Phosphorus and Lake Erie
perspectives from between the land and lake

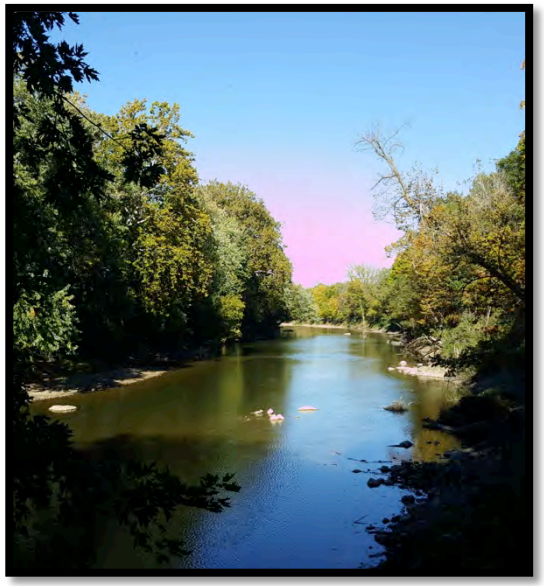
Laura Johnson

National Center for Water Quality Research
HEIDELBERG UNIVERSITY

Heidelberg UNIVERSITY

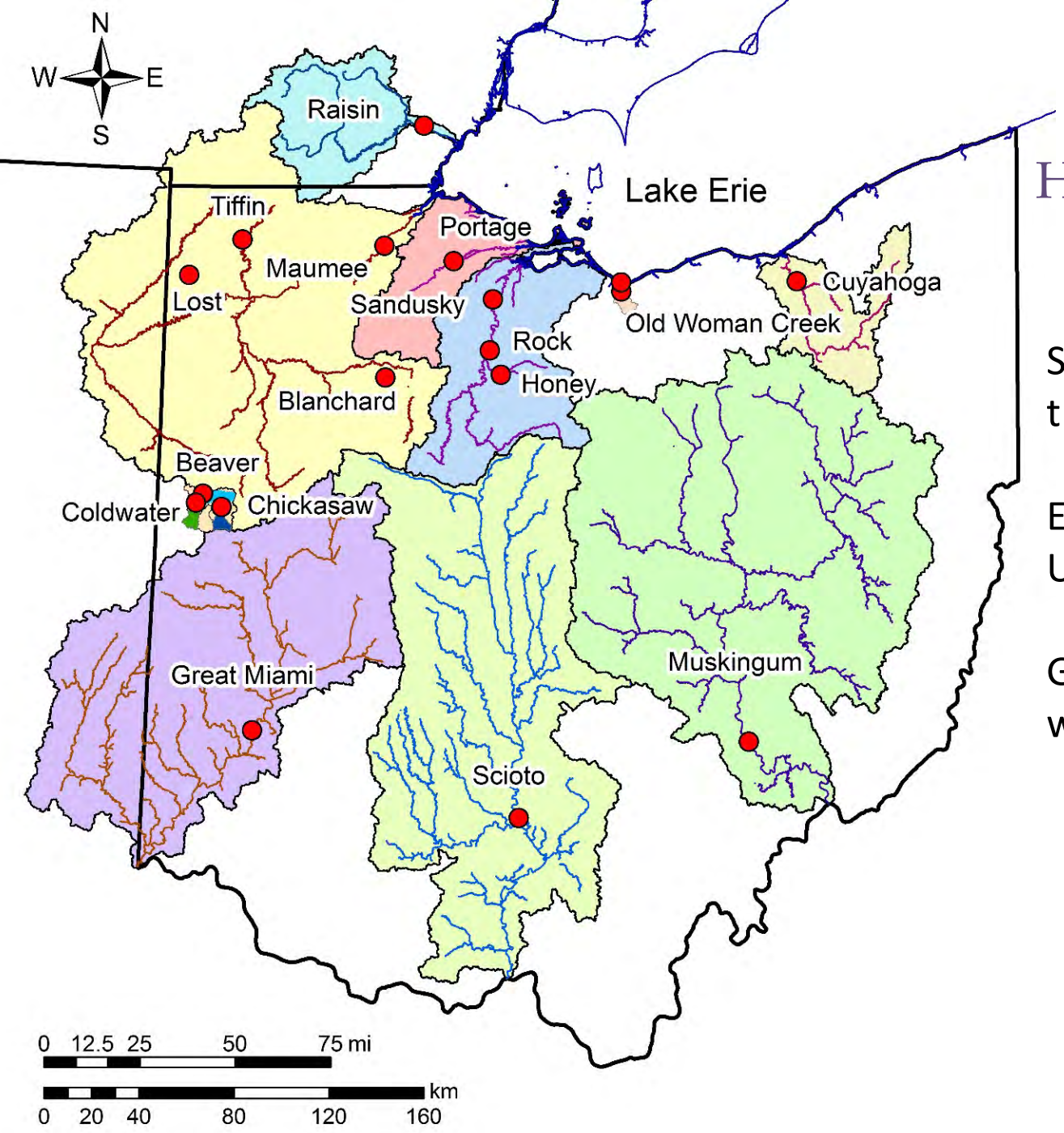
Rivers are perfectly poised to answer questions along the land-lake continuum

LAND



RIVER

LAKE



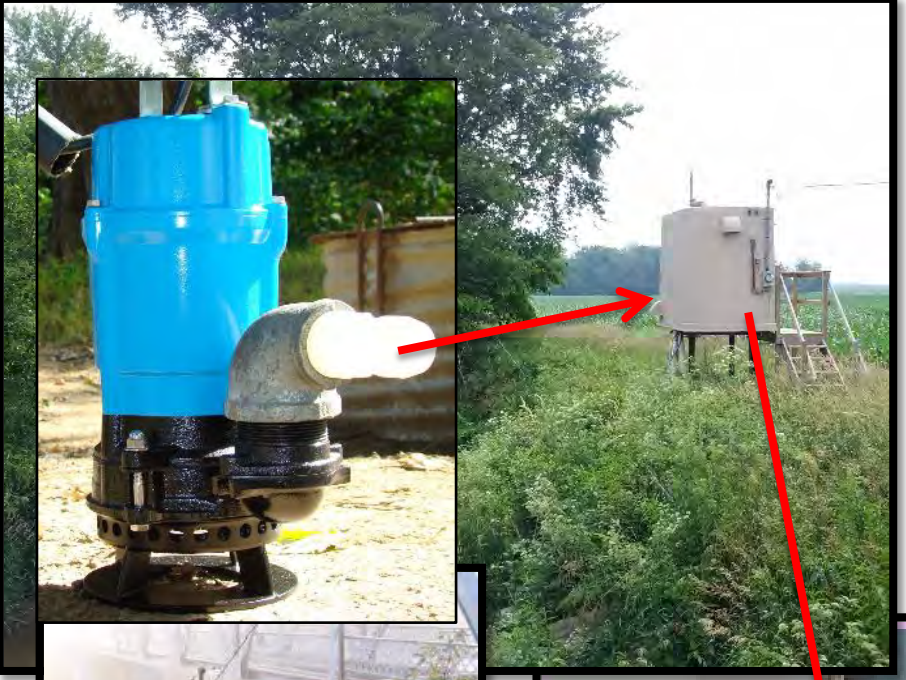
Heidelberg Tributary Loading Program

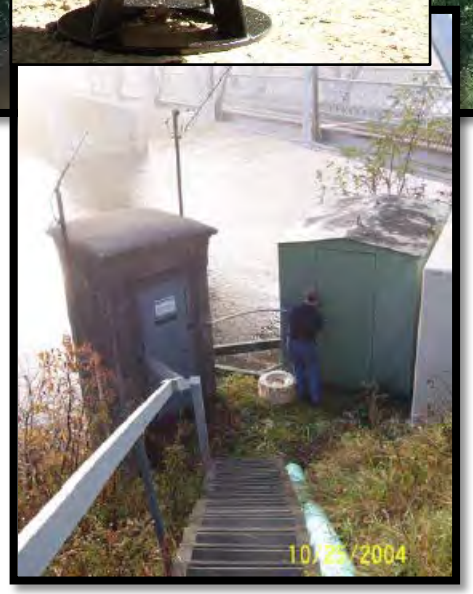
Sampling began in 1974 in the Maumee and Sandusky

Each station paired with a USGS gage

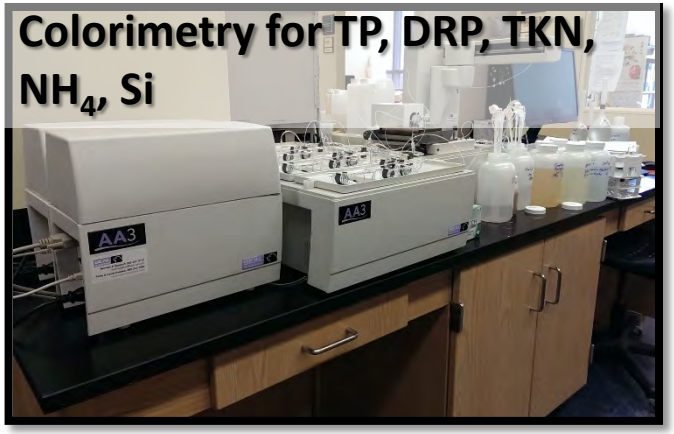
Goal is to quantify watershed loads

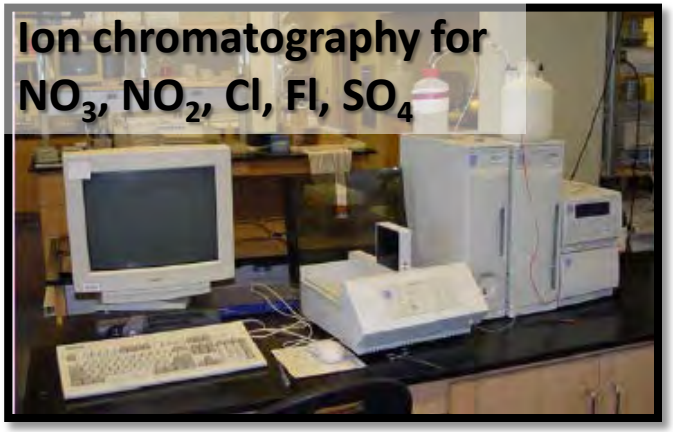
USGS
science for a changing world





Samples collected 3x a day!

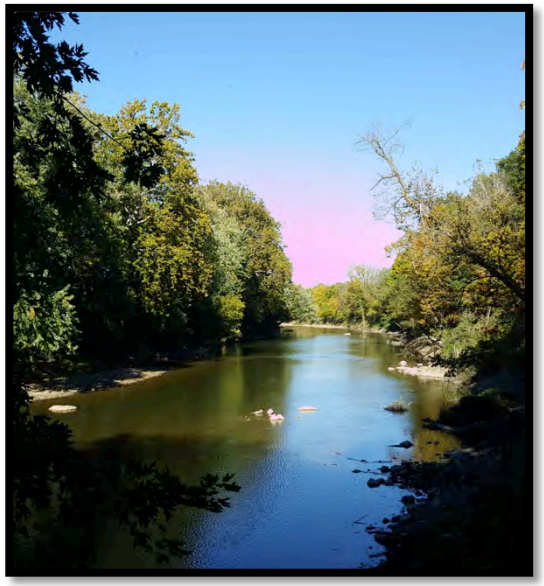

Colorimetry for TP, DRP, TKN, NH_4, Si


Ion chromatography for NO_3, NO_2, Cl, Fl, SO_4


Suspended Sediments

What have we seen recently in the lake?

LAND

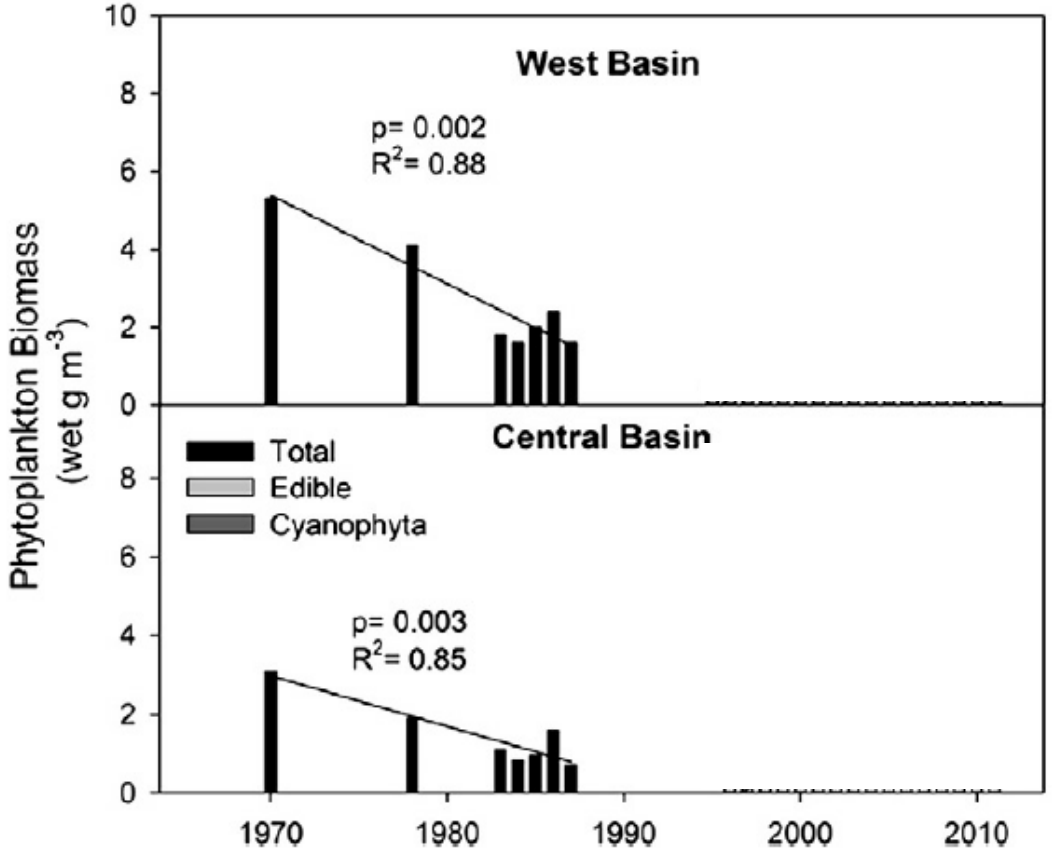


RIVER

LAKE

Algal blooms were prevalent in the 1960s and 1970s and the lake appeared to recover in the early 1990s

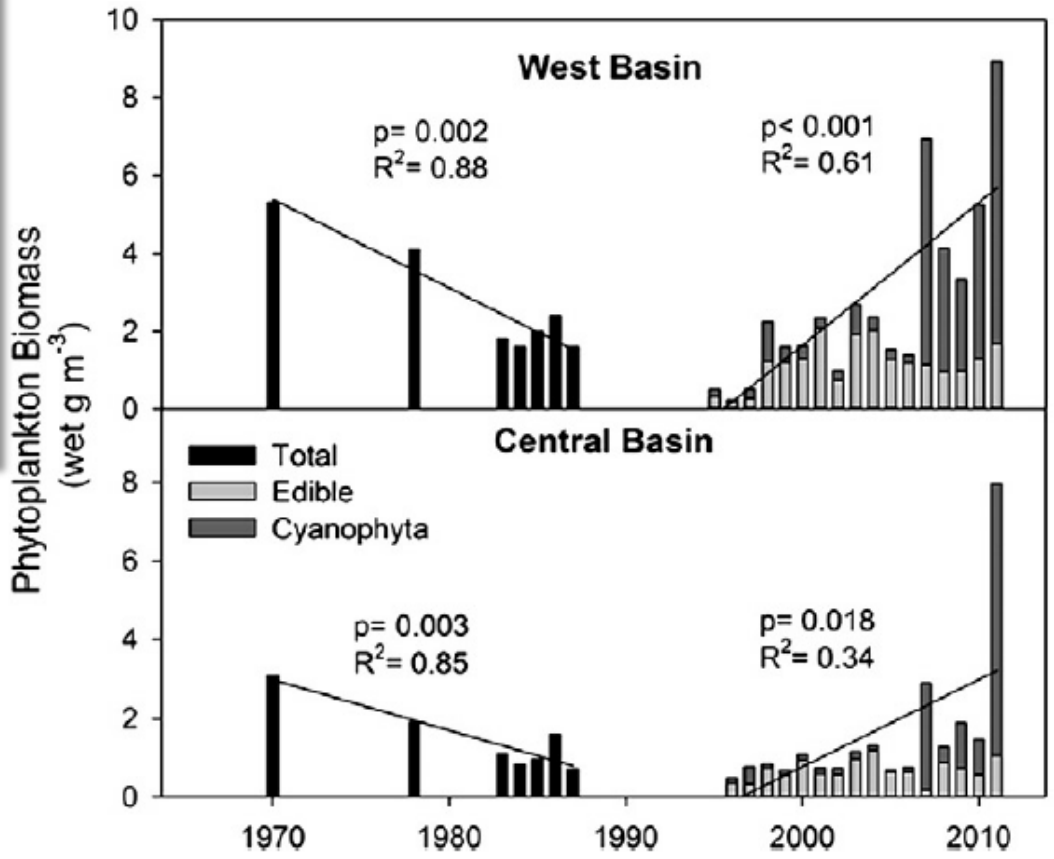
1971



Scavia et al. 2014, JGLR

Algal blooms returned to Lake Erie in the early 2000s, with 7 of the largest blooms over the past 9 years

