

Optimizing P removal at South Shore Water Reclamation Facility

Wisconsin Wastewater Operators Association
Conference October 23, 2013



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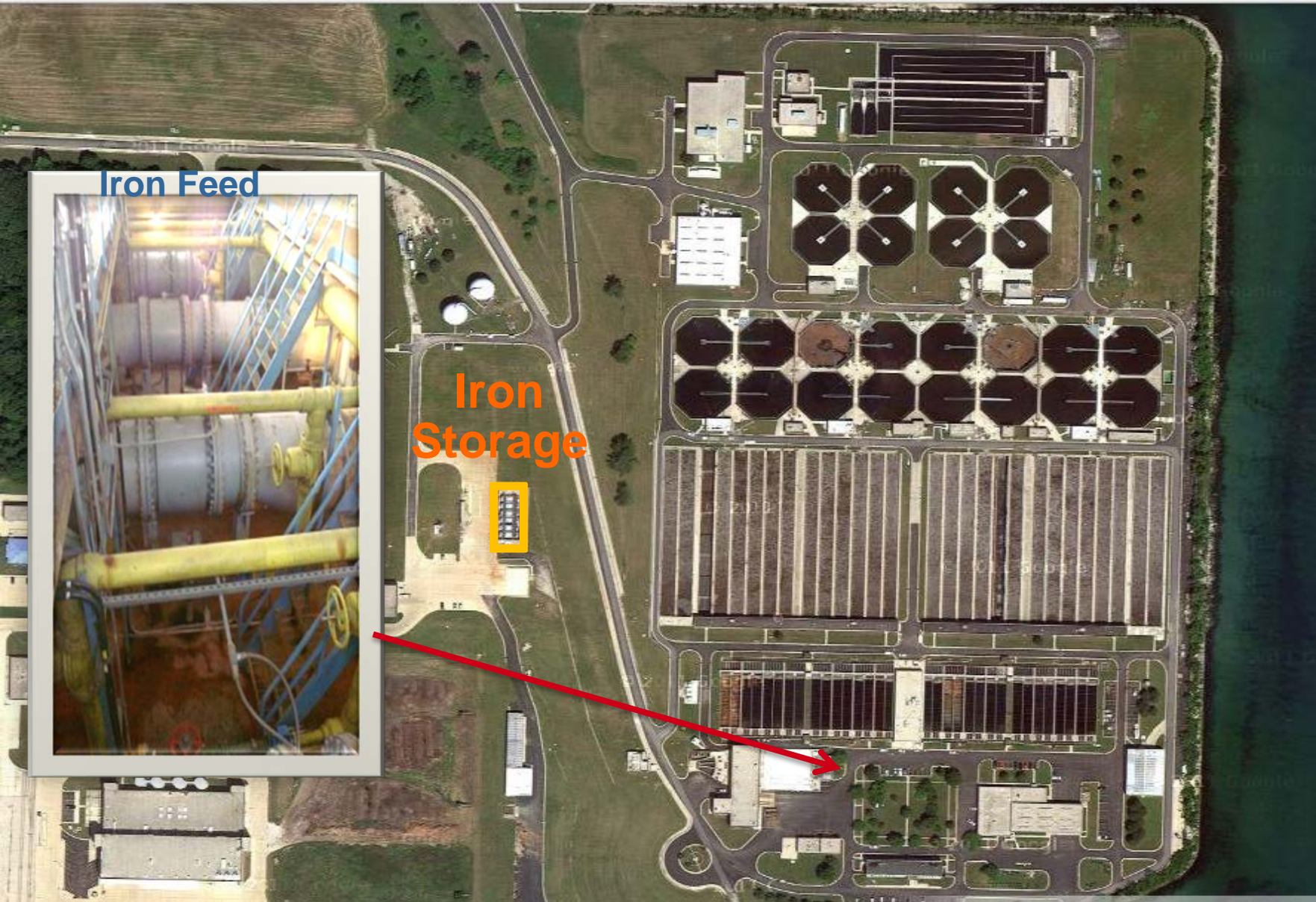
Historical & Current Conditions



