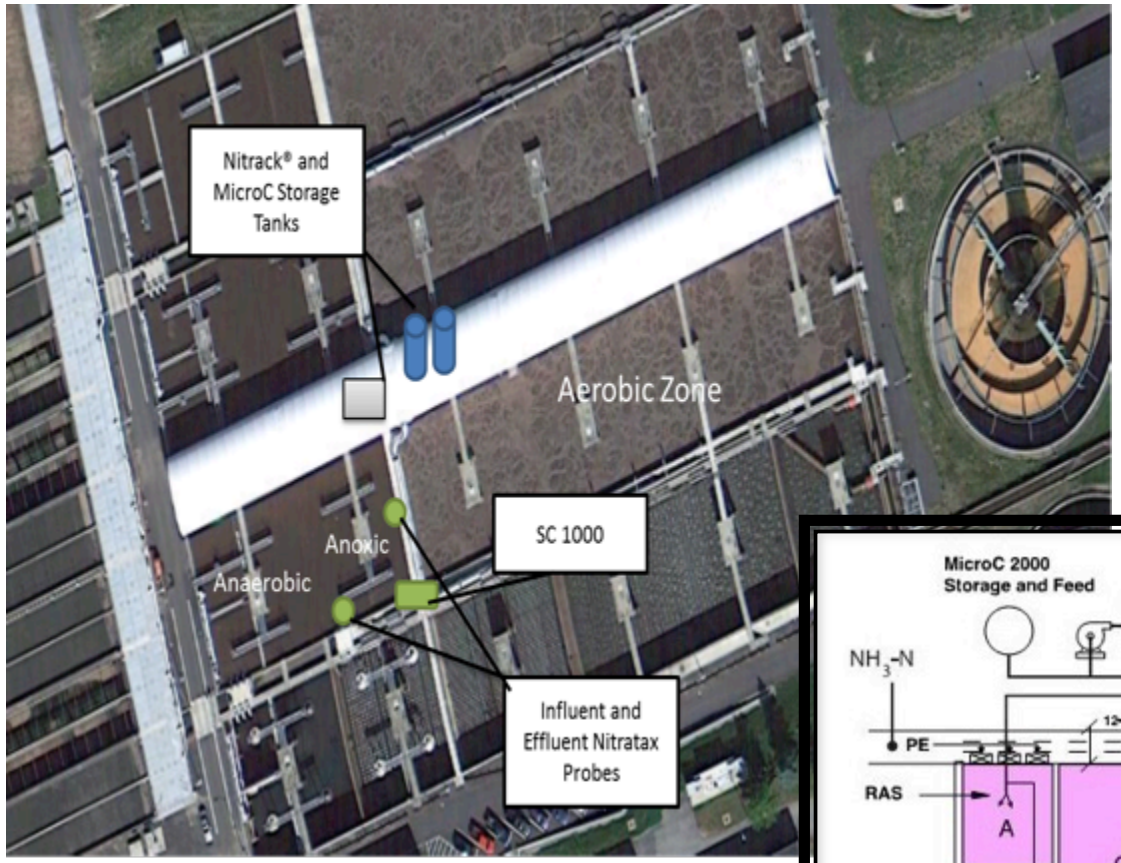
UBWPAD WWTF

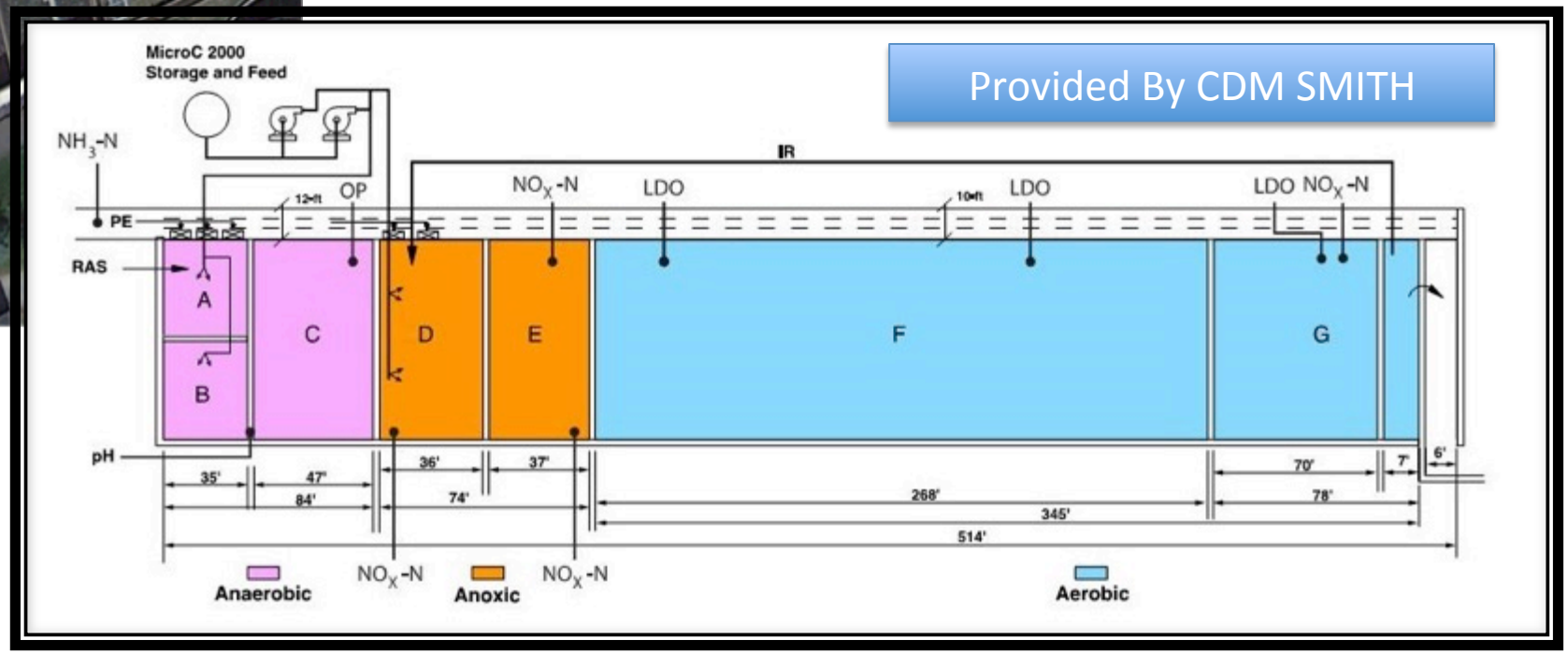
- 45 MGD Design Average flow
- A^2/O process with 4 biological treatment trains (AT1 – AT4)
- Interim permit limits for TN and TP of 6 mg/L and 0.45 mg/L respectively
- Pilot study began at quarter scale and progressed to full scale

