

State of the Lake

2018 Water Quality in Delavan Lake

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U.S. Geological Survey, Upper Midwest Water Science Center

April 3, 2019

In Collaboration with:

Town of Delavan

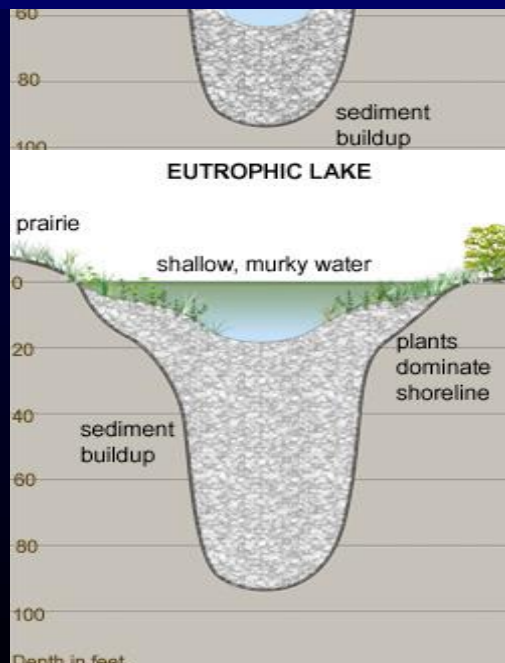
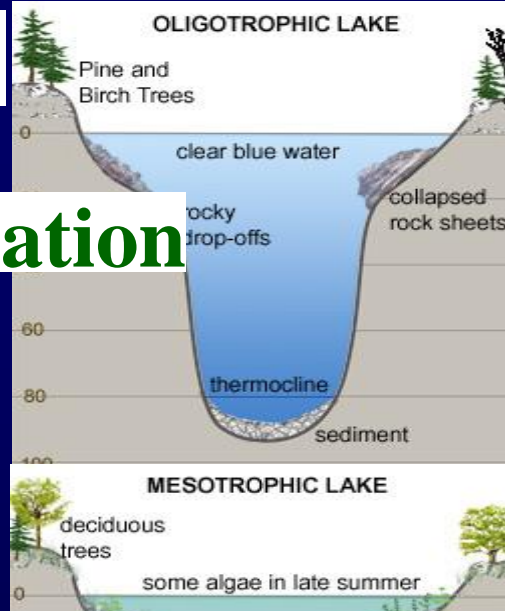
Delavan Lake Sanitary District



Types of Lakes

Eutrophication

Time &
Nutrients – Cultural Eutrophication



Oligotrophic – *Young*

- Low Nutrient Conc.
- Low Productivity.
- Clear Water
- Desirable Fishery but often limited

Mesotrophic

Moderate Nutrient Conc.

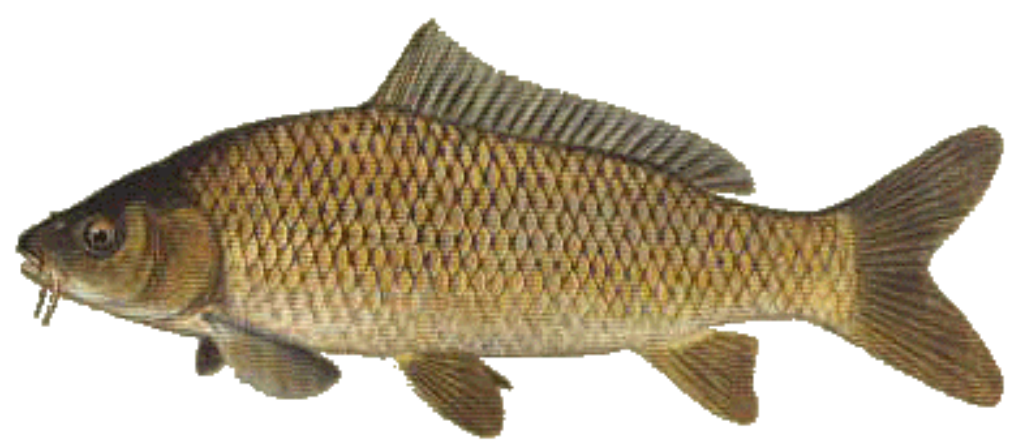
Increased Productivity

- Occasional Algal Bloom
- Good Fishery

Eutrophic - *Old*

- High Nutrient Conc.
- Very Productive
- Frequent Algal Blooms
- Freq. Deep DO Depletion
- Rough Fish Common

Delavan Lake – 1970s
“2nd worse lake in the State”

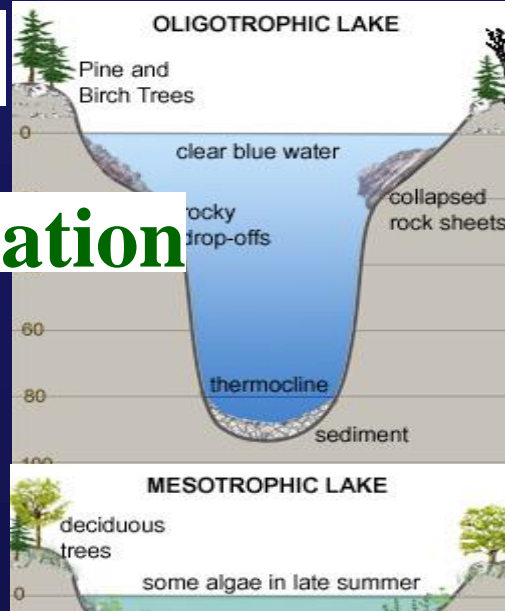


Types of Lakes

Eutrophication

Time &
Nutrients – Cultural Eutrophication

Delavan Lake Rehabilitation



Oligotrophic – *Young*

- Low Nutrient Conc.
- Low Productivity.
- Clear Water
- Desirable Fishery but often limited

Mesotrophic

Moderate Nutrient Conc.

Increased Productivity

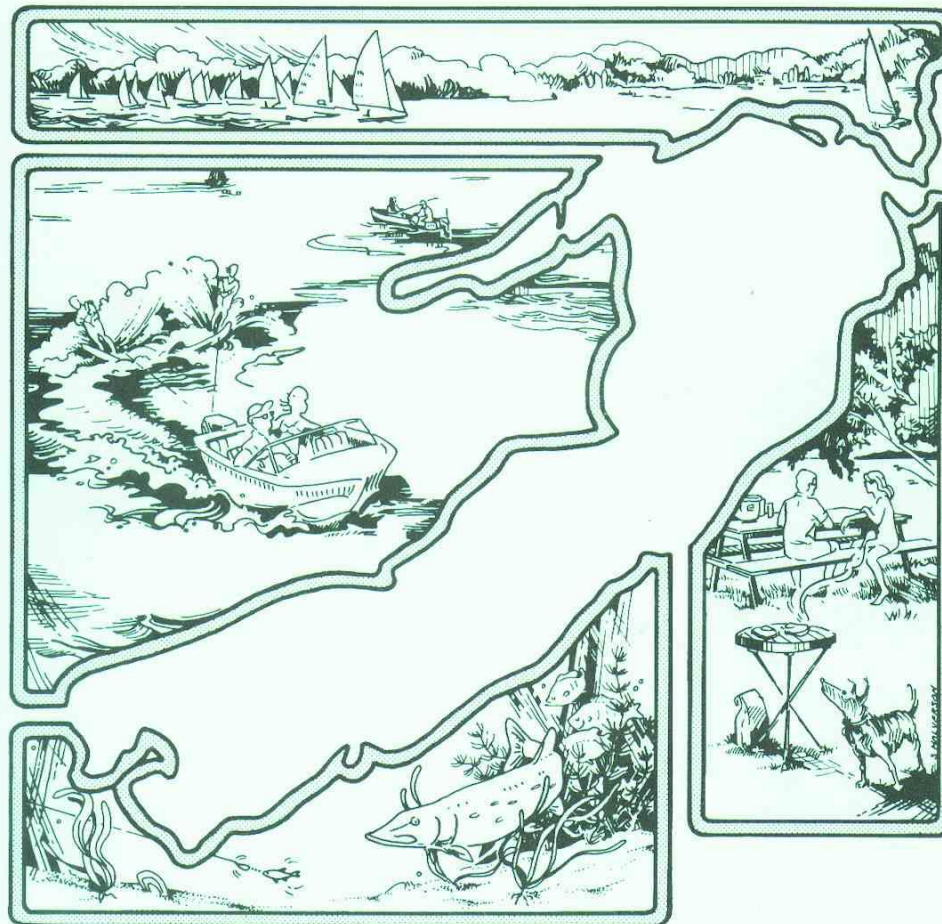
- Occasional Algal Bloom
- Good Fishery

Eutrophic - *Old*

- High Nutrient Conc.
- Very Productive
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Delavan Lake: A Recovery and Management Study

Water Resources Management Workshop



Institute for Environmental Studies, University of Wisconsin—Madison
in cooperation with
Wisconsin Department of Natural Resources

September 1986

Based heavily on USGS studies

**Experimental Study
on Lake 226 in
Canada in the 1970s
demonstrated that
phosphorus was
usually the limiting
nutrient**



Carbon and Nitrogen Added

Carbon, Nitrogen, and Phosphorus Added

Goals for Delavan Lake Rehabilitation

Increase Water Clarity – Increase Average Summer Secchi Depth from ~1.0 m to at least 1.5 m



Water Quality Model

Decrease Average Summer Chlorophyll a concentration from ~30 – 50 ug/L to 14 ug/L



Water Quality Model

Decrease in lake spring P concentration from ~100 – 120 ug/L to about 34 ug/L



Lake Loading Model

Decrease P Loading to the lake from about 8,700 kg/yr to about 1,900 kg/yr (80%)

Typical conditions associated with trophic status

Oligotrophic

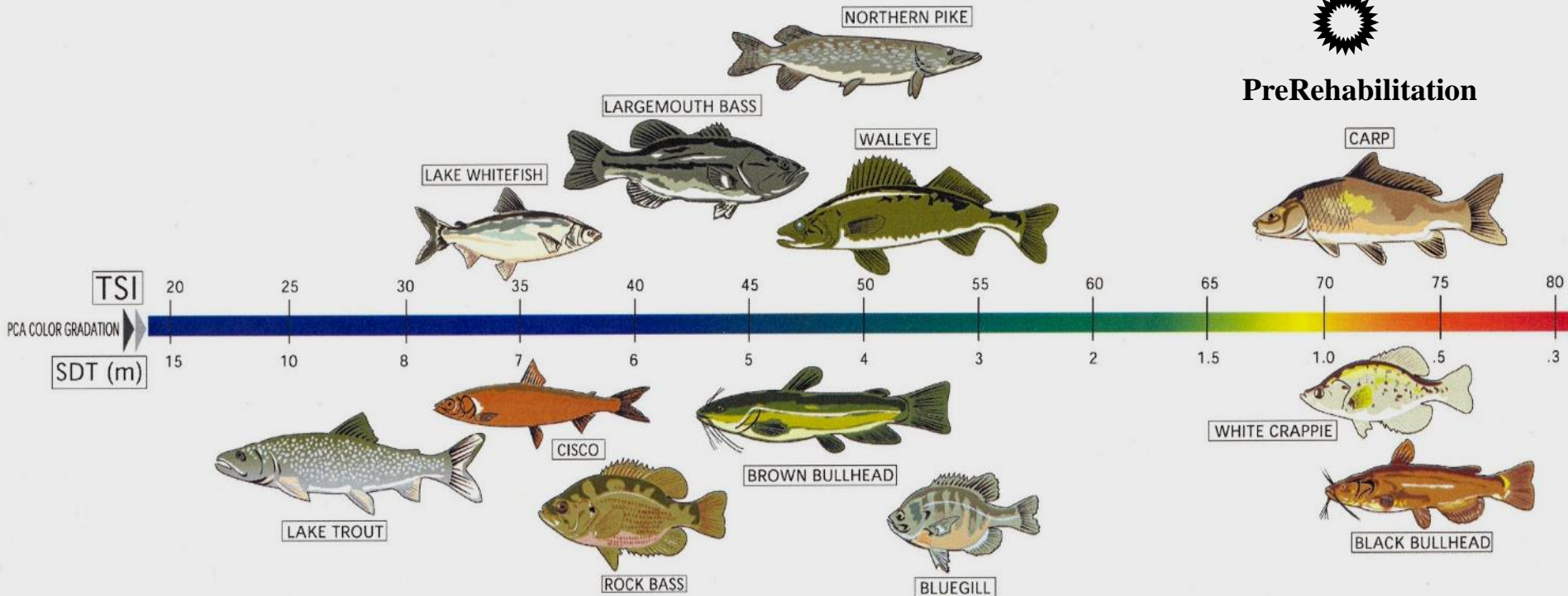
Mesotrophic

Eutrophic

Hyper-eutrophic



PreRehabilitation



Every change of 10 in the TSI corresponds to a doubling of a lake's algae biomass and a halving of water clarity.



Based on work of Dennis Schupp MDNR Fisheries

Rehabilitation of Delavan Lake



WDNR > Dingle Johnson Funds

Local Support > Cash and In-kind

State Government

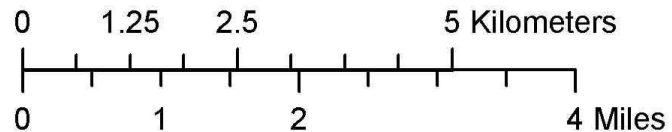
Dept. Ag. > Nonpoint Funds

USGS > Cooperative Funds

USEPA > Clean Lake Funding

- > Water Pollution Control Project House Public Works Committee
- > Natural Prototype Project for Rehabilitating Lakes
- >> ~\$ 7 Million

1979-1992
plus maintenance

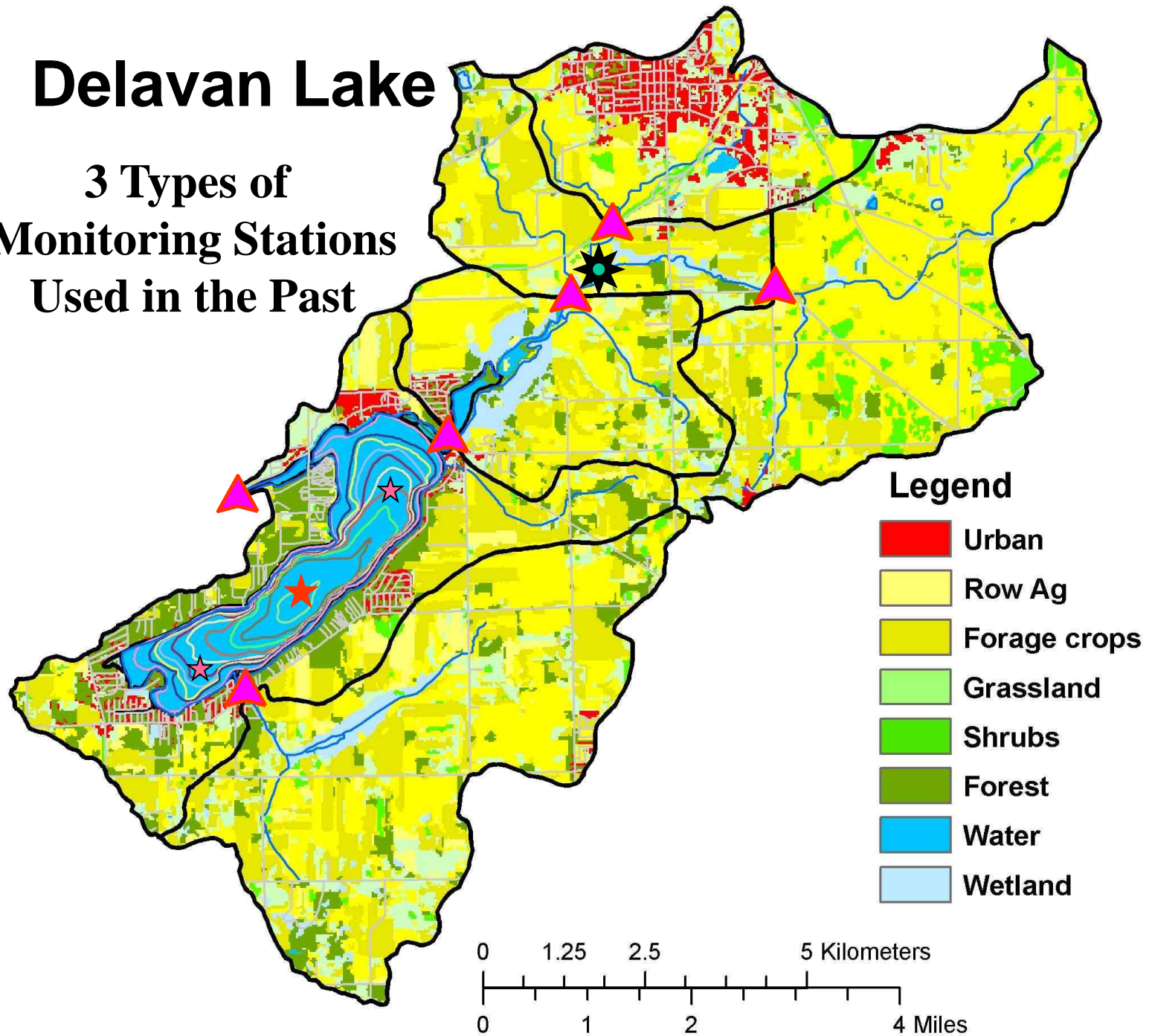


Main Questions Addressed by the USGS

1. What is the water quality of the lake?
Physical, chemical, and biological conditions.
2. How are each of the rehabilitation efforts working?
3. Is the water quality of the lake changing?
4. What are the concentrations and loads of phosphorus and sediment in Jackson Creek
5. What is the total loading of phosphorus to the lake?
6. How has and how will the lake respond to changes in loading?

