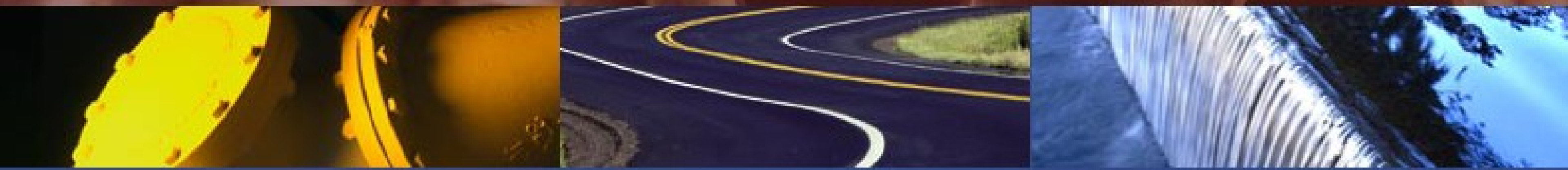

Aeration System Automation: Control Strategies to Maximize Energy Savings at Low Capital Cost

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Goals

1. Introduce aeration controls of various levels of complexity and instrumentation requirements.

   Case Studies & Examples:

   1. Most Open Valve Logic
   2. Ammonia-Controls
   3. Dual Loop Cascading Controls

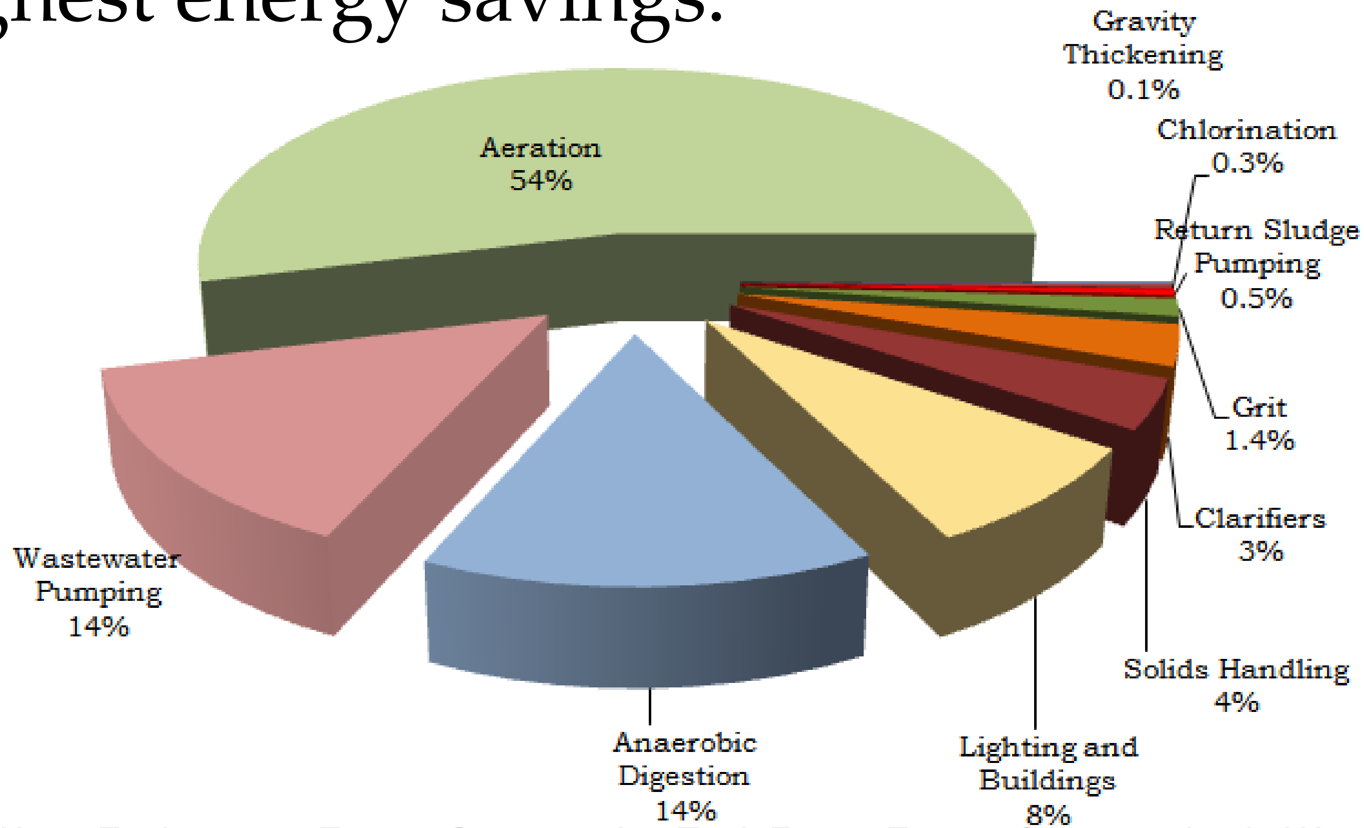
2. Analyze which control schemes optimize
   - –Energy
   - –Process

Agenda

- Project Background
  - Why look at controls?
- Review Control Schemes
- Wheaton Sanitary District Case Study
  - Methodology
  - Results
  - Conclusions
- Take Home Message

Typical Wastewater Treatment Plants use most energy in aeration.

Targeting the aeration system can yield the highest energy savings.



Source: Water Environment Energy Conservation Task Force: Energy Conservation in Wastewater Treatment

Experience with Similar Projects helps Identify Opportunities for Savings

- Benchmarks of energy consumption at over 25 aeration systems in the Chicagoland area
- Aeration improvements projects including:
  - Controls only
  - Blower Replacement
  - Diffuser Replacement
  - Comprehensive

Past Experience Highlights the Importance of Controls

- Significant savings available through controls.

- Typically blower replacement alone can produce ~20-35% savings for two reasons:
  - Higher efficiency at design speeds.
  - Maintains high efficiency at lower speeds.

To achieve uncaptured savings, control the blower to run at lower speeds!

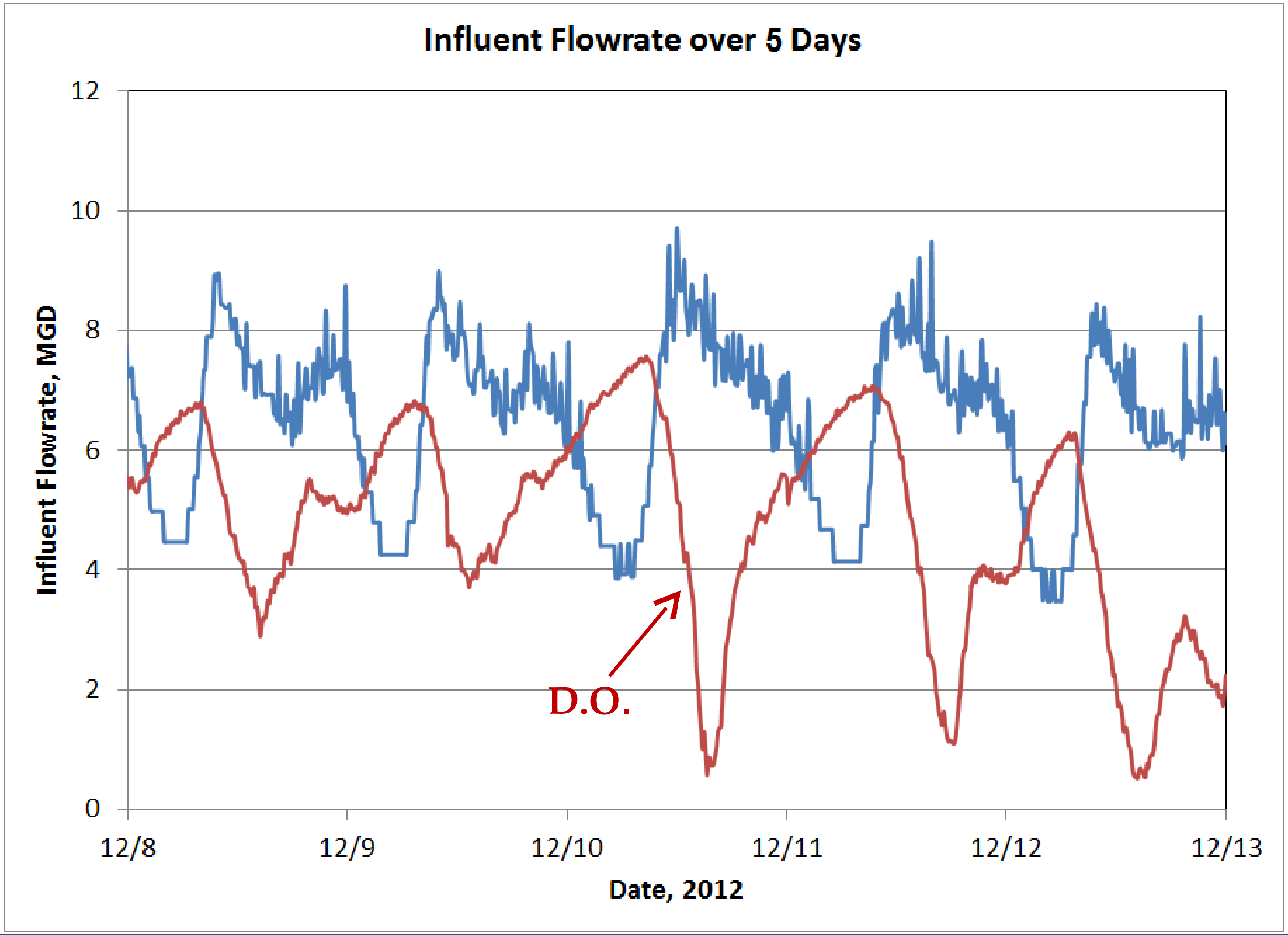
Equipment control with automation can provide as much as 30% energy savings.

