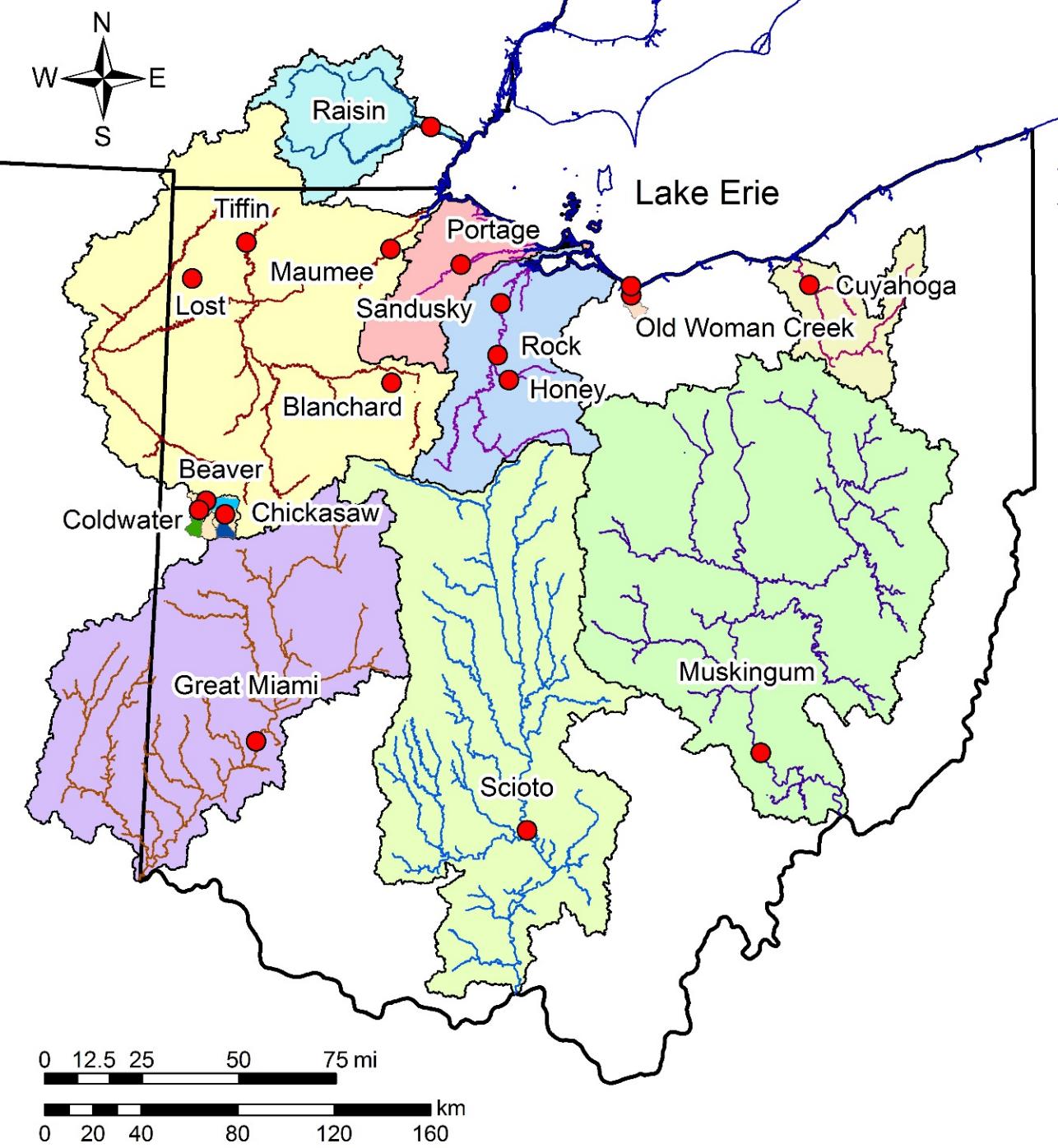


# Sources, transformation, and measurement of dissolved reactive phosphorus in Lake Erie tributaries

Laura Johnson, David Baker, Rem Confesor, Jack Kramer, Ellen Ewing, Barb Merryfield, Aaron Roerdink, and Jake Boehler





