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Push it to the Limit: Low Level Phosphorus Pilot Studies at the Fond du Lac Water Pollution Control Plant

WWOA Annual Conference
October 13, 2016

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Jeremy Cramer and Autumn Fisher, City of Fond du Lac

Outline of Presentation

- Background
- Optimization and Source Reduction
- Tertiary Treatment Technology Pilot Study Results
- Sidestream Phosphorus Harvesting
- Preliminary Cost Evaluation
- Next Steps

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Fond du Lac, WI Water Pollution Control Plant

- 9.8 mgd design average flow
- Discharge to Lake Winnebago
- Fine screens, grit removal, primary clarification, activated sludge with nitrogen removal, chemical P removal (CPR), UV disinfection

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WPDES Permit – P Effluent Limits

Item	Limit
Current/Interim Limit	1 mg/L
Future WQBELs	
Six-Month Average	0.04 mg/L
Monthly Average	0.12 mg/L
Mass limits are also included	

*WQBEL = Water Quality Based Effluent Limit

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Reissued Permit Sets Timeline for Various Phosphorus Compliance Steps

Item	Date
Permit Effective	1/1/13
Operational Evaluation Report	12/31/13
Study of Feasible Alternatives:	
Start	12/31/13
Status Report	12/31/14
Preliminary Compliance Plan*	12/31/15
Final Compliance Plan	12/31/16
Achieve Compliance with 0.04 mg/L**	1/1/2022

*WDNR allowed more of a status report

**if tertiary treatment is selected

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Timeline for Related Initiatives

Item	Date
Permit Effective	1/1/13
Operational Evaluation Report	12/31/13
Study of Feasible Alternatives:	
Start	12/31/13
Status Report	12/31/14
Preliminary Compliance Plan	12/31/15
Final Compliance Plan	12/31/16
Statewide Multidischarger Variance	**2016-17?**
Upper Fox/Wolf Total Maximum Daily Load for P	**2017?**
Design Treatment Improvements	**2017-2018**
Achieve Compliance with 0.04 mg/L	1/1/2022

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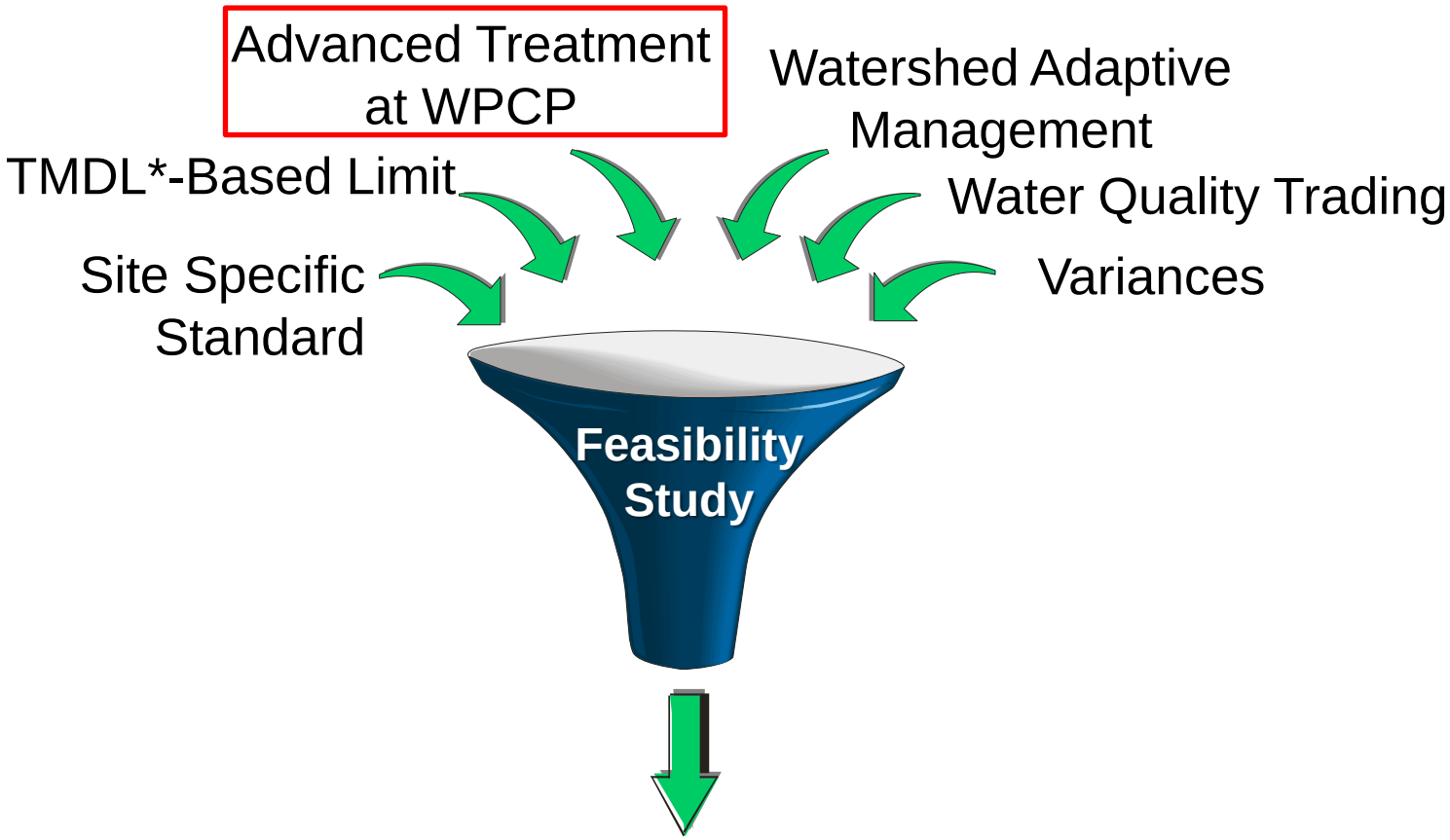
Study of Feasible Alternatives



Best Option(s) for Fond du Lac

*TMDL = total maximum daily load

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Operational Evaluation and Optimization

- P minimization
- Monitoring
- Full-scale biological phosphorus removal (BPR)
- Optimize chemical addition
  - Ferric Chloride
  - Alum
  - SorbX-100

Left to Right – Ferric Chloride, Alum, SorbX

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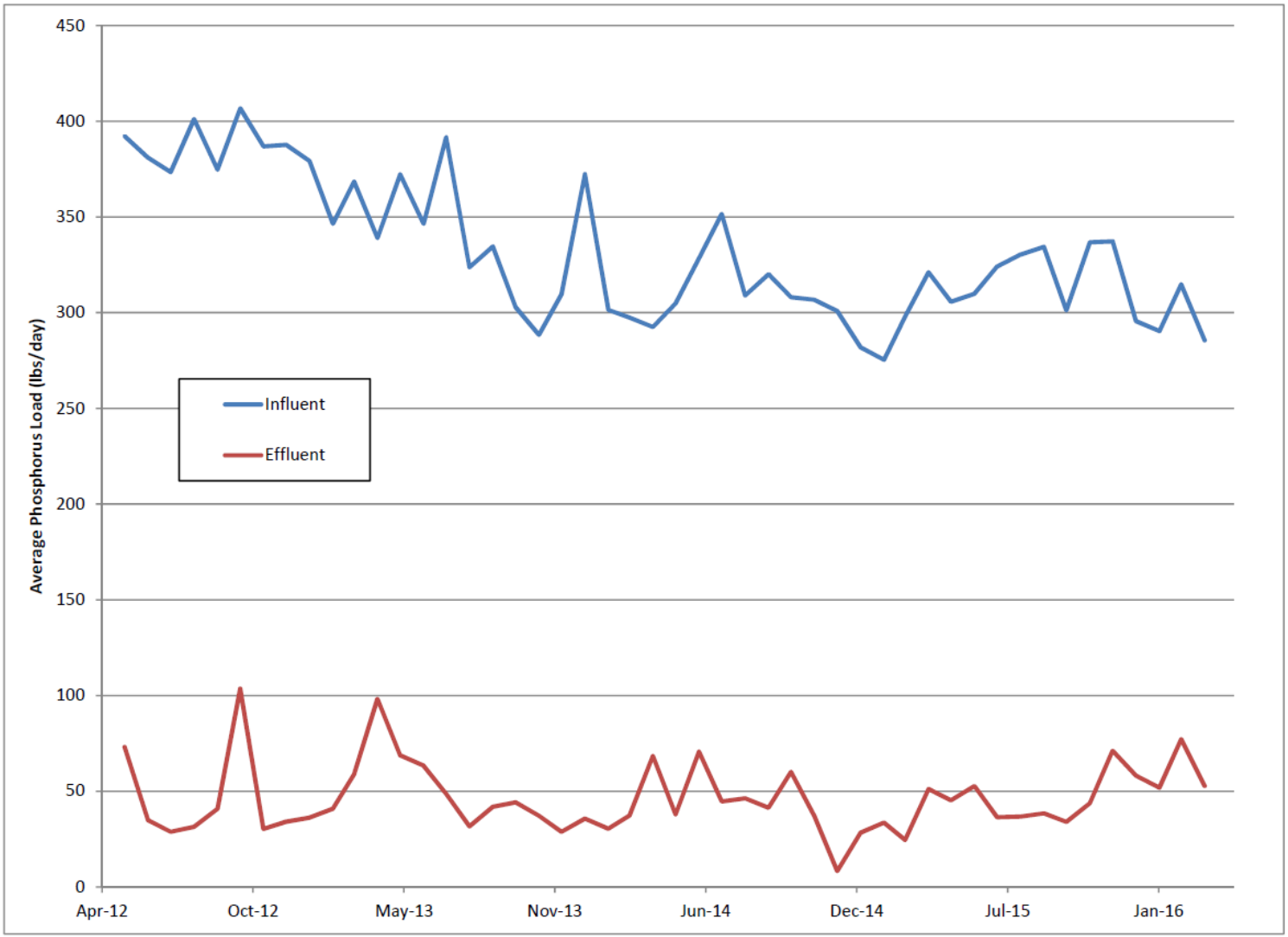
Influent Load Trend – Last Four Years



