Sweeney Lake aeration study

August 16, 2018 BCWMC meeting

Laura Jester, Administrator BCWMC

Greg Wilson, PE, Barr Engineering Co.

outline

- project background/historical water quality monitoring and goals
- lake ecology, stratification, and aeration configuration
- effects of phosphorus and aeration on lake water quality
- three-dimensional water quality modeling
- discussion of management options

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project background

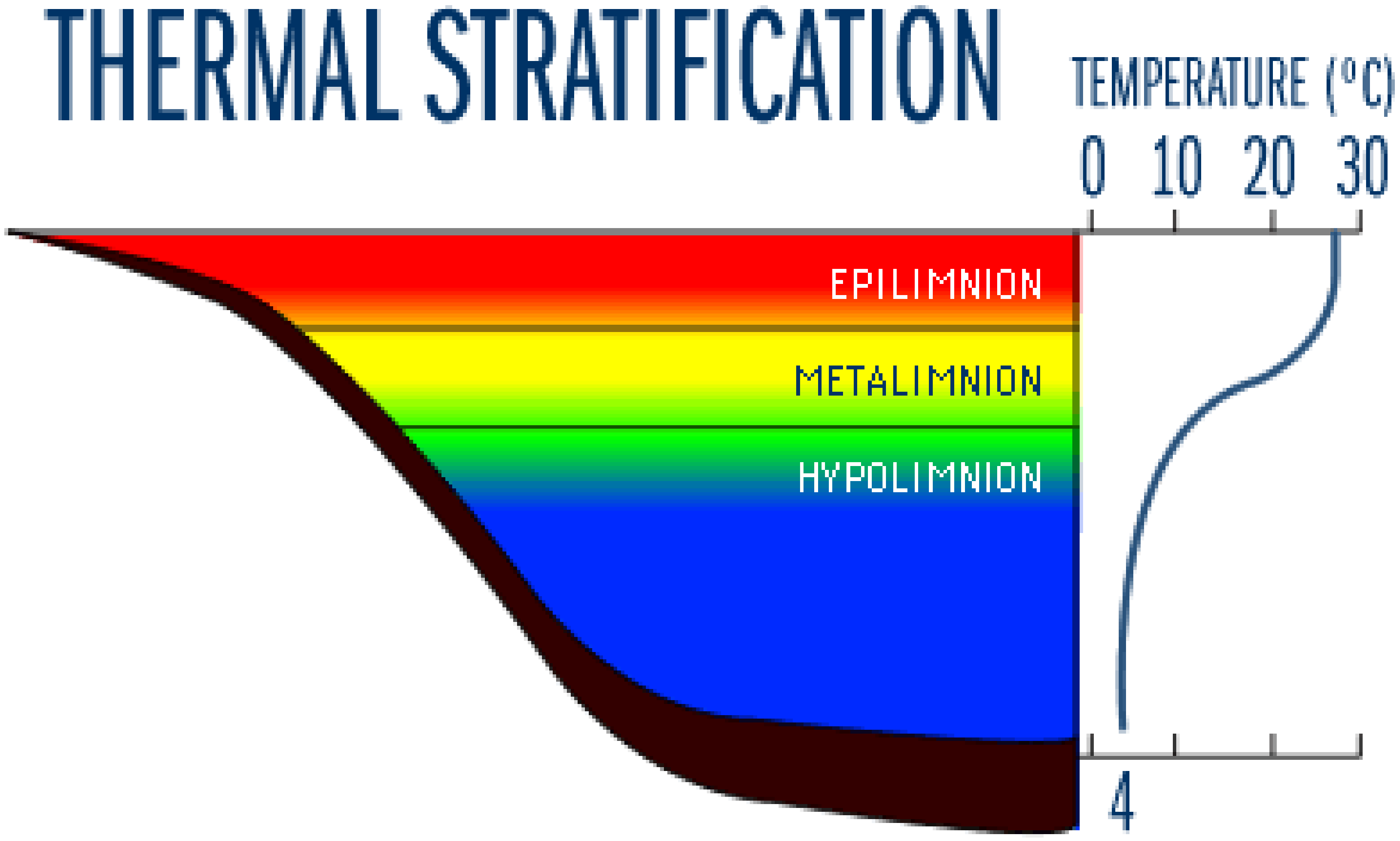
- 2004: Sweeney Lake designated as impaired water by MPCA
- 2011: BCWMC completed Sweeney Lake TMDL, including modeling of two years w/o aeration
- Sweeney has long history (~40 years) with aeration and water quality goals are not met
- Meeting w/MDNR regarding aeration permit application
- Aeration study initiated—collect data in 2017 and model potential in-lake management options

lake stratification

epilimnion:
warmer, more light

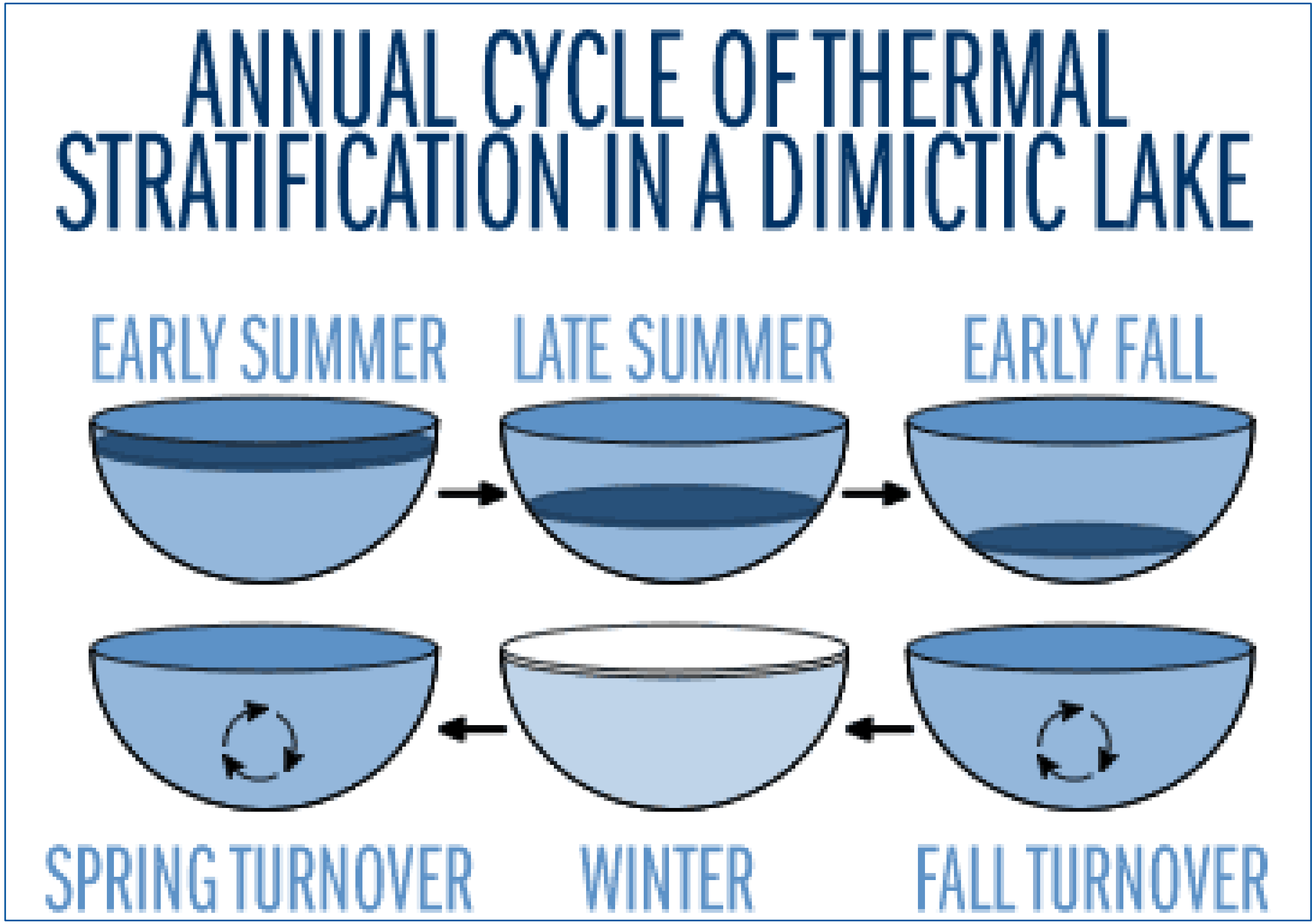
metalimnion:
transitional layer

hypolimnion:
cold, dense water,
sometimes anoxic



lake stratification

"dimictic" lakes mix twice per year

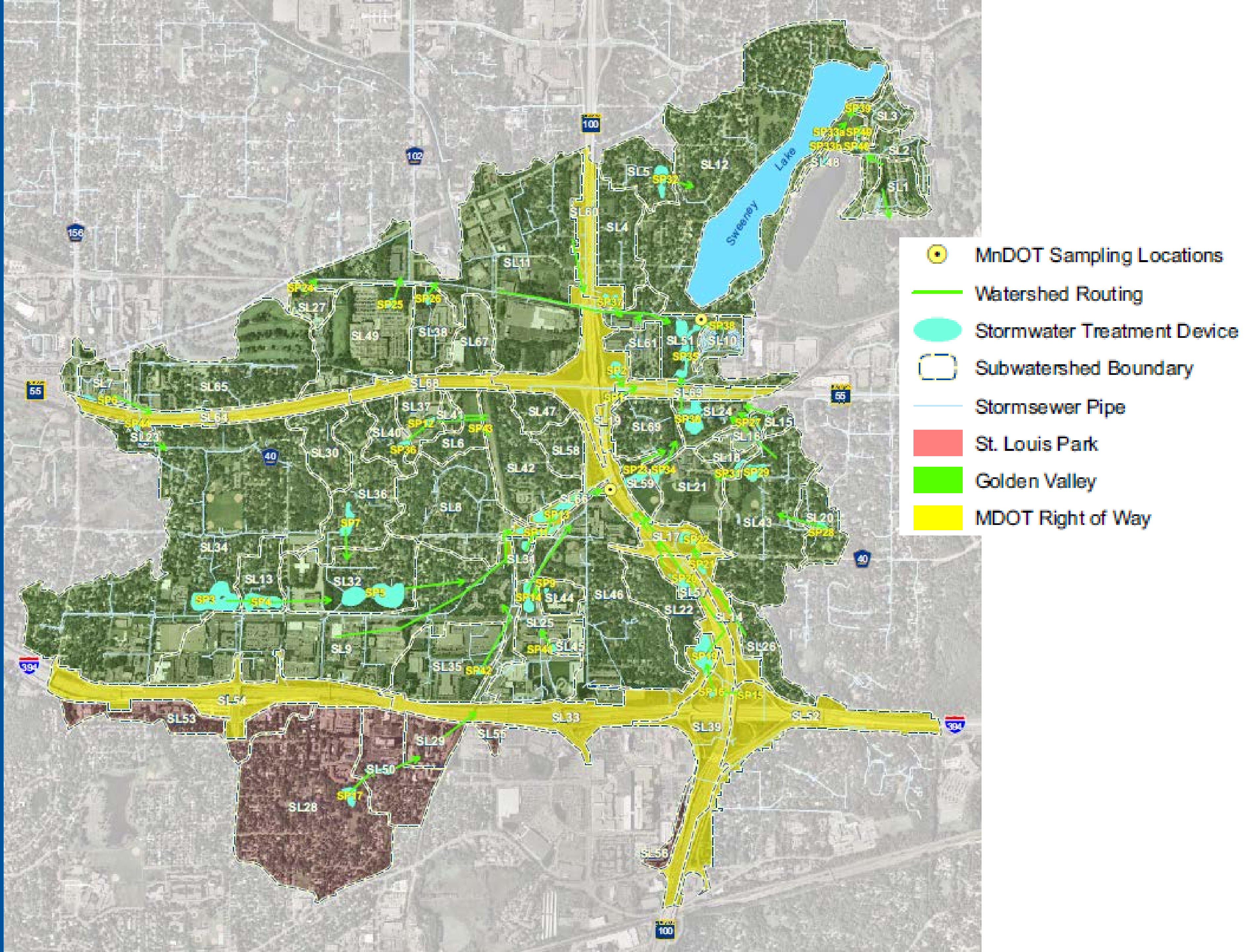


phosphorus is the key

Excess phosphorus means poor water quality

- Phosphorus feeds algae and causes algal blooms
- Algae decreases water clarity
- Algal decay depletes dissolved oxygen near the lake bottom

