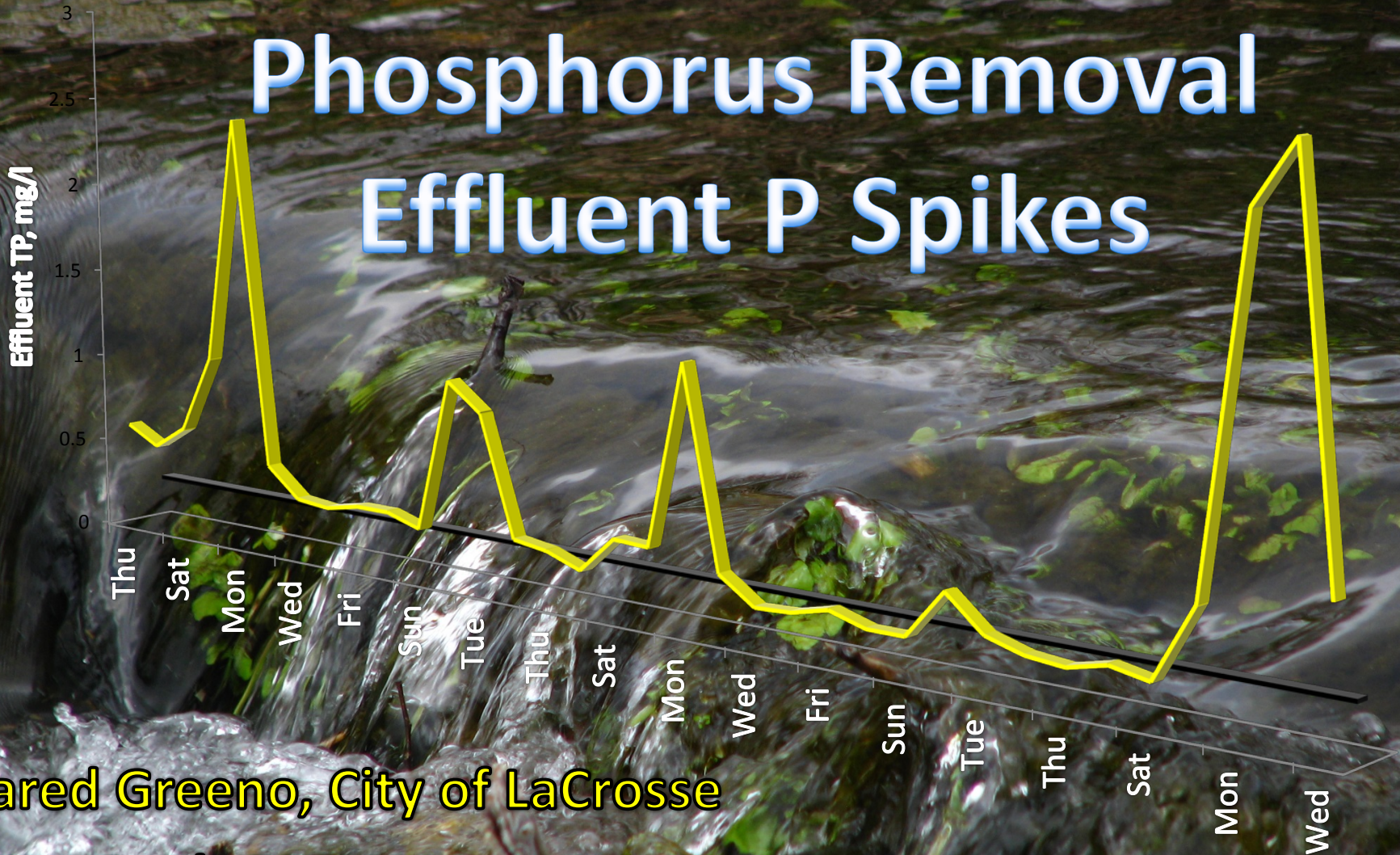


Taming Biological Phosphorus Removal Effluent P Spikes



Jared Greeno, City of LaCrosse

Greg Paul, QLF

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Study Objective & Intro

- Resolve Problem of Effluent Total Phosphorus SPIKING in a Biological Phosphorus Removal (BPR) System
- Proposed Solution – Automatically Feeding a high rbCOD product
- LaCrosse - Logical Place for Study
 - Has Effluent TP Spiking -- Already Using high rbCOD product on Weekends
 - Close to Home

