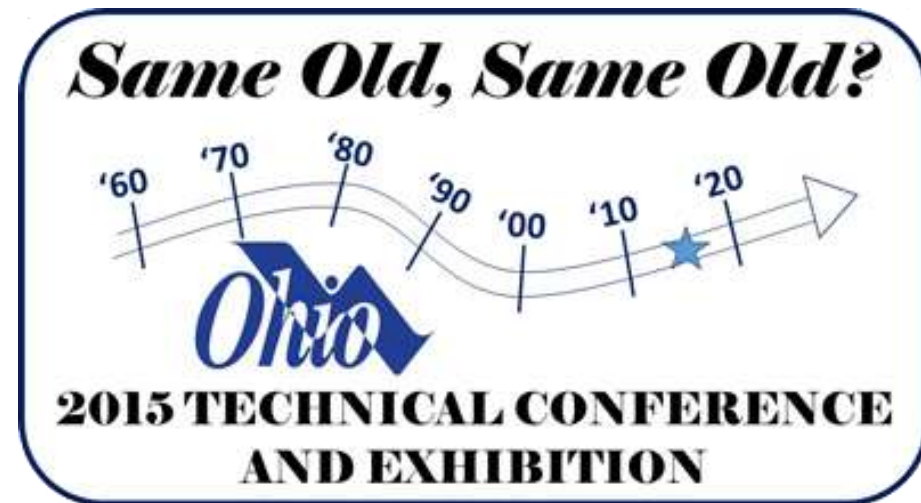


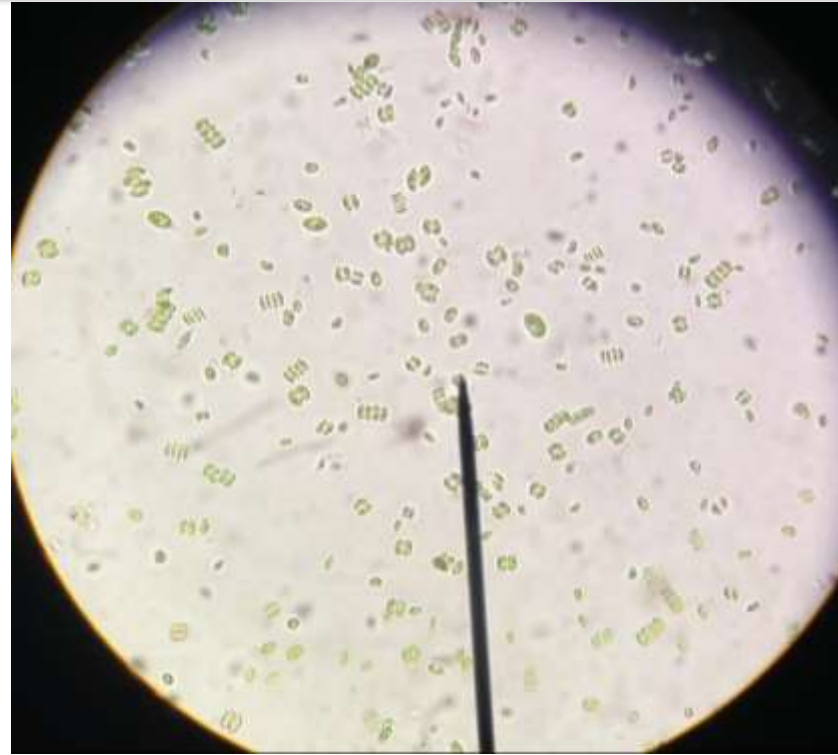
NUTRIENT REDUCTION THROUGH THE USE OF ADVANCED BIOLOGICAL NUTRIENT RECOVERY

Rick Johnson
Vice President, Market Development



Agenda

- What is the trend
- Technology description
- Results
- Economics



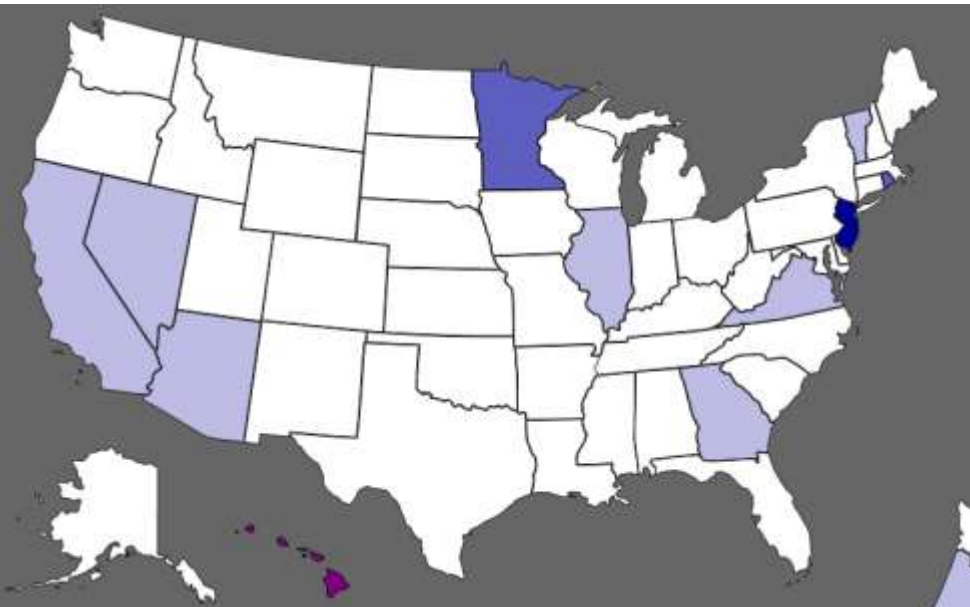
"Vision without action is a daydream. Action without vision is a nightmare"

-Japanese Proverb

State Nitrogen and Phosphorus Criteria

| | |
|----------------|---|
| Level 5 | Complete set of N and P criteria for all watertypes |
| Level 4 | 2 or more watertypes with N and/or P criteria |
| Level 3 | 1 watertype with N and/or P criteria |
| Level 2 | Some waters with N and/or P criteria |
| Level 1 | No N and/or P criteria |

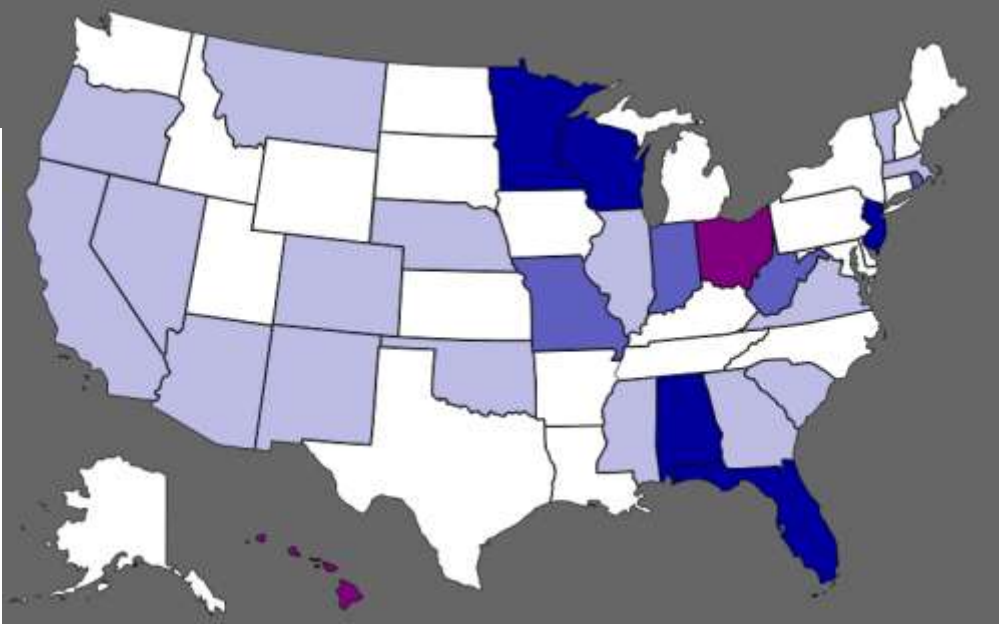
Source: <http://cfpub.epa.gov/wqsits/nnc-development/>