Objective of this study: To determine the most effective control system to control process and optimize savings.

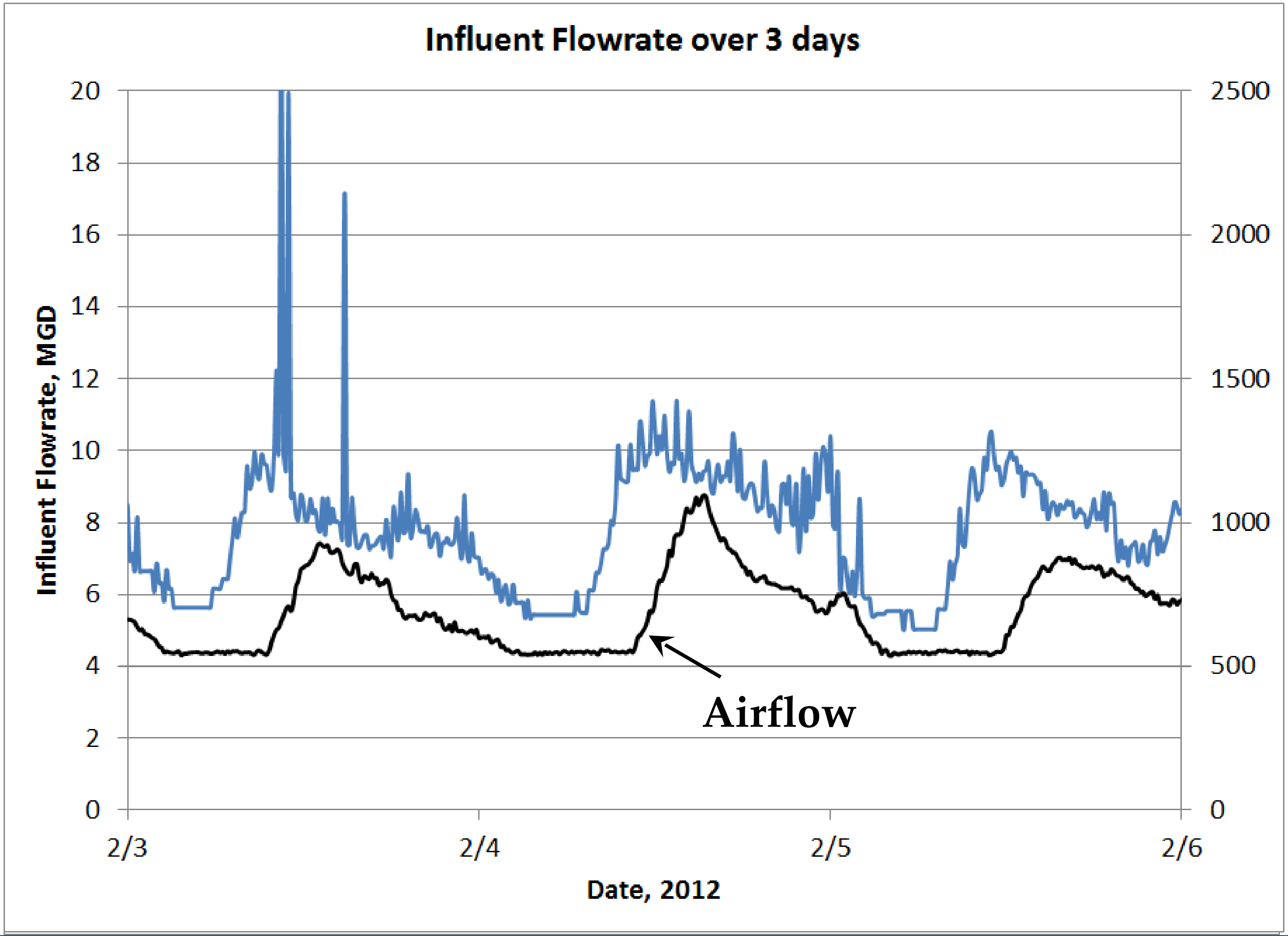
Typical blower control arrangements:

1. No control.
2. Manual or Automatic inlet valve control.
3. Manual or Automatic VFD control of blower speed.

1. No Blower Control
(Fixed Airflow)



2. Manual Control of Inlet Valve
3. Manual Control of VFD



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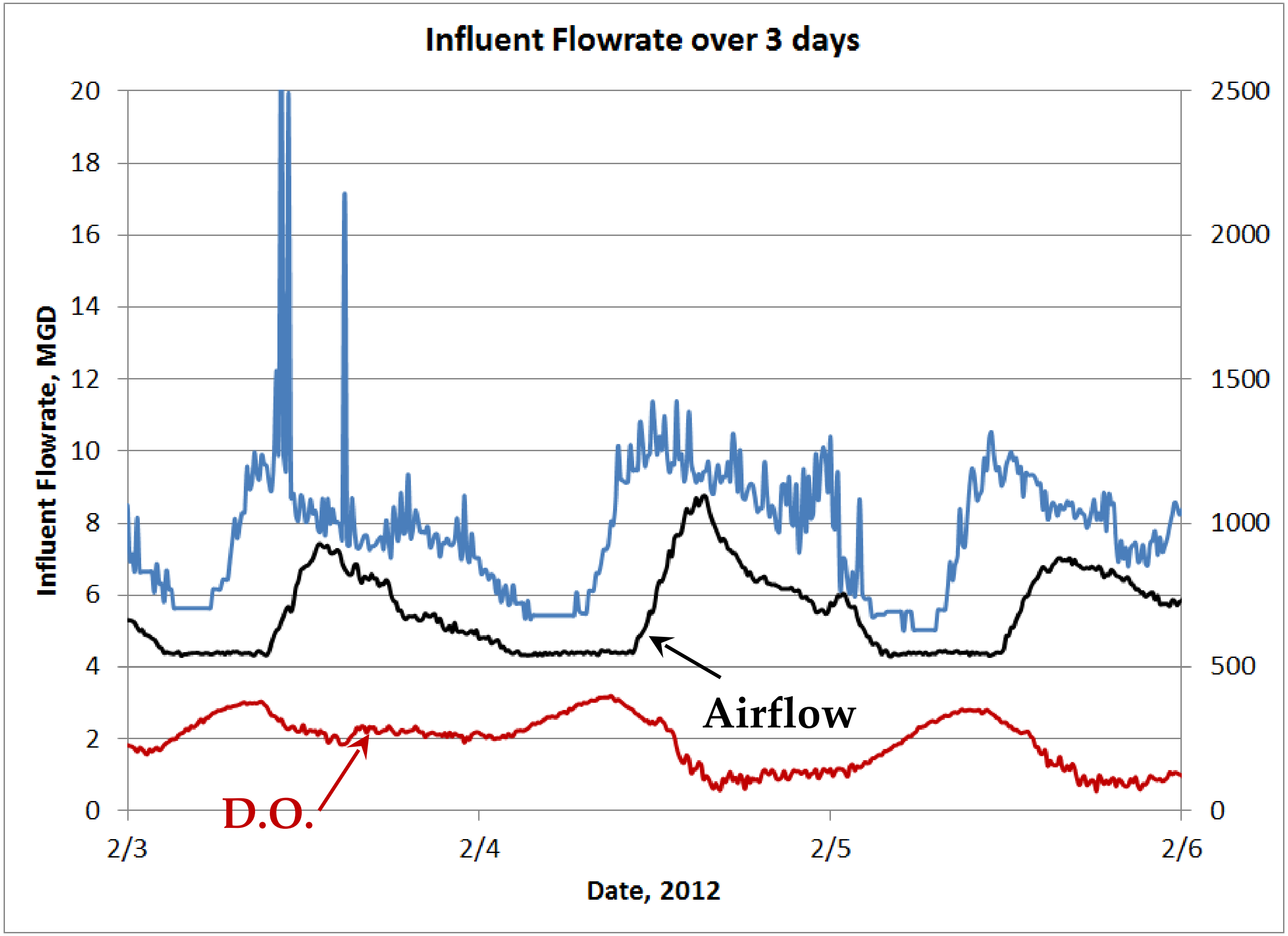