## 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

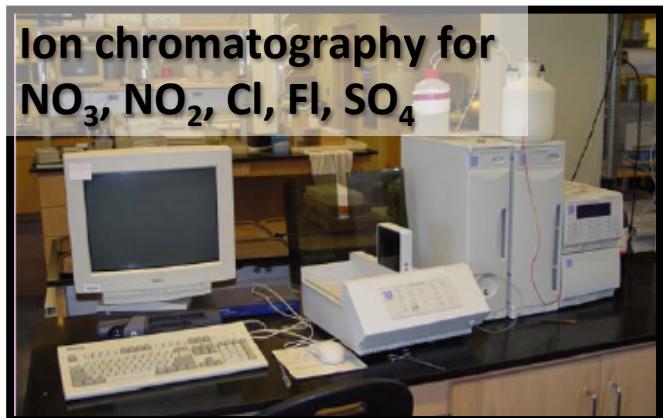
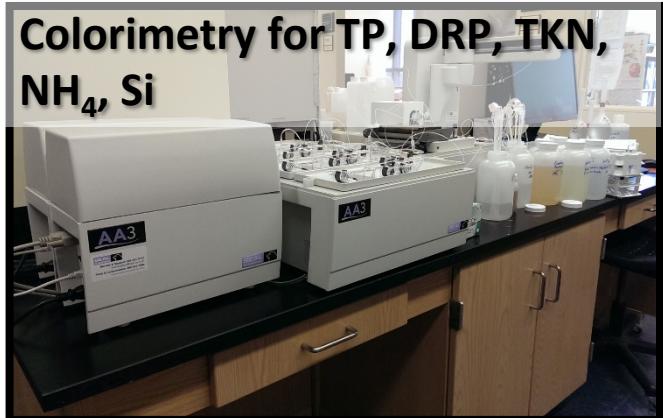




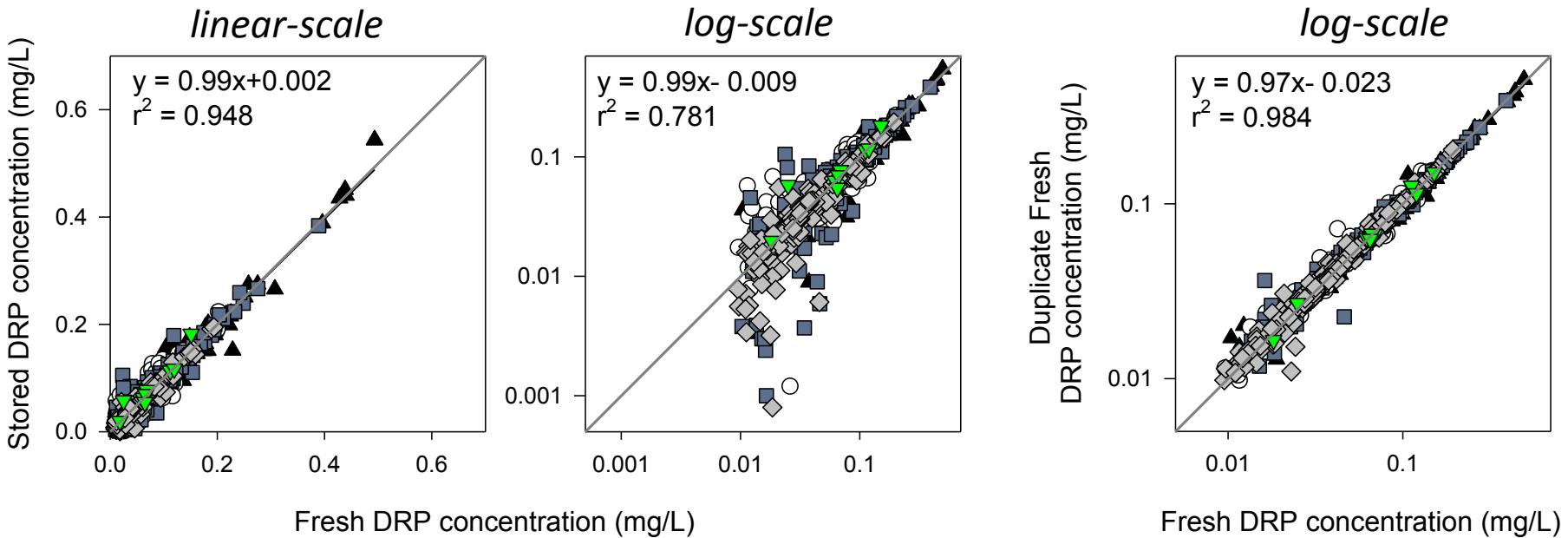
Samples collected  
3x a day!



