N2: Phosphorus

Need Filtration or Equivalent? Demonstration Testing Prepares Communities for Low Level Phosphorus

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Eric Lynne, P.E.

DONOHUE® & ASSOCIATES

Presentation Will Cover……

1. Background
2. Technology Review
3. Demonstration Tests
   a) RESULTS!?!
   b) Key Points
4. Wrap Up and Questions

1 – Background

- ….NR102/NR217
- 2010: 7-9 yrs to construct filters or equivalent
- Demonstration Tests
  - Performance
  - O&M costs
  - Operability/Familiarity

2 – Technology Review

- **Basic 2 Steps:**
  - **Conversion to Particulate**
  - **Removal of Particulate**

2 – Technology Review

- **Basic 2 Steps:**
  - **Conversion to Particulate**

    (Biological or Chemical)
  - **Removal of Particulate**

    (Settling or Physical Barri

- Multi-Point
- Rapid Mix
- Flocculation
- Coagulant Selection
- pH Adjustment

2 – Technology Review

- **Basic 2 Steps:**
  - **Conversion to Particulate (Biological or Chemical)**
  - **Removal of Particulate (Settling or Physical Barrier)**

(Settling

Lagoons, Clarifiers, High-Rate Clarifiers

2 – Technology Review

- **Basic 2 Steps:**
  - **Conversion to Particulate**

    (Biological or Chemical)
  - **Removal of Particulate**

    (Settling or Physical Barrier)

Filters
- **Shallow Sand**
- **Multi-media Sand**
- **Cloth-media Disk**

Membranes
- **Ultrafiltration**
- **MF, NF, RO**

Which Technologies are a Good Fit?

Technology	Achievable Limit (mg/L)	Donohue Comment
Conventional Sand Filters	01. - 0.15	High headloss; non-proprietary package
Disc Filtration	0.1 - 0.15	Reduced headloss; reduced capital
Compressible Media Filtration	0.15	Emerging technology; little full scale experience
Coagulation-Flocculation-Sedimentation	0.05	Large capital; high level of performance
High Rate Clarification	0.05 - 0.1	High level of “moving parts”; high level of treatment; expandable with filters
Solids Contact Clarifier	0.1 0.05 with filters	High level of “moving parts”; high level of treatment; solids contact a concern as tertiary treatment; expandable with filters
Biomag	0.3	Emerging technology
Continuous Backwash Filtration	0.1	High capital; typically applied for flows less than 2 mgd (but not always…)
DAF Clarifier	0.2	Emerging technology; based on floating limited solids
Membranes	0.05	Almost guaranteed performance; high capital; high energy; treatment exceeds requirement

2 – Technology Review

- Ultrafiltration Membranes
  - Capital Cost
  - Membrane Replacement Cost
  - Energy Cost

- Typically a "worst-case" placeholder for Long-Term Planning

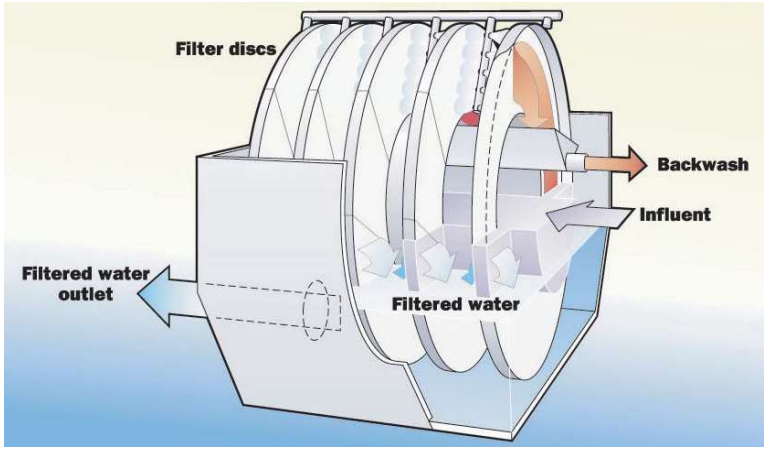
What about those other technologies?

Jackson, WI (2010)

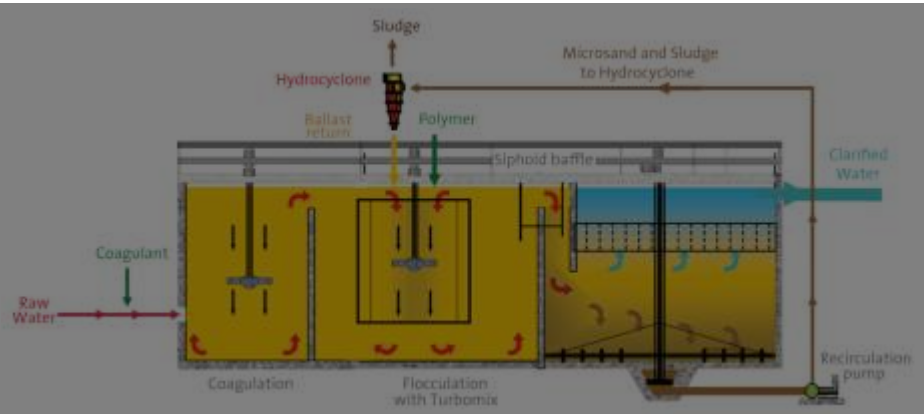
- **Filter Replacement (1.37 mgd avg)**
  - What about future TP requirements (0.075 mg/L)
- **Membrane/CBW Filters/Actiflo = 0.075**
  - still need RM/Coag/Floc
- **Disk Filter mfrs would not guarantee 0.075**
  - TP depends on the WWTP
  - Might tout 0.1 mg/L TP as long as influent is "good" (<15 TSS and <0.3 TP)
  - 0.075 mg/L TP if piloted