Energy Saving Successes: Case Studies

Location	Overall Energy Reduction	Energy Reduction from Blowers	Energy Reduction from Diffusers	Energy Reduction from Process/ Controls
Typical		20-35%	~30%	10-30%
Downers Grove Sanitary District	60%	20%	30%	30%
Village of Glendale Heights	35%	35%	N/A	N/A
Village of Carol Stream	58%	20%	N/A	~45%
City of Belvidere	80%	20%	30%	50%

Blower Control Strategies

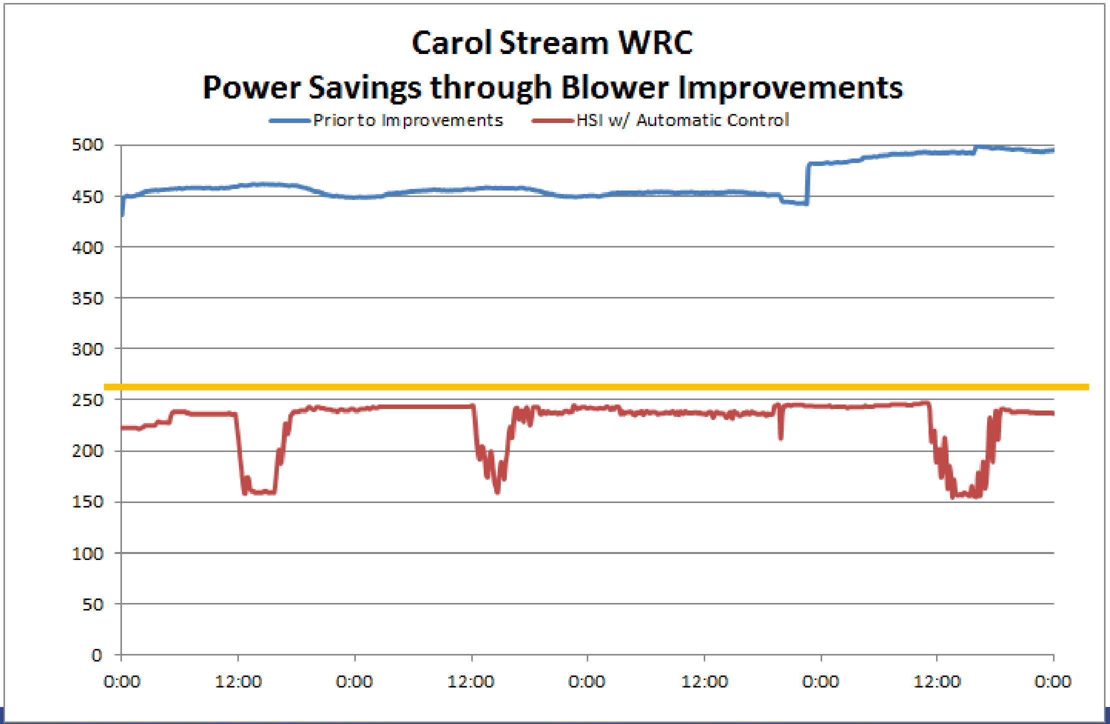
1. D.O. control from mid-tank
2. Most Open Valve Logic
3. Dual Loop Cascade
4. Ammonia Control

Disclaimer: The savings from each control are site-specific and depend on the controls and condition of the system prior to improvements. Use these to judge relative savings by control systems, not for firm savings estimates.

Case Studies

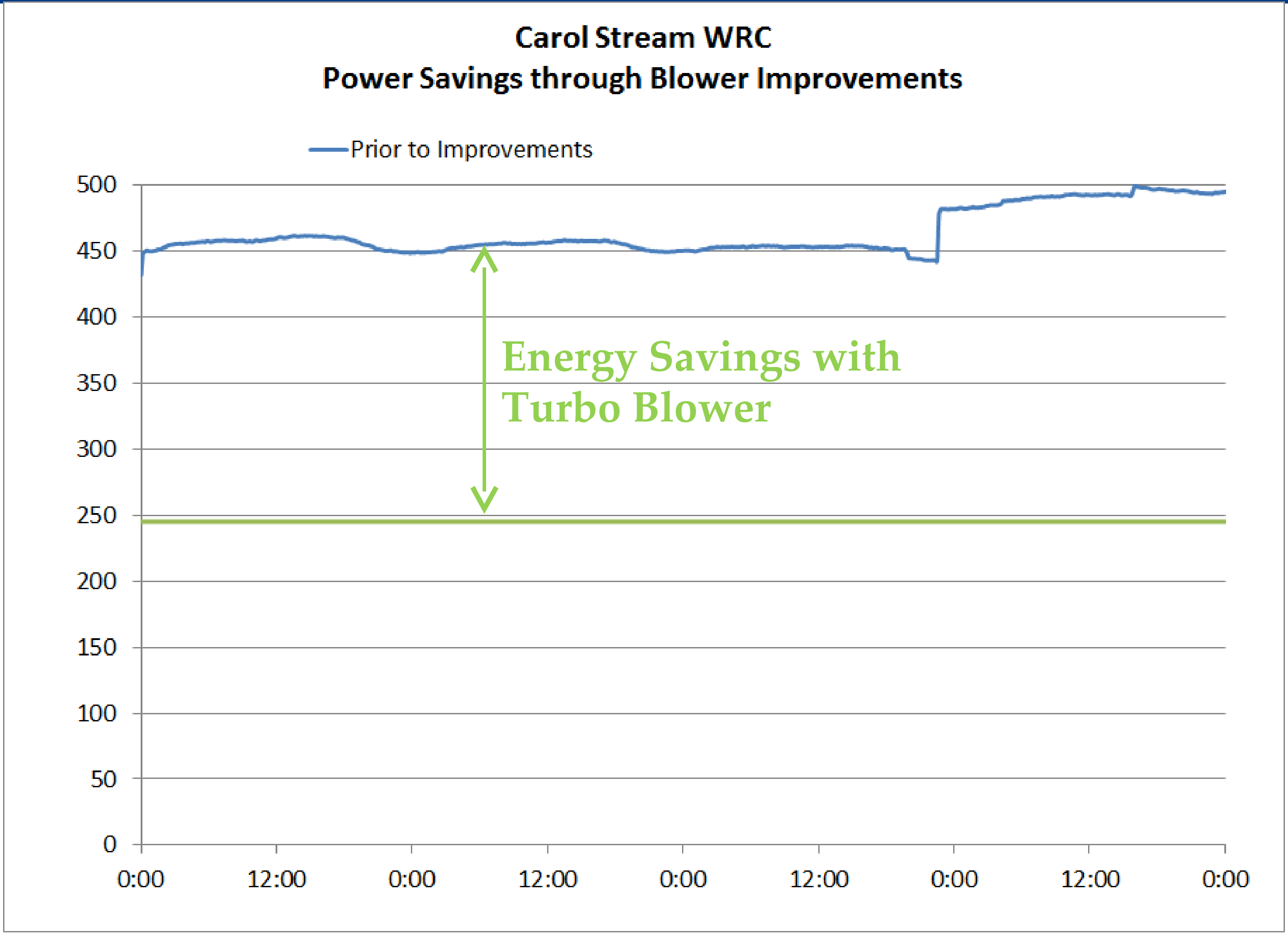
D.O. control at 1 point in the process

- At Carol Stream, only about 4% savings from turndown.
- Controls allowed reduction from 2-3 blowers normally running to just the turbo blower.