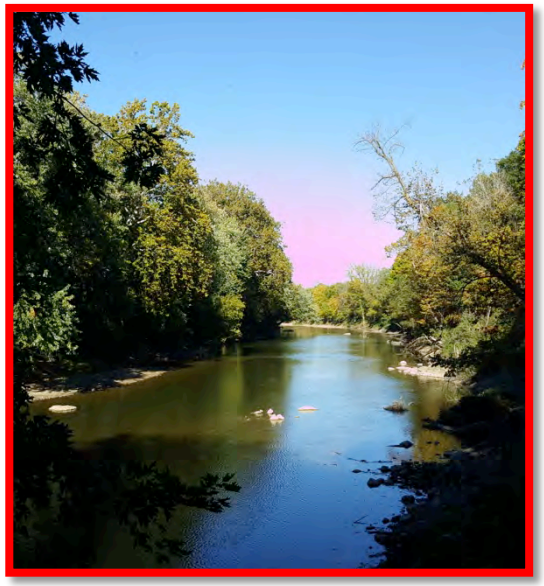
2011



Scavia et al. 2014, JGLR

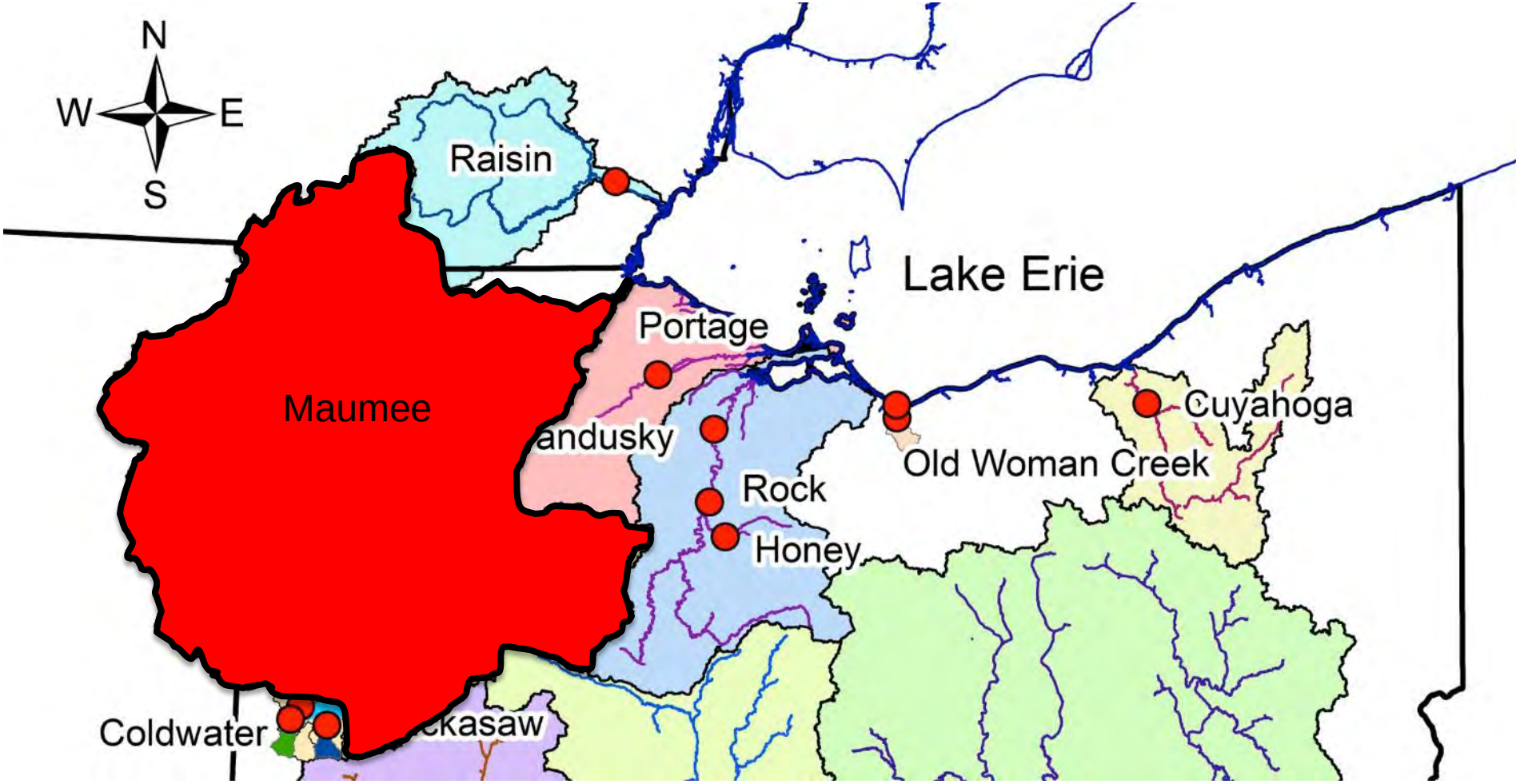
Why have blooms returned to Lake Erie?

LAND



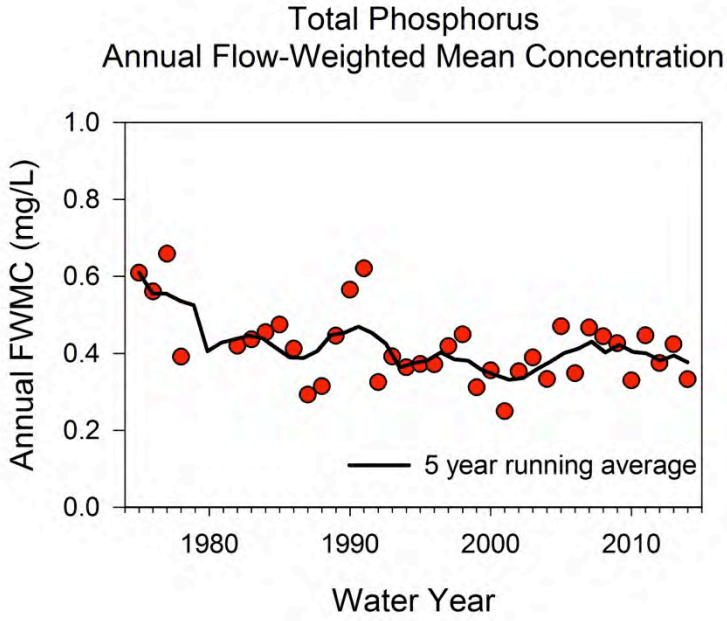
RIVER

LAKE

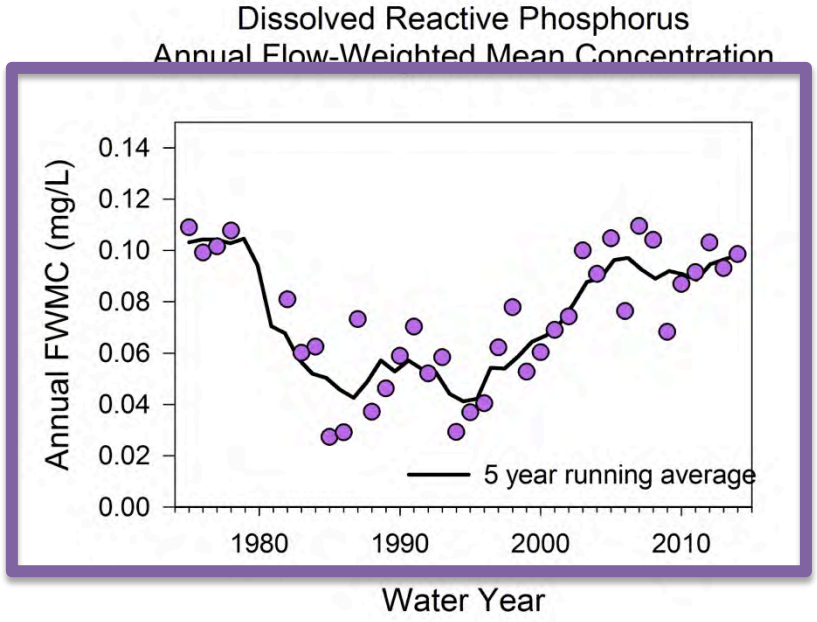


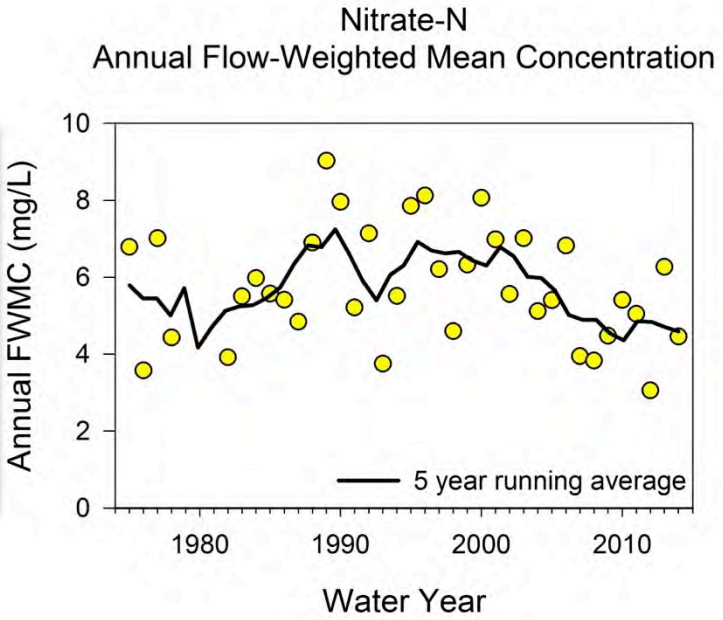
Maumee is the largest tributary to any of the Great Lakes

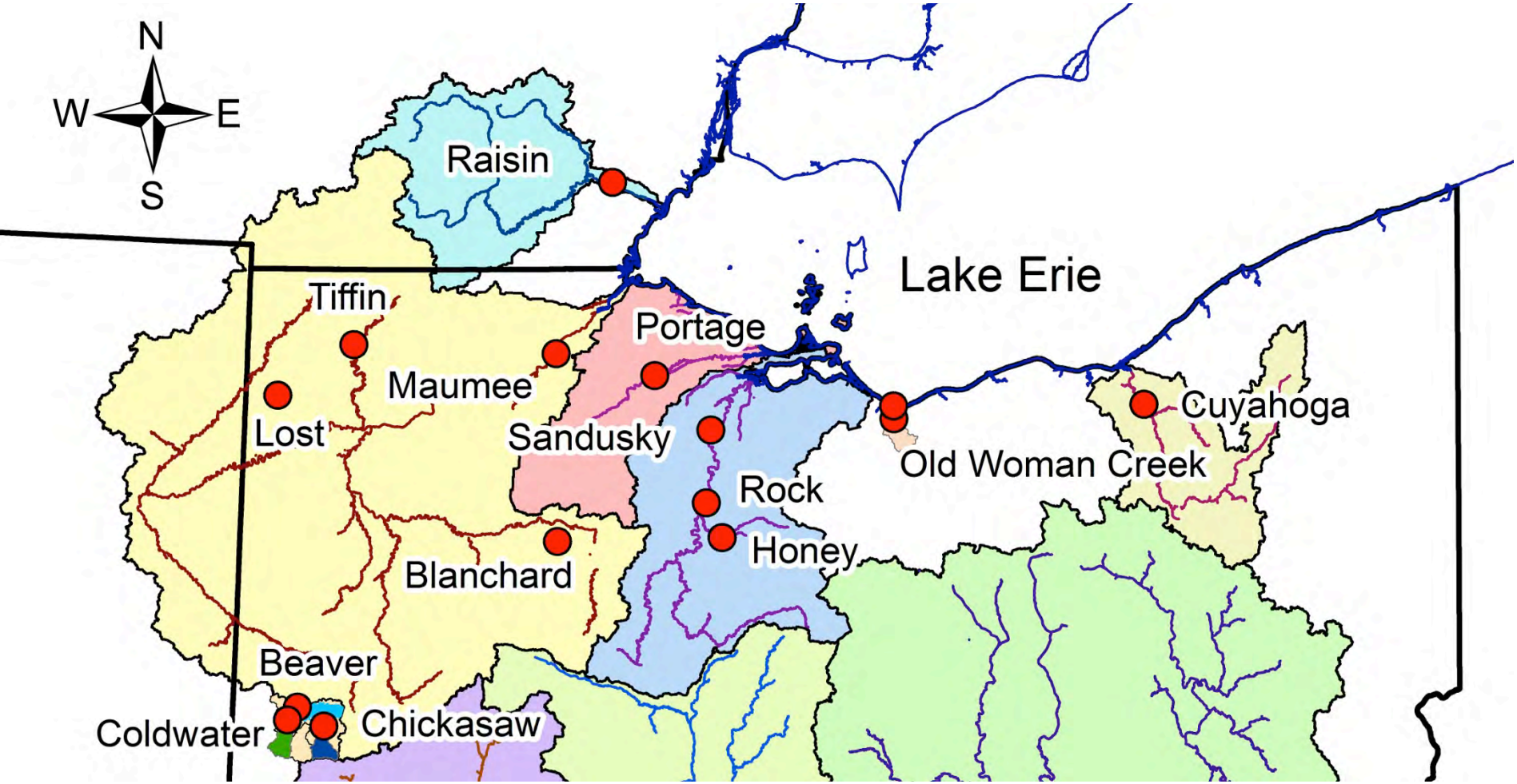
Maumee River trends

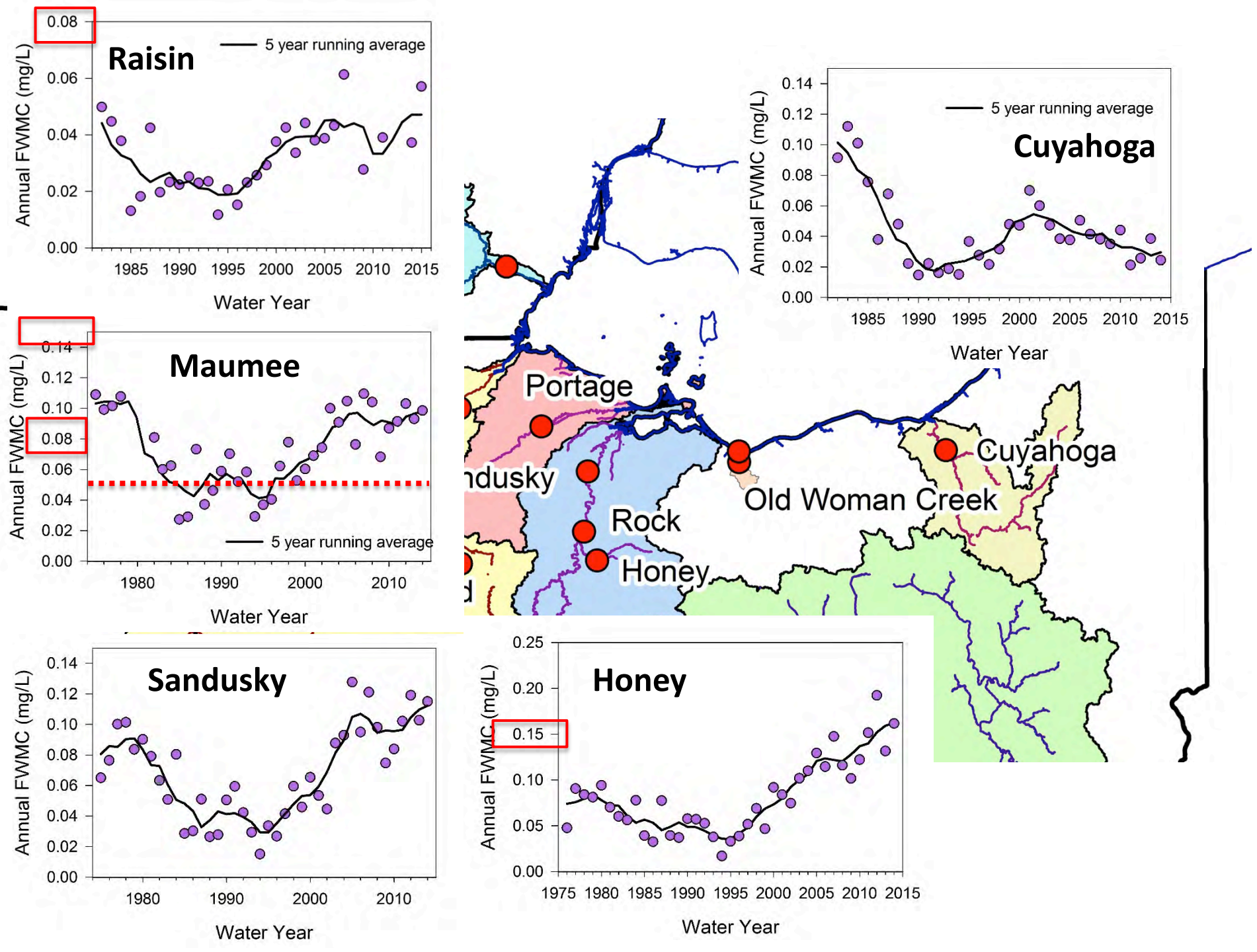


- Total P has decreased slightly over time
- Dissolved P has increased almost 2 fold since the mid-1990s
- Nitrate-nitrogen has decreased since 2000