3 – Demonstration Testing

- **2013 WI Testing:**
  - **Hydrotech Discfilter (<0.1 mg/L)**



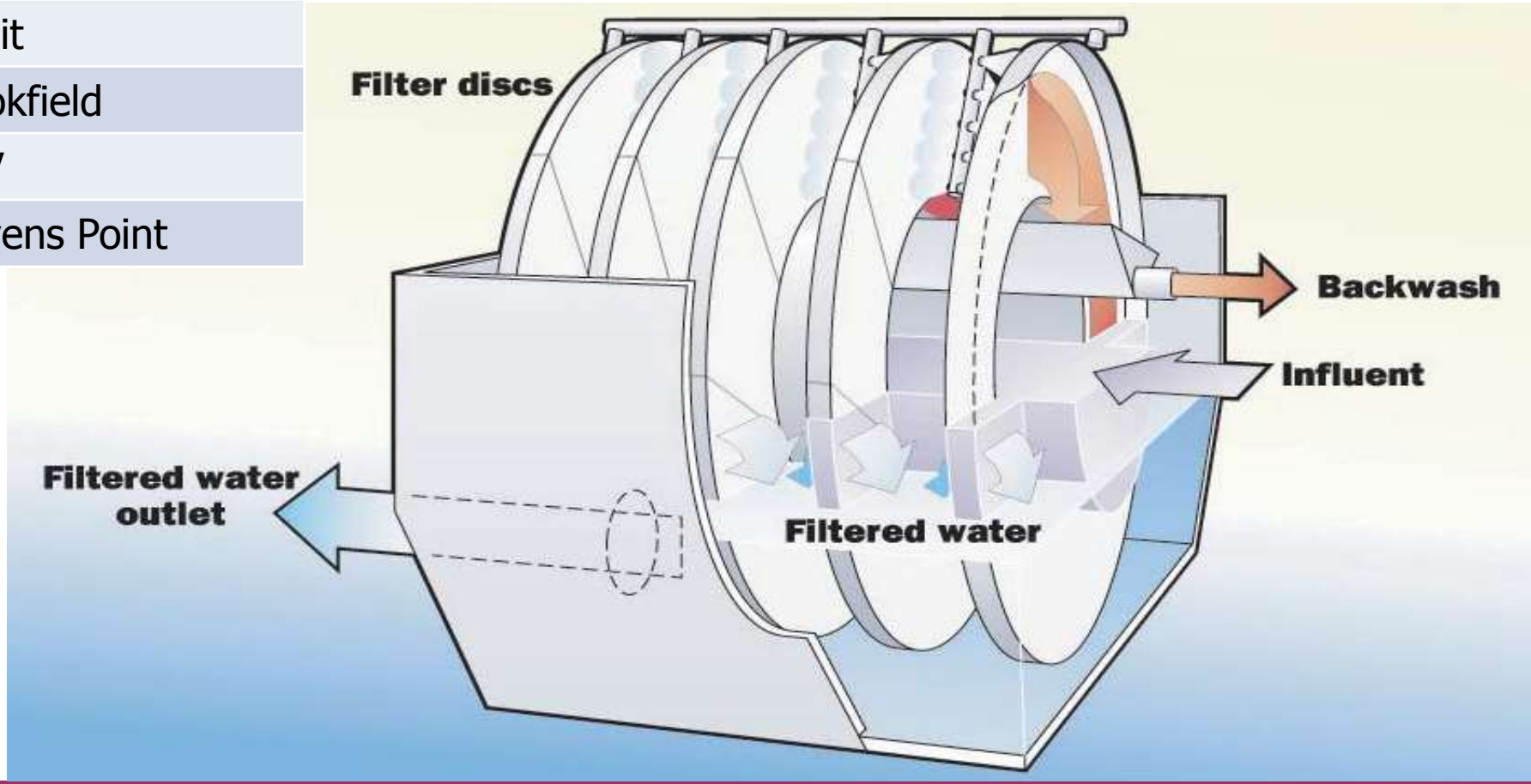
  - **Actiflo (<0.075 mg/L)**



KRÜGER VEOLIA WATER

3 – Demonstration Testing

Sun Prairie
Beloit
Brookfield
HOV
Stevens Point



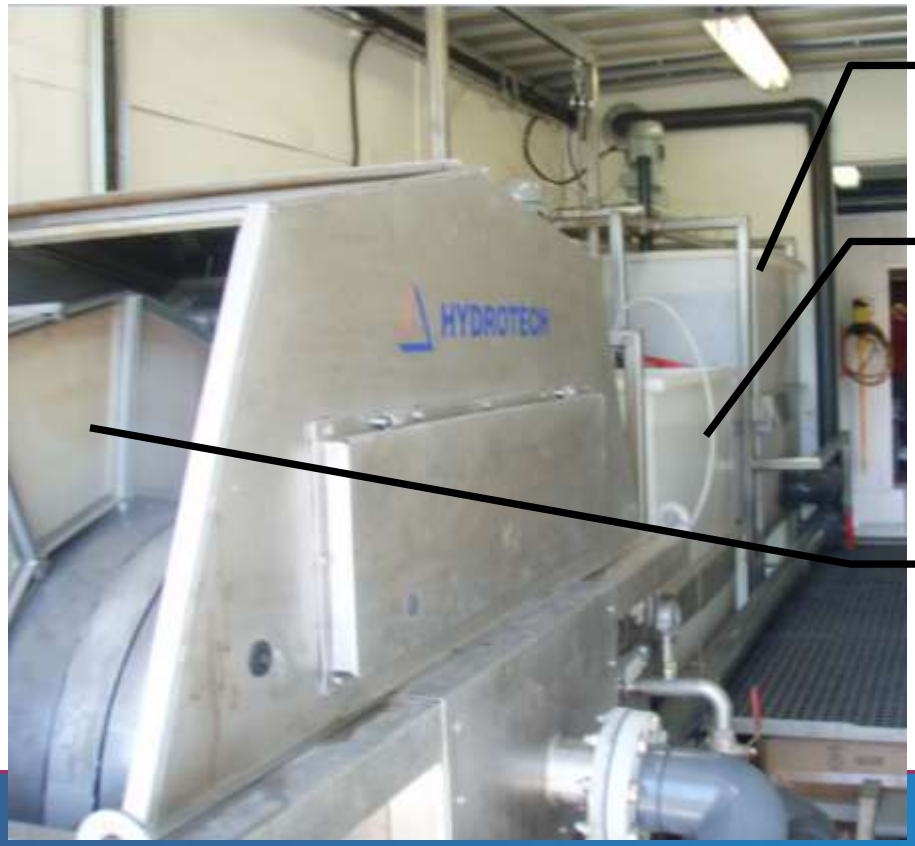
Cloth Media Filters (Hydrotech Discfilter)

3 – Demonstration Testing

- Tertiary: "Influent" = FC Effluent
- Goal: confirm <0.10 mg/L claims
  - Confirm <0.10 mg/L claims
  - Coagulant & Polymer Dose Response
  - Potential Hybrid Solution
  - Familiarity

3 – Demonstration Testing

- Chemical Feed (Ferric Chloride, Polymer)
- Coagulation, Flocculation, Filtration