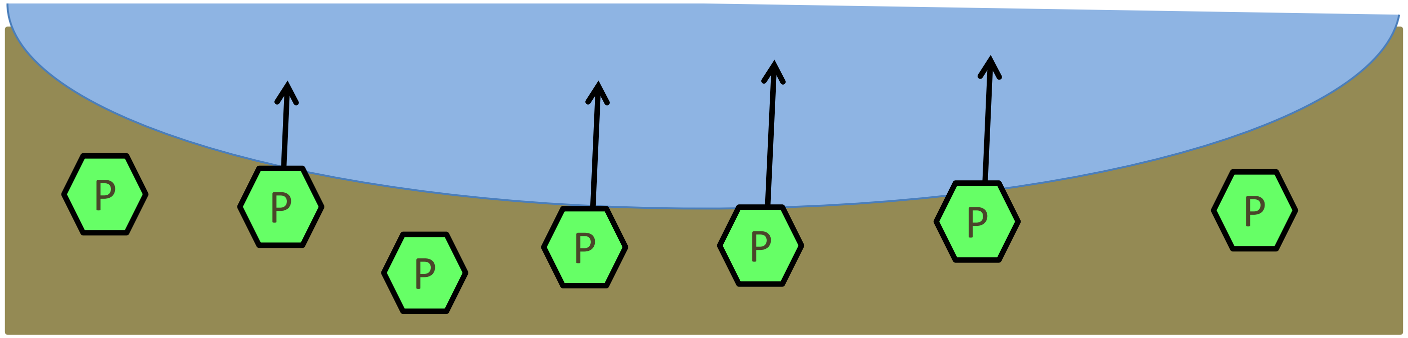
Sweeney Lake watershed



where does phosphorus come from?

Internal sources

- Phosphorus can be stored in lake bottom sediments and released when oxygen levels are low

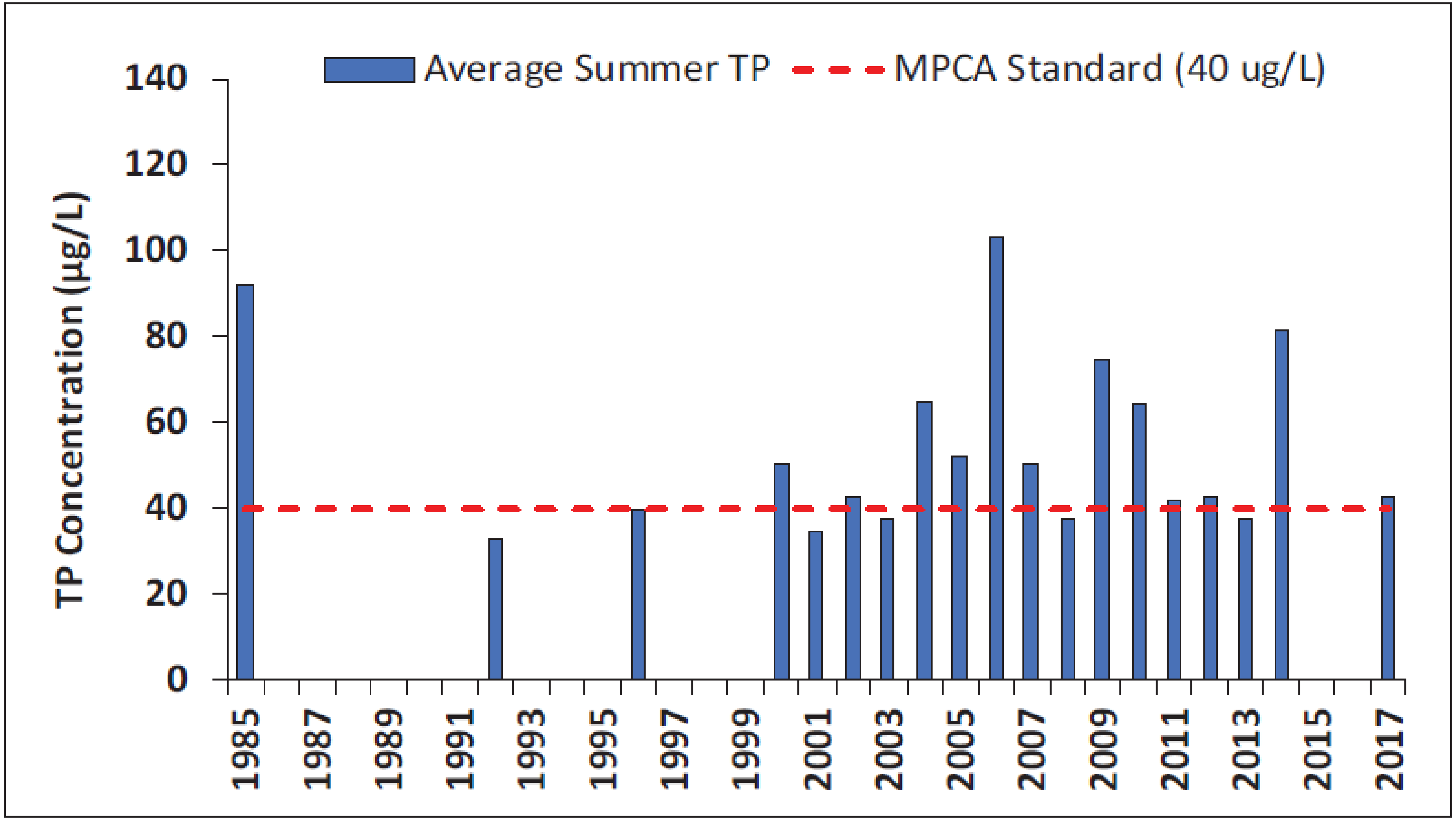


historical water quality and BCWMC/ MPCA goals

total phosphorus
≤ 40 ug/L

chlorophyll-a
≤ 14 ug/L

water clarity
≥ 1.4 m (4.6 ft)



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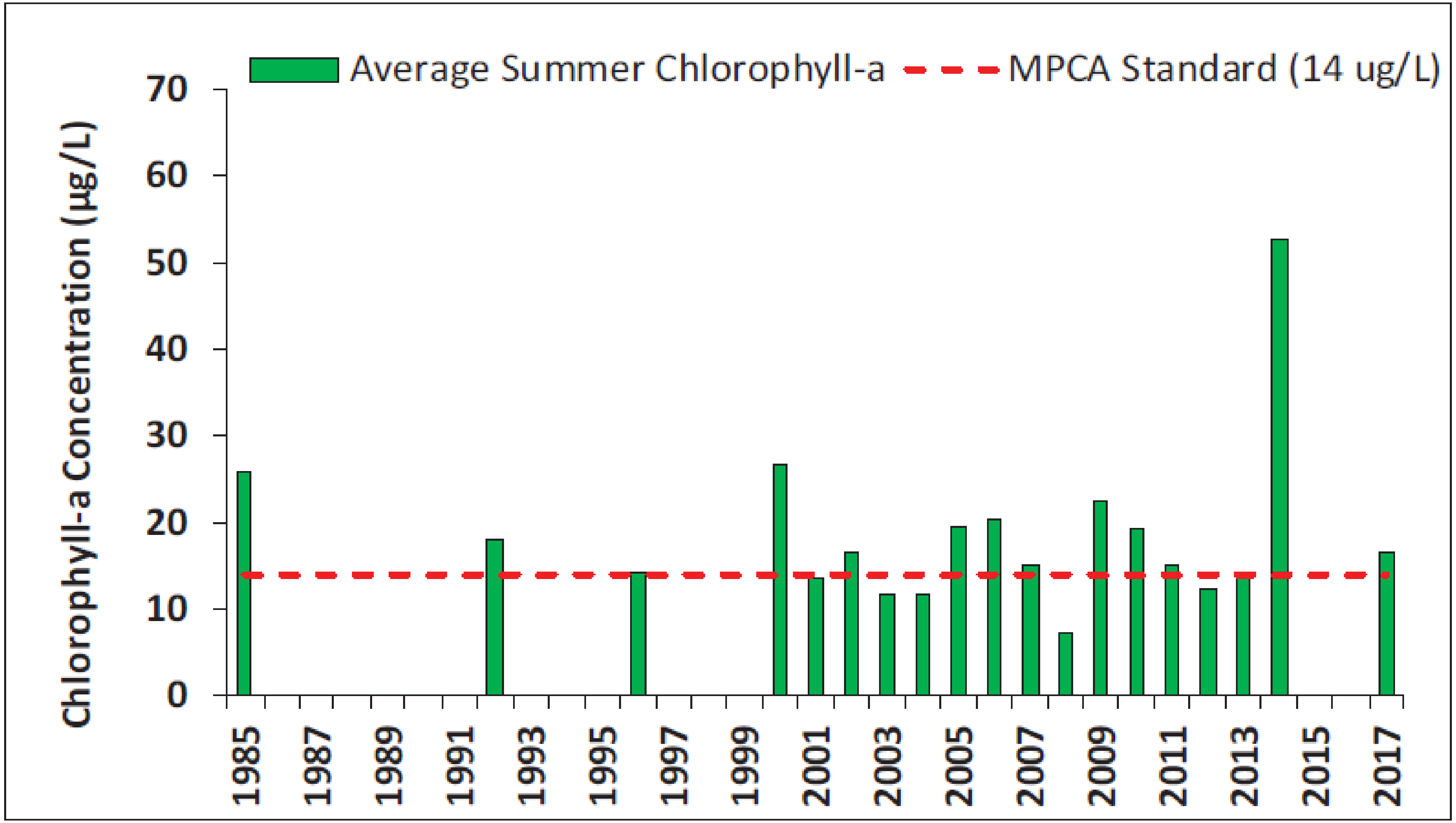