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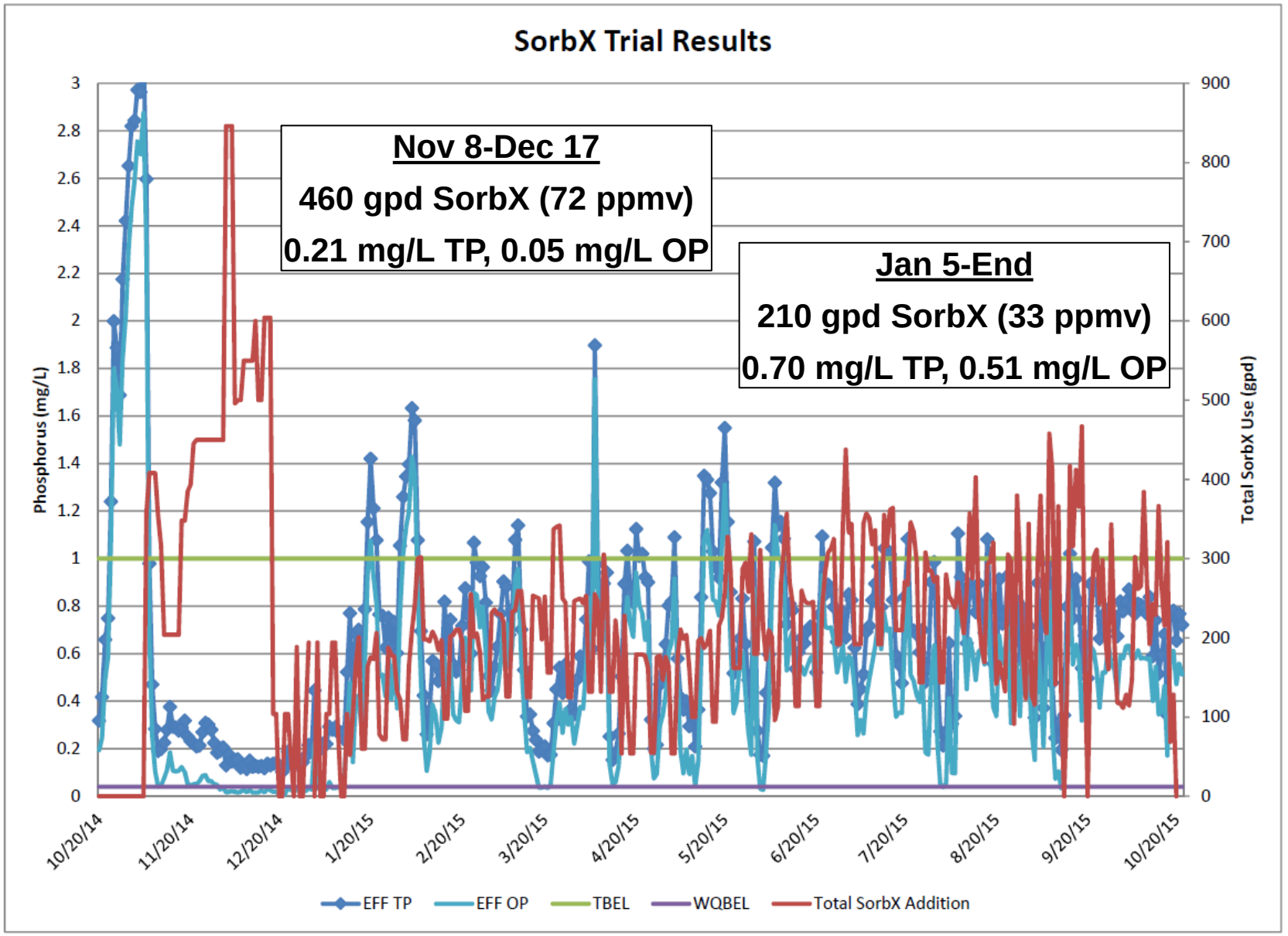
Full-Scale Chemical P Removal Test with SorbX-100



Full-Scale Chemical P Removal Test Observations

- Reduced struvite
- Cake solids similar
- Polymer use initially lower
- Aquatic toxicity and crop test results favorable
- May be more cost effective for lower limits

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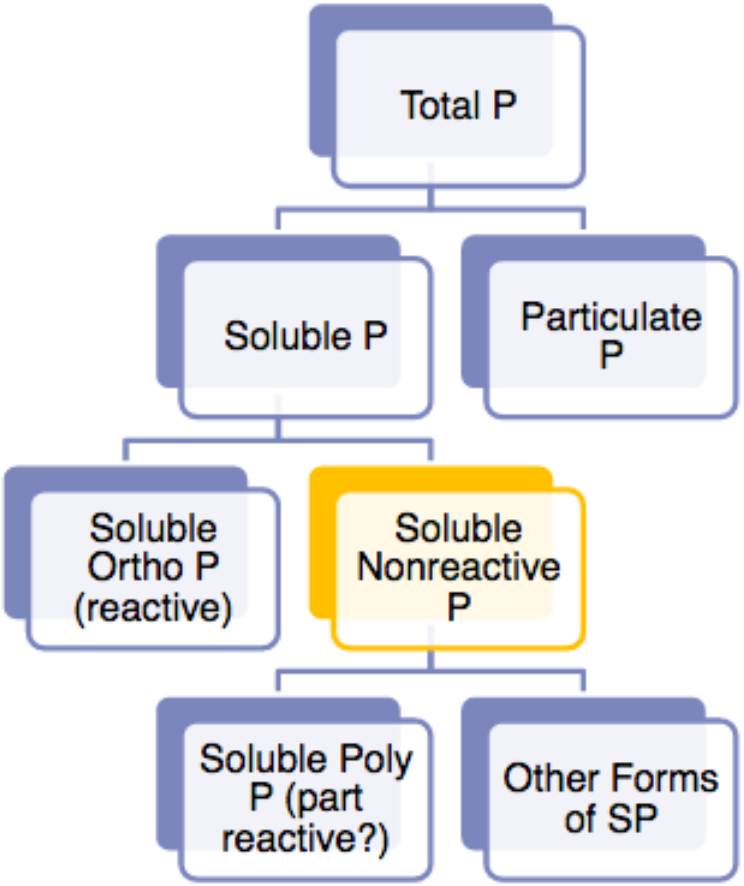
Soluble Nonreactive Phosphorus

- Not easily removed with chemical addition
- Can have major impacts on treatment costs
- Influent SNRP in Fond du Lac has varied – often over 0.04 mg/L WQBEL



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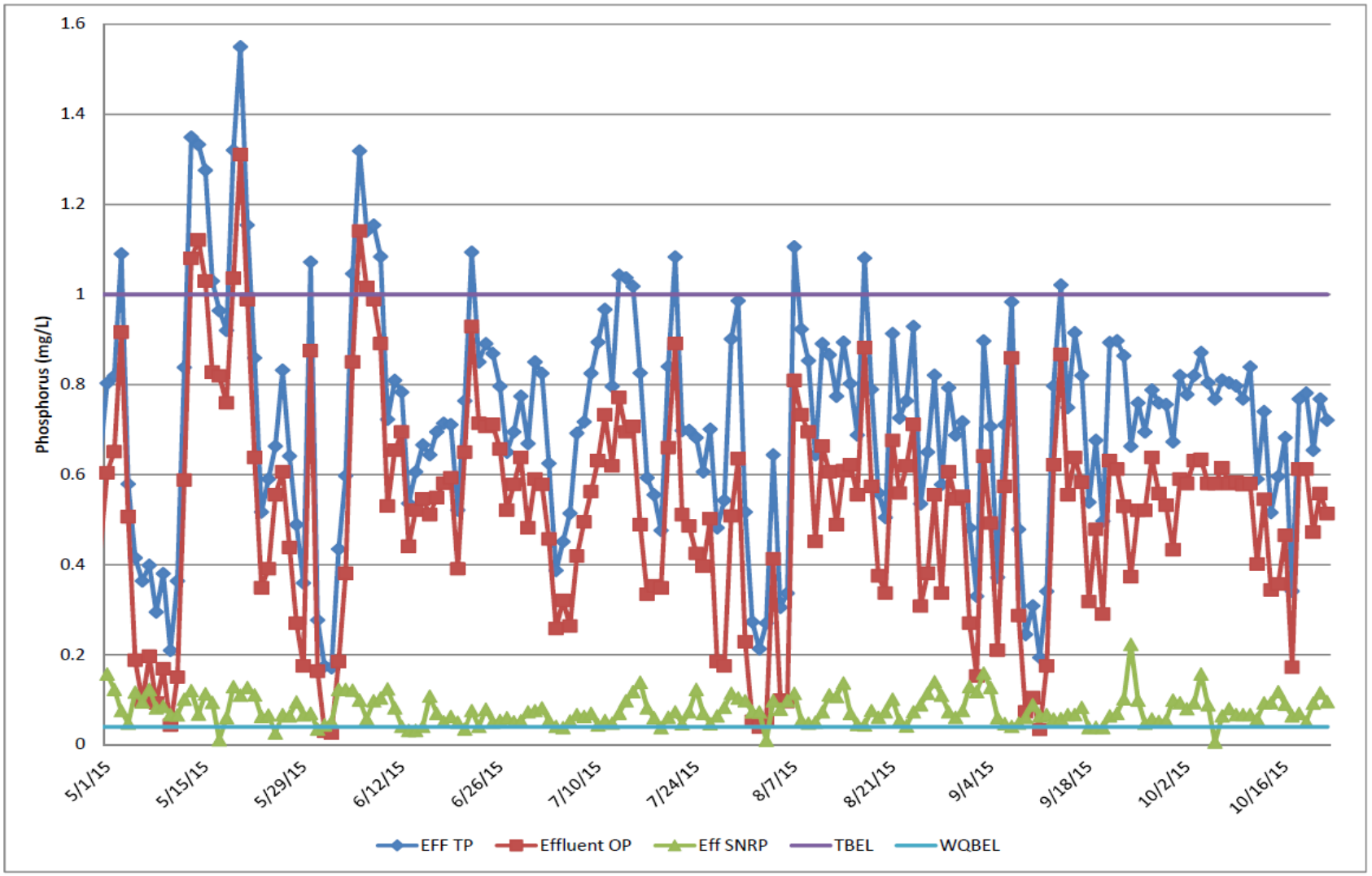
Soluble Nonreactive P (SNRP) Monitoring