South Shore Water Reclamation Facility



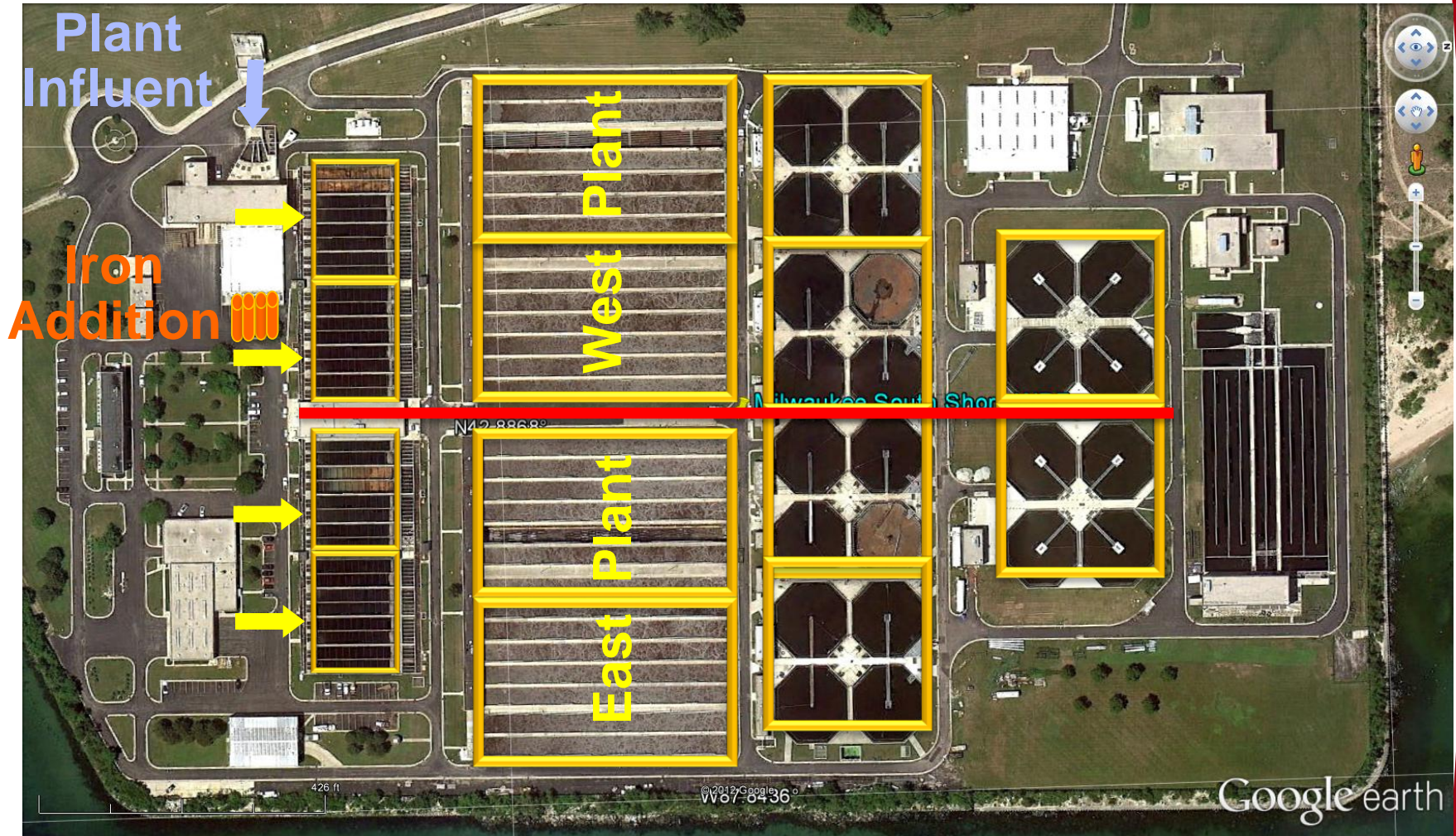
South Shore Water Reclamation Facility



Iron Feed

Iron Storage

South Shore Water Reclamation Facility



South Shore WRF P Removal– Historical Perspective

- Iron salts are added to the primary influent (PI) flow after screening & grit removal
 - Phosphorus Percent Removal in primaries depends on iron salt
 - higher when ferric chloride is used and
 - lower when pickle liquor is used
- Pickle Liquor/Ferric Chloride are mixed with dilution water and fed to the primary influent channels.
- Chlorine (Sodium hypochlorite) can be added to oxidize the pickle liquor iron (This option has not been used in years due to the cost of chlorine)
- South Shore Effluent discharged into Lake Michigan

South Shore WRF P Removal

- Residual iron in the plant's sludges are needed to meet the guaranteed iron in Milorganite
- Residual iron in the plant's primary sludge helps reduce H₂S in the plant's digesters & digester gas
- Effluent phosphorus limit since the 1970's = 1 mg/L TP
- Effluent TP limits changed recently
 - 0.80 mg/L Starting January 2013 (6-month Average)
 - 0.60 mg/L Starting November 2016 (6-month Average)





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Evaluation of Conditions Favorable for Bio-P at SS



Volatile Fatty Acids

• Why is it Important?

- Organic Material entering anoxic zone should be soluble and readily available to Phosphorus Accumulating Organisms (PAOs)
- Volatile Fatty Acids (VFAs) uptake and PHA? storage is the primary mechanism that give PAOs a selective advantage

• Recommended range in Literature

- 5-10 mg/L of VFAs for every 1 mg/L of phosphorus removed.
(*BNR Operation in WWTPs MOP 29*)

• South Shore Primary Effluent Data Results

- VFA concentration 85 mg/L During fall of 2011
- VFA concentration 75 mg/L During fall of 2012
- VFA:P ratio at SS 20:1 during 2011 and 2012 pilot tests

BOP : P Ratio

• Why is it Important?

- An adequate amount of organic material must be available to support PAOs

• Recommended range in Literature

- BOD₅:P ratio of at least 20:1, or
- COD:P ratio of at least 45:1, is needed for EBPR
(*Janssen et al., 2002*)

• South Shore Primary Effluent Data Results

- Primary Effluent BOD₅:P ratio = 36:1
- Primary Effluent COD:P ratio = 67:1

Nitrates in RAS

• Why is it Important?

- If nitrate (combined oxygen) enters the anaerobic zone, uptake of VFAs by the PAOs and phosphorus release is adversely impacted.
→ VFA are consumed by Denitrifiers

• Recommended range in Literature

- $\text{NO}_3 = 0 \text{ mg/L}$

• South Shore RAS NO_3 Results

- NO_3 concentration measured during the test period was 4 mg/L





Optimizing P Removal At South Shore



Optimize Iron Feed Starting in 2010

- Optimizing Iron Use by taking advantage of Aeration Basins Phosphorus Removal
- Aeration basins can remove around 30-40% of influent phosphorus (without anoxic zones)
- % P removal depends on primary effluent BOD:P Ratio and Soluble BOD
- Iron Salts Consumption reduced by 35%



Partial Bio P Starting Spring 2012

- Quasi-anaerobic/anoxic zones were created in the first zone of all aeration basins
 - Reduced air in first 12.5% of aeration basin
- Iron feed to the primary influent was maintained
- Air bumping for 2-4 hrs Weekly in the front zone of each aeration basins
 - To minimize solids settling and re-suspend settled solids in the front zone

Full Scale Bio P Pilot Fall 2011 and Fall 2012



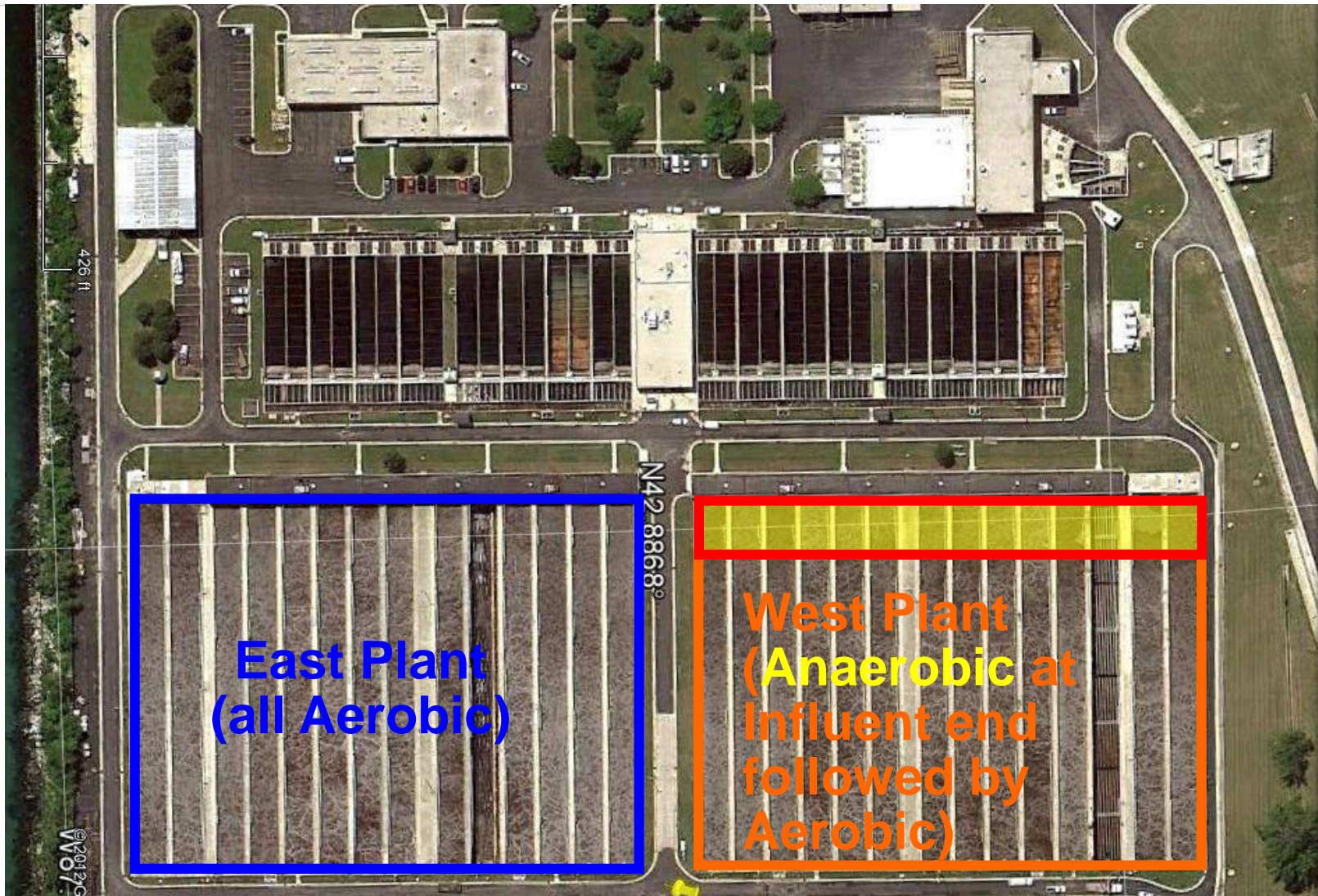
• Purpose of the testing:

- Feasibility of Bio P at South Shore WRF
- Capability to meet proposed effluent P limit of 0.80 mg/L (6 month Ave)

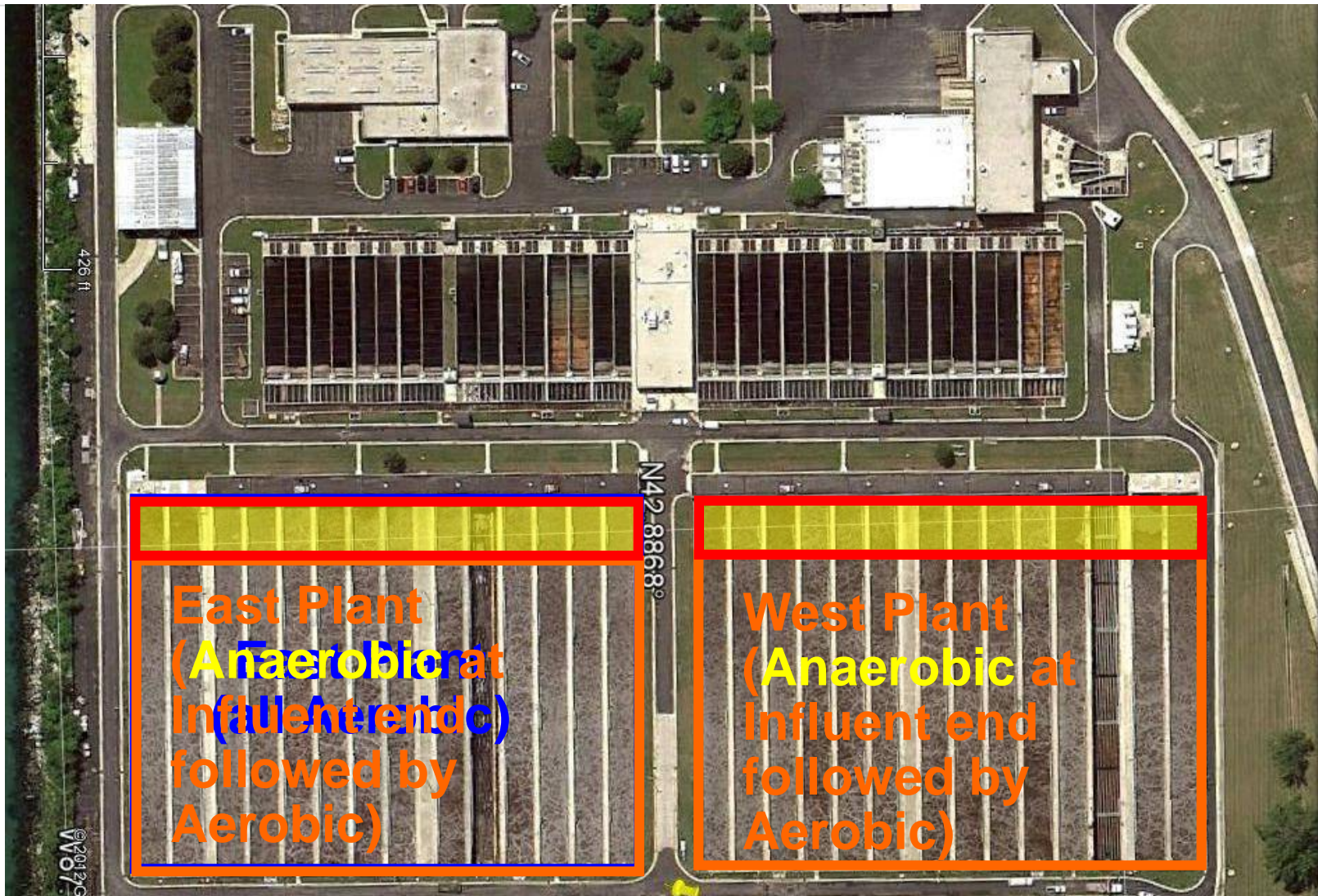
• Bio P Pilot Test Configuration:

- Anoxic Zone was created by lowering the air in first 12.5% of aeration basins in half of the Plant.
- After sometime iron feed was stopped
- Then Anoxic Zone was created in other half of the Plant
- After sometime Iron Feed was stopped