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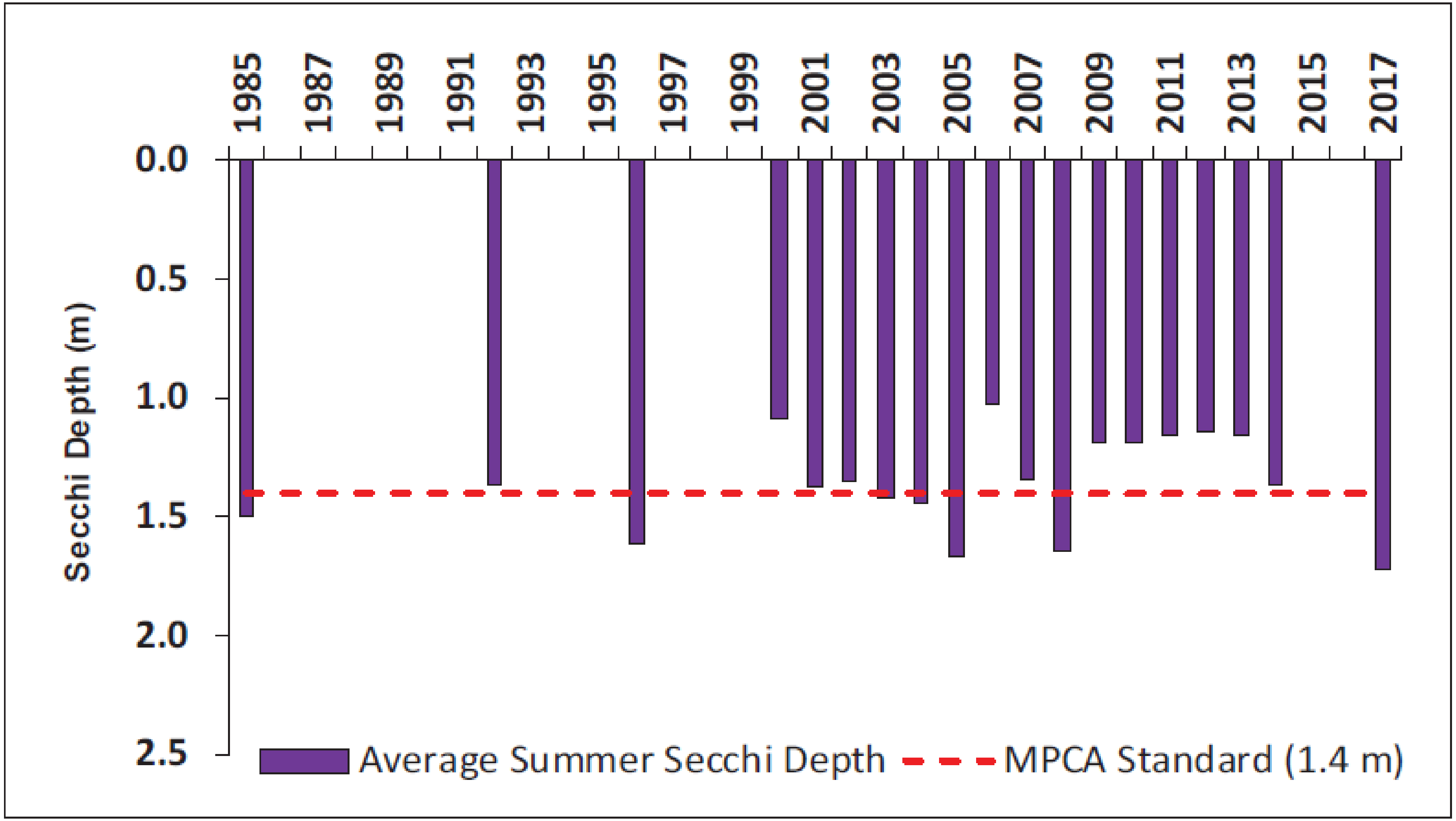

results of past studies/data evaluations

Consensus that

- Aeration resulted in complete lake mixing and moderated nutrient levels
- Aeration did not prevent anoxia or internal phosphorus load
- Normal lake stratification resulted in higher phosphorus at bottom, lower phosphorus at the surface of lake (once during drought)
- Insufficient/inconclusive data to differentiate management actions
- Monitor w/o aeration and re-evaluate

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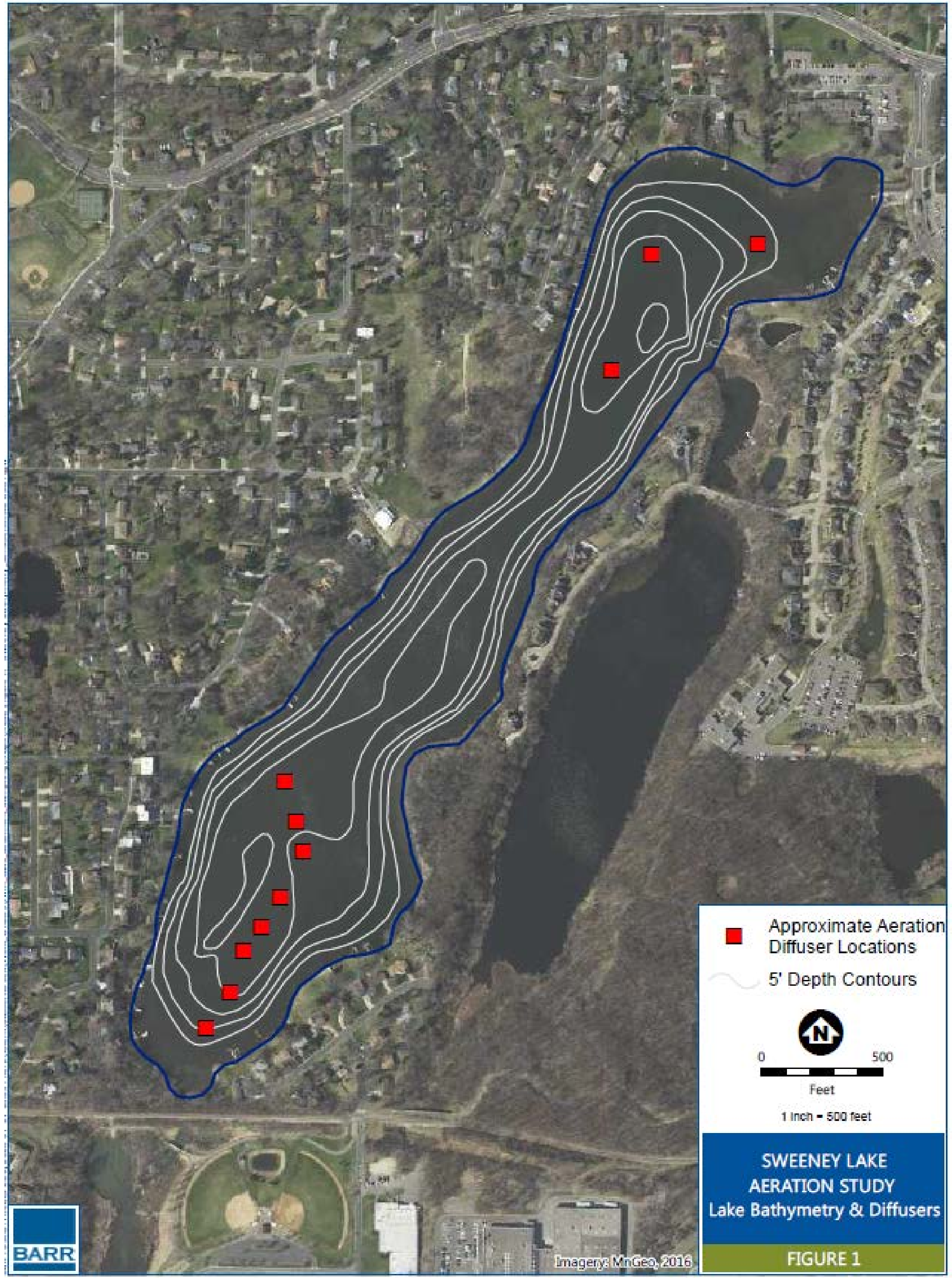
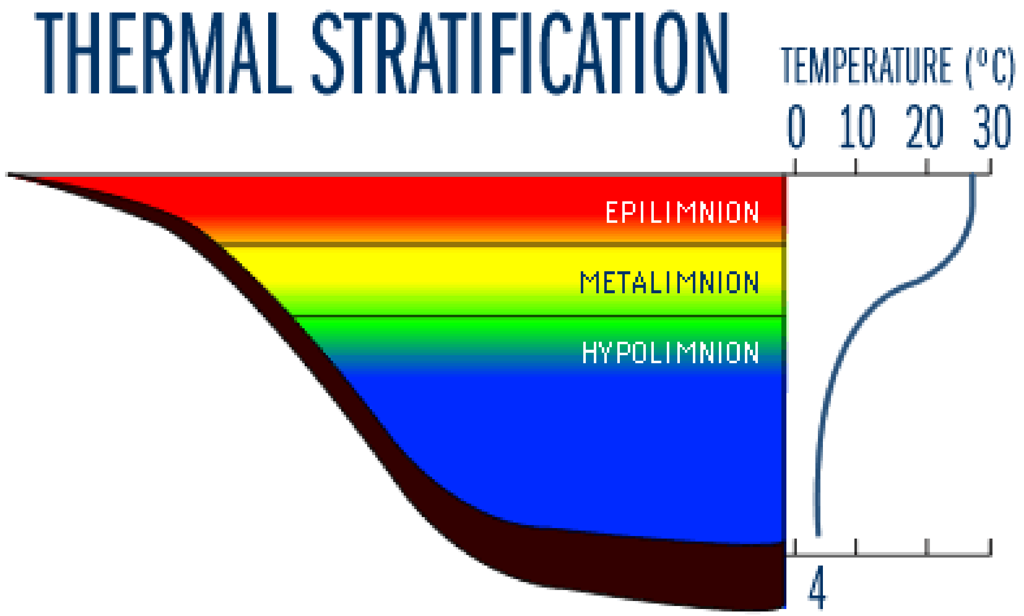
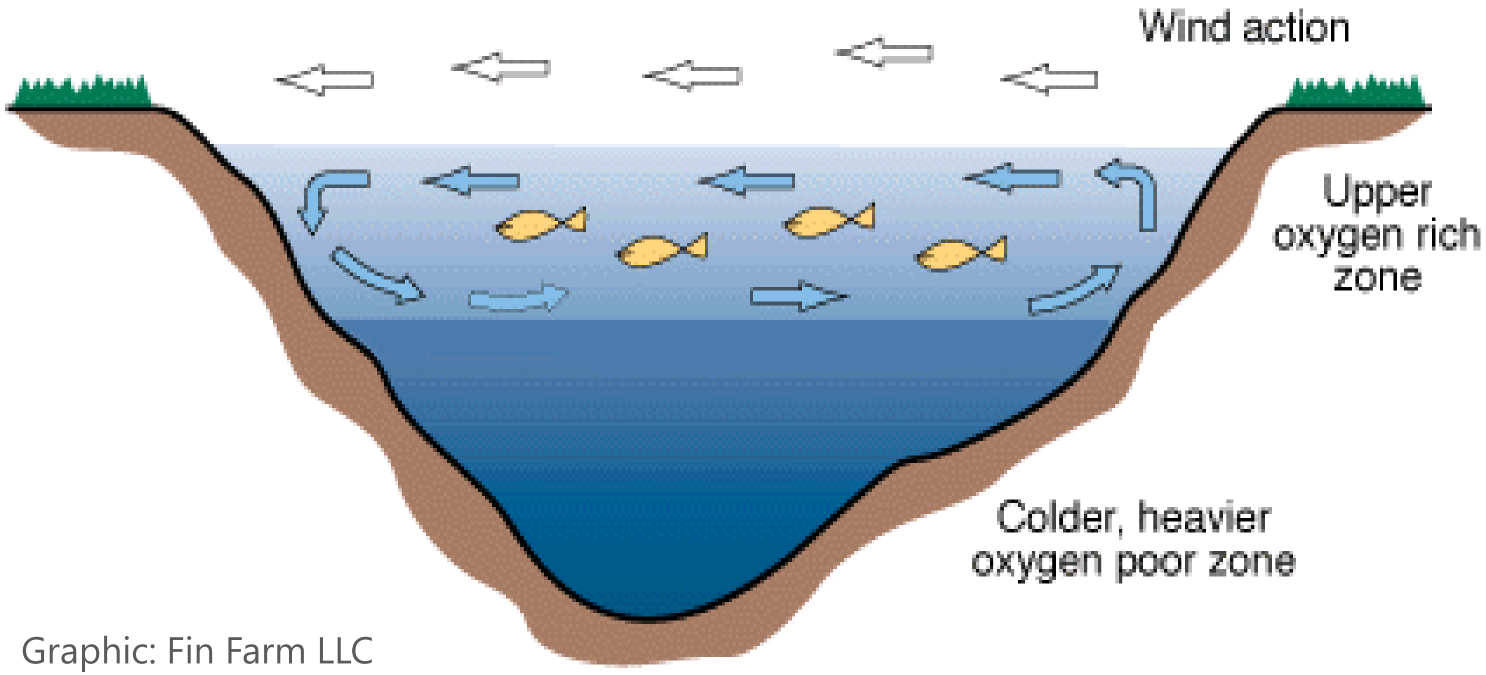
lake contours and diffusers



