Engineered Biofiltration:

Enhancing Performance with Low-Level Supplementation

Chance Lauderdale, Jess Brown, Jennifer Stokke,

Carollo Engineers, Inc.

Engineers...Working Wonders With Water™

Biological activity impacts biofilter…..

Water treatment performance

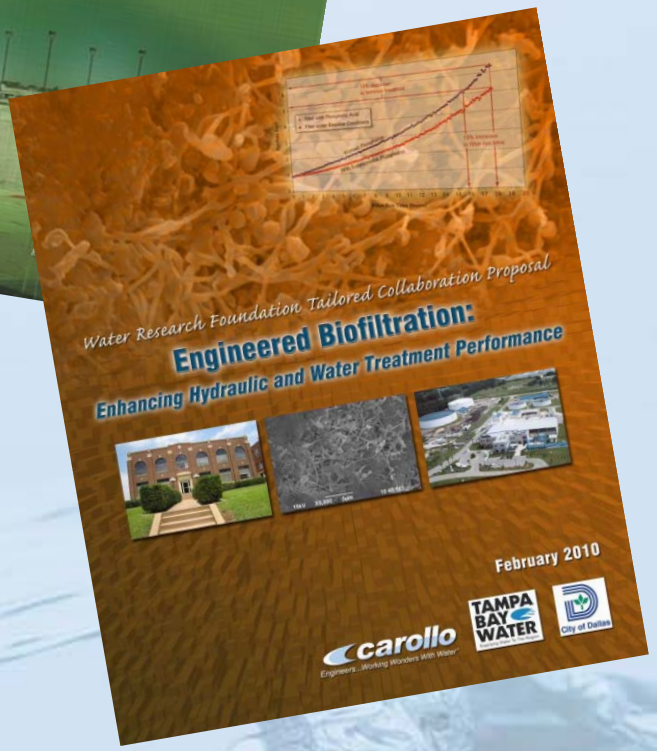
- Effluent stability
  (disinfectant residual, regrowth, odors)
- Contaminant breakthrough
  (turbidity, trace organics, color, T&O, metals, etc.)

Hydraulic and mechanical performance

- Headloss
- Unit filter run volumes
- Water efficiency
- Underdrain support and backwash equipment

This presentation discusses…

- Concept
- Highlights from Water Research Foundation TC 4215
  - Low-level nutrient supplementation
  - H_2O_2 addition
- Validation and Optimization TC 4346
- Implementation

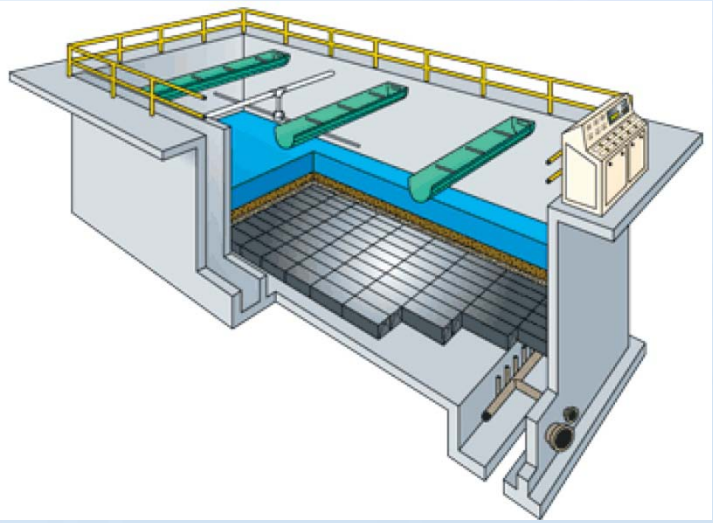


Biofiltration as We Know It:

Design & operation of biofilters are essentially driven only by filtration

Conventional biofilter operational considerations focus on particle removal and production

- Flow equalization
- Media selection (design)
- Hydraulic loading rate
- Backwashing strategy



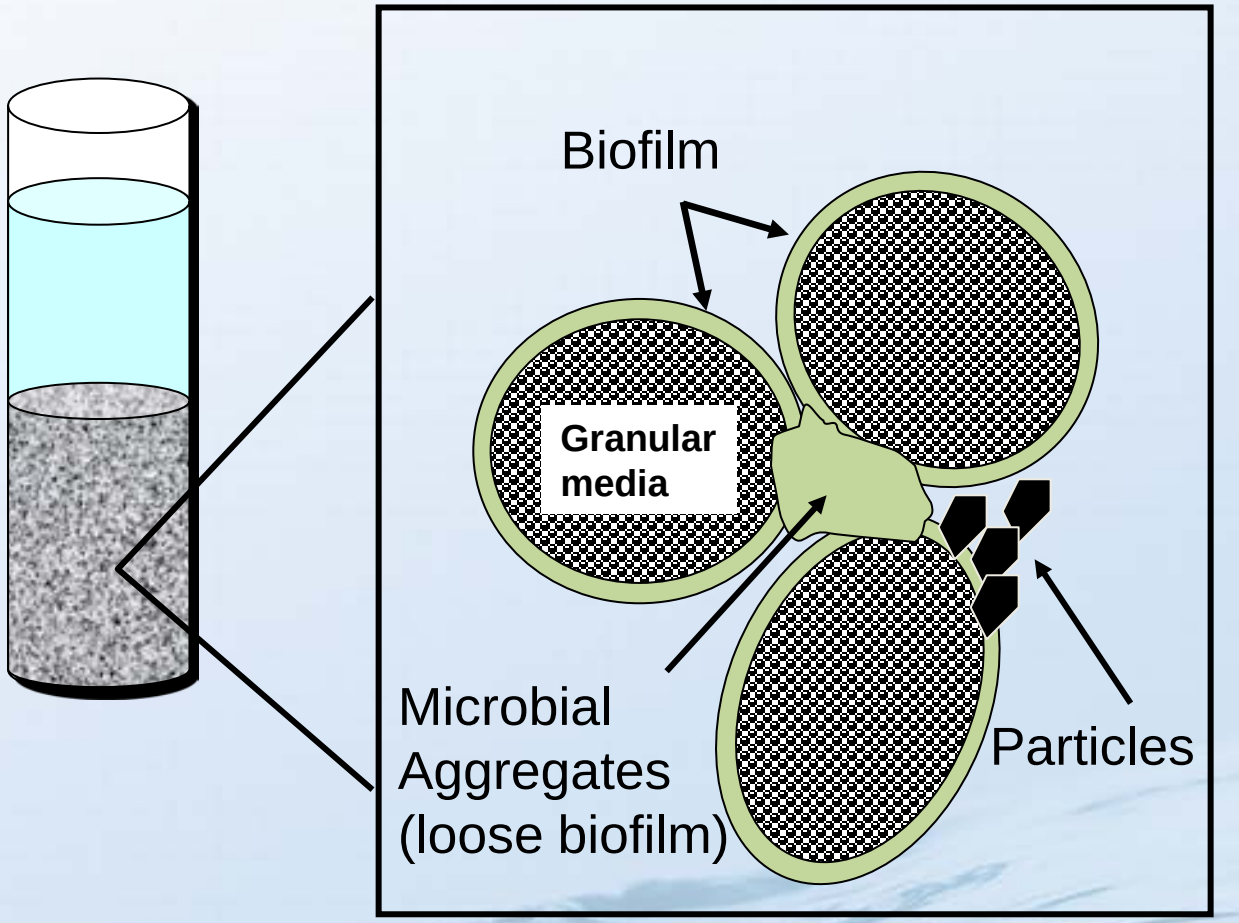
Biofiltration Moving Forward:

Filtration *and* Biological Activity should drive design and operation of biofilters

"Engineered Biofiltration"