1998

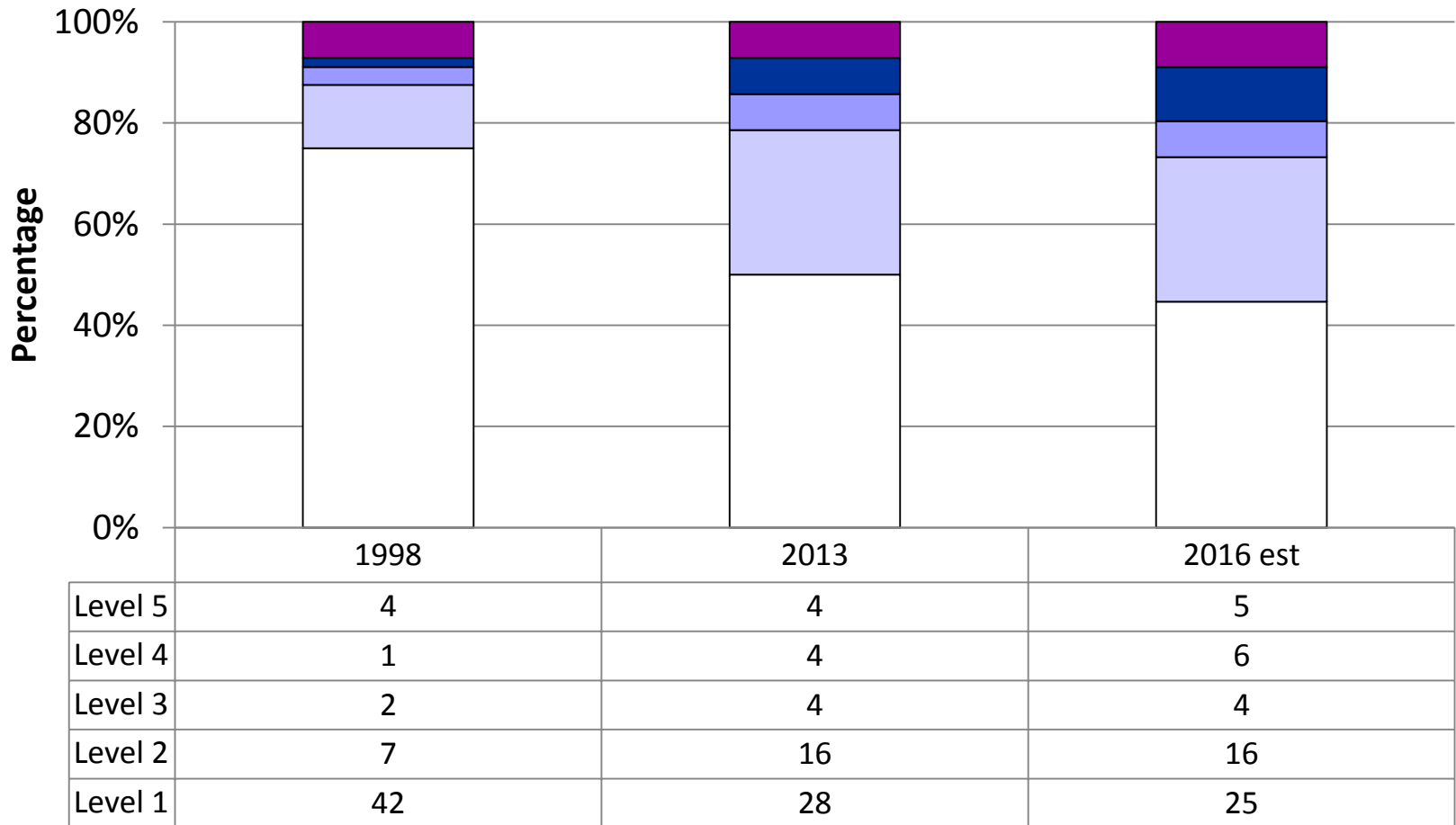


2016 (est)



Numeric Criteria Trend: States & Territories

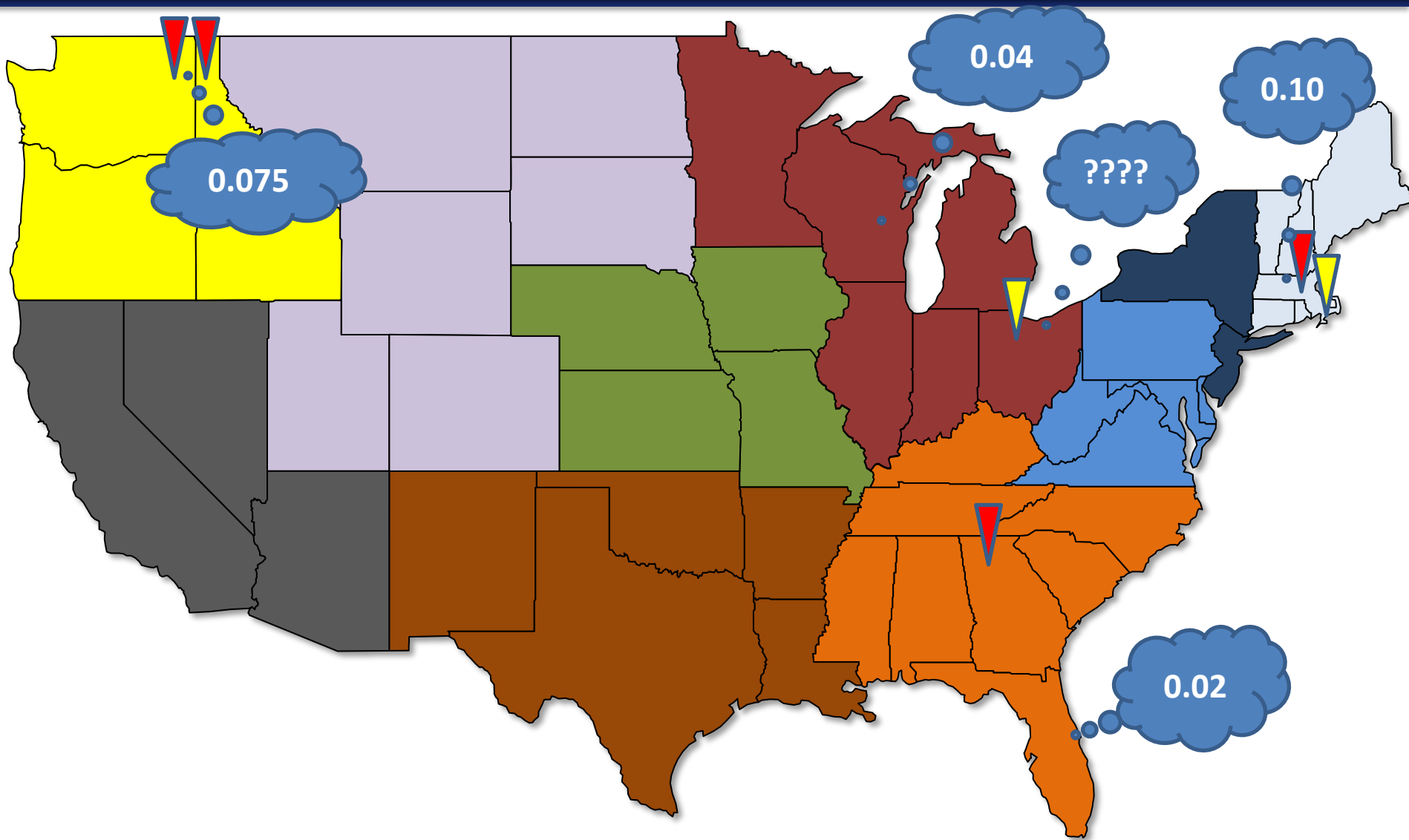
Level 1
 Level 2
 Level 3
 Level 4
 Level 5





CLEARAS

WATER RECOVERY



The challenge:

- Reducing targeted nutrients in a ***cost effective*** manner

Our solution:

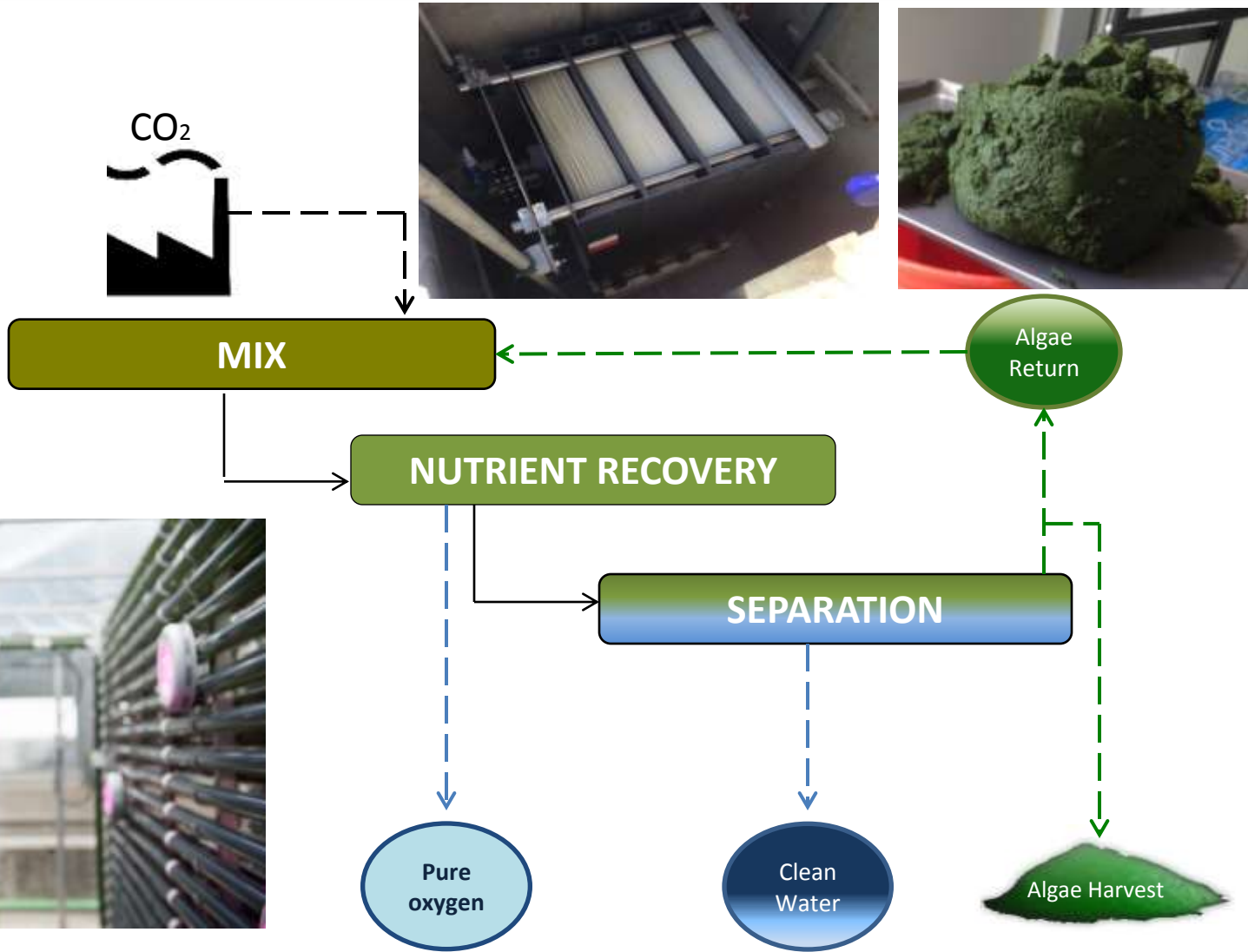
- View algae as a process...not a product
- Sustainable, advanced nutrient recovery
 - *US Patent 8,101,080*

The benefits:

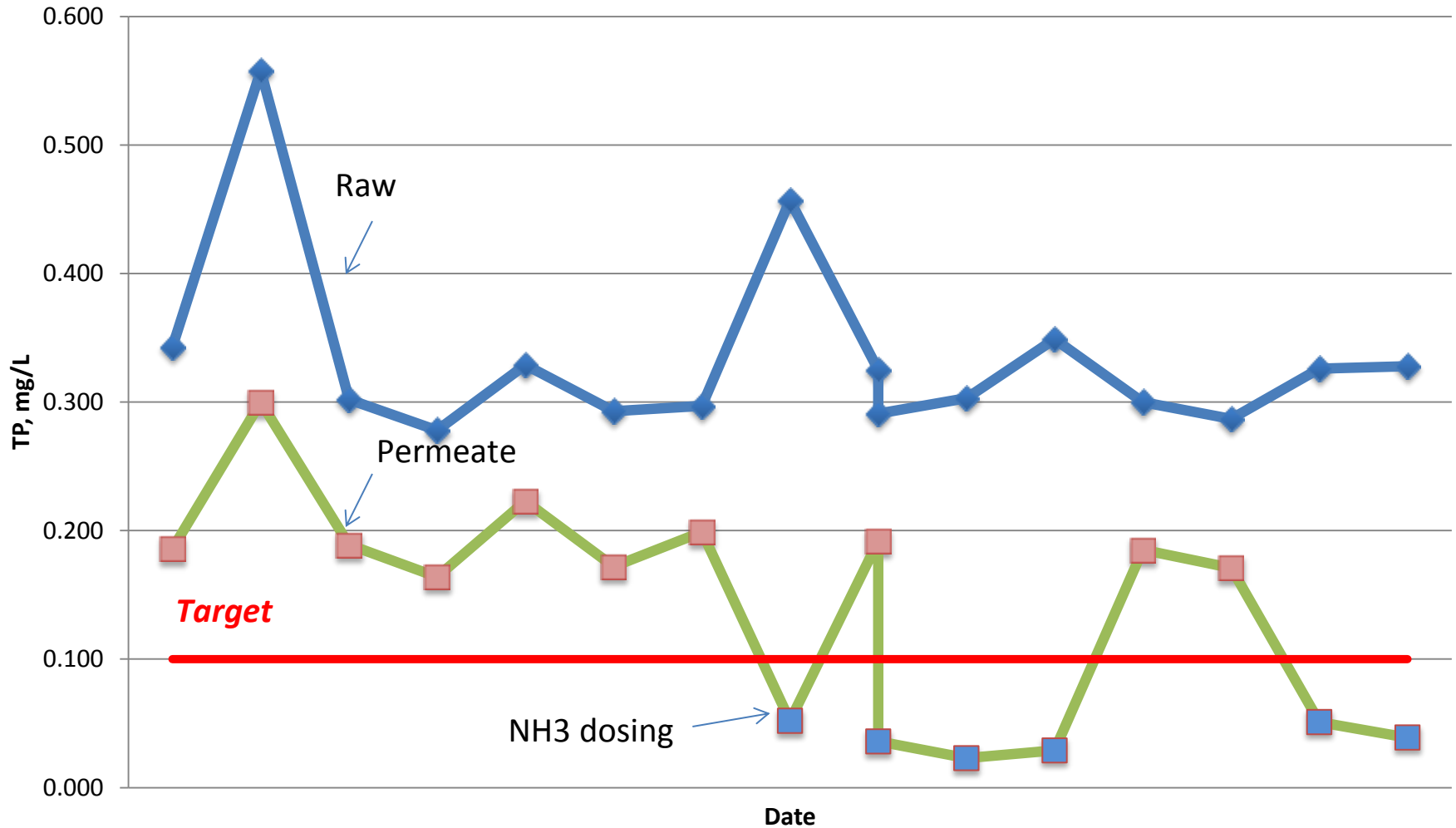
- Best in Class performance
- No chemical sludge produced
- Sustainable
- Multi-generational, single technology