2011 EBPR Pilot – Initial Setup



2011 Final and 2012 EBPR Pilot Setup

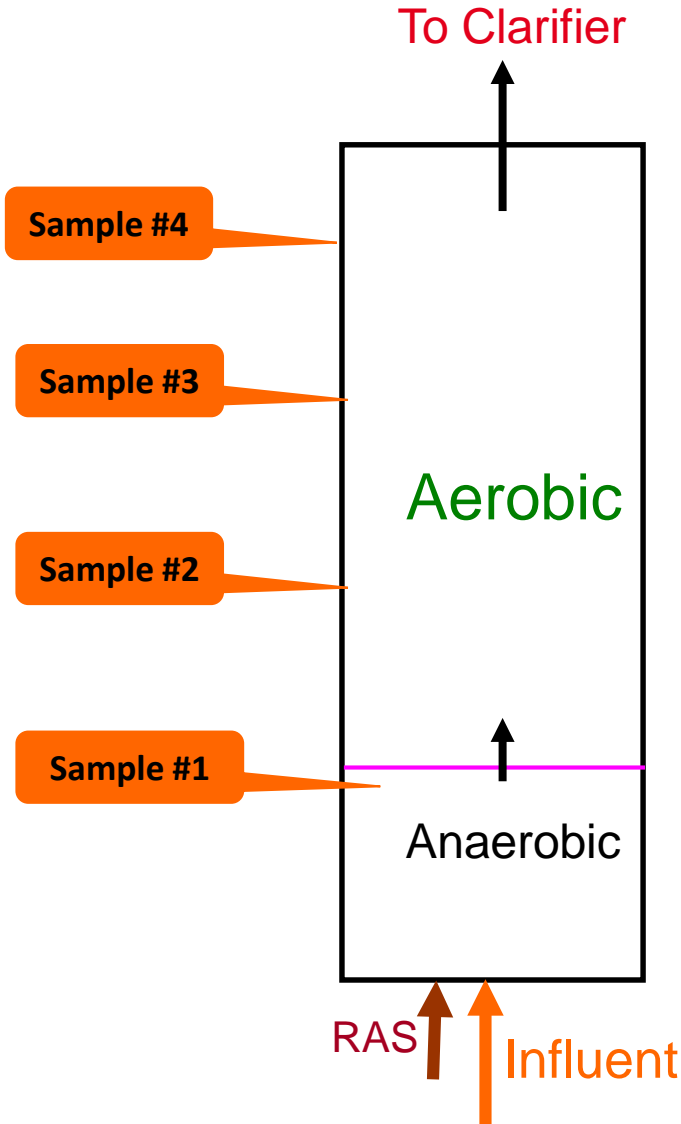


South Shore EBPR – Sampling and Testing

- Primary Effluent (West & East Plants): BOD, Total Phosphorus, Ortho P and VFA
- Secondary Effluent (West & East Plants): Total Phosphorus, Ortho P and Nitrates
- Final Effluent: Total Phosphorus and Ortho P
- RAS: Nitrates

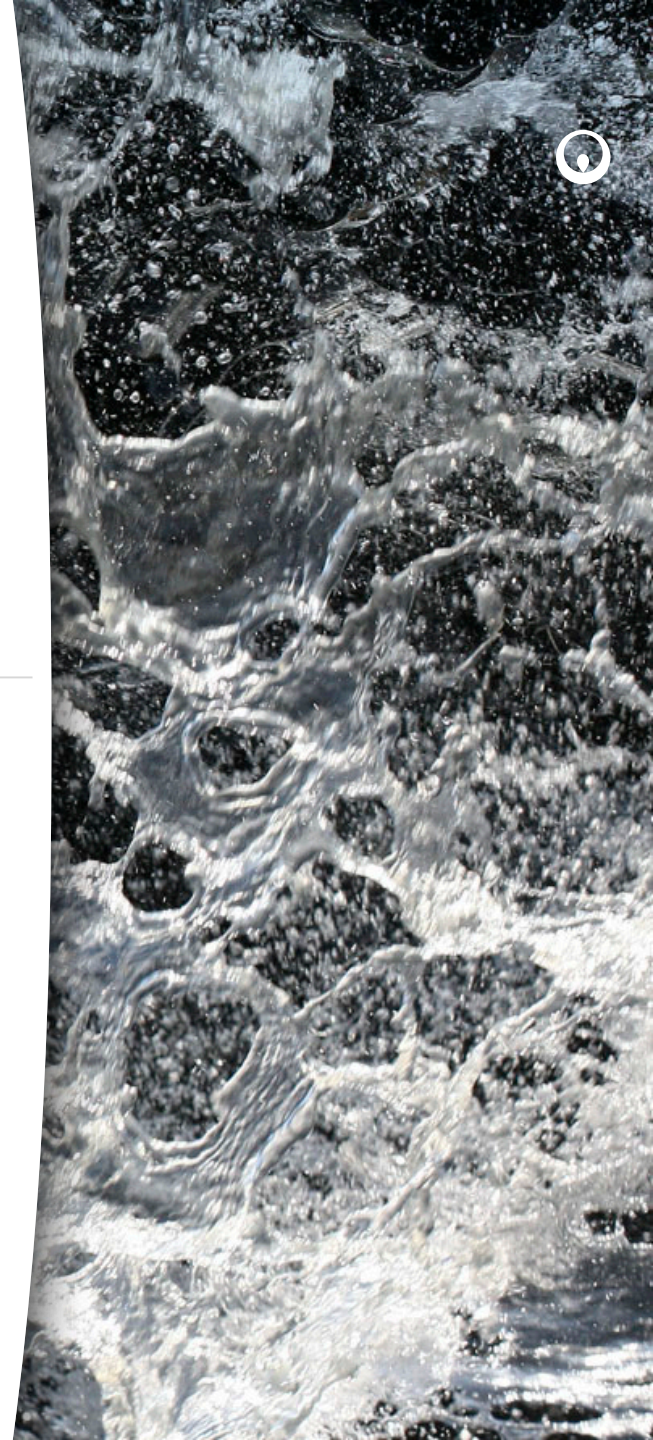


Aeration Basins Profiling-DO, Ortho P and NO3



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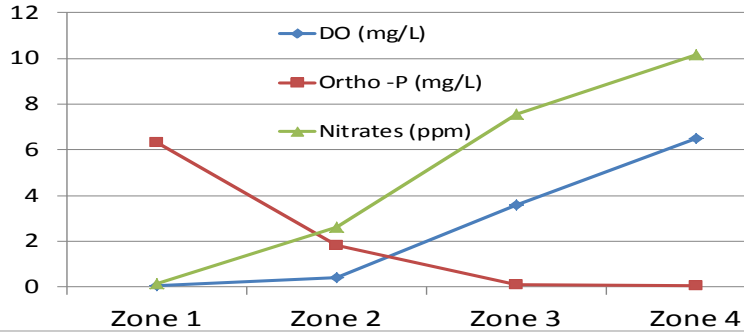
Pilot Study Results