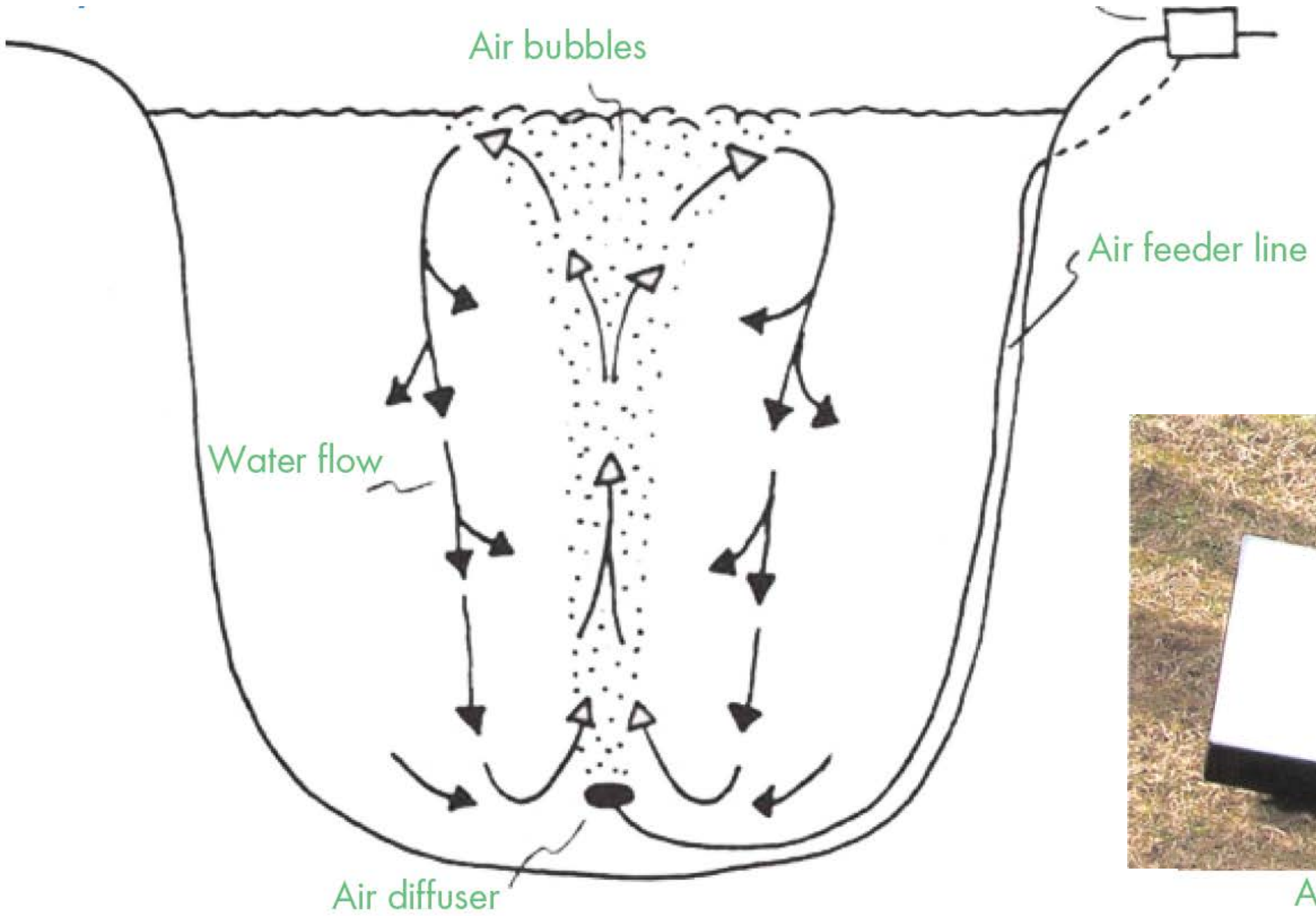
lake stratification/ without aeration





Graphic: Fin Farm LLC

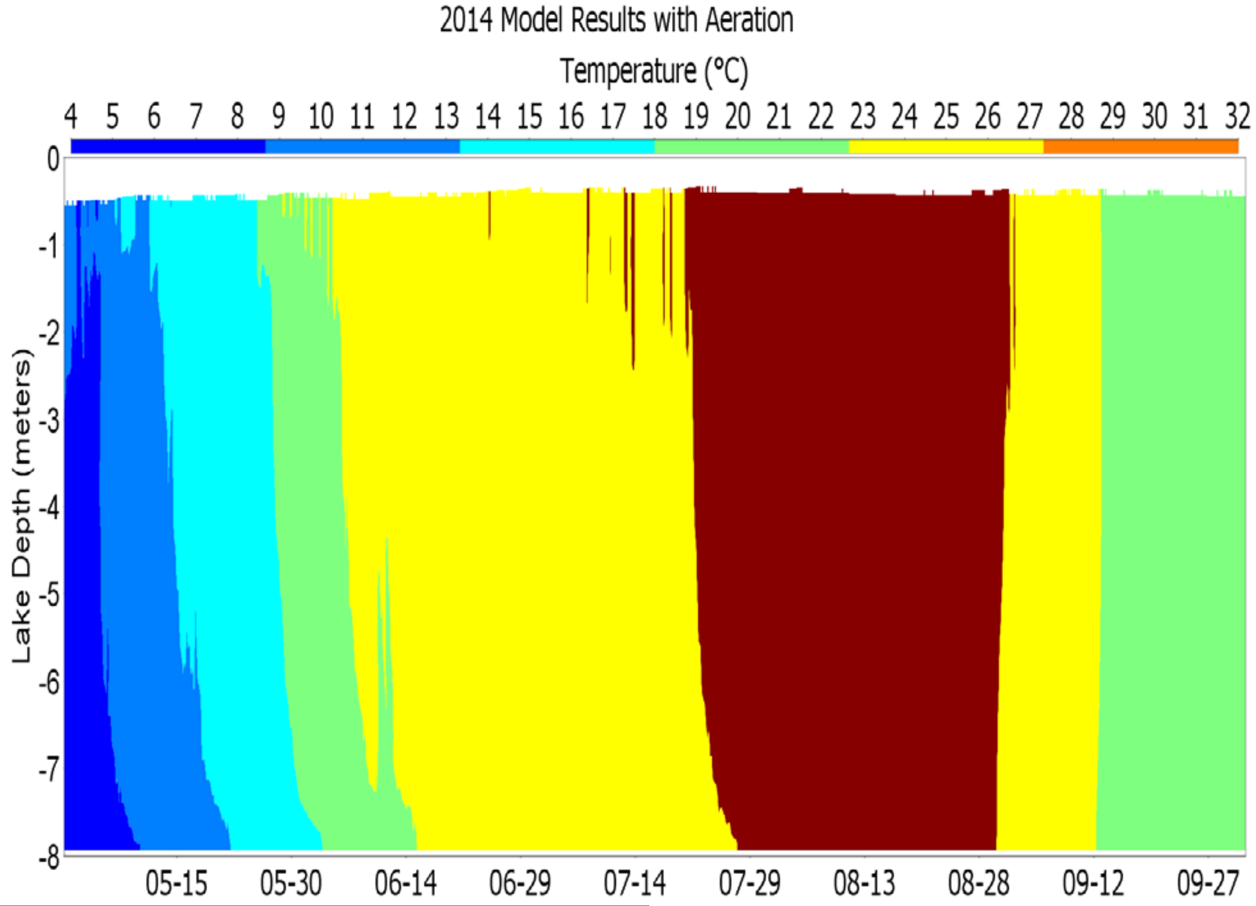
lake stratification/ effects of aeration

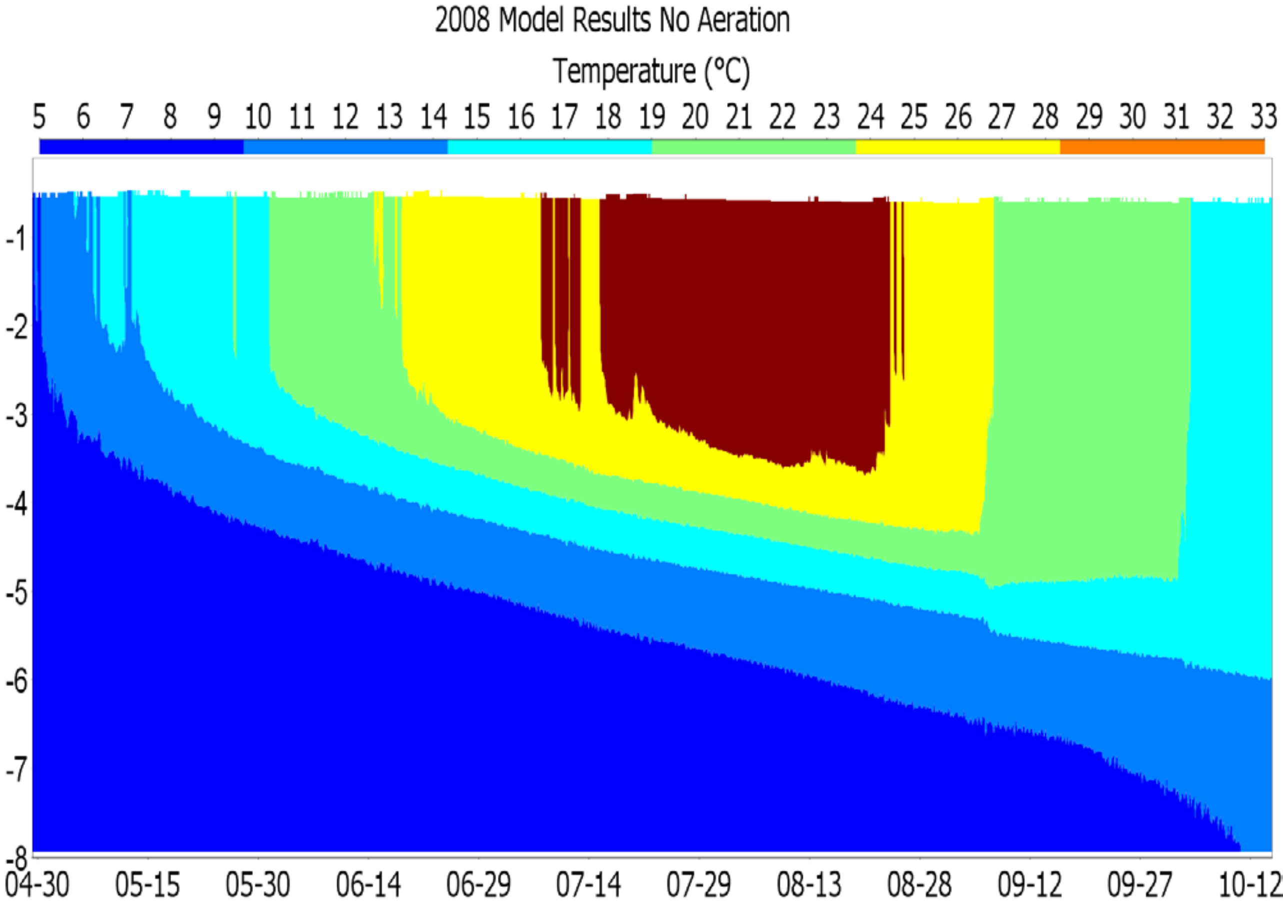


Air diffuser

effects of aeration

- 2014 graphic—aeration prevents stratification as temperatures were uniform top-to-bottom
- 2008 graphic—w/o aeration shows thermal layers during the middle of the summer





study approach

Steps

- Completed water quality and sediment monitoring
- Compiled/evaluated historical monitoring/aeration system information
- Performed watershed modeling
- Completed three-dimensional lake water quality modeling
- Evaluated possible management actions