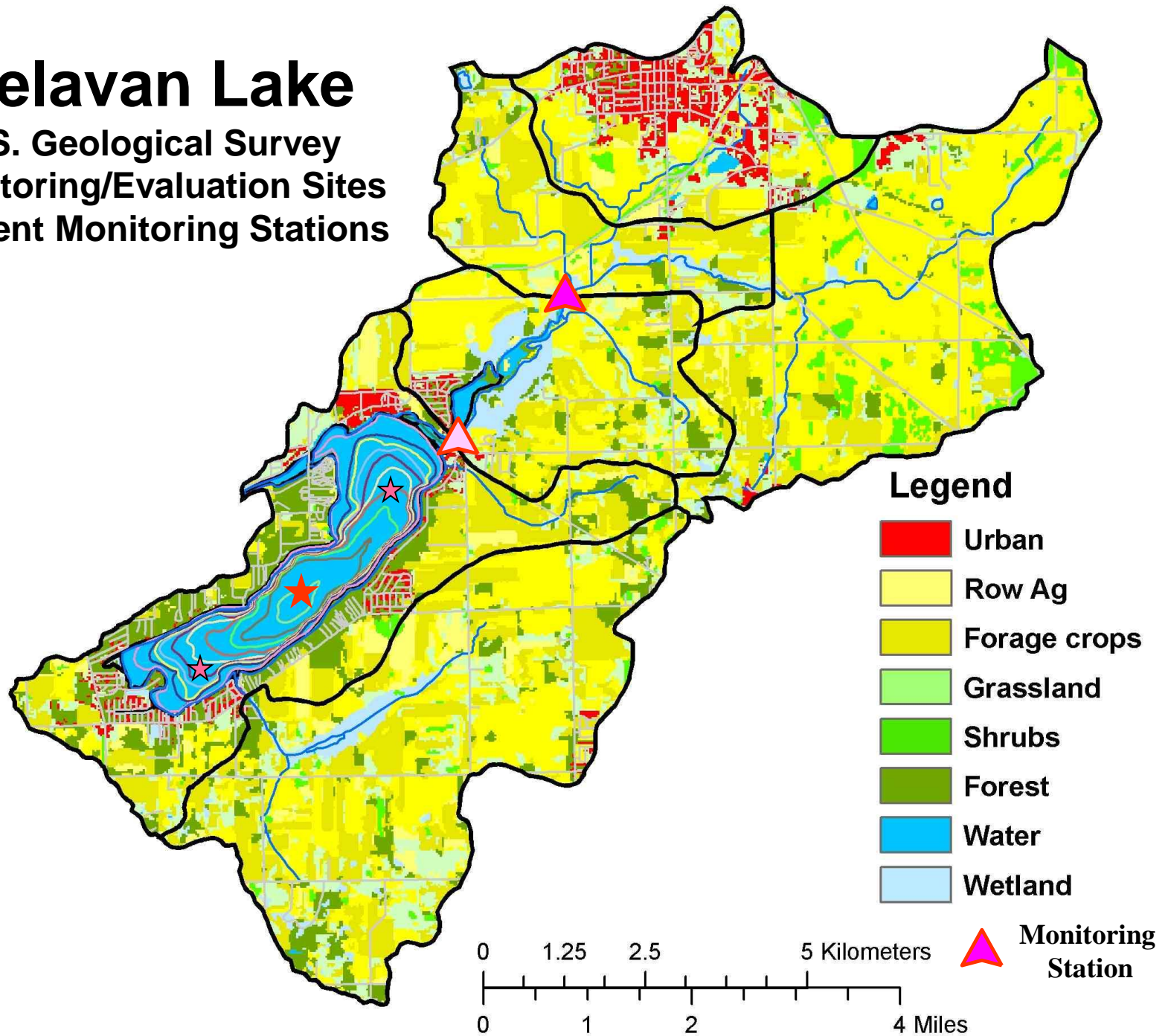
Delavan Lake

3 Types of Monitoring Stations Used in the Past



Delavan Lake

U.S. Geological Survey
Monitoring/Evaluation Sites
Present Monitoring Stations

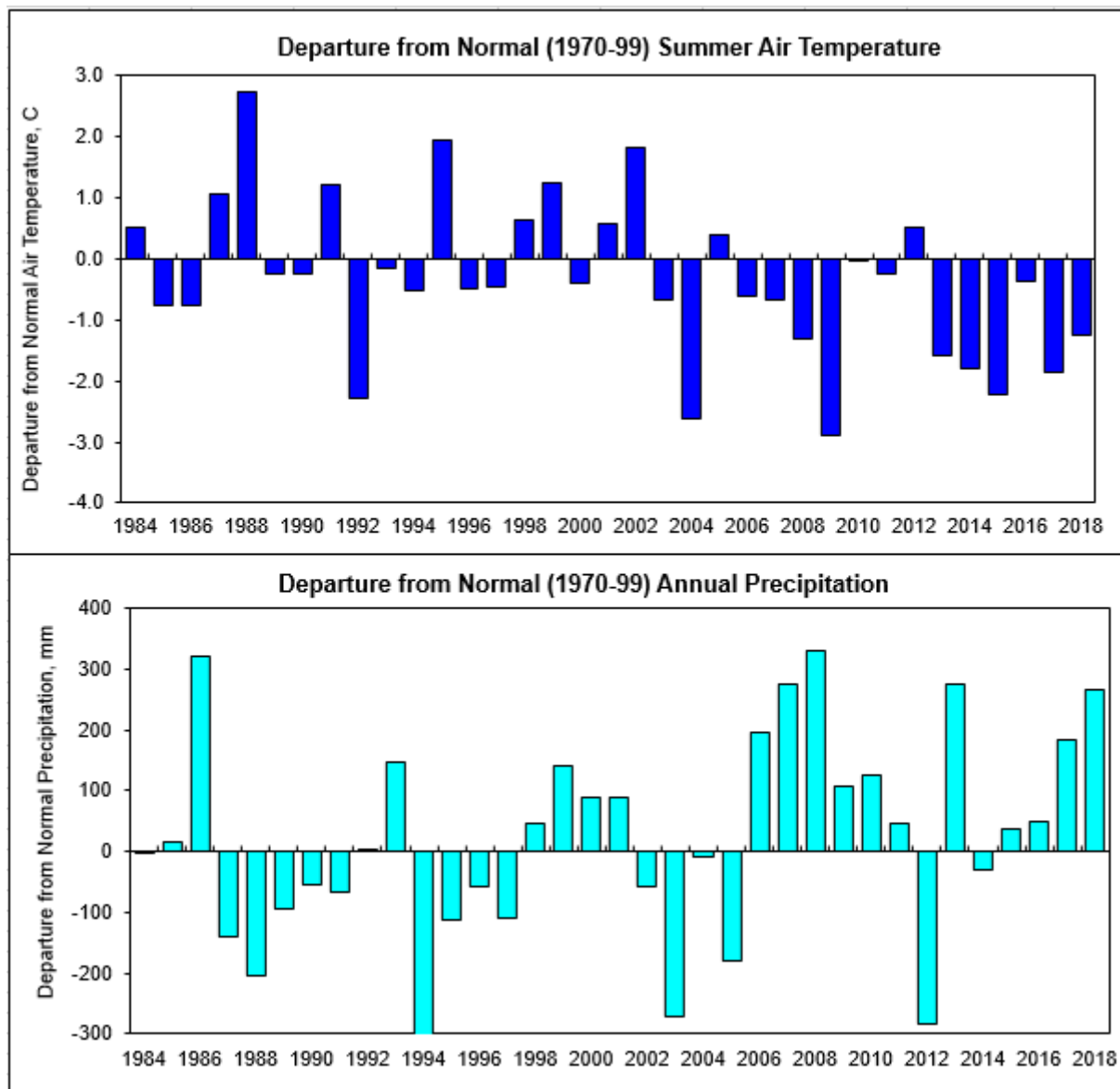


State of the Lake

2018 Water Quality - Delavan Lake



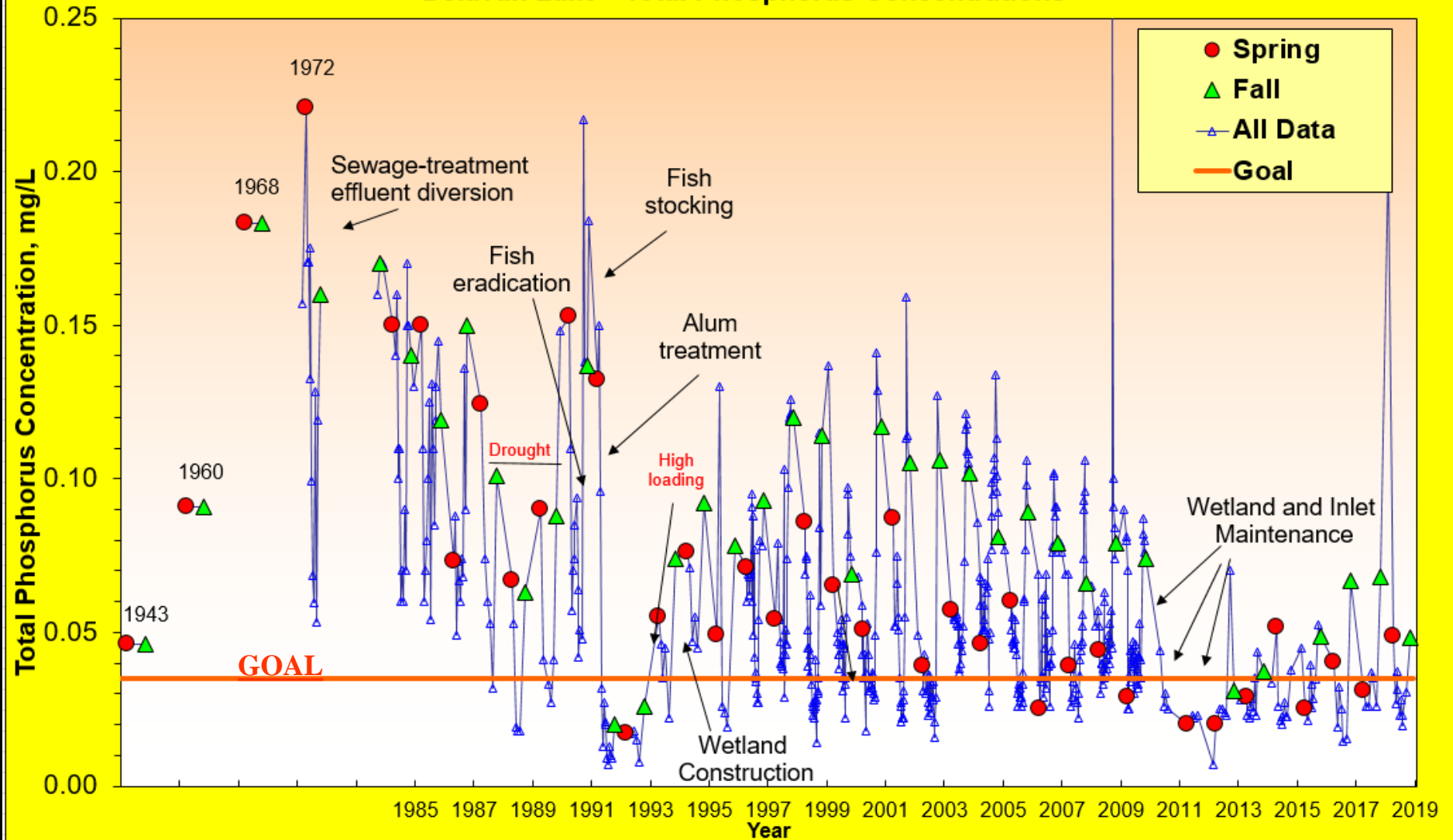
Weather Conditions in 2018