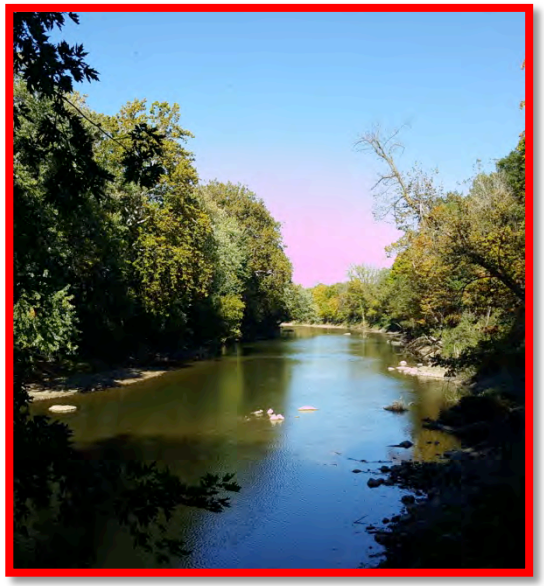



N
W
E
S
Raisin
Lake Erie
Tiffin
Portage
Maumee
Lost
Sandusky
Cuyahoga
Old Woman Creek
Rock
Honey
Blanchard
Beaver
Coldwater
Chickasaw


Raisin
5 year running average
Annual FWMC (mg/L)
Water Year
Cuyahoga
Maumee
Portage
Sandusky
Rock
Honey
Old Woman Creek

The river is tightly linked to the lake

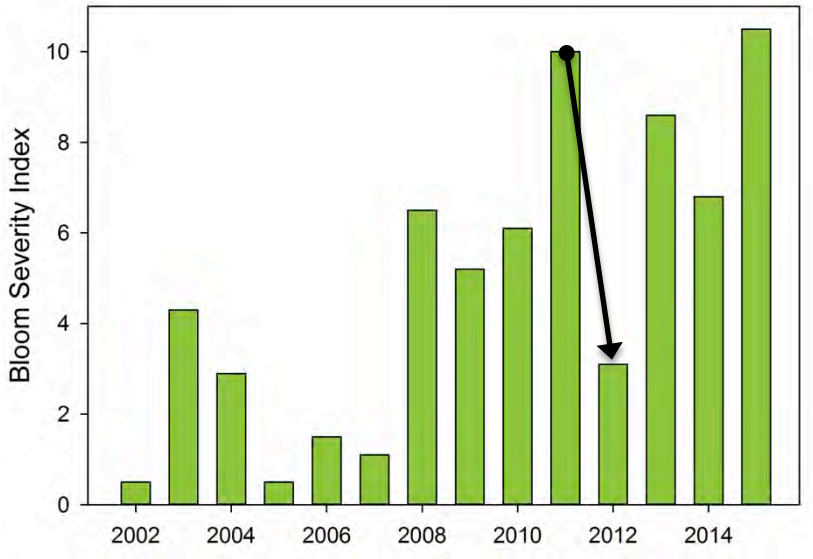
LAND



RIVER

LAKE

09/03/2011 (DOY=246)

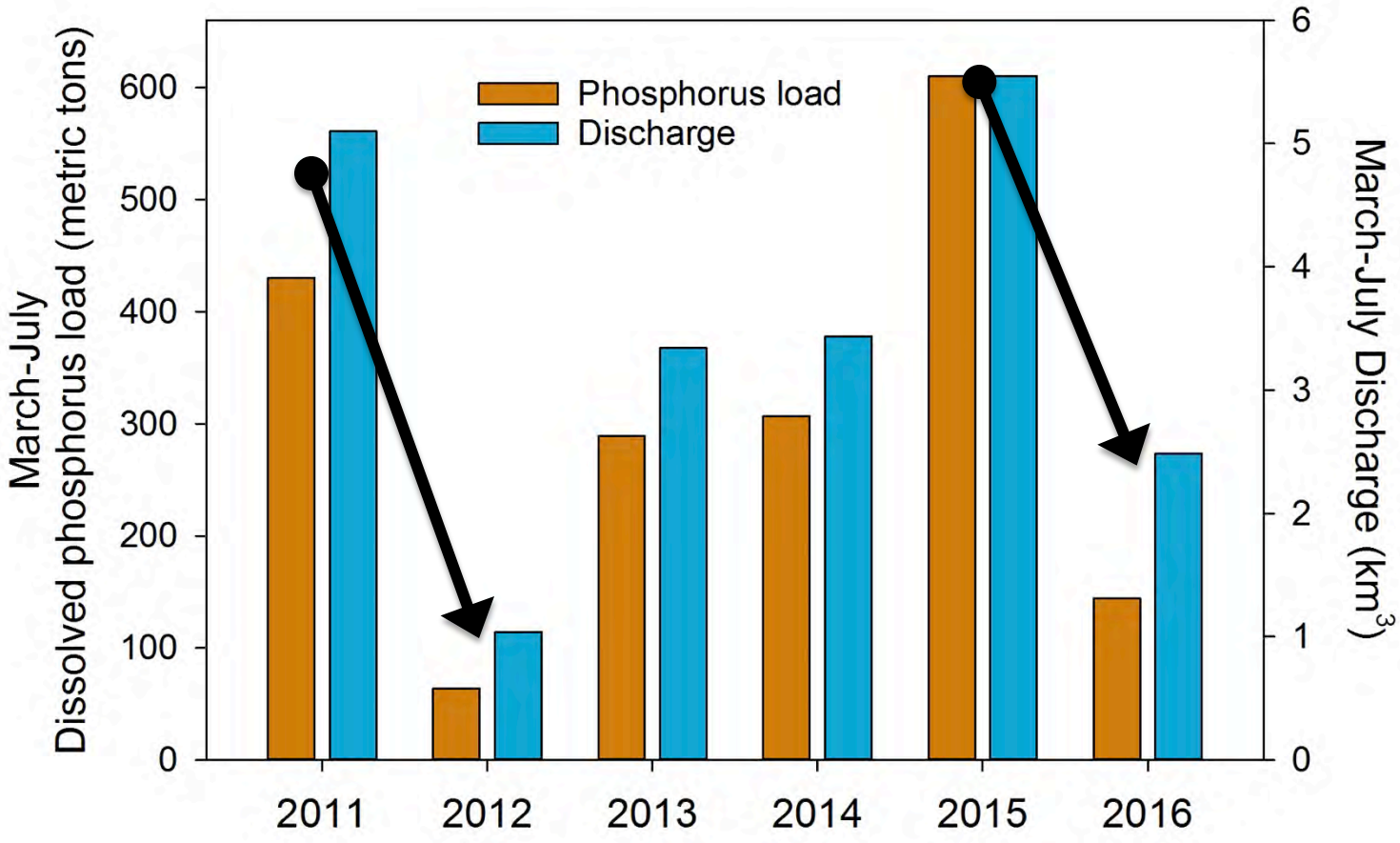


08/30/2012 (DOY=243)

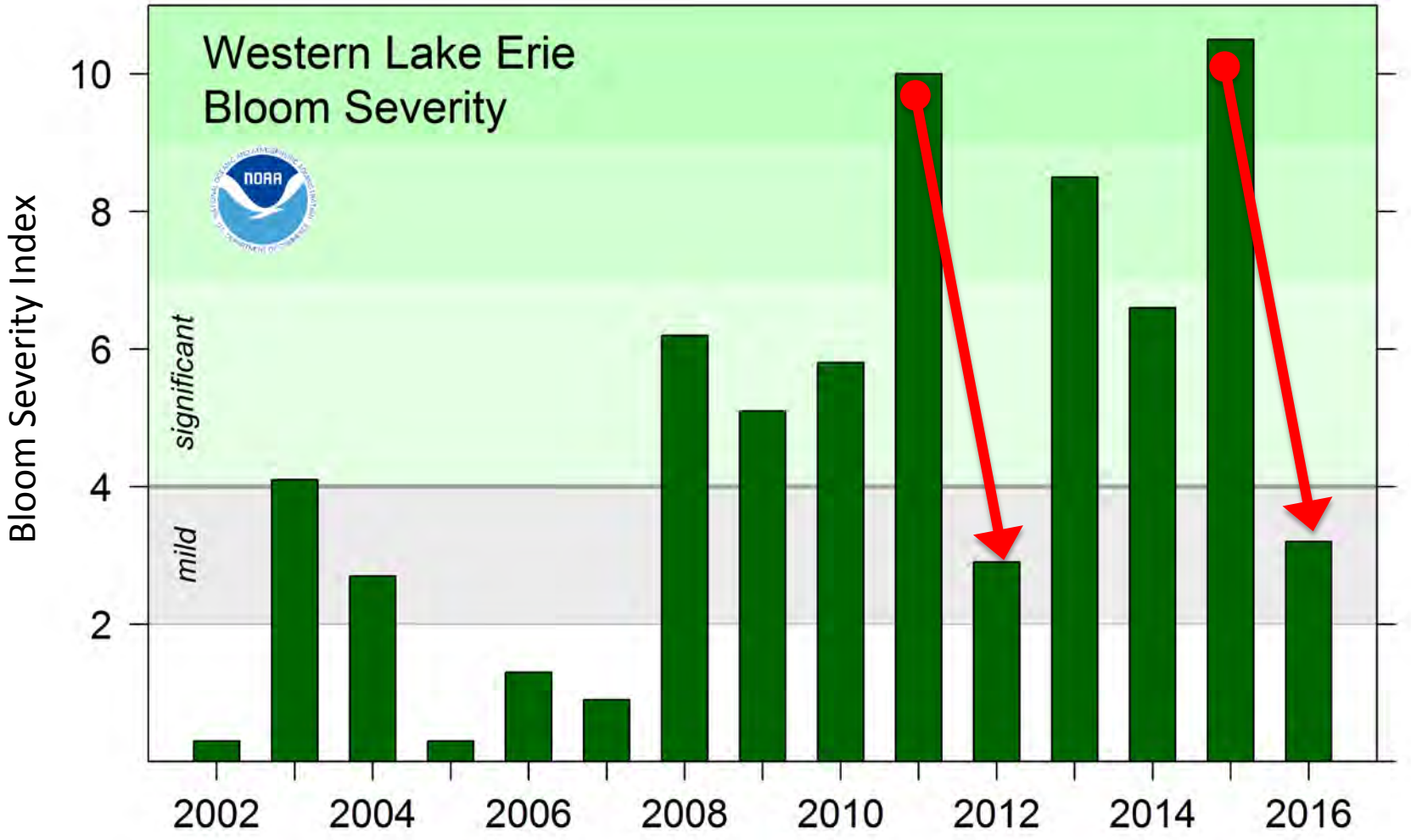
But 2011 and 2012 had almost the same annual load!

(570 vs 614 t dissolved P)

The March through July discharge and P loading drives HAB severity

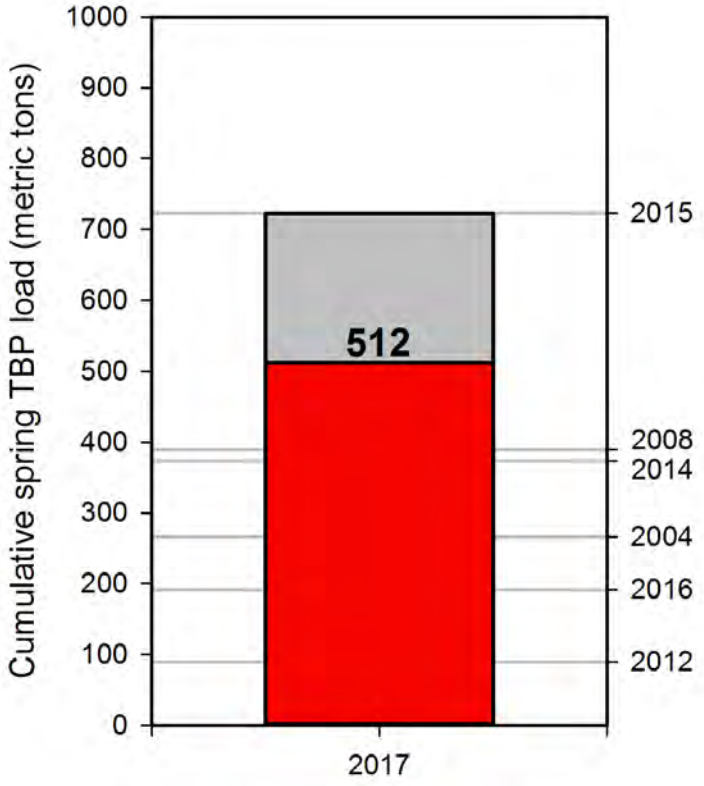


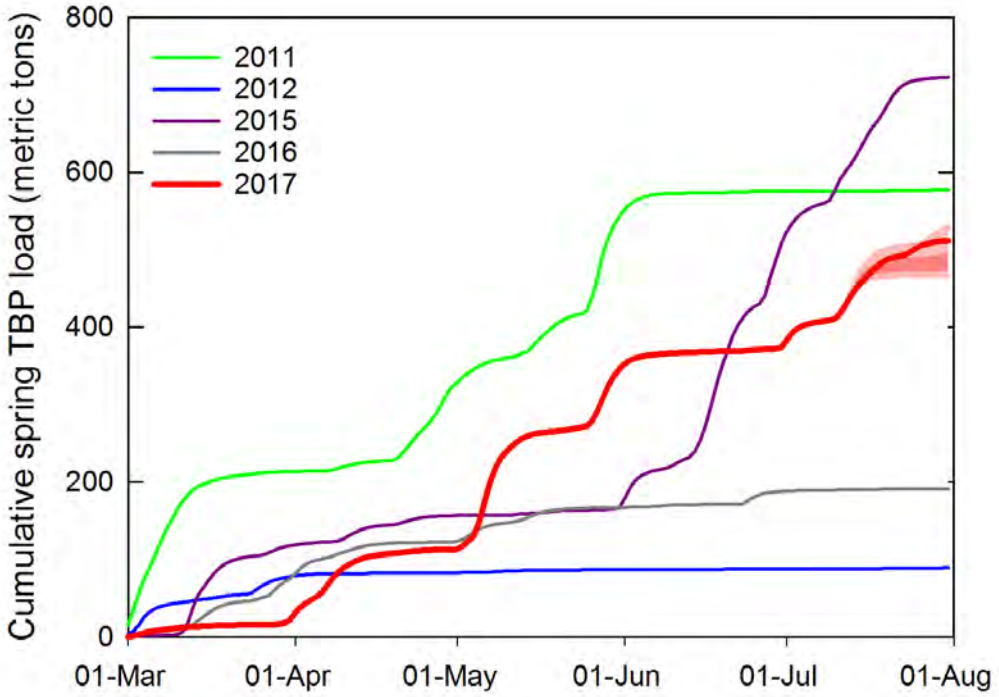
The Western Lake Erie harmful algal bloom responds strongly to annual variation in runoff



*Indicates nonpoint sources are drivers and that internal loading is not a cause

Total Bioavailable P load projected to July 31st using data from the NWS Ohio River Forecast Center data