3D modeling

Why it's needed, what it does for us

- Aeration causes circulation in three dimensions
  - Each diffuser influences circulation differently
- Each area of lake sediment has unique oxygen demand
- Modeling shows phosphorus, algae and oxygen dynamics
  - Temporally and spatially
  - With and without aeration

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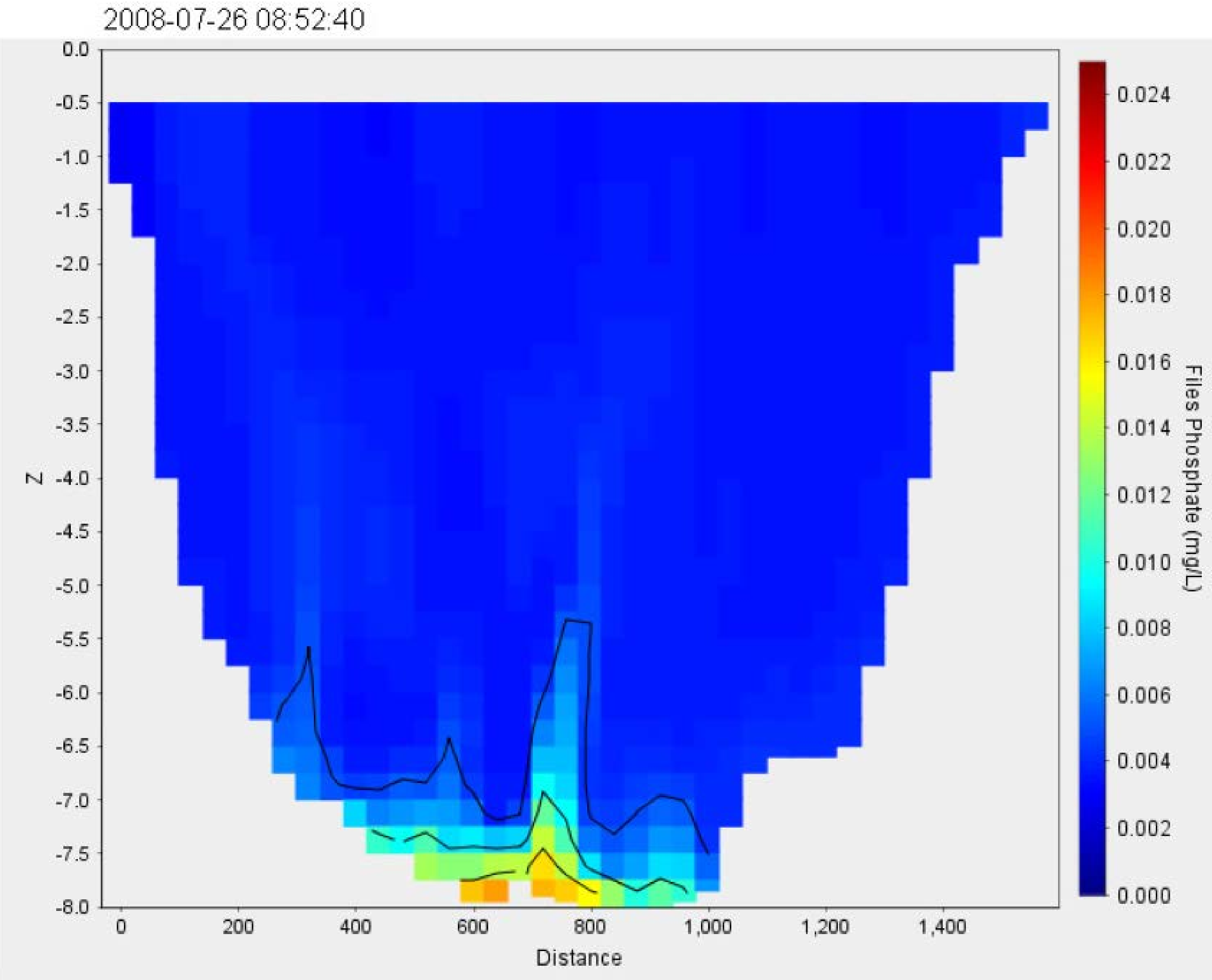
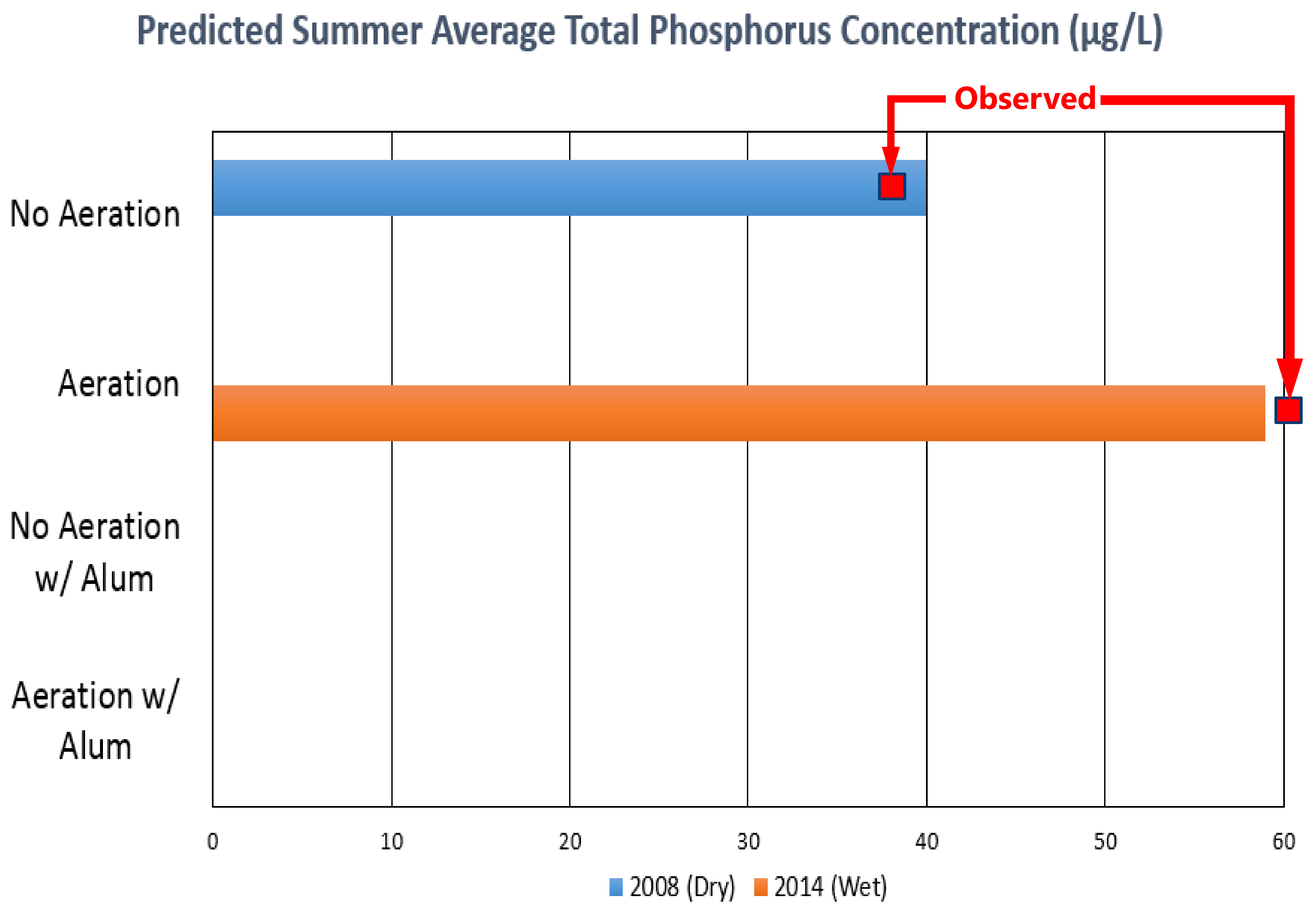
3D model scenarios

Year	Climate Condition	Calibration Scenario	Scenario #1	Scenario #2	Scenario #3
2008	Dry	No aeration	Aeration	No aeration w/alum	Aeration w/alum
2014	Wet	Aeration	No aeration	No aeration w/alum	Aeration w/alum

3D animated model scenarios



3D model scenarios



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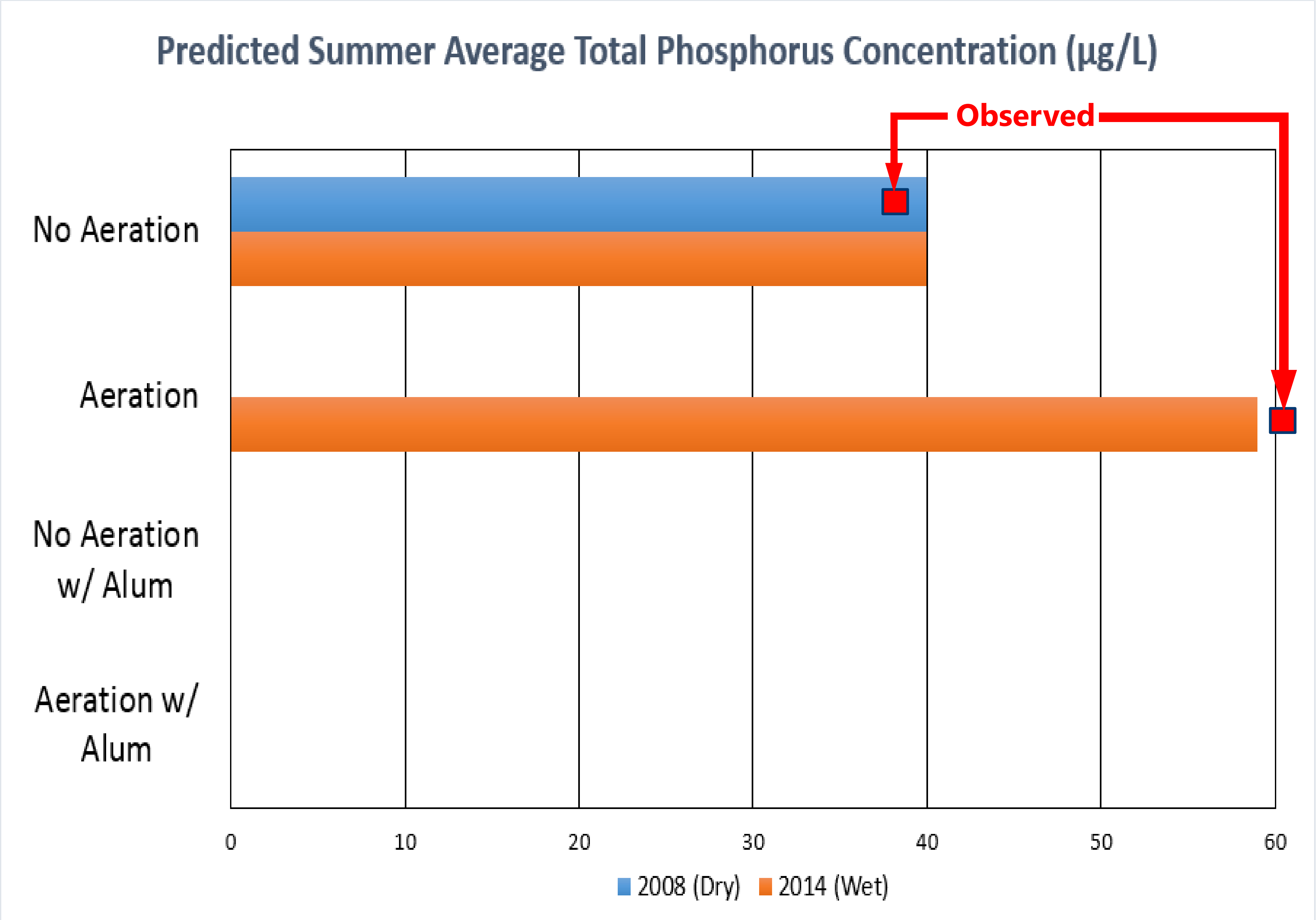