Water Quality in Delavan Lake

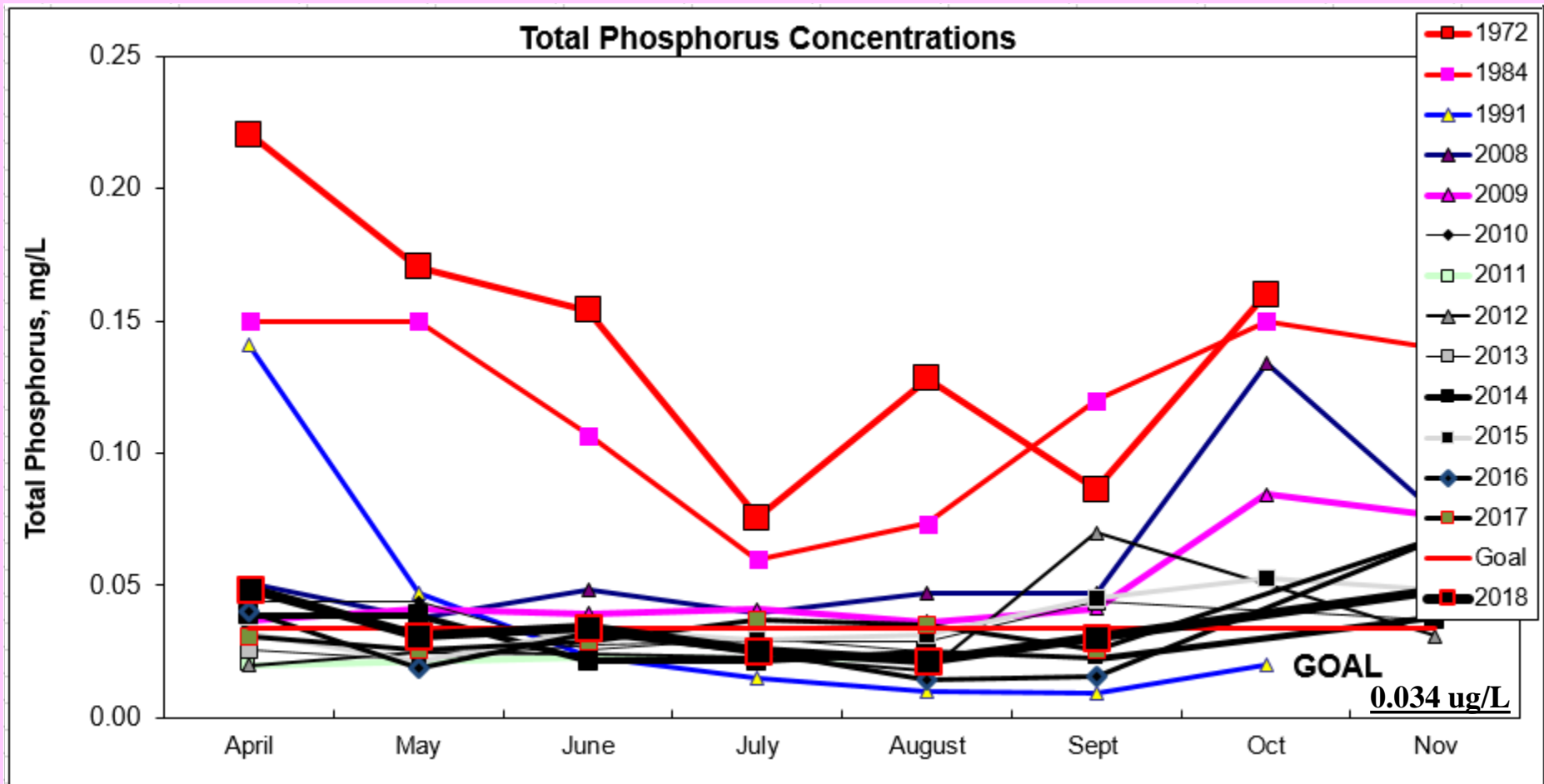


Delavan Lake - Total Phosphorus Concentrations

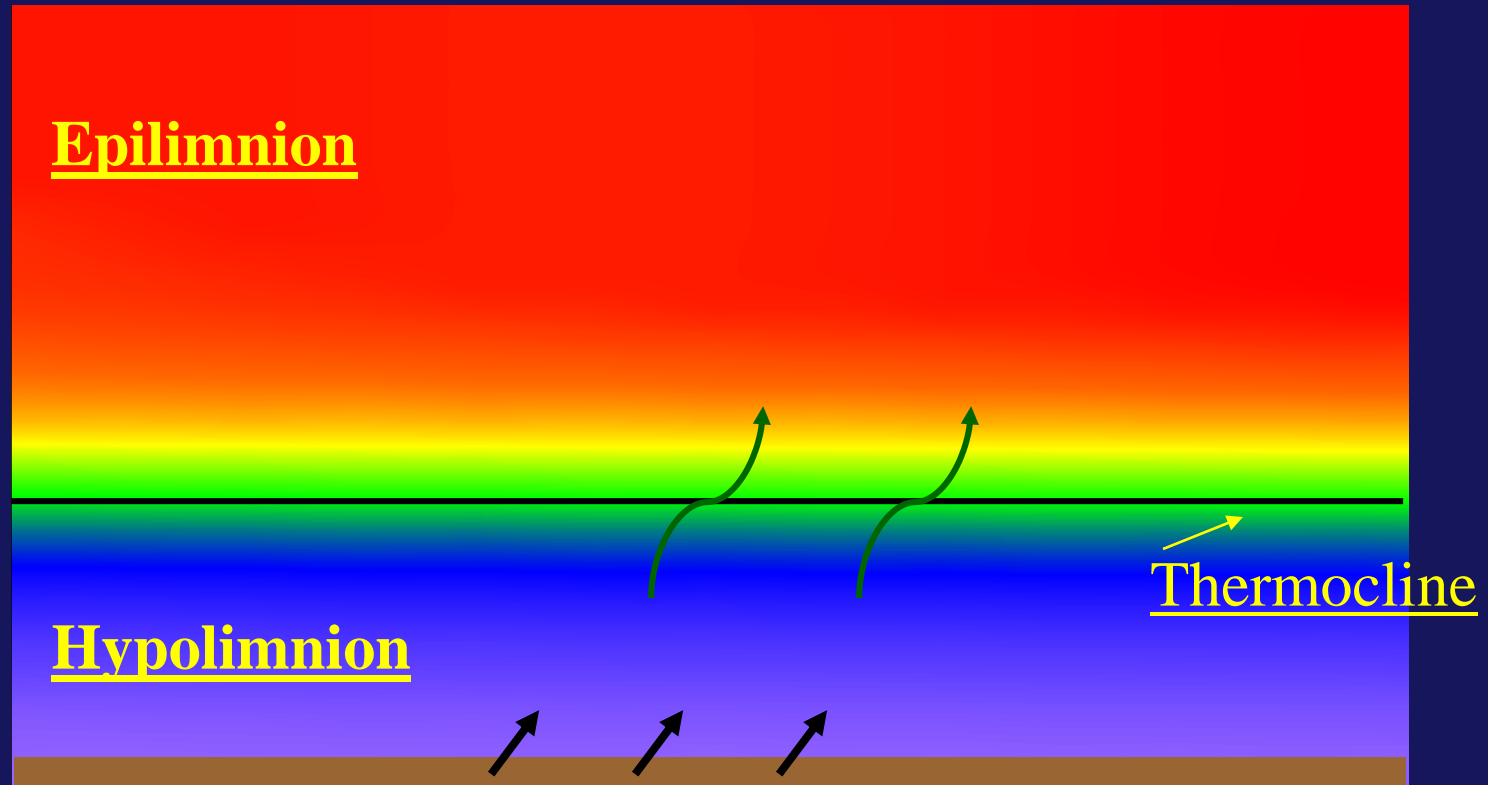


2018 Water Quality – Surface Phosphorus Concentrations

Indicator of the Source of the Potential Problems

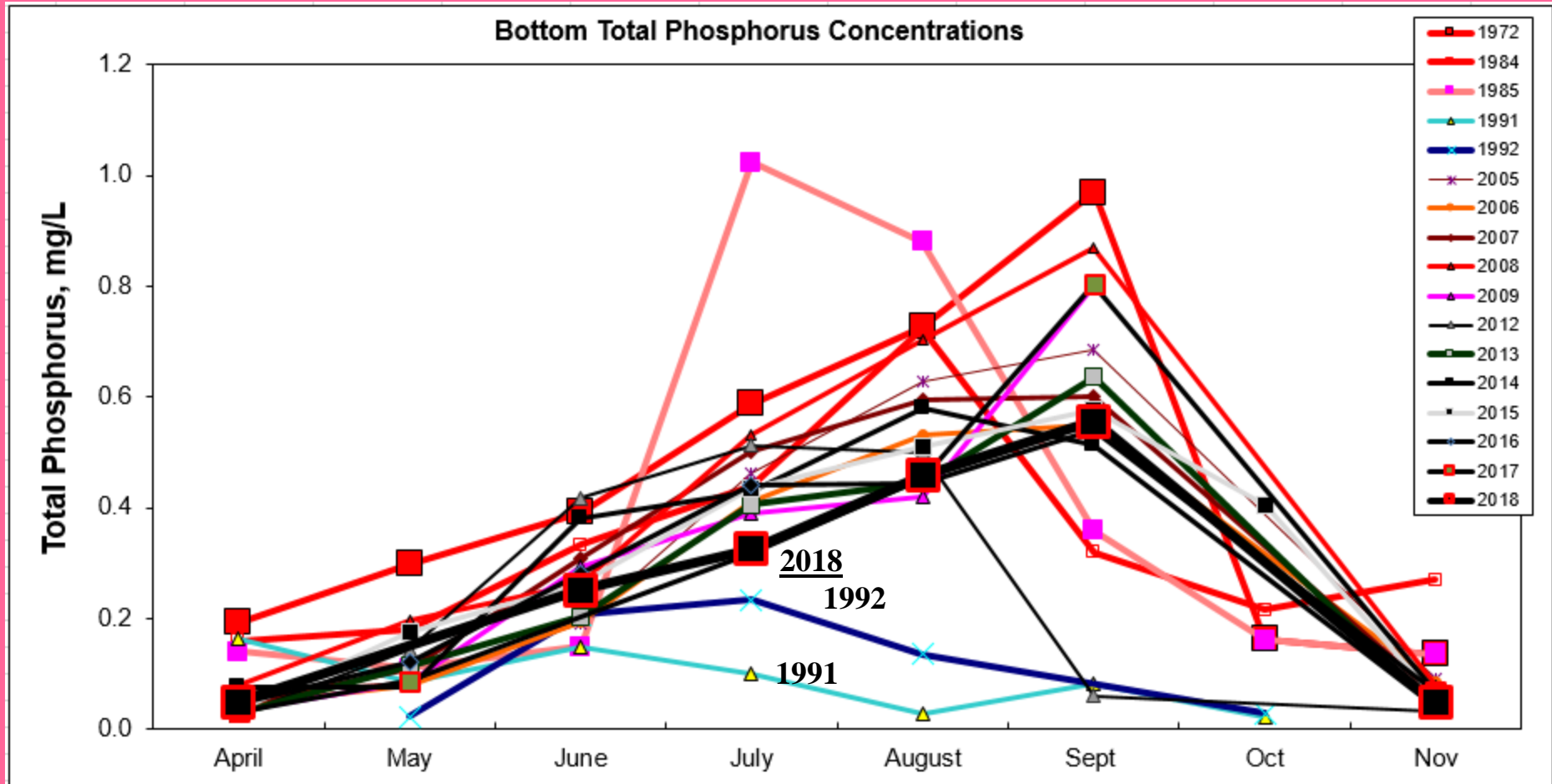


Internal Release of Phosphorus from Deep Sediment “Internal Loading”