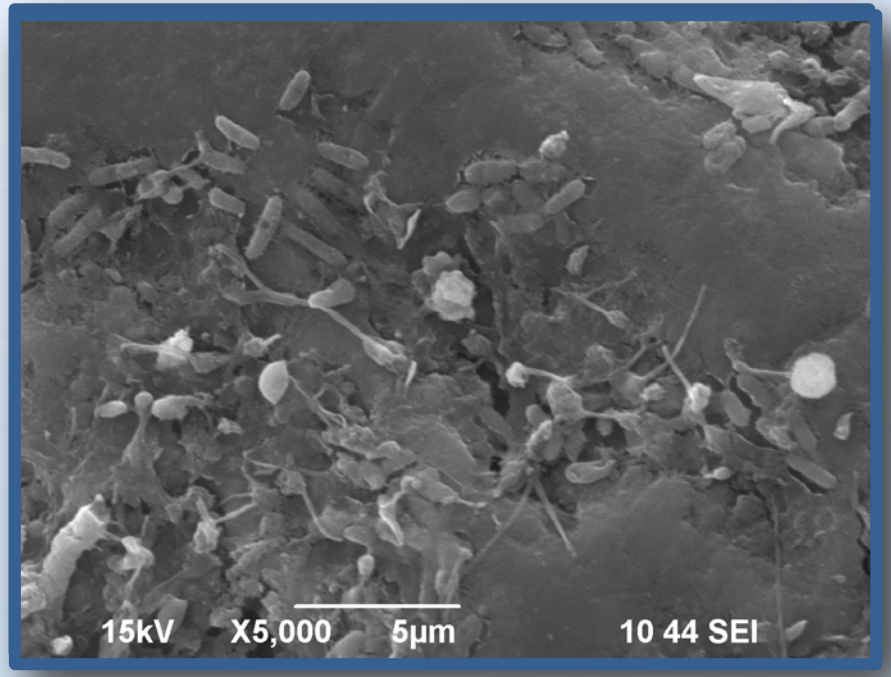
“Engineered” Biofiltration

Over time, biofilter void space becomes occupied by particulates and biofilm

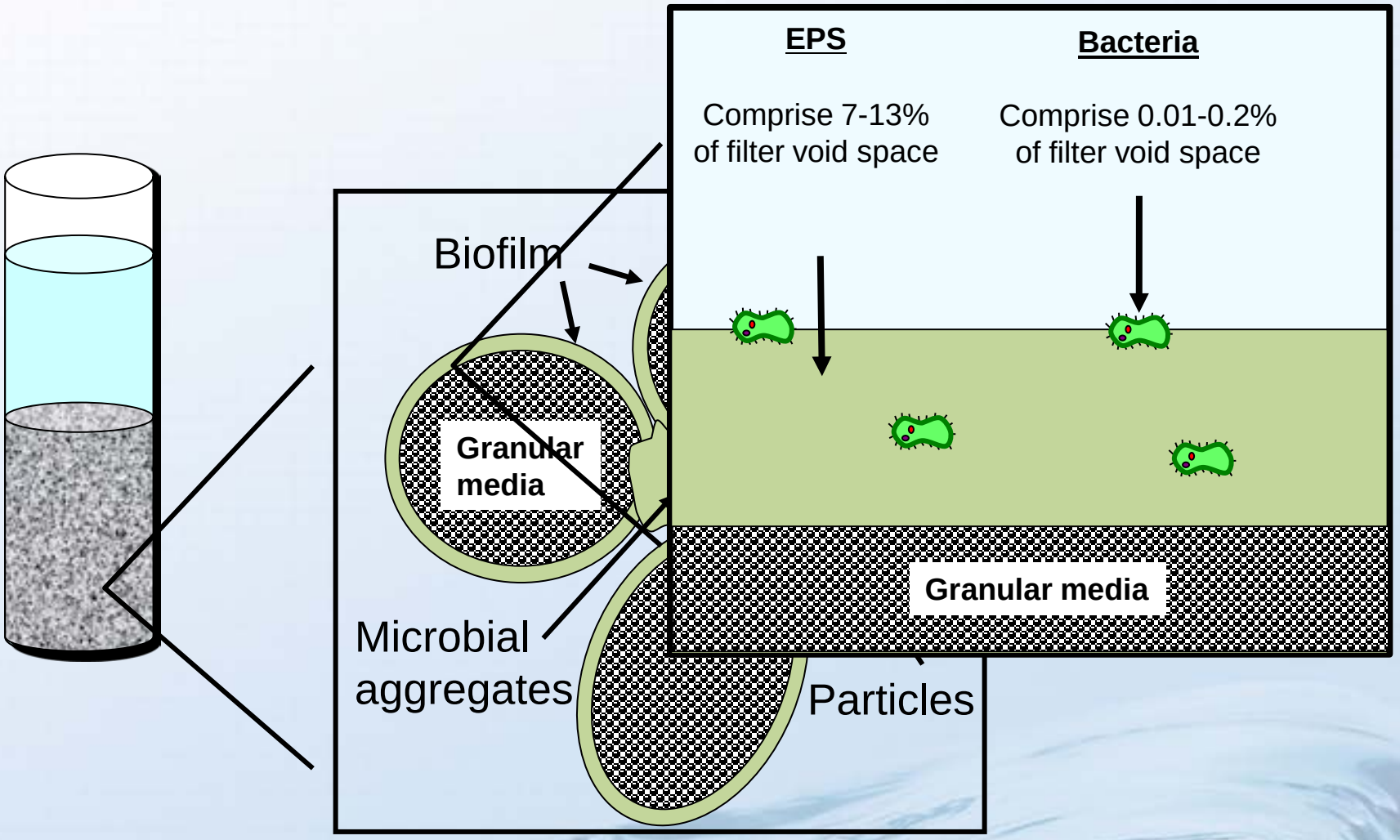


Biofilm is predominately extracellular polymeric substances (EPS)

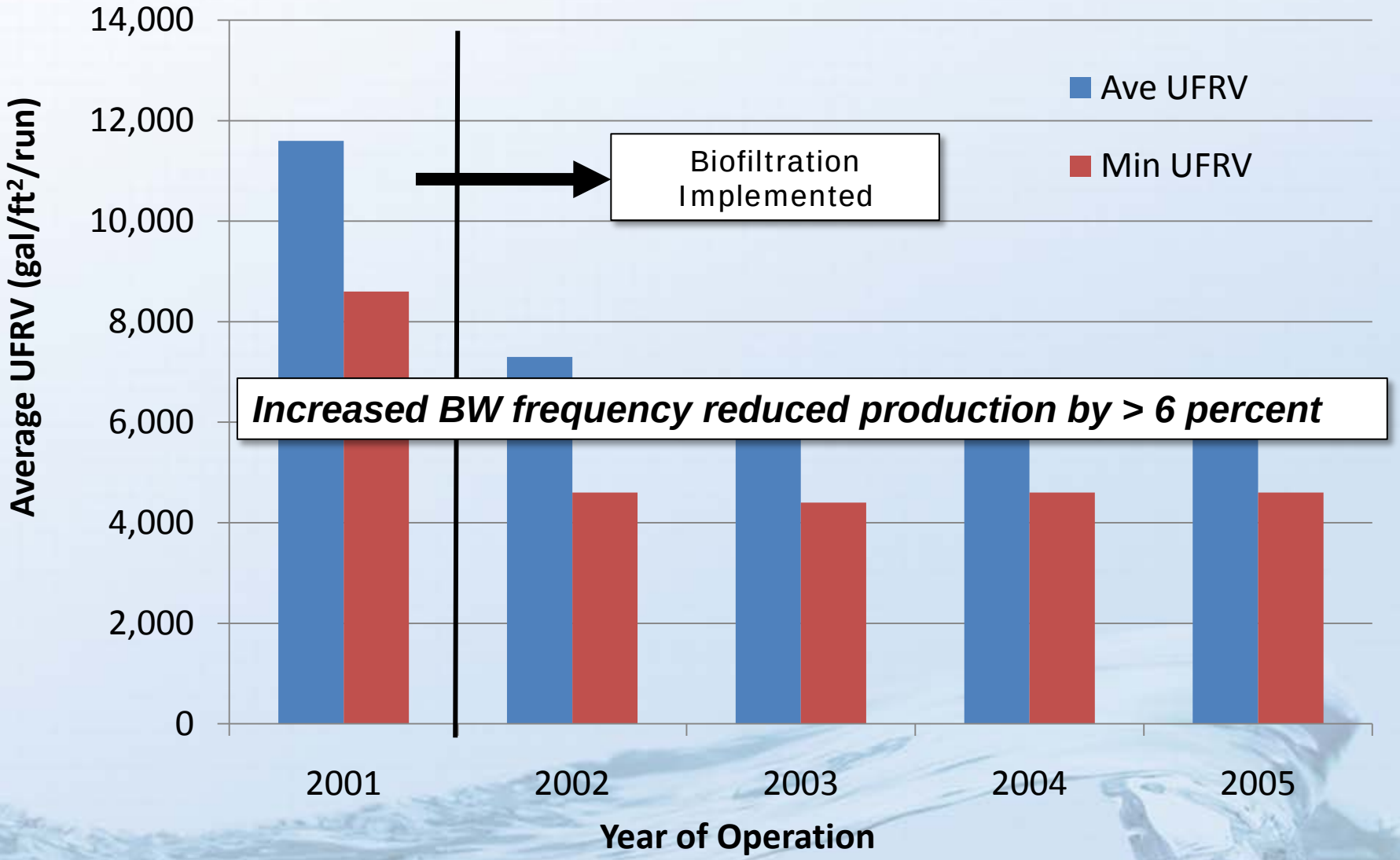
- EPS benefits bacteria
  - Adhesion
  - Protection
  - Storage
- Excess EPS impairs filter performance
  - Headloss
  - Clogging



EPS occupies >1000x more void space than bacteria in clogged "conventional biofilters"



WTPs may experience decreased unit filter run volumes (UFRV) after conversion to biofiltration



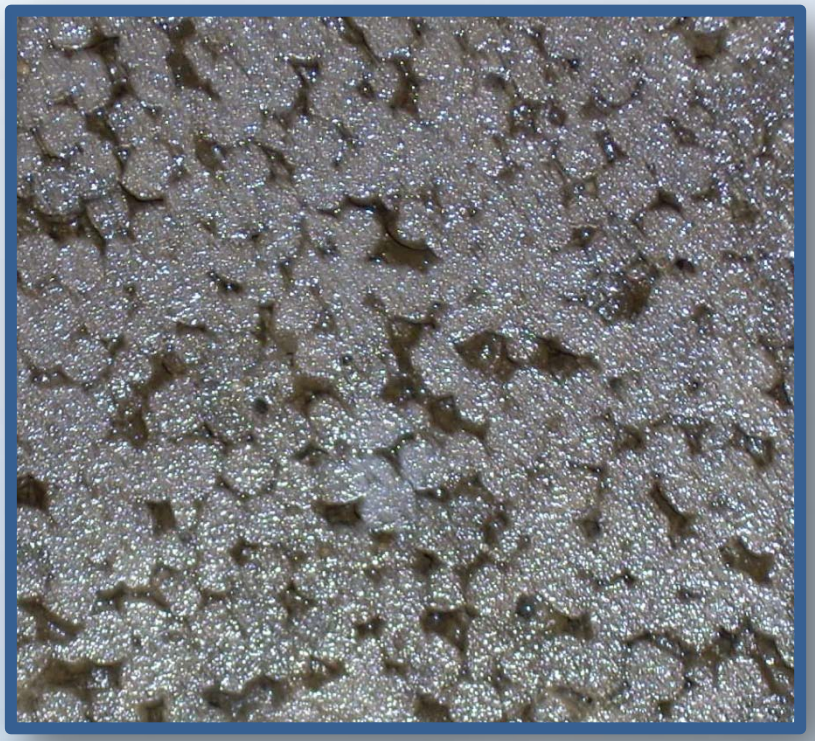
Excess EPS may lead to media and underdrain clogging