Pilot Study Objectives

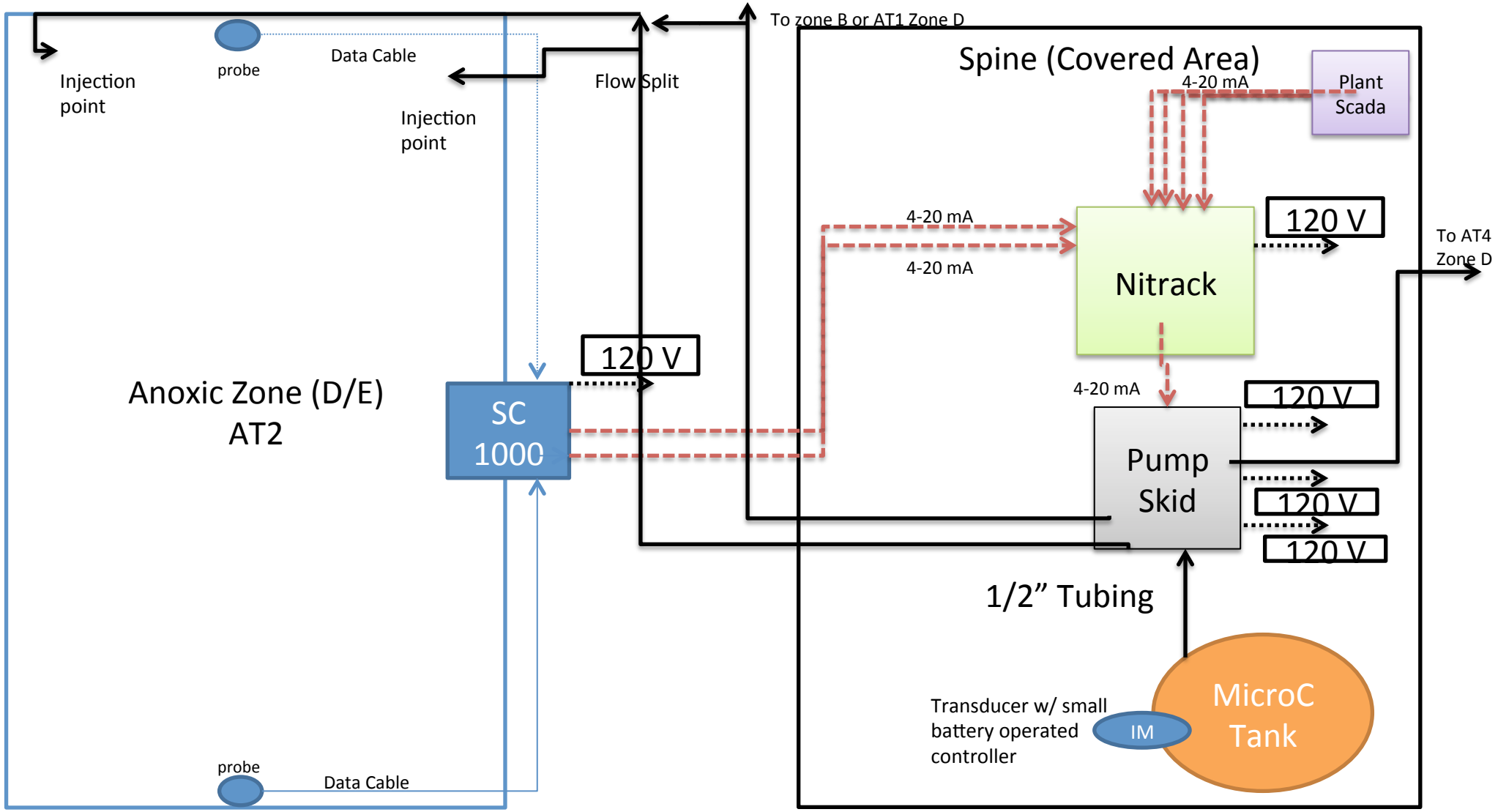
- Drive the denitrification process to achieve an average effluent NOx-N under 3.5 mg/L and total nitrogen (TN) under 5 mg/L
- Optimize carbon feed using Nitrack® control system to achieve a carbon to nitrogen ratio (COD:N) less than or equal to the theoretical minimum of 5.5 (lbCOD:lbNremoved)