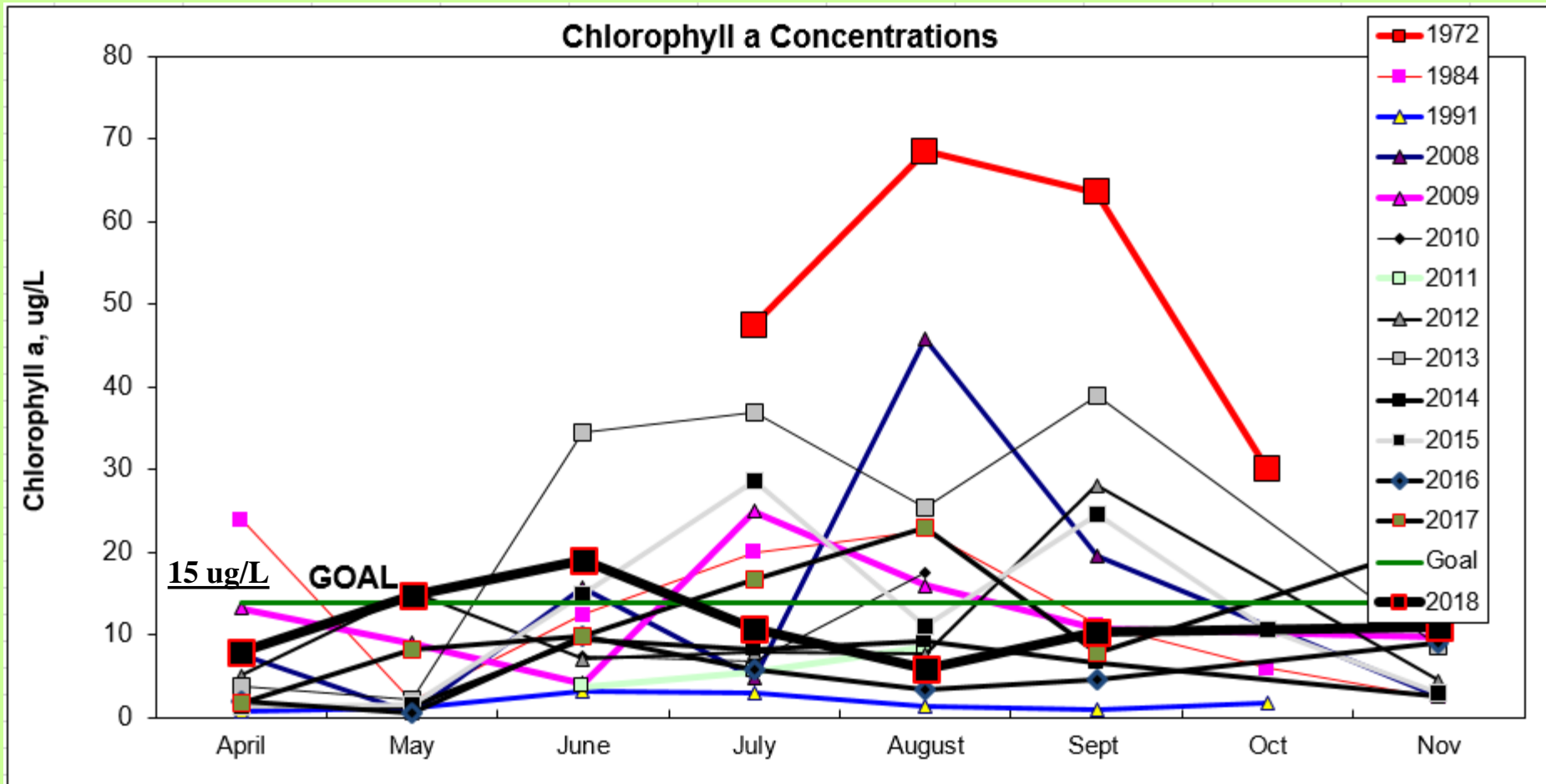


2018 Water Quality – Bottom Phosphorus Concentrations

Indicator of the amount of P coming in from lake sediments

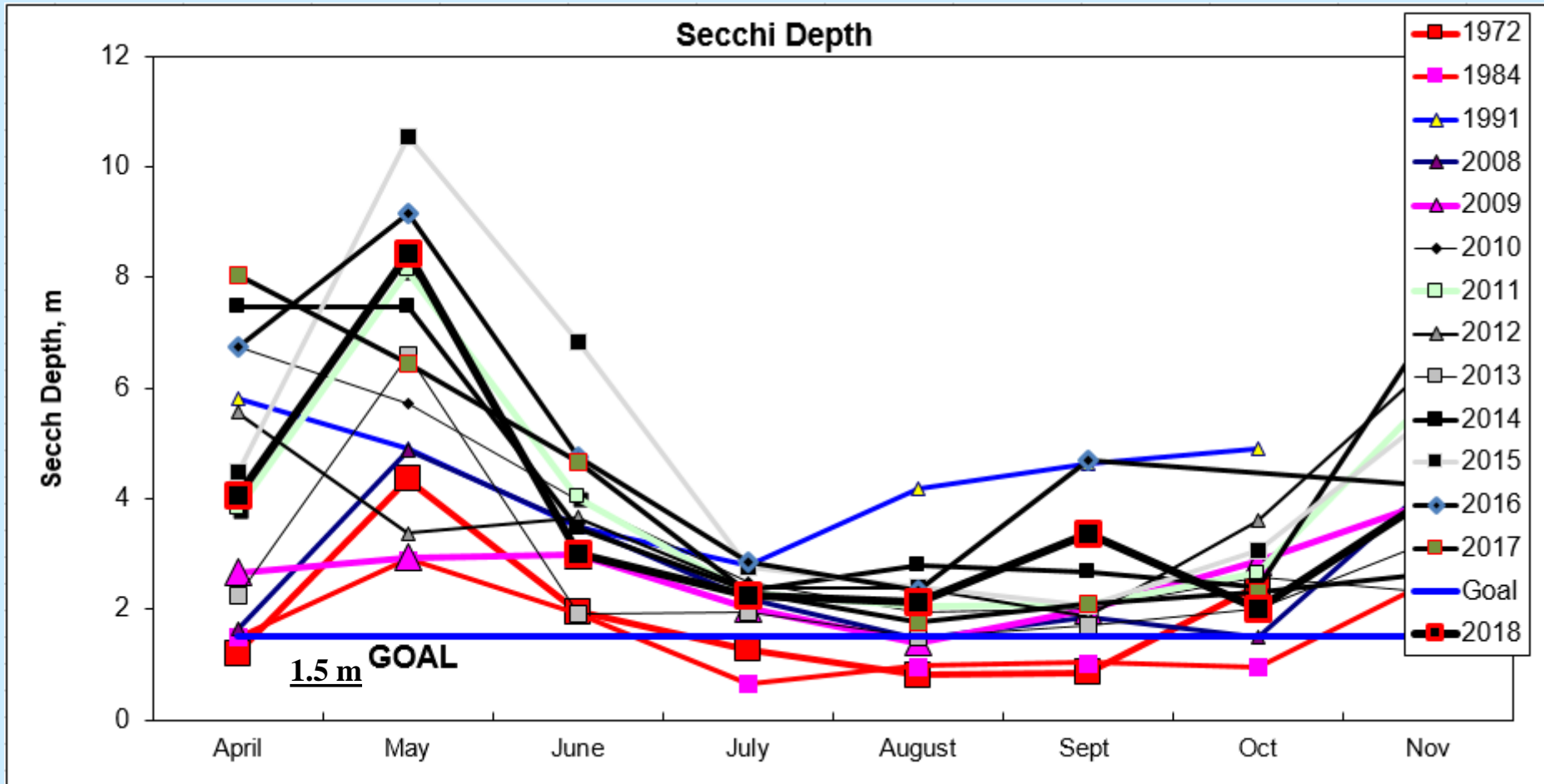


Indicator of the amount of algae in the lake

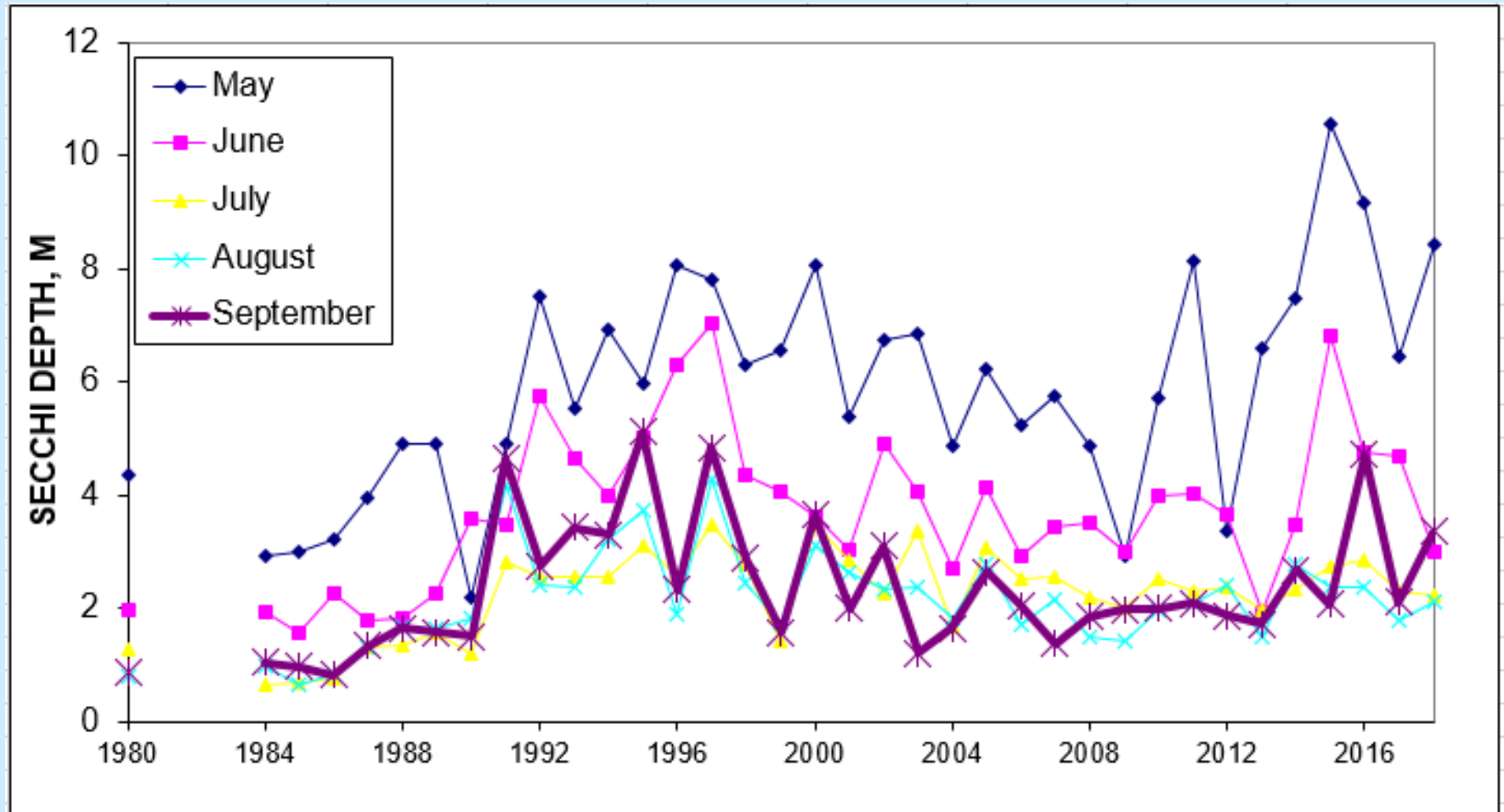


2018 Water Quality – Secchi Depth

Indicator of the water clarity in the lake



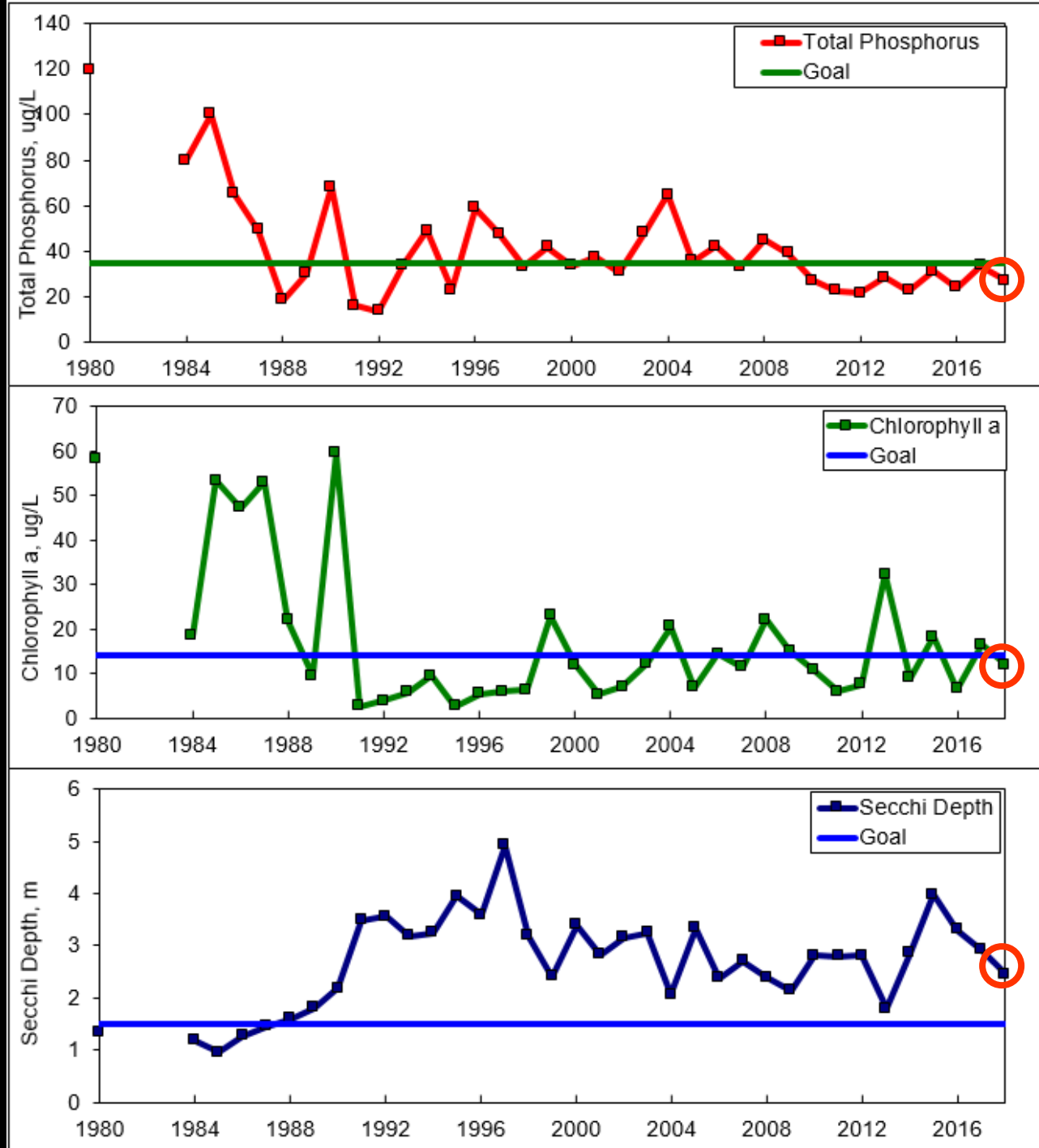
Monthly Changes in Water Clarity



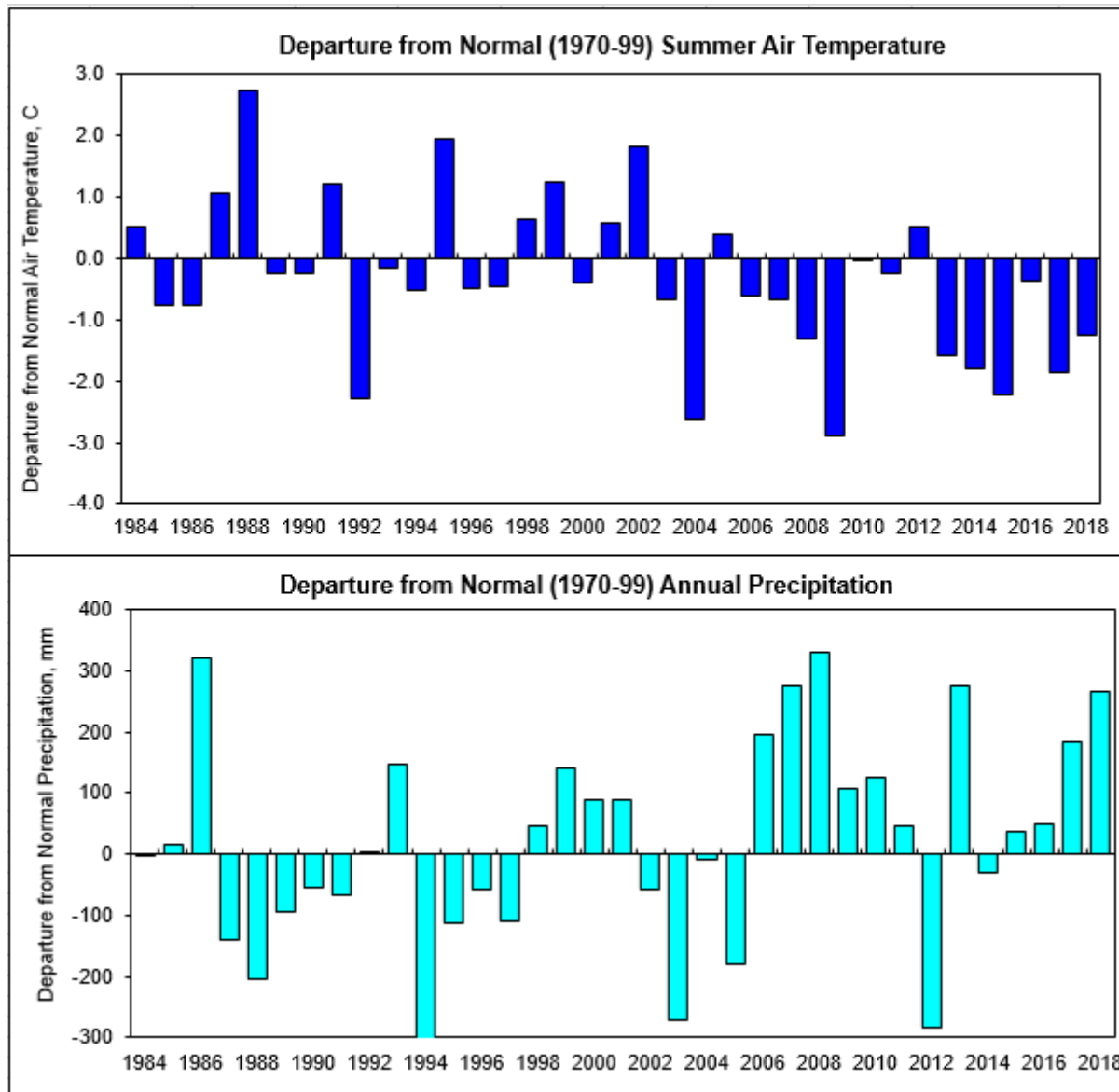
2018

Summer Average (June-August) Water Quality

What caused
this small
change in water
quality?