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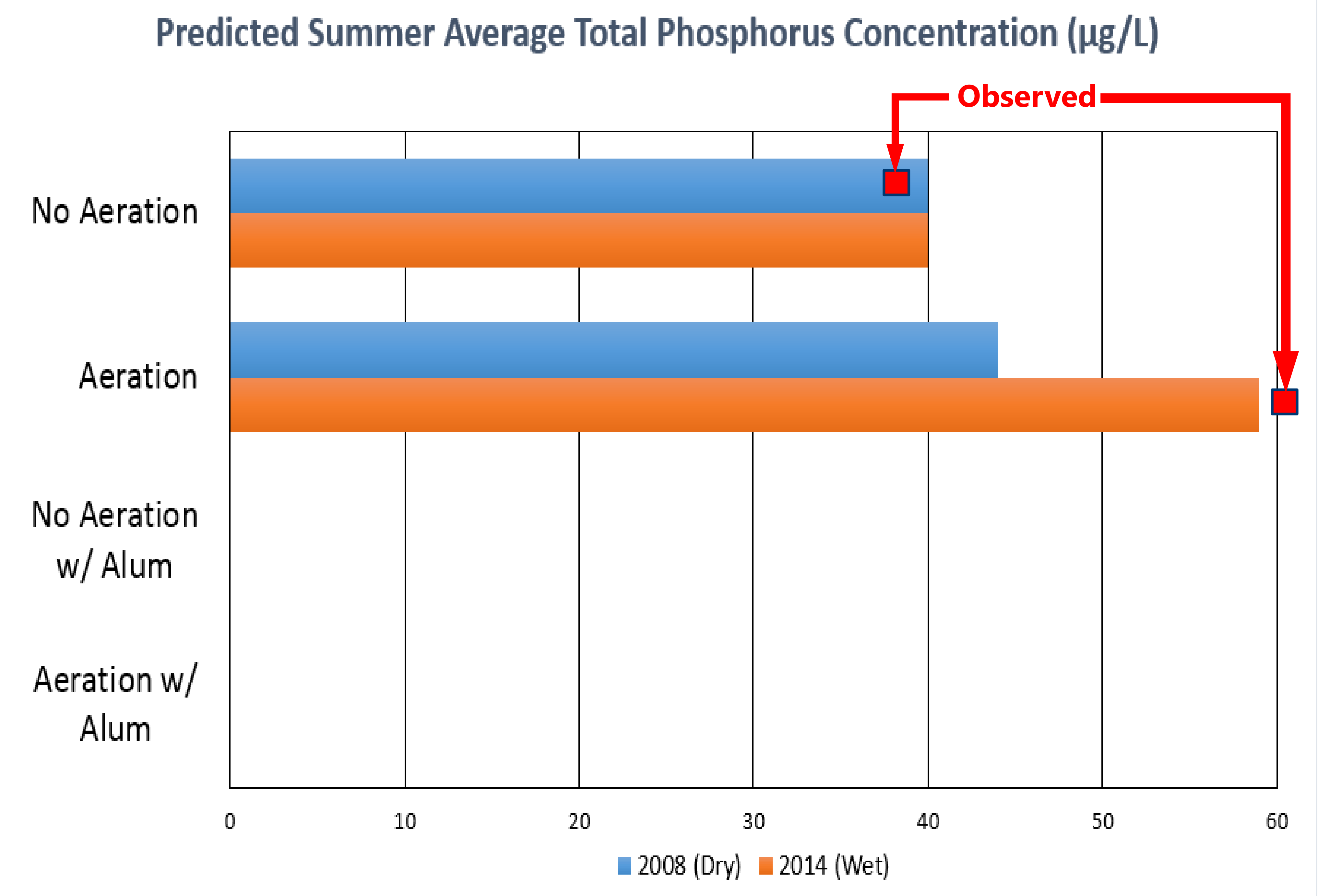

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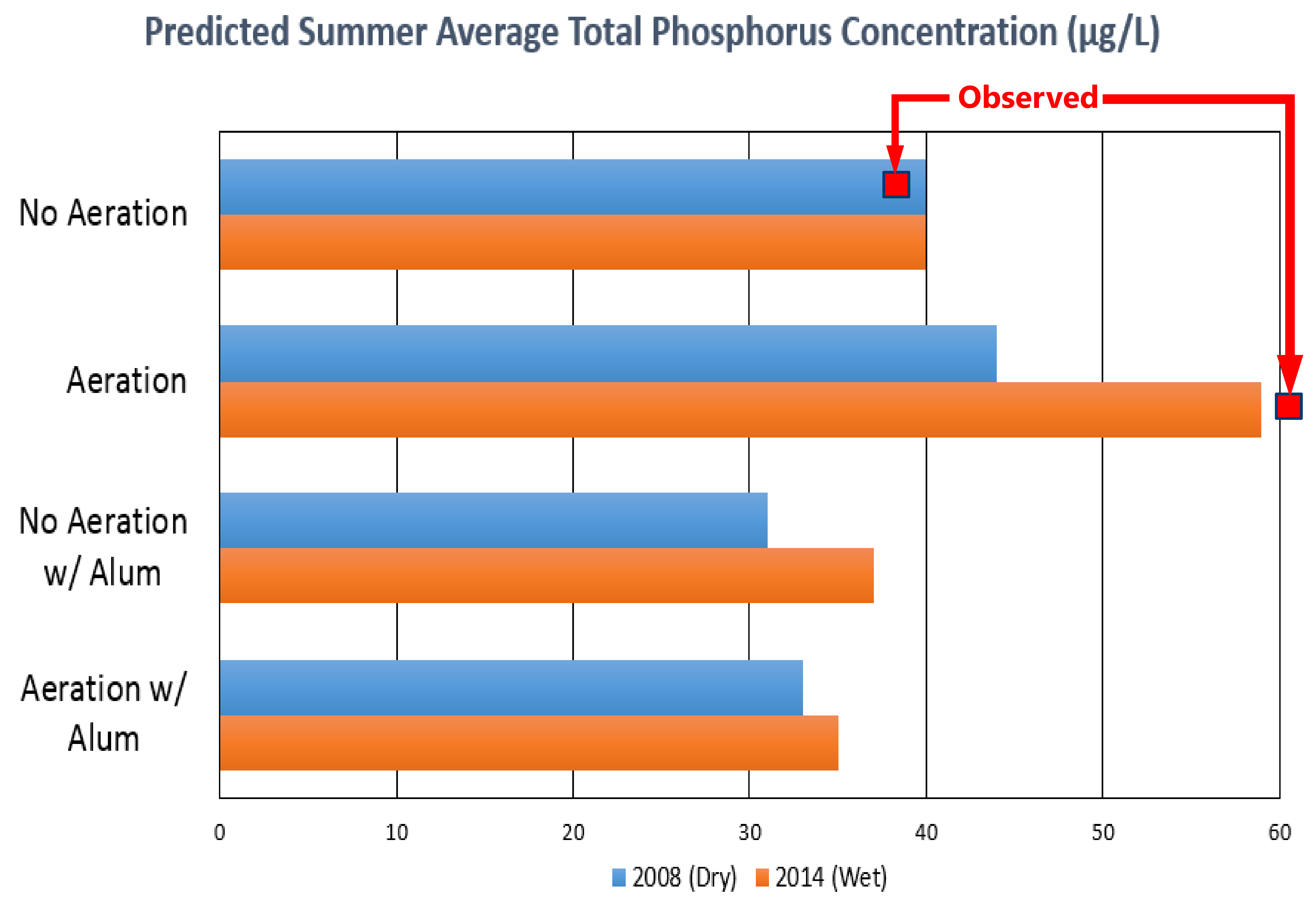
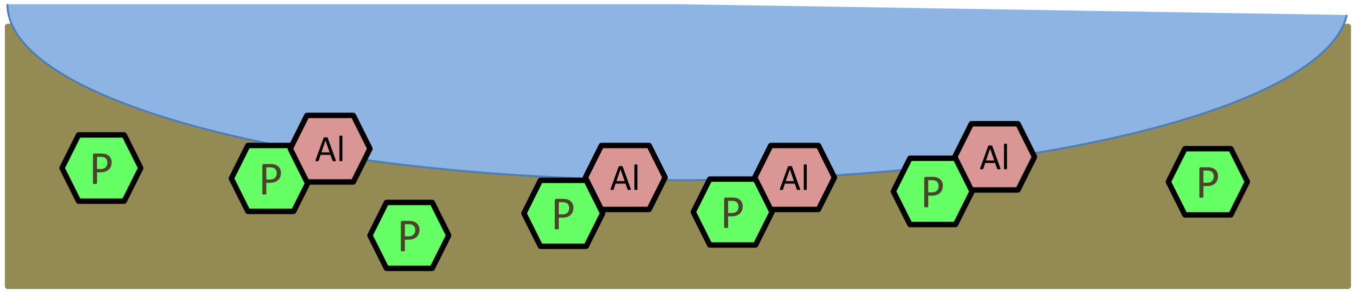


what is alum?

aluminum sulfate

- Chemical precipitant used in hundreds of lake treatments in the past 45 years
- Safe, non-toxic and non-hazardous
- Forms “floc” that sweeps phosphorus from the water column and locks phosphorus on lake bottom
- Works regardless of oxygen conditions



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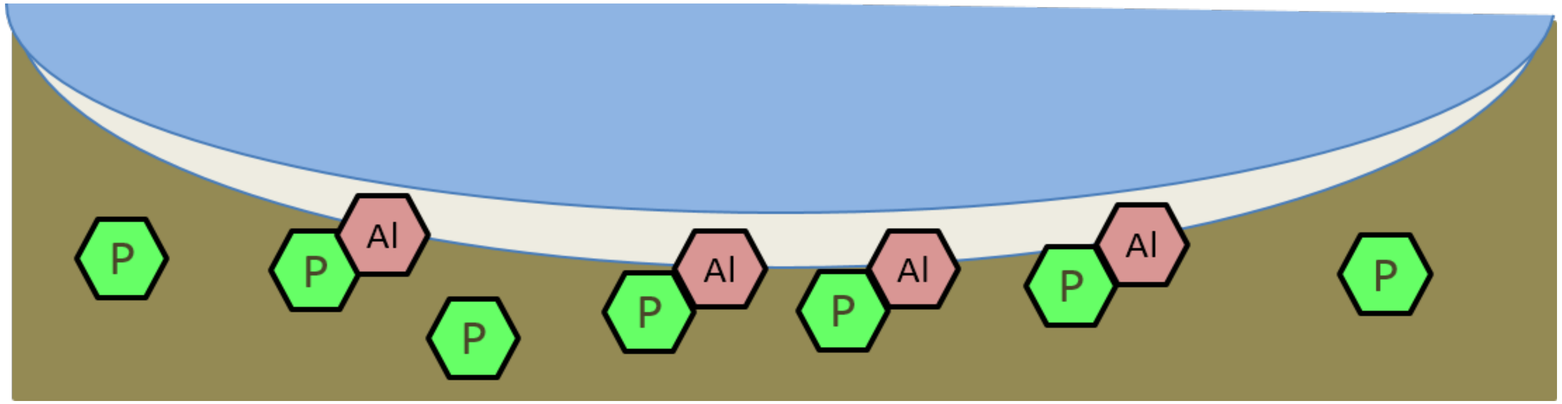
how long do alum treatments last?