UBWPAD A^2/O Treatment Train and Sensor Placement





UBWPAD Supplemental Carbon Pilot Schematic




Nitrack


1
2

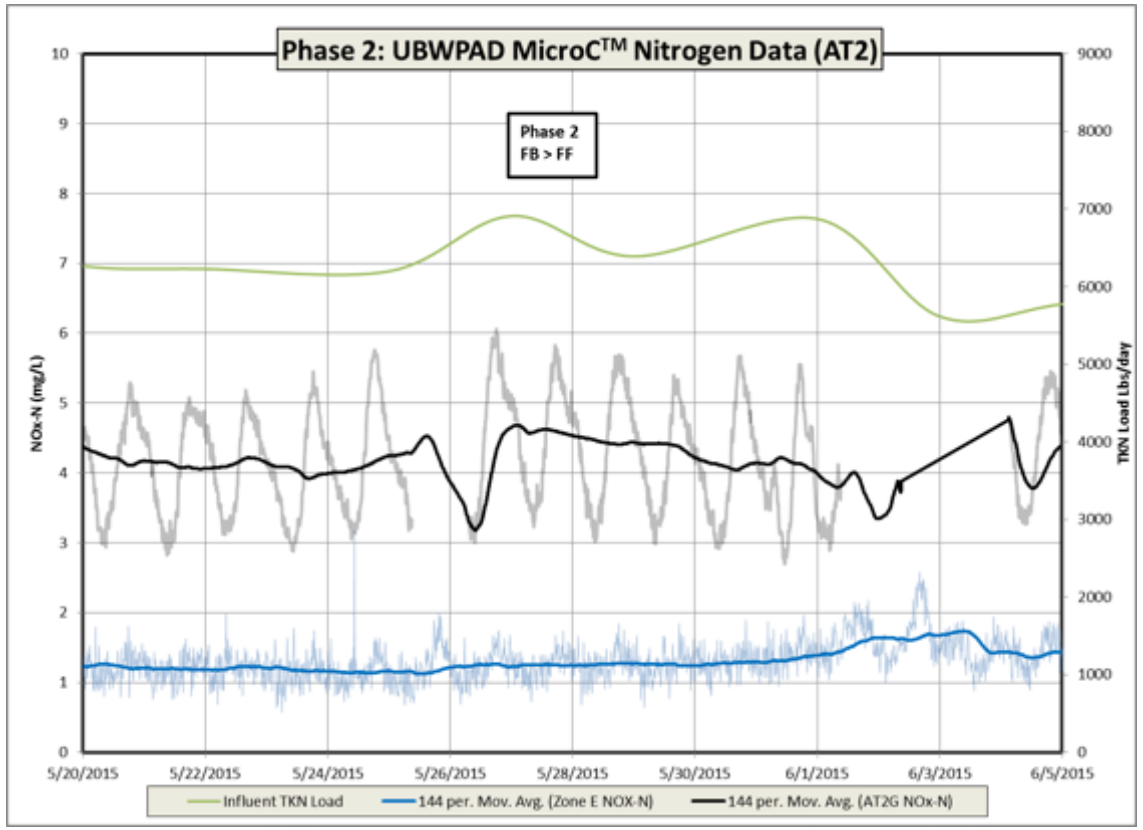
Phase 2: Feedback > Feedforward

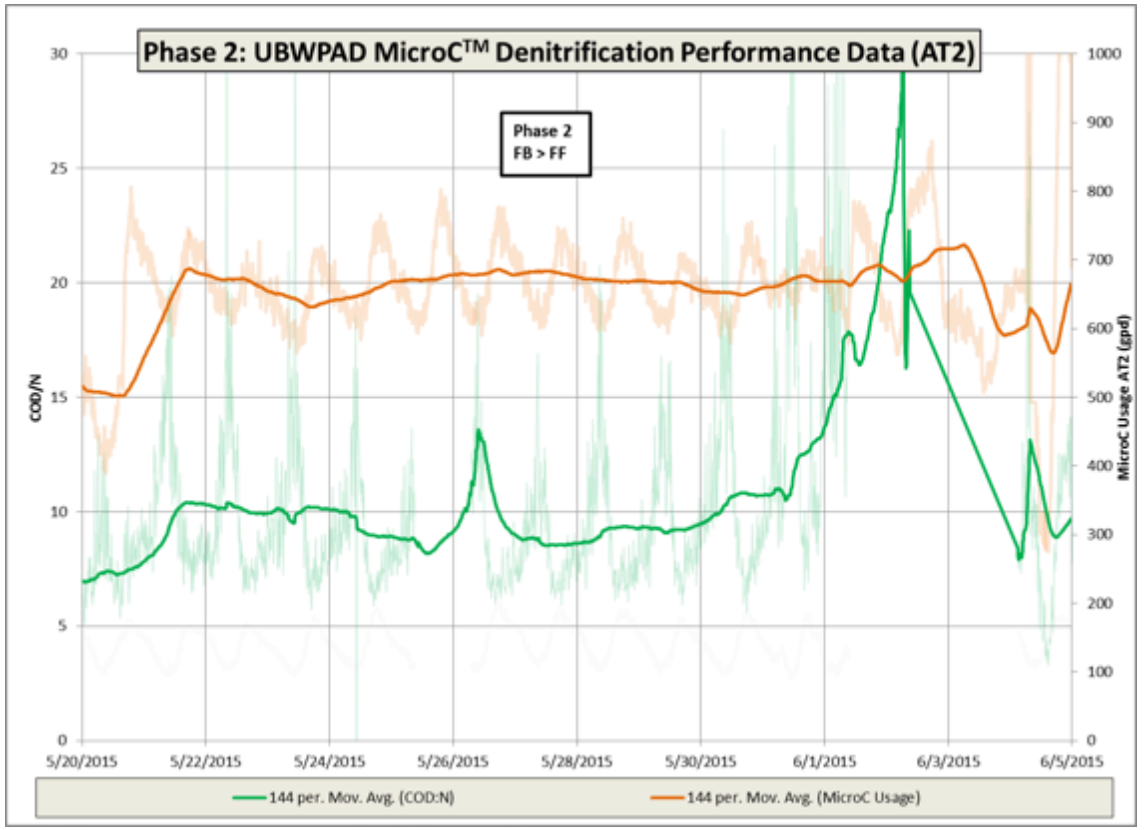
Reasoning for Feedback Dominated Control