Weather Conditions in 2018



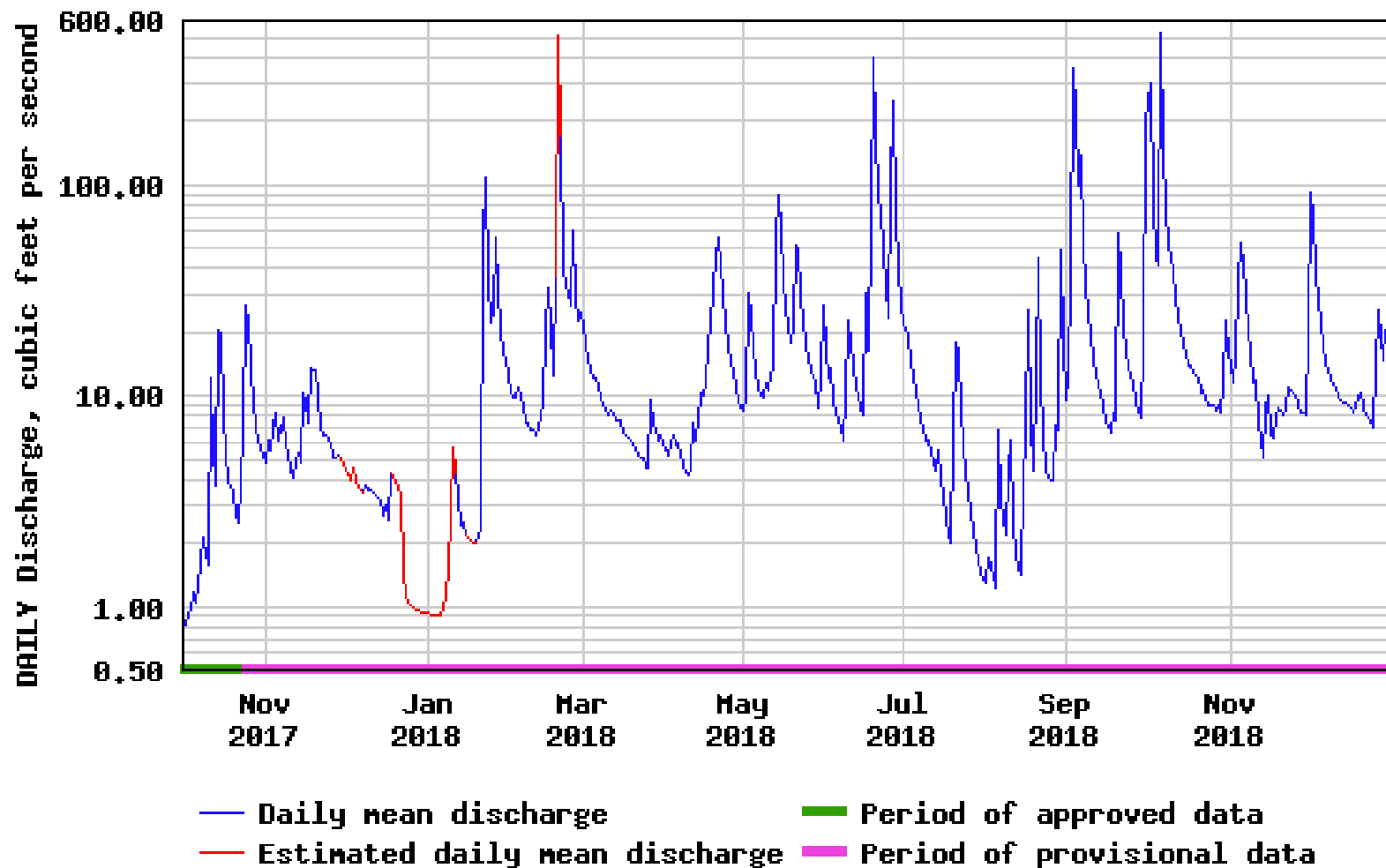




Floods of 2017



USGS 05431016 JACKSON CREEK AT MOUND ROAD NEAR ELKHORN, WI



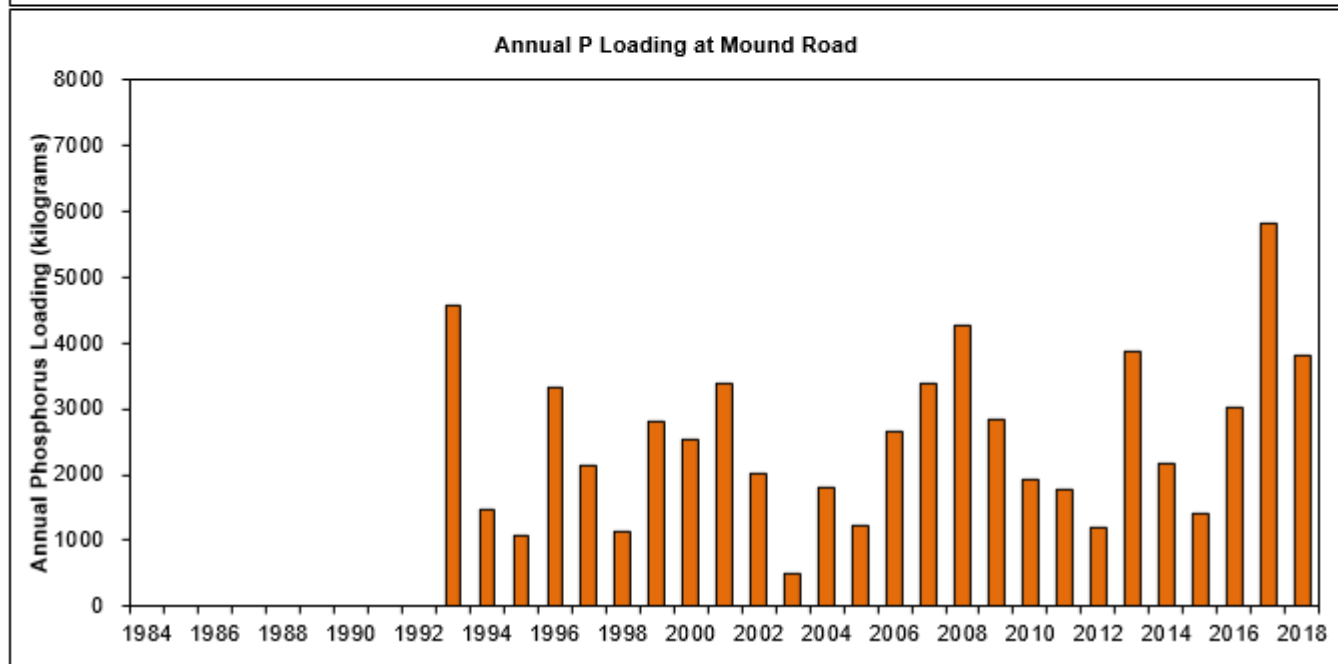
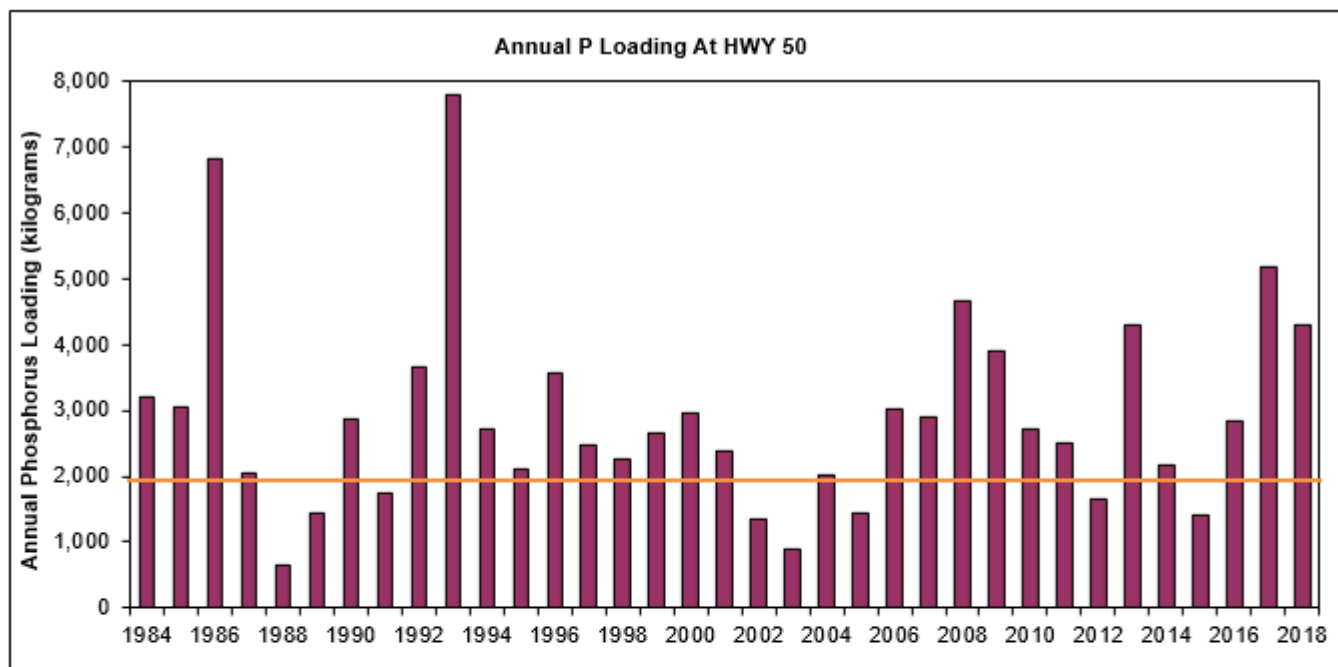
Water Level
and Stream
flow



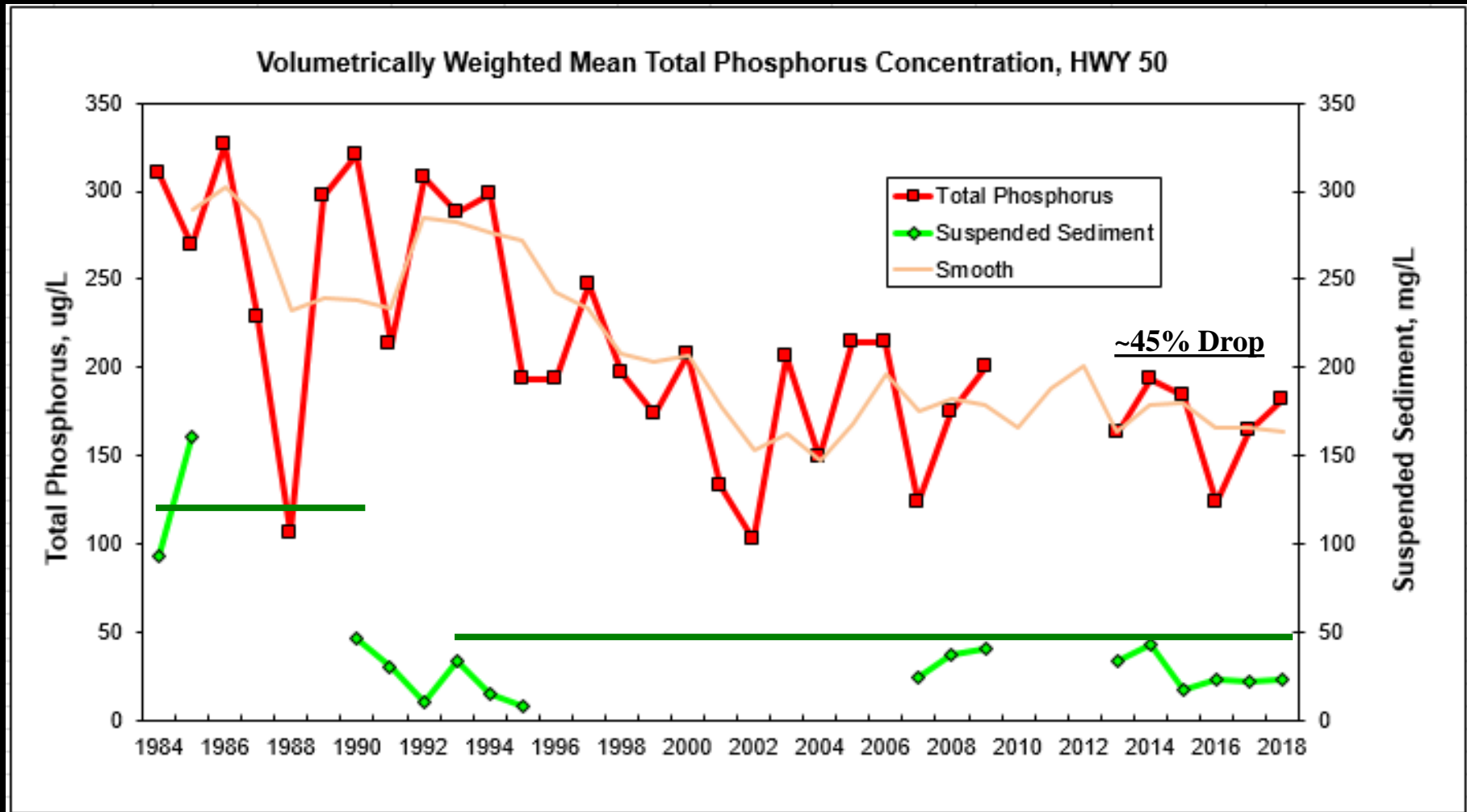
Water samples



Phosphorus Loading to Delavan Lake from Jackson Creek

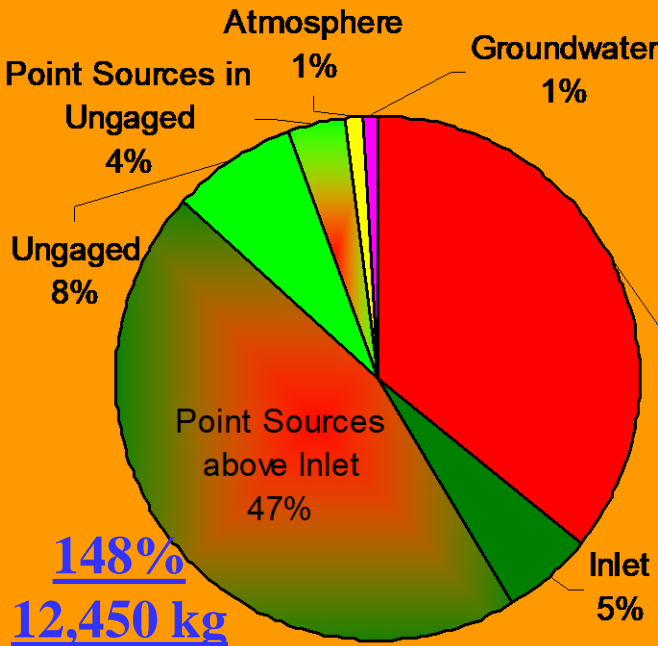


Changes in the Watershed Appear to Be Working After you remove the effects of differences in flow

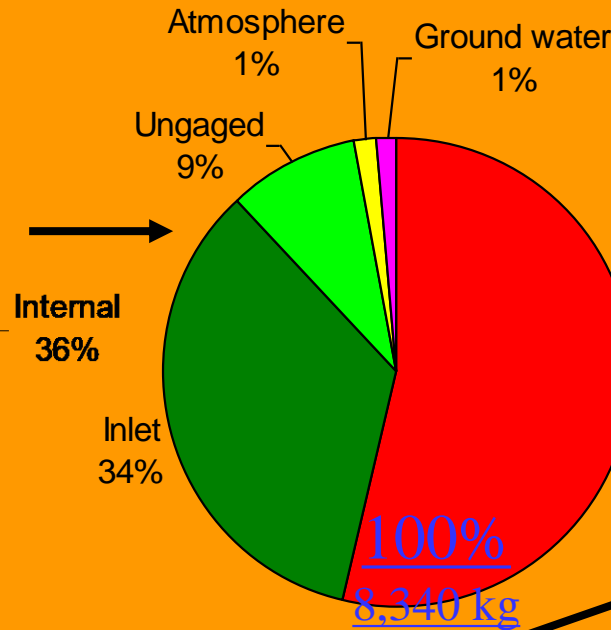


Phosphorus Budgets For Delavan Lake

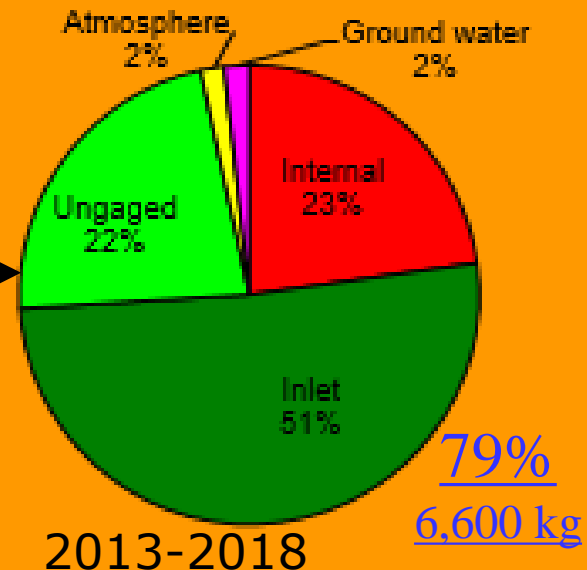
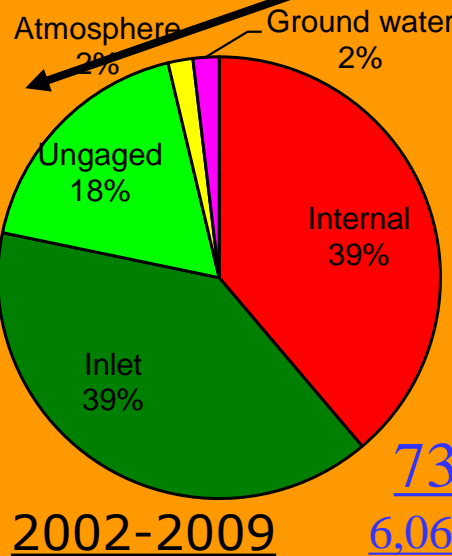
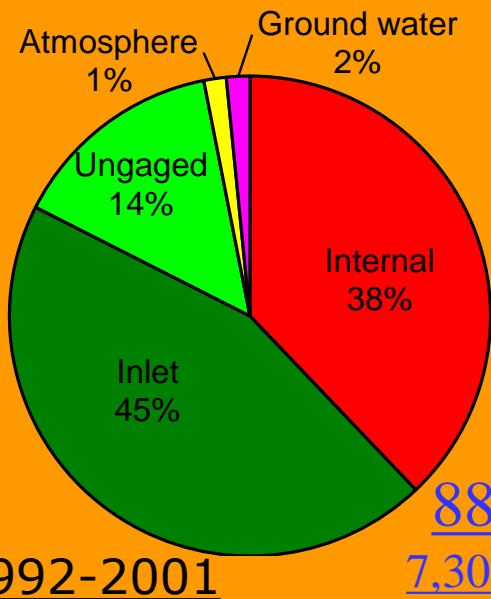
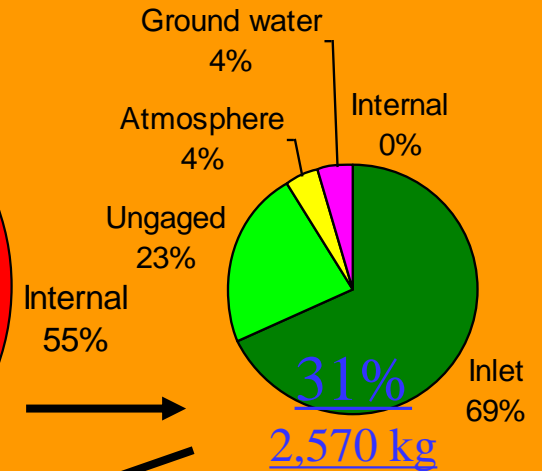
1972