Stripped Anchors

Blown Mastic

Excess EPS may lead to media and underdrain clogging

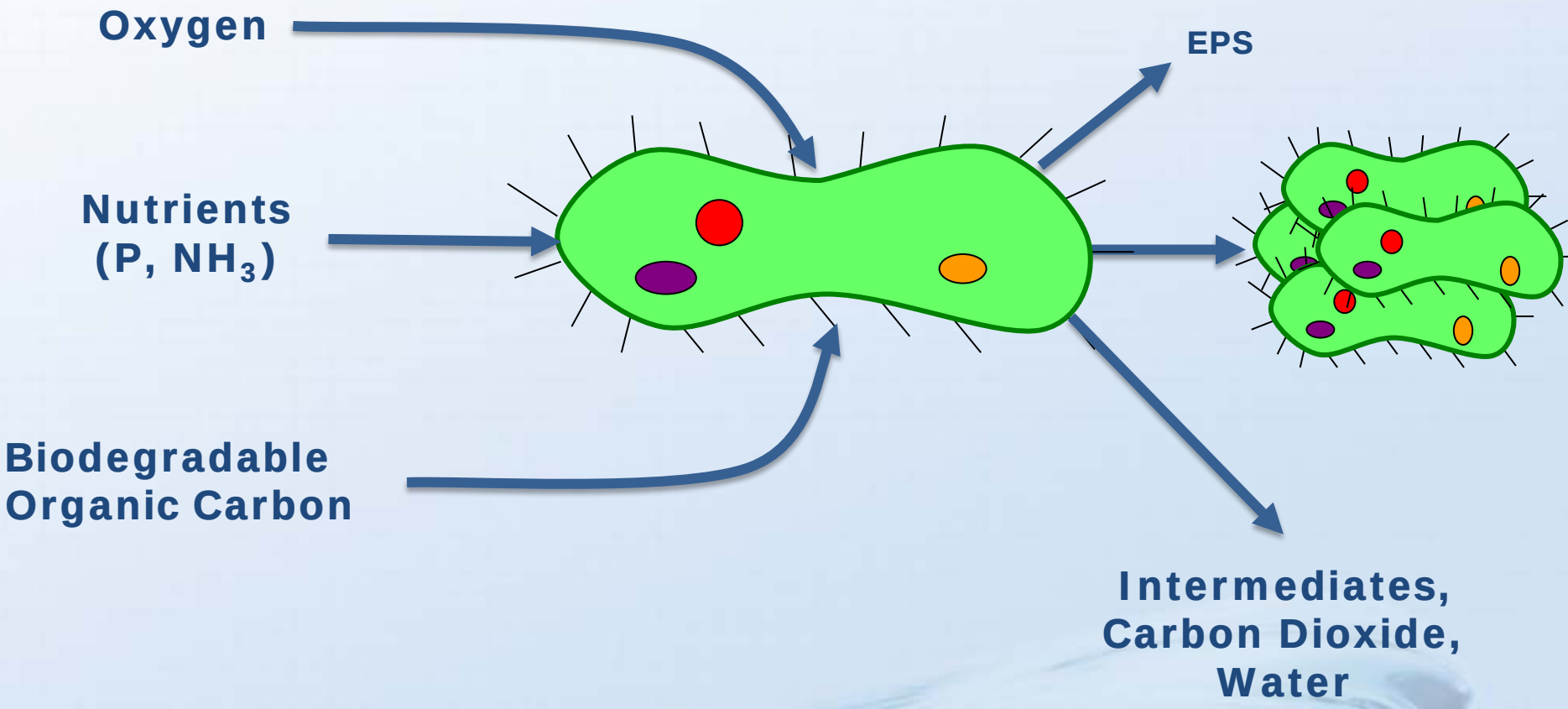
Clean IMS Cap



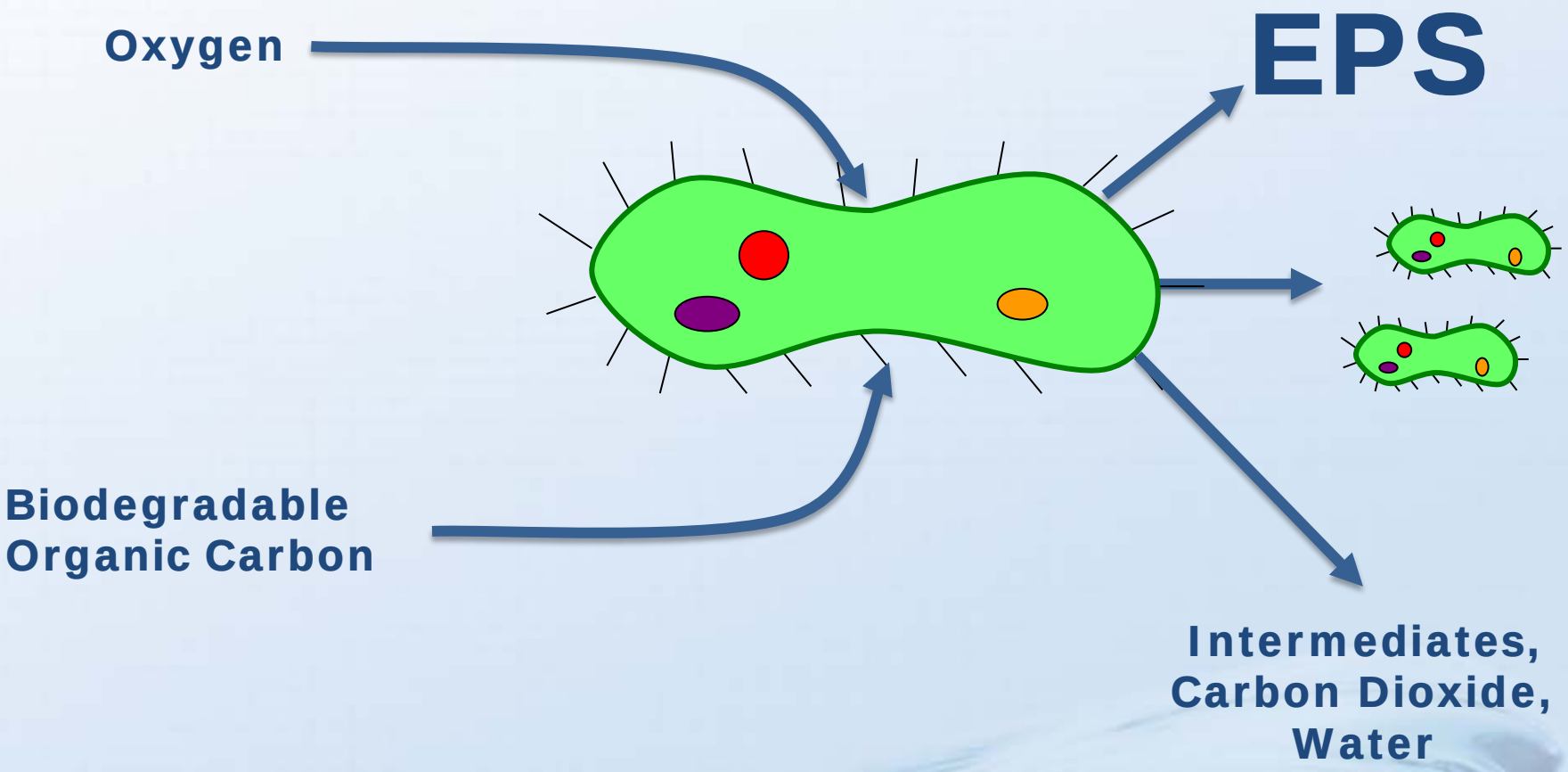
Clogged IMS Cap

Nutrient Enhancement

Effective biofiltration requires a nutritional balance

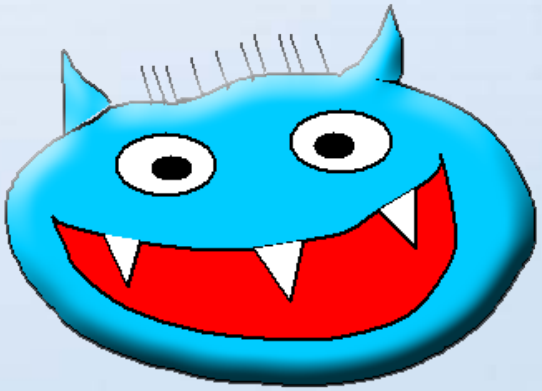


Nutritional limitations create stressed biofilter conditions



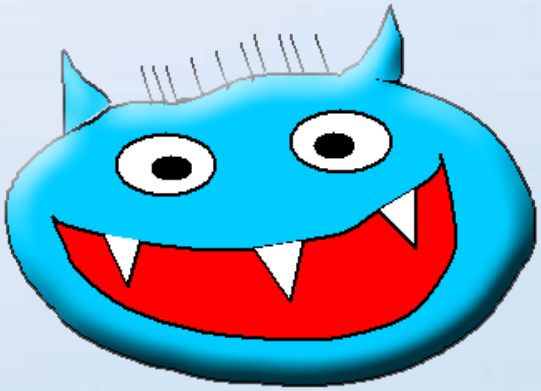
Implementation of nutritional ratio reduces biological stress

Carbon :	Nitrogen :	Phosphorus
100 :	10	: 1

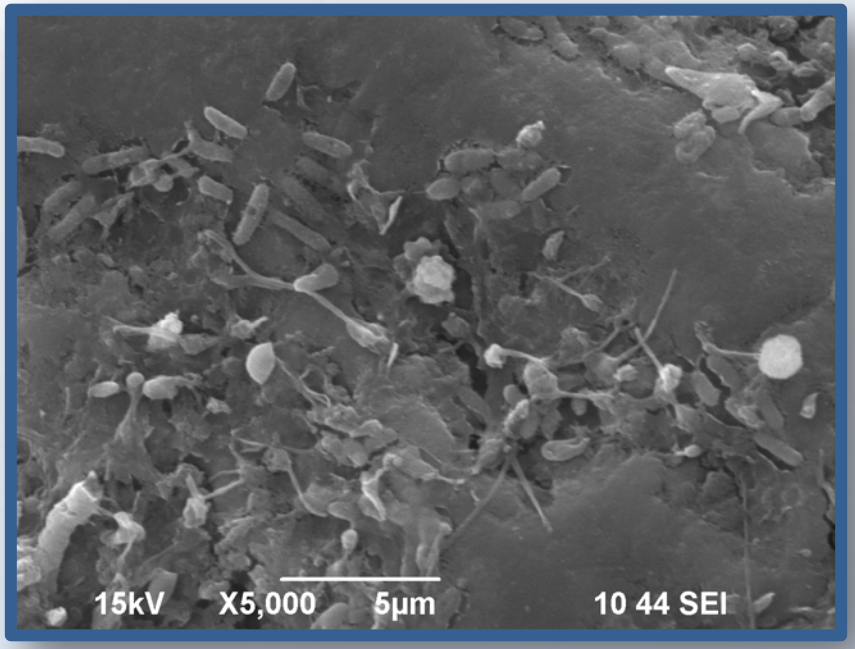


Implementation of nutritional ratio reduces biological stress

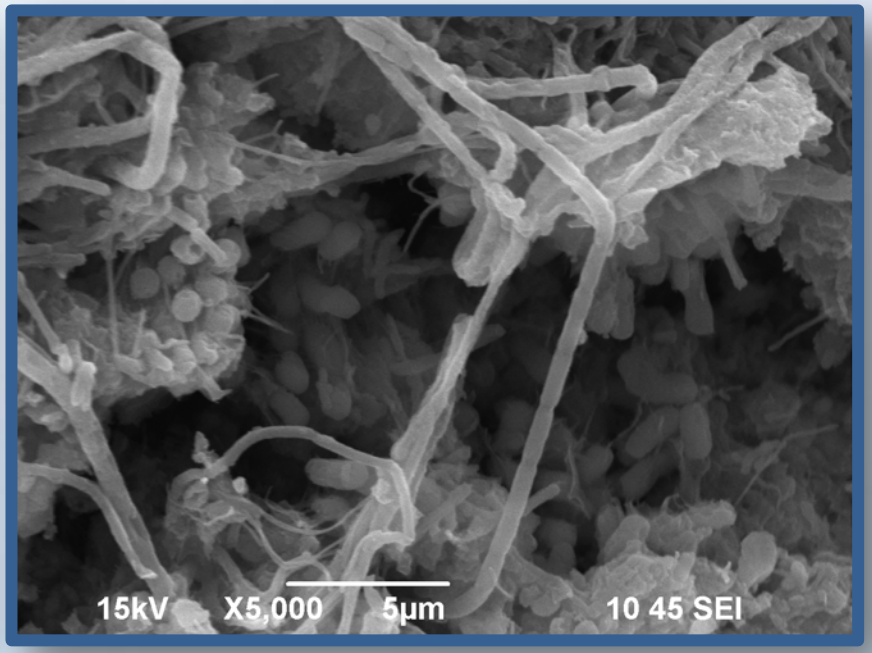
Carbon	Nitrogen	Phosphorus
1 mg/L	0.117 mg/L	0.026 mg/L