- Short HRT (Under 30 minutes)
- Influent Probe under influent of Carbon Feed
- Influent COD a fixed input

Phase 2 Performance

- Due to low effluent set-point of 0.7 feedback dominated control overfed carbon leading to high COD:N
- Feedforward portion not responding quickly to diurnal pattern





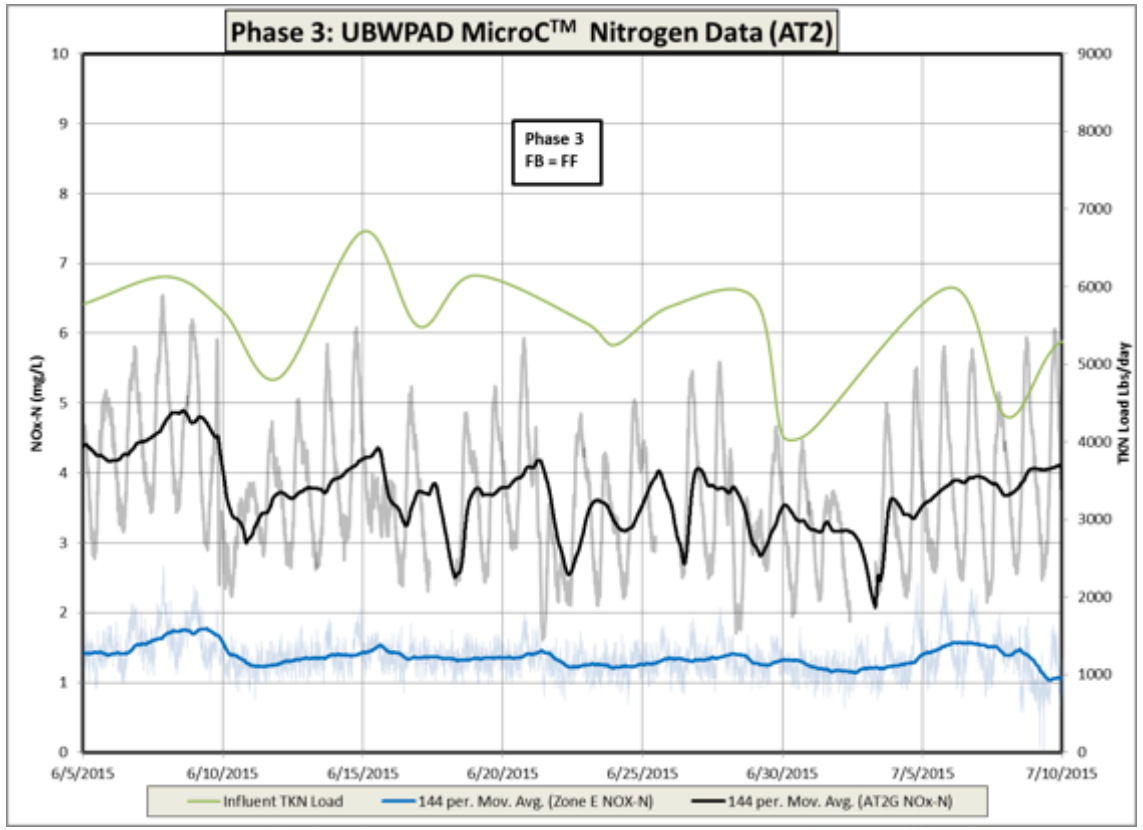
Phase 3: Feedback = Feedforward

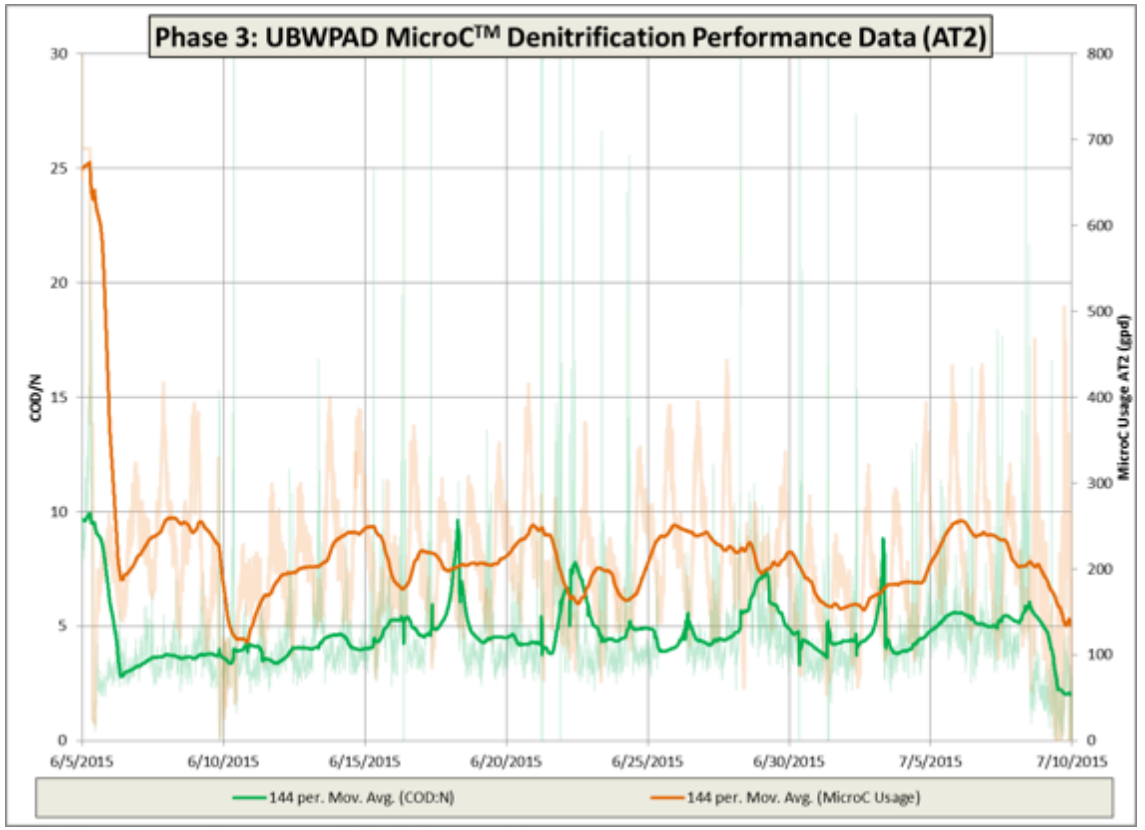
Reasoning for Change in Control Mode