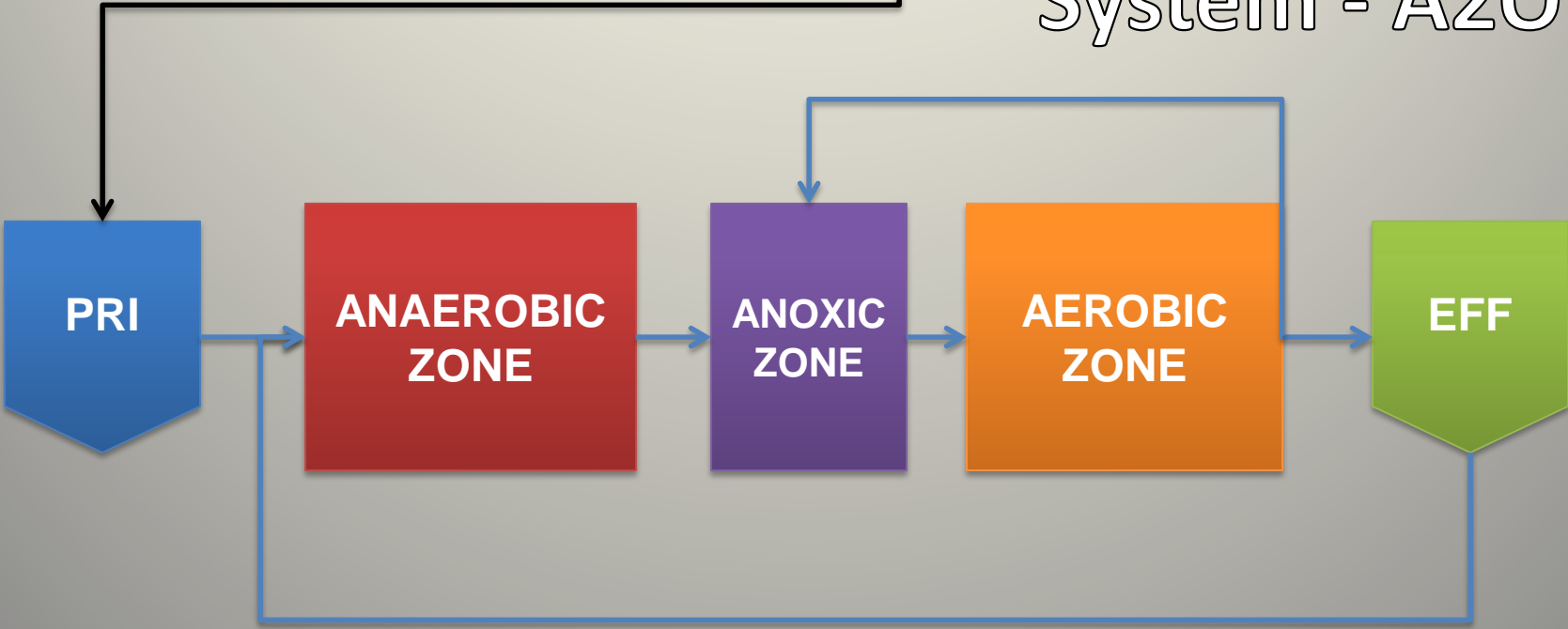
La Crosse WWTP

- Design - 20 MGD
- Present - 10 MGD
- Liquid - Fine Screen/Grit/Primaryes/BPR/UV
- Solids – Co-Thicken Gravity
Thickeners/Anaerobic Digestion/GBT
Thickening/Storage/Liquid Injection
- Major Contributor – City Brewery, high
rbCOD

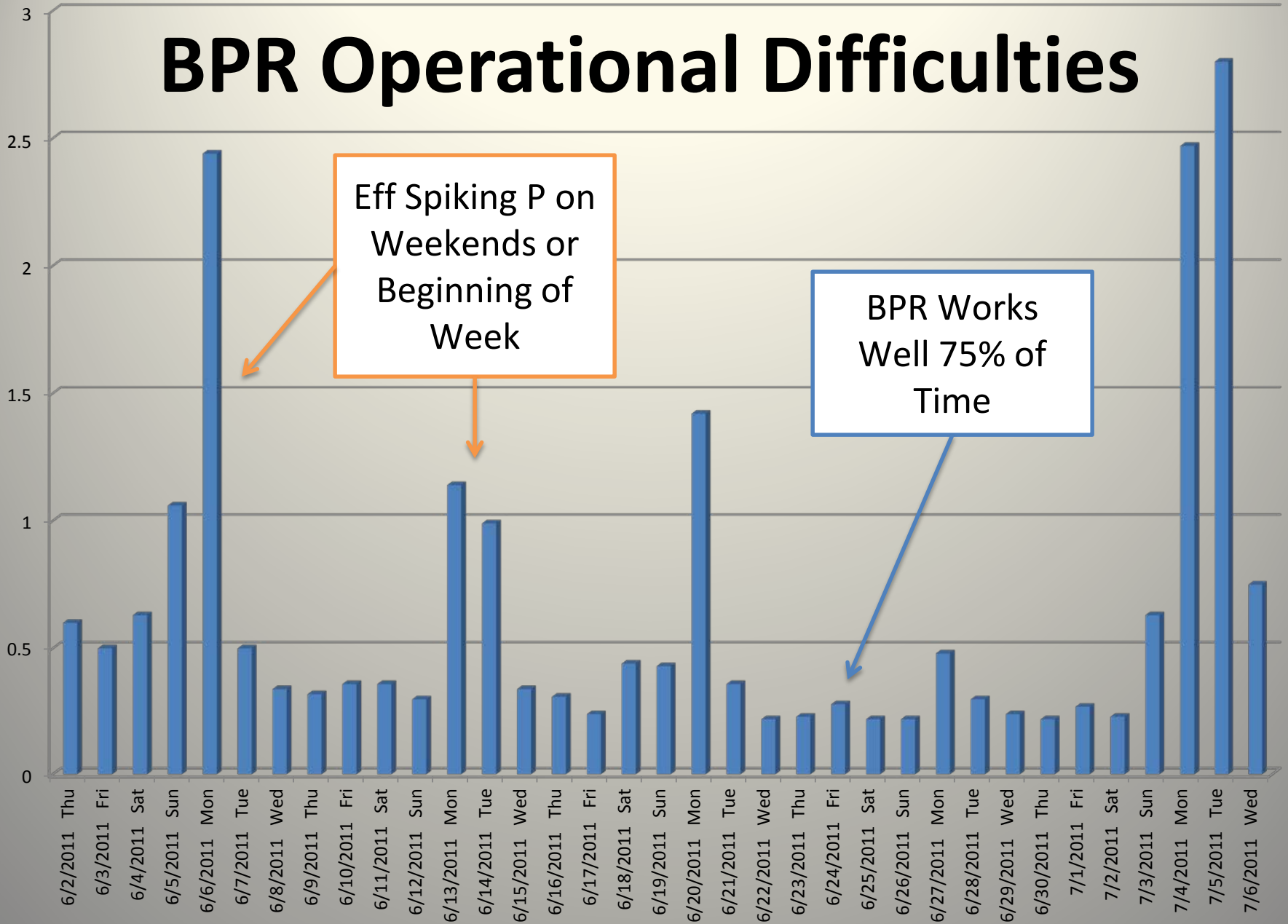
Molasses
Formulate
Product

High rbCOD Product
added to Primary
Clarifier Effluent Trough

La Crosse BPR System - A2O



BPR Operational Difficulties



Investigate/Analyze Difficulties

- Survey/Investigate BPR systems using P profile testing
 - What is P profile testing?
 - Snapshot in time
 - Why use it for this investigation
 - P-Release in Anaerobic Zone
 - P-Uptake in Aerobic Zone
 - Are there Trends?
 - Simple analyses– on-line analyzers available