Nutrient supplementation promotes healthy biomass



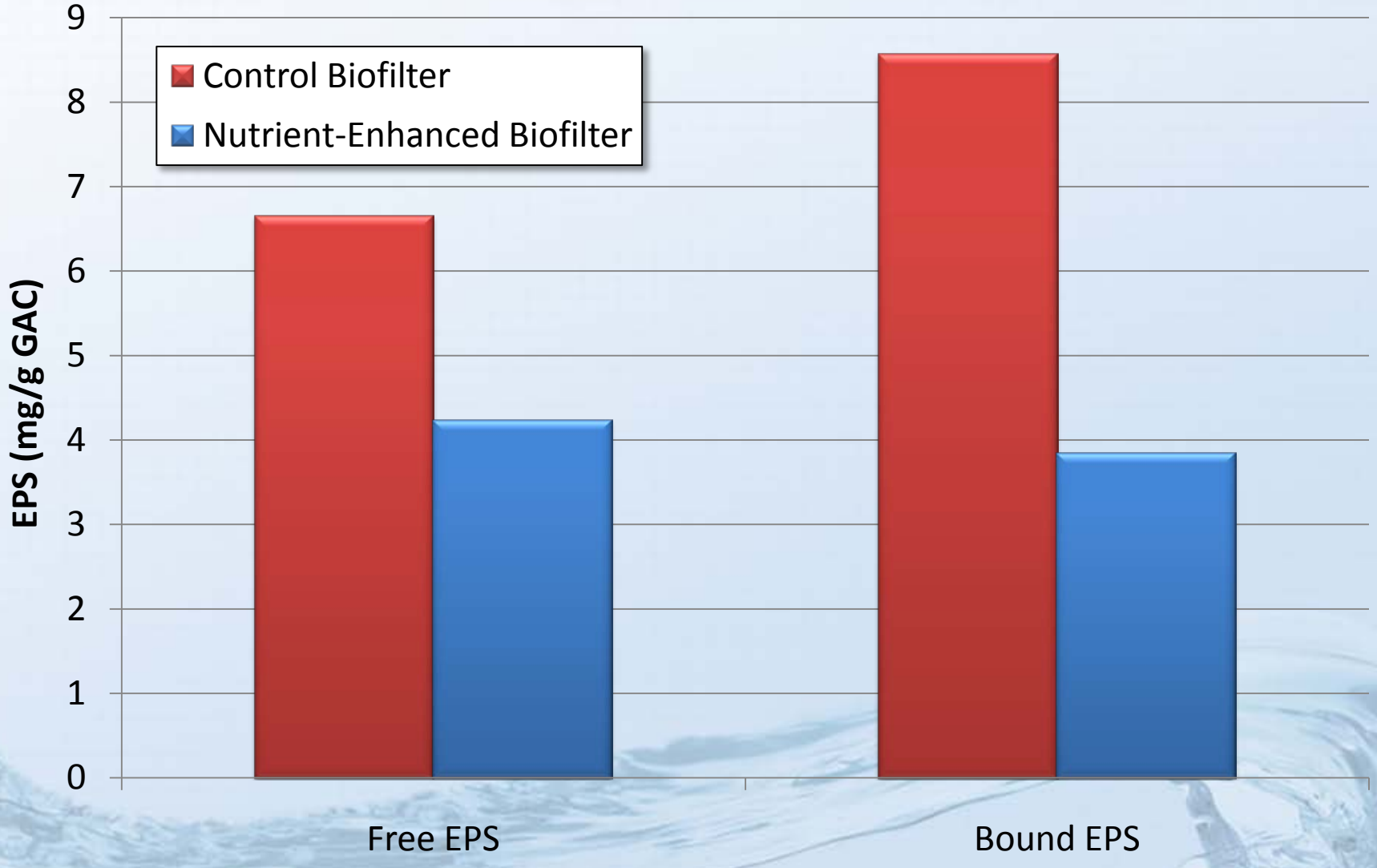
Stressed Biomass
(Nutrient Limited)



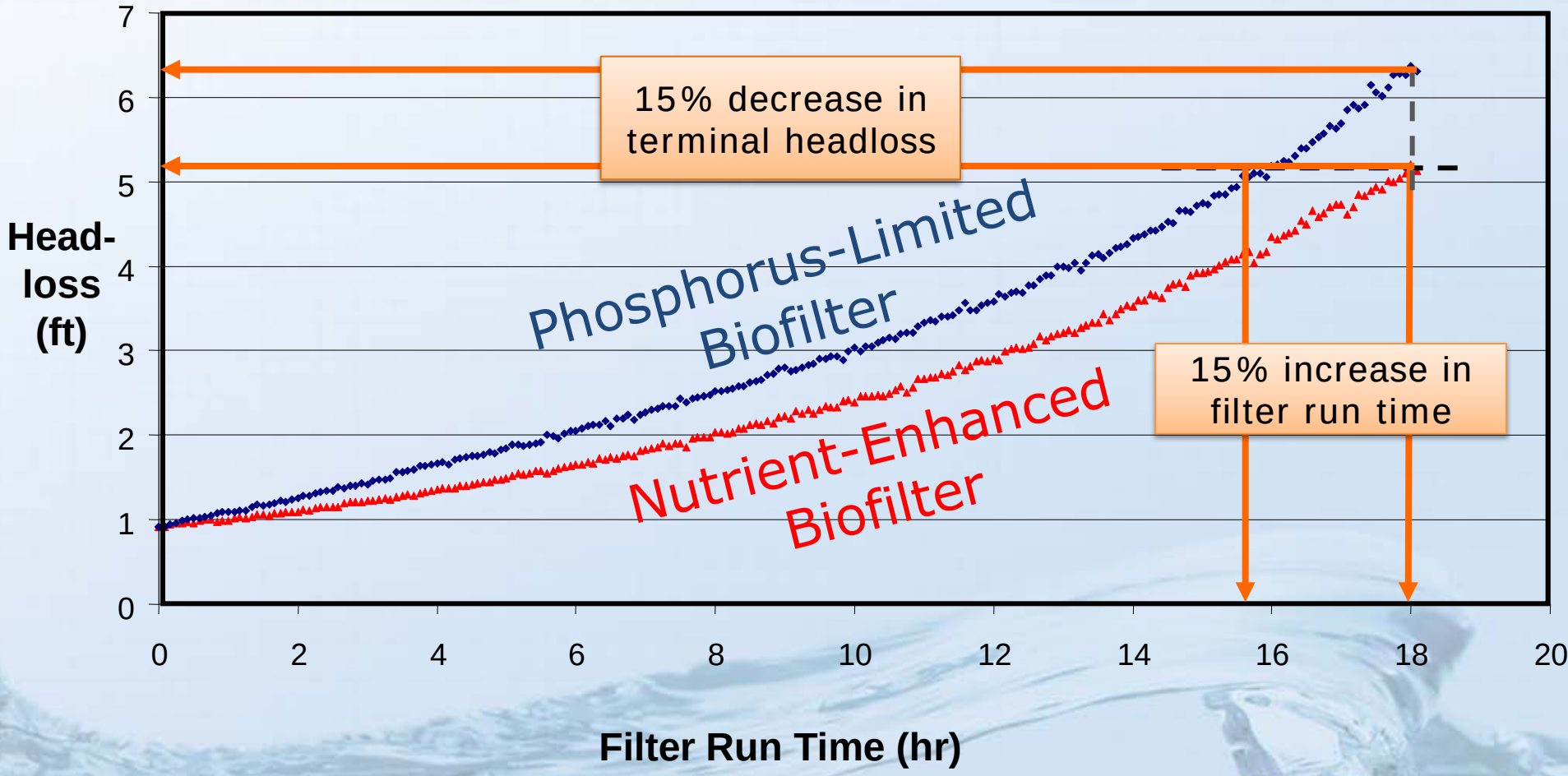
Healthy Biomass
(Nutrient-Enhanced)

SEMs courtesy of USEPA

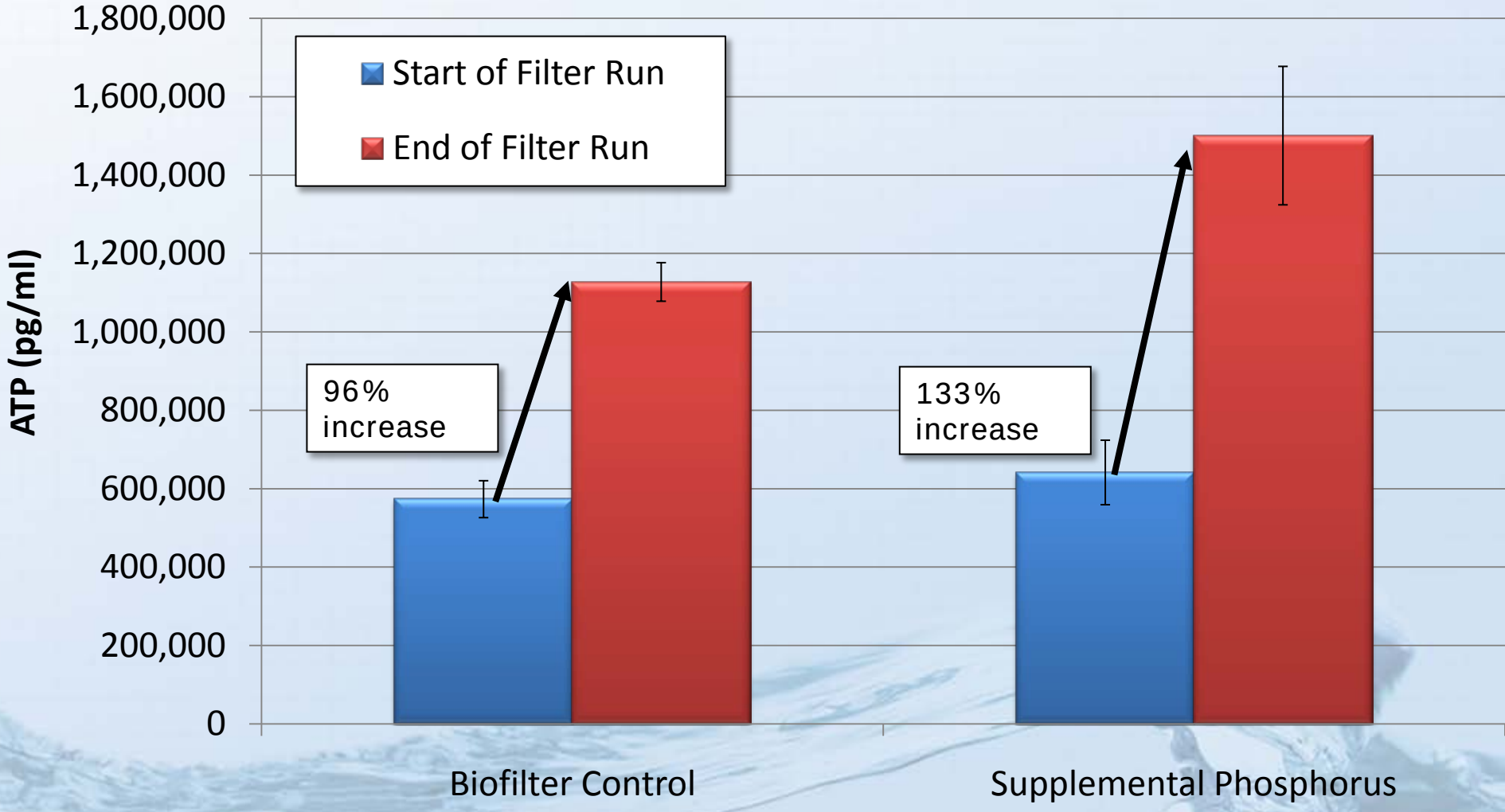
Nutrient supplementation decreased free and bound media EPS