CO₂ recycling & O₂ release

Biomass co-product

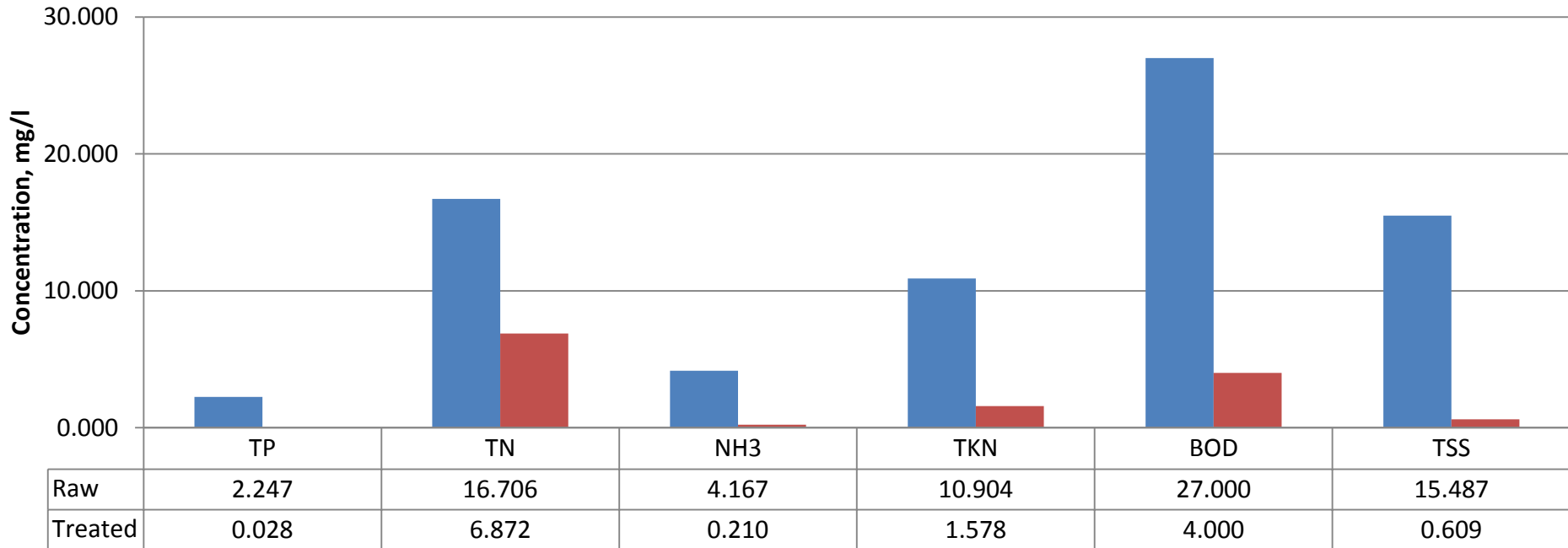


Controlled experiment: Nitrogen : Phosphorus relationship



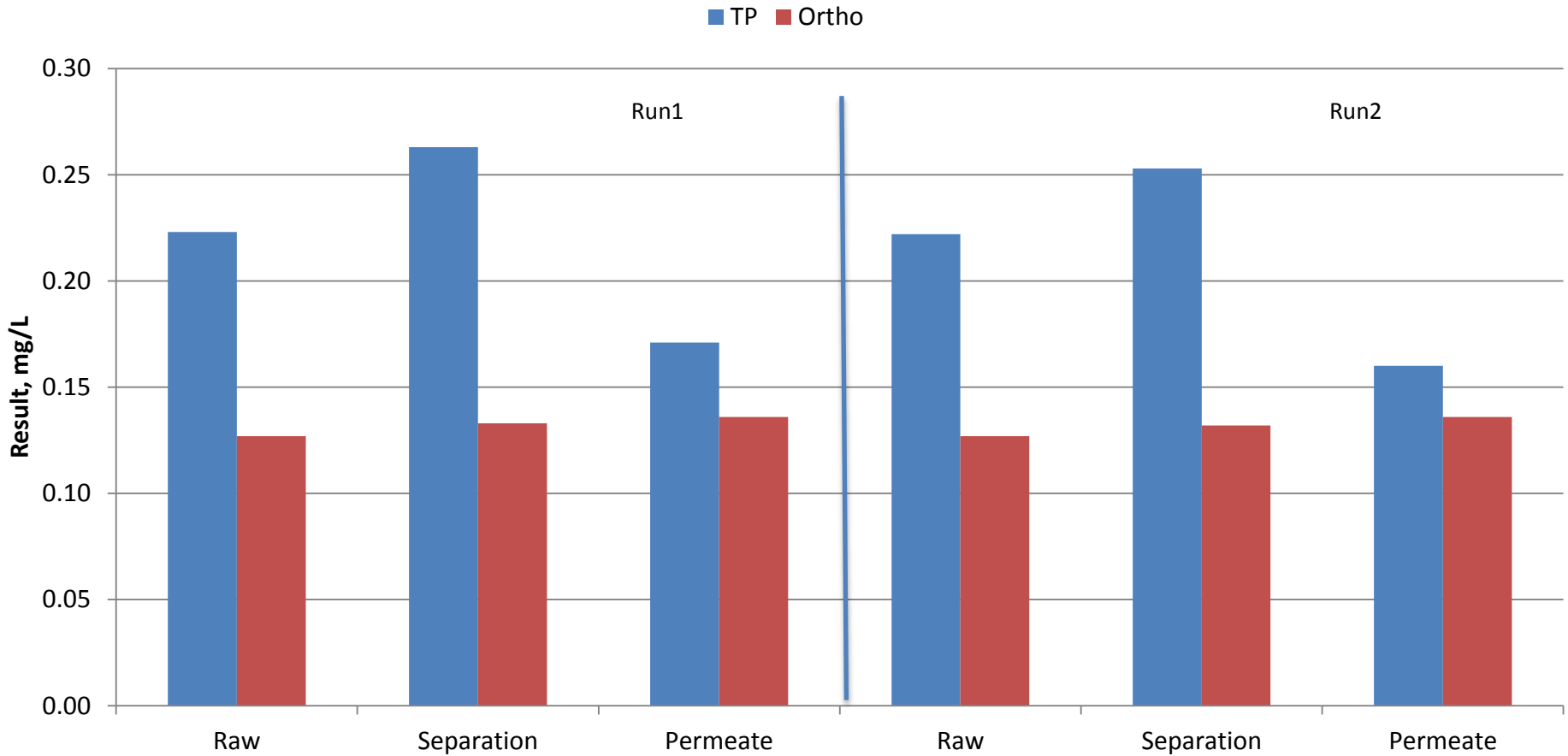
Municipal Summary

■ Raw ■ Treated

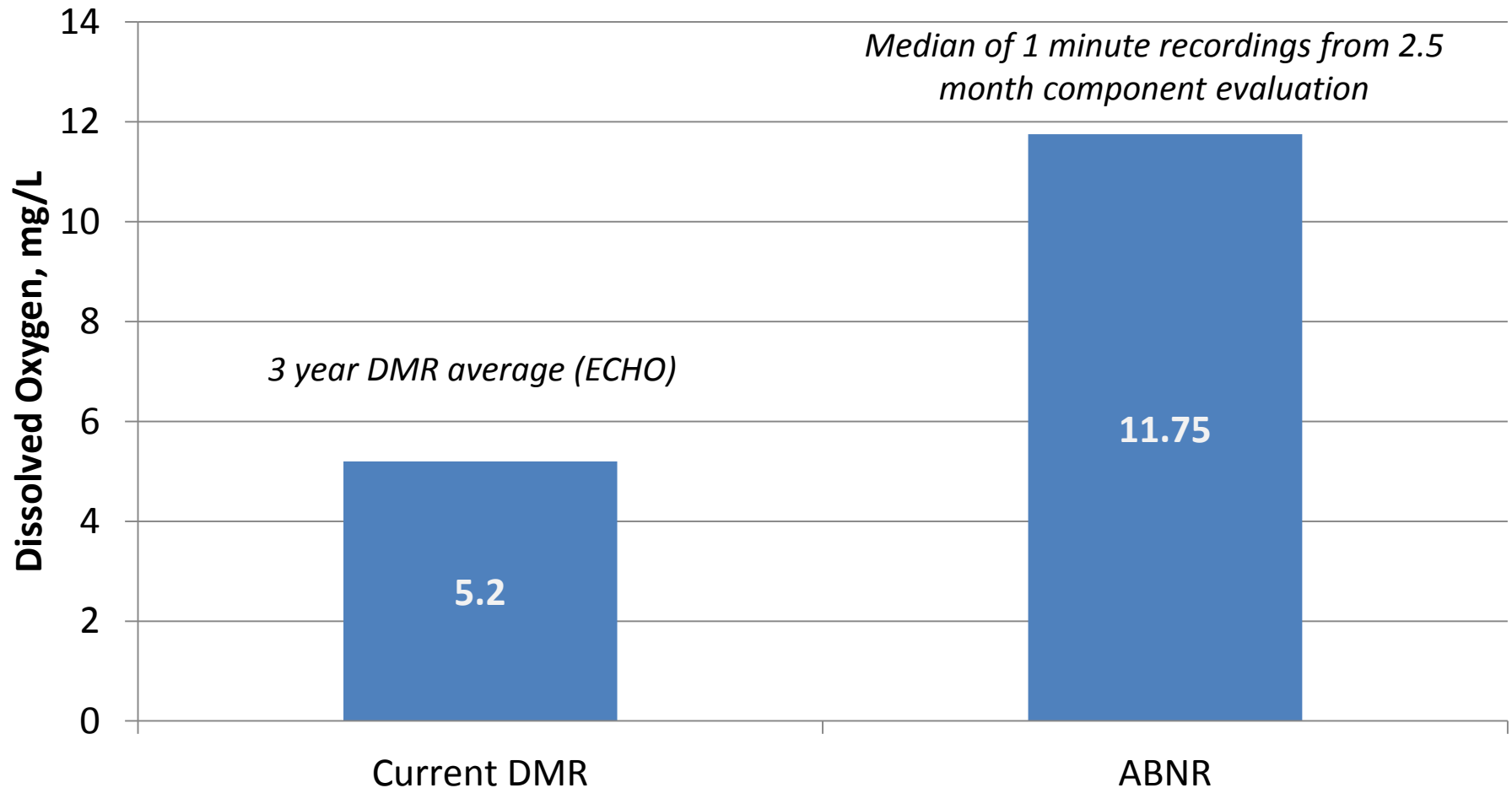


Nutrient Recovery Test

Influence of separation on phosphorus reduction



Dissolved Oxygen

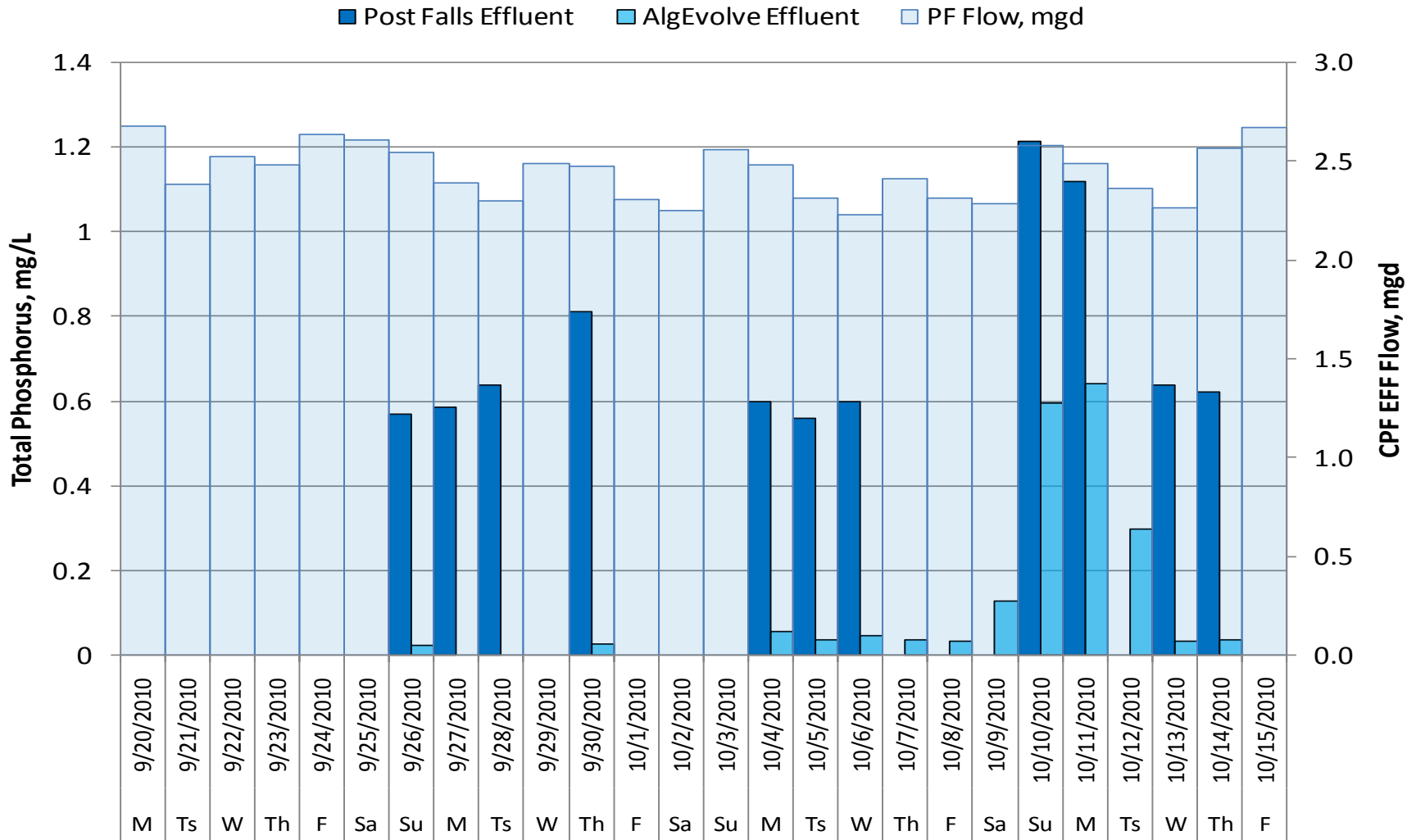




5 MGD Municipality
Primarily residential
36,000 Residents
TMDL: 0.075mg/L TP

Municipal wastewater treatment

| Constituent | Before | After | % Removal |
|----------------|--------|-------|-----------|
| Total P (mg/L) | 0.625 | 0.036 | 94.14% |
| TSS (mg/L) | 12.18 | 0.24 | 98.00% |
| PCB (pg) | 2141 | 144.1 | 93.00% |





Results:

| Constituent | Before | After | % Removal |
|----------------|--------|-------|-----------|
| Total P (mg/L) | 2.68 | 0.18 | 93.3% |
| Ammonia (mg/L) | 0.60 | 0.05 | 91.7% |
| Total N (mg/L) | 14.1 | 3.26 | 76.9% |