P-Release in Anaerobic Zone

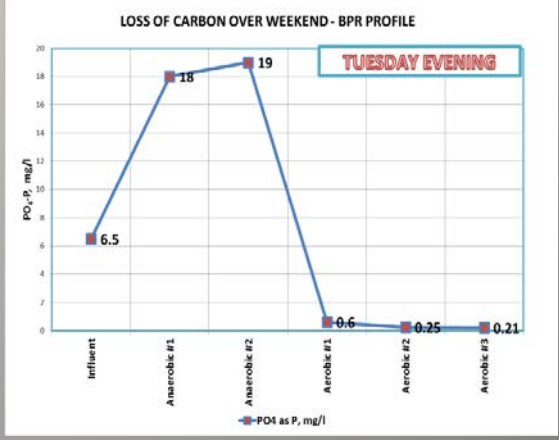
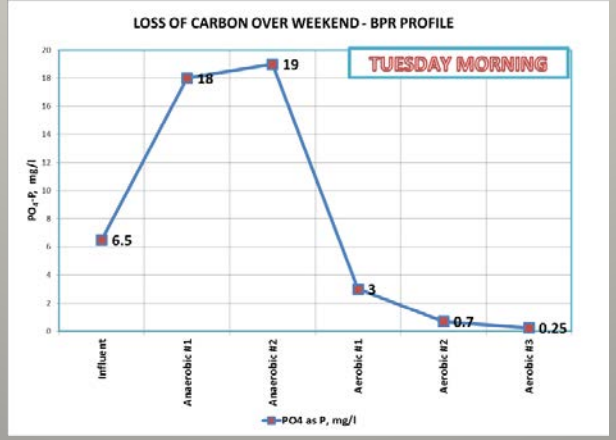
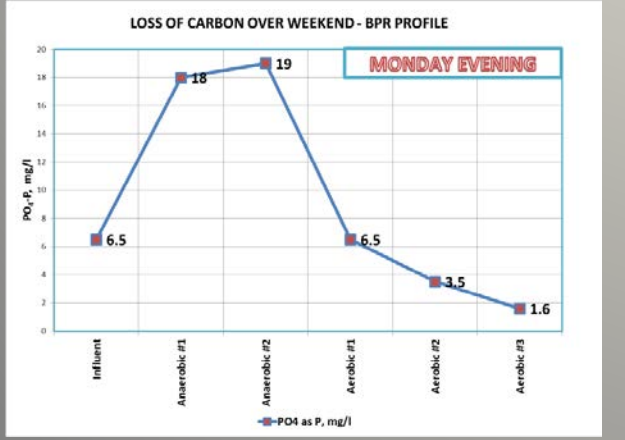
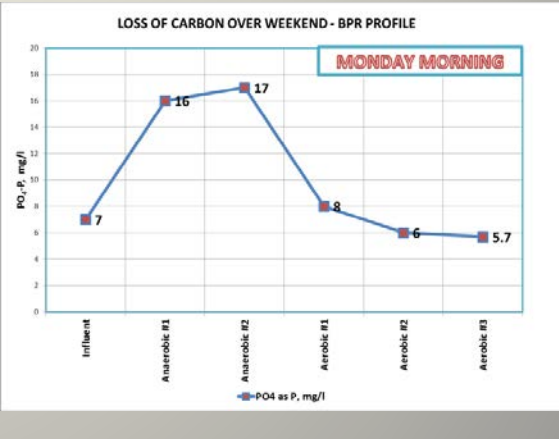
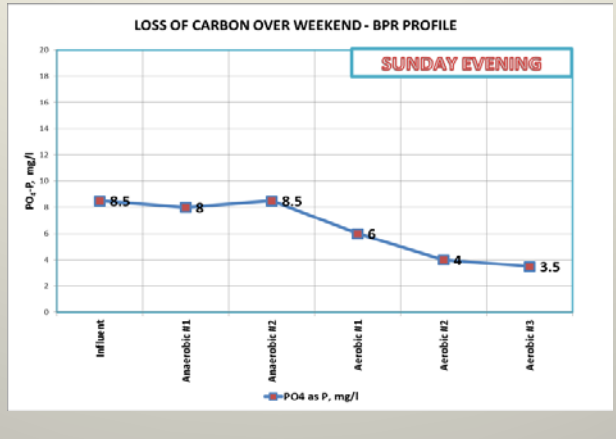
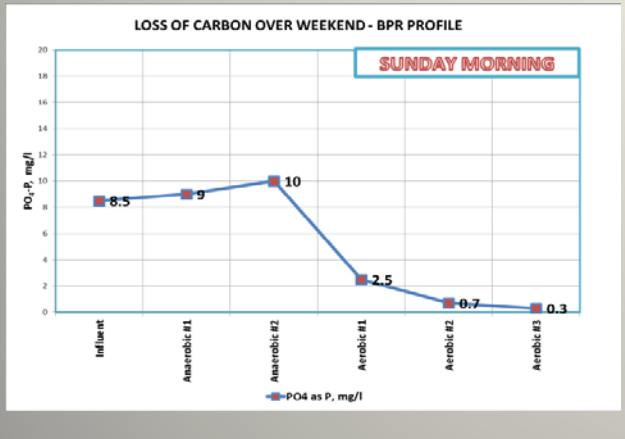
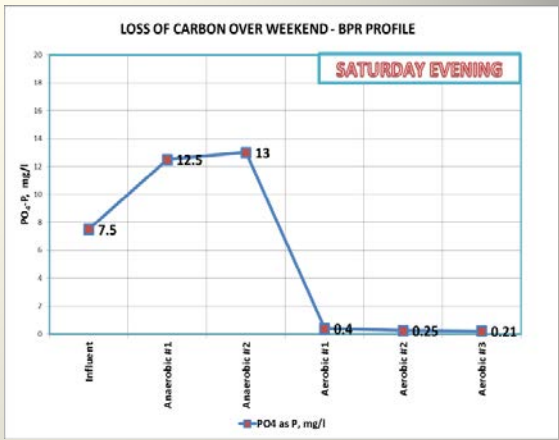
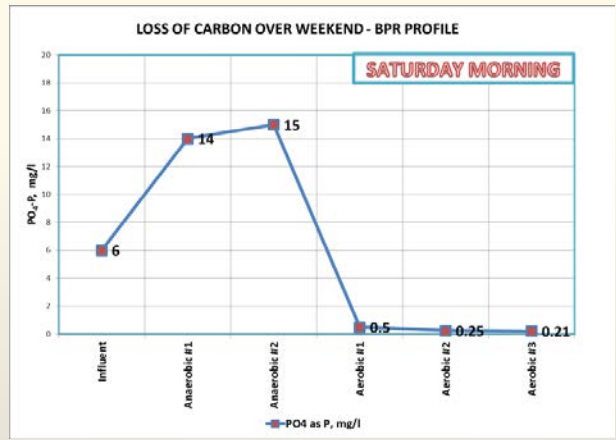
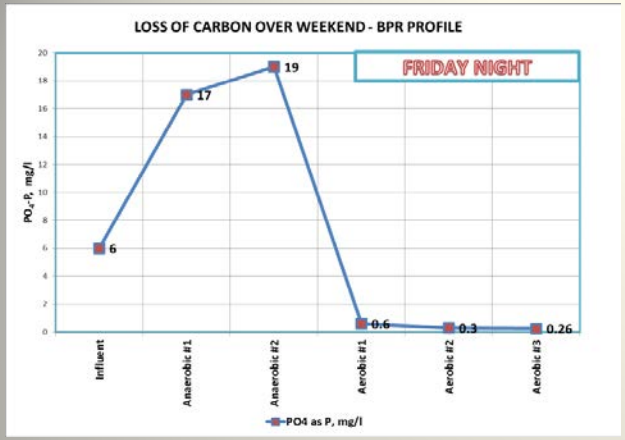
WEF (2010), *Nutrient Removal WEF Manual of Practice No. 34* (Page 523, Section 2.3.4)