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Pilot Studies of Tertiary Treatment Technologies

- Demonstrate ability of technology to achieve anticipated WQBEL
- Evaluate treatment response to stress tests
- Determine appropriate design criteria for full-scale implementation
- Provide familiarity of technologies to City staff

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Treatment Technologies Pilot Tested to Date

- COMAG® Ballasted Settling System
- ACTIFLO® Ballasted Settling System
- Ovivo TriSep Membrane System
- Aqua-Aerobic Systems AquaDisk® CMF and UF
- Clearas Water Recovery
- CNP AirPrex® Struvite Harvesting

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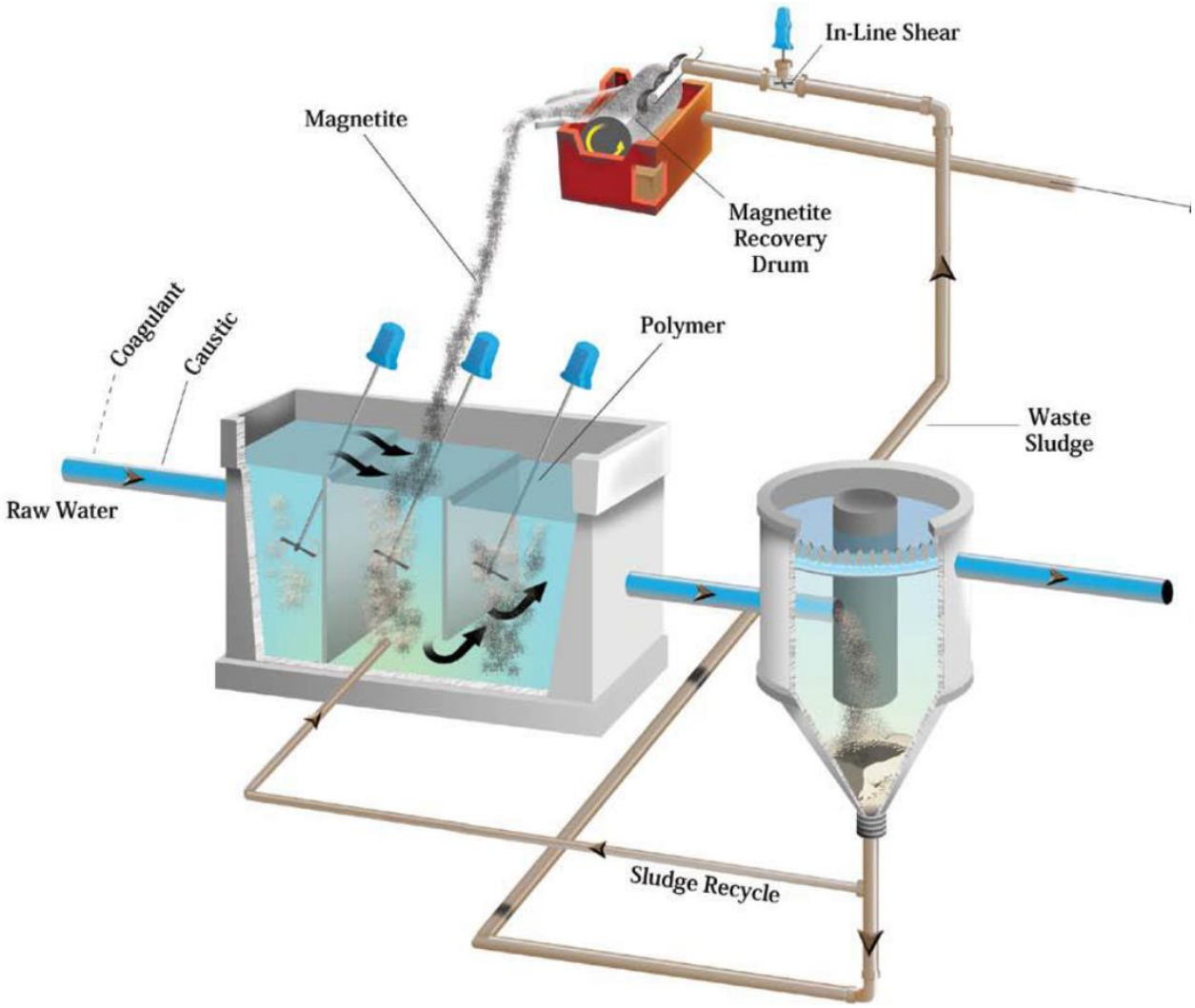
COMAG® Ballasted Settling System



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COMAG® Ballasted Settling System

- September 16, 2013 to October 15, 2013
- Normal operating pilot flow = 50 gpm
- Operated with alum, ferric chloride, and PACl
- Range of coagulant dosages used to generate dose-response curves

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COMAG® Ballasted Settling System

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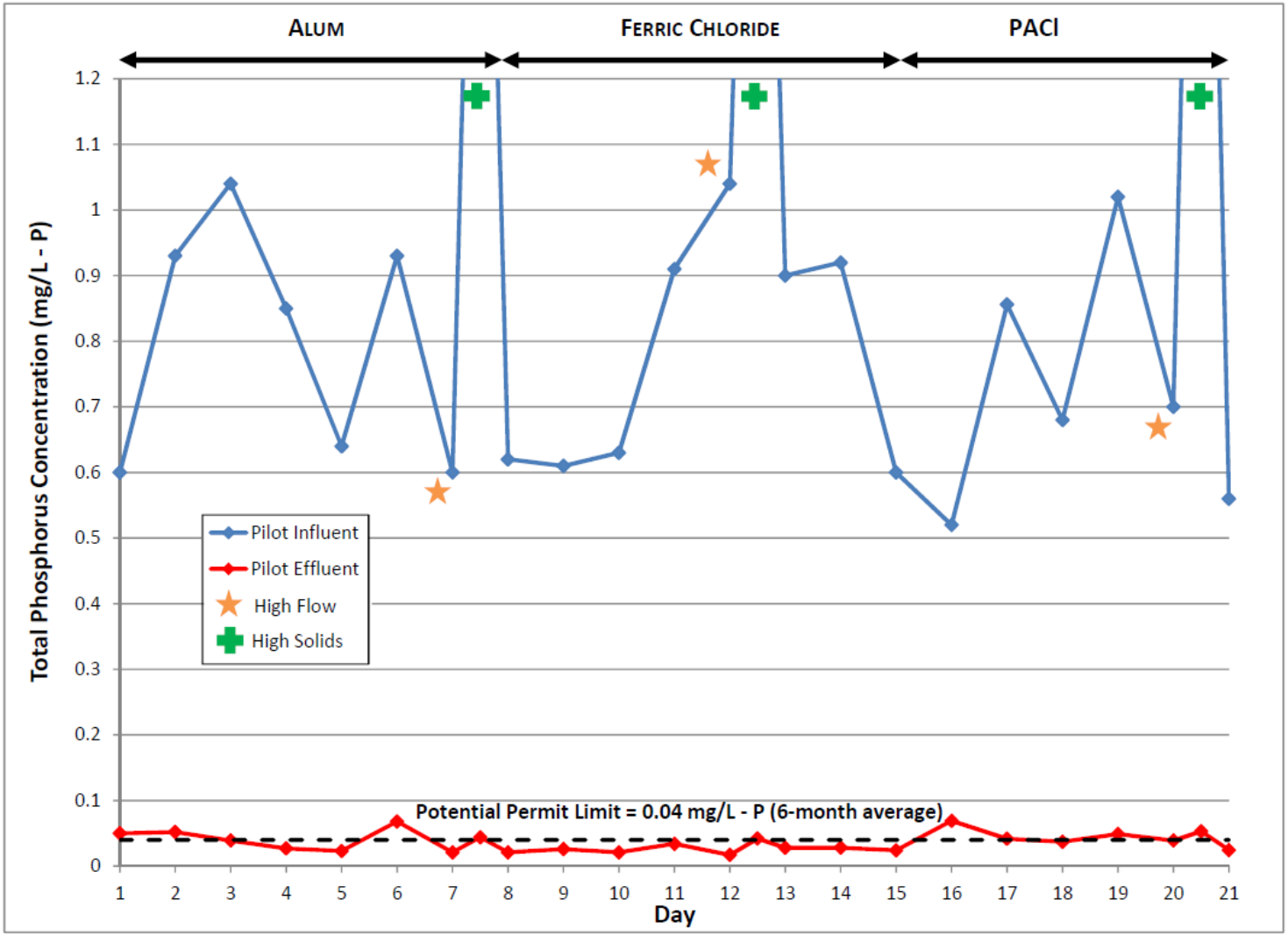
COMAG® Ballasted Settling System