- Desire to decrease COD:N
- Desire to lower effluent NOx-N by accounting for influent diurnal load pattern
- Ability to increase fixed COD Factor

Phase 3 Performance

- Immediate impact: Lower COD/N and lower feed rate
- More varied carbon feed rate
- Still observing COD/N spikes
- Lower effluent nitrate (note: lower influent load)





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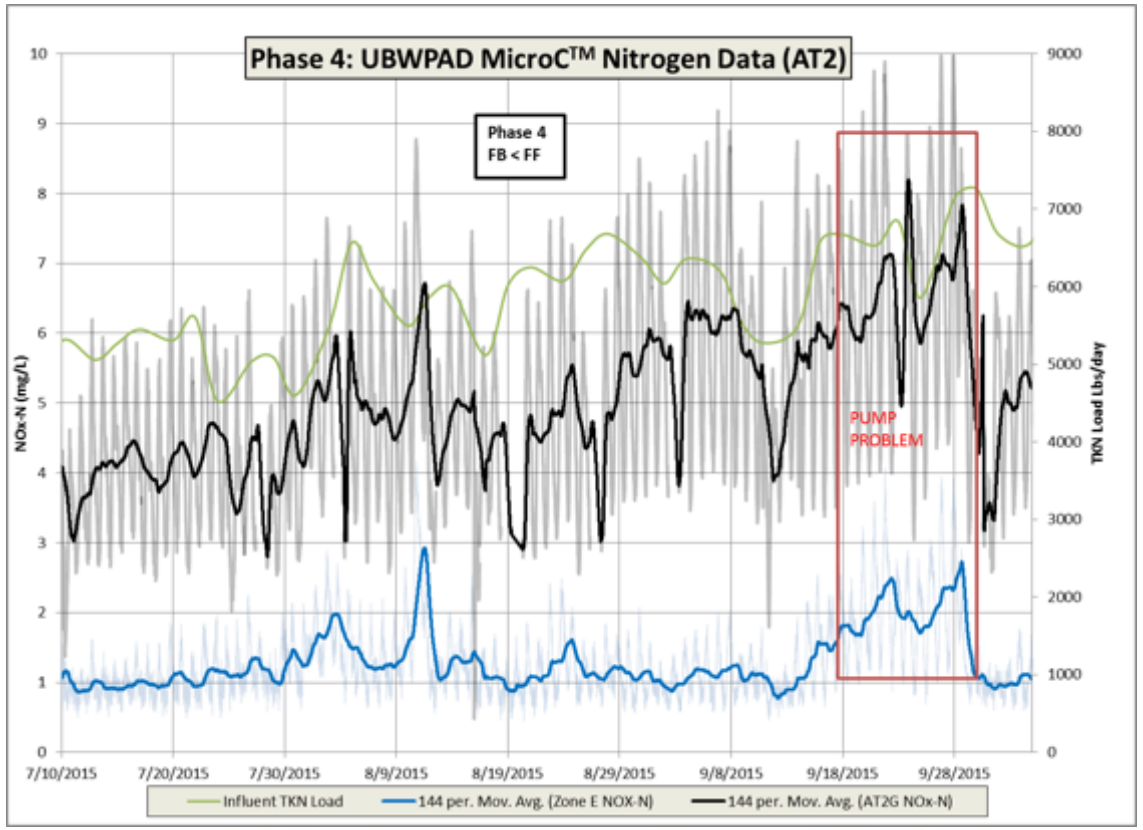
Phase 4: Feedforward > Feedback