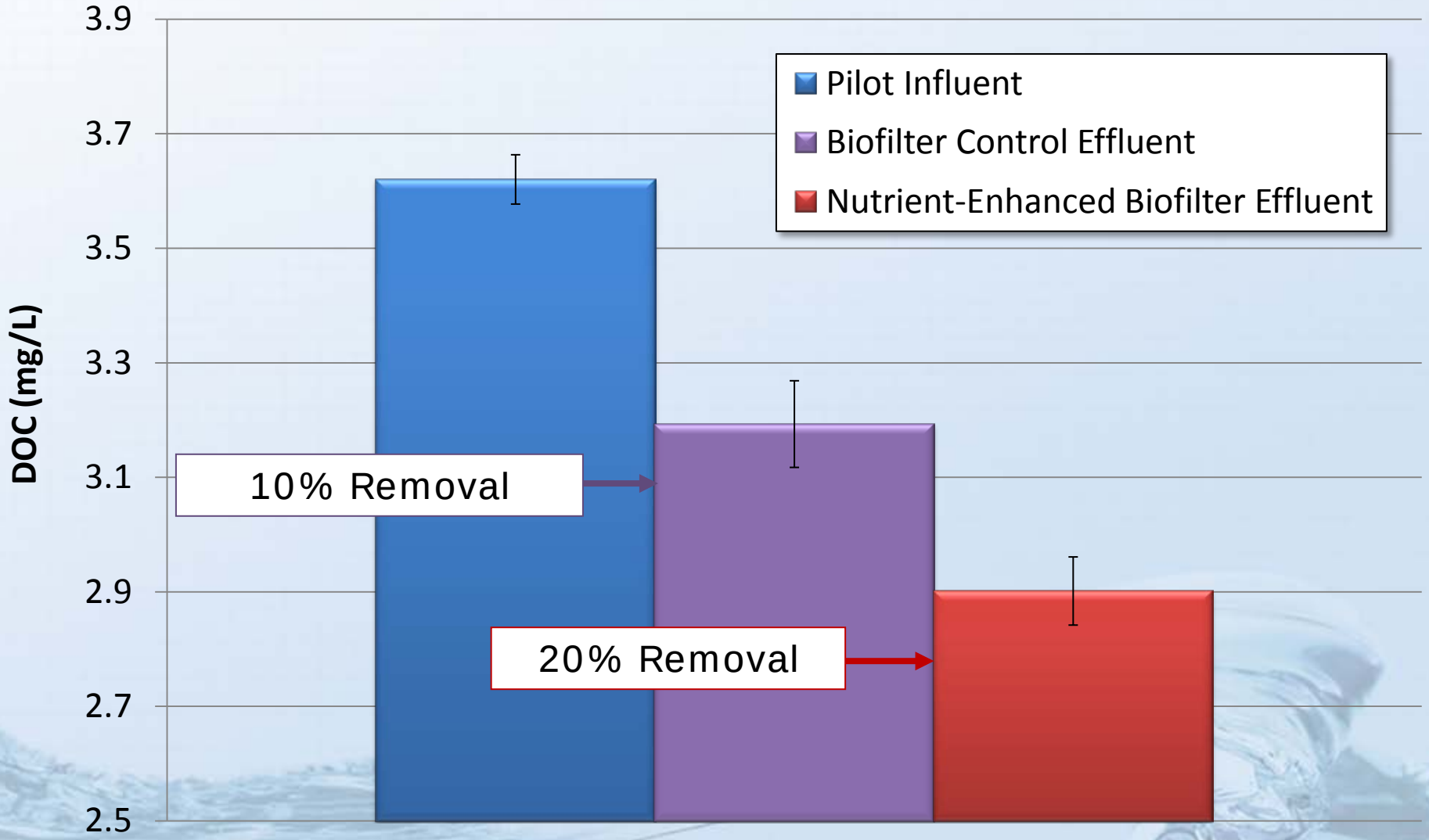
Correct Nutrient Balance Decreases Headloss and Increases Filter Run Time



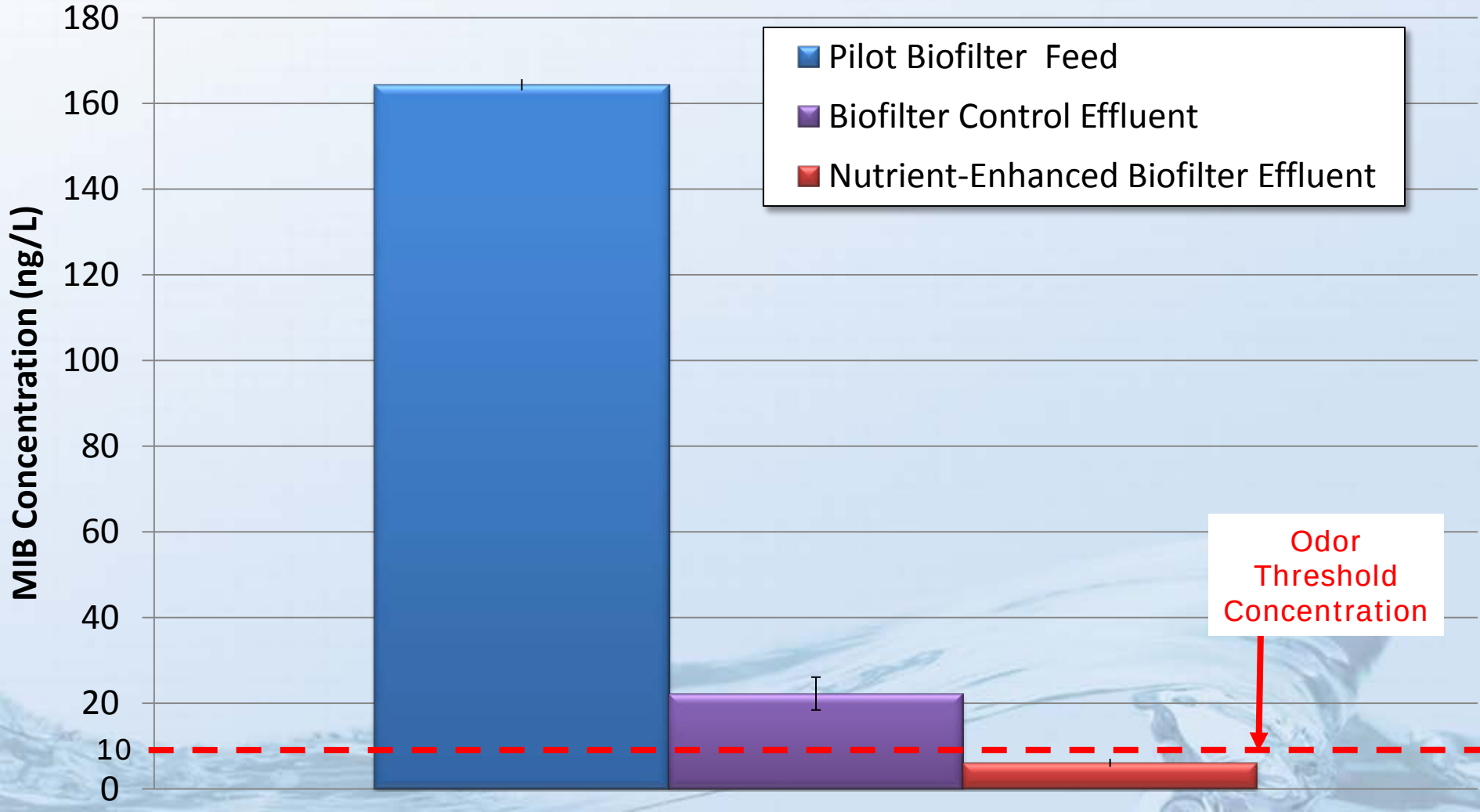
ATP analyses confirm increased biofilter activity with phosphorus supplementation



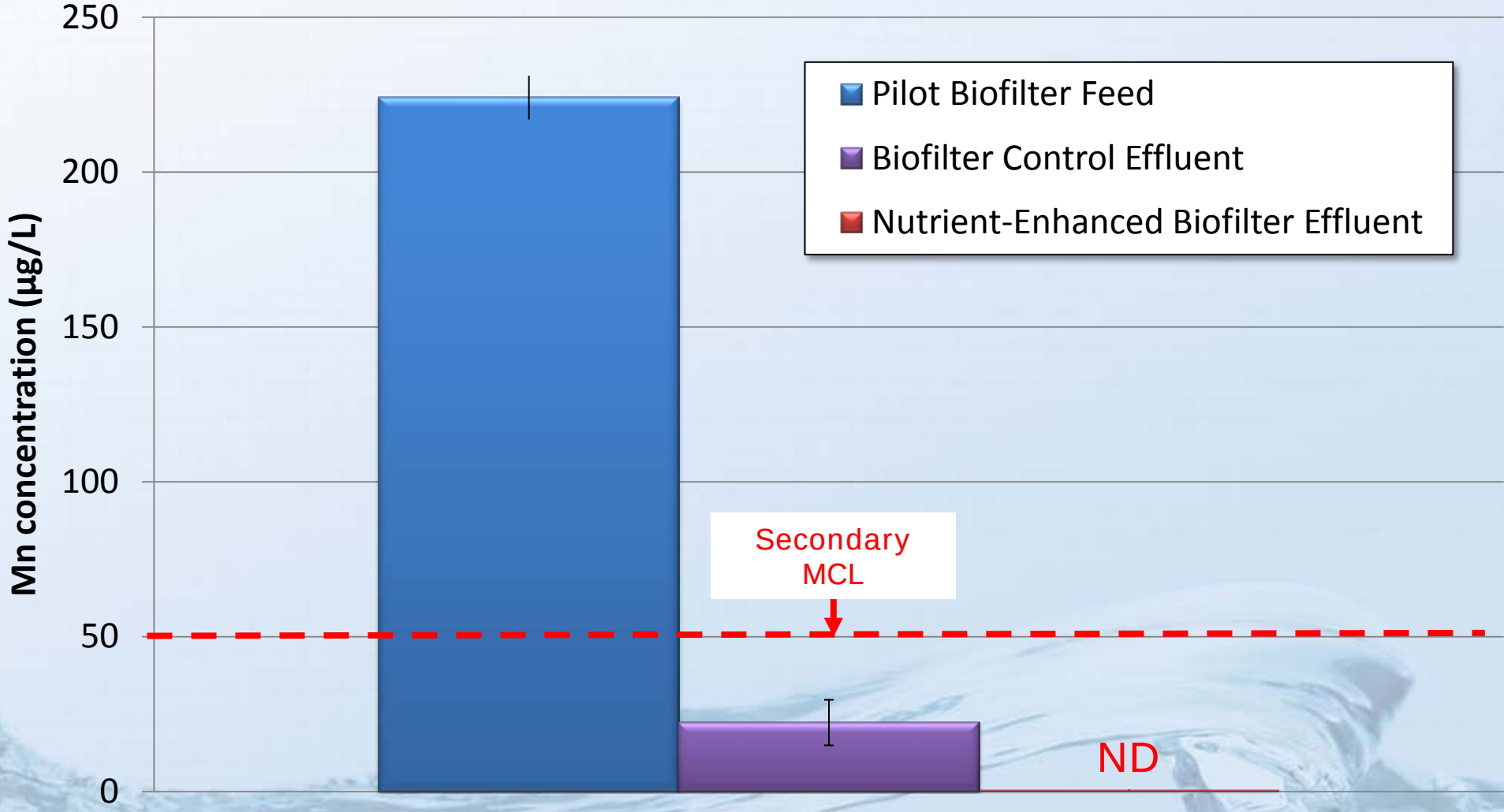
Increased biofilter activity yields higher DOC removal



Phosphorus supplementation improves MIB degradation under high loading conditions