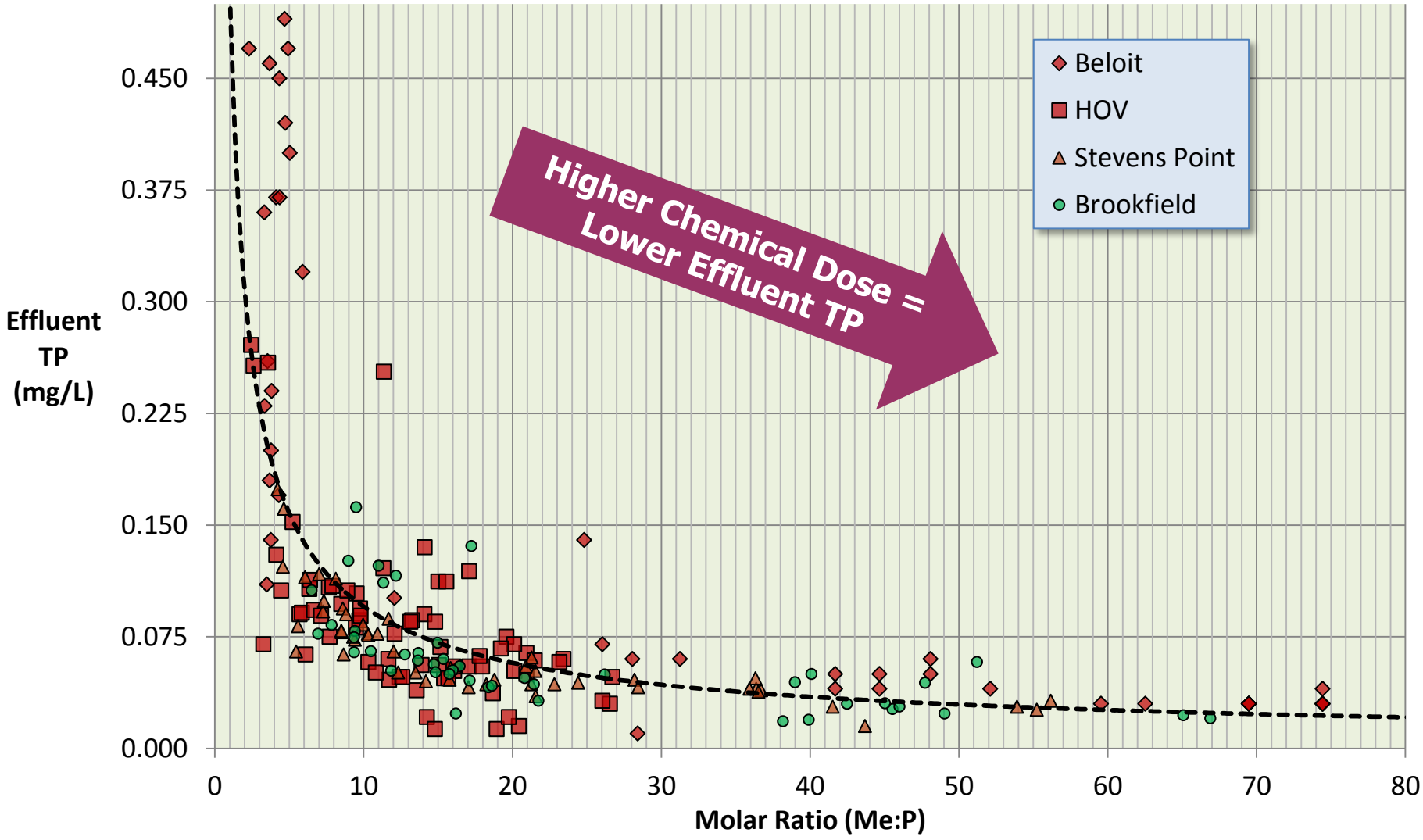


3 – Demonstration Testing

- **Larger Particle Size = Easier Separation**

3 – Demonstration Testing

- **Results: Compiled Data**



3 – Demonstration Testing

- **Check the units!**
  - **Reported as mg/L**
    - ✓ **mg/L as Fe or Ferric Chloride?**