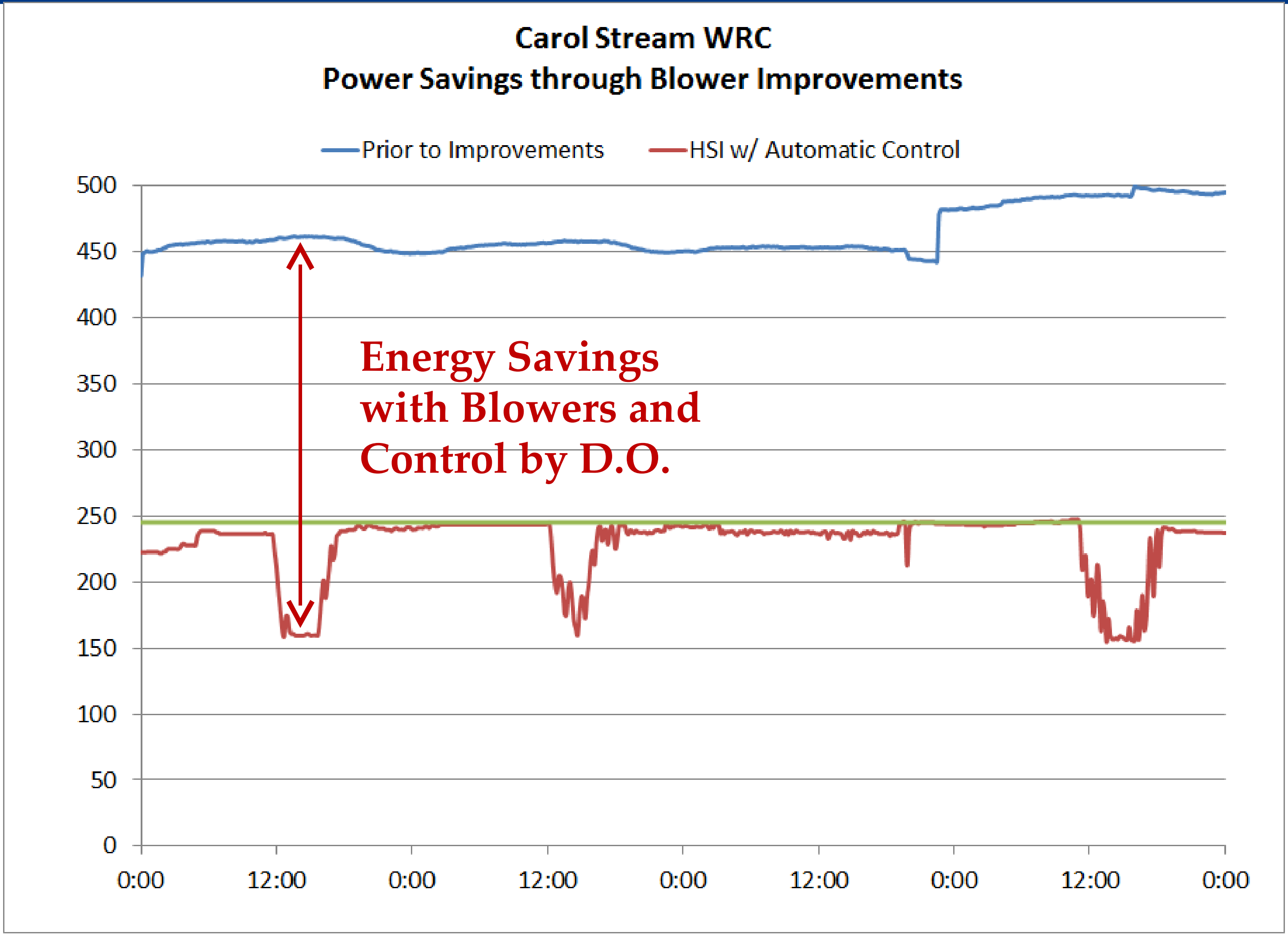
Case Studies

D.O. control at 1 point in the process



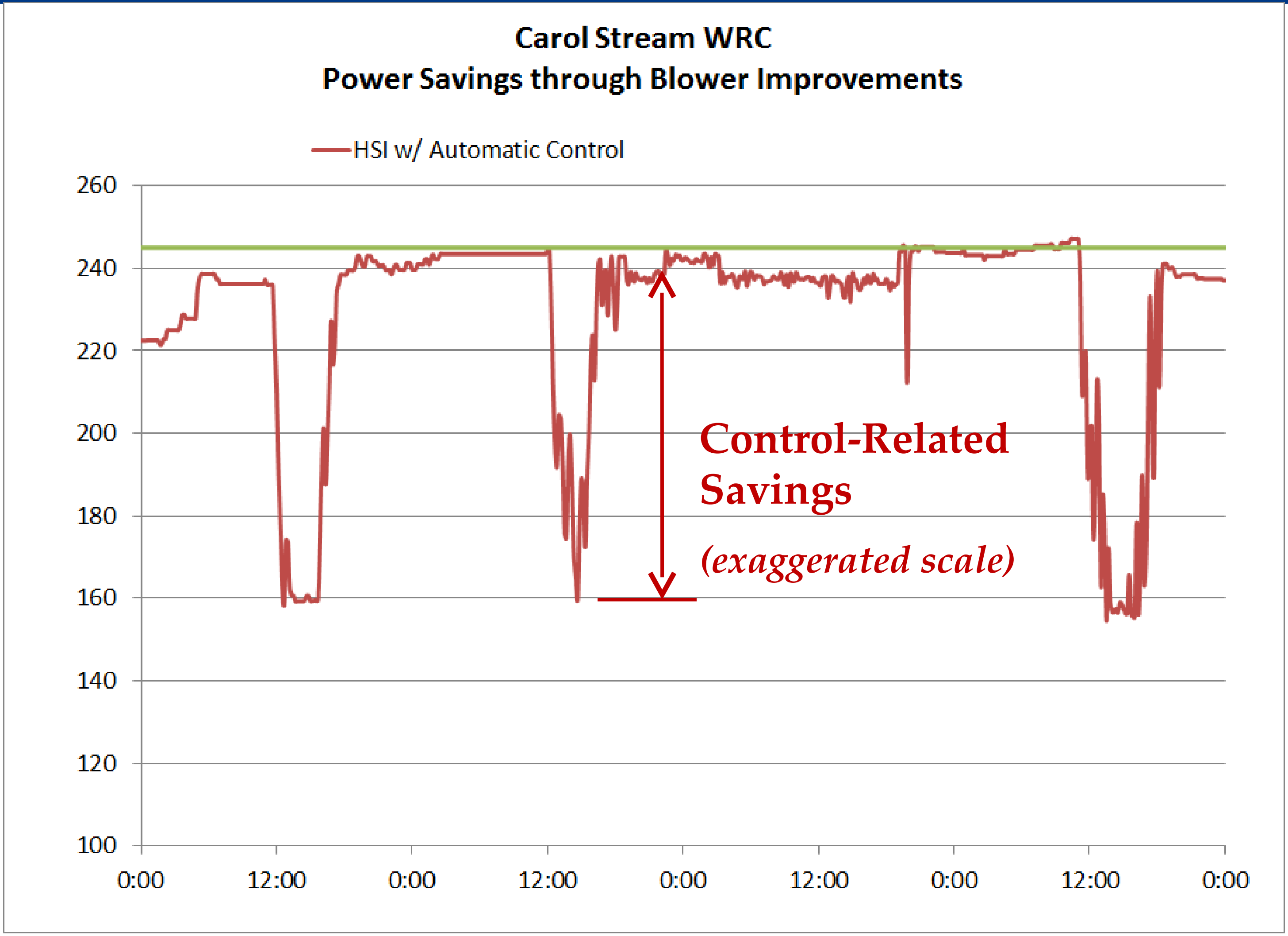
Case Studies

D.O. control at 1 point in the process



Case Studies

D.O. control at 1 point in the process



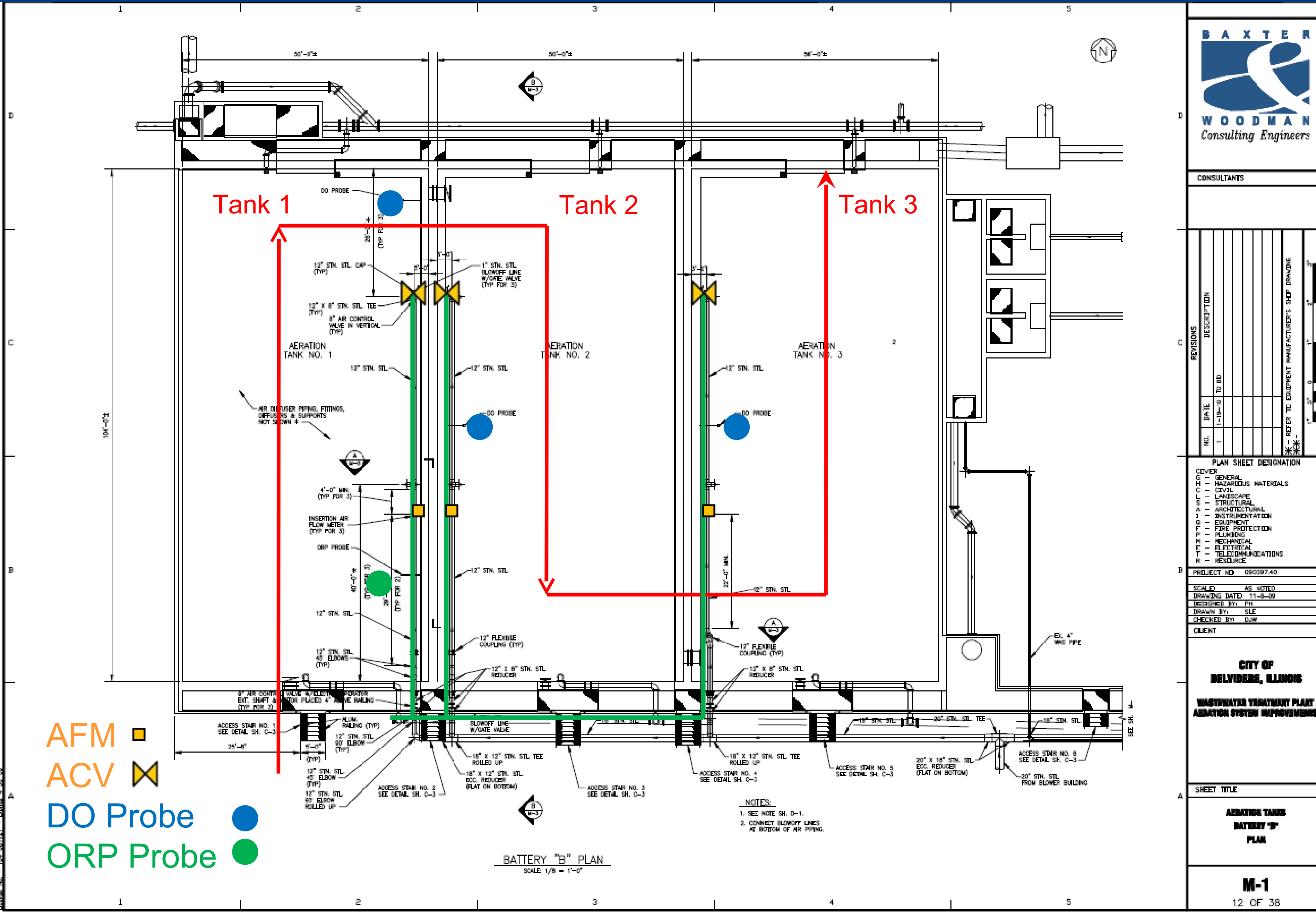
Case Studies

Most Open Valve Control Logic Saves Energy

- Air control valves are used to adjust airflow distribution.
- If there is a valve on the air header to each tank, at least one should be 100% open at all times.

An increase in backpressure as low as 0.5 psi raises energy consumption by 5%.

City of Belvidere: Most Open Valve



Case Studies

Most Open Valve Control Logic Saves Energy

	Valve HOA	DO Actual (PPM)	DO SP (PPM)	ORP Actual	ORP SP	Air Flow Actual (SCFM)	Air Flow SP (SCFM)	Valve Pos Actual (%)	Valve Pos SP (%)
Tank #1 MOV Auto	Remote	0.26	0.50 Active	78	30 Inactive	1549	MOV Control	100	100.0
Tank #2 Auto	Remote	4.50	0.80			887	840	92	92.7
Tank #3 Auto	Local	4.04	1.00			-136	840	31	20.0