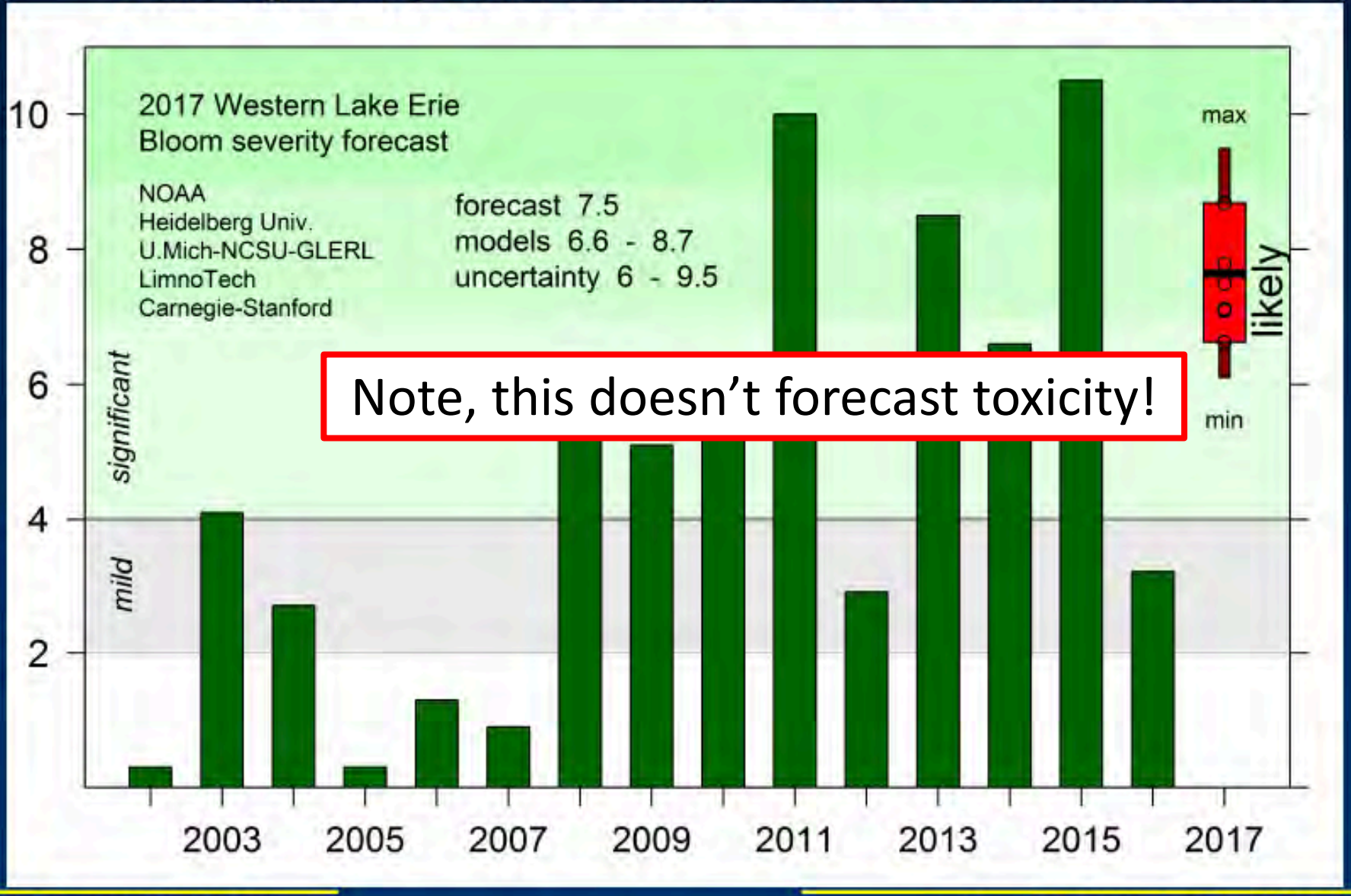


March 1 – July 31, 2016

- TBP load : 465 – 530 t [512 t]
- DRP load: 352 – 402 t [400 t]
- TP load: 1815 – 2042 t [1831 t]

2017 Forecast: 7.5 severity

While significant, similar to 2013, less intense than 2011 or 2015



Western Lake Erie HAB

September 21, 2017

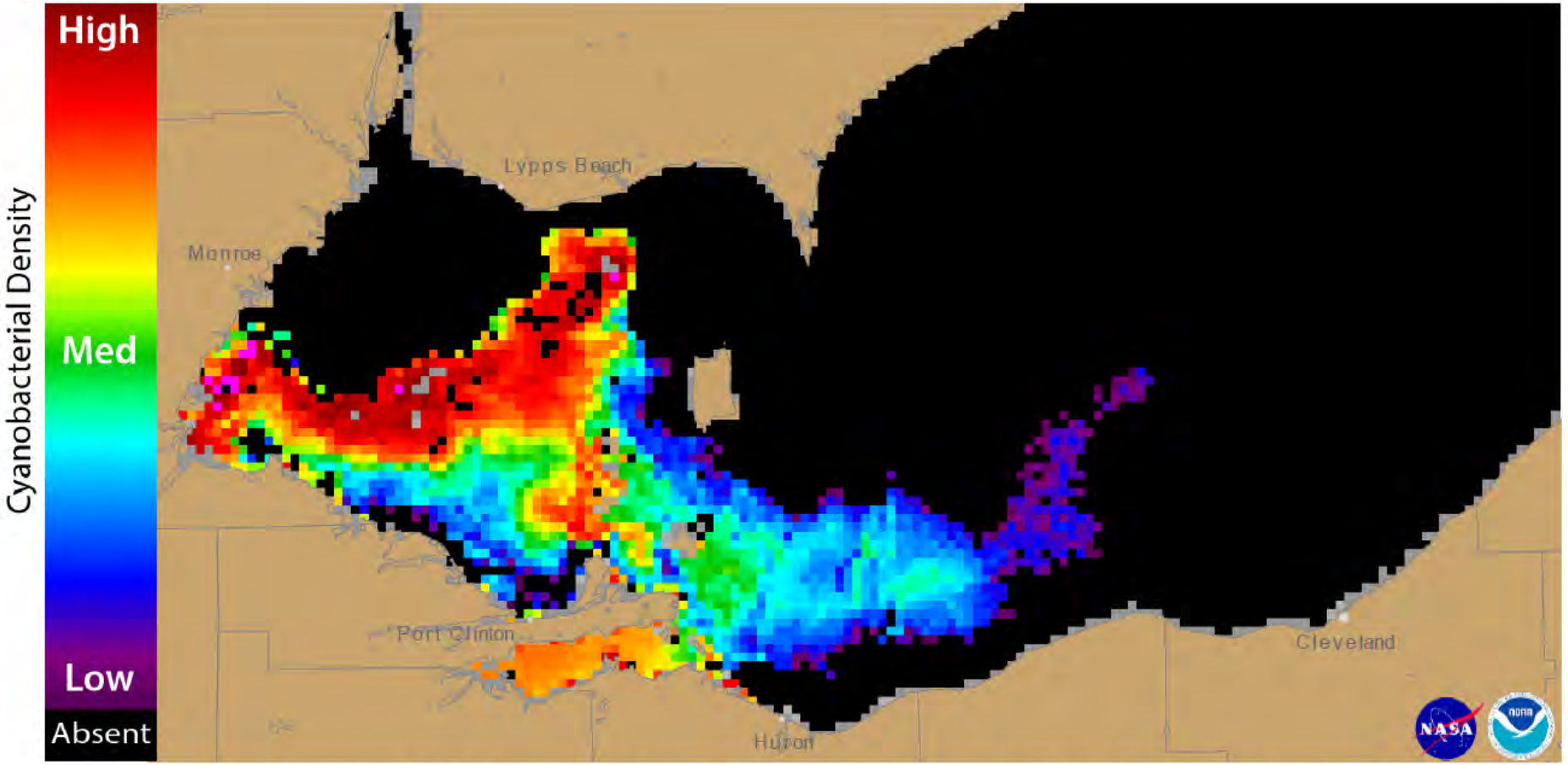
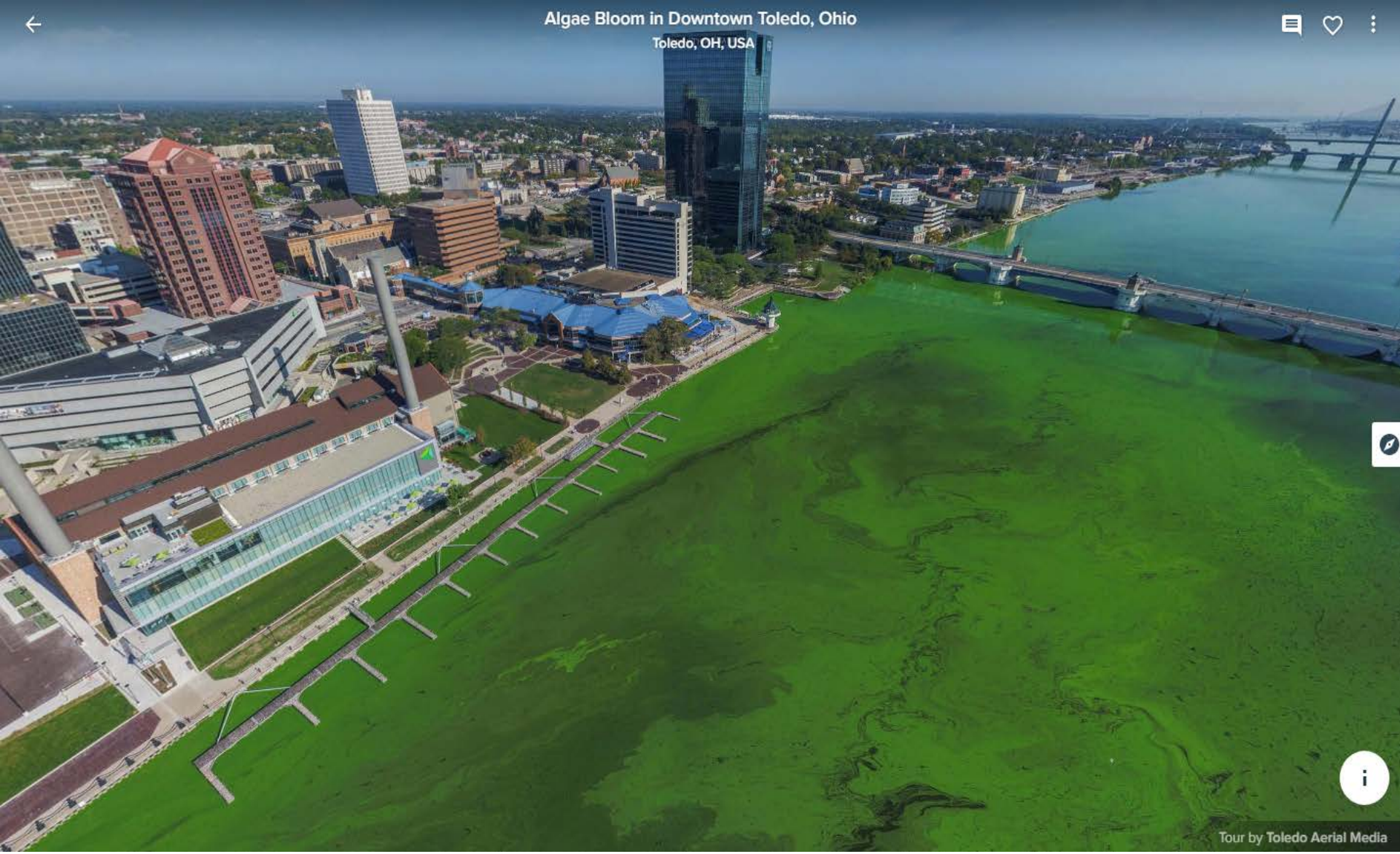


Figure 1. Cyanobacterial Index from NASA MODIS-Terra & Aqua data collected 20 September, 2017 at 12:20 EST. Grey indicates clouds or missing data. The estimated threshold for cyanobacteria detection is 20,000 cells/mL.

From the NOAA Lake Erie Harmful Algal Bloom Bulletin

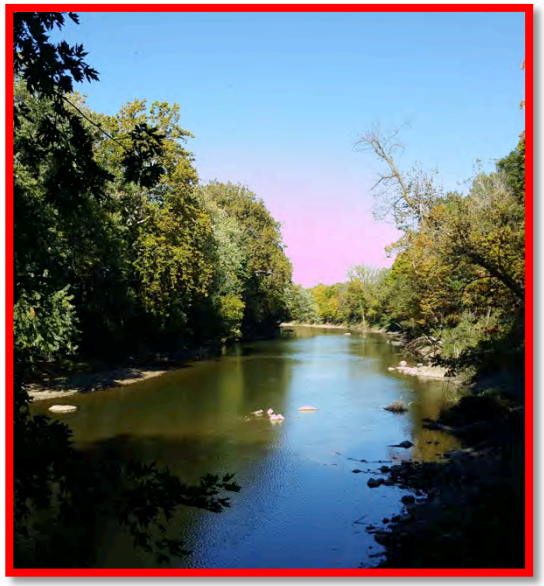
Early August, 2017



https://roundme.com/tour/200123/view/536203/

What can the river tell us about the land?

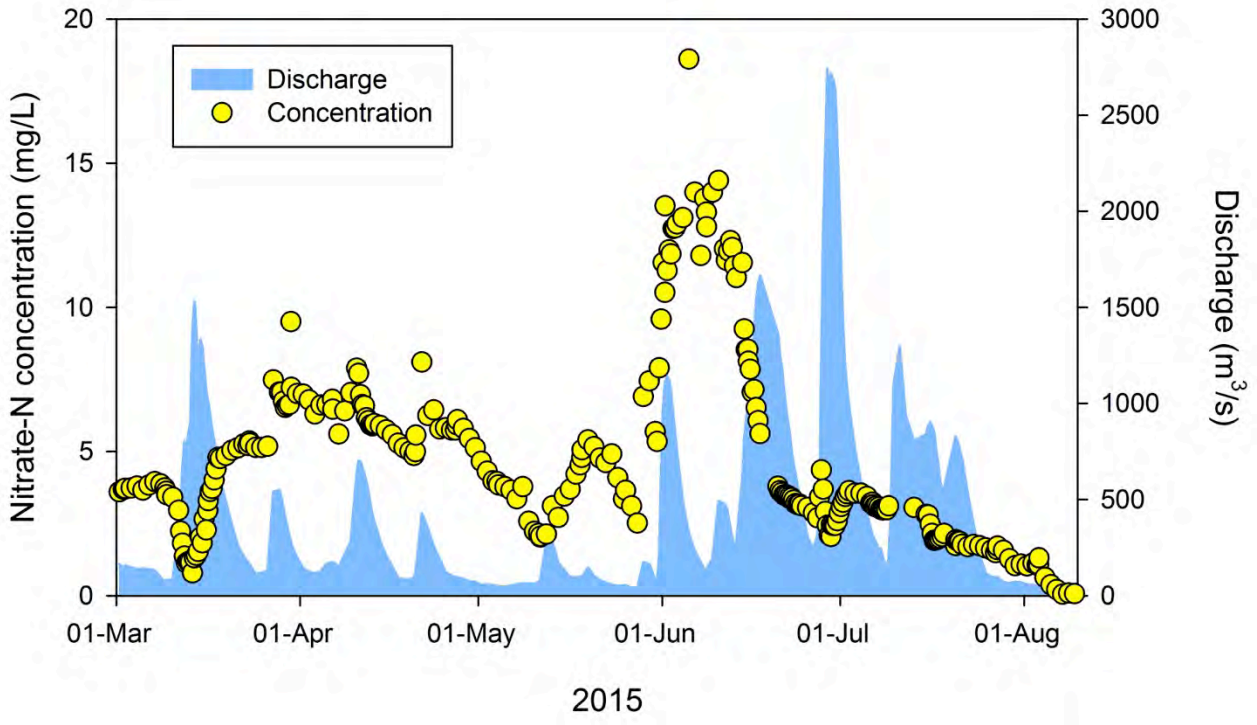
LAND



RIVER

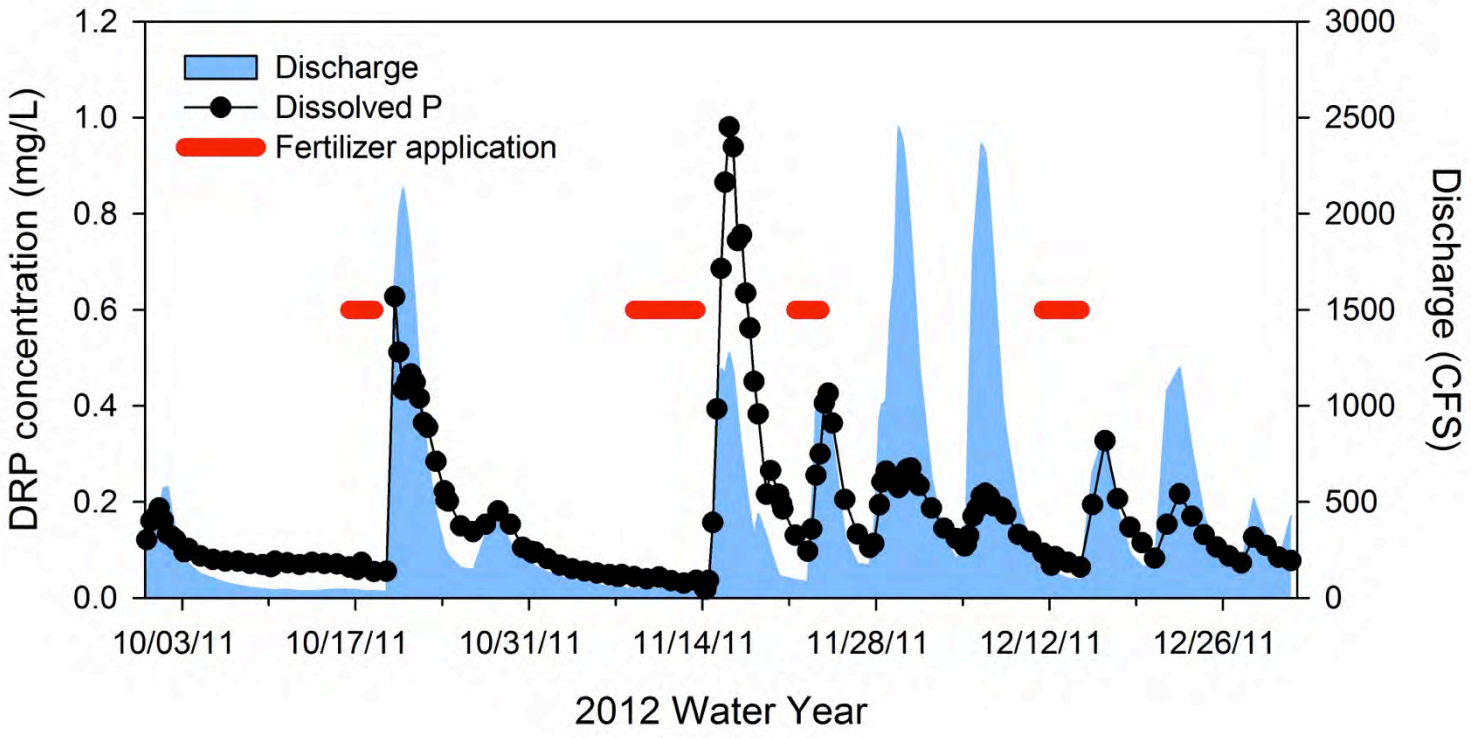
LAKE

Maumee River dissolved P export is chemostatic- indicating a large source present