1984-89

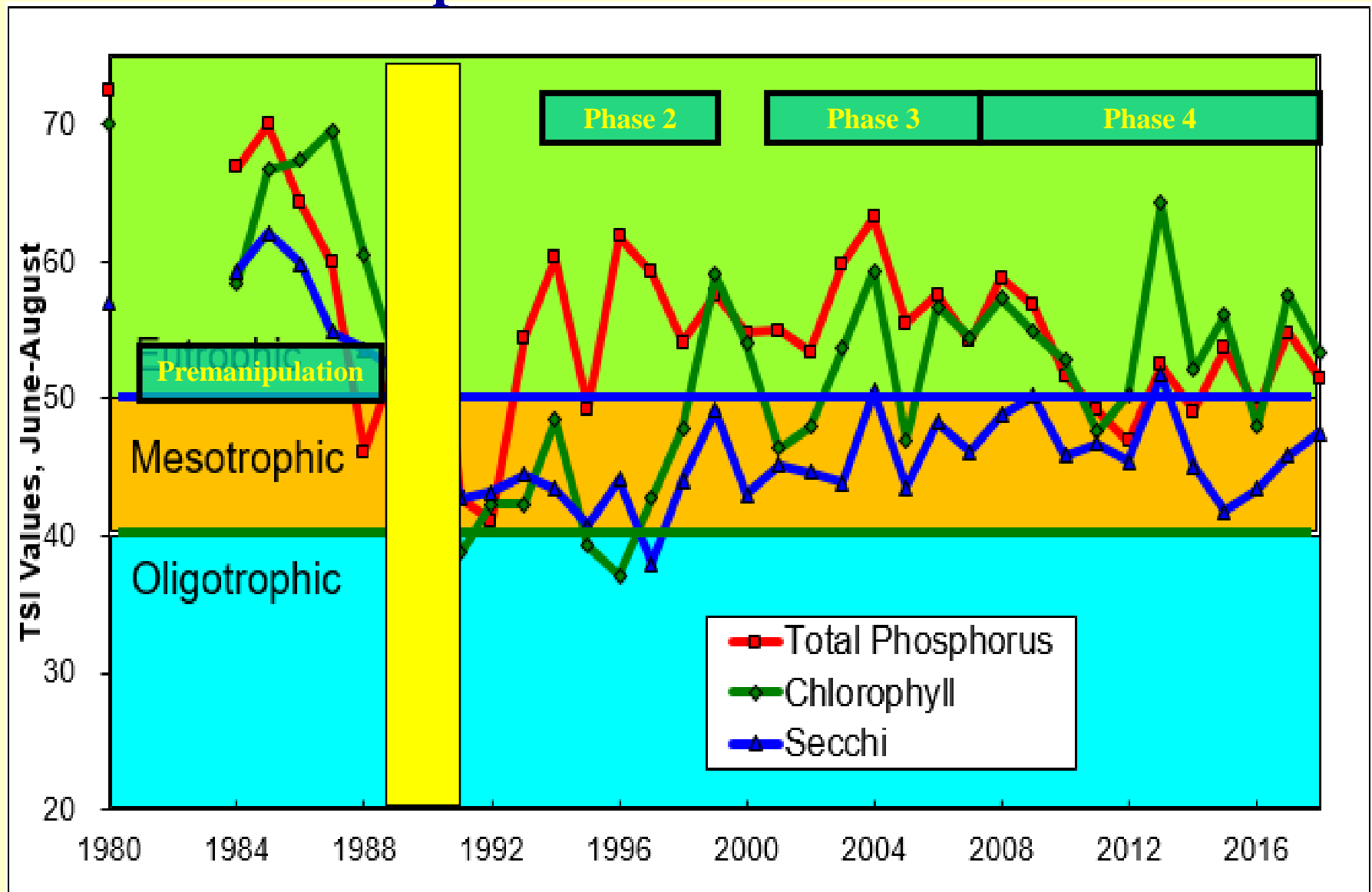


1991



**Is there more than just changes in
Phosphorus Loading and
Phosphorus Concentrations in the
Lake that are affecting the Water
Quality we see???**

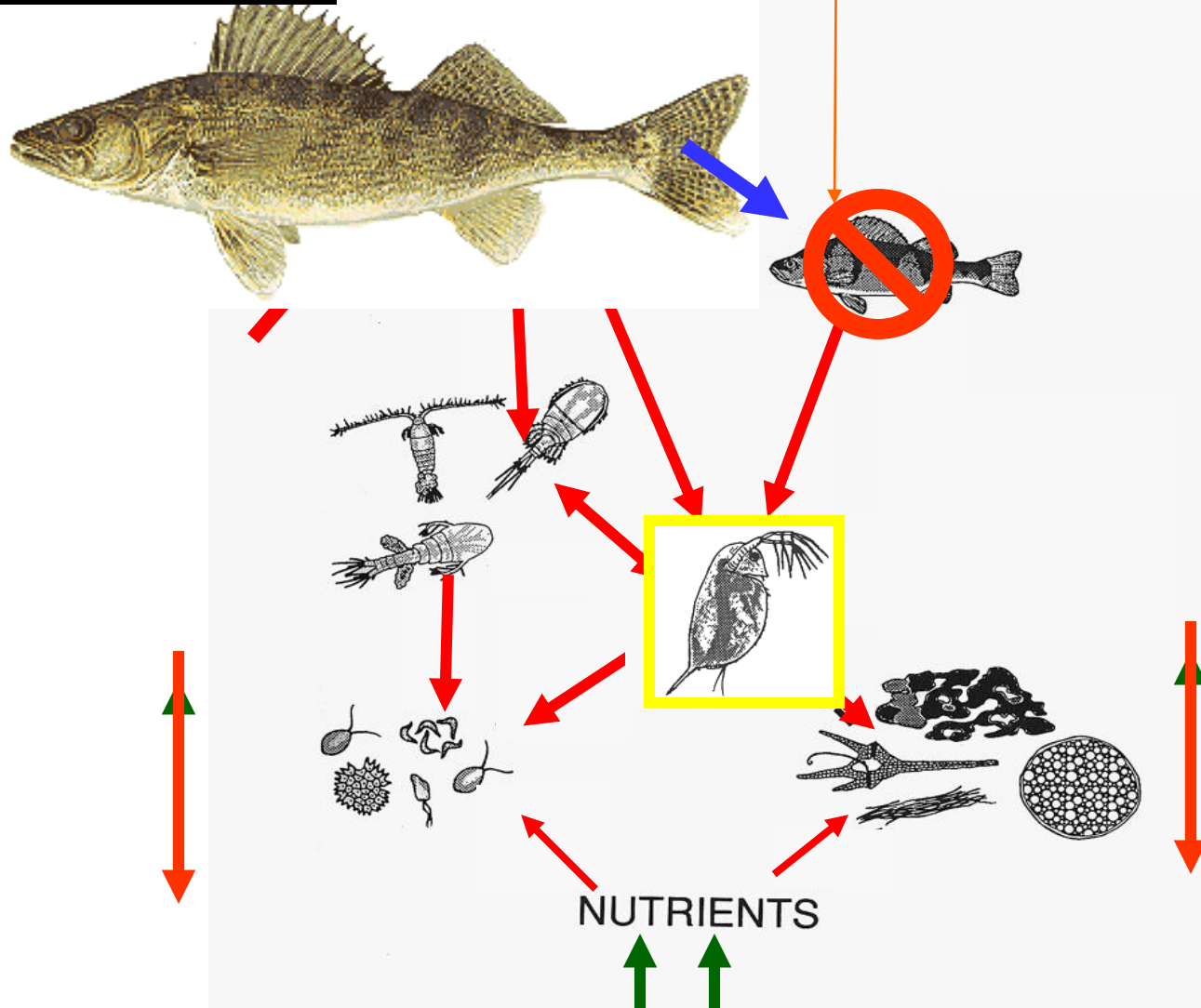
Trophic State of Delavan Lake



**The biology in the lake is affecting
the amount of algae and clarity in
the lake...**

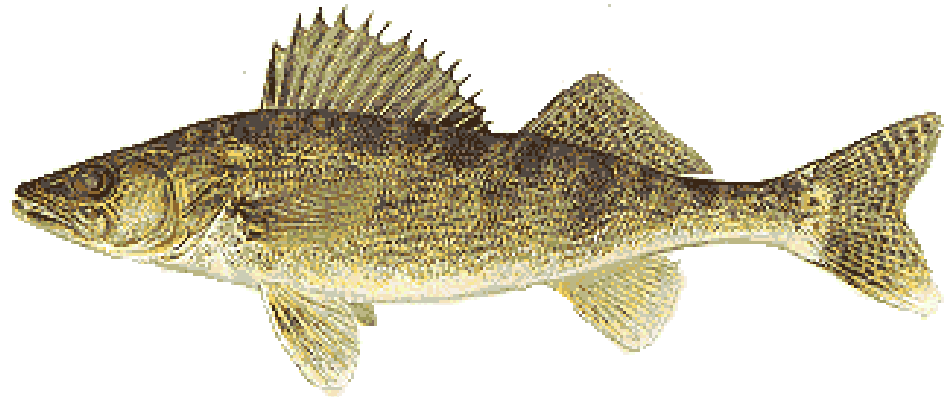
Delavan Lake - Postmanipulation

Biological - Biomanipulation Phase 2

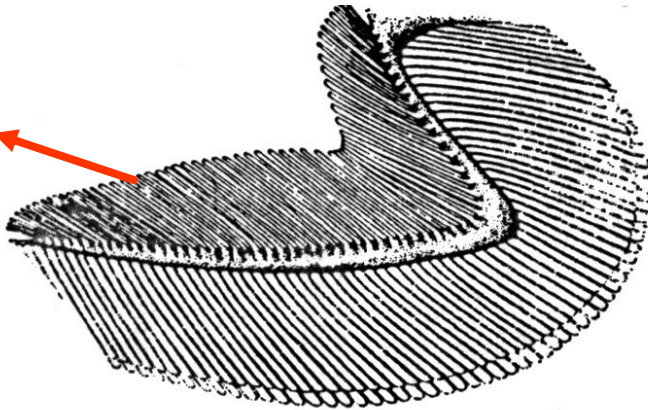




Planktivores



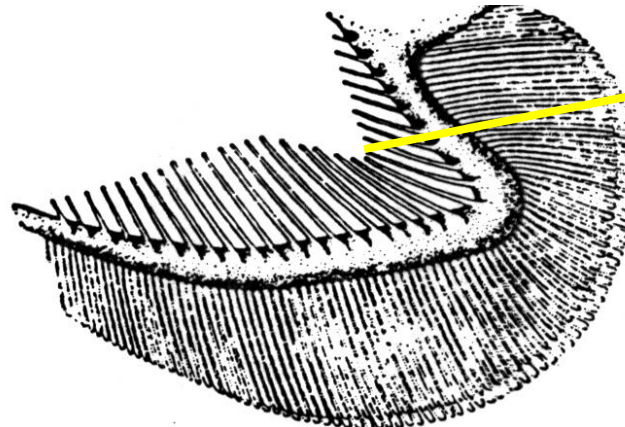
Piscivores



PREmanipulation

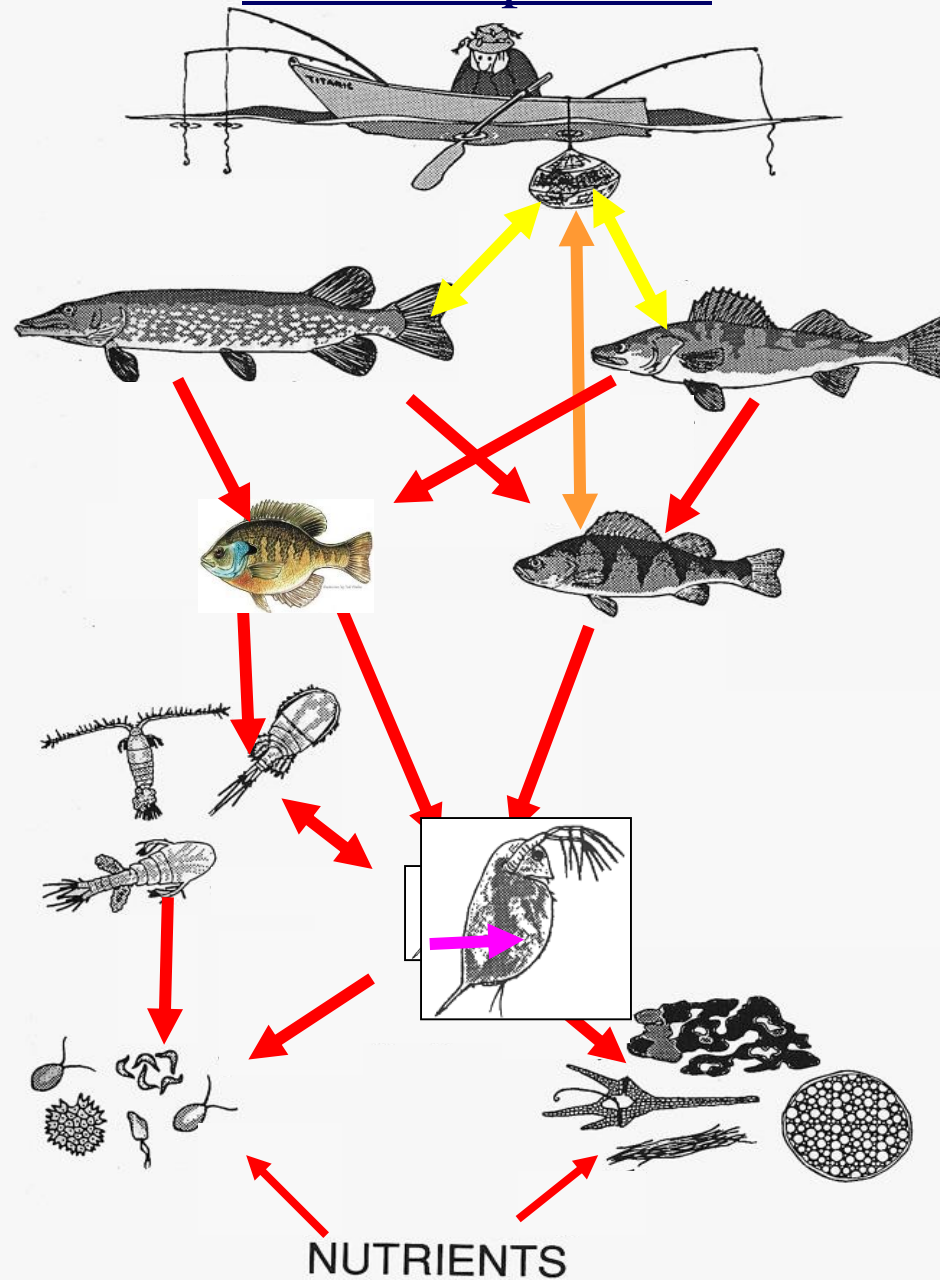
Figure 16-29.

Lower left: First branchial arch with closely spaced gill rakers that act as a plankton sieve. Lower right: First branchial arch with widely spaced gill rakers of *A. mediocris*, a species that feeds primarily on small fish. (From Brooks, J. L., and Dodson, S. I.: Predation, body size, and composition of plankton. Science, 150(3692):28-35, 1965. Copyright 1965 by the American Association for the Advancement of Science.)