Typically maintains water quality improvements for 15 to 20 years

- Aluminum reactivity remains for first couple of years
- Long-term: slow but continual sedimentation adds phosphorus on top of alum floc layer, internal load will slowly return



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conclusions

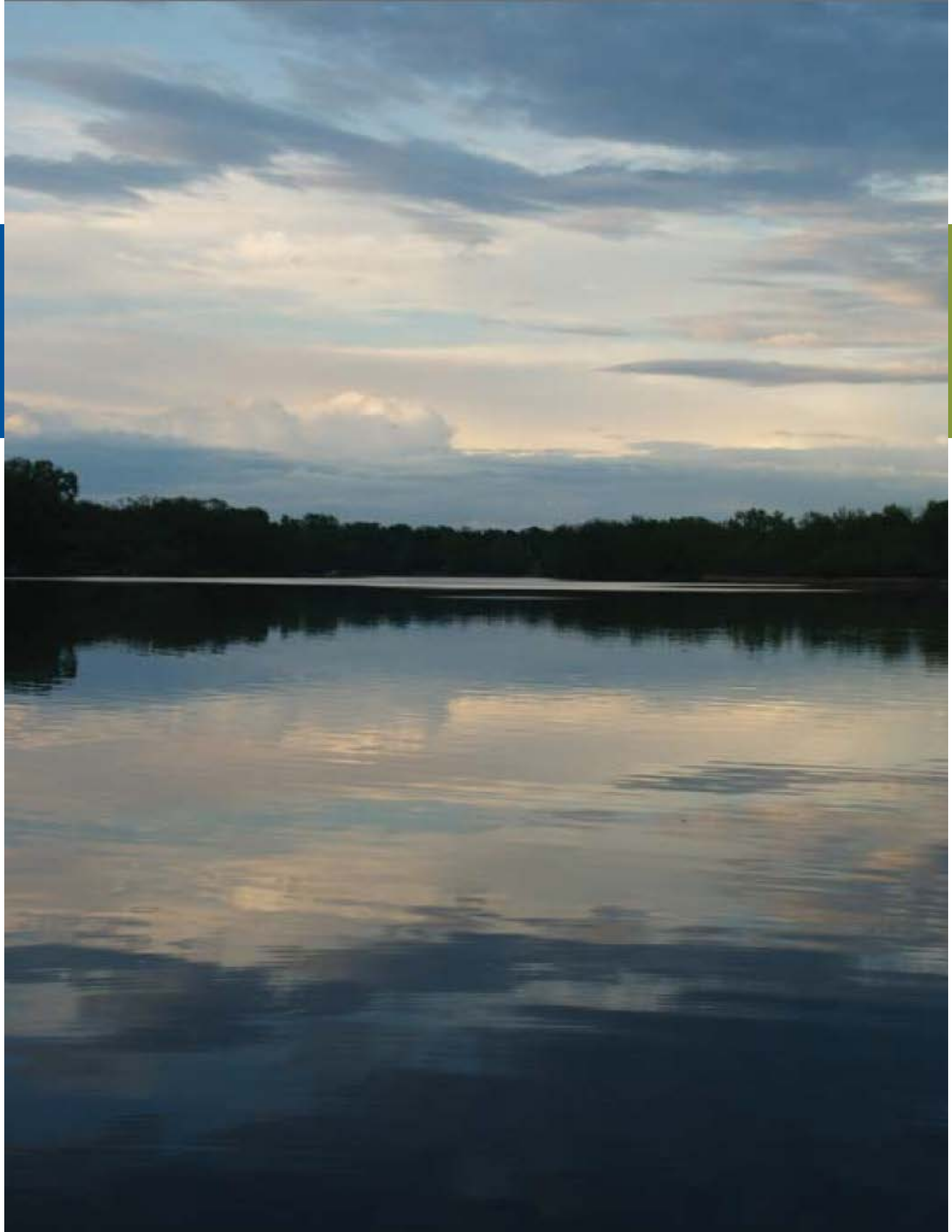
comparing management options

- Internal phosphorus load is the most important source during summer
- Aeration exacerbates summer water quality problems (10-30% increase in total phosphorus in upper layer of lake)
- In-lake alum treatment greatly improves water quality—meets goals
- Aeration after an alum treatment may not provide significant benefits
  - Depends on watershed TP & mixing

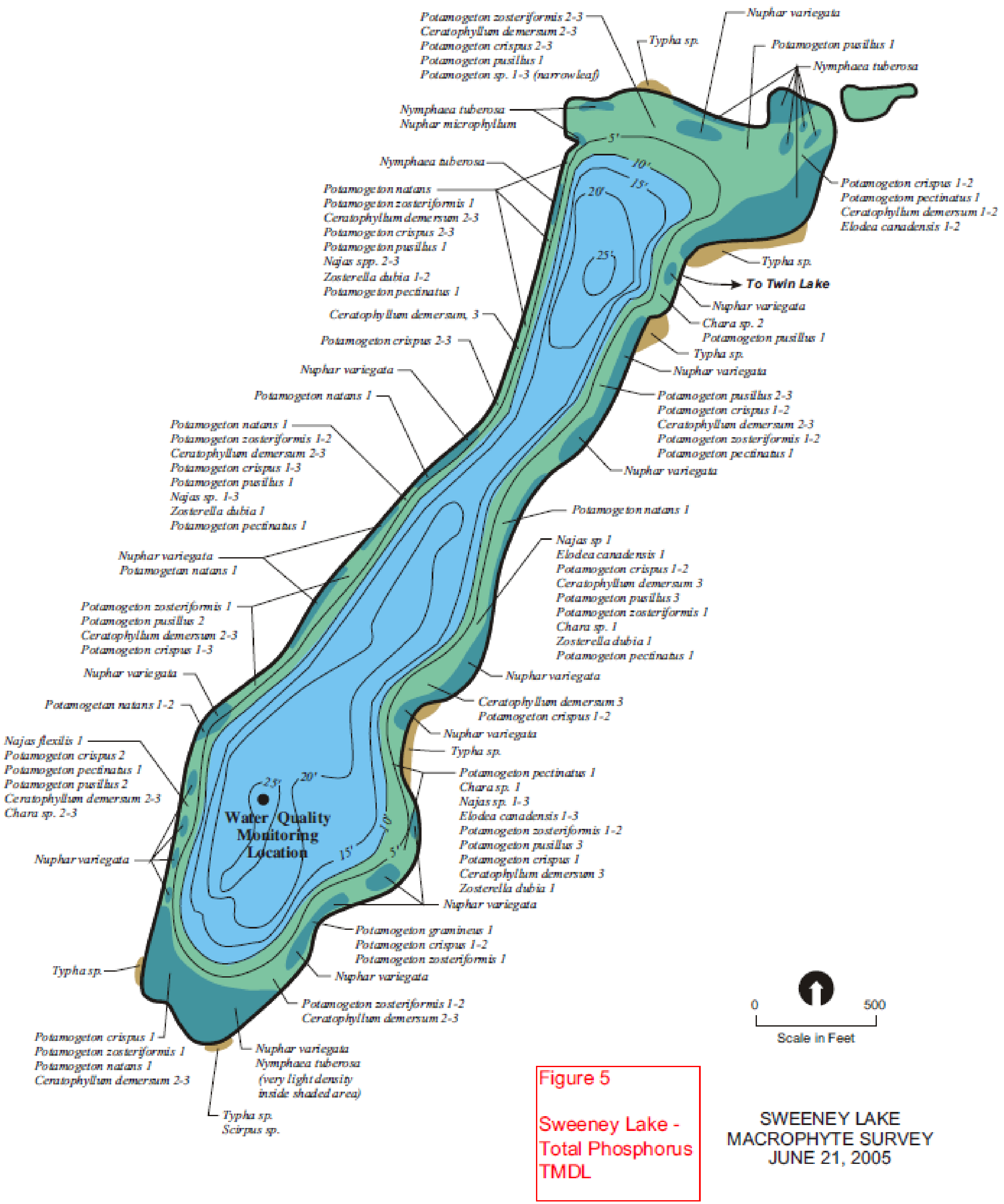
recommendations

- Suspend aeration and plan for first phase of alum application
- Monitor lake water quality and biota for two-year period
- Report results and reconsider aeration and/or other management actions

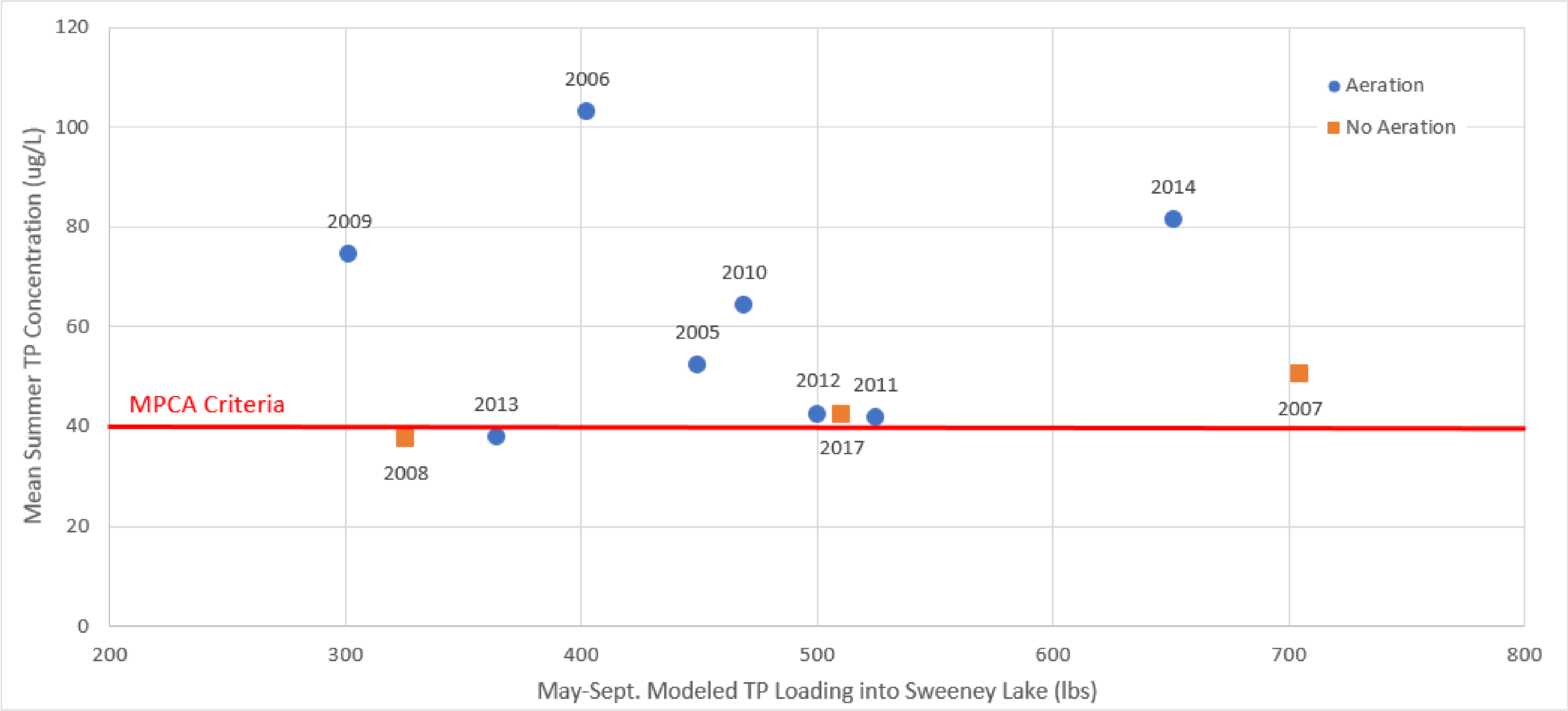
Questions?