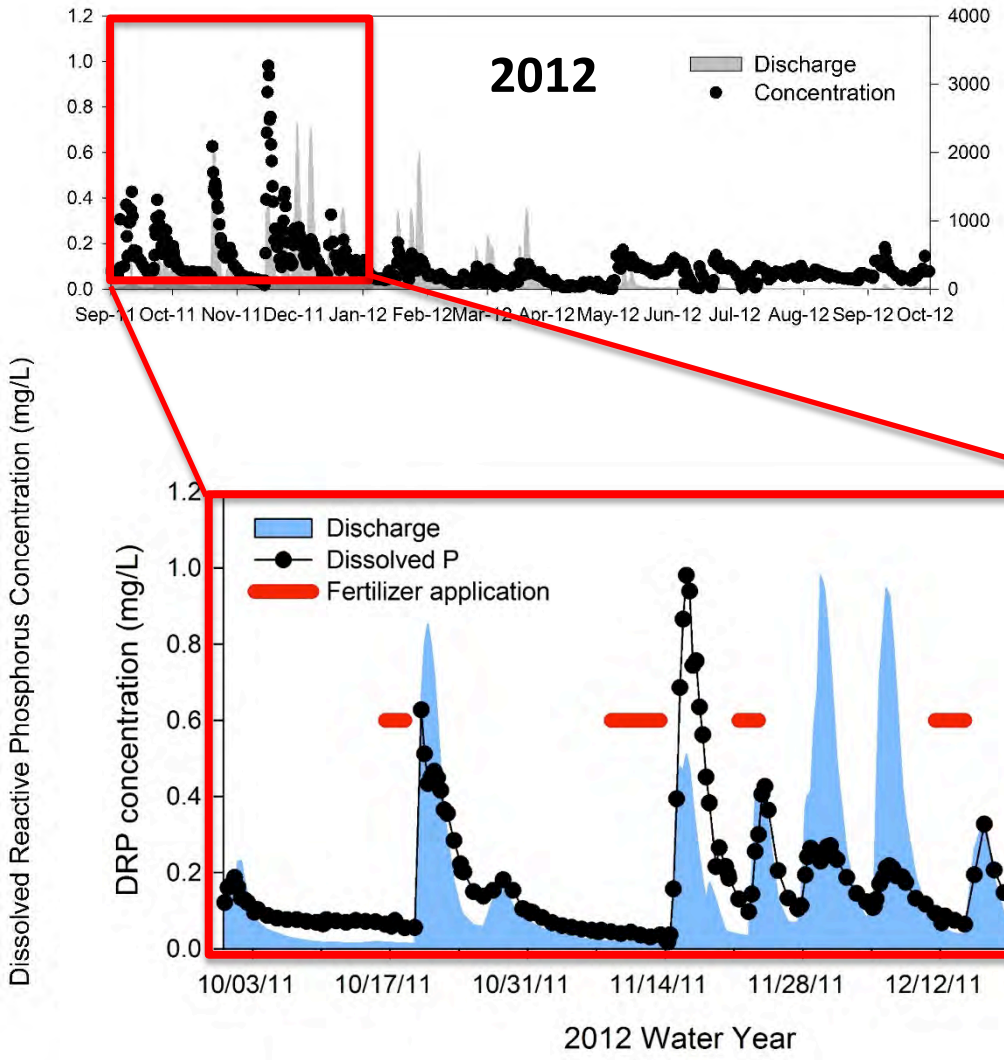


There are instances of acute runoff

Honey Creek in Fall 2011

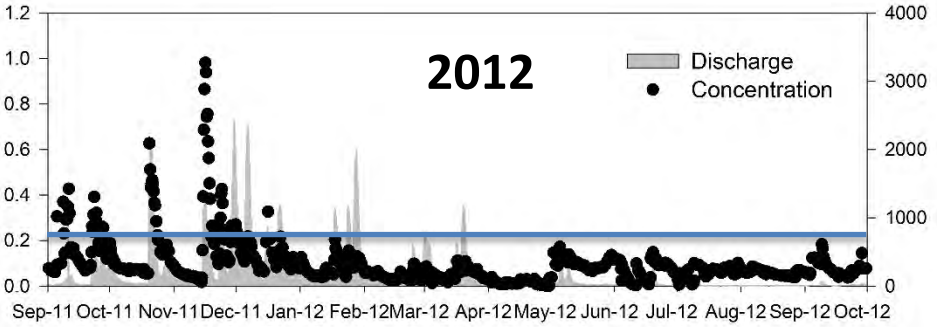


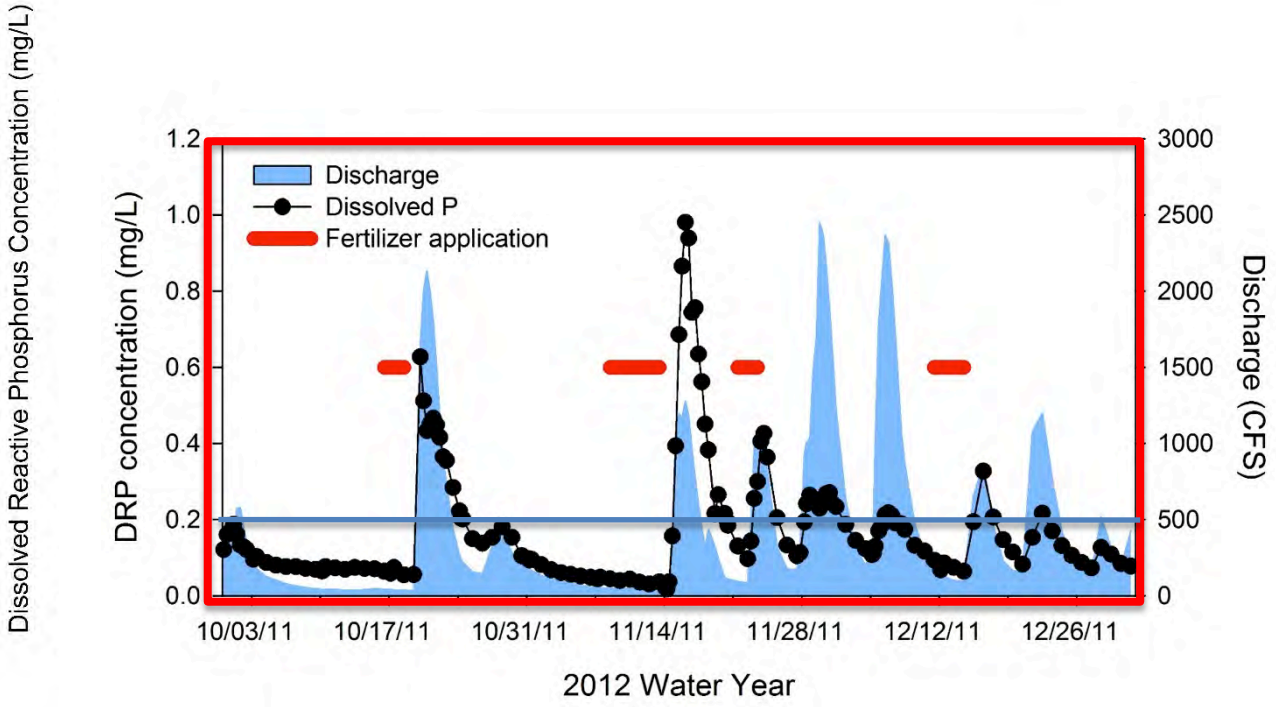
Chronic losses are prevalent



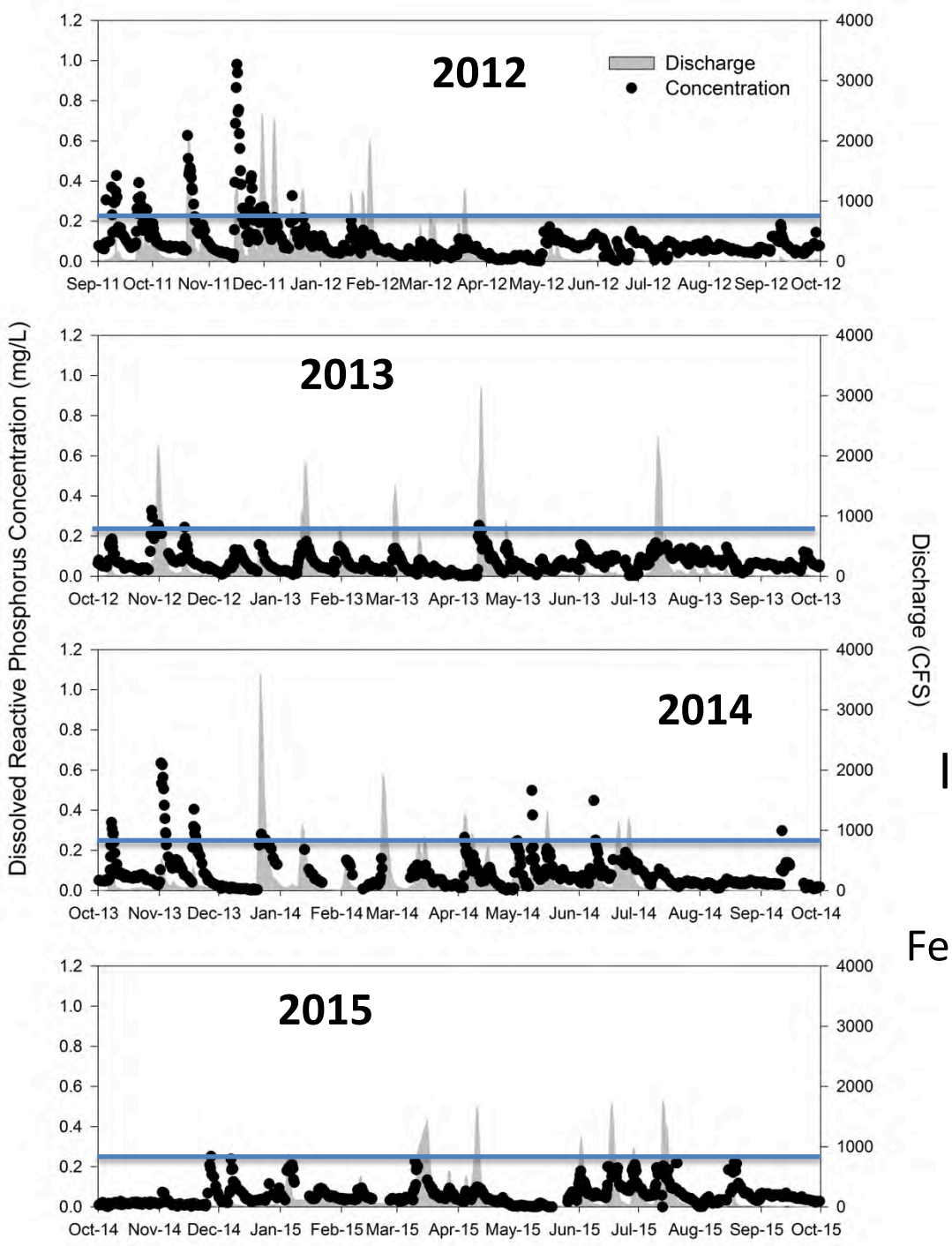
Honey Creek
2012-2015

Chronic losses are prevalent





Honey Creek
2012-2015



Chronic losses are prevalent

Honey Creek
2012-2015

Indicates a large source in soils

Either P stratification is prevalent

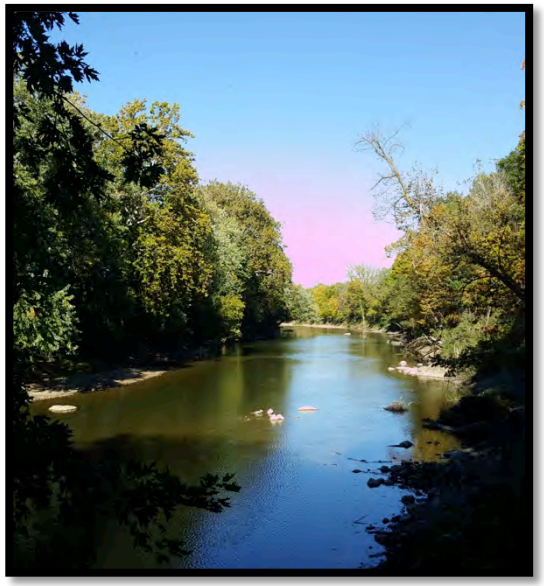
OR

Fertilizer recommendations are too high

Or both!

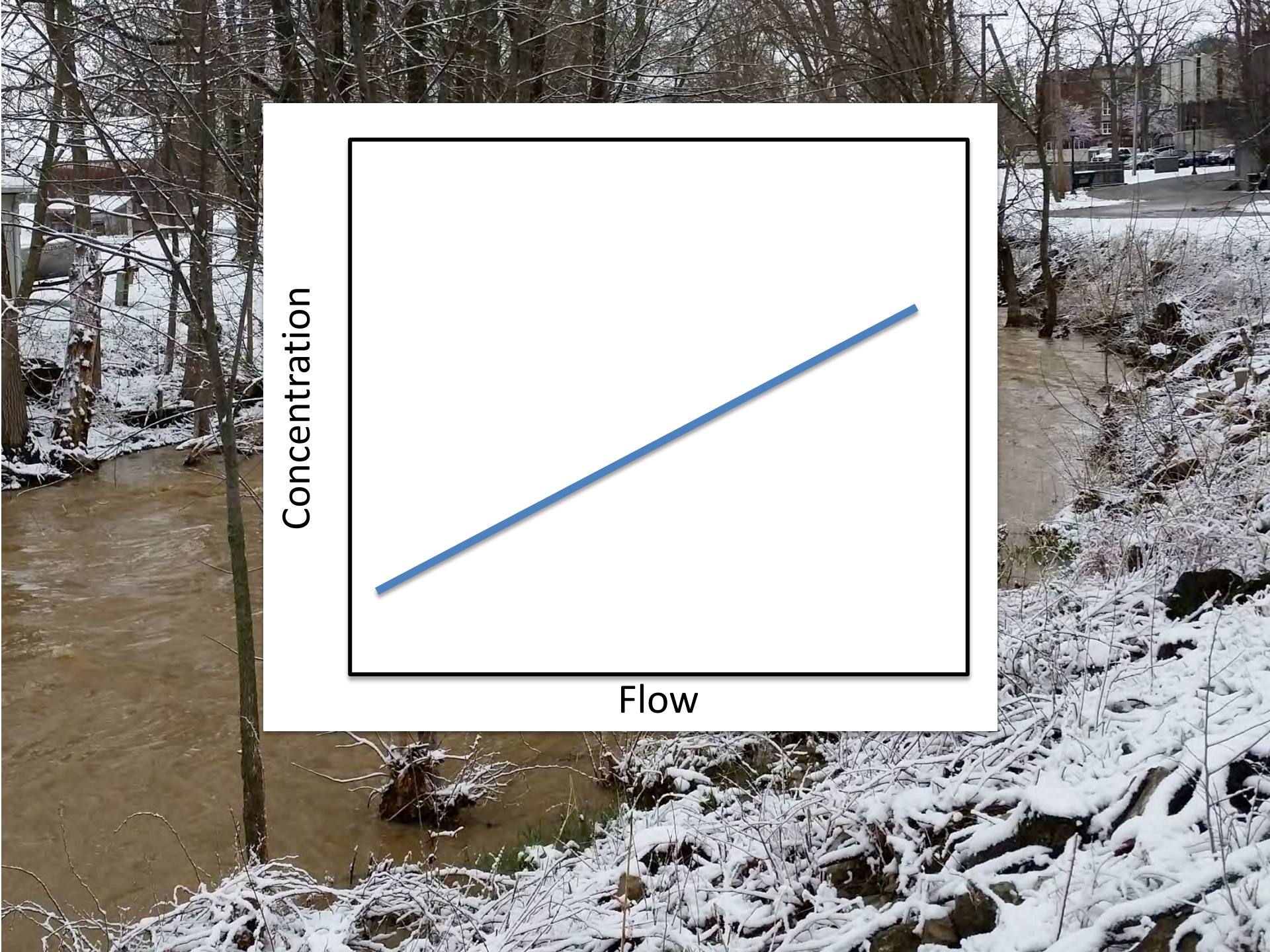
What on the land could lead to patterns in the river?