- “..higher overall release..better P removal”
- "The release of P can result in P concentration in the anaerobic zone from *two to four times* the influent concentration and still result in good P uptake in the aeration basin."

Performing P Profiles - BPR Systems

- Ran Multiple P Profiles on LaCrosse System and at numerous other WWTPs
- Taking pulse of system
- Multiple profiles/day multiple days - weekends
- Understand BPR under Various rbCOD Loading Conditions

QLF Specialty Products...Phosphorus Profiles of a BPR System Which has Lost and Then Regained rbCOD Loading Over a Weekend



Analyze Results for Patterns

- Need a Mathematical Expression
 - For a baseline to measurement BPR performance
- Back to **ANAEROBIC ZONE** - Healthy BPR System
 - PAO's uptake VFAs and P Release
 - Small P-Release – low influent rbCOD
 - High P-Release – high influent rbCOD

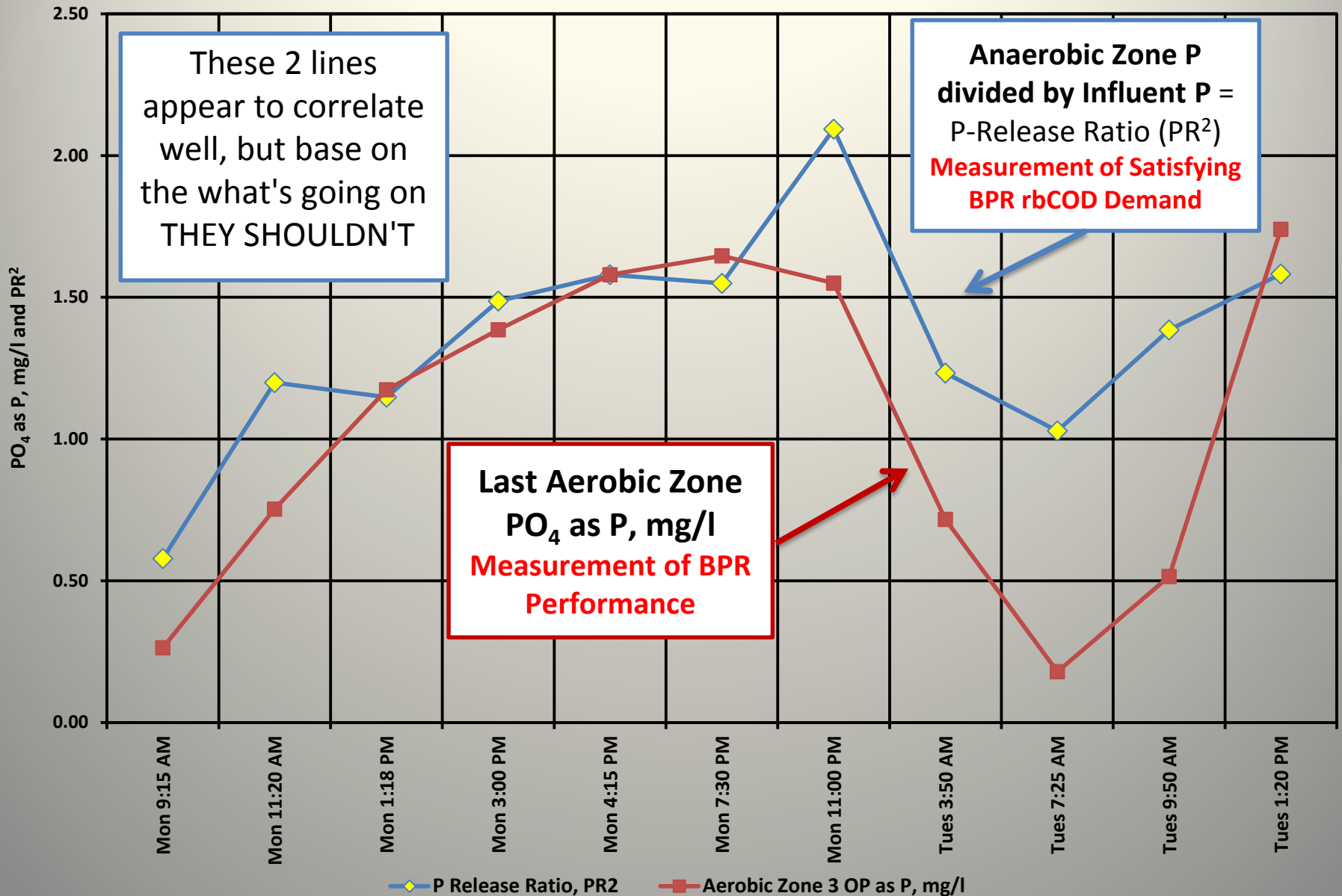
Analyze Results for Patterns

- Using ONLY anaerobic zone P release as a sole measure of BPR health had problems;
 - Changing influent P concentrations
 - Side streams can give False High P-Release
 - Need to Compare anaerobic P-Release to something--WEF