- Stress test for high solids – 100 mg/L TSS
- Stress test for high flow – 2X flow

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COMAG® Ballasted Settling System

Coagulant	Pilot Influent TP Average	Pilot Effluent TP Average	TP Percent Reduction
Alum	1.0 mg/L	0.039 mg/L	96%
Ferric Chloride	0.97 mg/L	0.025 mg/L	98%
PACl	0.91 mg/L	0.040 mg/L	96%

- Required Coagulant Dosages:
  - Alum – 12 mg/L as Al
  - Ferric Chloride – 24 mg/L as Fe
  - PACl – 20 mg/L as Al
- Polymer 0.7-0.8 mg/L dry weight

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COMAG® Ballasted Settling System

Coagulant	Influent TSS Average	Effluent TSS Average	TSS Percent Reduction
Alum	28.9 mg/L	1.6 mg/L	95%
Ferric Chloride	19.3 mg/L	1.9 mg/L	90%
PACl	25.1 mg/L	3.2 mg/L	87%

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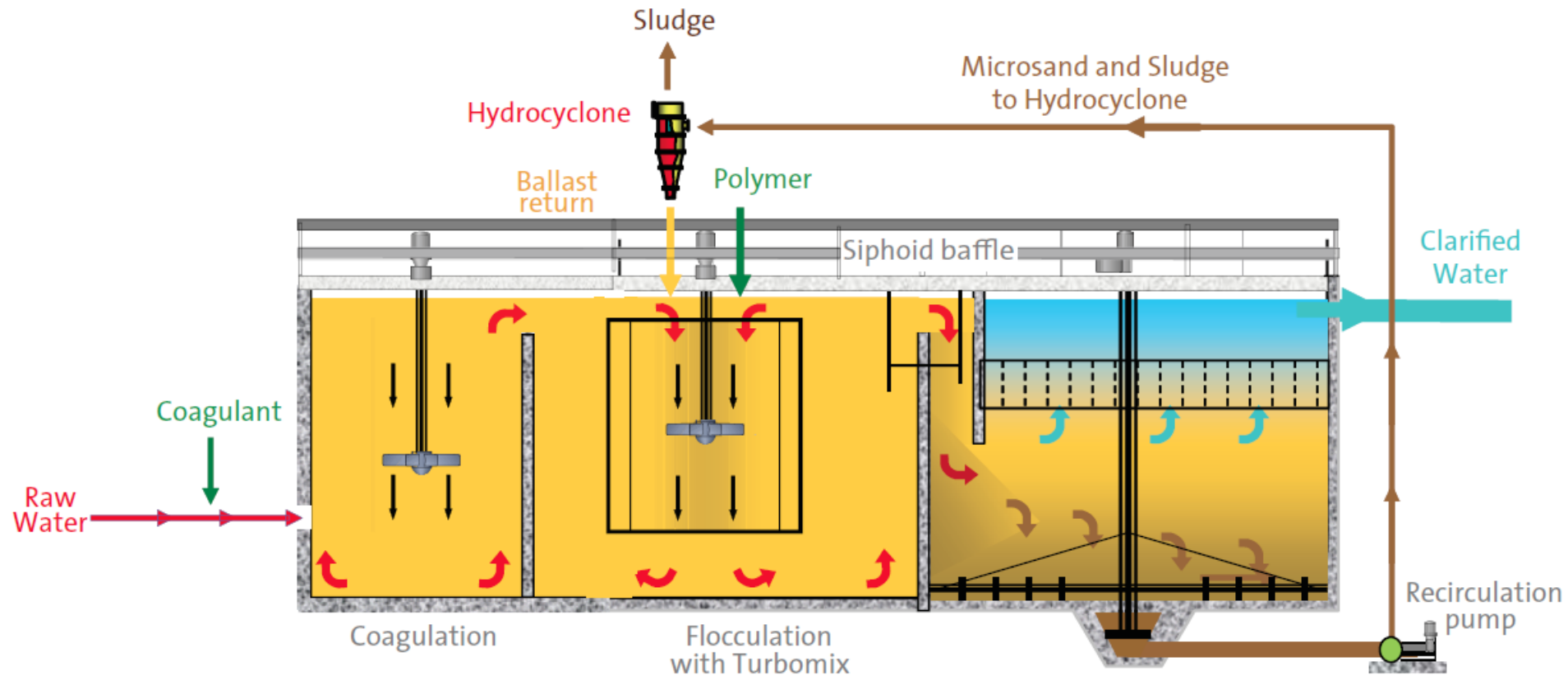
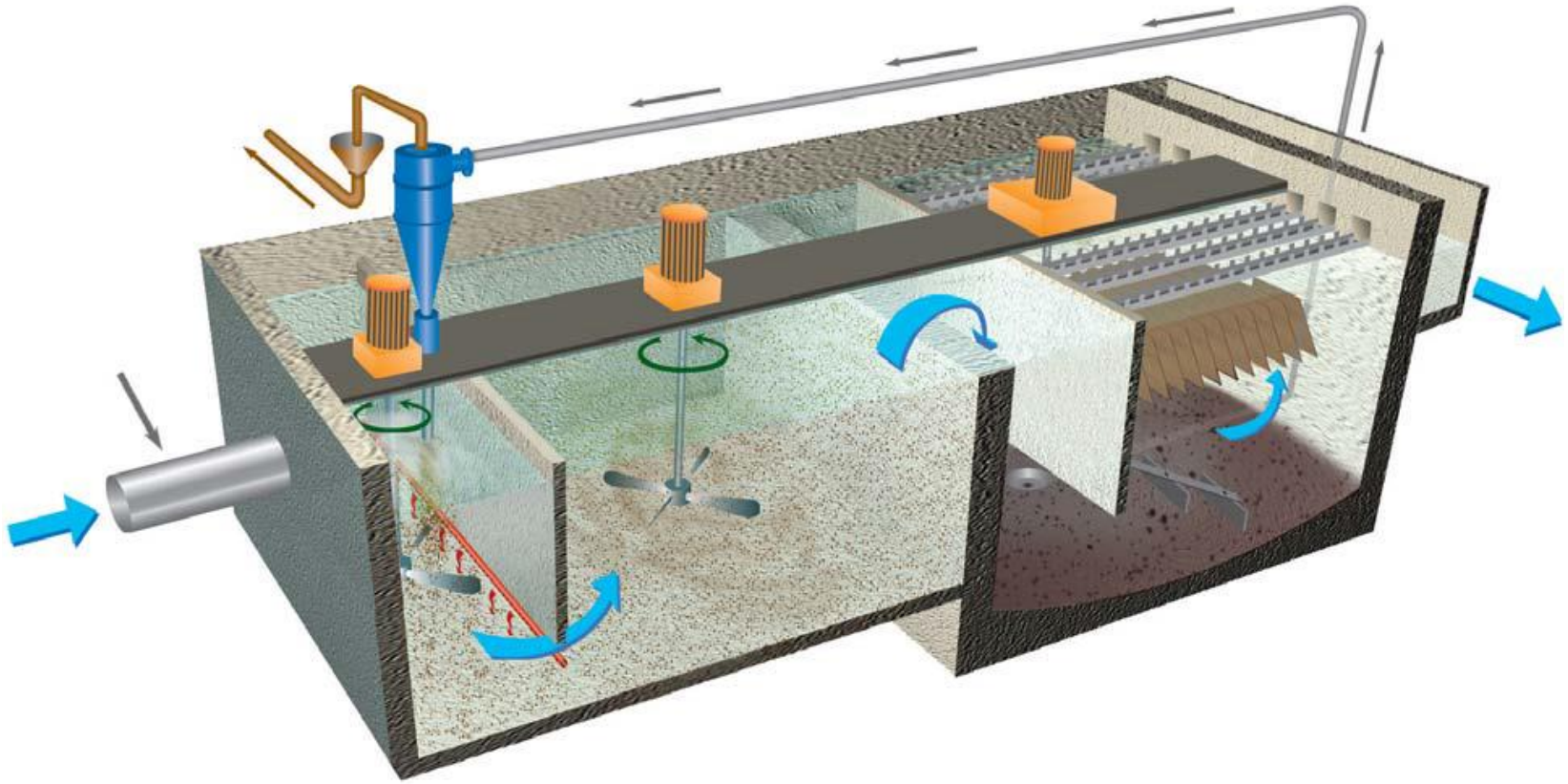
ACTIFLO® Ballasted Settling System

- June 1st through June 19th, 2015
- 59-242 gpm (8-40 gpm/sf)



Source: Veolia

ACTIFLO® Ballasted Settling System



Source: Veolia

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ACTIFLO® Ballasted Settling System