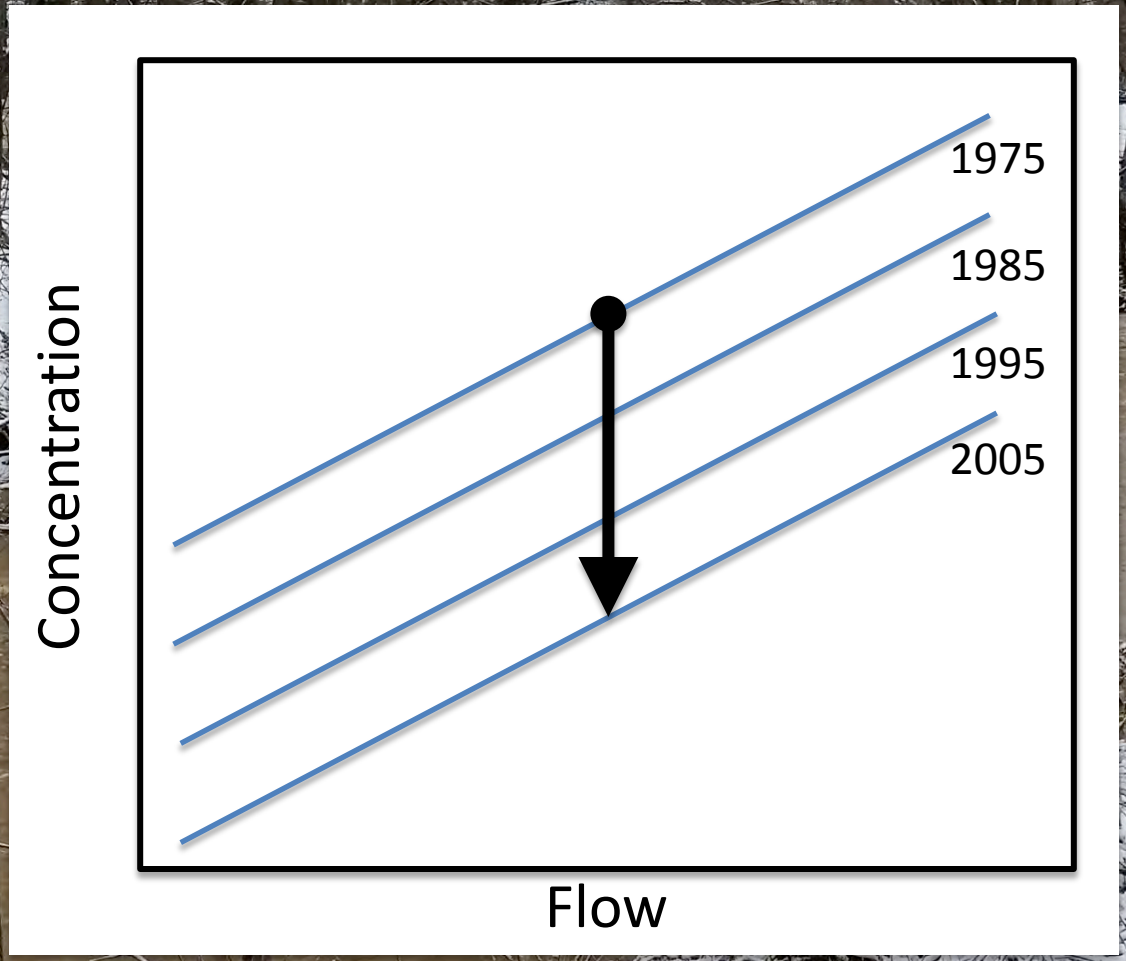
LAND



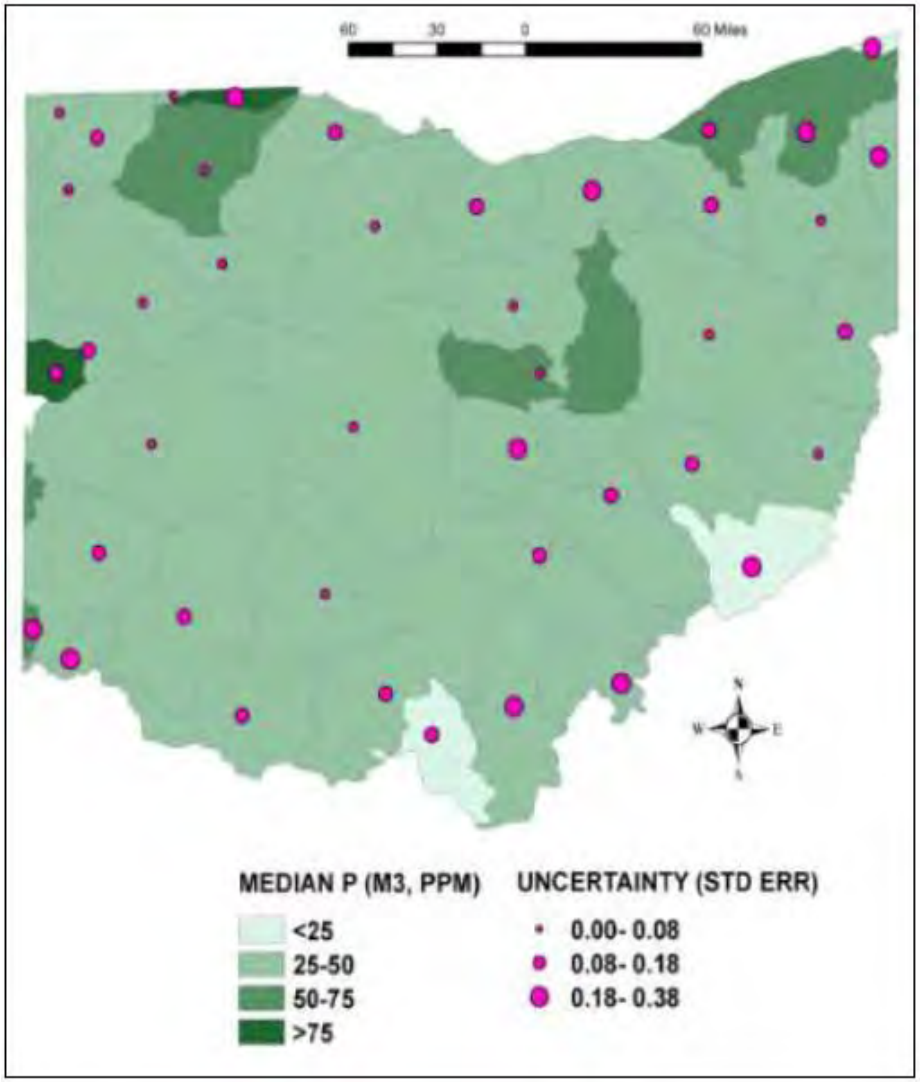
RIVER

LAKE

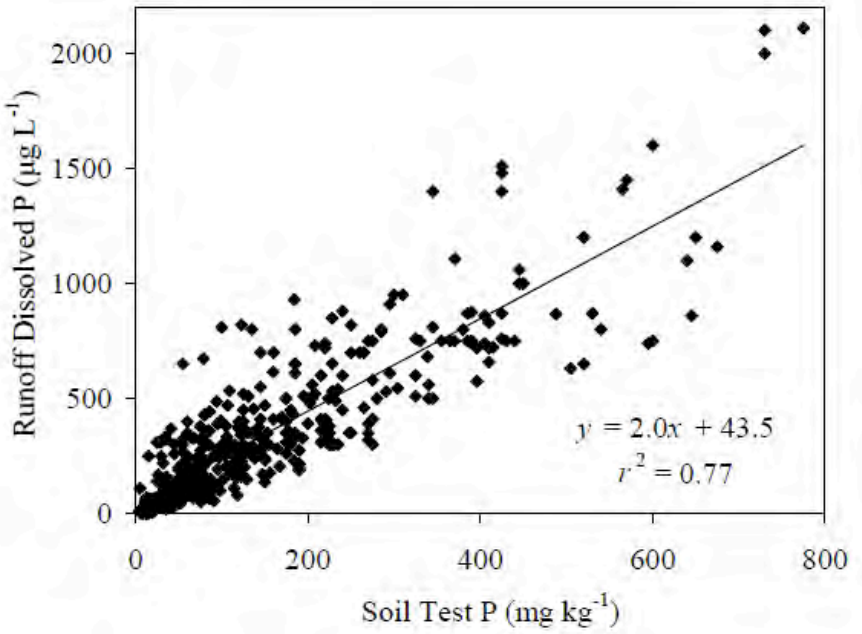

Concentration
Flow


Concentration
1975
1985
1995
2005
Flow

Is soil P high indicating over application of fertilizer or manure?



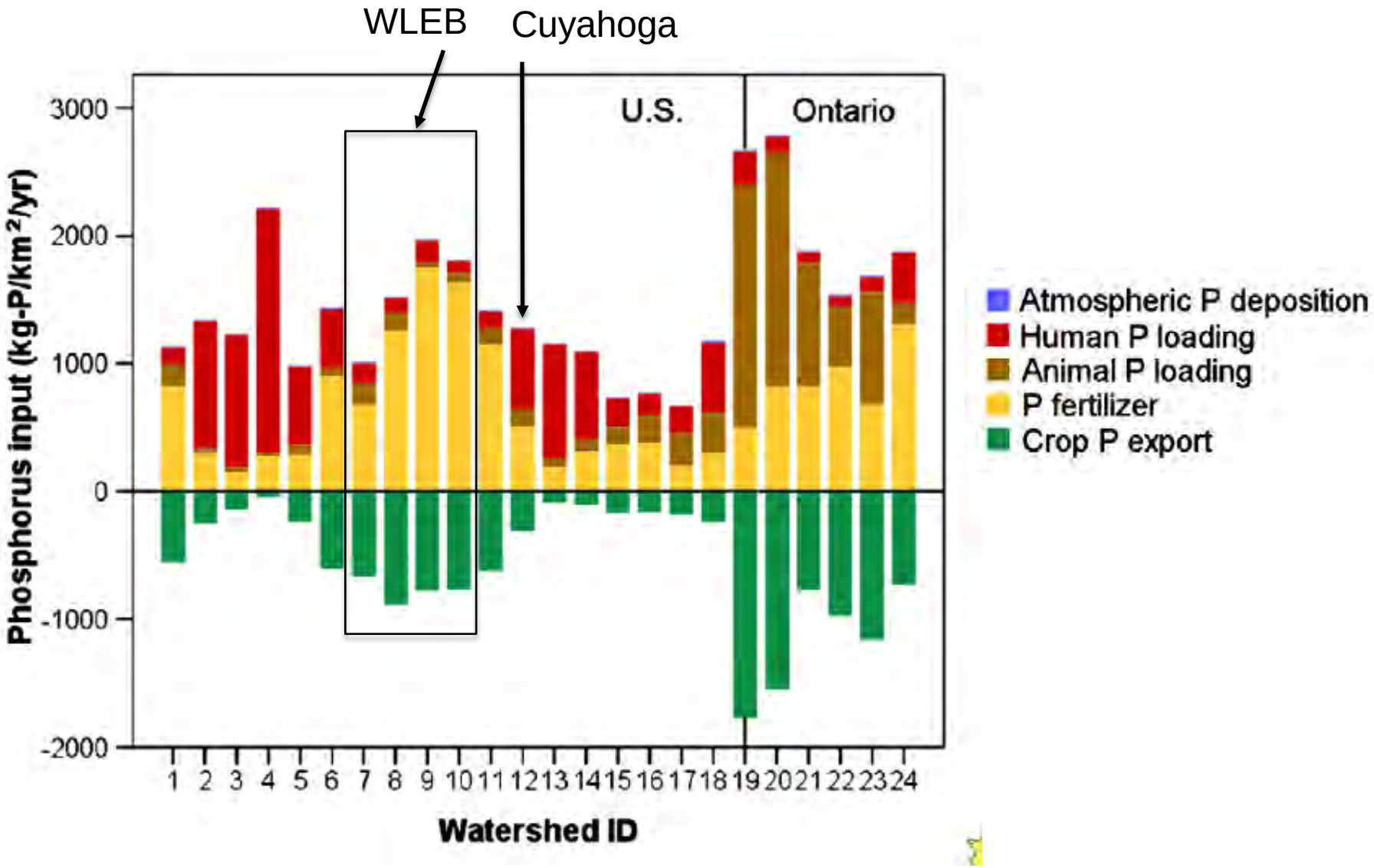
Ohio Phosphorus Taskforce II report



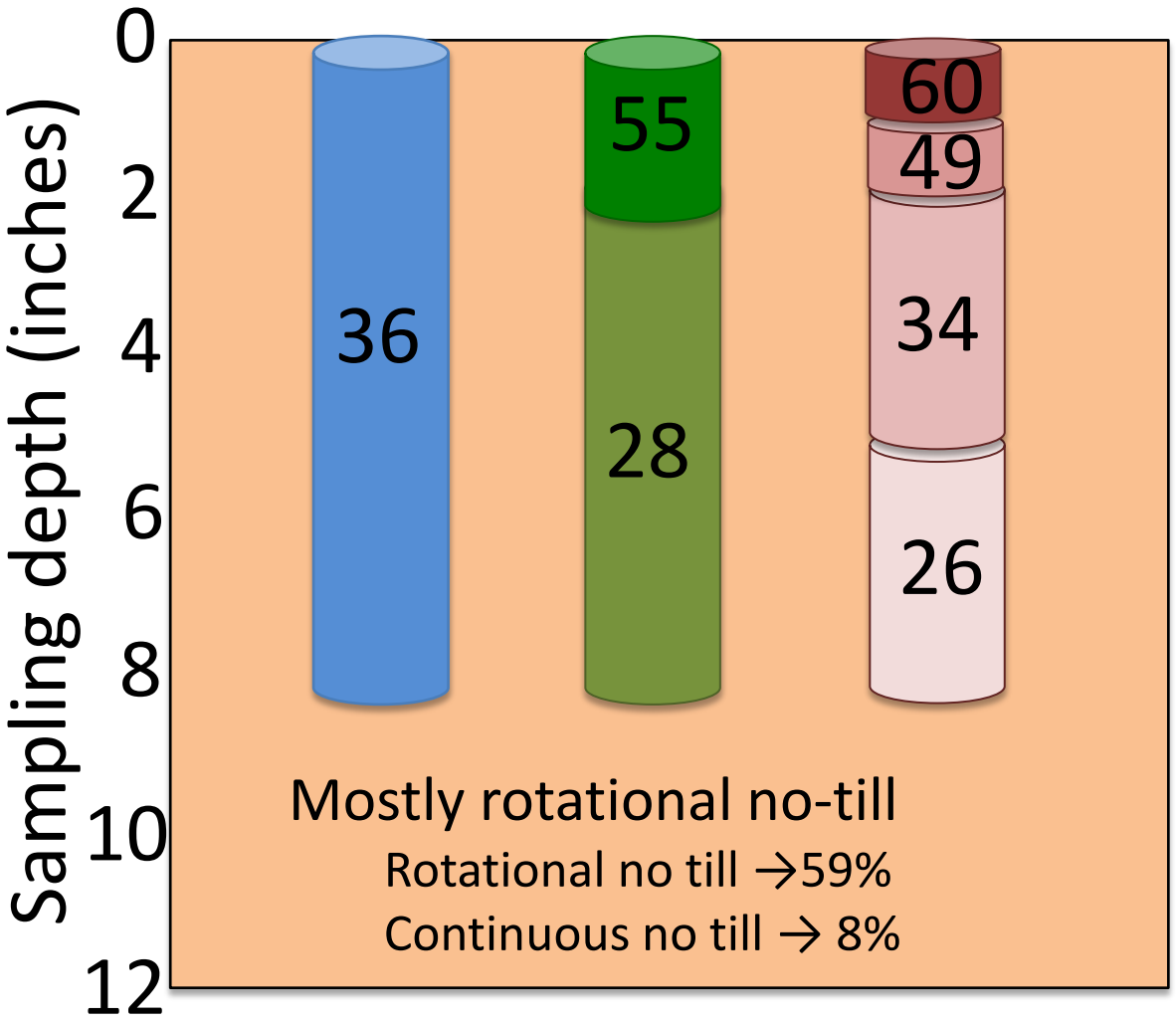
From Vadas et al. 2005

Phosphorus input budget

Scavia et al. 2014



Average soil test P (Mehlich 3 P)