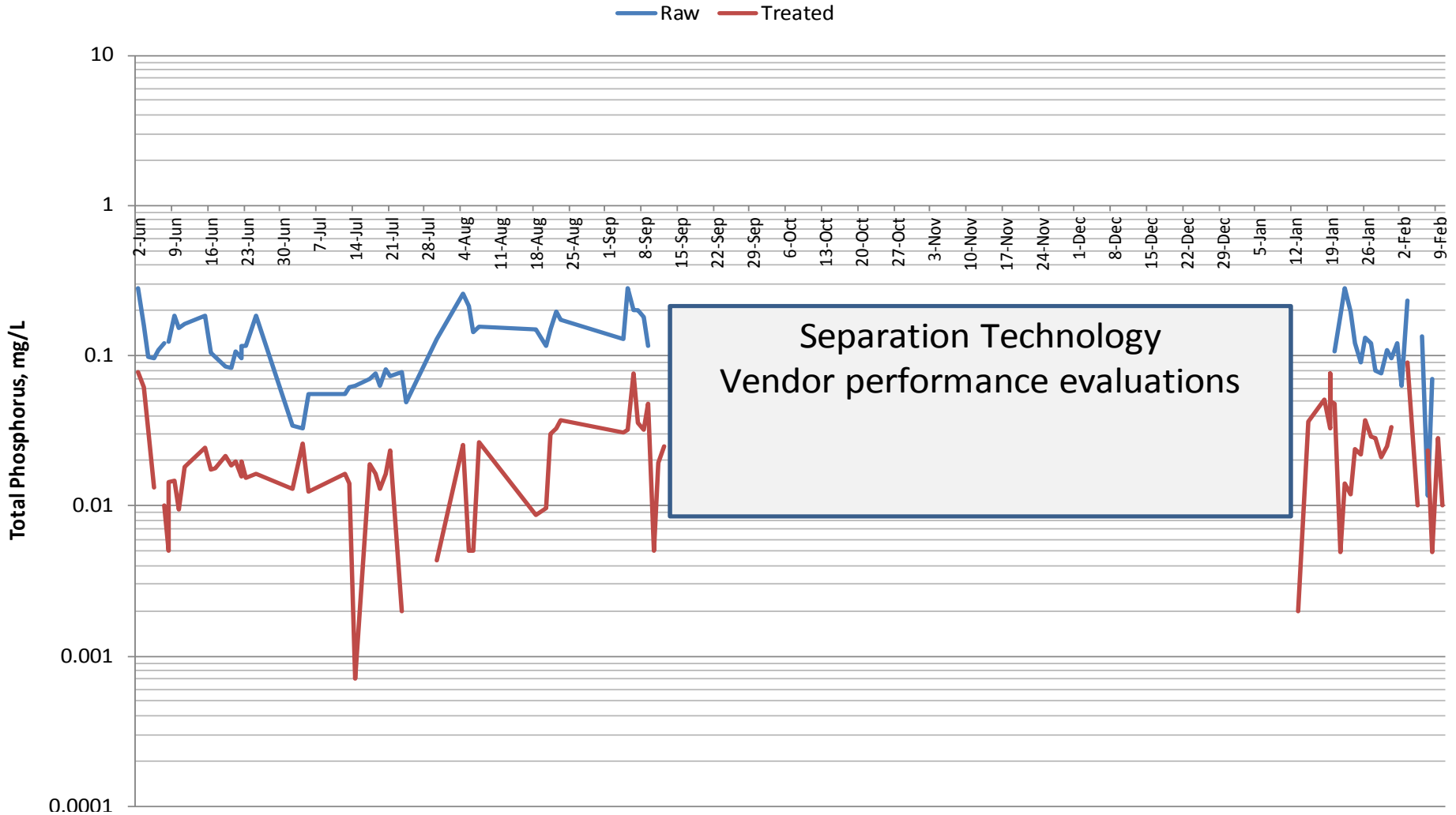
**3 MGD Pulp & Paper
Process recycled paper
130 year old company
TMDL: ~0.075mg/L TP**



Inland Empire Paper Company Results

| Constituent | Before* | After* | % Removal |
|----------------|---------|------------|-----------|
| Total P (mg/L) | 0.26 | 0.033 | 87.31% |
| BOD (mg/L) | 18 | 4 | 77.78% |
| TSS (mg/L) | 149 | 1 | 99.33% |
| PCB (pg) | 10,000 | Non Detect | 100% |
| Color | 500 | 230 | 54.00% |

Total Phosphorus Trend



45 MGD Municipality

- **250,000 residents**
- **Biosolids management for 14 communities**

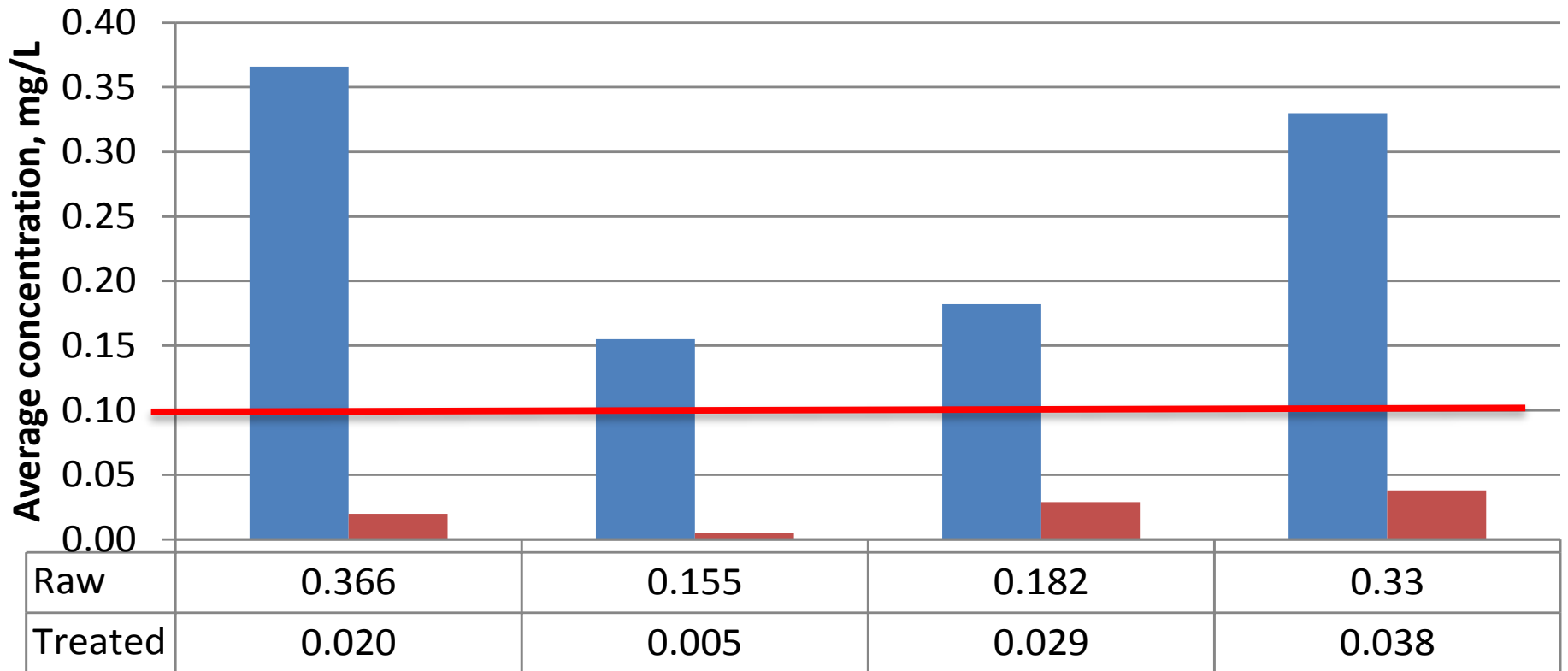
Heavy Industrial Base (26 SIU's)