Pilot Study Procedure:

- Coagulant dose optimization
- Polymer dose optimization
- Hydraulic loading rate response
- Extended run to demonstrate performance

- Conducted with Ferric Chloride, Alum, and SorbX-100

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ACTIFLO® Ballasted Settling System

Pilot Study Procedure:

- Coagulant dose optimization
- Polymer dose optimization
- Hydraulic loading rate response
- Extended run to demonstrate performance

Coagulant	Optimum Dose
Ferric Chloride	70-80 mg/L
Alum	>220 mg/L
SorbX-100	80-95 mg/L

Effluent TP >0.04 mg/L

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ACTIFLO® Ballasted Settling System

Pilot Study Procedure:

- Coagulant dose optimization
- Polymer dose optimization
- Hydraulic loading rate response
- Extended run to demonstrate performance

Coagulant	Optimum Dose
Ferric Chloride	0.6 to 1.2 mg/L No significant impact
Alum	-
SorbX-100	0.6 to 1.2 mg/L No significant impact

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ACTIFLO® Ballasted Settling System

Pilot Study Procedure:

- Coagulant dose optimization
- Polymer dose optimization
- Hydraulic loading rate response
- Extended run to demonstrate performance

Coagulant	Rise Rate
Ferric Chloride	40 gpm/sf
Alum	-
SorbX-100	32 gpm/sf

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ACTIFLO® Ballasted Settling System

Pilot Study Procedure:

- Coagulant dose optimization
- Polymer dose optimization
- Hydraulic loading rate response
- Extended run to demonstrate performance

Coagulant	Influent TP Average	Effluent TP Average
Ferric Chloride (32 gpm/sf, 72-100 mg/L)	0.67 mg/L	0.04 mg/L
Alum	-	-
SorbX-100 (16 gpm/sf, 95 mg/L)	0.77 mg/L	0.04 mg/L

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ACTIFLO® Ballasted Settling System

Soluble Nonreactive Phosphorus Results

Coagulant	Influent SNRP Average	Effluent SNRP Average
Ferric Chloride	0.08 mg/L	0.02 mg/L
Alum	0.13 mg/L	0.03 mg/L
SorbX-100	0.07 mg/L	0.03 mg/L

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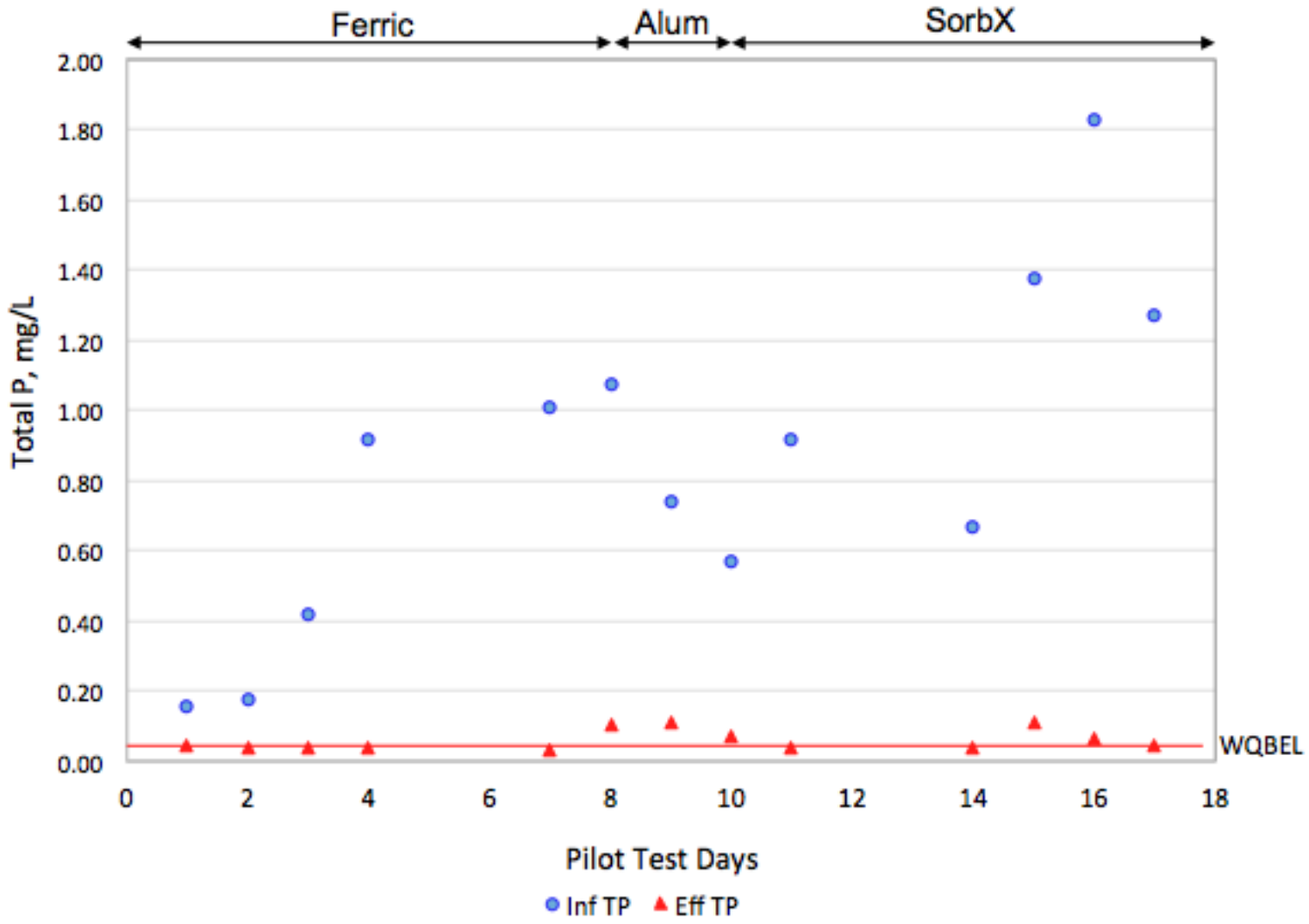
ACTIFLO® Ballasted Settling System



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Ovivo TriSep Membrane System

- March 18, 2015 – April 23, 2015
- iSep™ 500-PVDF UF membrane
- 6 gpm pilot unit
- Operated with alum and SorbX-100

Source: TriSep

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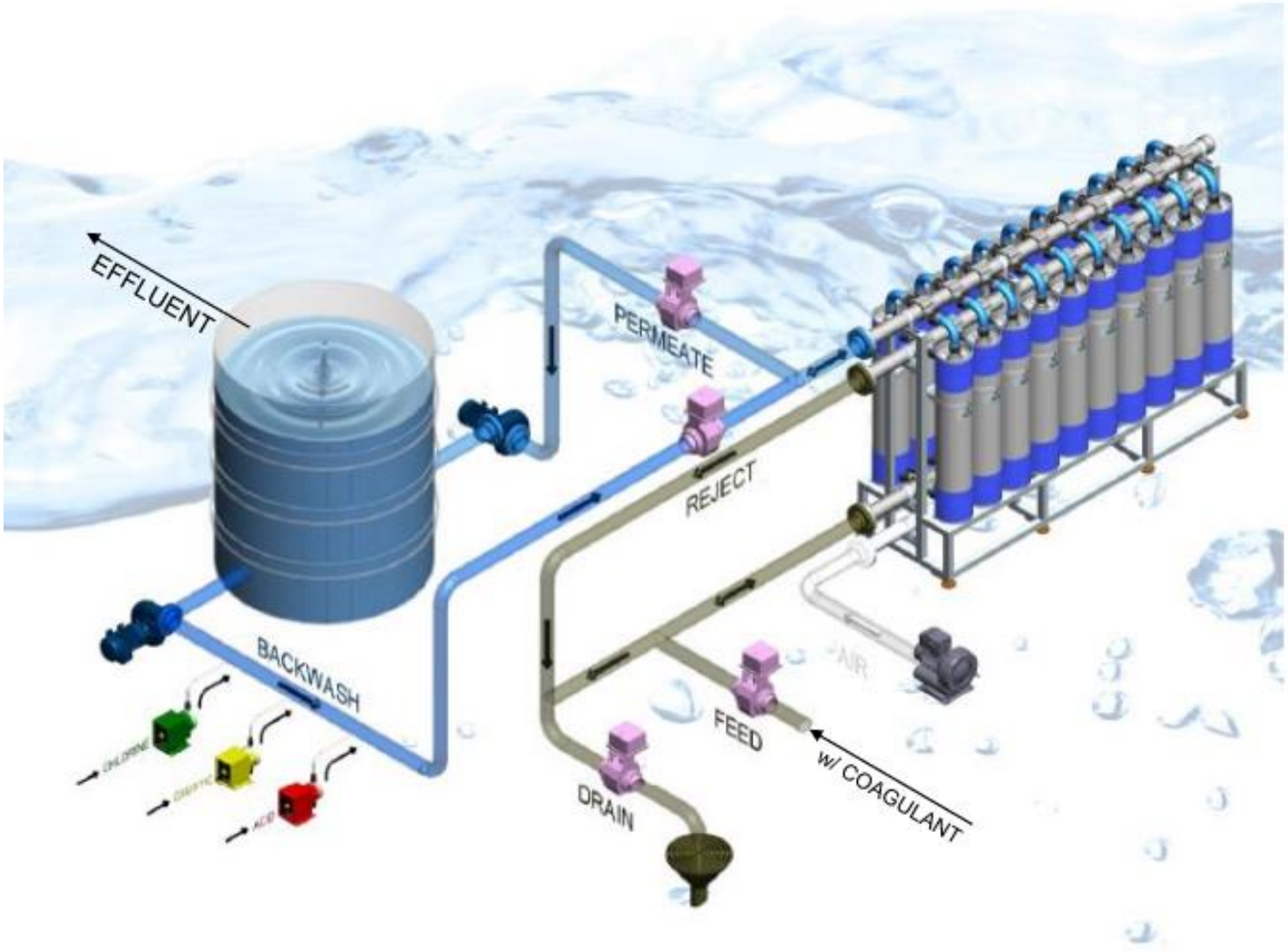
Ovivo TriSep Membrane System