3 – Demonstration Testing

- **Changes to the "influent" shift the molar**

Situation: Constant Dose 60 mg/L Ferric Sulfate
~ 11.3 mg/L as Fe

Case 1:
Influent TP = 0.26 mg/L
Effluent TP = 0.06 mg/L
Removal = 0.20 mg/L

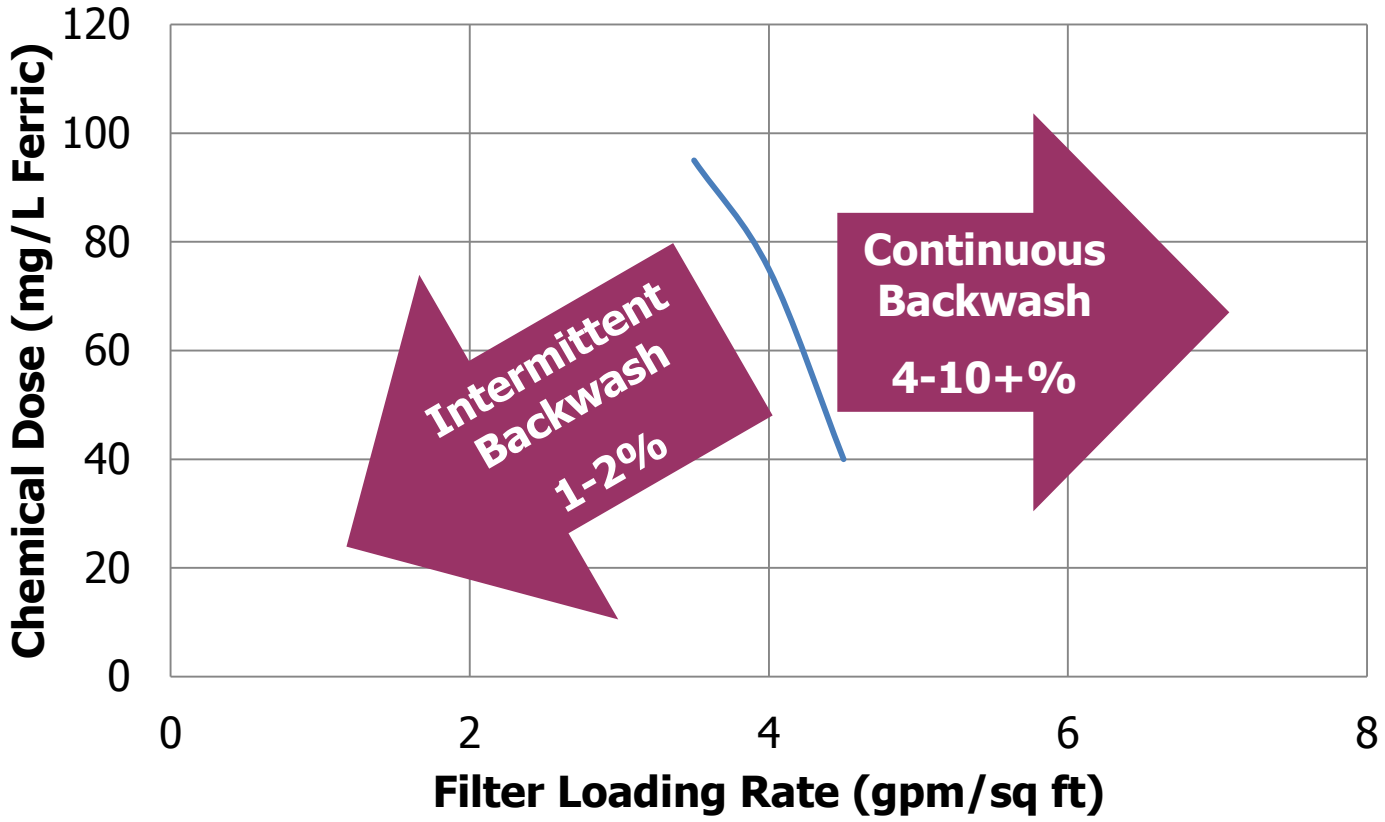
Fe:P Molar Ratio = 31

Case 2:
Influent TP = 0.19 mg/L
Effluent TP = 0.06 mg/L
Removal = 0.13 mg/L

Fe:P Molar Ratio = 48

3 – Demonstration Testing

- **Results: Recycle Flows**



3 – Demonstration Testing

- Key Points
  - Sampling Requirements

    LOD/LOQ for <0.075 Accuracy

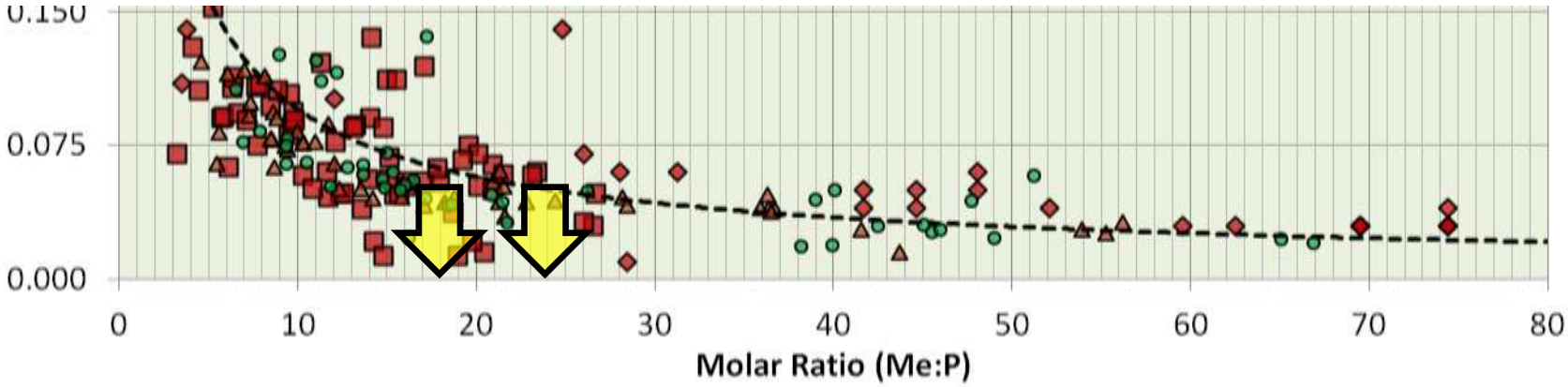
    Multiple vials per day/setup
  - Lab turn around

    In-house vs. Commercial Lab
  - Operations

    Normal vs. Stress-test the pilot

3 – Demonstration Testing

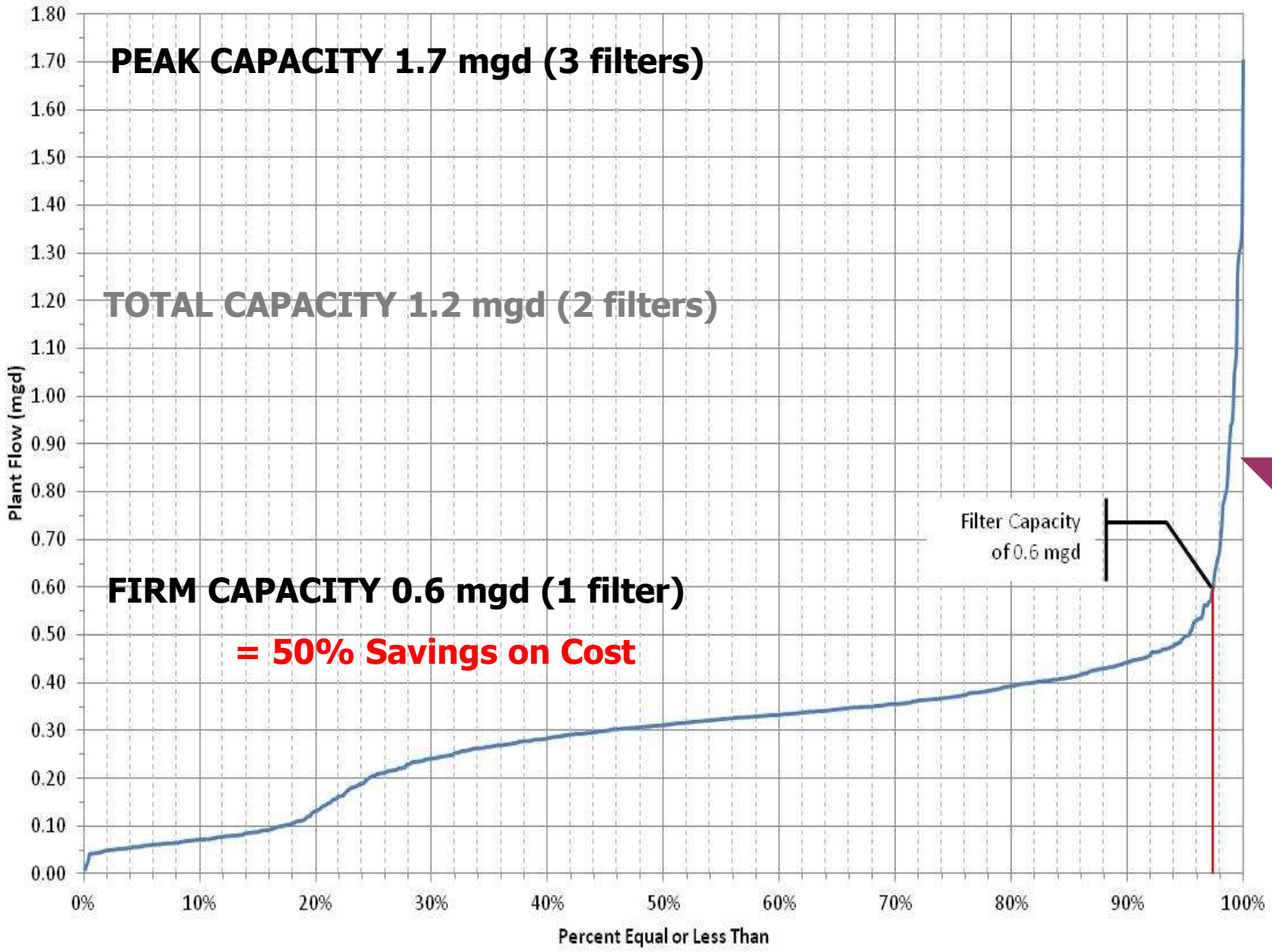
- **Discfilter:**
  - **Exceeded goal of 0.1 mg/L Eff TP**
  - **Sustained <0.075 mg/L when influent TP was <0.3 mg/L**
- **Staff enthusiastic about process simplicity**
- **Chemical dose ~ 18-25 molar ratio**