Seasonal Permit: 0.1mg/L TP & 5.0mg/L TN

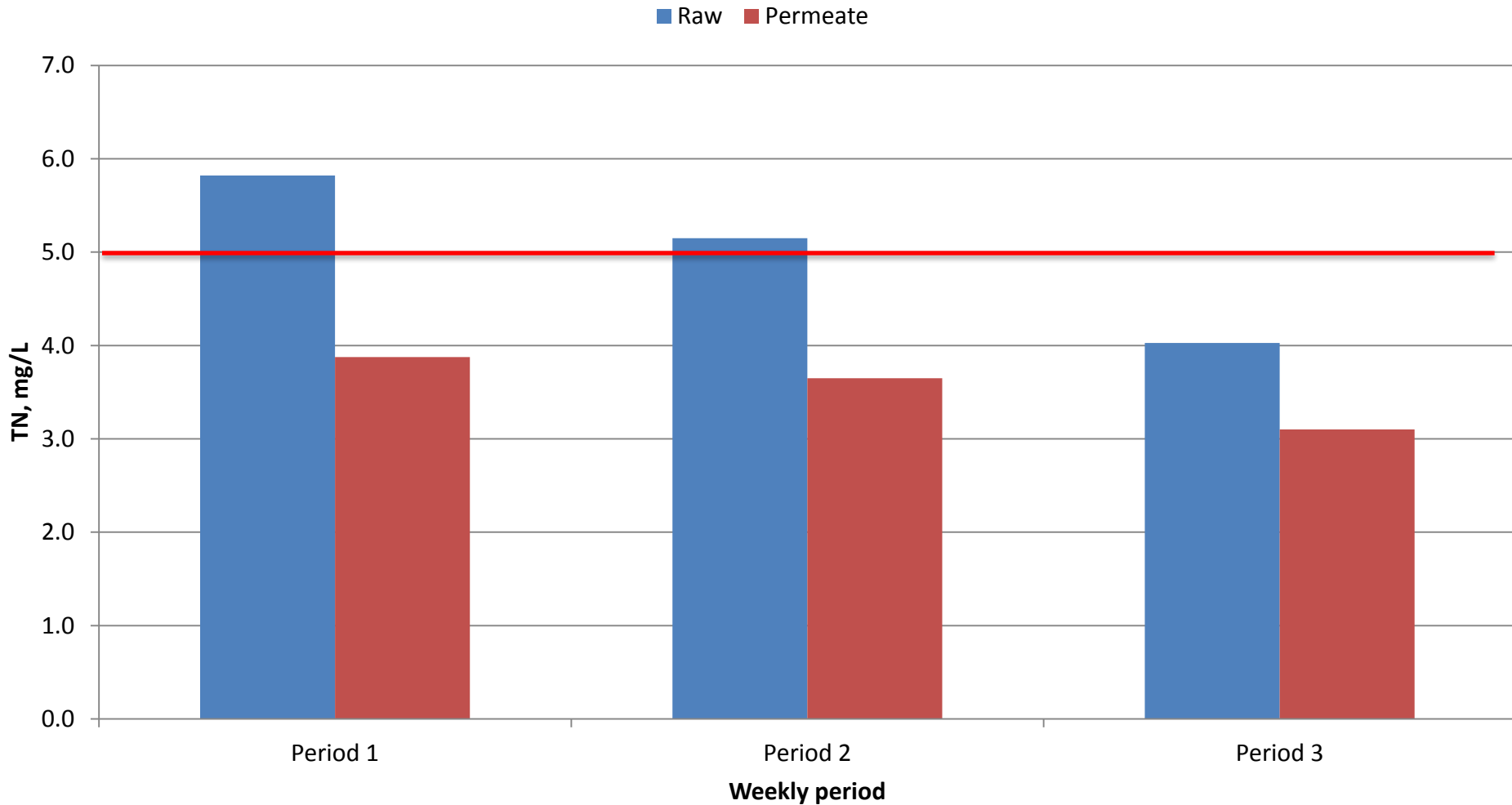


Total Phosphorus

■ Raw ■ Treated

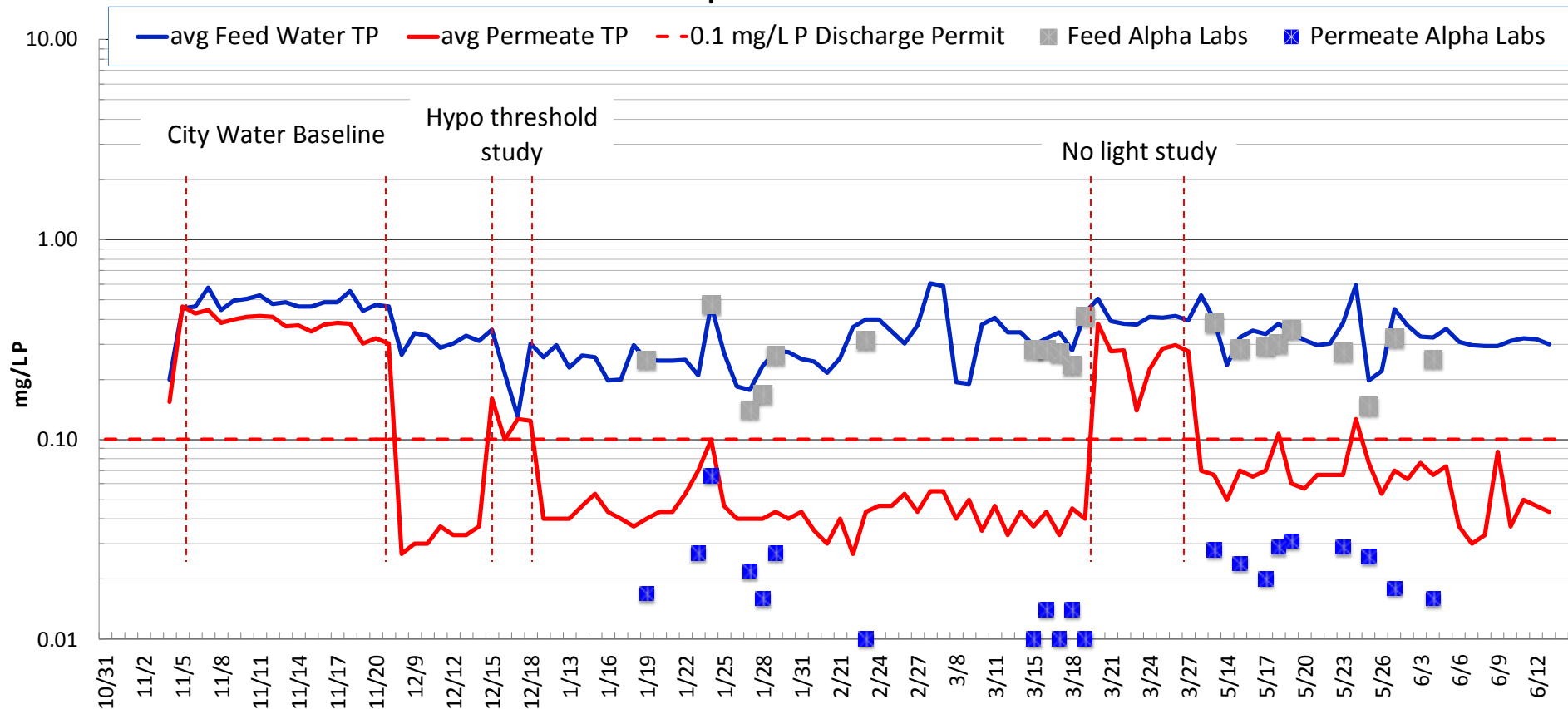


Total Nitrogen response



- Feed: 0.285mg/L
- Permeate: 0.02mg/L

Total Phosphorus Feed and Permeate



Permeate results below detection limit of hand held meter-results supplemented with 3rd party lab results