Aeration Basins Profiling for DO, Ortho P and Nitrates- 2011 Pilot

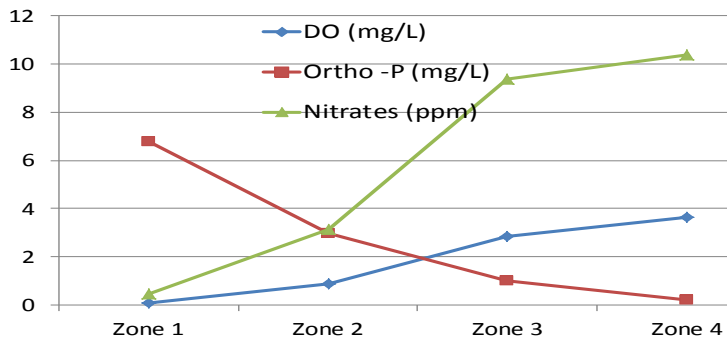


Aeration Basin 4 Profiling



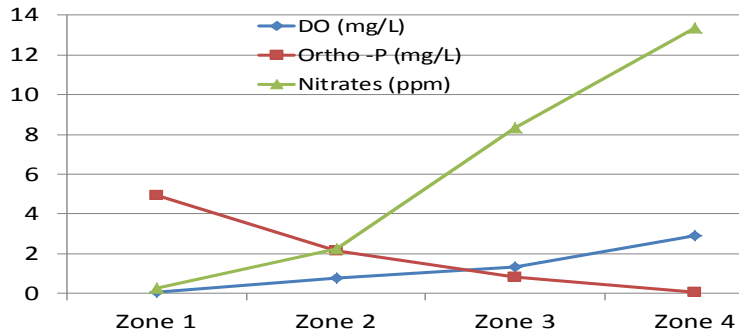
Average (9/19 - 10/10)	Aeration Basin 4			
	Zone 1	Zone 2	Zone 3	Zone 4
DO (mg/L)	0.07	0.42	3.59	6.51
Ortho -P (mg/L)	6.34	1.82	0.12	0.07
Nitrates (ppm)	0.14	2.64	7.57	10.14

Aeration Basin 12 Profiling



Average (9/19 - 11/10)	Aeration Basin 12			
	Zone 1	Zone 2	Zone 3	Zone 4
DO (mg/L)	0.08	0.89	2.83	3.65
Ortho -P (mg/L)	6.78	2.98	1.00	0.20
Nitrates (ppm)	0.45	3.14	9.37	10.39

Aeration Basin 17 Profiling

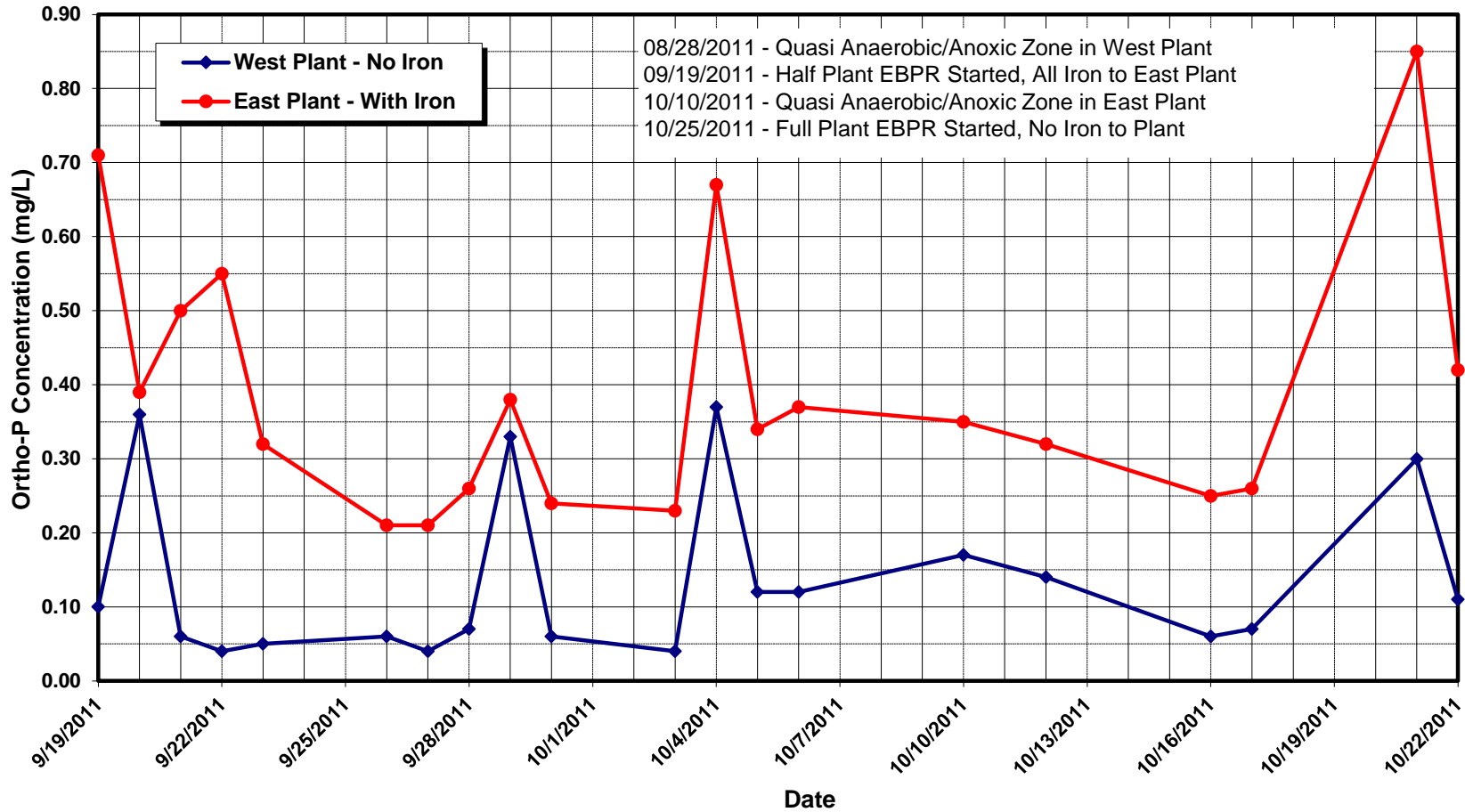


Average (10/29 - 11/10)	Aeration Basin 17			
	Zone 1	Zone 2	Zone 3	Zone 4
DO (mg/L)	0.09	0.79	1.33	2.93
Ortho -P (mg/L)	4.96	2.15	0.81	0.09
Nitrates (ppm)	0.25	2.25	8.33	13.33