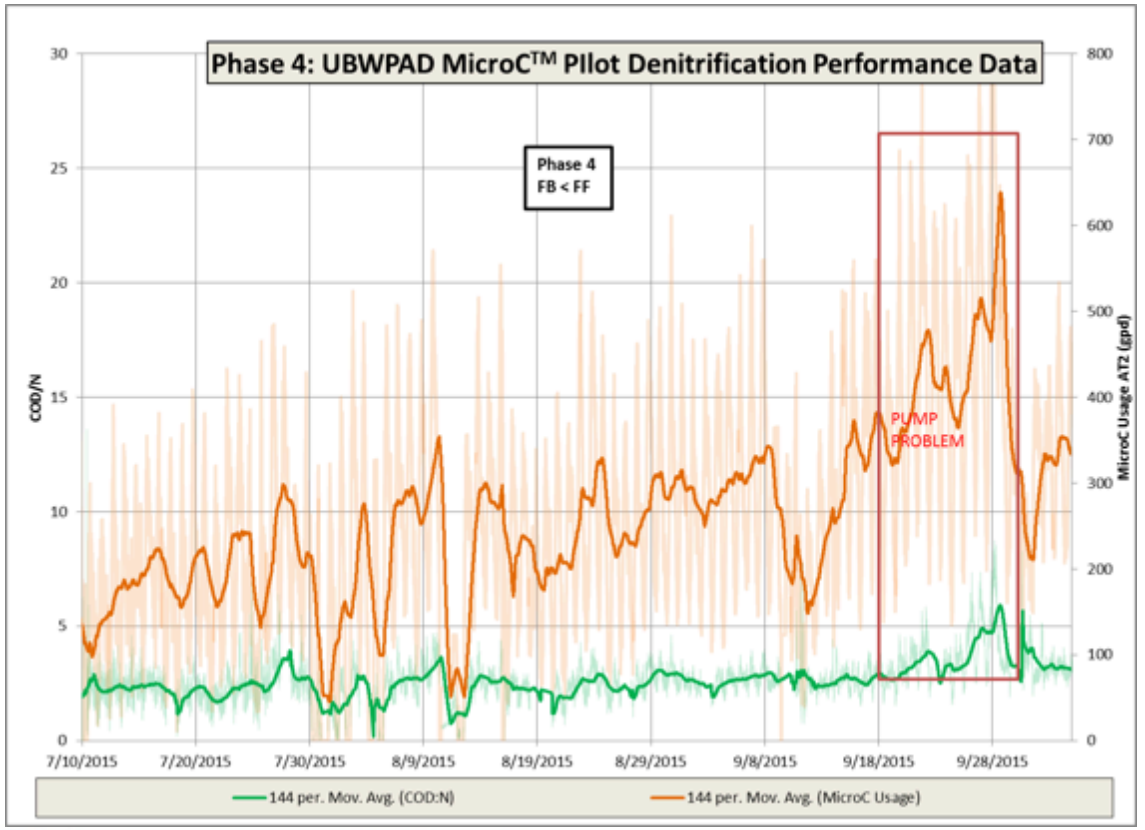
Reasoning for Change in Control Mode

- Focus on process efficiency (COD/N)
- Maintain performance
- Influent loading and diurnal variation increased significantly throughout this period

Phase 4 Performance

- Achieved a lowest COD/N; under 5.5 nearly the entire phase
- To some degree compromised performance however still maintained reasonable effluent Nitrate
- Not able to fully accounting for diurnal loading pattern
- Brought 2 additional trains online during this period, which created some pumping problems.





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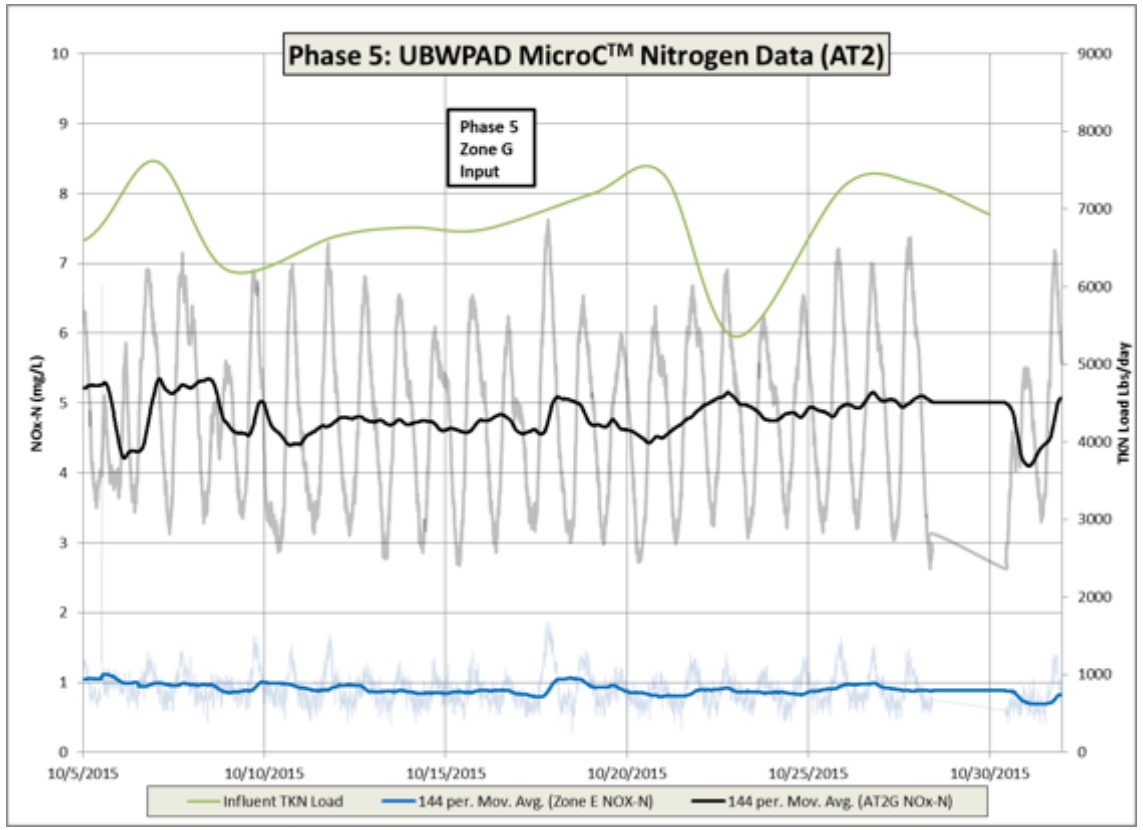
Phase 5: FF > FB Zone G Input