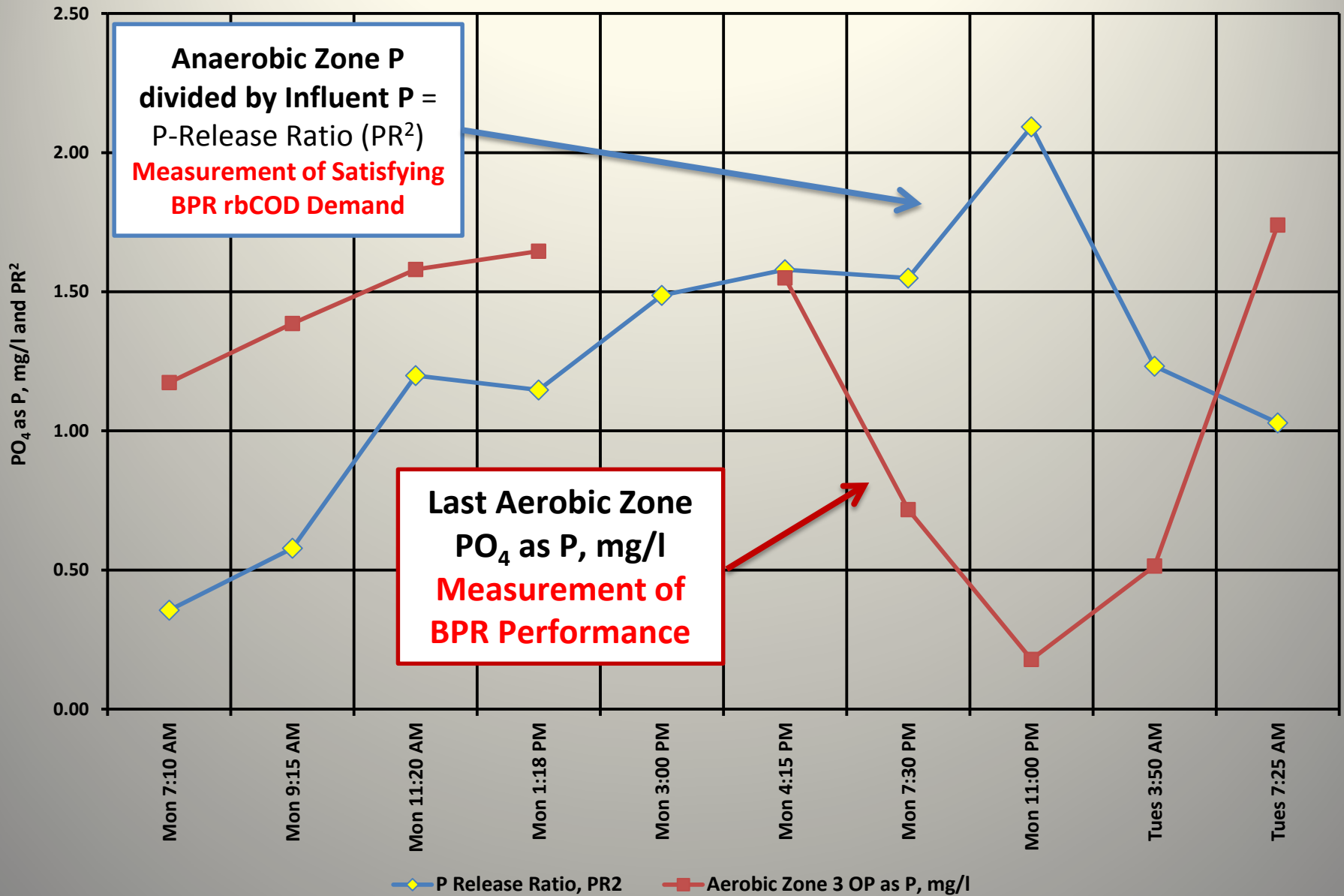
Analyze Results for Patterns

- Created Mathematical Expression
- Anaerobic Zone P-Release divided by BPR Influent P
- For this study we will refer to it as Phosphorus Release Ratio - PR^2
- Can PR^2 be used to measure the health and performance of a BPR system?
WEF - PR^2 between 2 and 4 GOOD

P Uptake Compared to PR² - Is NOT Adjusted for Detention Time



P Uptake Compared to PR² - Is Adjusted for Detention Time



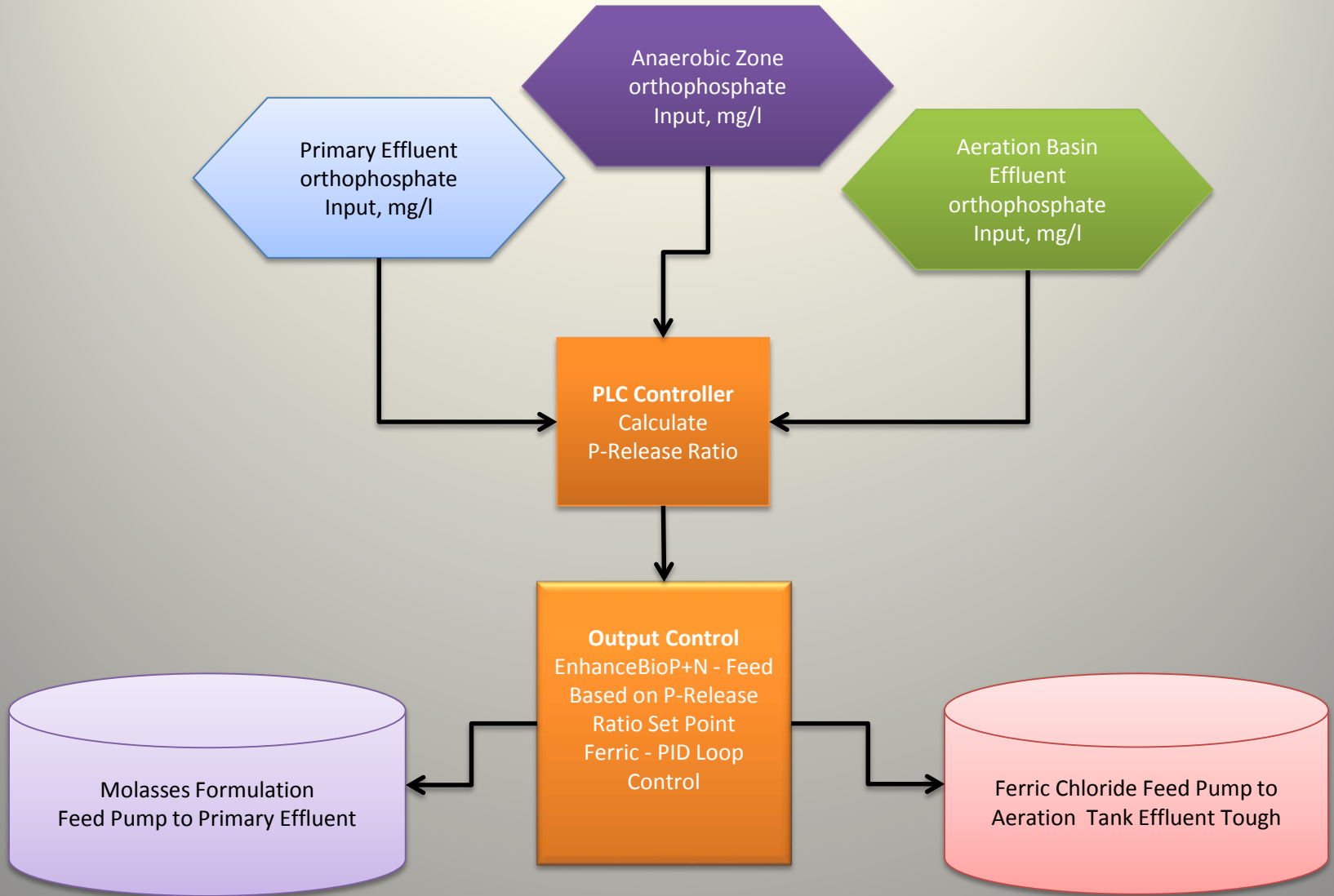
Multiple P Profiles Adjusted for System Detention Time were Performed - Results