- Over 1500 farms sampled throughout the Sandusky River Basin
- Most farms within the maintenance range
- Only 10% of the farms were above 71ppm
- P has accumulated on the surface

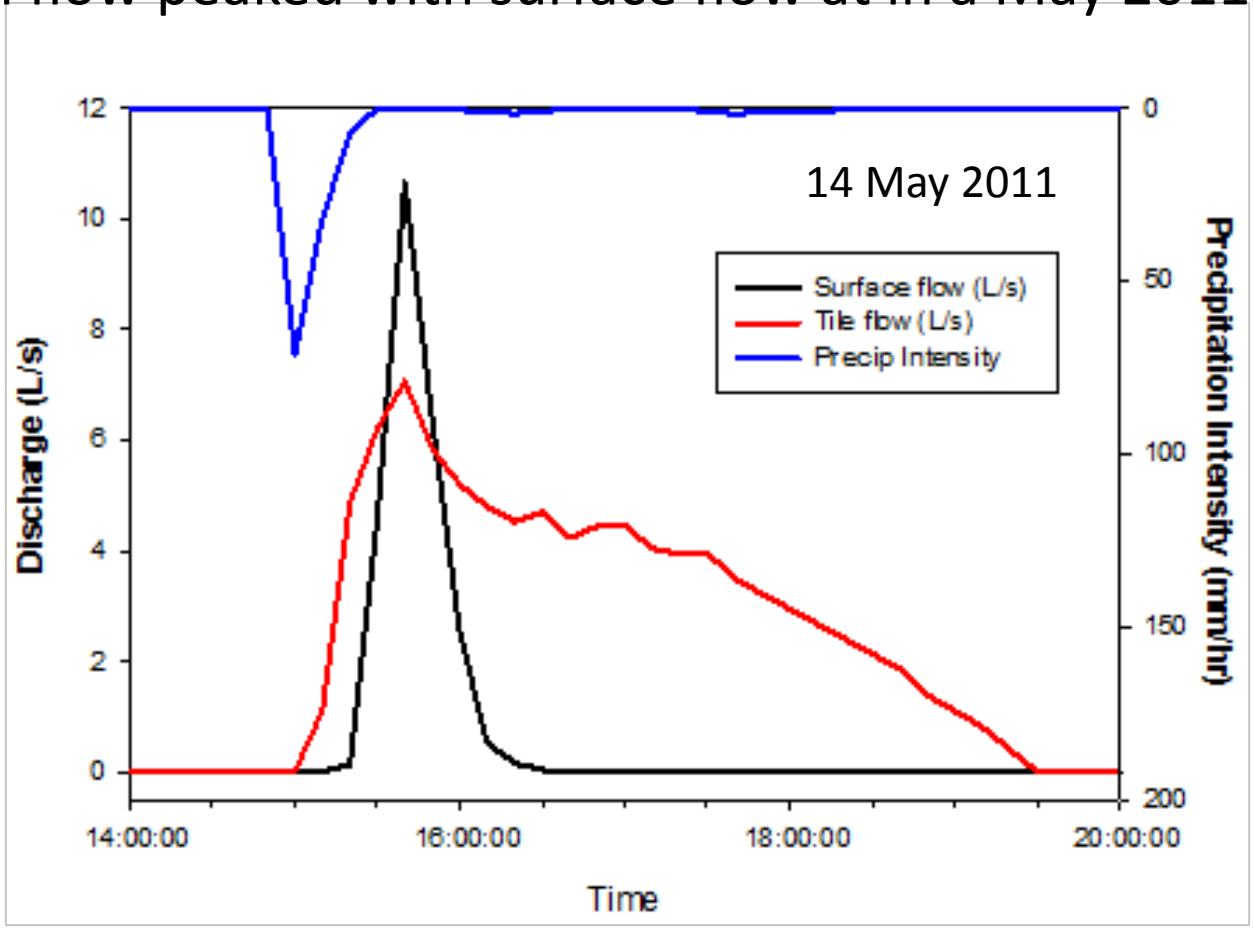

9
8
7
6

Evidence of macropore tile drain flow

Data from Doug Smith, USDA-ARS

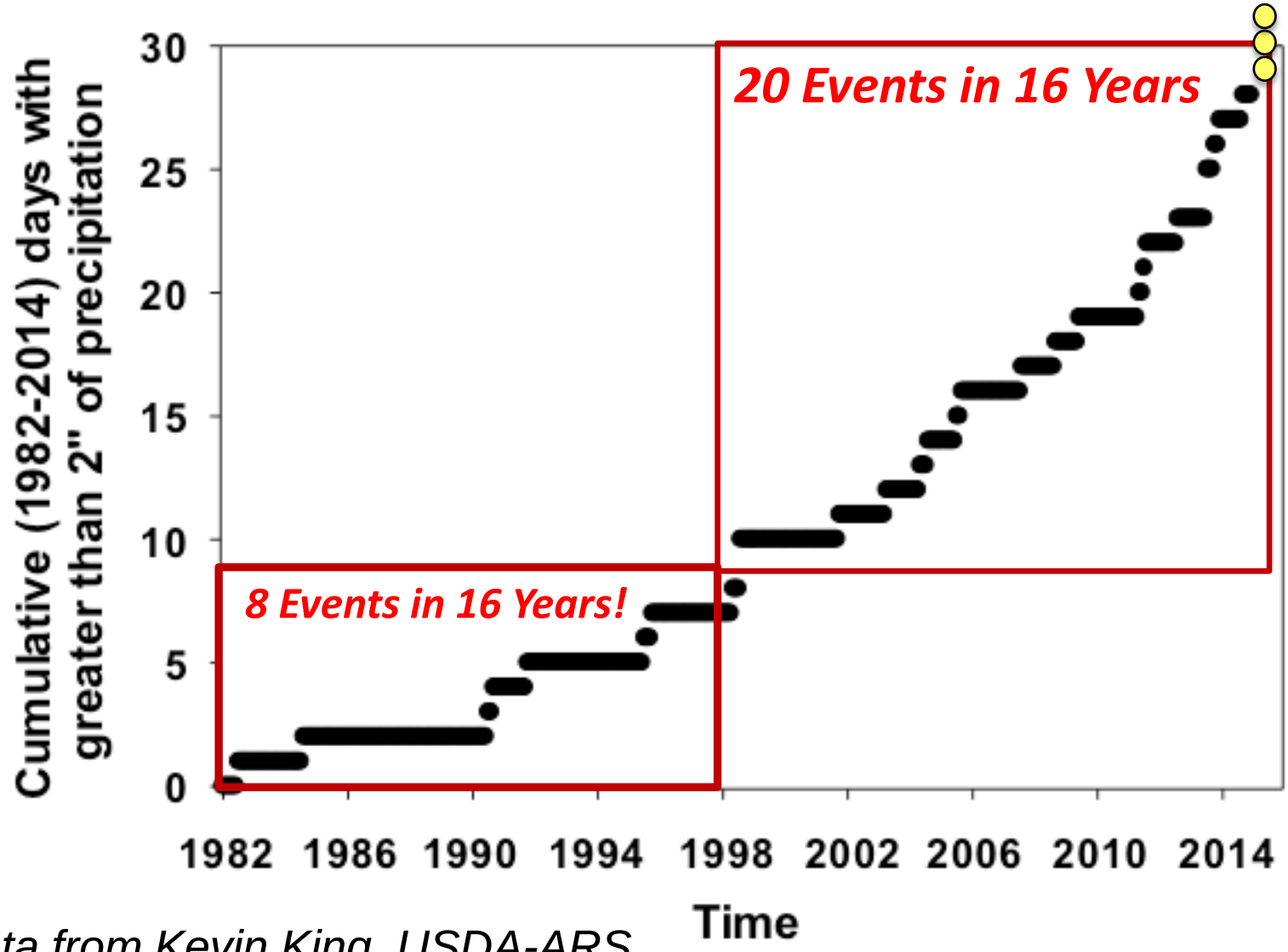
St. Joseph River watershed

- Tile drain flow peaked with surface flow at in a May 2011 storm



Smith et al. 2014, JEQ

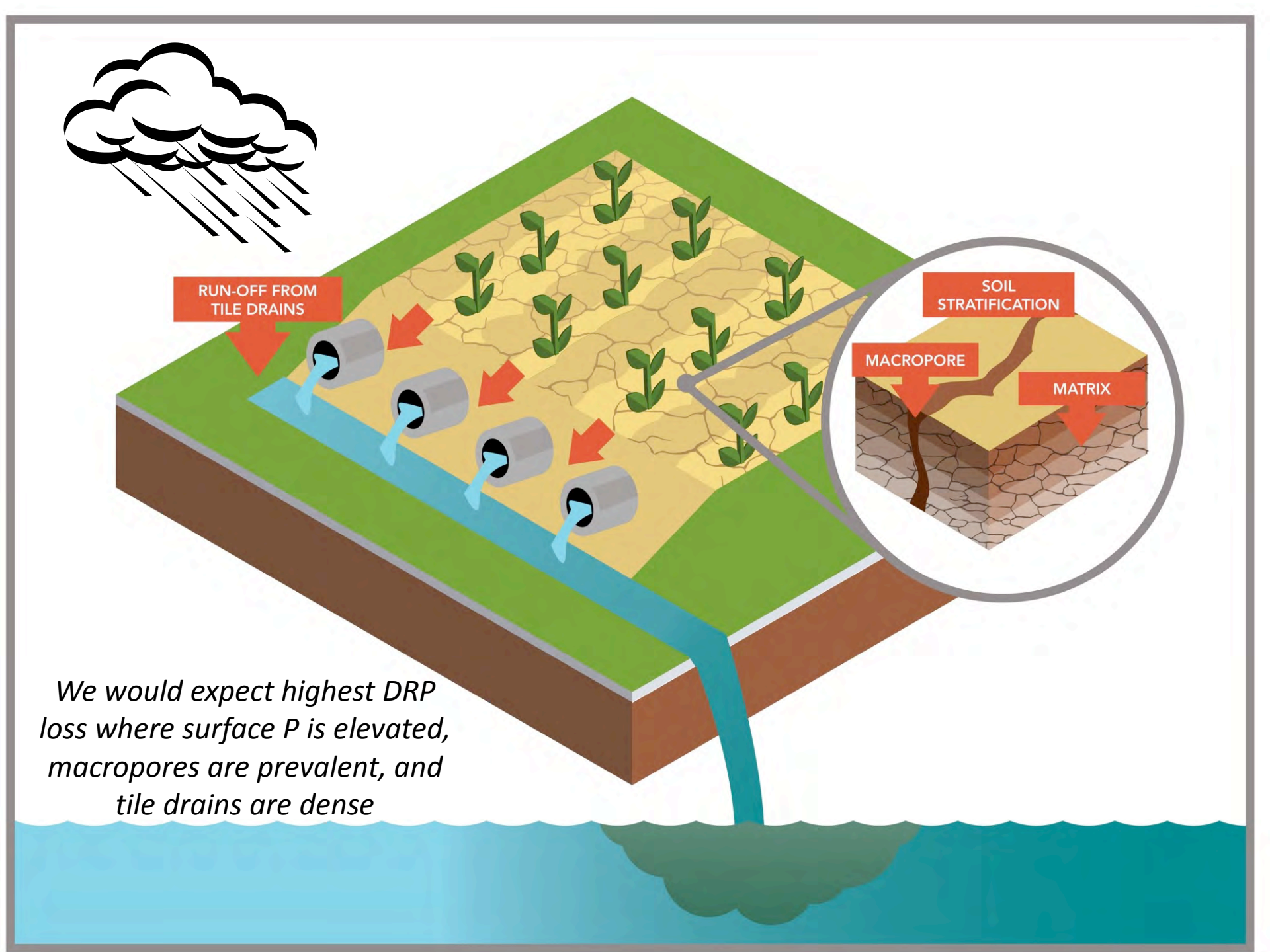
Intense precipitation (2”+) is increasing



Data from Kevin King, USDA-ARS

Kevin King, USDA-ARS, Edge-of-Field

- >80% of dissolved P load from tile drainage
- Losses are only ~1% of inputs
- Soil phosphorus is at recommended levels
- <u>Soil phosphorus must be in the wrong place!</u>



We would expect highest DRP loss where surface P is elevated, macropores are prevalent, and tile drains are dense

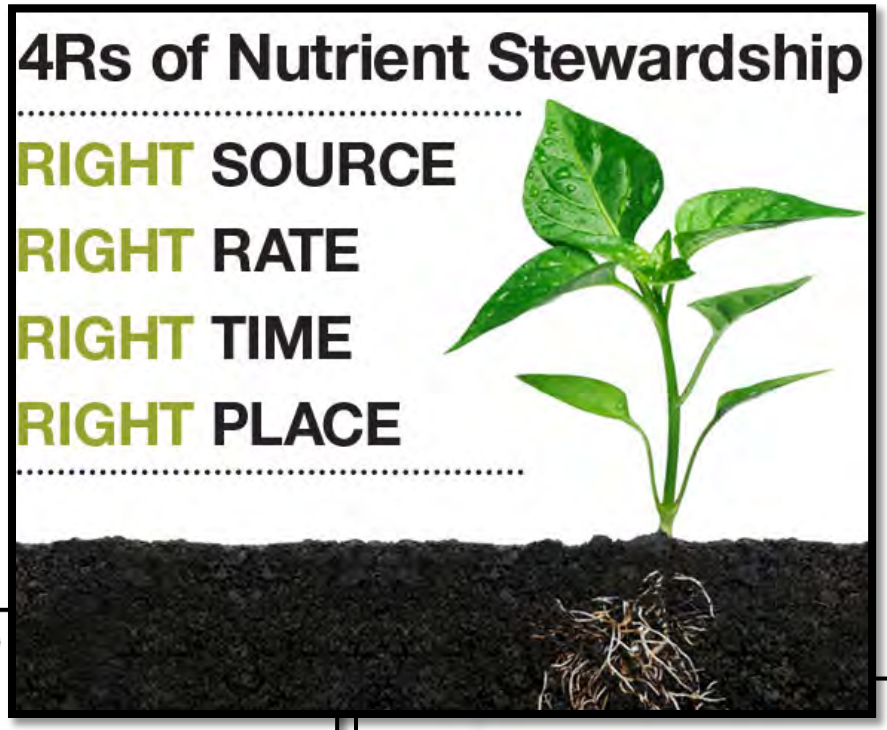
4Rs of Nutrient Stewardship

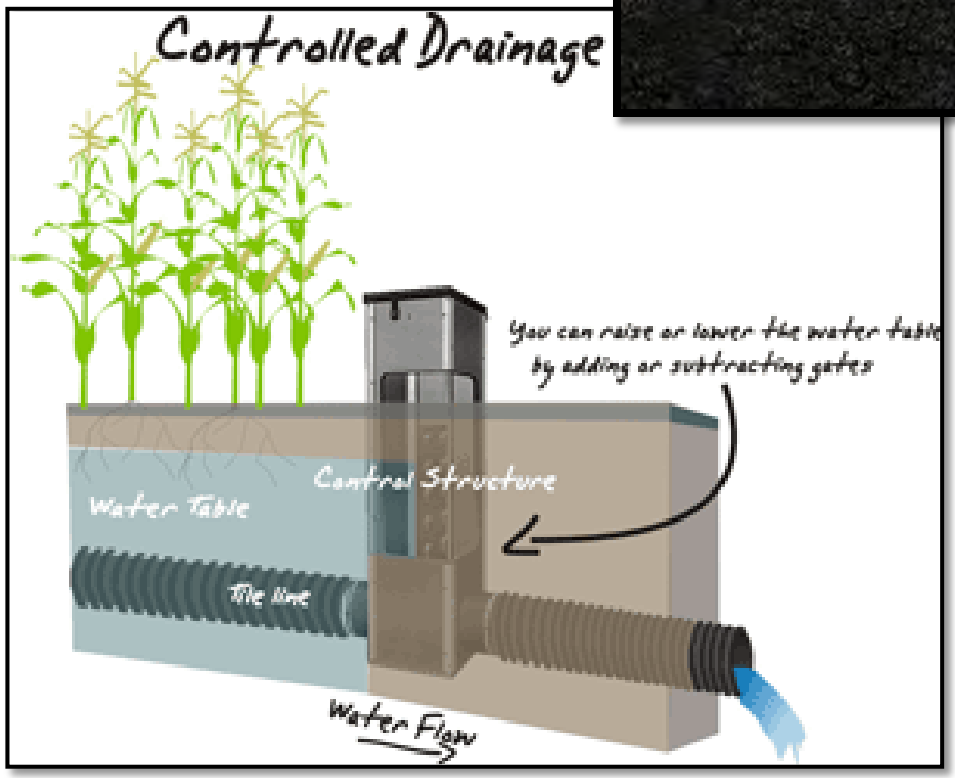
RIGHT SOURCE

RIGHT RATE

RIGHT TIME

RIGHT PLACE


4Rs of Nutrient Stewardship
RIGHT SOURCE
RIGHT RATE
RIGHT TIME
RIGHT PLACE


Controlled Drainage
You can raise or lower the water table by adding or subtracting gates
Control Structure
Water Table
Tile line
Water Flow