Tank #4 Auto	Remote	0.56	0.50 Active	46	30 Inactive	1491	1871	100	100.0
Tank #5 Auto	Remote	5.12	0.80			840	840	100	100.0
Tank #6 Auto	Remote	5.50	1.00			865	840	63	65.3

Case Studies

Dual Loop Cascading Control using Ammonia Response

Logic: Control using ammonia as a predictive variable will result in better process control than control by D.O.

- Dissolved oxygen is indicative of excessive oxygen.
- Excess D.O. can interfere with denitrification processes.
- Real-time oxygen requirements are driven by ammonia because of its high oxygen demand, so control by ammonia can more closely match real-time demand conditions.

CASE STUDY: WHEATON SANITARY DISTRICT

Methodology

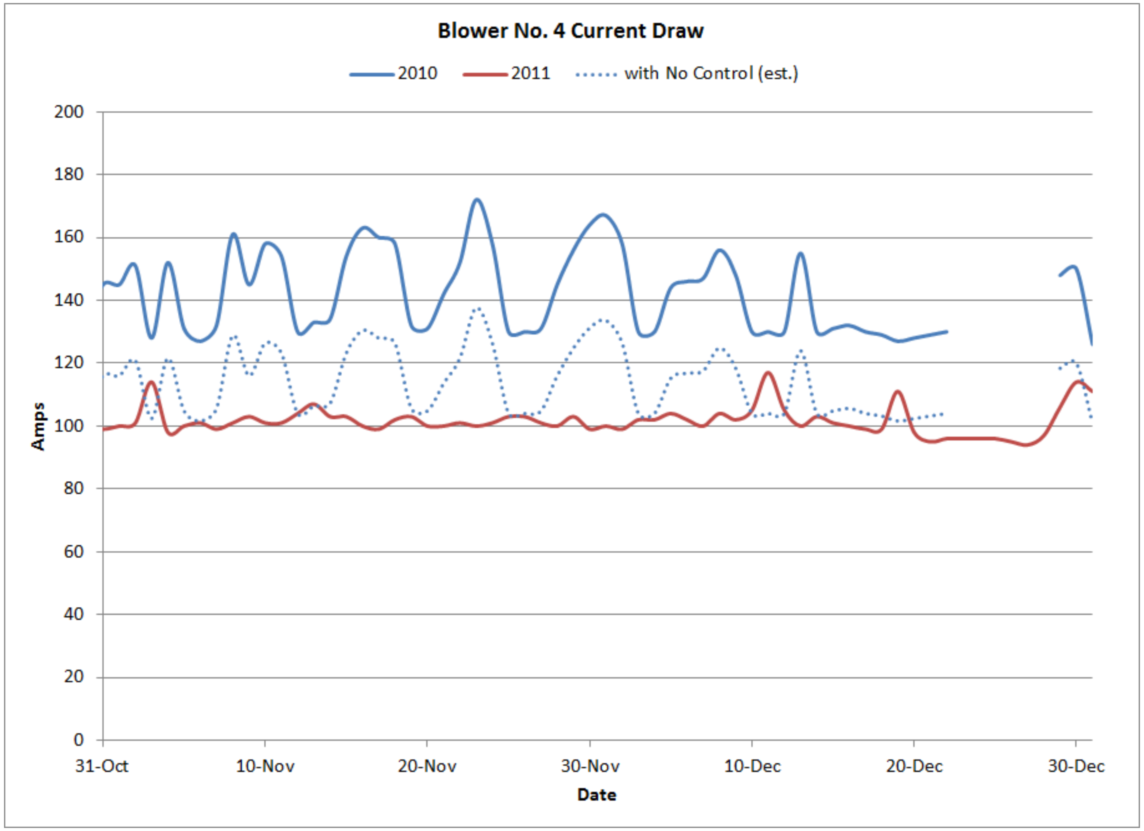
- Wheaton SD has 5 aeration tanks in parallel
  - Each tank has an airflow meter and modulating air control valve
- New turbo blower installed in 2011 to replace an existing multistage centrifugal blower.
- Only the turbo blower runs to aerate and mix the aeration tanks.
- Online meters monitor power consumption.