2011 West Plant vs. East Plant Ortho Phosphorus



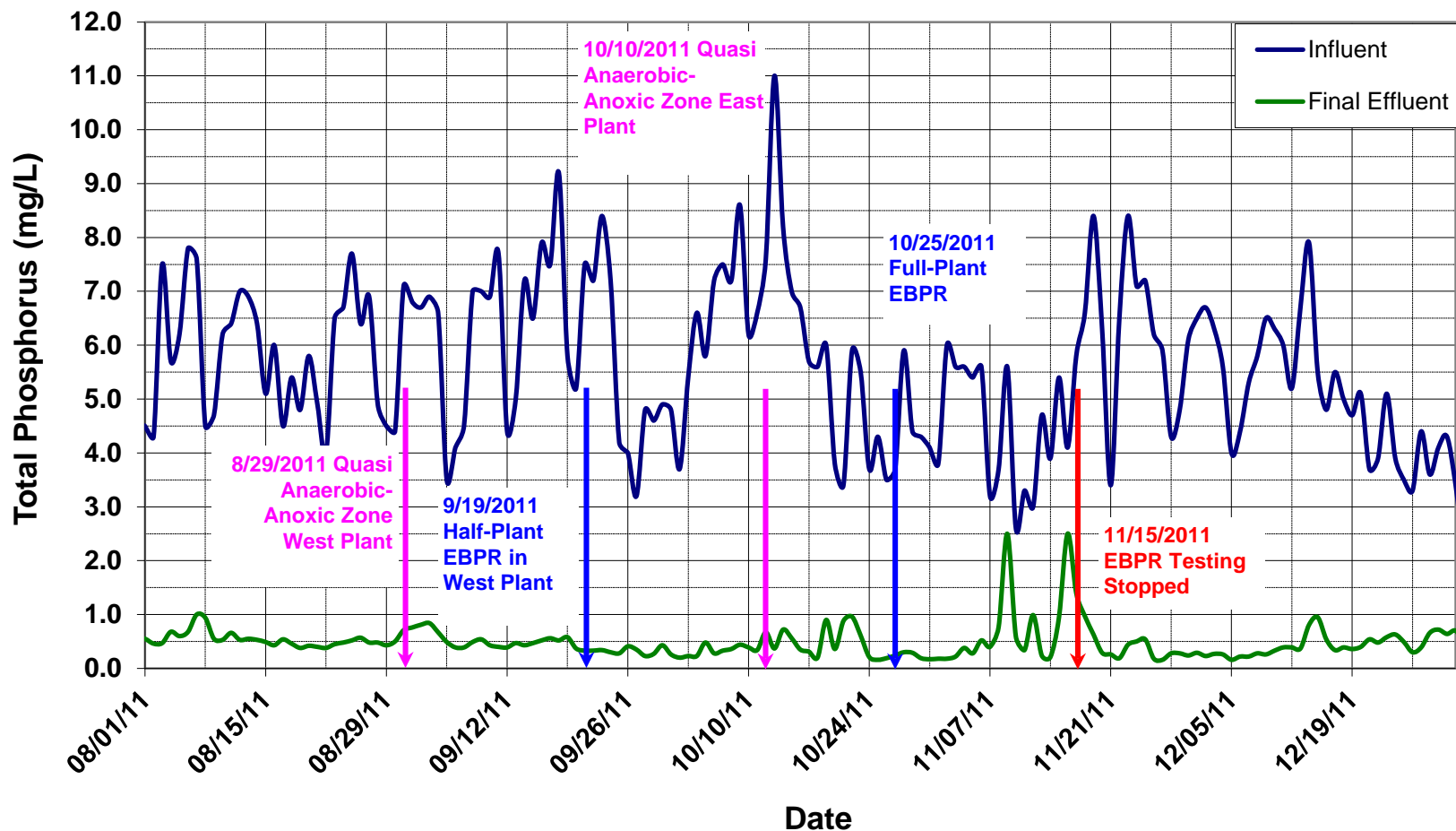
Effluent Ortho-P During EBPR



2011 EBPR Results



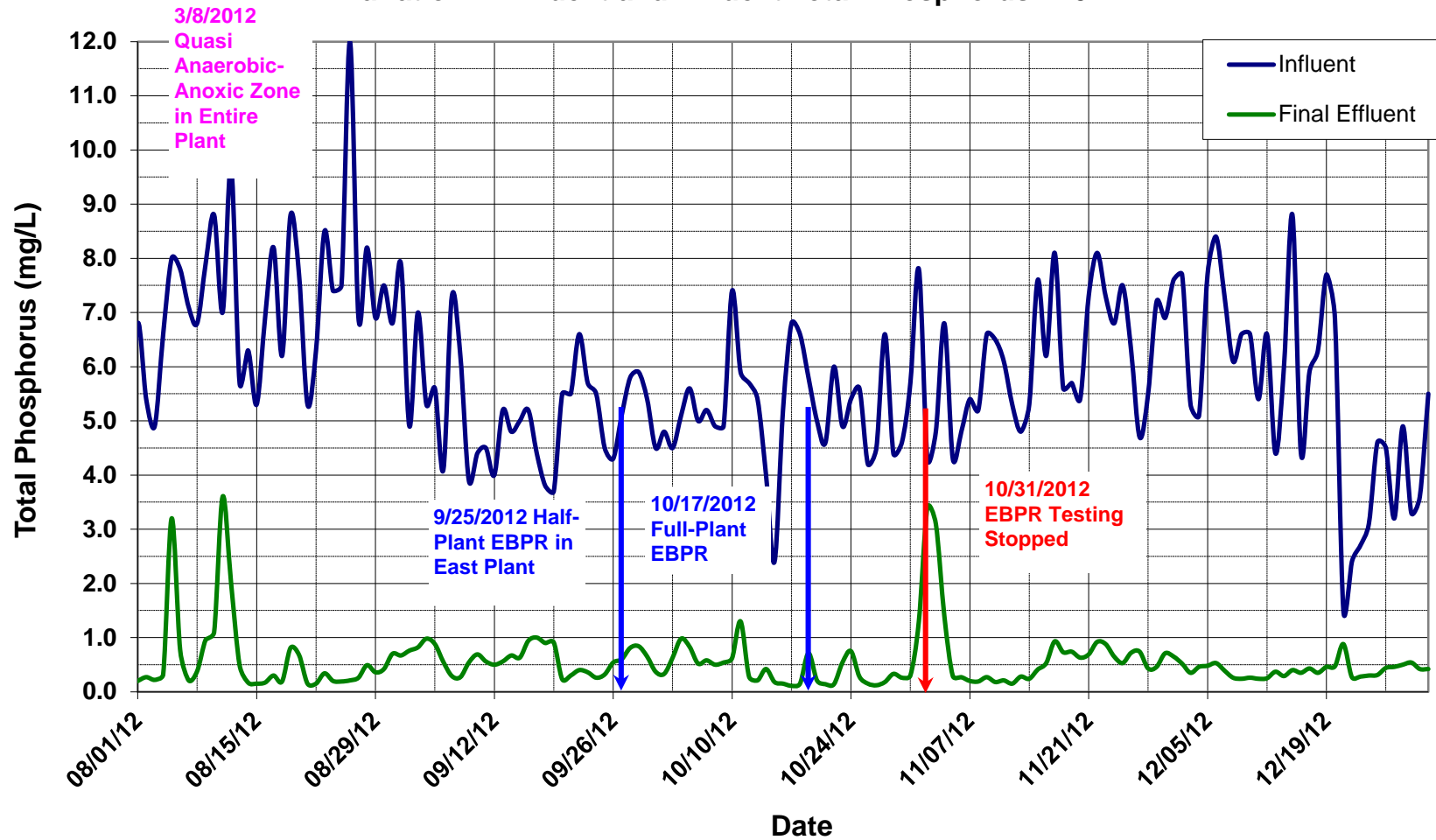
Variation in Influent and Effluent Total Phosphorus - 2011