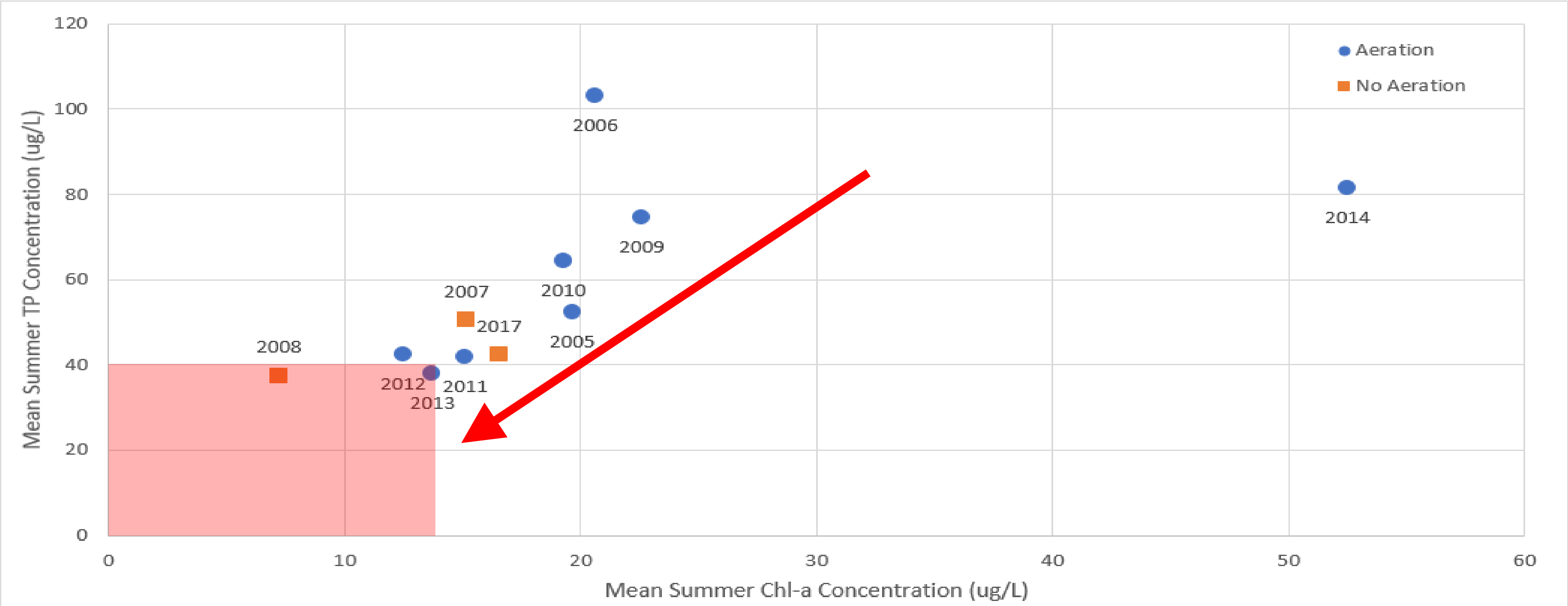
Aquatic plants

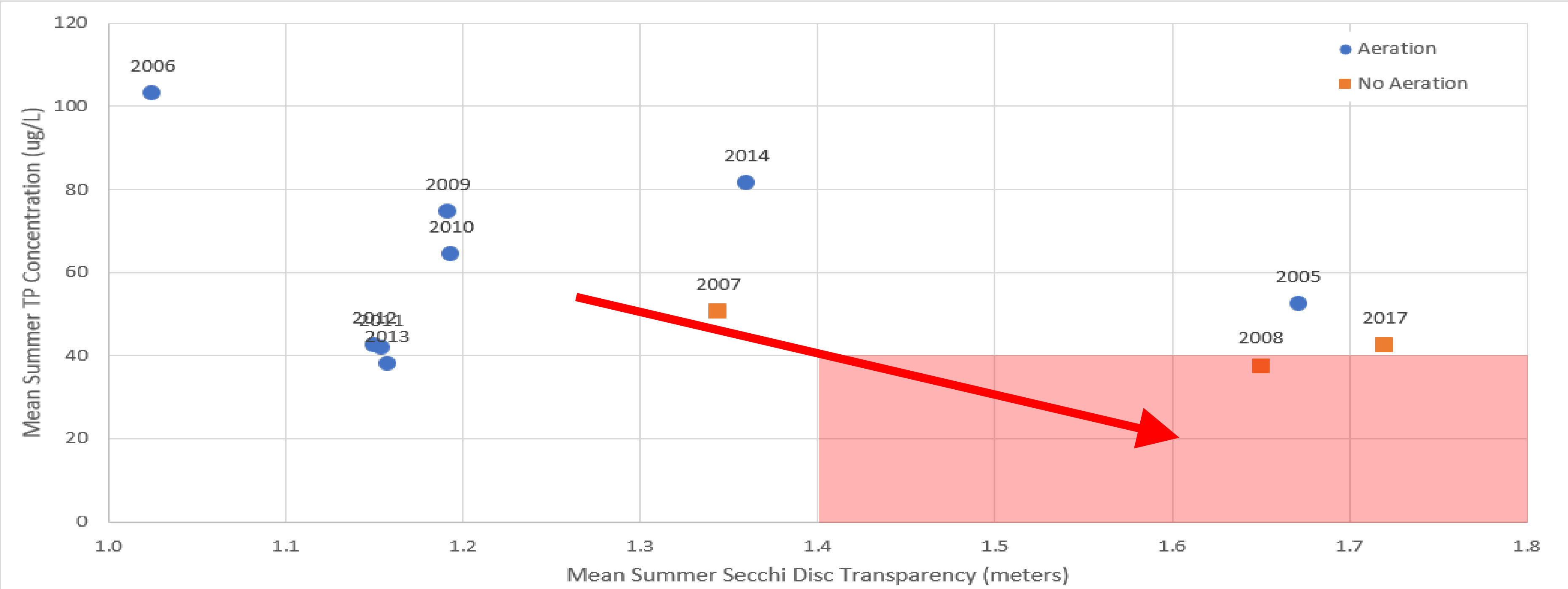


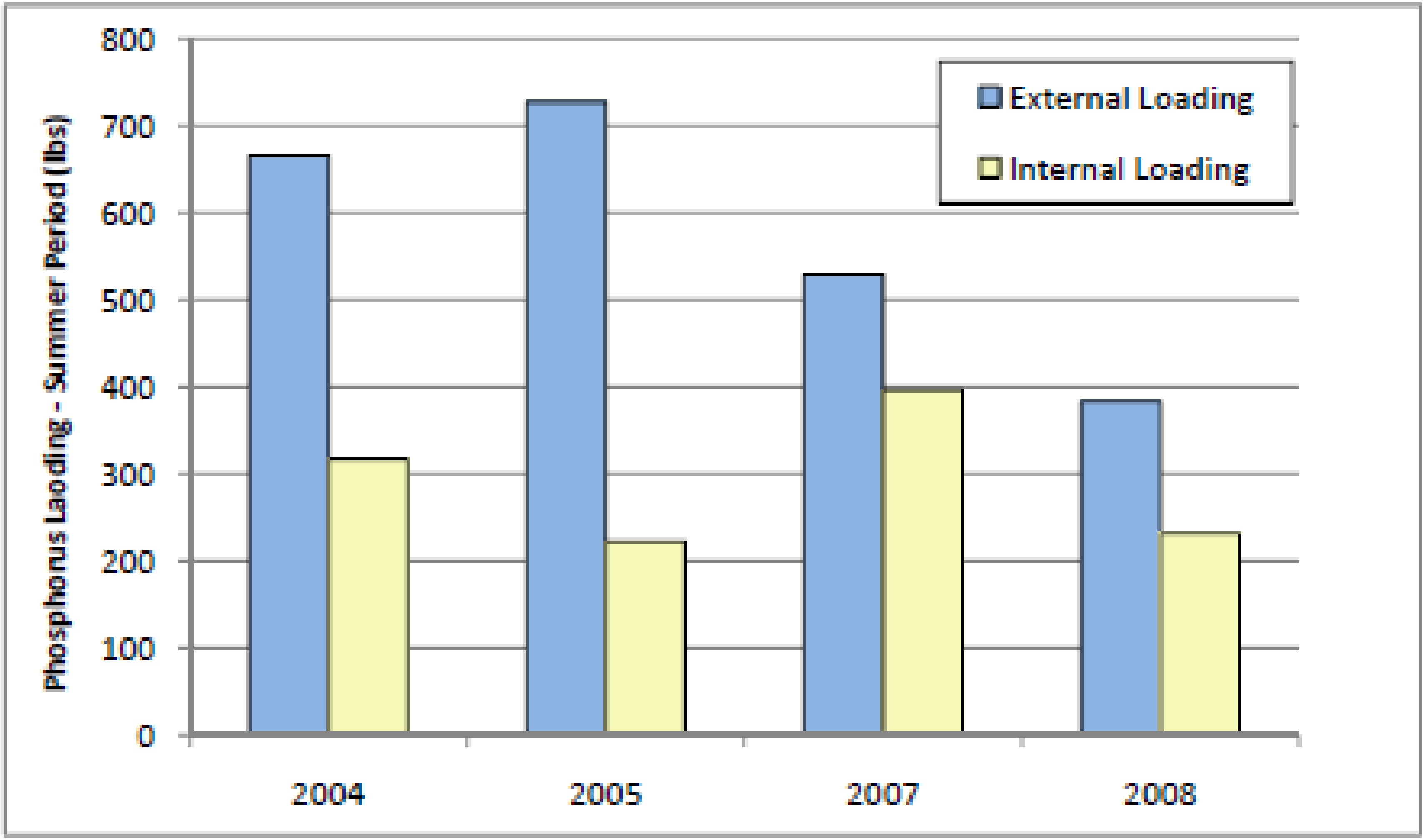
water quality effects of watershed TP load and aeration



water quality effects of phosphorus and aeration







Phosphorus Laoding - Summer Period (lbs)
800
700
600
500
400
300
200
100
0
External Loading
Internal Loading
2004
2005
2007
2008