Source: Ovivo

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Ovivo TriSep Membrane

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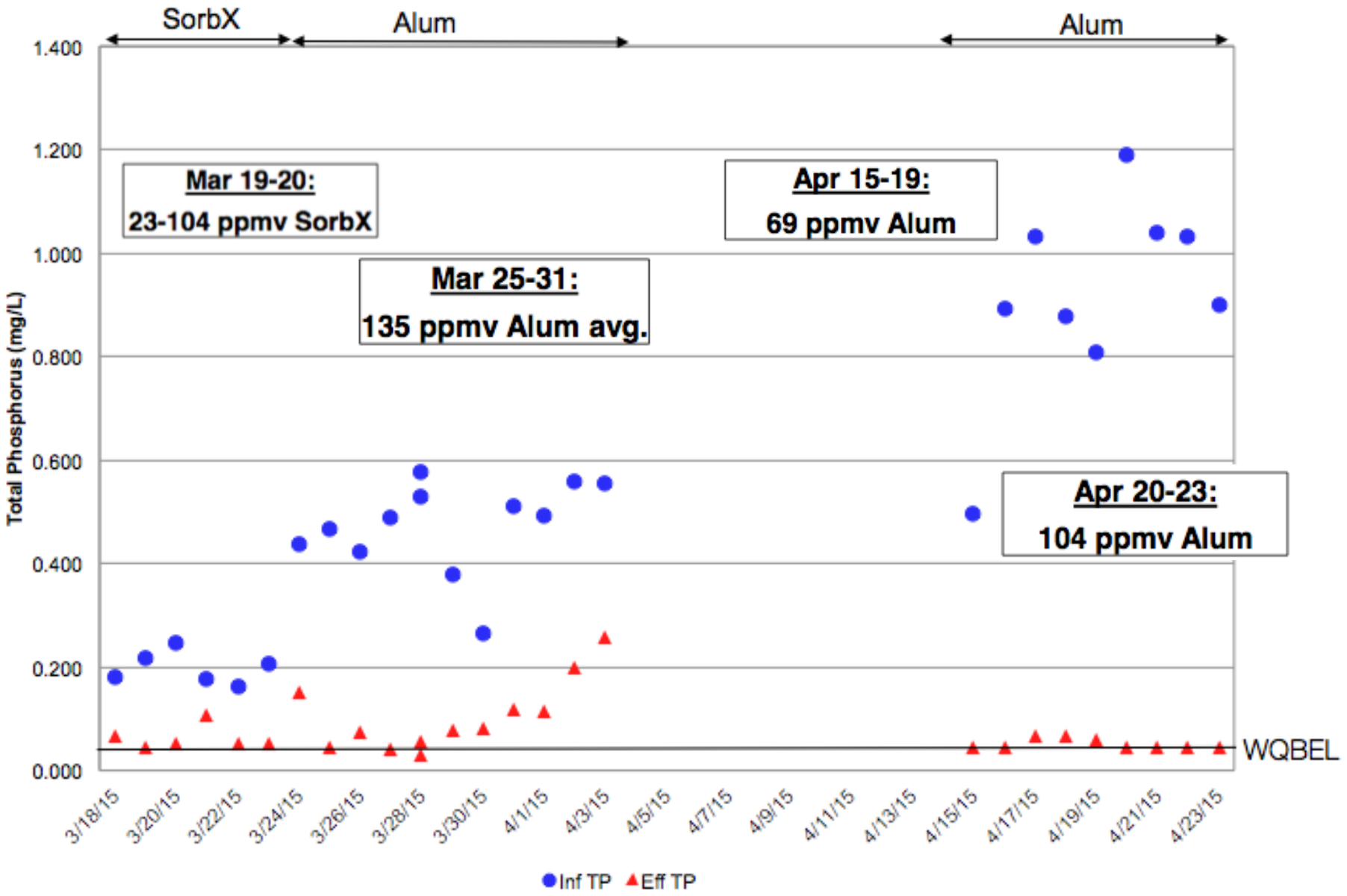
Ovivo TriSep Membrane Pilot Results



Ovivo TriSep Membrane Pilot Results

Coagulant	Influent TP Average	Effluent TP Average
Alum	0.92 mg/L	0.05 mg/L
SorbX-100	0.23 mg/L	0.07 mg/L

- SorbX found to be incompatible with UF membrane
- Effluent SNRP average ~0.05 mg/L

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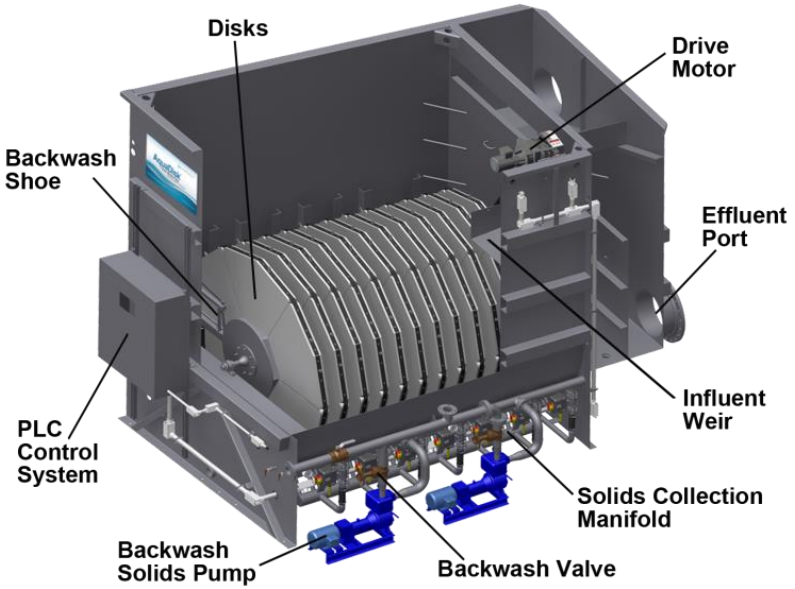
Aqua-Aerobic Systems AquaDisk®

- September 29 – October 27, 2015
- Cloth media filter and ultrafiltration filter
- CMF – OptiFiber PES-14 polyester microfiber pile
- SorbX used for secondary phosphorus removal for most of pilot – switched to alum toward end of pilot



Source: Aqua-Aerobic Systems Inc.

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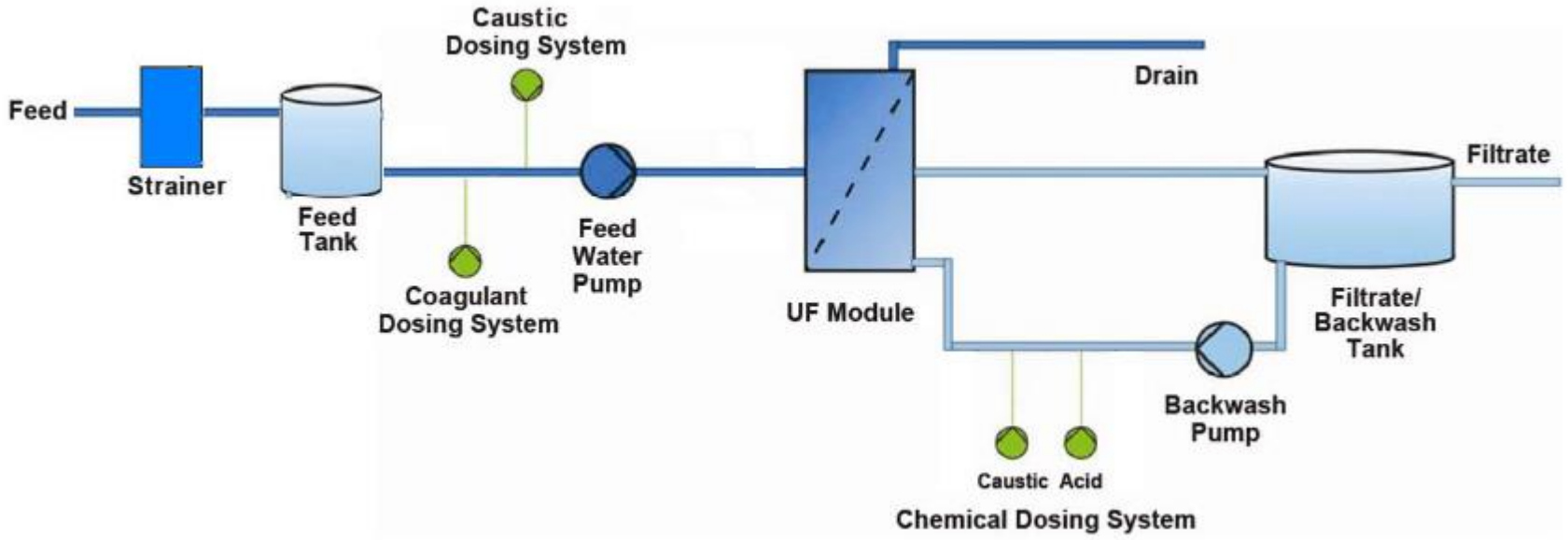
Aqua-Aerobic Systems Arrangement – AquaDisk Cloth Filter Plus Ultrafiltration Membrane



Polymer plus Ferric Chloride, Alum, or SorbX-100

Source: Aqua-Aerobic Systems Inc.