Wheaton Sanitary District: Aeration Basin Configuration

Energy Savings from Blower Replacement

Blower replacement reduced energy by 28% from 2010 to 2011.

Control using fixed airflow accounted for 10% of the savings.

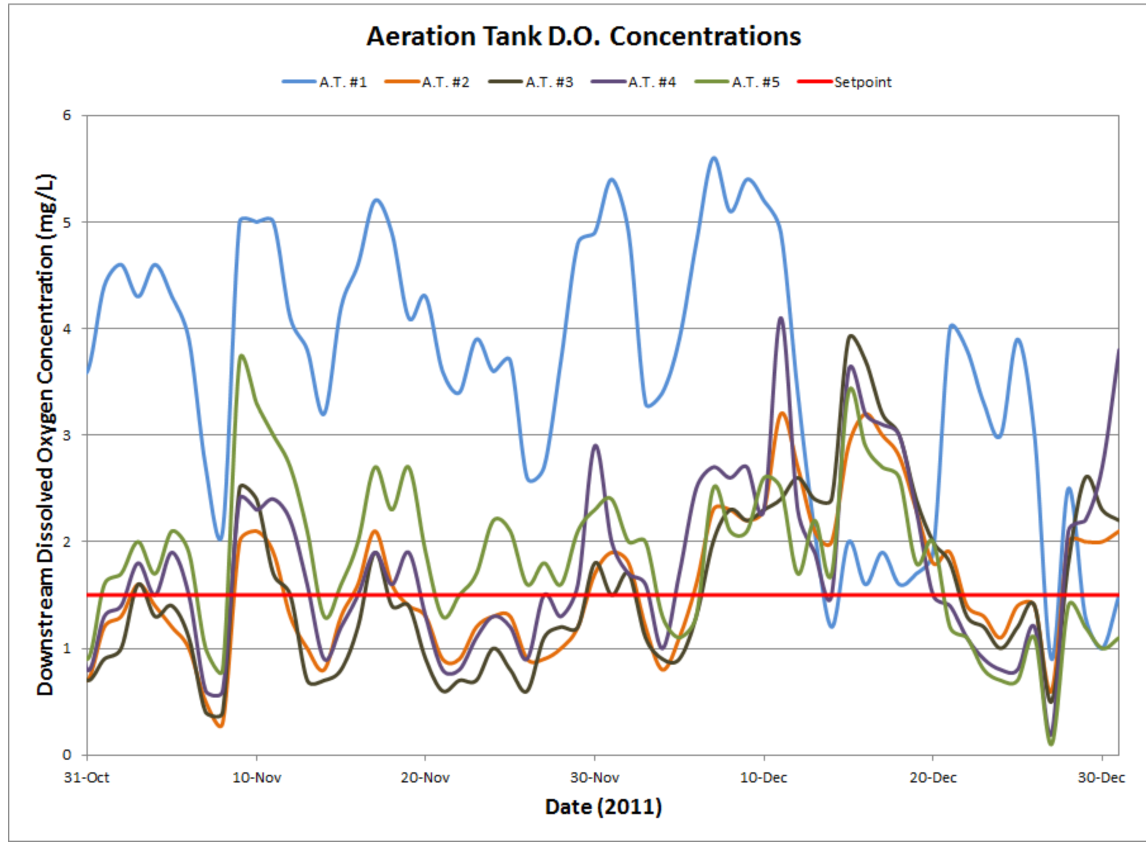


Can we do better?

Case Study: Wheaton Sanitary District

Current Control:

- Fixed airflow to each tank
- Results in excessive D.O.
- Wastes Energy



→ Control by D.O. instead. …. Or?

Case Study: Wheaton Sanitary District

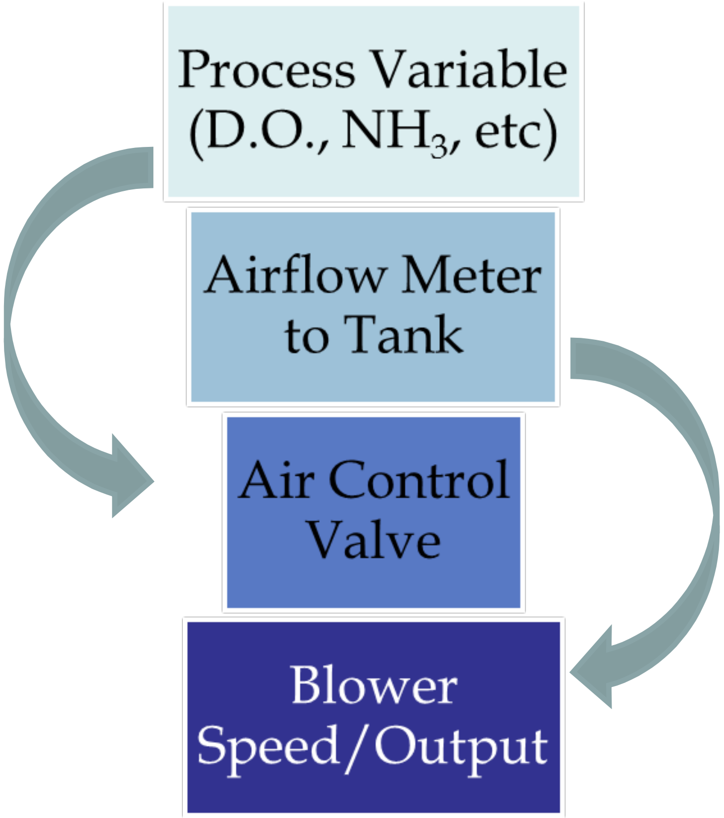
Dual Loop Cascading Control

Airflow to each tank is proportional to that tank's power consumption. To compare power, look at relative airflow.

- Airflow setpoint
- Dissolved Oxygen Control
- Ammonia Control

Failsafes:

- – Minimum airflow
- – Minimum D.O.



Case Study: Wheaton Sanitary District

ISEmax CAS40D

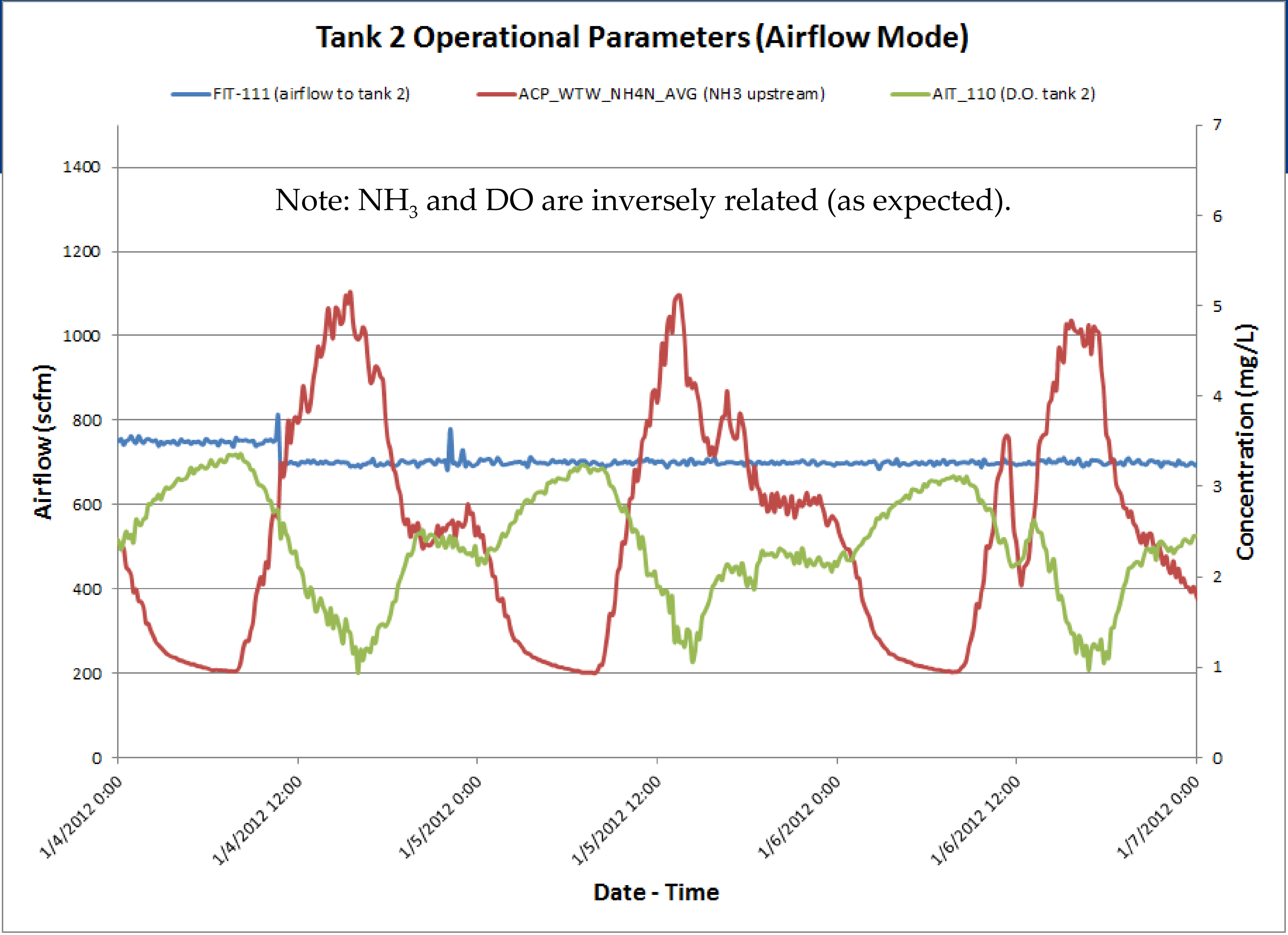
Endress+Hauser
People for Process Automation