2012 EBPR Results



Variation in Influent and Effluent Total Phosphorus - 2012



South Shore Final Effluent Phosphorus



Average for Period	SS Final Effluent Phosphorus, mg/L
Bio-P Test 2011	
Test Period <i>(Sep. 19 to Nov. 14, 2011)</i>	0.42
Outside of EBPR test period for 2011	0.51
Bio-P Test 2012	
Test Period <i>(Oct. 11 to Oct. 31, 2012)</i>	0.33
Outside of the EBPR test period for 2012	0.67
2006 – 2010 Average	0.60

Results Summary

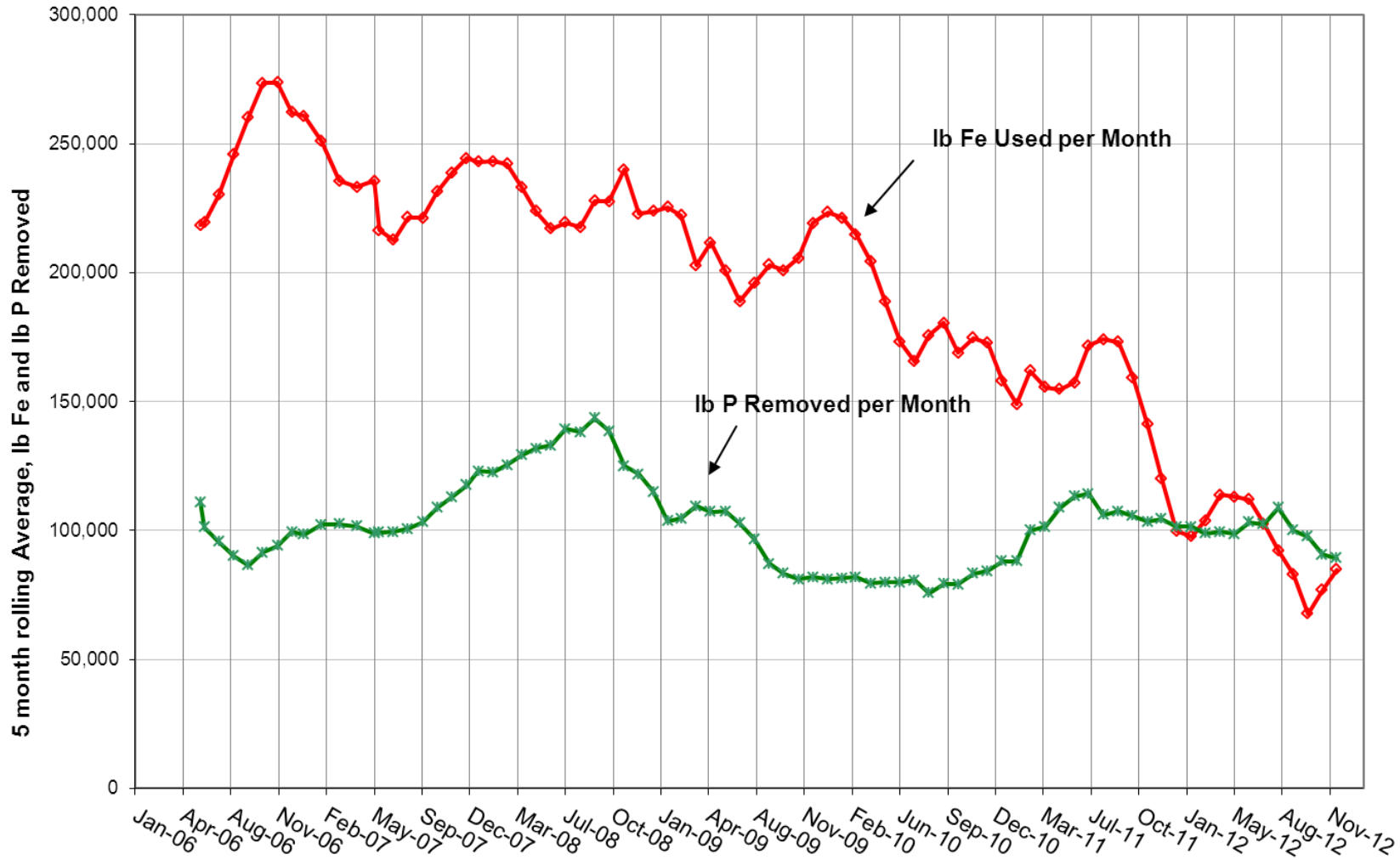
- Enhanced Biological Phosphorus removal is feasible at South Shore
- Bio P is capable of meeting the new effluent P limit of 0.80 mg/L (6 month Ave)
- Some free oxygen or nitrates did not appear to affect EBPR performance to a significant extent
- South Shore WRF service area includes northern and Western Suburbs
 - Very long detention time in sewer (>12 hrs)
 - Higher VFA than typical