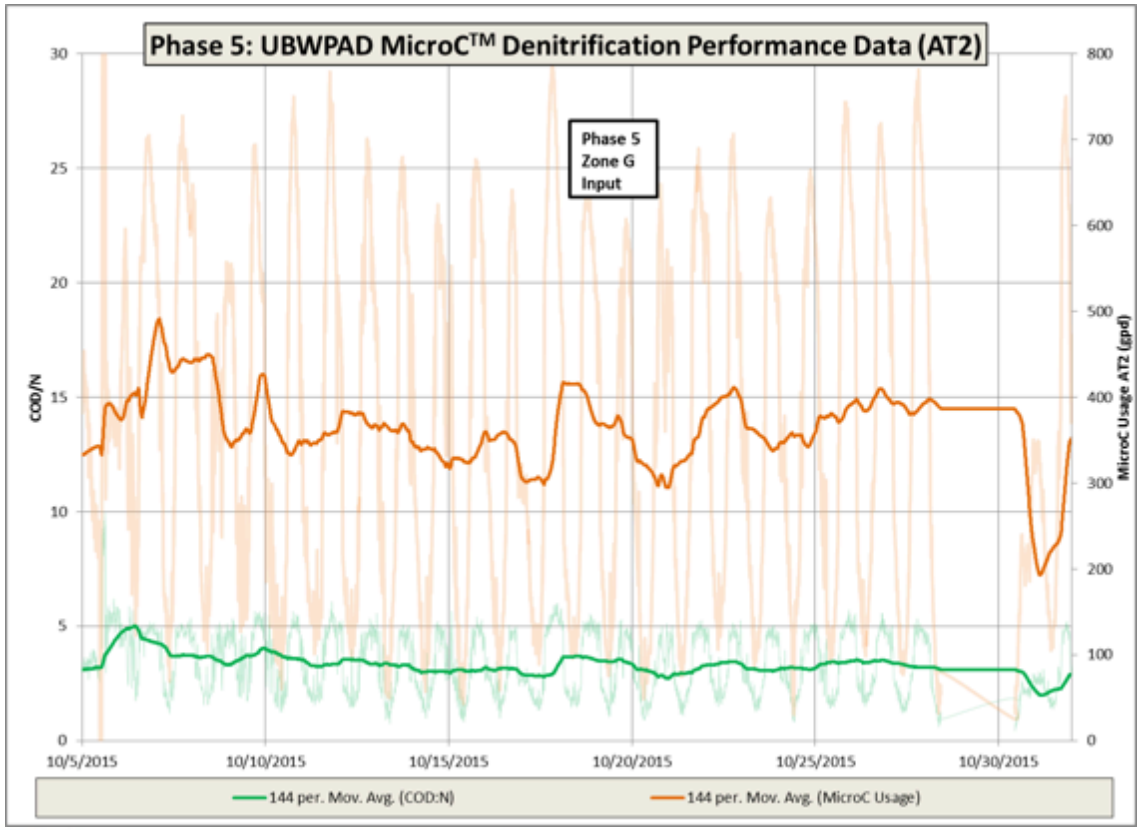
Reasoning for Change in Sensor Input

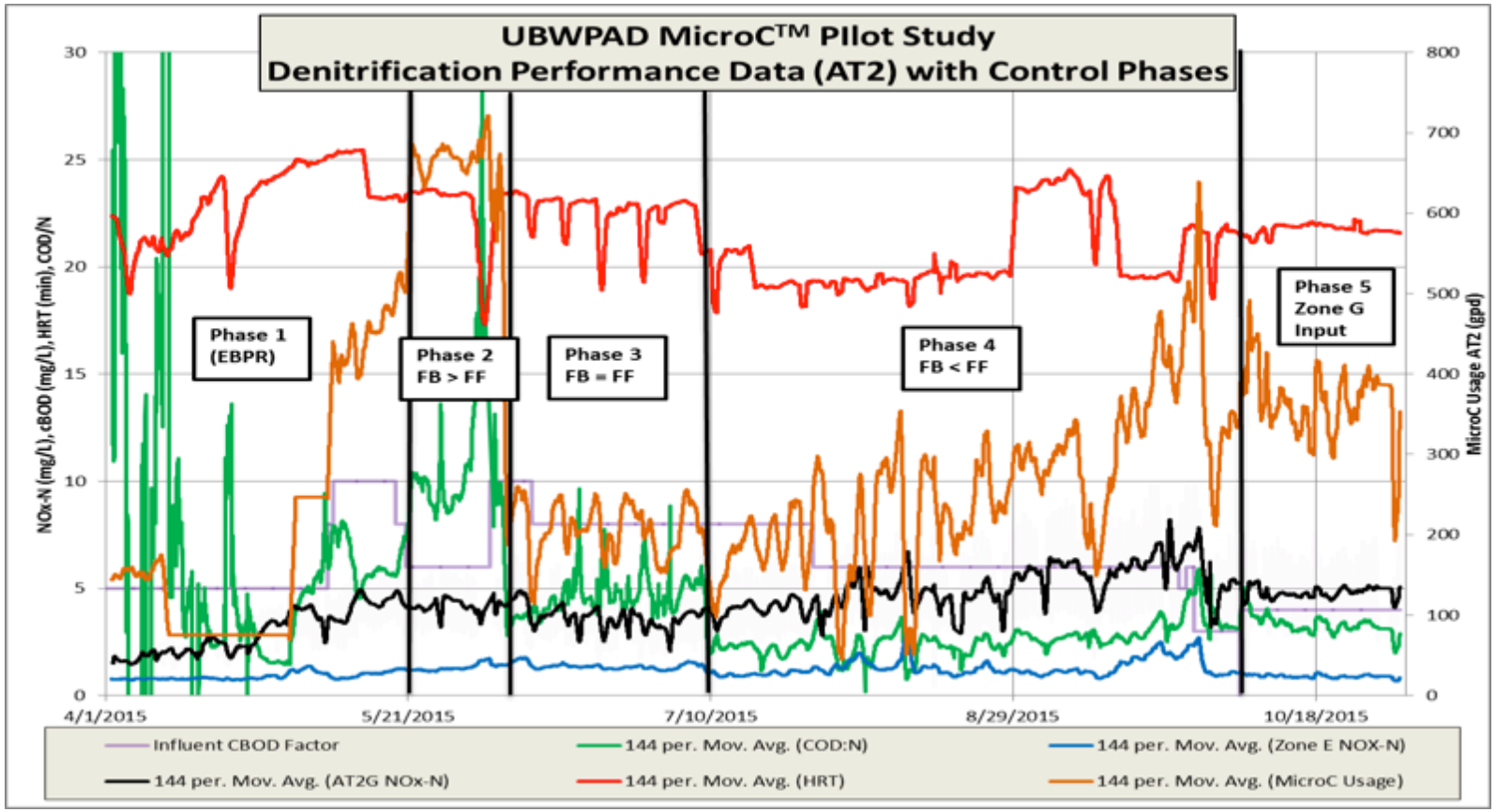
- Influent Nitrate signal changed to Zone G probe
- Control algorithm changed to account for IR nitrate load only
- More accurate Feedforward control