POSTmanipulation

Post-manipulation

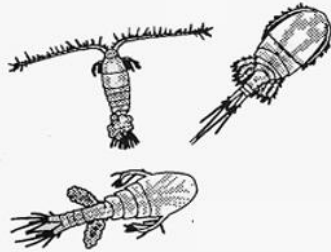
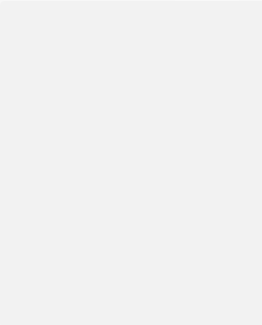
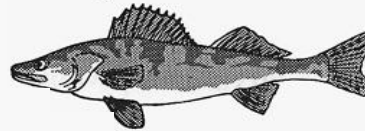
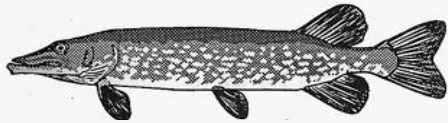


Phase 2

Manipulated

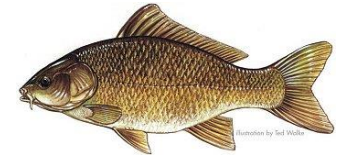
Post-Manipulated

Phase 2



NUTRIENTS

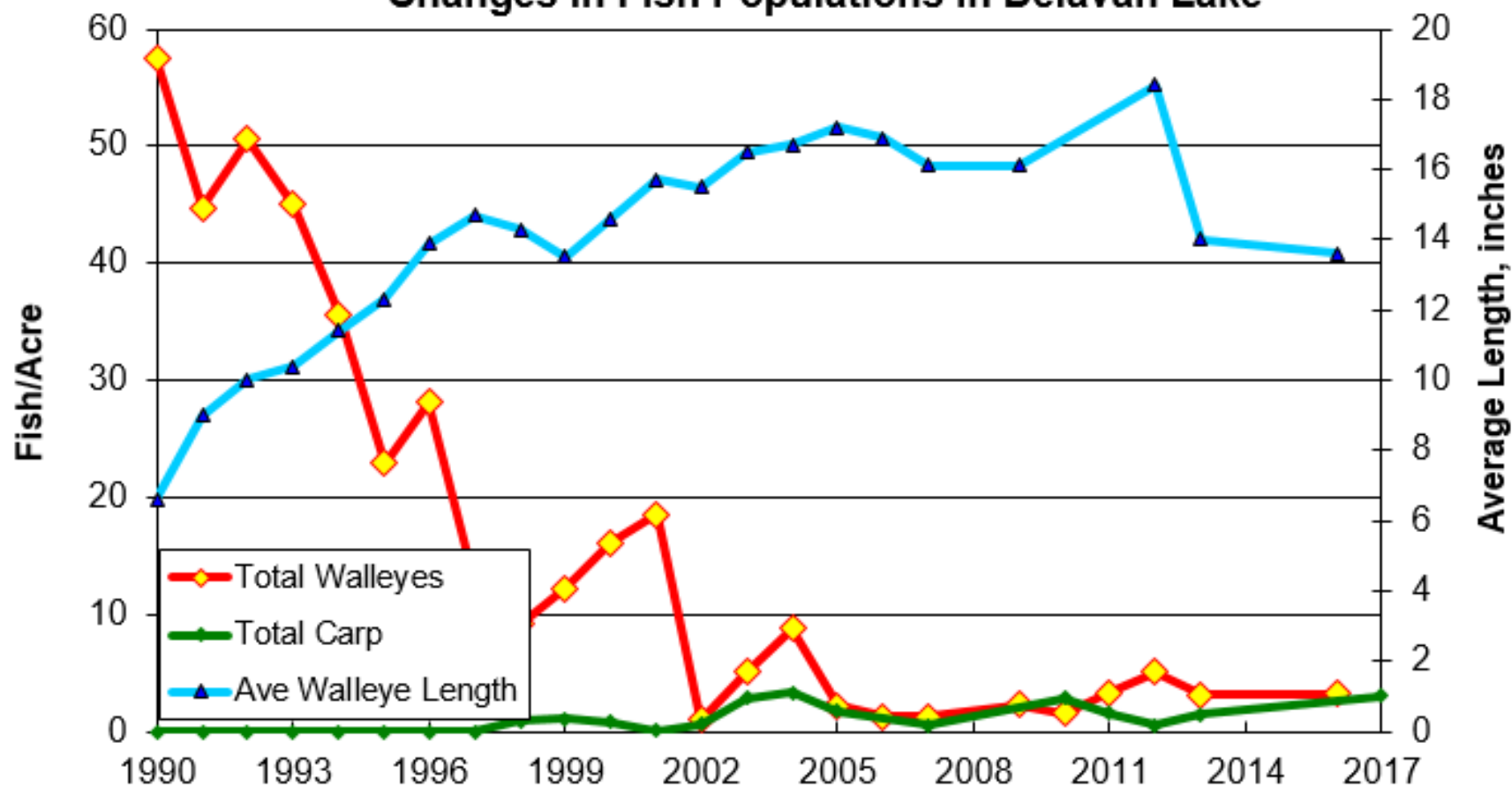
Phase 3

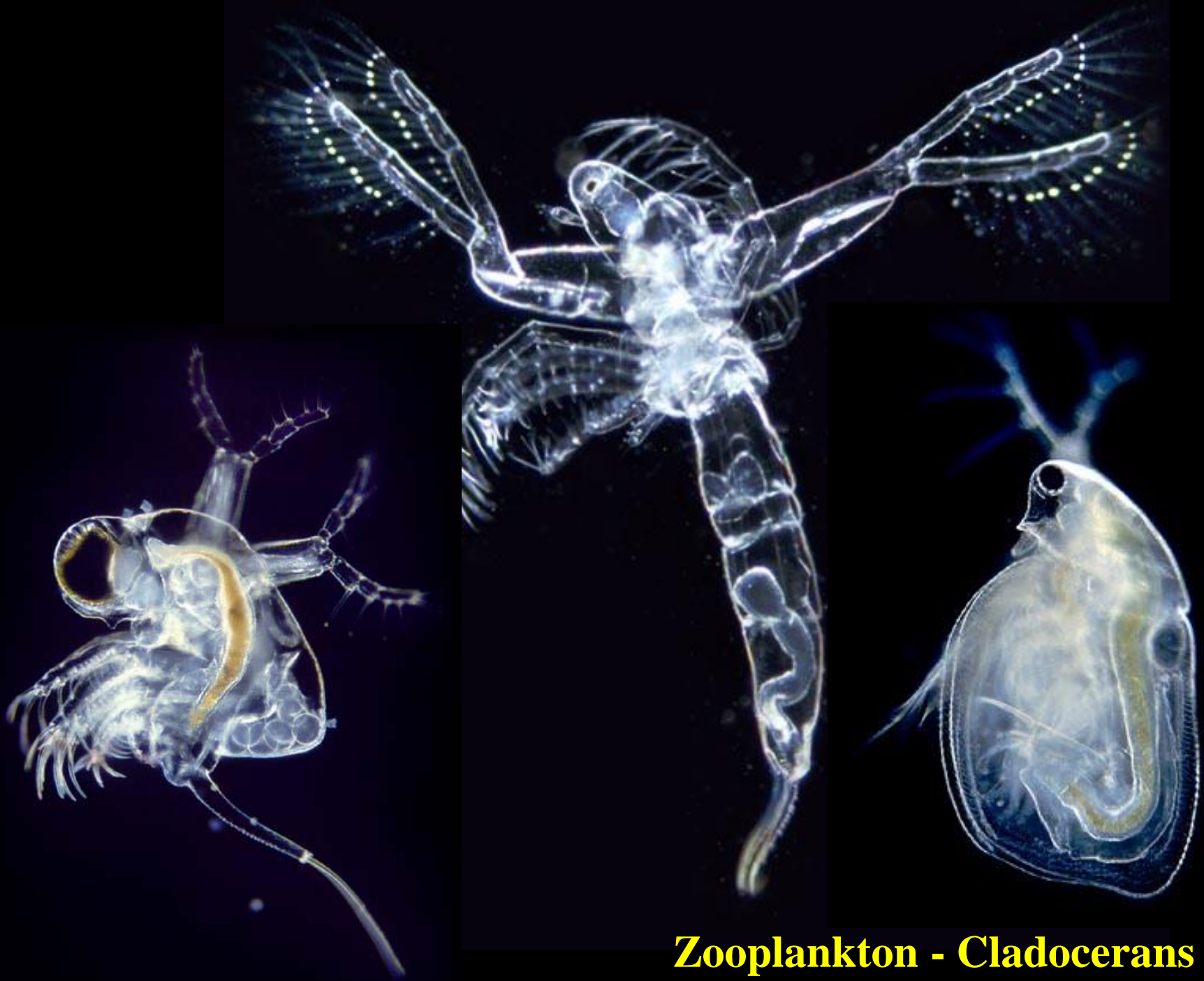


Zebra Mussels



Changes in Fish Populations in Delavan Lake





Zooplankton - Cladocerans

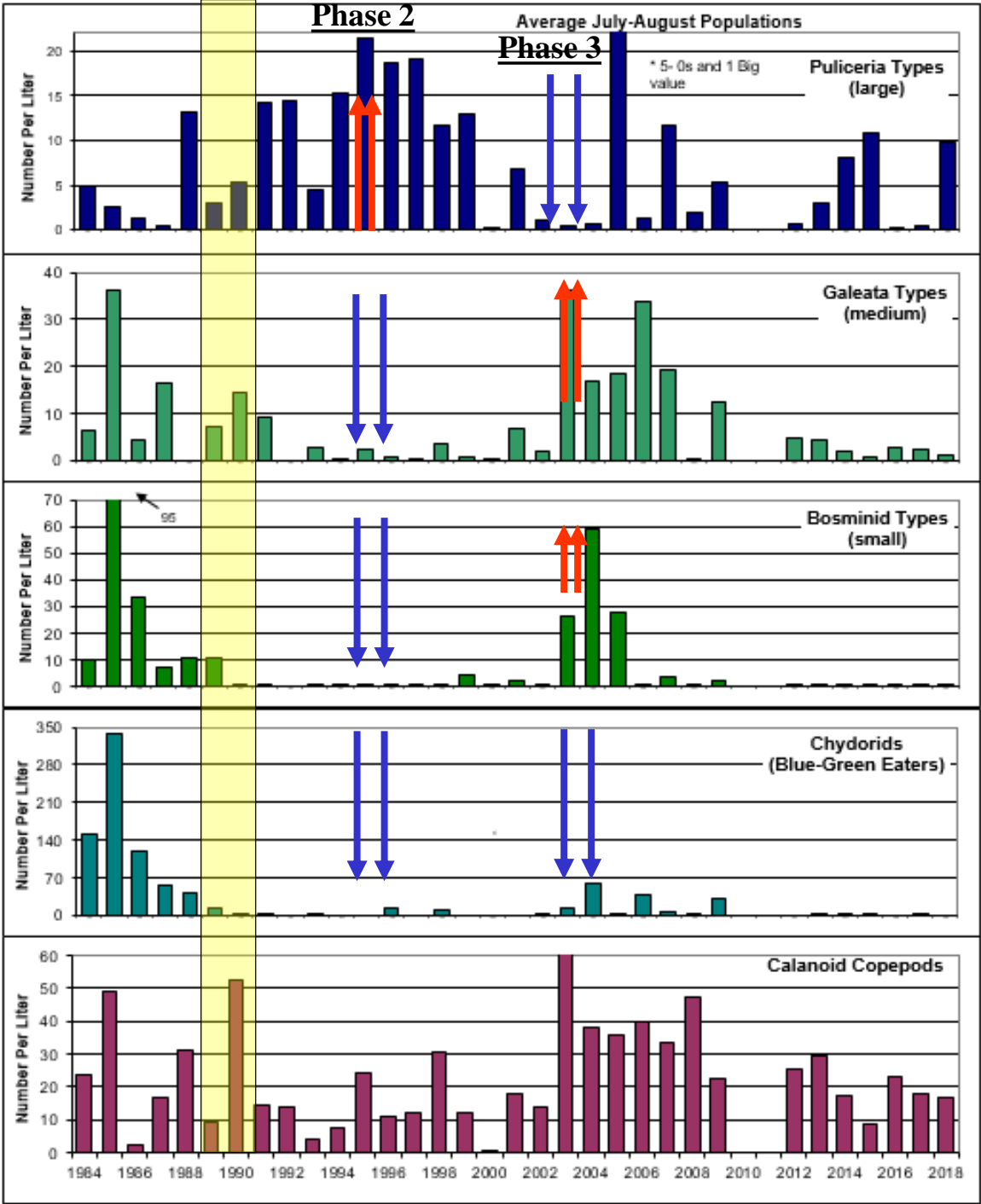


Zooplankton - Copepods





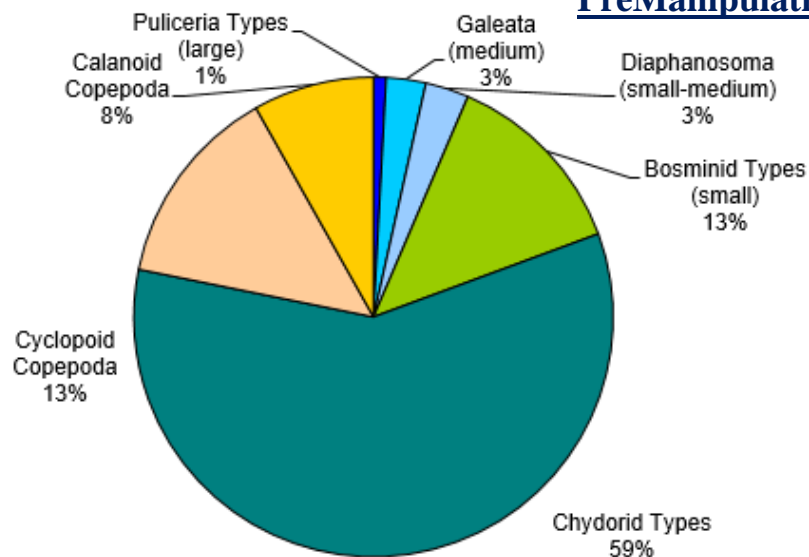
Zooplankton Populations



Four Different Biological Periods

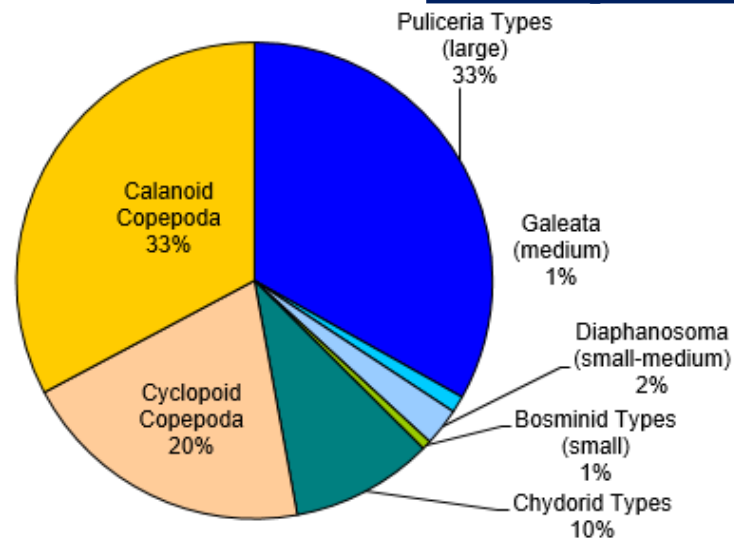
Zooplankton 1984-87

PreManipulation



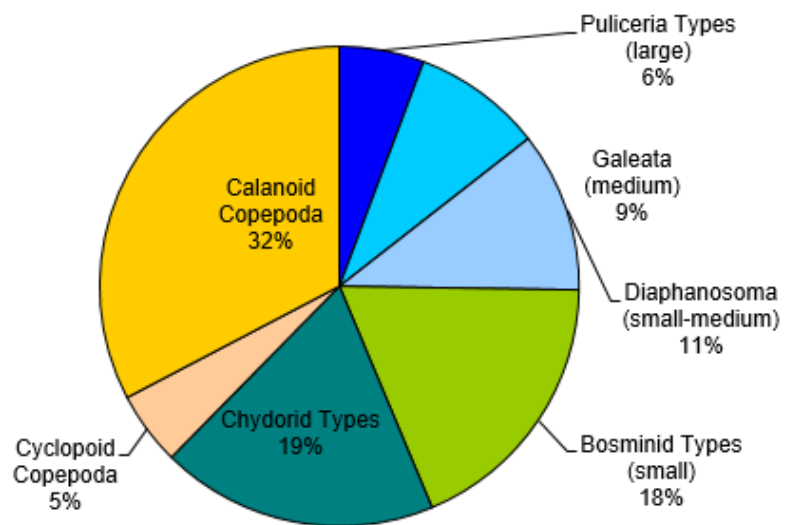
Zooplankton 1993-98

Post Manipulation - 2



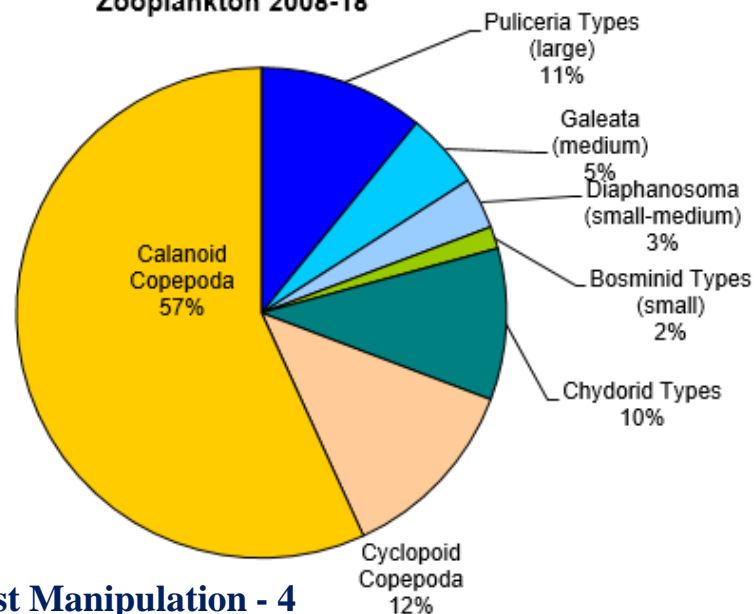
Zooplankton 2001-07

Post Manipulation - 3



Zooplankton 2008-18

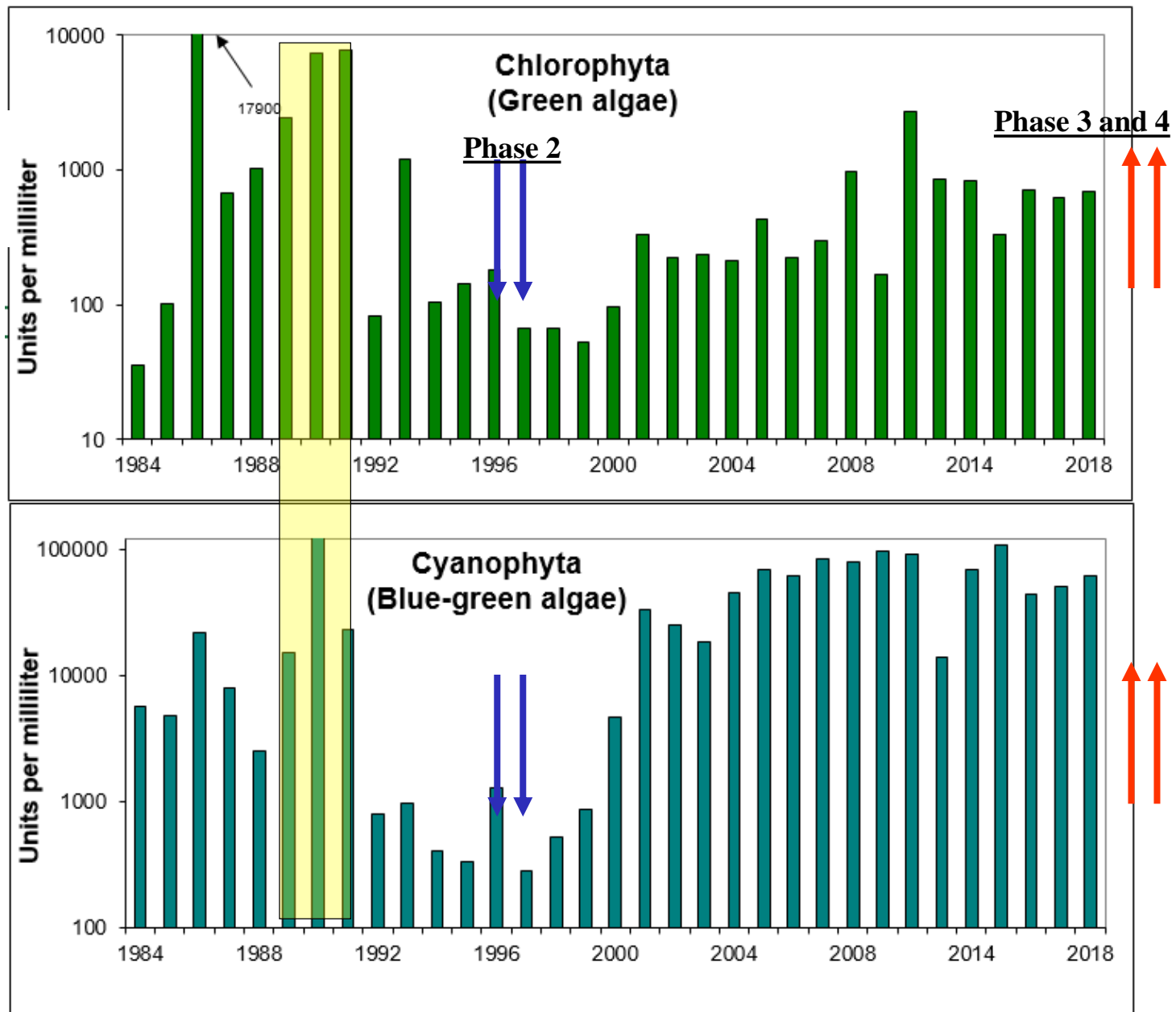
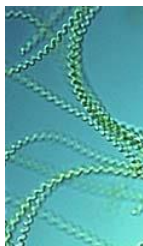
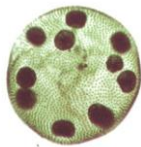
Post Manipulation - 4



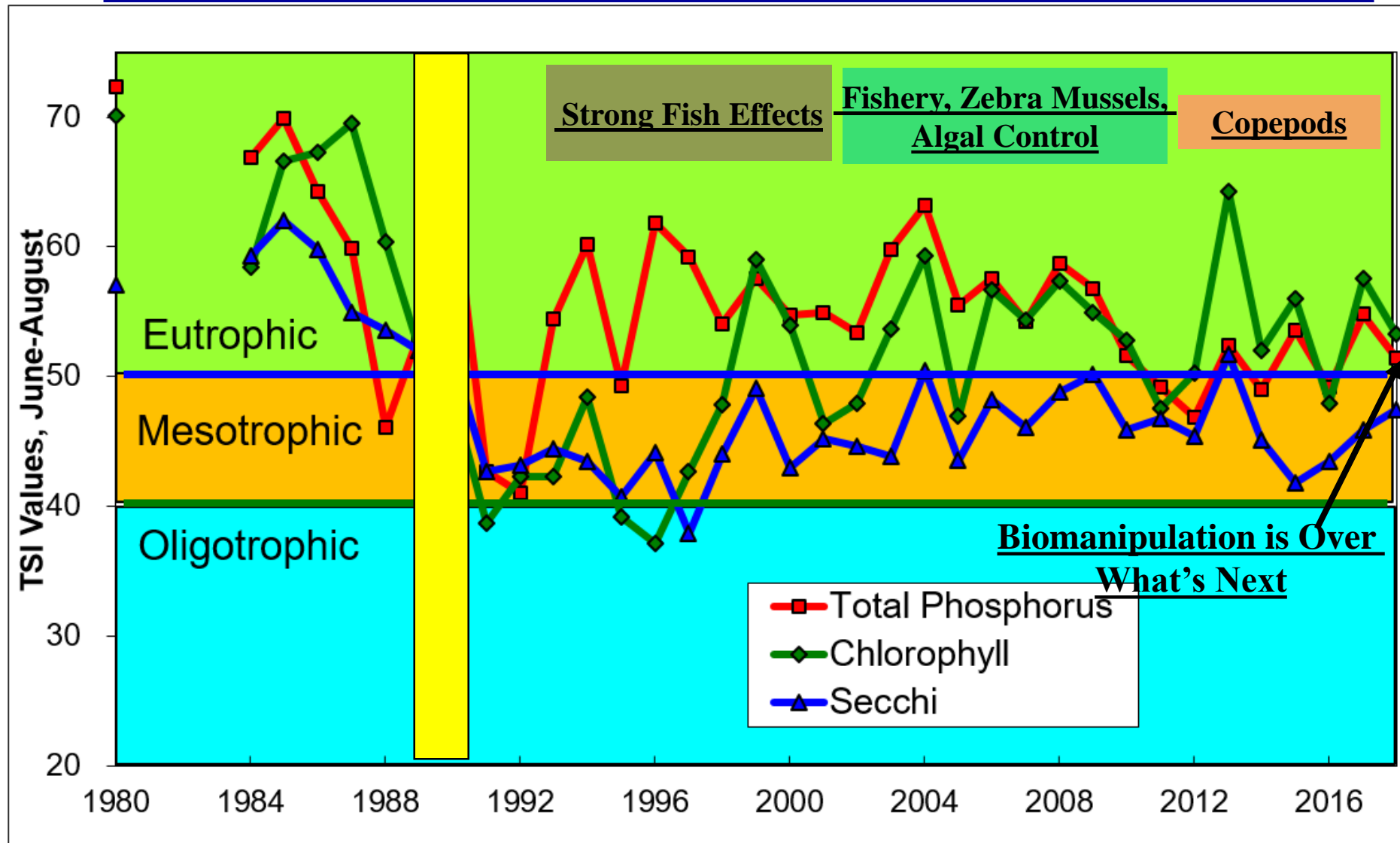
Phytoplankton (algae) in Delavan Lake



Phytoplankton Populations



Trophic State of Delavan Lake & Food Web Changes



What is the importance of Monitoring Delavan Lake and its tributaries

- 1. To understand how the various factors (controllable and uncontrollable), including management actions, affect the water quality of the lake.**
- 2. To quantify the “real” water quality of the lake, not what someone feels by looking at a few selected days.**

Floods of July 2017



What is the importance of Monitoring Delavan Lake and its tributaries

- 1. To understand how the various factors (controllable and uncontrollable), including management actions, affect the water quality of the lake.**
- 2. To quantify the “real” water quality of the lake**
- 3. To use what we have learned to help manage Delavan Lake and other lake systems.**

Is Delavan Lake Officially Impaired?

WDNR's protocols for determining Impairment

Table 6. Recreational impairment thresholds for lake natural communities



Note: For all parameters, the assessment period is the most recent 10 year period. For TP and chl a, data from within the most recent 5 year period are prioritized for impairment assessments.

Indicators	Min. Data Requirement (see text for details)	Exceedance Frequency (see text for details)	Impairment Threshold - LAKES - Recreational Use						
			Headwater Drainage Lake	Shallow Lowland Drainage Lake	Seepage Lake	Headwater Drainage Lake	Deep Lowland Drainage Lake	Seepage Lake	Two-story fishery lake