AmmoLyt®^{Plus} 700 IQ

WTW

Wheaton Sanitary District: Aeration Basin Instrumentation

Fixed Airflow Control

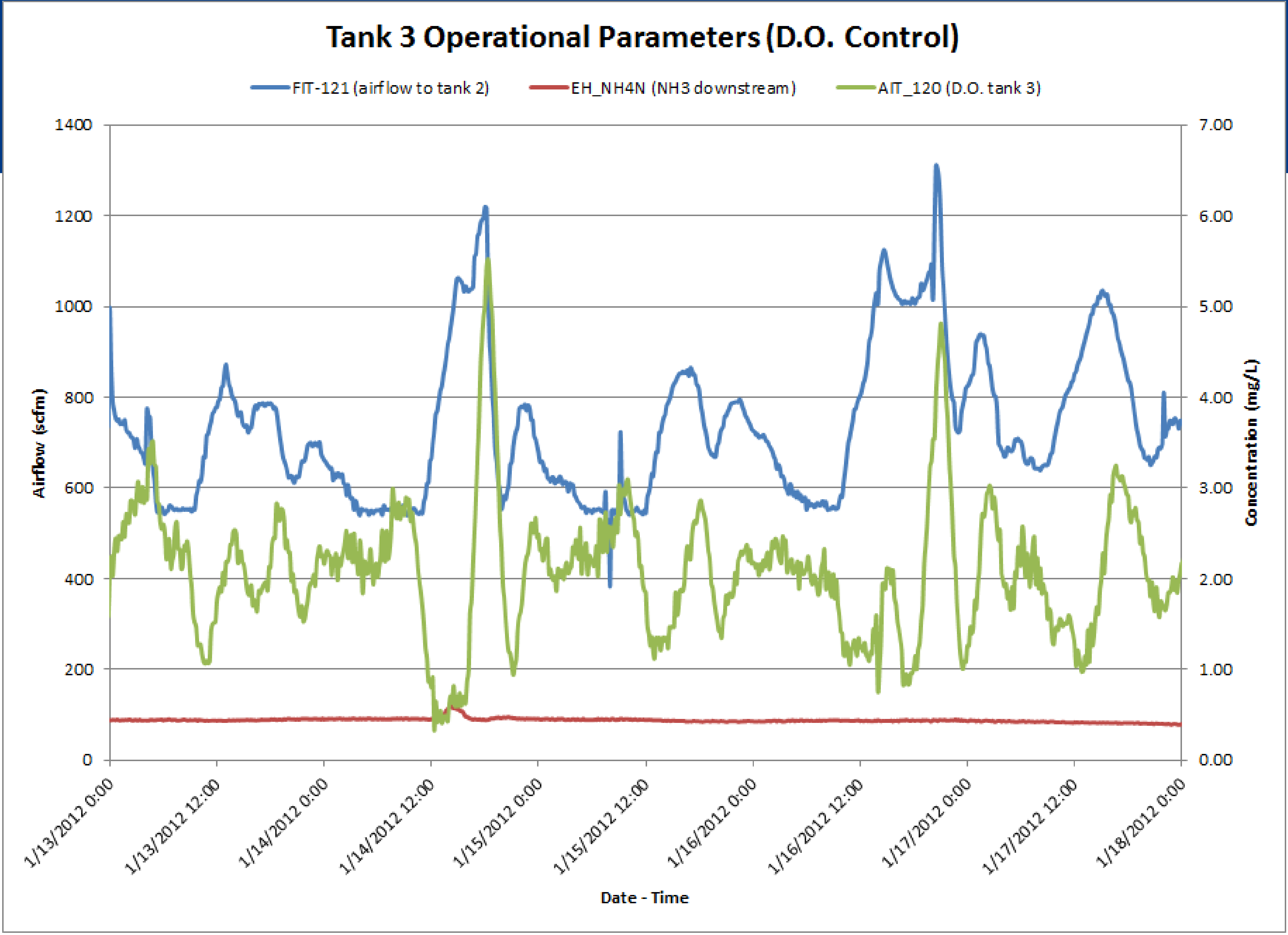


Tank 2 Operational Parameters (Airflow Mode)
FIT-111 (airflow to tank 2)
ACP_WTW_NH4N_AVG (NH3 upstream)
AIT_110 (D.O. tank 2)
Note: NH3 and DO are inversely related (as expected).
Airflow (scfm)
Concentration (mg/L)
0
200
400
600
800
1000
1200
1400
0
1
2
3
4
5
6
7
1/4/2012 0:00
1/4/2012 12:00
1/5/2012 0:00
1/5/2012 12:00
1/6/2012 0:00
1/6/2012 12:00
1/7/2012 0:00
Date - Time

Case Study: Wheaton Sanitary District

- Controlling based on airflow, Wheaton can achieve low effluent NH_3
- D.O. fluctuates significantly throughout the day
- Effluent ammonia concentrations are difficult to maintain in high flow events.