3 – Demonstration Testing

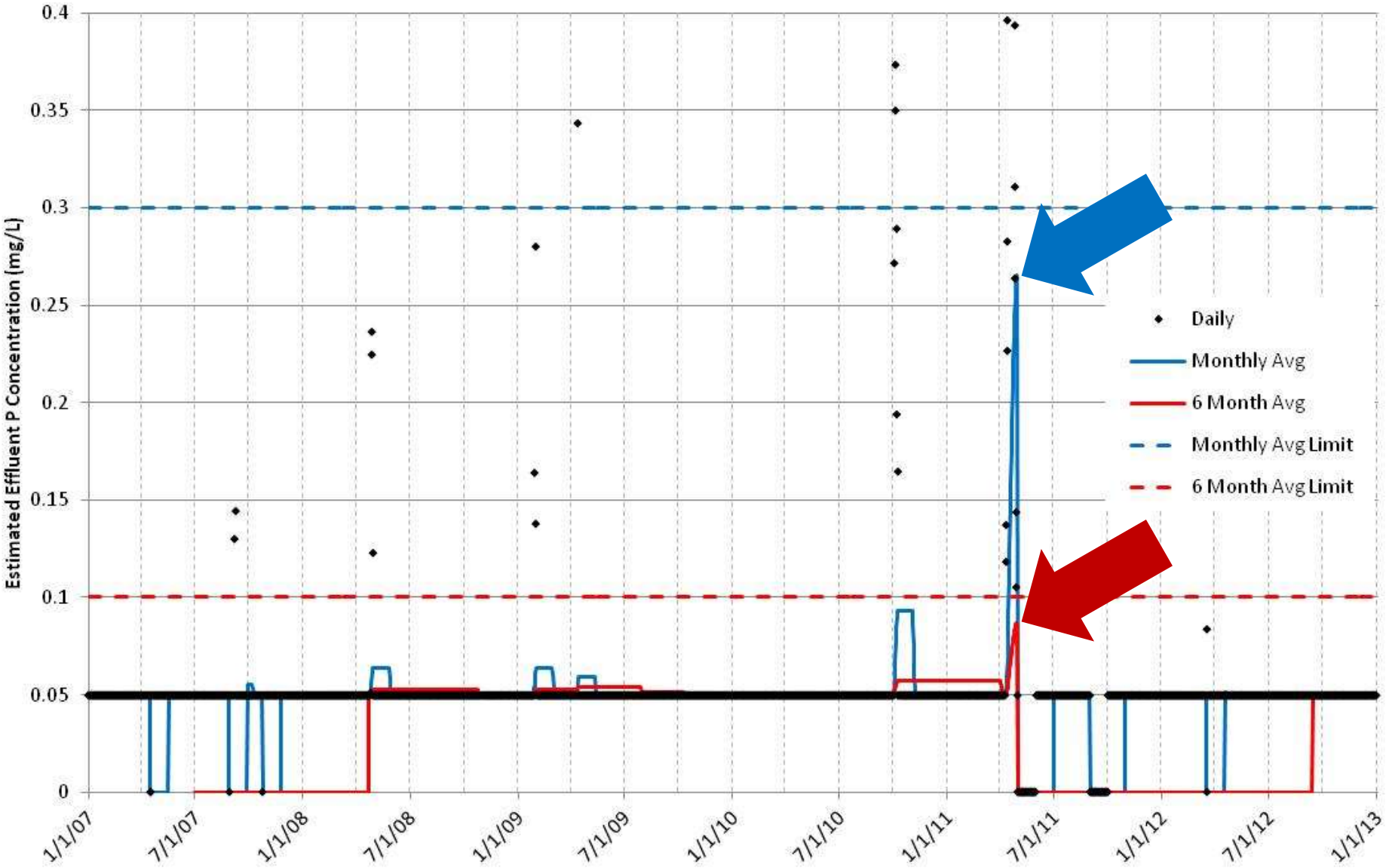
- **Compliance Note:**
  - **0.075 mg/L** (or 0.1 mg/L) **on a 6-mo avg**
  - **Monthly limit = 3x**
- **With one month excursion up to 0.2 mg/L**
  - **Avg Day needs to be <0.05 mg/L**
  - **Mass Balance = Right-size filters**

Figure 5-4
2010-2012 Flow Probability



COST

Figure 5-3
0.6 mgd Filtered at 0.05 mg/L Effluent P
0.6 mgd Filter Bypass at 1.0 mg/L Effluent P



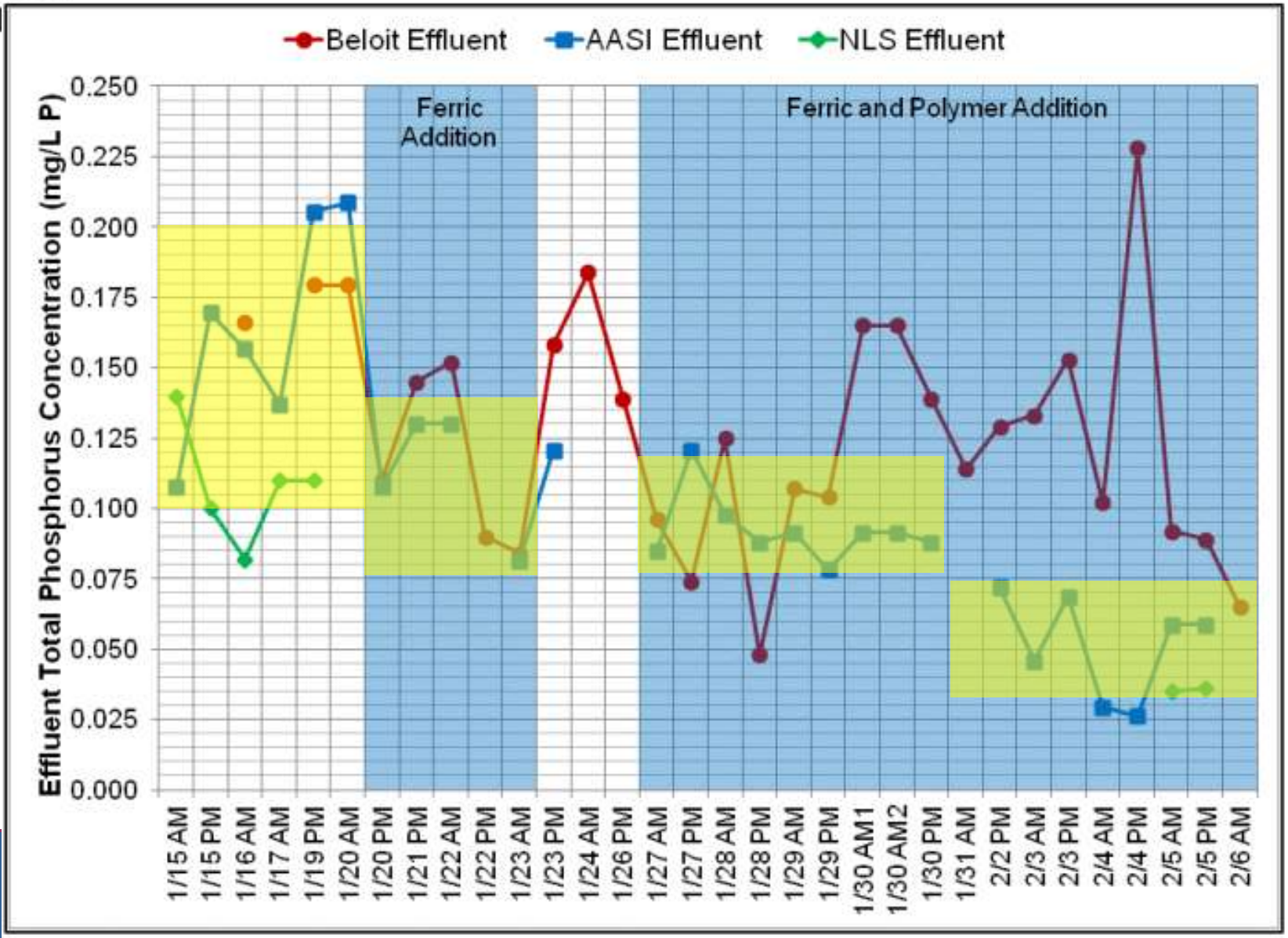
4 – Other Manufacturers

- **2013 WI Testing:**
  - **AquaDisk (Beloit, Brookfield, Sheboygan)**

(<0.075 mg/L)