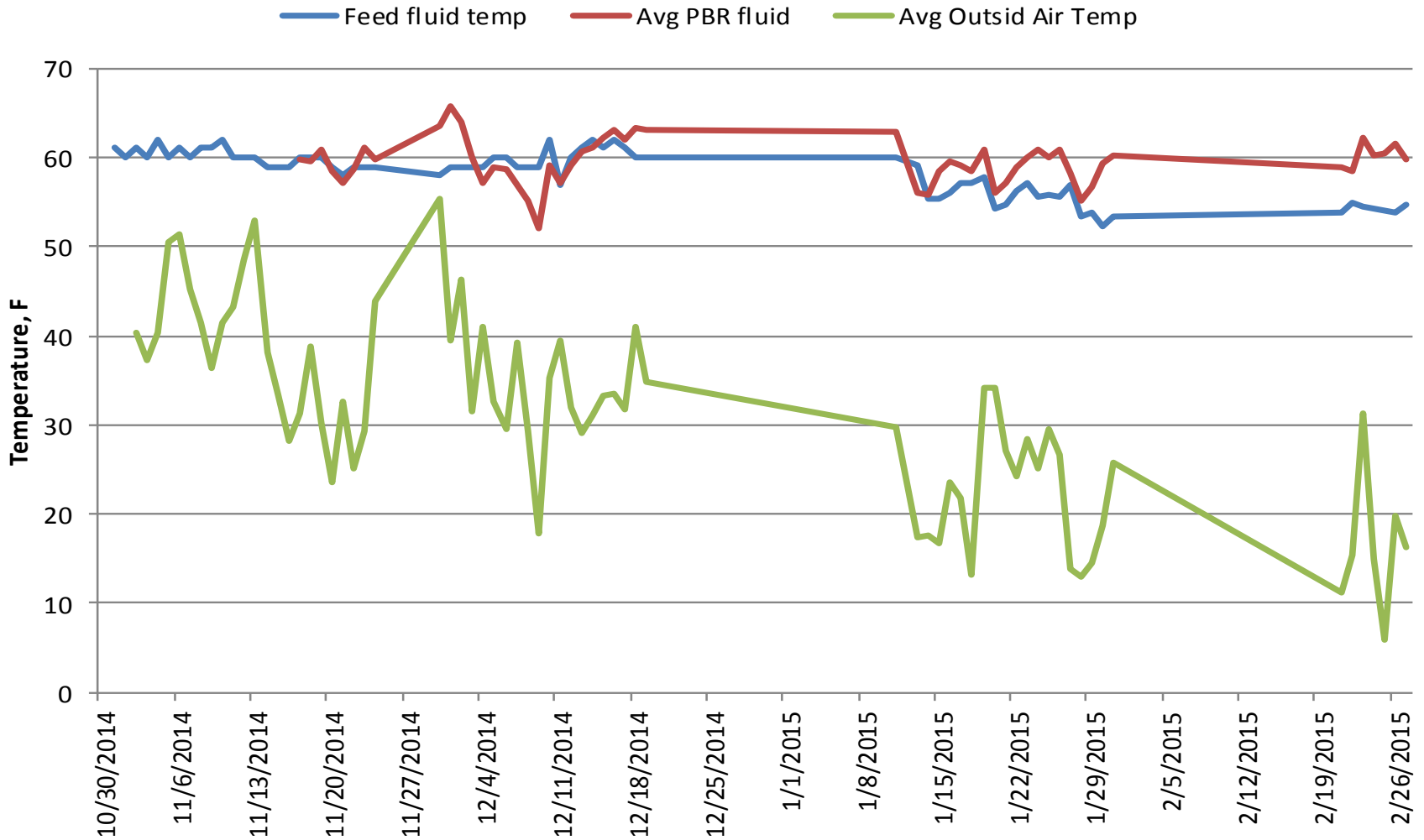
| Date | COD, mg/L | | TOC, mg/L | |
|------------------|--------------|--------------|--------------|-------------|
| | Feed | Permeate | Feed | Permeate |
| 3/19 | 26 | 24 | 4.86 | 4.81 |
| 3/20 | 35 | 24 | 5.17 | 4.62 |
| 5/18 | 20 | 20 | 6.54 | 5.91 |
| 5/25 | 26 | 20 | 6.91 | 2.5 |
| 6/4 | 28 | 20 | 5.94 | 5.86 |
| Average | 27.00 | 21.60 | 5.88 | 4.74 |
| Reduction | 20.0% | | 19.4% | |

Numbers in red reported as “Non Detect”. Level of detection shown



| | Temperature, F | | |
|---------|----------------|------|-------|
| | Feed | PBR | Air |
| Average | 58.2 | 59.6 | 30.4 |
| St Dev | 2.63 | 2.54 | 11.14 |

Temperature influence



Average Biomass characteristics

| | N, % | P2O5, % | Potash, % | Protein, % | Fat, % | Carb, % |
|----------------|-------------|----------------|------------------|-------------------|---------------|----------------|
| Average | 4.4 | 1.7 | 0.6 | 30.3 | 3.1 | 32.4 |
| Low | 0.6 | 0.3 | 0.1 | 11.4 | 0.2 | 6.1 |
| High | 7.8 | 3.4 | 2.3 | 48.3 | 7.8 | 63.2 |
| Sample size | 25 | 25 | 25 | 18 | 18 | 18 |

Typical applications

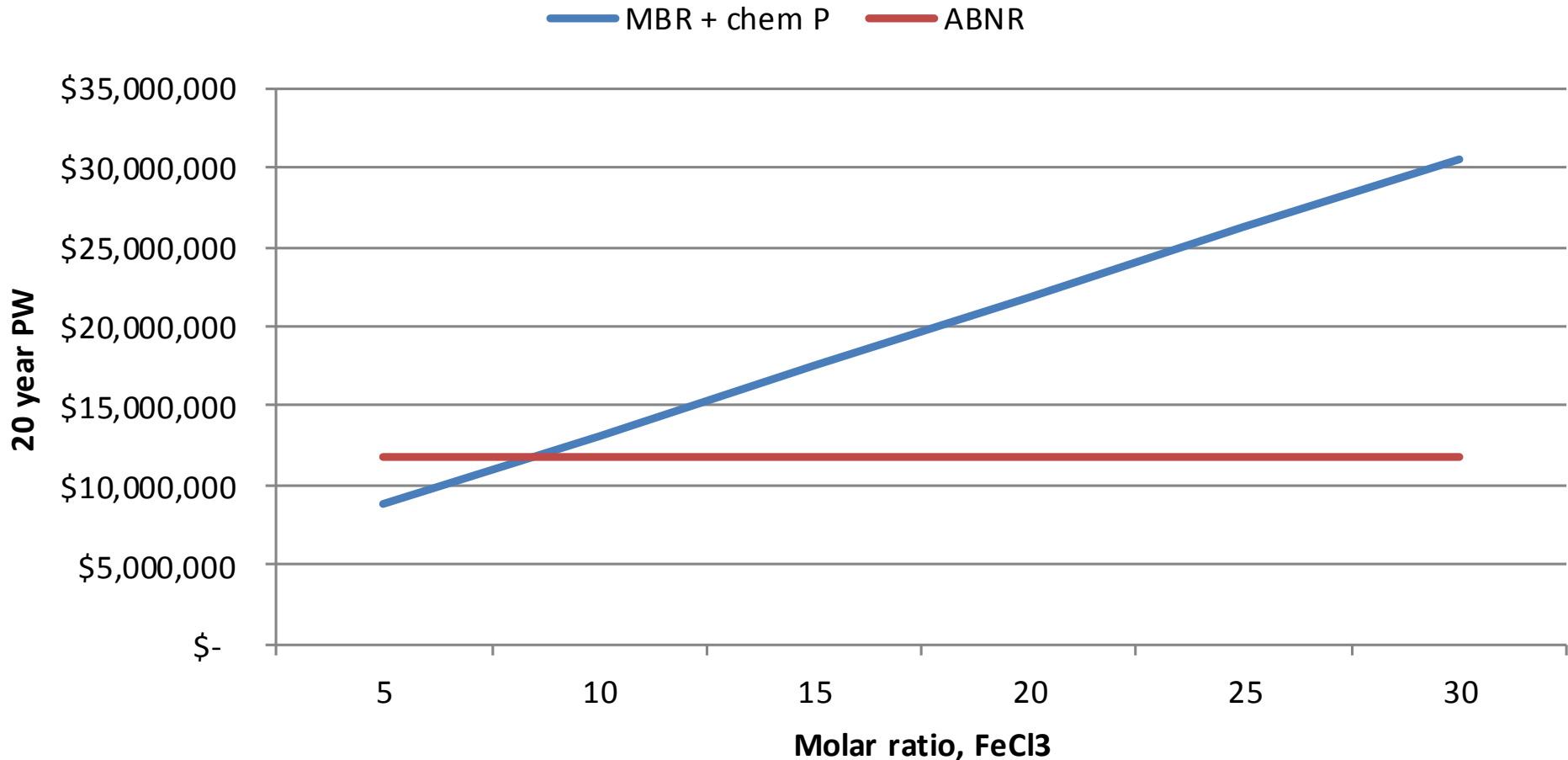
- Bio-plastics
- Soil amendment / composting aid
- Fuel source
- Others

5 Year TAM, \$M

\$478 - \$638
 \$71 - \$94
 \$2 - \$3
 In development

Average of 25 municipal / industrial sources

Break even technology comparison



Thank You

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