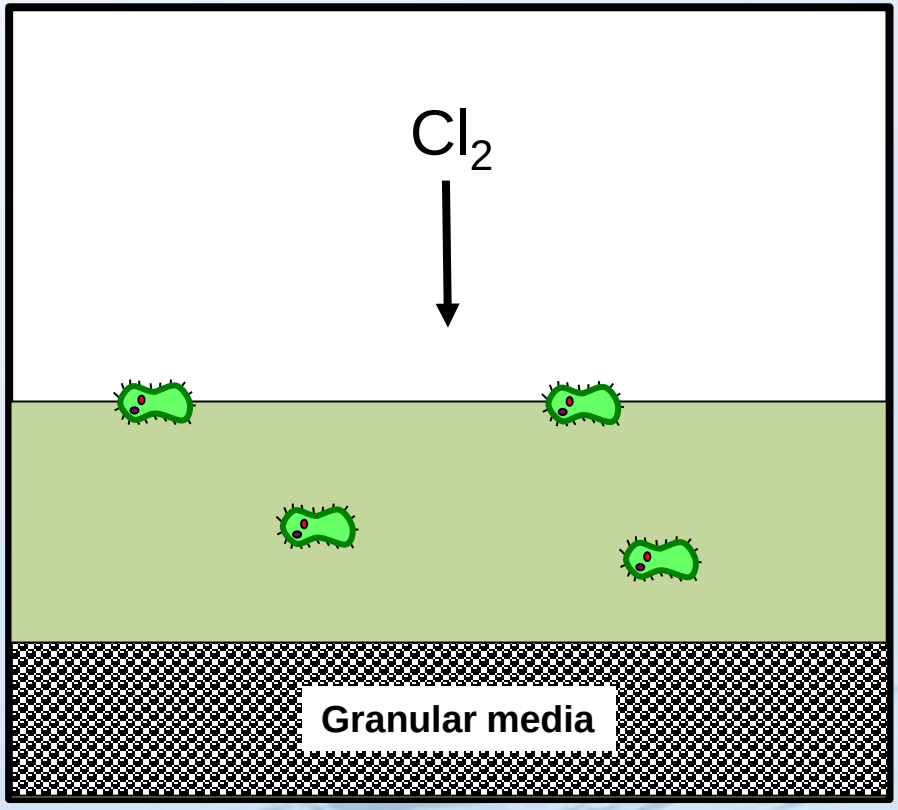


Phosphorus supplementation improves manganese removal under peak loading conditions

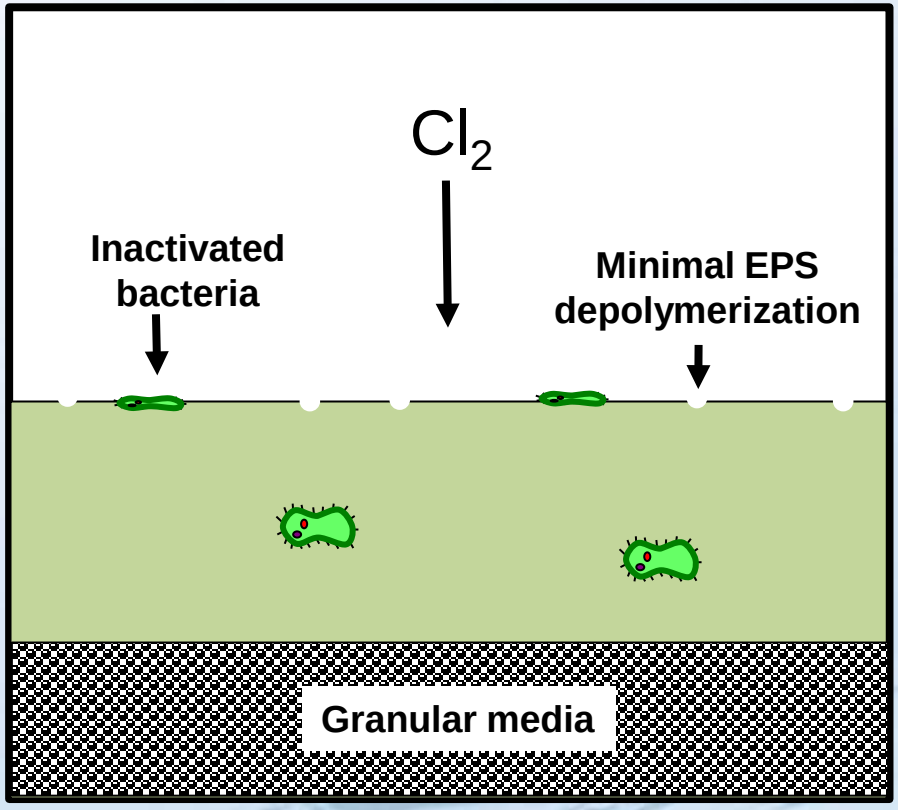


Peroxide Enhancement

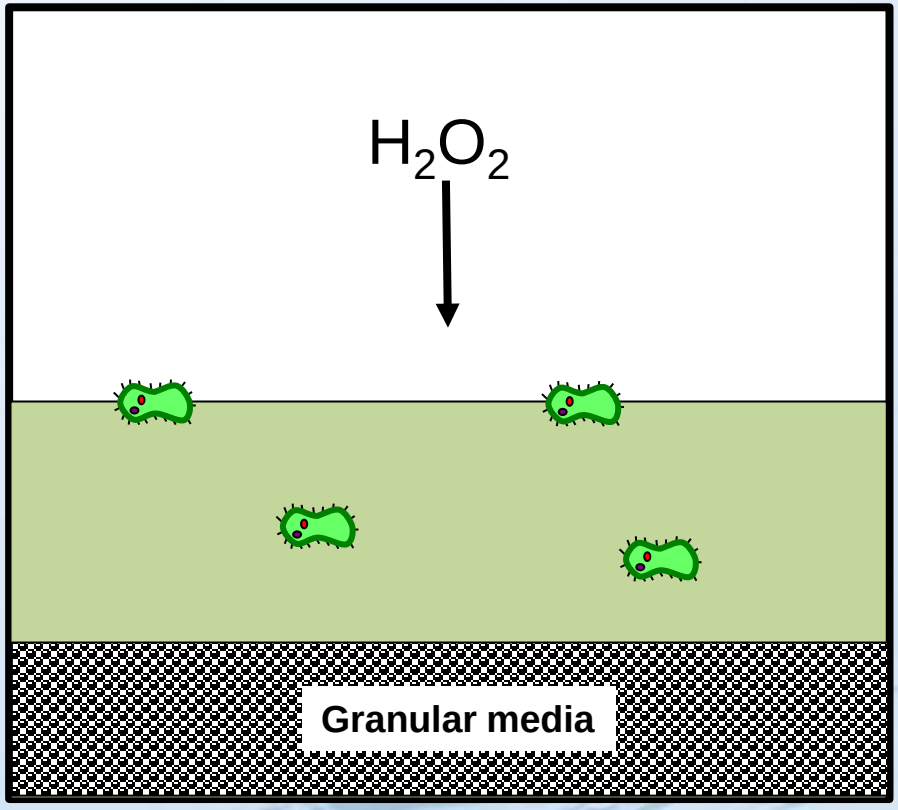
Chlorine backwash is the common biofilm control strategy



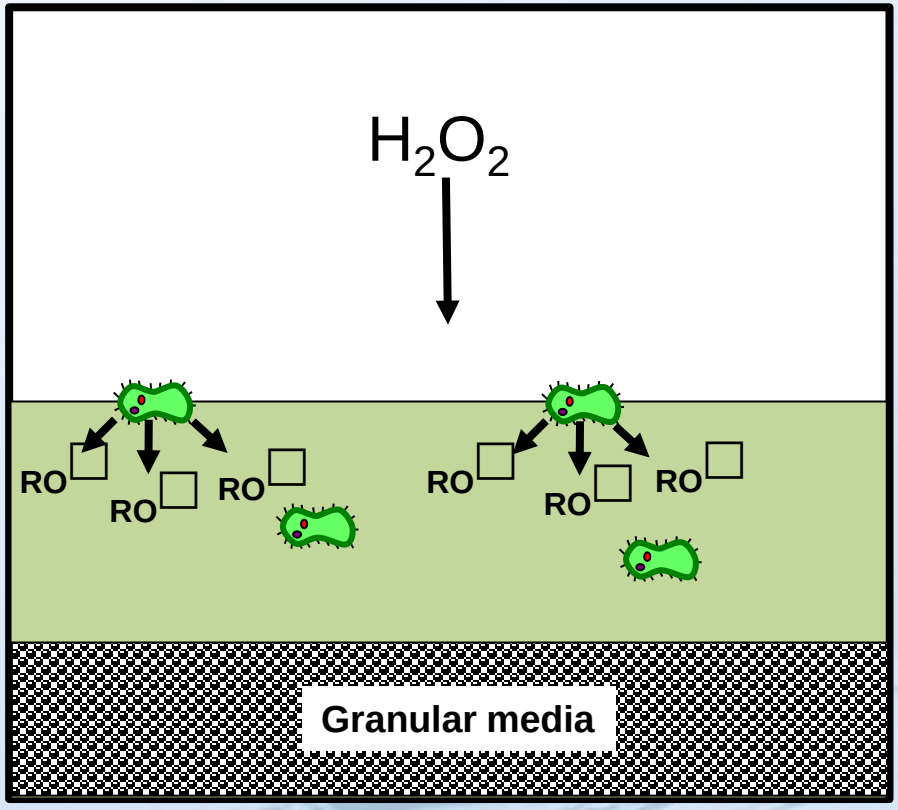
Chlorine inactivates filter bacteria, but is less effective at EPS removal



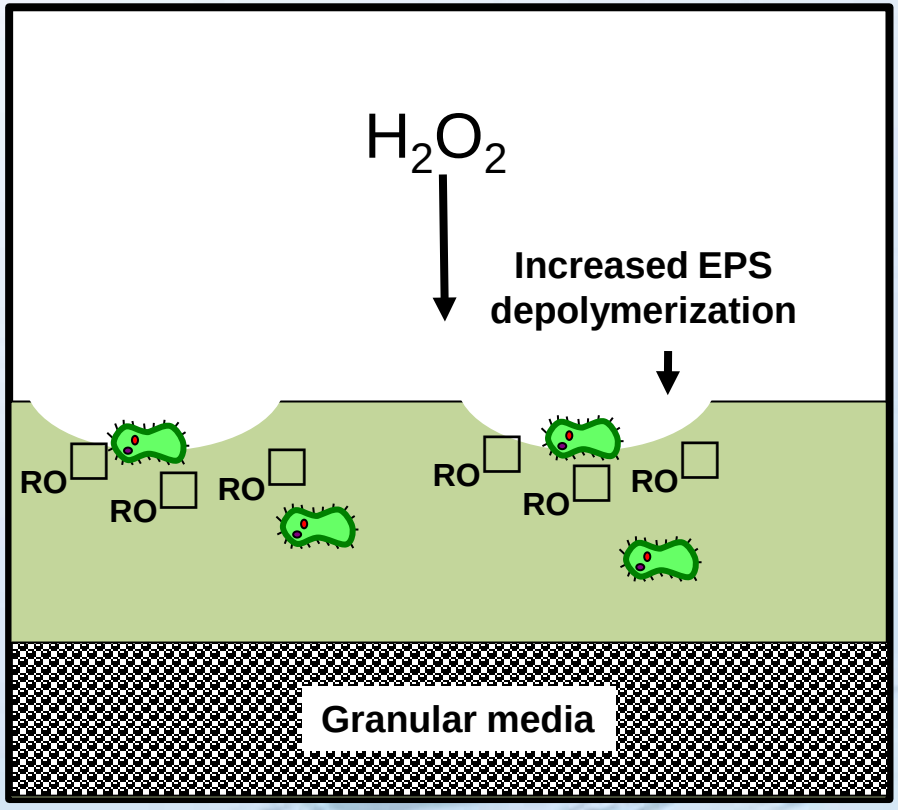
Hydrogen peroxide may be an effective alternative for biofilm control