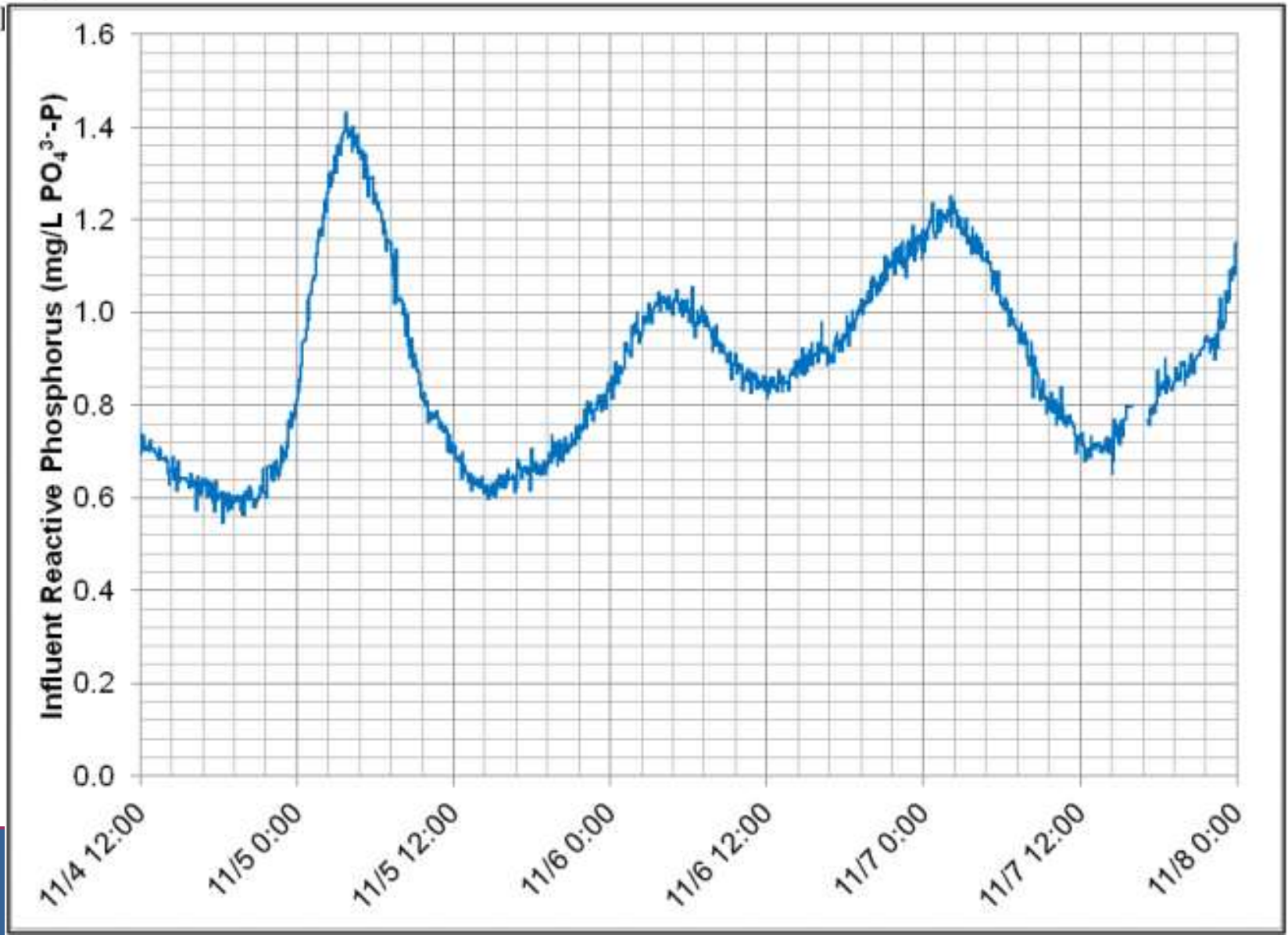
AQUA-AEROBIC SYSTEMS, I

4 – Other Manufacturers



AQUA-AEROBIC SYSTEMS, I

4 – Other Manufacturers