Conventional physico-chemical indicators									
TP	3 monthly values from the period June 1 –Sept. 15	Lower bound 90%CI of the mean exceeds threshold	≥40 ug/l	≥40 ug/l	≥40 ug/L	≥30 ug/L	≥30 ug/L	≥20 ug/L	≥15 ug/L
Biological indicators									
chlorophyll a ⁽¹⁾	3 monthly values from each of two years ⁽²⁾ from the period July 15 –Sept. 15	Lower bound 90%CI of the mean exceeds threshold	> 30% of days in sampling season have "nuisance algal blooms (> 20 ug/L)"			> 5% of days in sampling season have "nuisance algal blooms" (> 20 ug/L)			
Aquatic plant metrics*	Baseline aquatic plant survey	N/A (one survey)	(reserved until guidance available)						

(1) While the TP impairment thresholds for the Recreational Use are based on codified criteria, the chlorophyll a thresholds for impairment and plant metrics assessments protocols are not codified.

(2) For bio-confirmation of TP criteria exceedance, chlorophyll data from only one year is required.

Guidelines for Evaluating Total Phosphorus Impairment:

- 1. Data should be collected using specific protocols (followed by the USGS).**
- 2. Data from only the most recent 10 years should be considered.**
-  **3. Data for the most recent 5 years is given preference.**
-  **4. Total phosphorus data should be collected from June 1 – Sept 15.**
- 5. Only near surface samples should be considered**
- 6. A lake is considered “impaired” by total phosphorus when the lower 90th confidence limit exceeds the impairment value.**

Average Total Phosphorus Concentrations

June-August

Average over the last 20 years

0.033

Average over the past 10 years

0.027

Average over the past 5 years

0.027

Lower C.L.

Mean

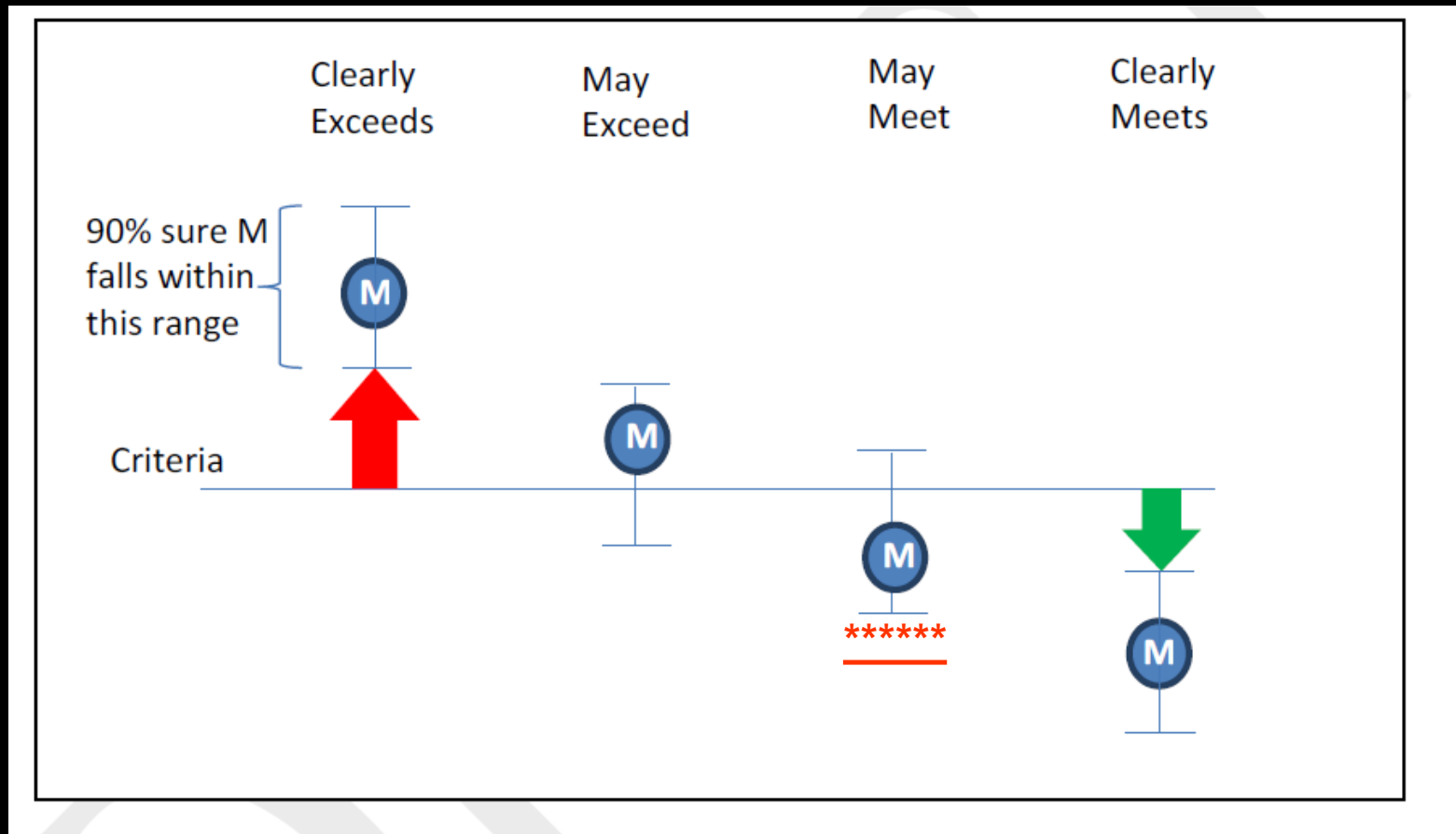
Upper C.L.

0.024

0.027

0.031

Delavan Lake - Current Status of Total Phosphorus Concentrations



Therefore, since the Upper 90% confidence limit exceeds the 30 $\mu\text{g/L}$ value, it should be classified as “May Meet” the Criteria, and actions should be taken (or continued to be taken) and water quality should be continued to be evaluated.

**What actions can be taken to
improve the water quality of
Delavan Lake??**



Potential Management Strategies Considered in 2018

DREDGING OF THE UPSTREAM WETLAND PONDS

A decorative graphic on the left side of the slide, consisting of a network of thin black lines and small open circles, resembling a circuit board or a stylized tree structure, extending from the top to the bottom of the frame.

2018 Field Sediment Changes with Pellet Applications

DEHAVAN LAKE INLET & WETLAND PONDS

State of the Lake

2018 Water Quality - Delavan Lake

Questions ??

Contact Information
dzrobert@usgs.gov