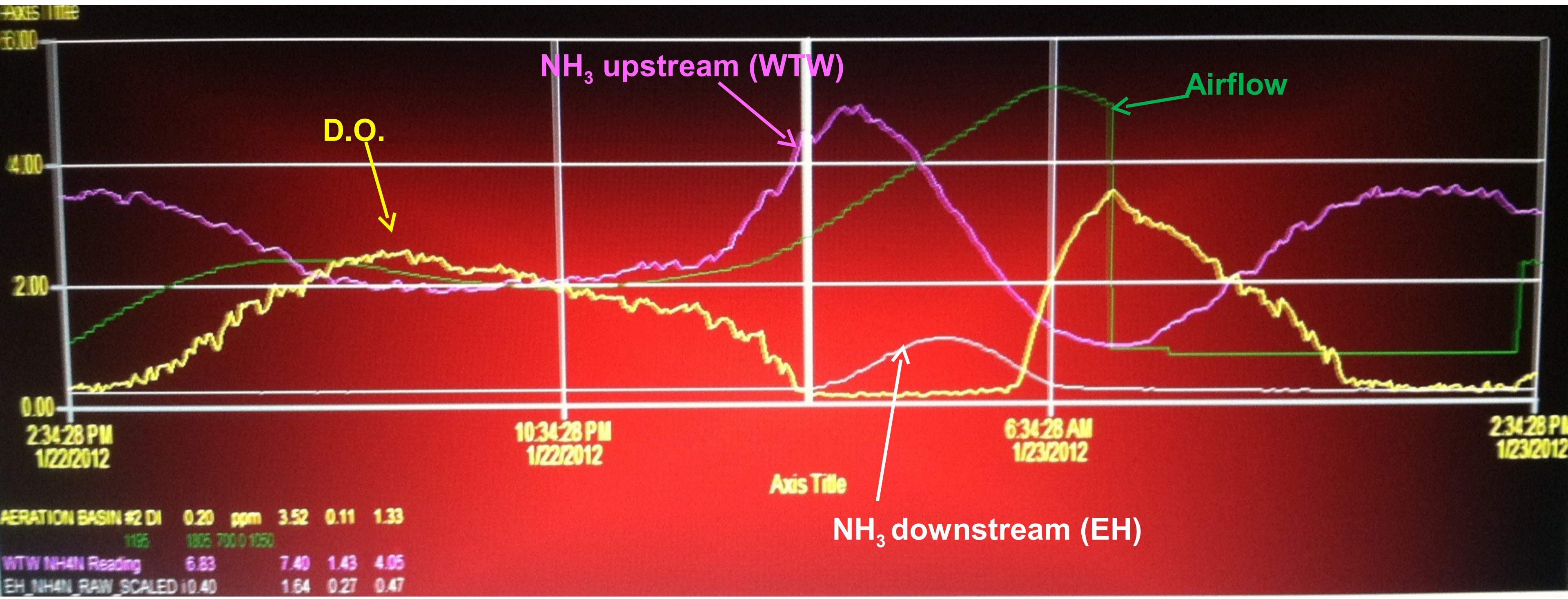
D.O. Control


Tank 3 Operational Parameters (D.O. Control)
FIT-121 (airflow to tank 2)
EH_NH4N (NH3 downstream)
AIT_120 (D.O. tank 3)
Airflow (scfm)
Concentration (mg/L)
0
200
400
600
800
1000
1200
1400
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
1/13/2012 0:00
1/13/2012 12:00
1/14/2012 0:00
1/14/2012 12:00
1/15/2012 0:00
1/15/2012 12:00
1/16/2012 0:00
1/16/2012 12:00
1/17/2012 0:00
1/17/2012 12:00
1/18/2012 0:00
Date - Time

Wheaton Sanitary District

Automatic Control using D.O. Control

- What can go wrong?



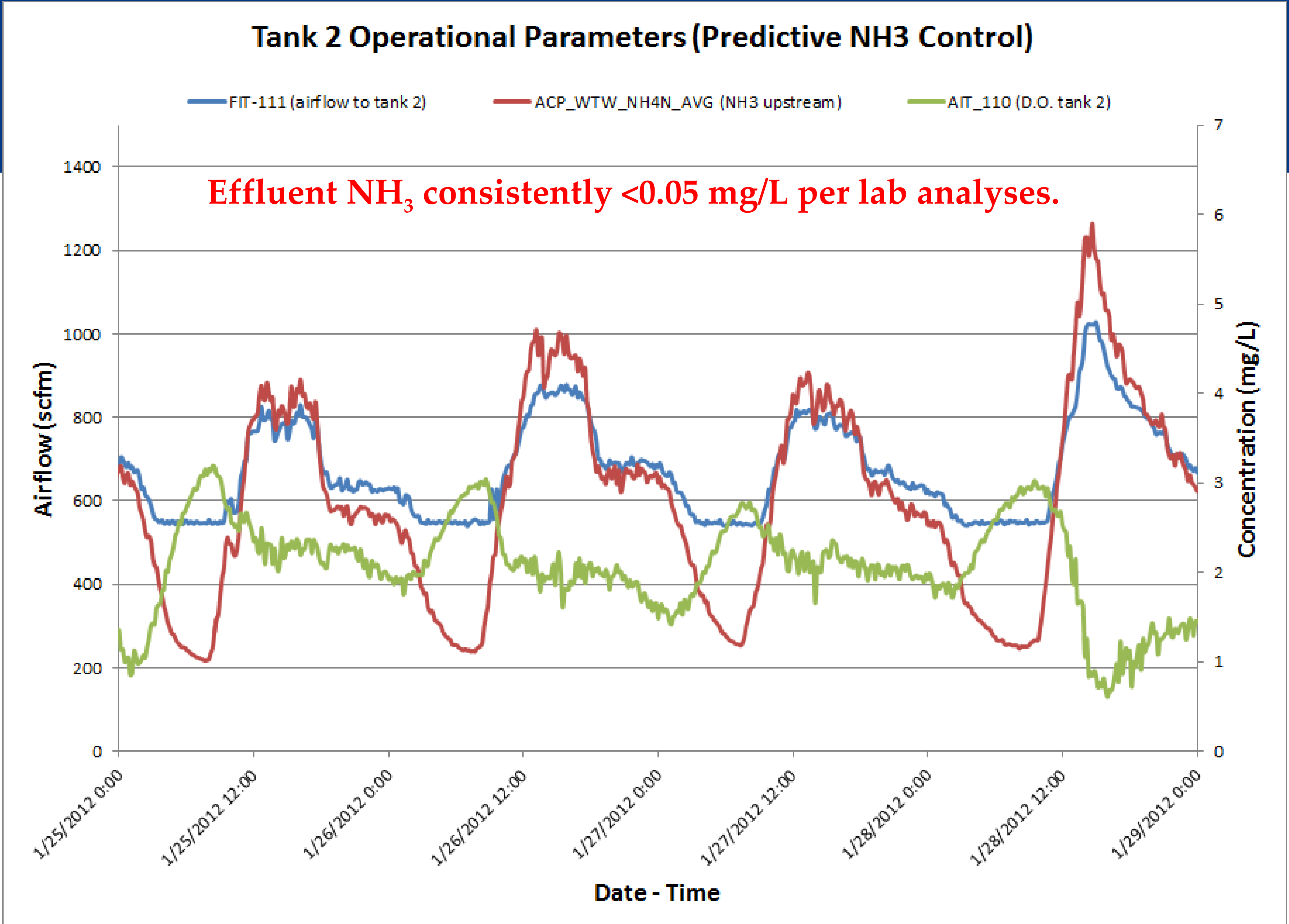
Wheaton Sanitary District

Automatic Control using D.O. Control

Summary

- D.O. crashes when a slug of ammonia comes through
- Ammonia break-through occurs about 2 hours (judging on the leading edge of the curve)
- Blower speeds up until D.O. is too high, then airflow drops drastically

NH_3 Control


Tank 2 Operational Parameters (Predictive NH3 Control)
FIT-111 (airflow to tank 2)
ACP_WTW_NH4N_AVG (NH3 upstream)
AIT_110 (D.O. tank 2)
Effluent NH_3 consistently <0.05 mg/L per lab analyses.
Airflow (scfm)
0
200
400
600
800
1000
1200
1400
Concentration (mg/L)
0
1
2
3
4
5
6
7
1/25/2012 0:00
1/25/2012 12:00
1/26/2012 0:00
1/26/2012 12:00
1/27/2012 0:00
1/27/2012 12:00
1/28/2012 0:00
1/28/2012 12:00
1/29/2012 0:00
Date - Time

Wheaton Sanitary District

Automatic Control using NH_3

Summary

- Blower speed/output respond to influent ammonia; curves match.

- D.O. peaks are minimized – stays closer to a 2.0 mg/L average.

- Effluent NH_3 is consistently non-detectable in the effluent (<0.05 mg/L) per lab reports.

- Controllability in High Flow Events? TBD

Control Summary

Wheaton Sanitary District

Summary of Controls: Compare with Design Airflows

Control Scenario	Average Airflow Required (scfm)	Savings compared to AOR-based design airflow
Airflow - Design based on AOR	4,200	-
Airflow – Fixed Speed	3,710	12%
Predictive NH_3	3,666	13%
D.O. – Based	3,917	7%

Wheaton Sanitary District

Summary of Controls: Compare with Design Airflows

Control Scenario	Average Airflow Required (scfm)	Savings compared to AOR-based design airflow	Savings per Performance (scfm/lb TOM)
Airflow - Design based on AOR	4,200	-	
Airflow – Fixed Speed	3,710	12%	0.18
Predictive NH_3	3,666	13%	0.27
D.O. – Based	3,917	7%	0.27

TOM = Total Oxidizable Material (1.2 lb O_2 per lb BOD removed + 4.6 lb O_2 per lb NH_3 removed)

Summary

- Airflow control:
  - 12% energy savings
- D.O. control:
  - 7% energy savings (less than fixed airflow)
  - More stable operations but slow response time
- NH_3 control:
  - 13% energy savings from NH_3 control
  - More stable operations; quicker response time
  - Optimizes energy savings and process control
  - Expected to improve performance in high flows

Summary

- Even simple control can provide significant energy savings
  - Take advantage of the low end of the blower curve
  - Minimal cost of implementation (VFD, in-tank instrumentation, programming)
- Design airflow requirements are very conservative! Save energy and dollars by providing smart controls.

Project Status / Next Steps

- The trial has been completed.
- Wheaton is in the process of incorporating NH_3 feed-forward control for their aeration system
- Power monitoring will be restarted once the system is finalized to determine the long-term savings.

Acknowledgments

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