- Increase/Decrease of rbCOD has almost instantaneous effect on Anaerobic Zone P-Release - PR^2
- PR^2 Appears to Predict BPR Performance - Effluent DRP Concentrations

Plans and Setup for Trial

- Related PR² findings to Method of Automatic Control
- Added Ramp Control - SCADA system
- Needed: An on-line analyzer – monitor 2 sample points with one analyzer
- Worked with Instrument vendor to supply an analyzer

PROGRAMMING CONTROL LOOP



SCADA System

Inputs and Dashboard

QLF Pump

Req'd	Auto Call	Hrs.	Starts
		7.6	0

- 35.0 Speed Control (%)
- 1.8 PR2 Ratio (0-3.0)
- 7.0 Pri Clar Eff OrthoPhosphate (0-15.0) mg/L
- 12.8 Anaerobic Zone 1 OrthoPhosphate (0-40.0) mg/L
- 0.0 Anaerobic Zone 1 Nitrate (0-20.0) mg/L

QLF Pump Speed Control

QLF Pump Speed Control	35.0
PR2 @ Min Speed (0-40.0)	4.5
PR2 @ Max Speed (0-40.0)	2.5
Pump Start PR2 Ratio (0-40.0)	4.0
Pump Stop PR2 Ratio (0-40.0)	4.2
Pump Min Speed (%)	3.0
Pump Max Speed (%)	35.0
Pump Manual Speed (%)	5.0