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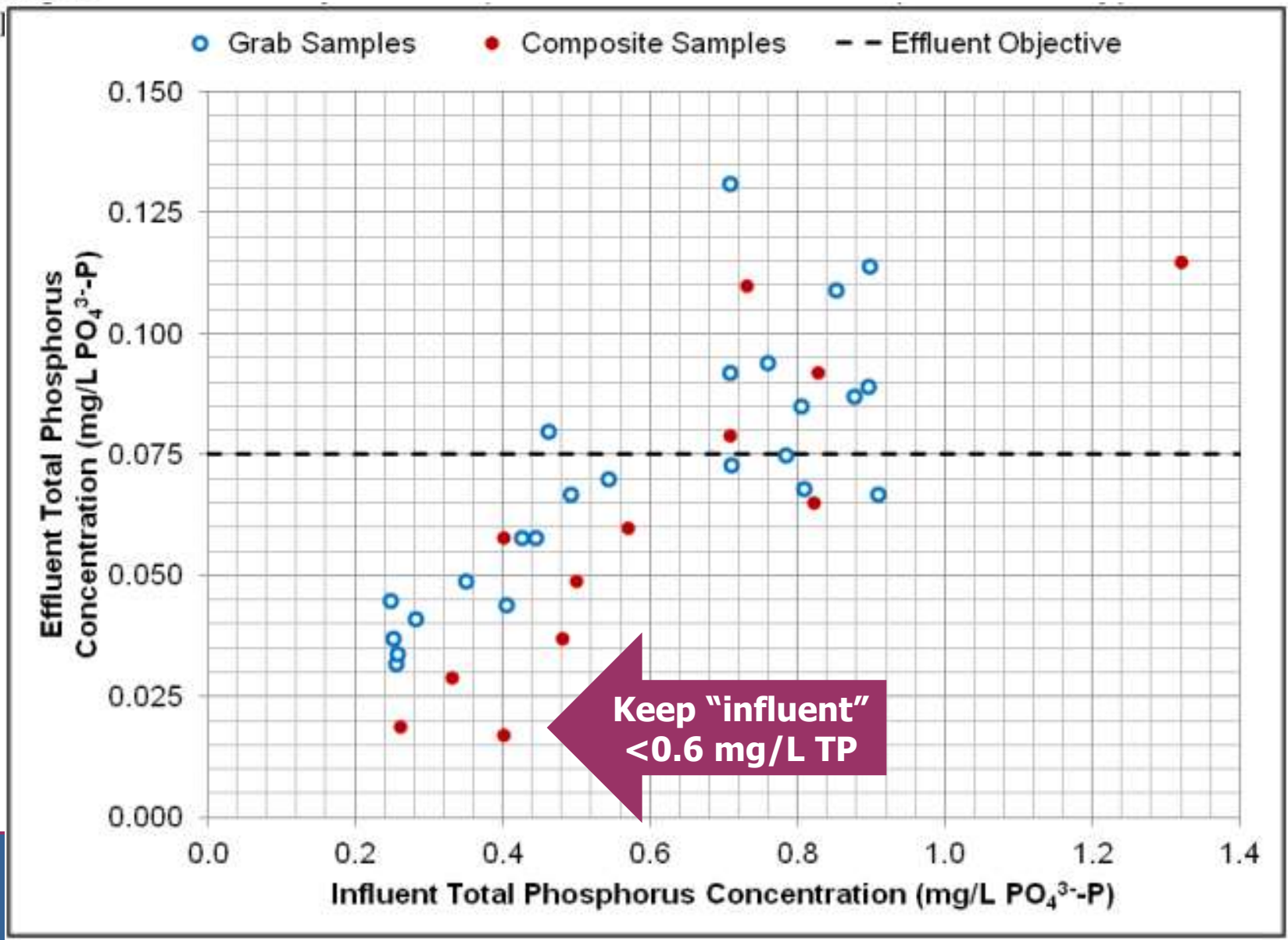
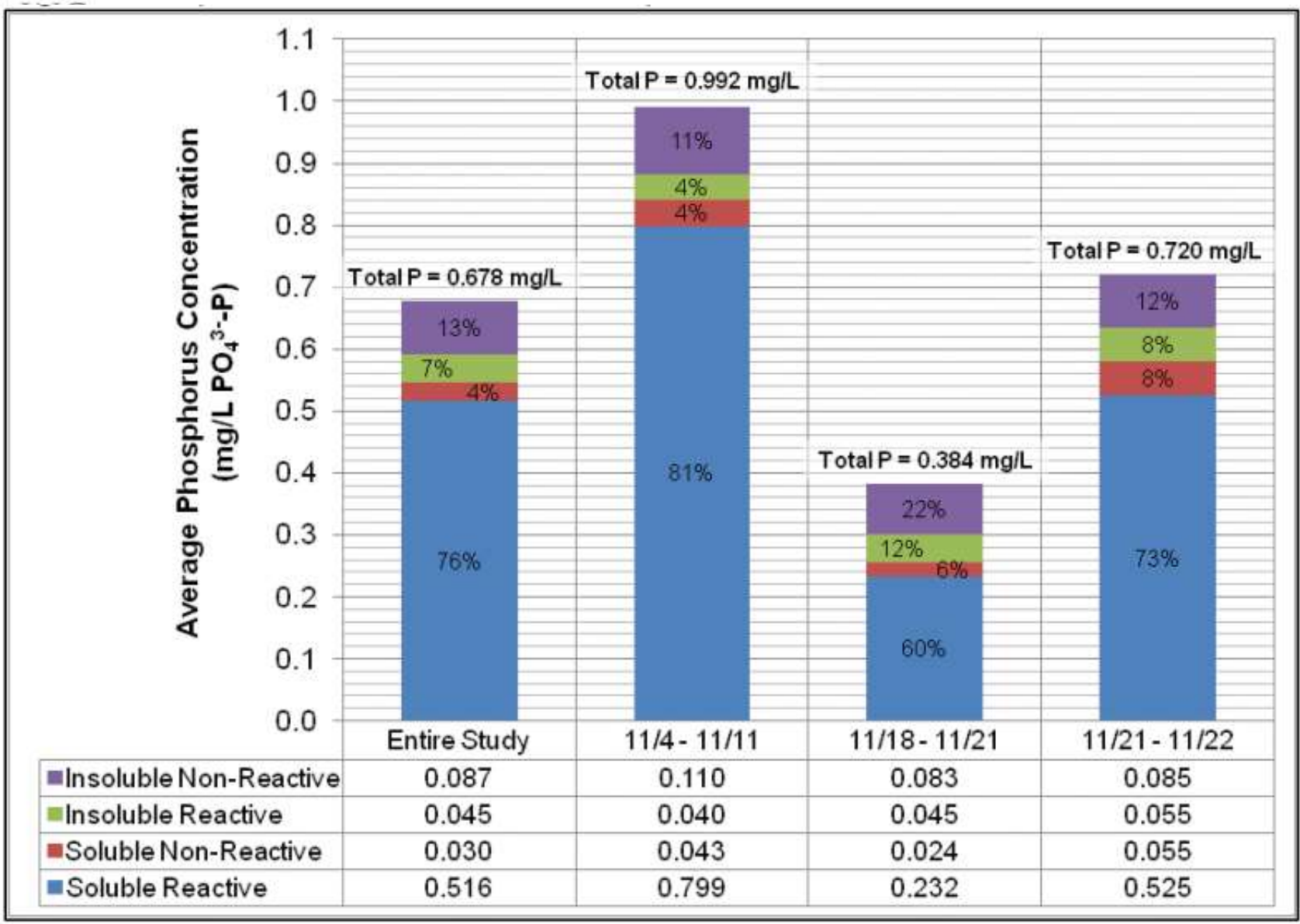