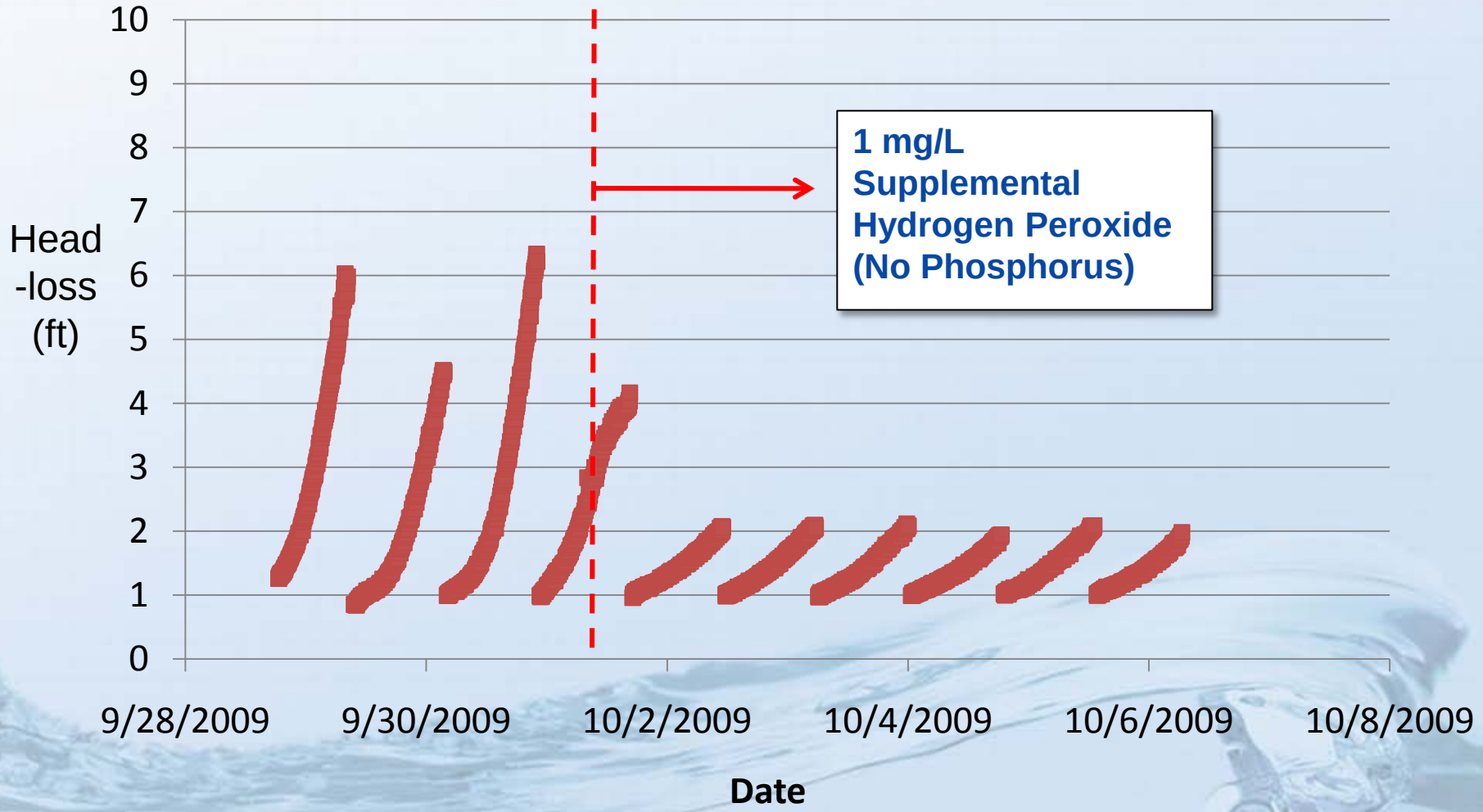
Oxidoreductase enzymes utilize organics as substrate for redox, some activate peroxide to form free radicals



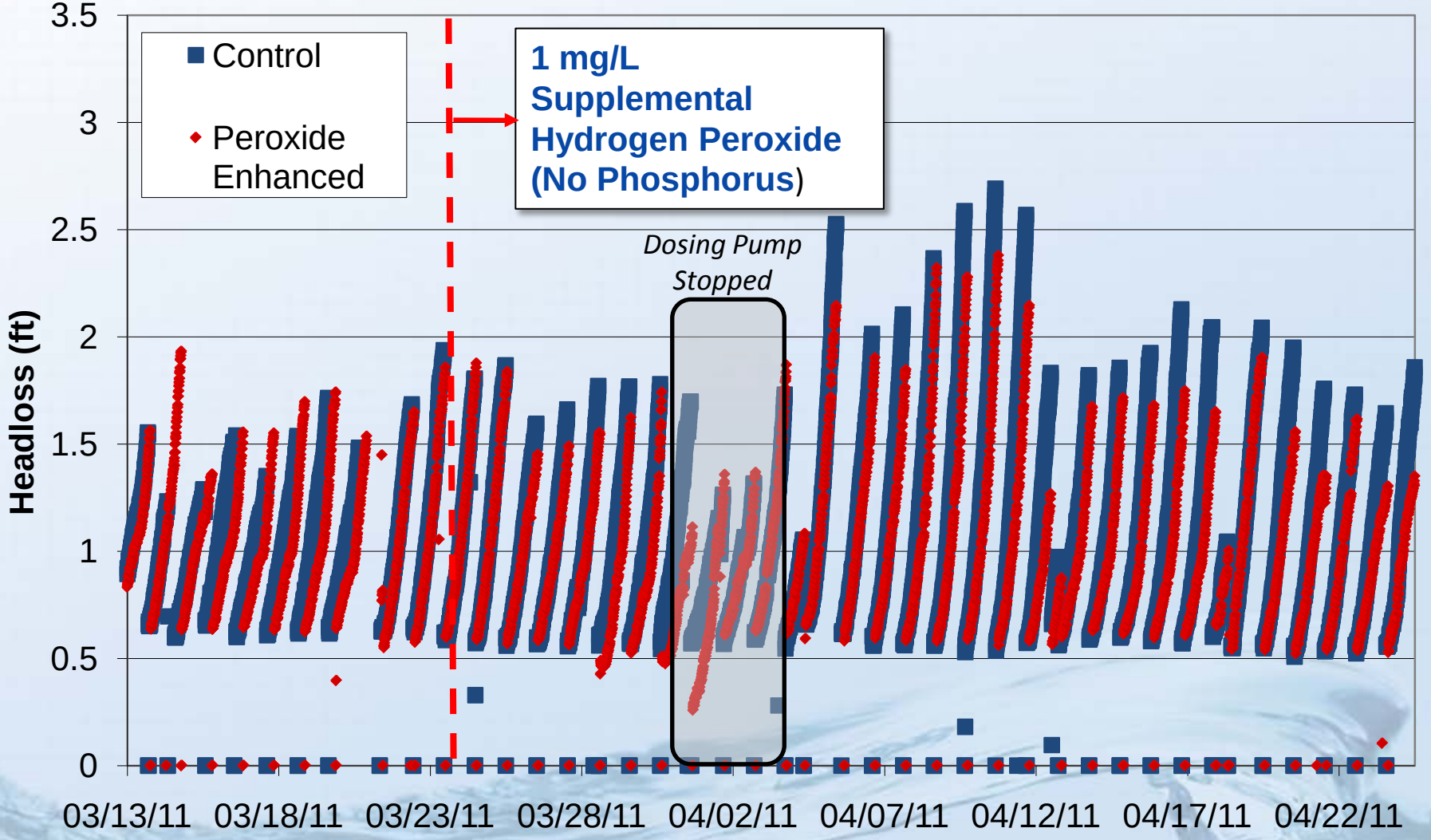
Free radicals may create chain reactions for EPS depolymerization



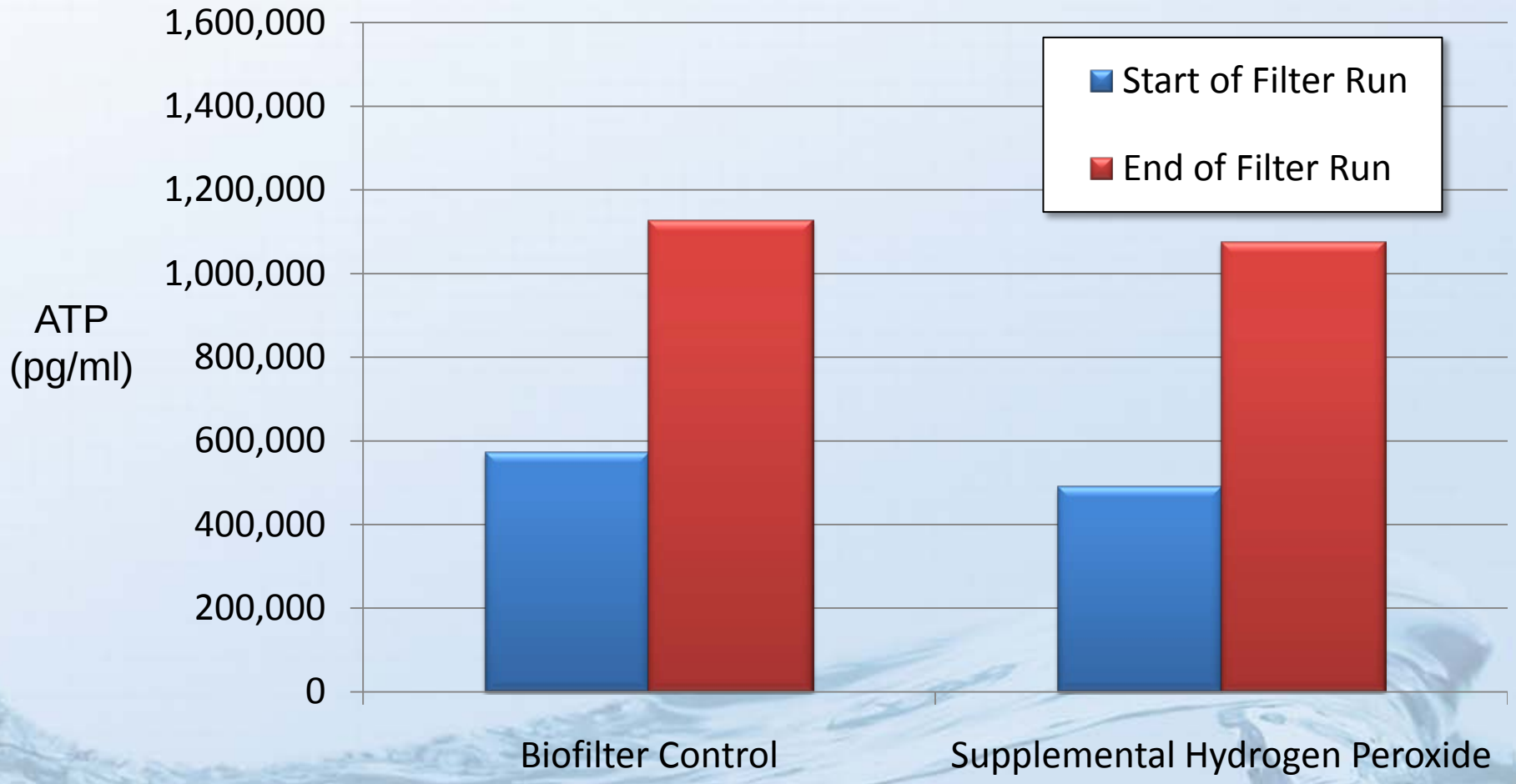
Hydrogen peroxide addition reduces headloss significantly in Arlington, TX