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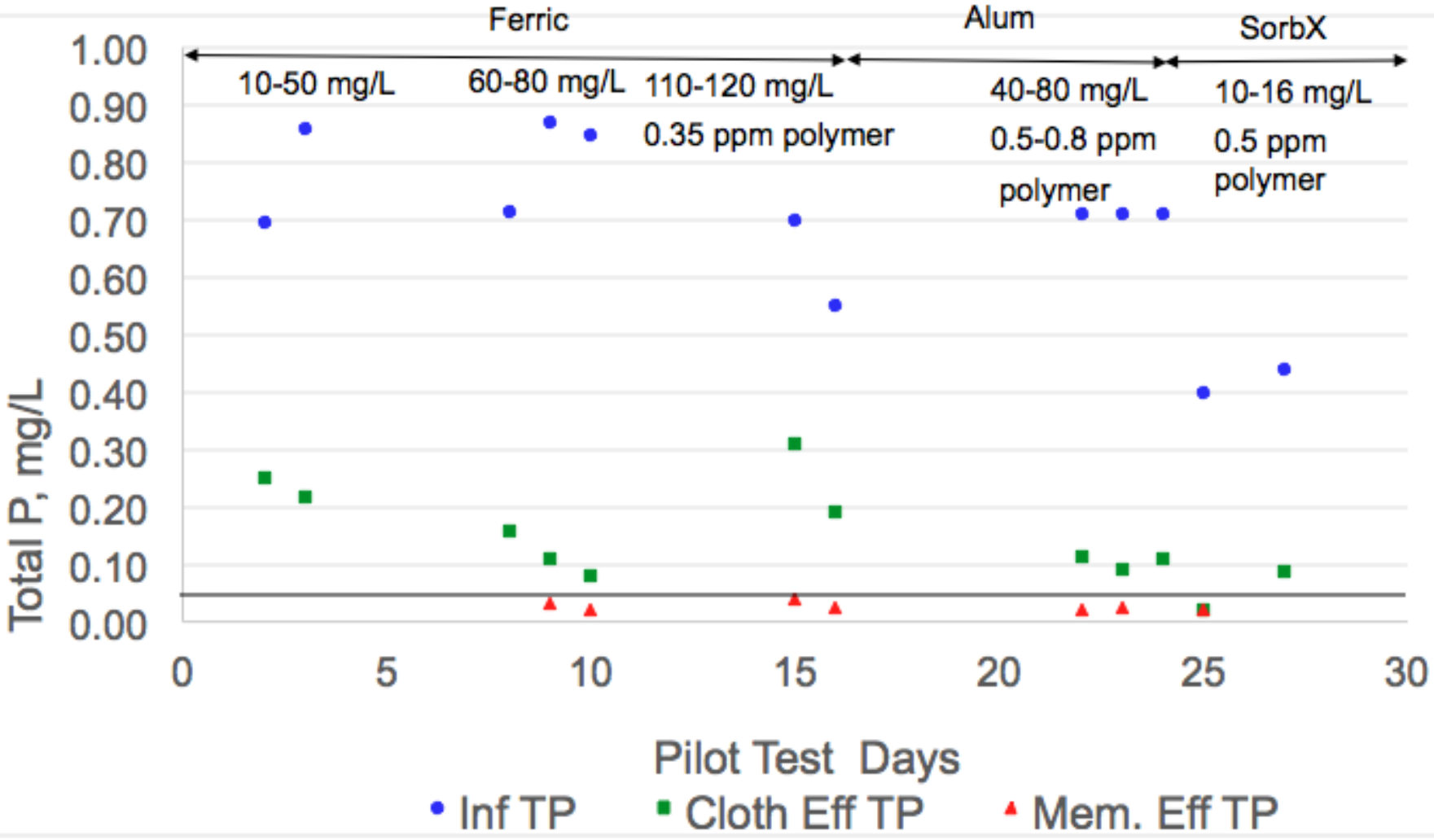
Aqua-Aerobic Systems Results



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Aqua Aerobic Systems Pilot Test

Soluble Nonreactive Phosphorus Results

Coagulant	Influent SNRP Average	Cloth Effluent SNRP Average	Membrane Effluent SNRP Average
Ferric Chloride	0.10 mg/L	0.05 mg/L	0.01 mg/L
Alum	0.10 mg/L	0.02 mg/L	0.01 mg/L
SorbX-100	0.05 mg/L	0.01 mg/L	-

Clearas Water Recovery

- August 9, 2016 to present
- Advanced Biological Nutrient Recovery (ABNR™) System
- Tertiary treatment system using suspended algae
- Removes phosphorus and nitrogen
- Increases dissolved oxygen
- Produces potentially marketable product

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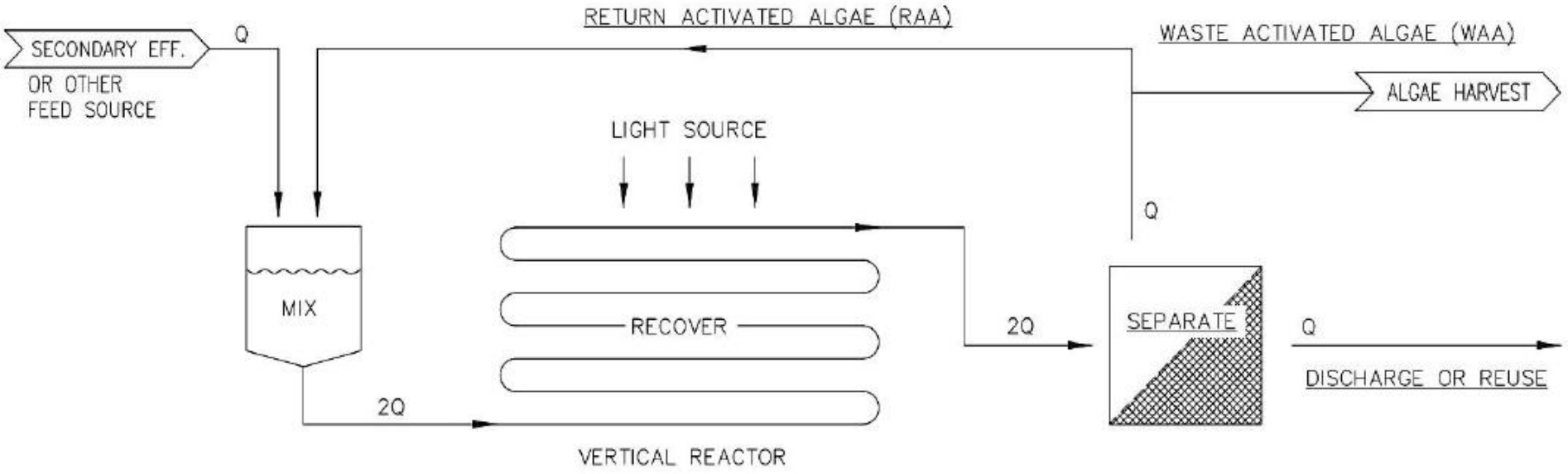
Clearas Water Recovery