QLF Pump HOA

HAND OFF AUTO

ON-LINE PROCESS ANALYZER

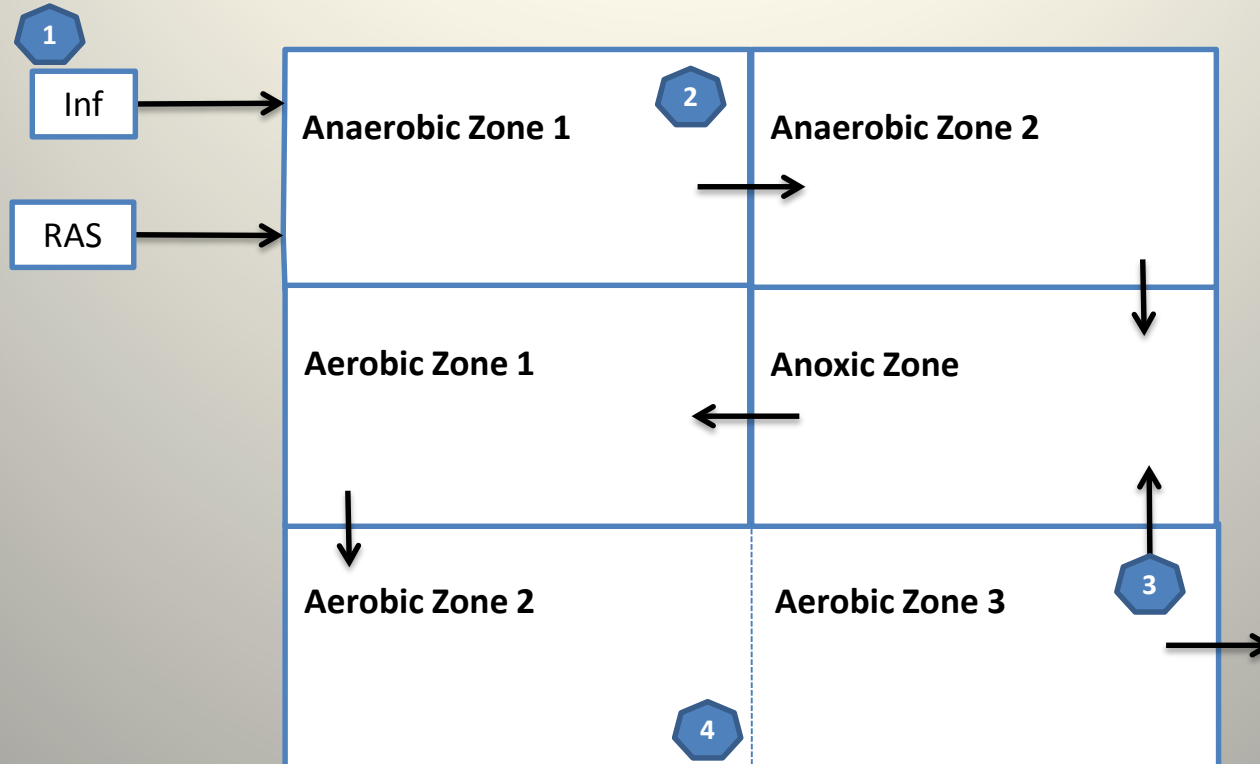
USED TO
CONTINUOUSLY
MONITOR 2 SAMPLE
POINTS, BPR INFLUENT
AND ANAEROBIC ZONE



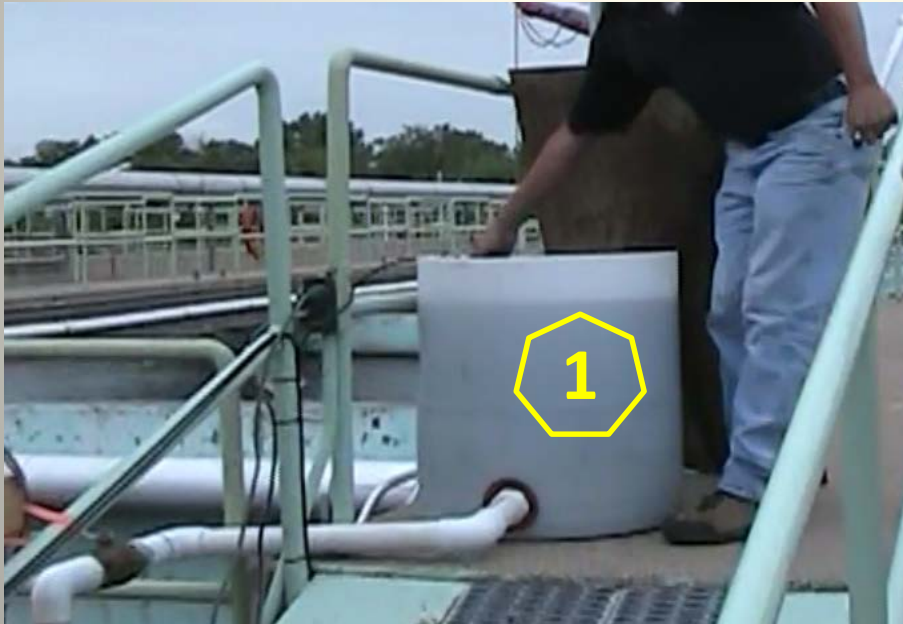
On-Line Analyzer Info

- 2 sample points
- In Situ filters
- Analyzes for orthophosphorus and nitrate
- Sampling Frequency – one every 15 minutes
- Analyte data can be used for monitoring and control

La Crosse WWTP BPR System A2/O



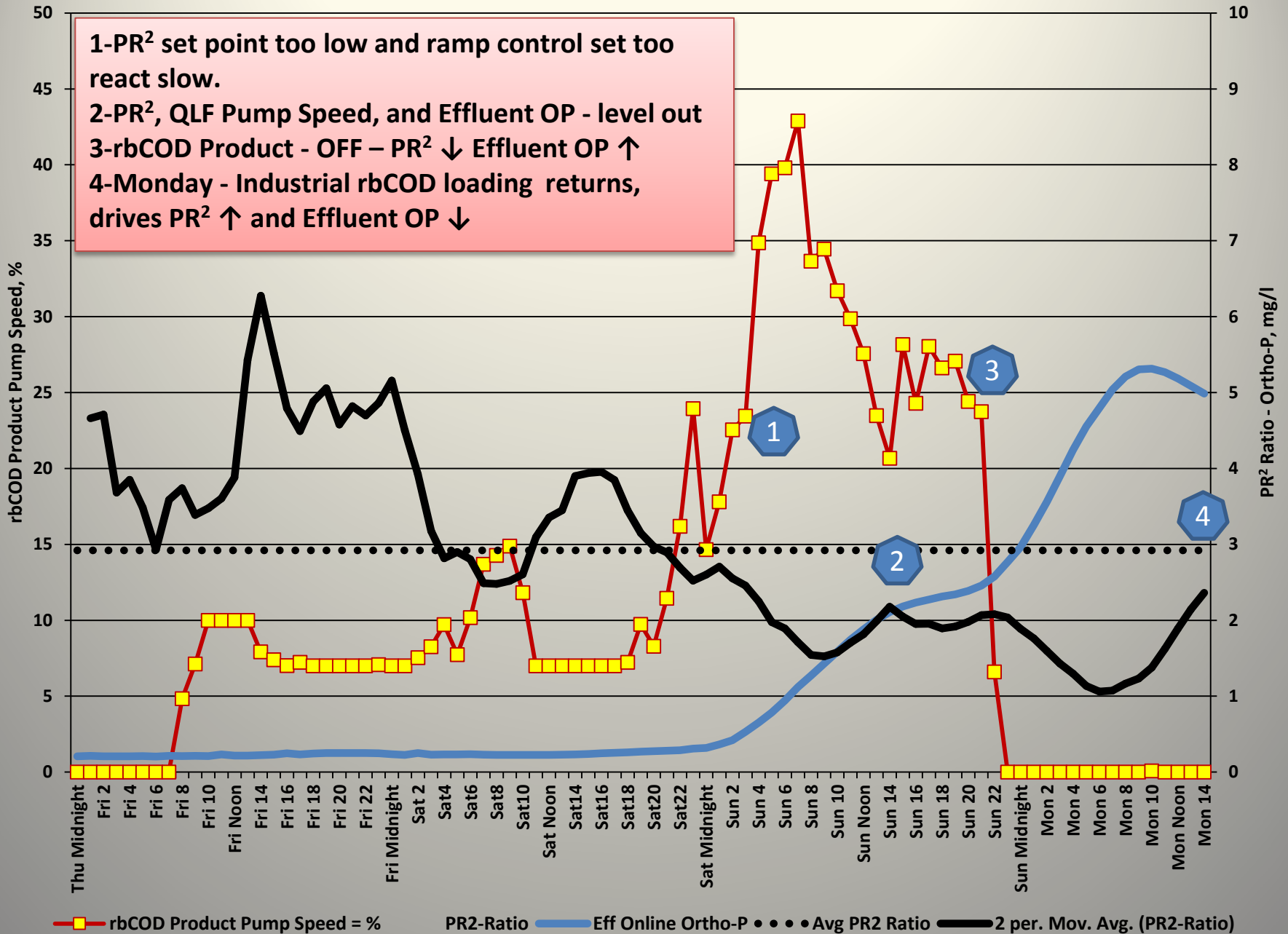
- 1 - BPR Influent Analyzer Sample Point
- 2 - Anaerobic Zone Analyzer Sample Point
- 3 - Nitrate Recycle Pump
- 4 - There is not wall at this location. It is divided into 2 zones for sampling purposes