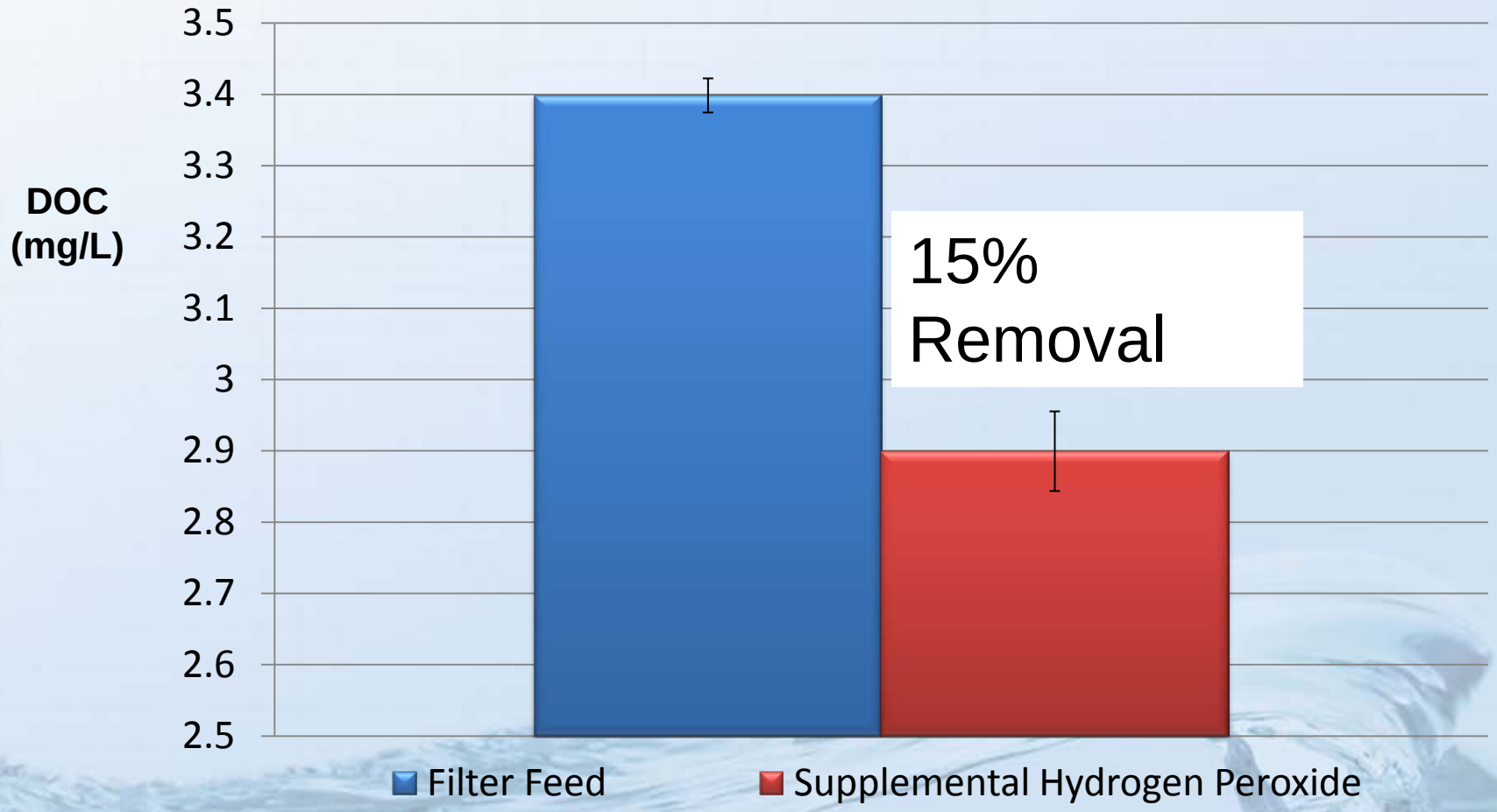
Hydrogen peroxide addition reduces headloss in Tampa, FL



Hydrogen peroxide supplementation does not appear to limit microbial activity

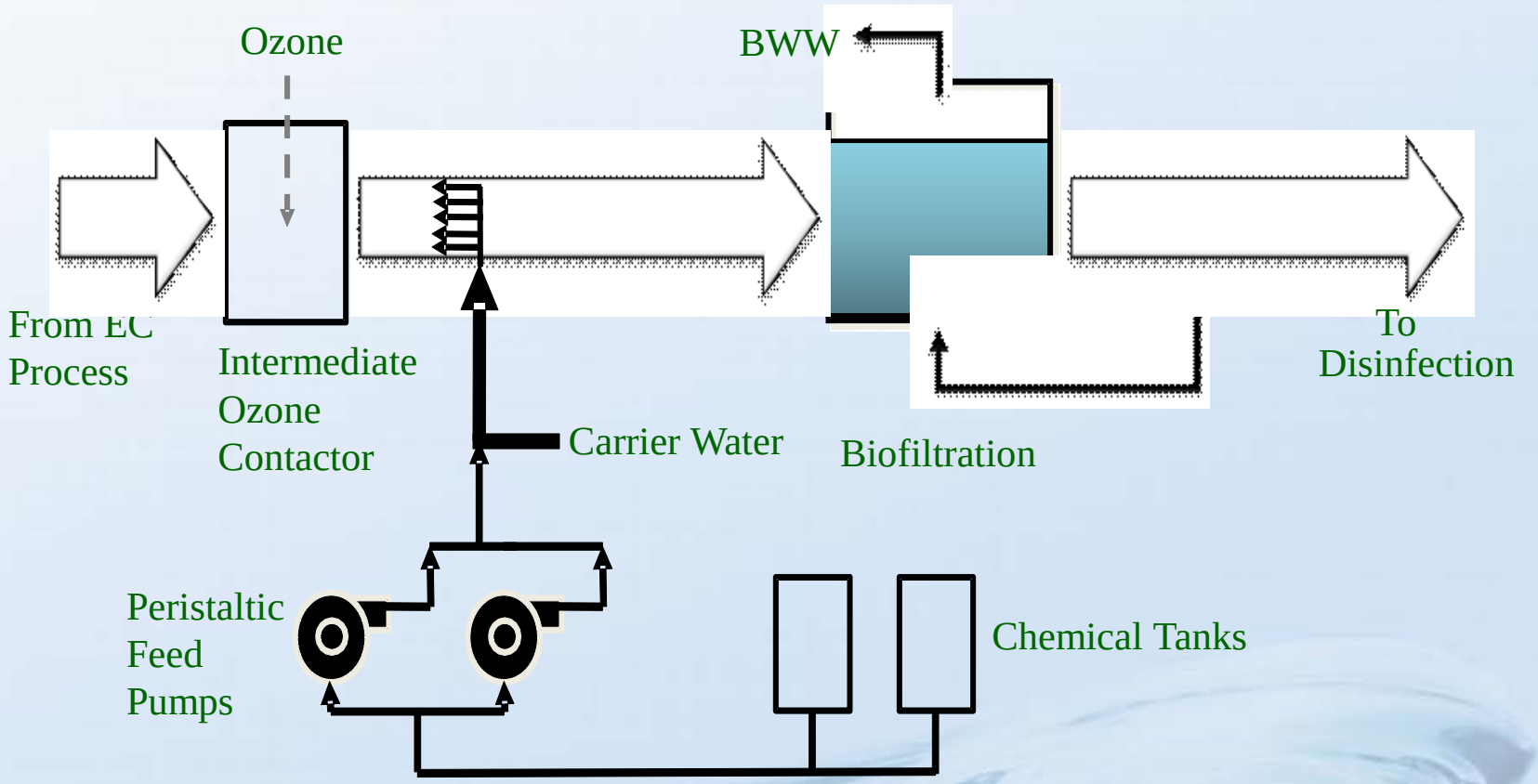


Hydrogen peroxide supplementation does not impair DOC removal

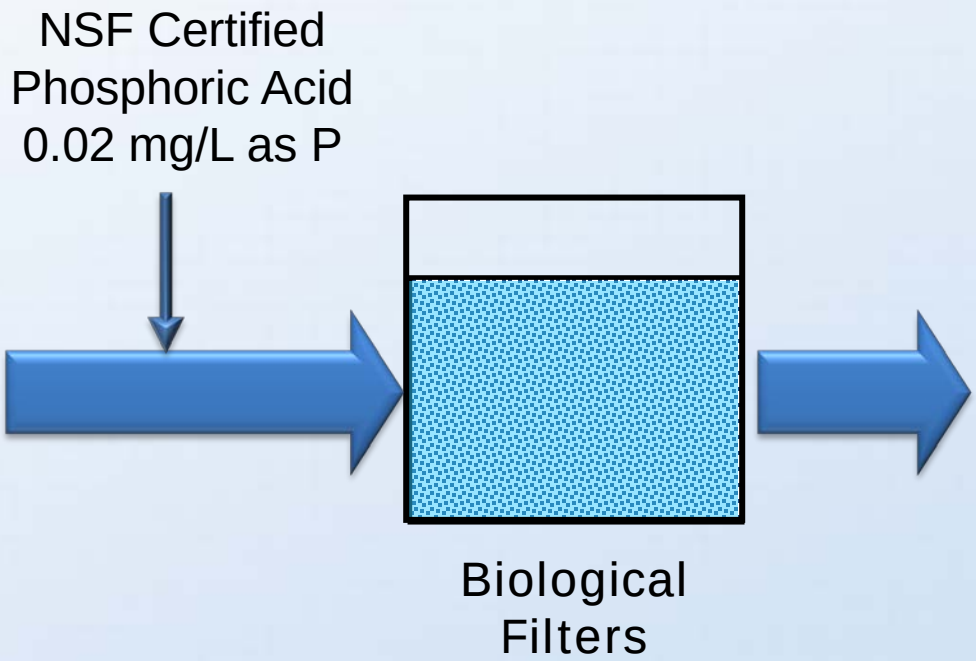


Implementation and Conceptual Costs

Implementation of nutrient-enhancement requires minimal process changes



Nutrient supplementation is a compliant and cost-effective strategy



- Estimated chemical cost: $0.40/MG or $0.0004/KG
- 4.3 gpd for 100 MGD
- Arlington would save $0.50-$1.0 per MGD treated

Questions?

Contact:

Chance Lauderdale, PE
Carollo Engineers
CLauderdale@carollo.com
(941) 504-5983

Acknowledgements

- Water Research Foundation
- City of Arlington
- Tampa Bay Water
- Dallas Water Utilities
- ITT Leopold
- Veolia
- University of Michigan

THANK YOU