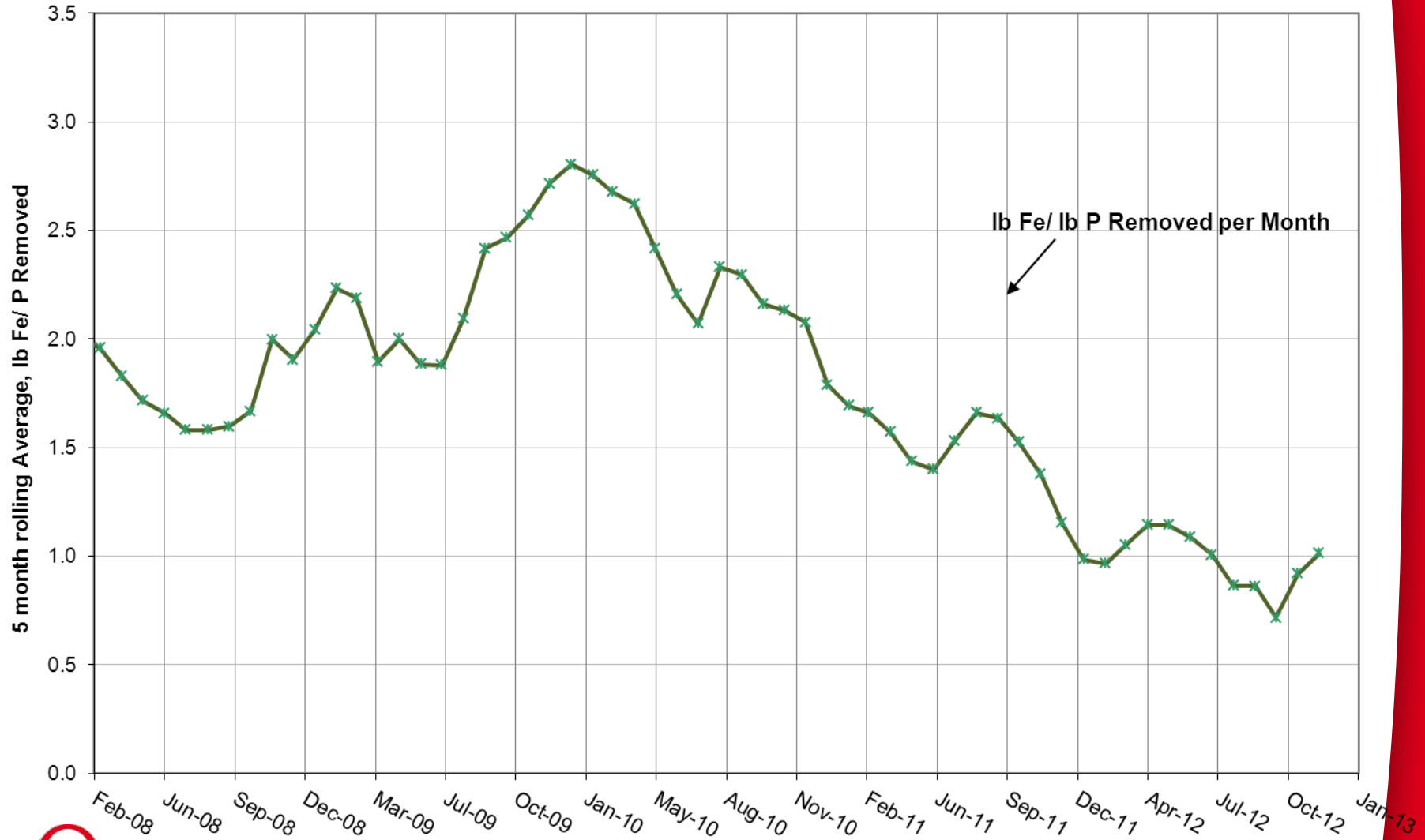
Overall Iron Use Reduction and Effluent P



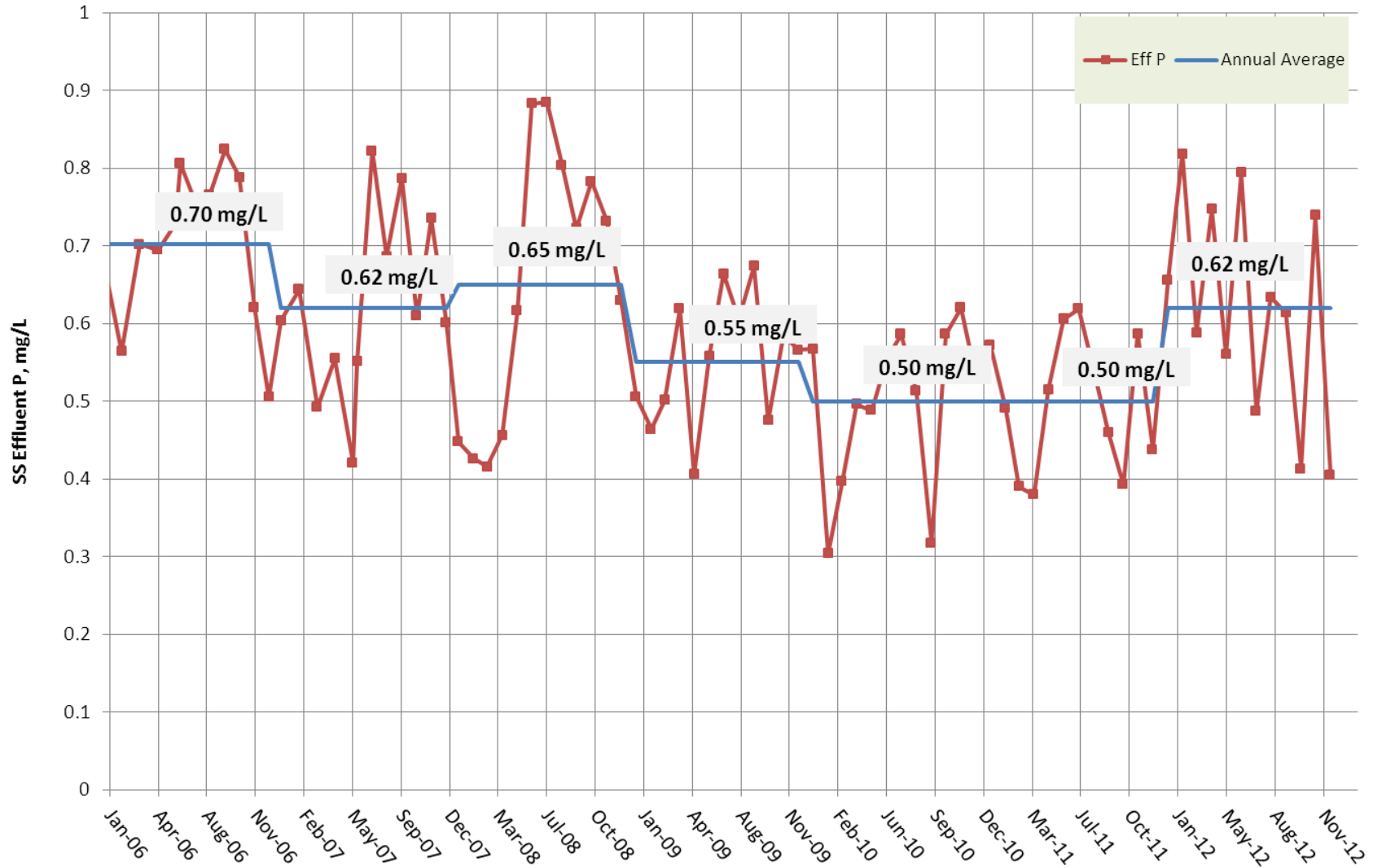
Iron (lb Fe) Used for SS Phosphorus Removal (2006-2012)



Iron (lb Fe) per Lb P Removed (2006-2012)



South Shore Effluent P 2006-Present (Monthly and Annual Averages)





Summary



Summary

- SS Aeration basins can remove around 30-99.9% of influent phosphorus biologically
- Iron use can be optimized by pushing some P to aeration basins
- Partial Bio P has proven to be a low cost P removal option
- Enhanced biological phosphorus removal is a “green” solution to remove phosphorus



Thank you for your time!