- 2 fresh samples are taken back to the lab immediately
- A third sample is stored and collected the following week



# DRP concentration

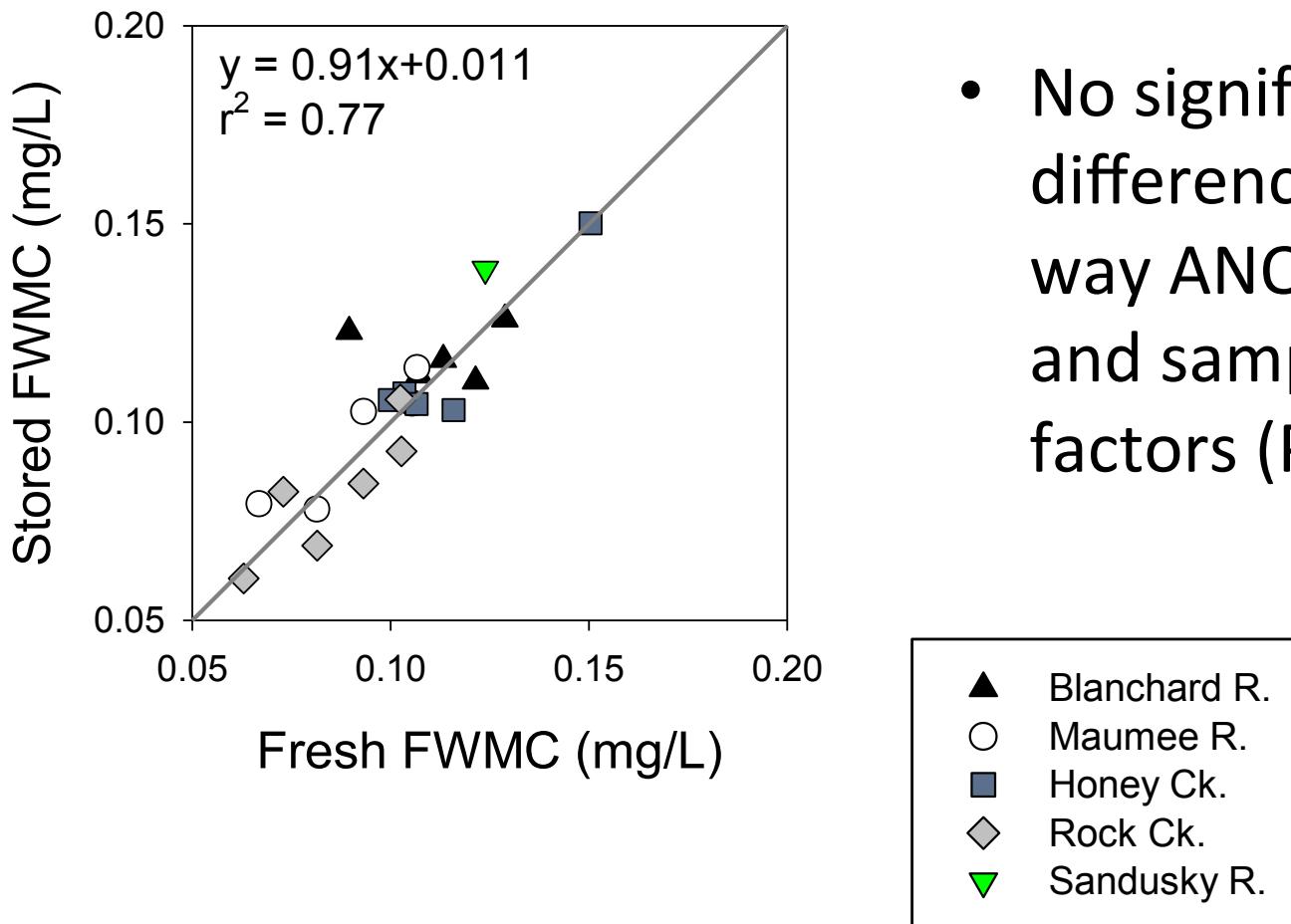


- Significant difference in concentrations between stored and fresh samples (paired t-test,  $P=0.019$ )
- Most differences are when concentration  $<0.1$  mg/L
- Variation beyond analytical precision are a result of storage