Phase 5 Performance

- Most consistent performance
- Significant variation in carbon feed
- Slightly higher COD/N but consistently under 5.5
- Preferred operating mode for future work



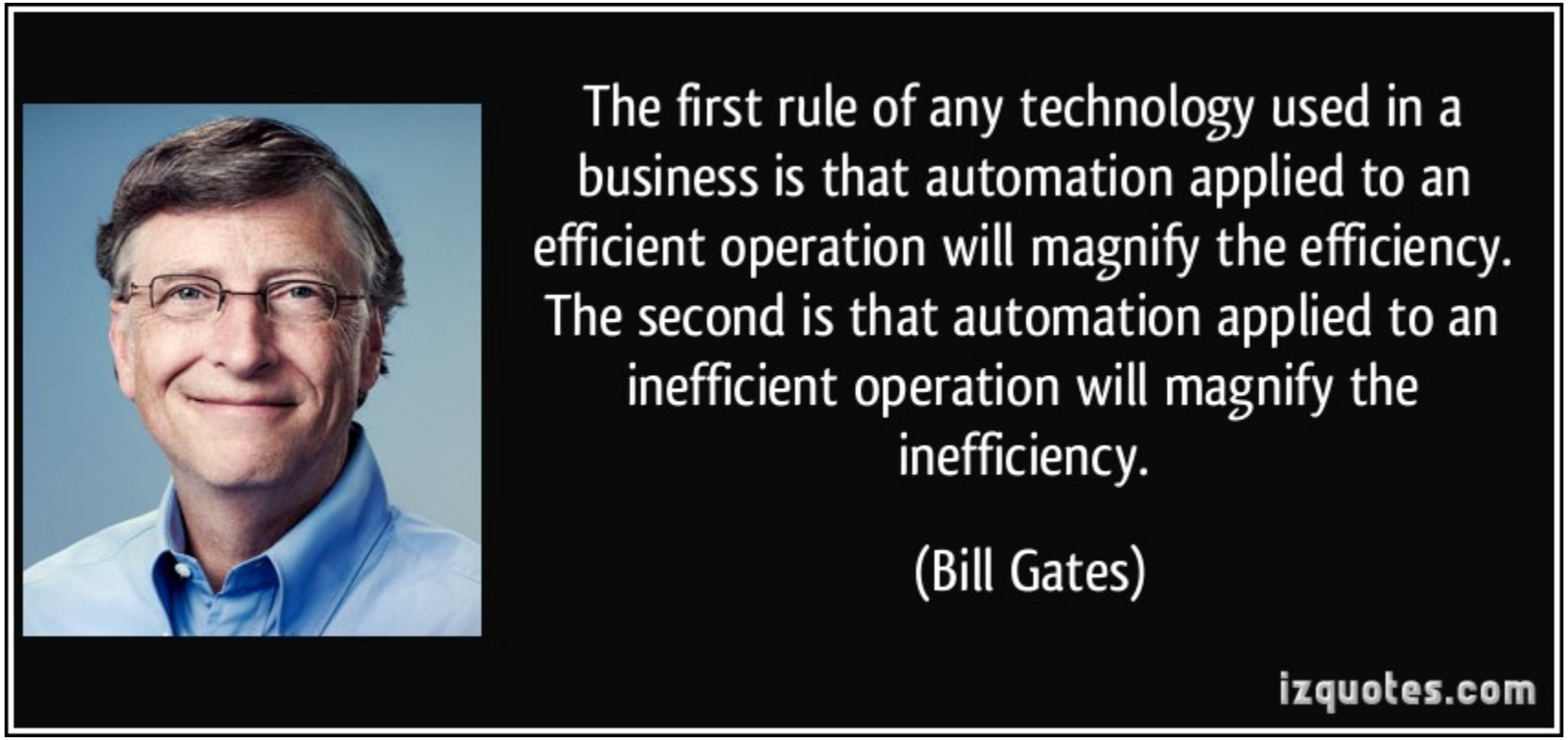




Data Summary

Control Phase Data Detail						
Phase	Time Frame	Zone G NOX-N	Zone E NOX-N	Observed COD/N	MicroC Usage	DO
	Dates	mg/L	mg/L	n/a	gpd	mg/L
2	5/20 - 6/5	4.2	1.3	10.4	665	0.5
3	6/5 - 7/8	3.7	1.4	4.6	207	0.3
4	7/8 - 10/5	5.1	1.3	2.7	260	0.3
5	10/5 - 10/31	4.8	0.9	4.2	365	0.3

#1 Rule of Automation



Lessons Learned: Carbon Feed Automation

- Process is already functioning properly in general, no major operational concerns
  - Optimize-Automate-Optimize
- NO_X-N probe placement is critical
  - Influent probe should be upstream of carbon source injection point
    - Upstream of any denitrification is best (will depend based on configuration)
  - Effluent probe should be in anoxic zone (not re-aeration or aerobic)
- Take your time when scaling inputs and outputs
- Set reasonable effluent set-point
- Balance feedforward and feedback control modes to managed process performance and efficiency.

Acknowledgements

- Upper Blackstone Water Pollution Abatement District: Karla Sangrey, Mark Johnson, Randy Komssi, Joe Nowak, Mike Foisy, Ken Pousland
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QUESTIONS?