AQUA-AEROBIC SYSTEMS

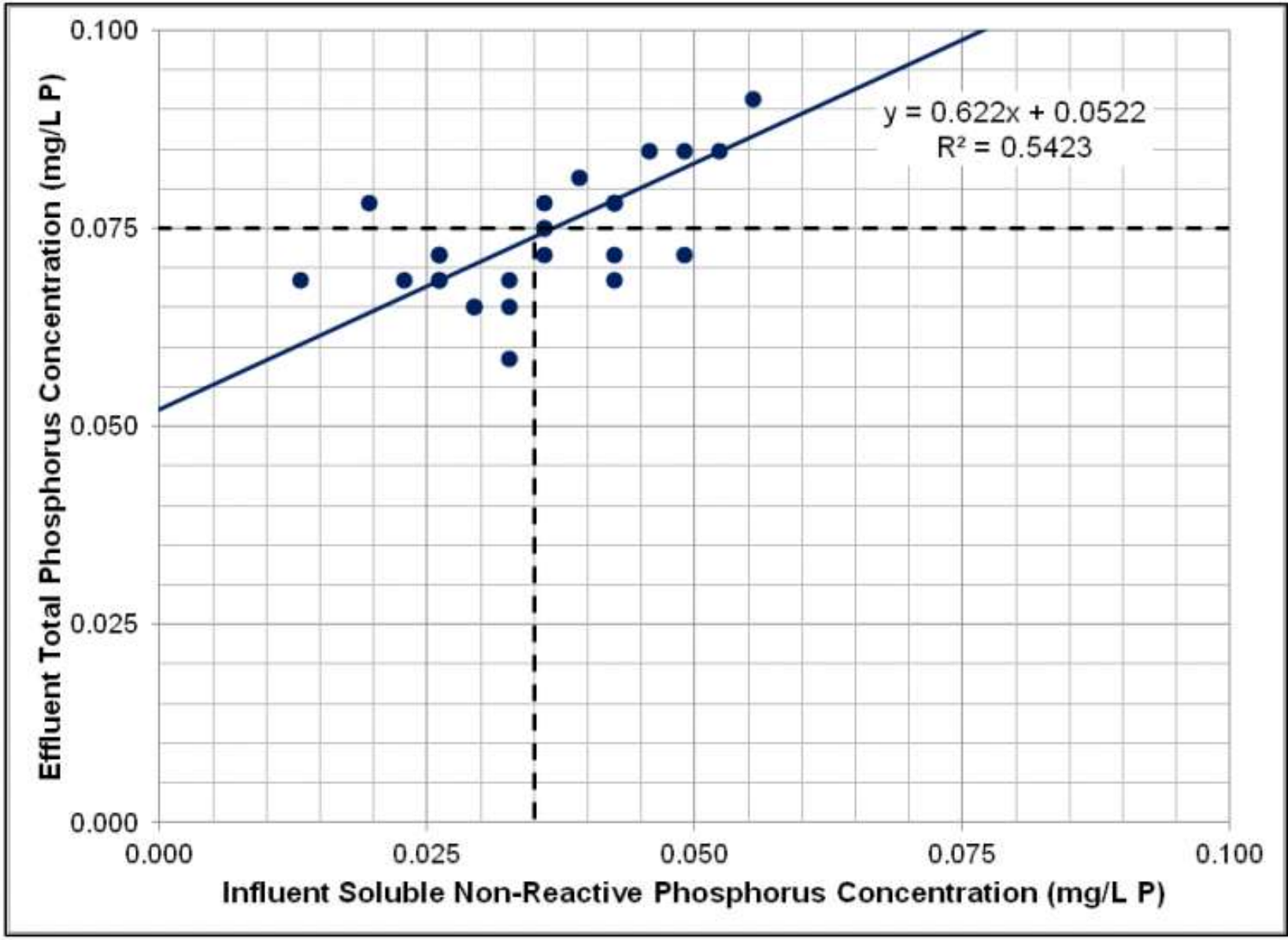
4 – Other Manufacturers

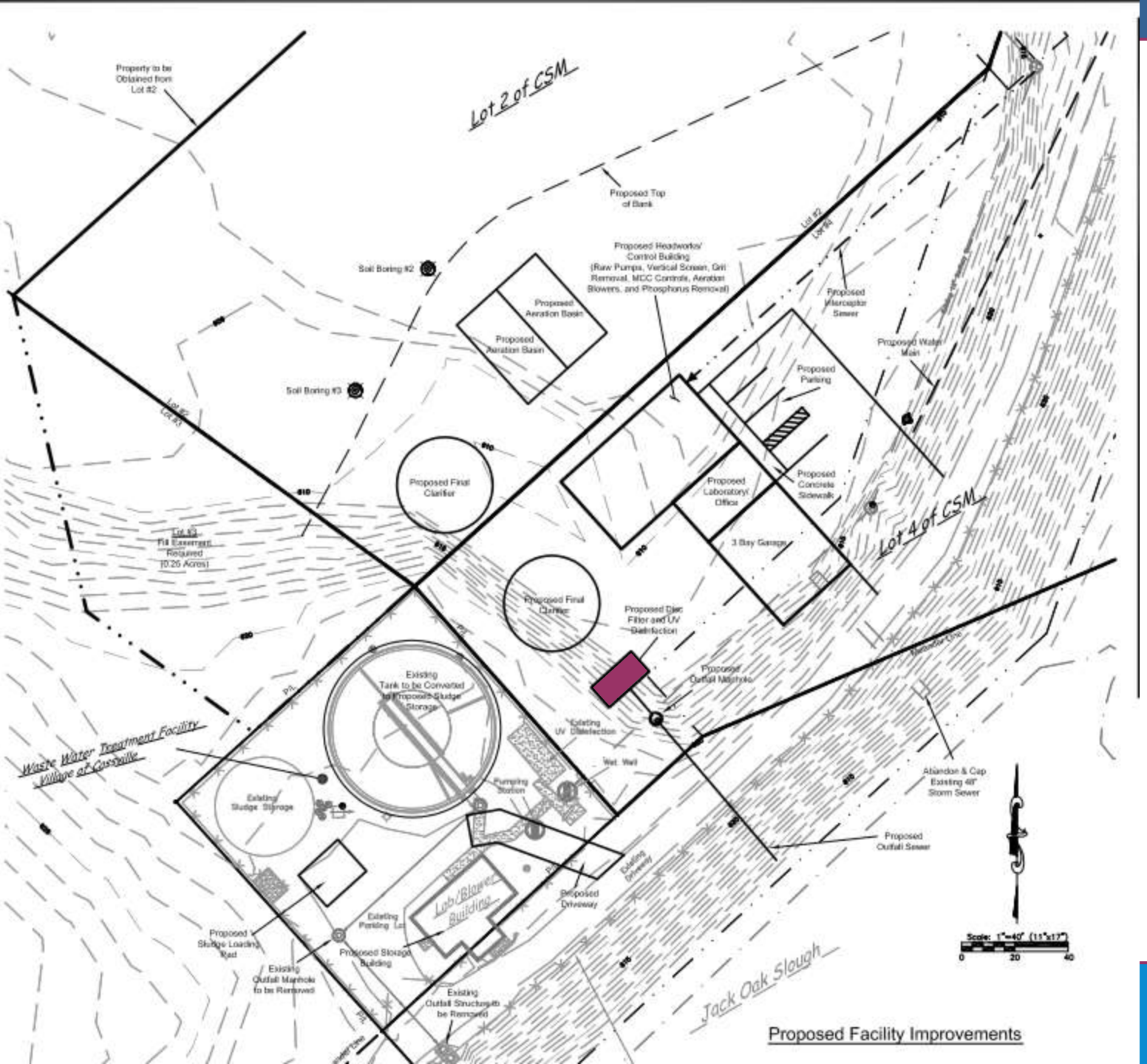


	Entire Study	11/4 - 11/11	11/18 - 11/21	11/21 - 11/22
Insoluble Non-Reactive	0.087	0.110	0.083	0.085
Insoluble Reactive	0.045	0.040	0.045	0.055
Soluble Non-Reactive	0.030	0.043	0.024	0.055
Soluble Reactive	0.516	0.799	0.232	0.525

AQUA-AEROBIC SYSTEMS, I

4 – Other Manufacturers





Proposed Facility Improvements

5 - Cost

- Capital Cost (it depends)
  - Need for pumping
  - Structure
  - Land
  - Chemical System

$1.0 – 2.0 million/mgd

5 – Cost

- Helps to have optimal "influent"
  - Use online analyzers
- Caution on downstream side
  - consider manual only based on a steady molar ratio to handle the remaining P.

5 – Cost

Main Plant Chem Feed: 4.5 mg/L down to 0.8 mg/L; molar ratio ~ 2:1

$20-30/mgd/day

Tertiary Filter Chem Feed: 0.8 down to 0.05; molar = 25:1

+$50-70/mgd/day

Or

$8-11/lb (chemical cost)

Inputs		Case 1	Case 2
Total Wastewater Flowrate to Process	gpm	694	694
Total Wastewater Flowrate to Process	MGD	1.000	1.000
Number of Parallel Ferric Feed Points in Process		1.0	1.0
Influent P Concentration to Process	mg/L	4.5	0.8
Est. P Taken Up Biologically Within Process	mg/L	0.0	0.0
Target Process Effluent TP Concentration	mg/L	0.8	0.05
Dosage Calculations			
P to be Removed Chemically	mg/L	3.7	0.8
Target Fe to P Molar Ratio		2.00	25.00
Fe Dosage	mg/L	13.3	33.8
Total FeCl3 Solution Feed Rate	gal/hour	3.7	9.3
Ferric Chloride Cost			
Ferric Price	$/DT	400	400
Daily Cost of Ferric	$/day	$ 22	$ 56
Annual Cost of Ferric	$/yr	$ 8,124	$ 20,585
Ferric Price	$/DT	500	500
Daily Cost of Ferric	$/day	$ 28	$ 70
Annual Cost of Ferric	$/yr	$ 10,155	$ 25,731

- **"Clean Waters Healthy Economy Act"**

  $50/lb
  - $10/lb Ferric Cost (conservative)
  $40/lb contrast with capital cost

$40/lb @ 0.8 mg/L @ 1 mgd ~ $100,000/yr

$100k/yr debt service = $1.4 million project

Essentially Equal, variance wins if effluent is optimized

Questions

Contact Info

ERIC LYNNE, P.E.

3311 WEEDEN CREEK ROAD

SHEBOYGAN, WI 53081

PHONE 920-803-7375

elynne@donohue-associates.com