Source: Clearas Water Recovery

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Clearas Water Recovery

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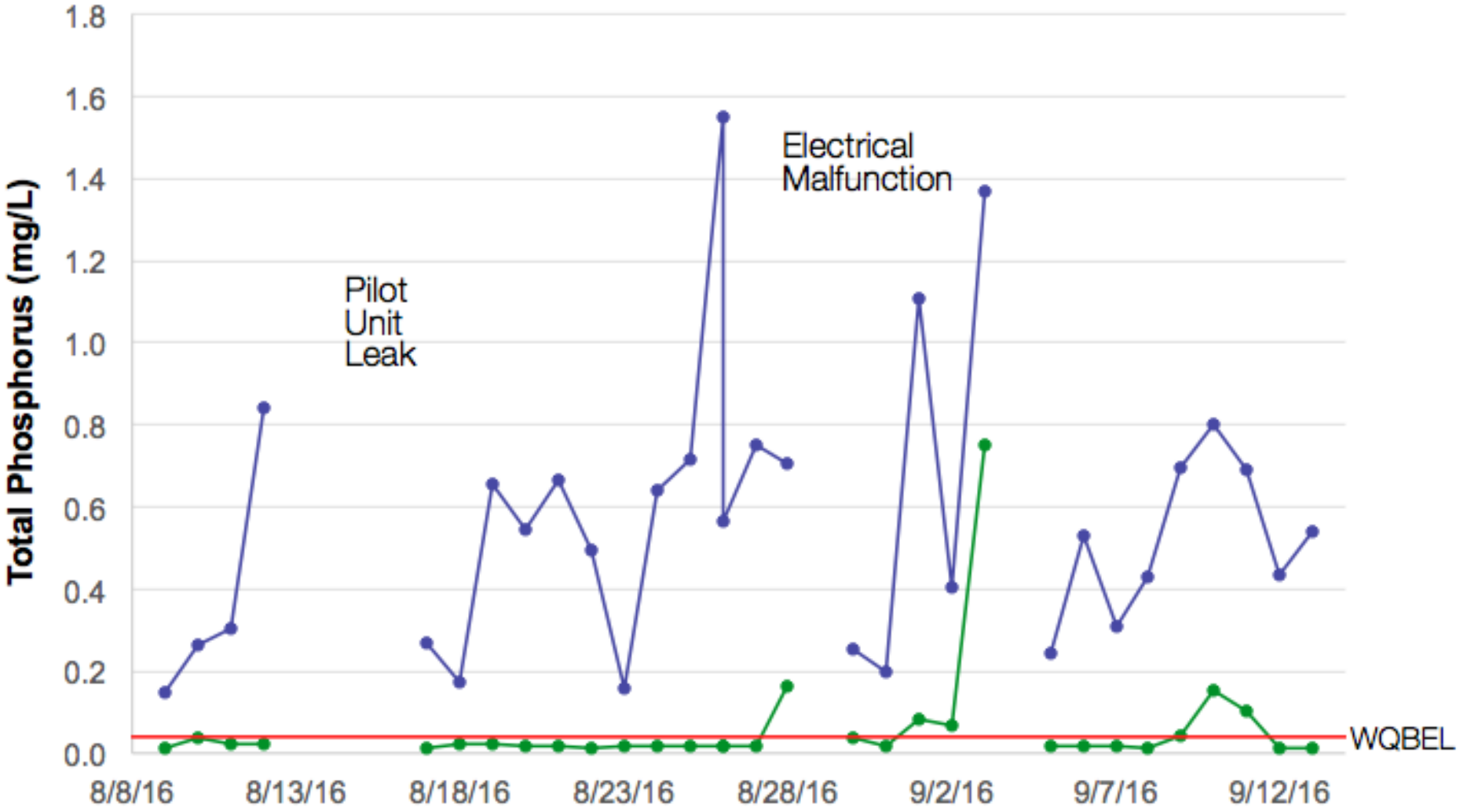
Clearas Water Recovery



Average Influent SNRP: 0.04 mg/L
Average Effluent SNRP: 0.01 mg/L

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Clearas Water Recovery

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Sidestream Struvite Harvesting

Source: CNP

Struvite - Magnesium Ammonium Phosphate

- Harvest from dewatering centrifuge centrate
  - Ostara
  - Multiform Harvest
- Harvest from digested biosolids upstream of centrifuge
  - CNP AirPrex

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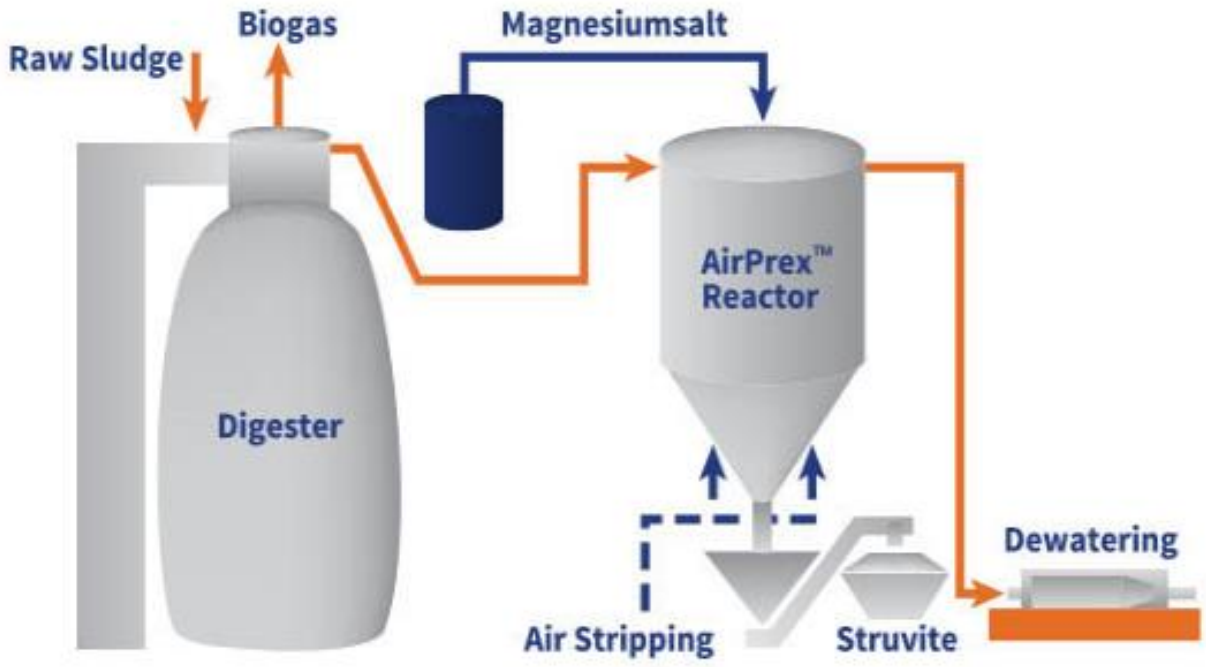
CNP AirPrex® Pilot Testing

Goals of P harvesting:

1. Reduce nuisance struvite formation.
2. Increase biosolids cake concentration with less polymer.
3. Recover a marketable struvite fertilizer product.



Source: CNP

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CNP AirPrex® Pilot Testing – November 2015

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AirPrex® Pilot Test Results

- Reduced soluble orthophosphate by 80 – 90%
- Improved cake solids concentrations at lower polymer dose with pilot centrifuge
  - thermophilic – 5% dryer cake with 16% lower polymer use
  - mesophilic – similar cake with lower polymer; less conclusive

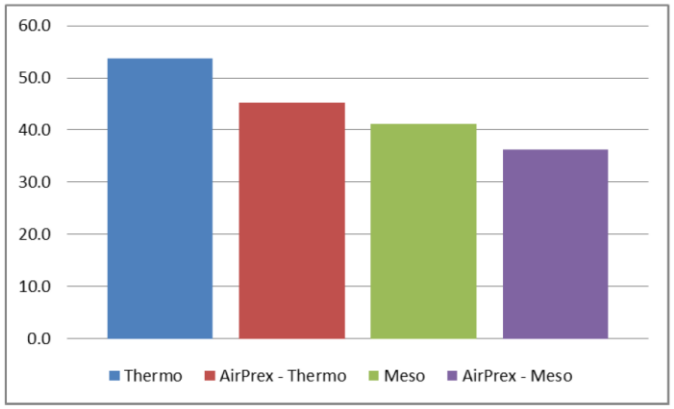

Figure 5: Average polymer consumption (lbs/dry ton) for each tested sludge

Source: Centrisys

Source: CNP

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Preliminary Cost Summary

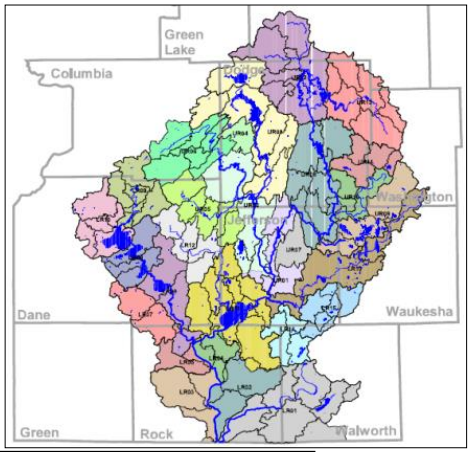
Alternative	20-Year Present Worth Cost
Advanced TP Removal	
CoMag™	$ 37,900,000
Blue PRO®	$ 70,300,000
Ovivo TFS®	$131,000,000
ACTIFLO	$ 32,800,000
AquaAerobic DF[1]	$ 23,100,000
AquaAerobic DF + UF[2]	$ 50,100,000

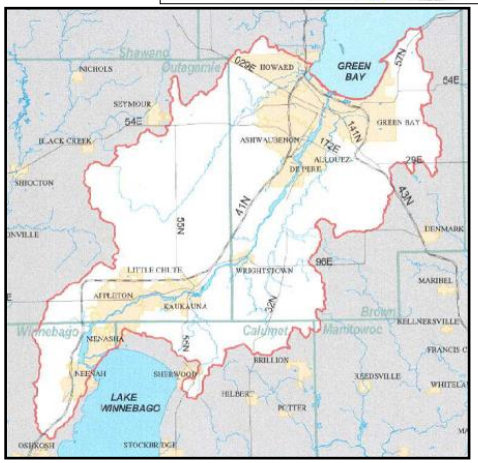
[1]Disk filter
[2]Ultrafiltration

- Clearas Water Recovery full-scale costs currently in development

Next Steps

- Continue to evaluate regulatory options (variance, TMDL).
- Continue to evaluate advanced treatment technologies.
  - Cost for combinations of options (i.e., filtration plus water quality trading).
- Explore potential watershed partnerships and opportunities for BMP implementation.
- Develop Final Compliance Alternatives Plan following TMDL completion.





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Acknowledgements – thank you!

- Mulcahy Shaw Water and Molycorp (SorbX-100)
- CNP (AirPrex) and Centrisys
- Peterson & Matz and Kruger/Veolia (ACTIFLO)
- Drydon and AquaAerobics (AquaDisc)
- Energenecs and Ovivo (TriSep)
- Mulcahy Shaw Water and Clearas Water Recovery

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Thank you for coming!

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