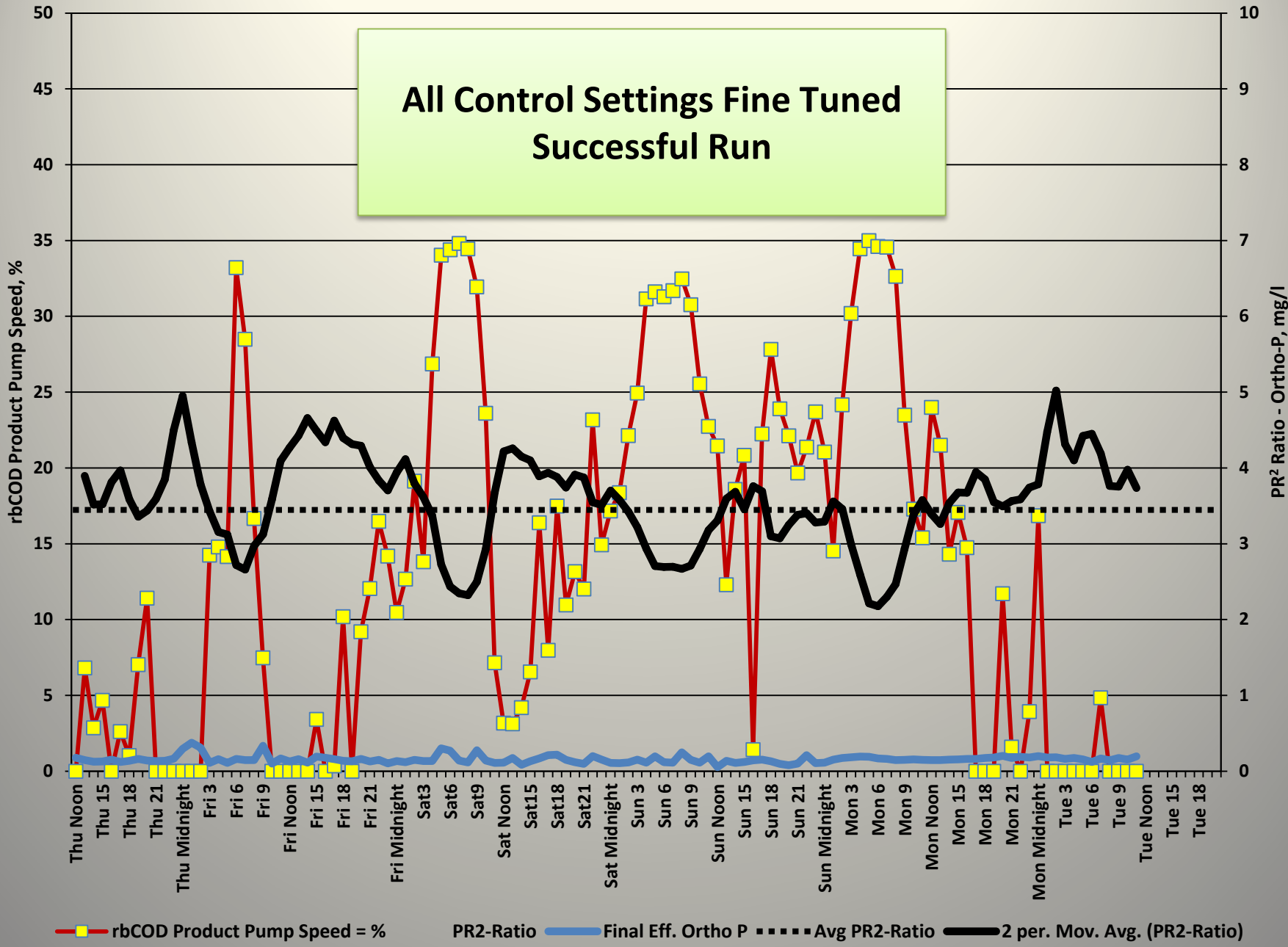
1. BPR influent sample point, primary effluent was pumped through drum to provide this sample point
2. Anaerobic Zone sampling point
3. Anaerobic Zone sample filter

Trial

- Length – 4 weeks
 - Focus on the weekends when rbCOD loading *changes*–
 - DID FEED AUTOMATICALLY DURING WEEK TOO AT HIGHER PR² SET POINT
- First Worked out Bugs, took 3 weeks
 - Learning the best dose setting required trial/error
 - Accidentally let on-line analyzer reagent run out
 - Etc



All Control Settings Fine Tuned
Successful Run



Conclusion

- Successful - Fed high rbCOD product automatically to maintain consistently low effluent DRP
- Each BPR system will have its own optimum PR^2 and its own unique rbCOD Demand to achieve that PR^2
- Auto feed high rbCOD system will not FIX Extreme rbCOD shock loads, operational issues and toxic loads - cover with automatic chemical feed system

Conclusion

- Benefits related to automated feed
 - Keep biology HAPPY – THEN IT PERFORMS
 - Providing rbCOD when necessary
 - Process covers multiple BPR sins
 - Nitrates in RAS or from recycle ammonia spikes – DATA FROM ANALYZER
 - Oxygen in RAS
 - P spikes in recycle
 - System works on rbCOD DEMAND not on influent rbCOD:TP ratio
 - Stops feeding – When Influent rbCOD is Adequate or High

Other Potential Benefits of Automatically Feeding High rbCOD

These need more investigation/assessment

- Reduced sludge production when compared to using chemical for P control
- Reduced effluent TSS because biological loading to system is stabilized
 - Eff TSS during the successful weekend of auto feeding study was very low – 1 to 2 mg/l usually 3 to 5 mg/l - **FIRST TIME EVER**

Other Potential Benefits of Automatically Feeding High rbCOD

These need more investigation/assessment

- Reduced heavy metals in sludge due to reduced ferric requirement
- Improved solids dewatering when compared to systems that use alum

Closing Thoughts

- How much rbCOD does a system need, and when?
- **BPR rbCOD demand (PR^2) vs. rbCOD:TP**
- Compare Chlorine Residual and PR^2
 - Chlorine residual is an indirect operational test
(Fecal) is demand met? -- nitrite \uparrow demand
 - PR^2 may also be an indirect measure of how much the BPR rbCOD Demand is satisfied
 - BPR systems have Real time Demands based on changing conditions in anaerobic zone
 - Changing rbCOD, P, NO_3 and O_2 loadings
- Establish the optimal PR^2 by comparing the PR^2 levels to effluent DRP

A photograph of a natural setting, likely a forest floor or stream bank. The background is a dense carpet of vibrant green moss. In the foreground, there are several bright green, leafy plants with rounded, lobed leaves, possibly a species of watercress or similar aquatic plant. A few thin, light-colored sticks or twigs are scattered among the plants and moss. The overall scene is lush and green.

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Questions