Cover Crops...
Protecting
Our Lake

Conclusions

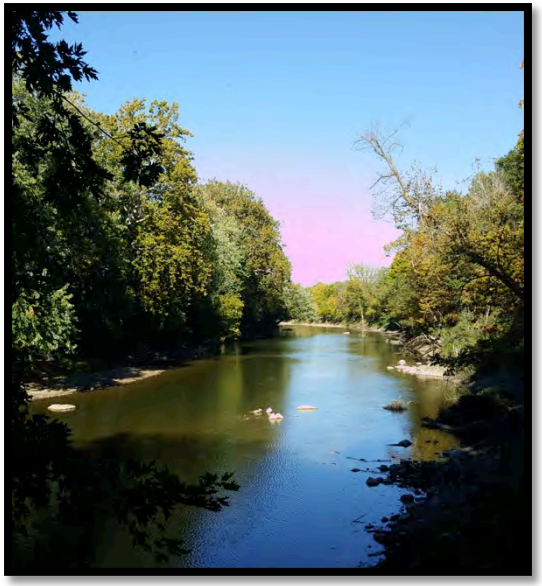
From measurements in the river we can:

- Forecast the size of the bloom in Lake Erie
- Determine the sources of nutrients to the river
- Understand dynamics of pollutant runoff

Paired with other studies we can suggest practices to reduce nutrient runoff

- Keep phosphorus off the surface and lower soil test levels

LAND



RIVER

LAKE

Heidelberg Tributary Loading Program – Current Sponsors

Muskingum Watershed Conservancy District

MCD Miami Conservancy District

The City of Columbus, Michael B. Coleman, Mayor

Ohio Department of Natural Resources

Northeast Ohio Regional Sewer District – Protecting Your Health and Environment

Ohio Water Development Authority

United States Environmental Protection Agency

National Oceanic and Atmospheric Administration, U.S. Department of Commerce

NSF

The Andersons

The Fertilizer Institute – Nourish, Replenish, Grow

Department of Environmental Quality

Sponsors of Current Research Projects

The Ohio State University – College of Food, Agricultural, and Environmental Sciences

United States Environmental Protection Agency

Great Lakes Restoration

R4 Research Fund

OhioHigherEd – Department of Higher Education

NOAA

great lakes observing system

Ohio Lake Erie Commission

NOAA

Sea Grant – Ohio Sea Grant College Program

Ohio Environmental Protection Agency

USDA

NRCS – Natural Resources Conservation Service

NSF

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Or contact me at ljohnson@heidelberg.edu

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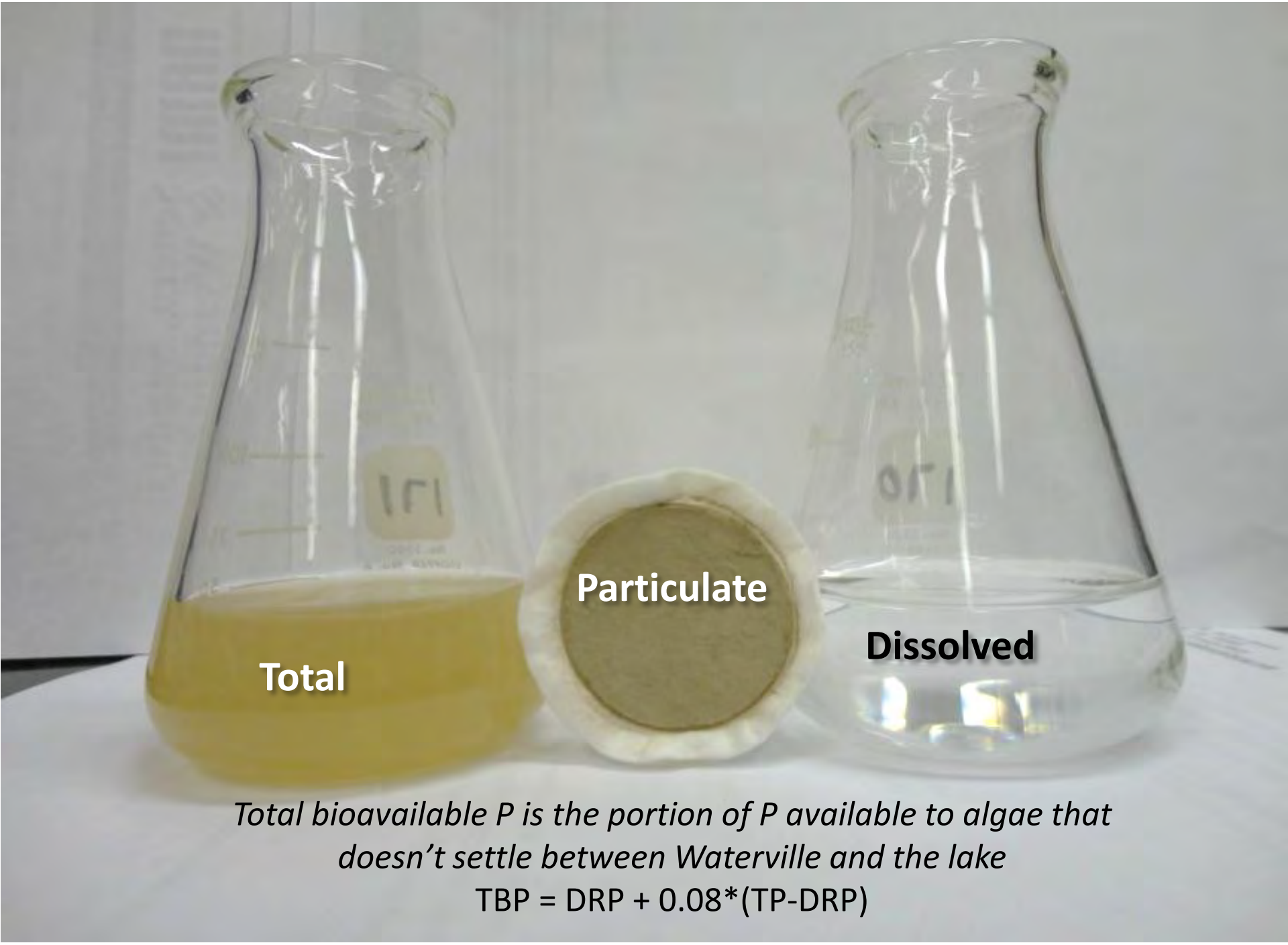
Questions?

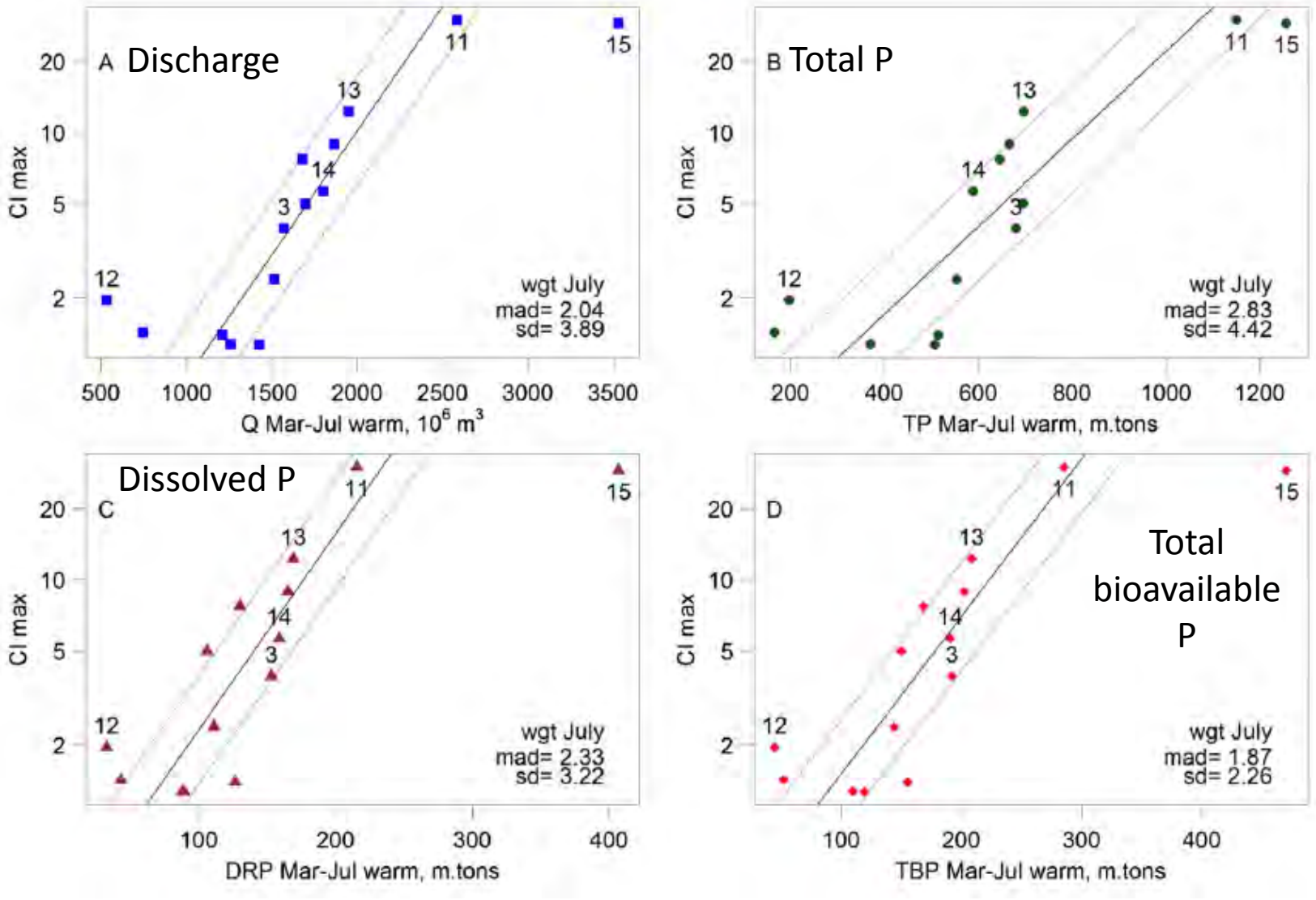
LAKE ERIE ALGAE.COM



Total bioavailable P is the portion of P available to algae that doesn't settle between Waterville and the lake

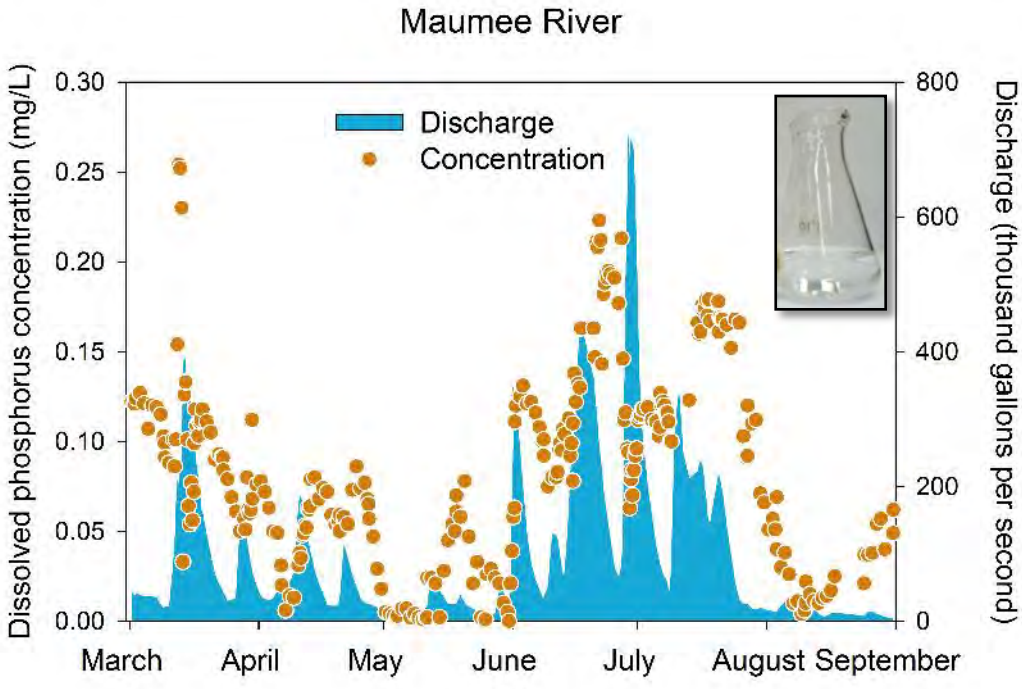
TBP = DRP + 0.08*(TP-DRP)

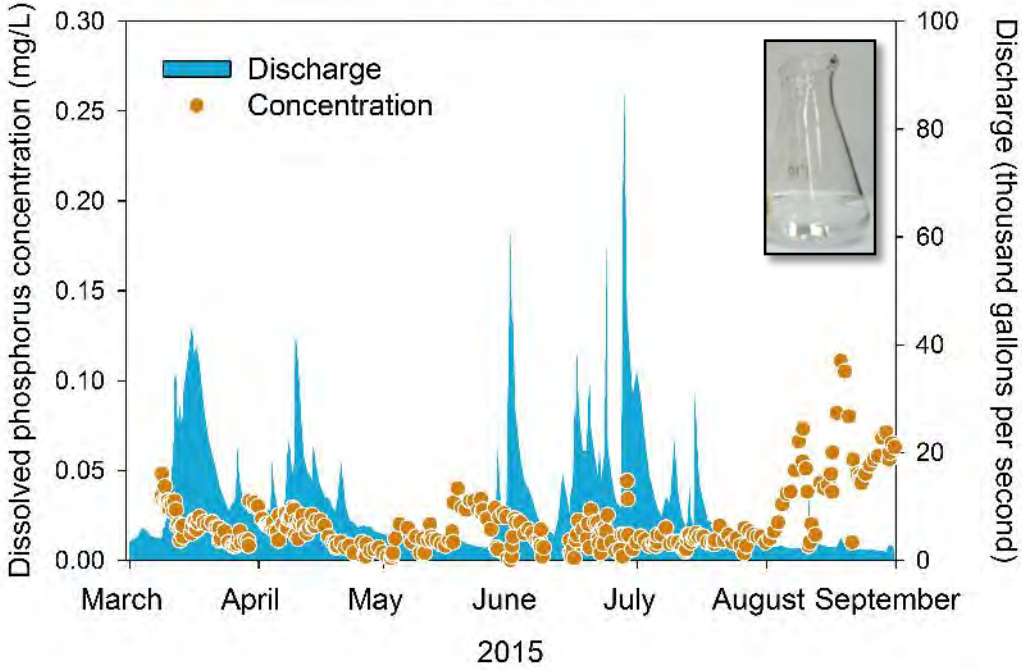
The size of the bloom is related to Maumee River phosphorus exports from March - July



Stumpf et al., 2016 JGLR

*note, there is no relationship with TN, NO_3^-, or TKN


Maumee River
Dissolved phosphorus concentration (mg/L)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Discharge
Concentration
800
600
400
200
0
Discharge (thousand gallons per second)
March
April
May
June
July
August
September


Cuyahoga River
Dissolved phosphorus concentration (mg/L)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Discharge
Concentration
100
80
60
40
20
0
Discharge (thousand gallons per second)
March
April
May
June
July
August
September
2015