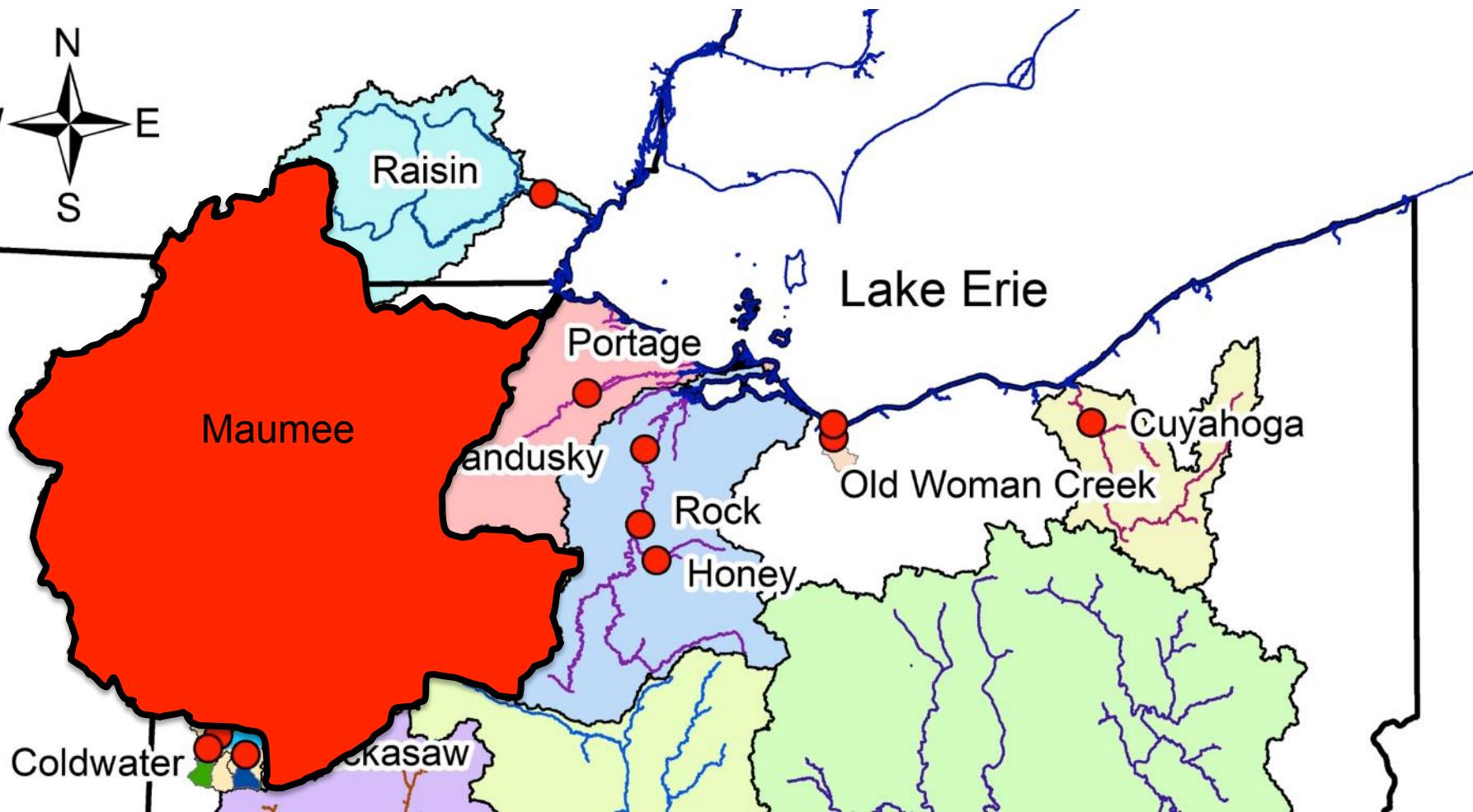
A legend box containing five entries, each with a marker symbol and a text label:

- Blanchard R. (black triangle)
- Maumee R. (open circle)
- Honey Ck. (blue square)
- Rock Ck. (grey diamond)
- Sandusky R. (green inverted triangle)

# Annual flow-weighted mean concentration

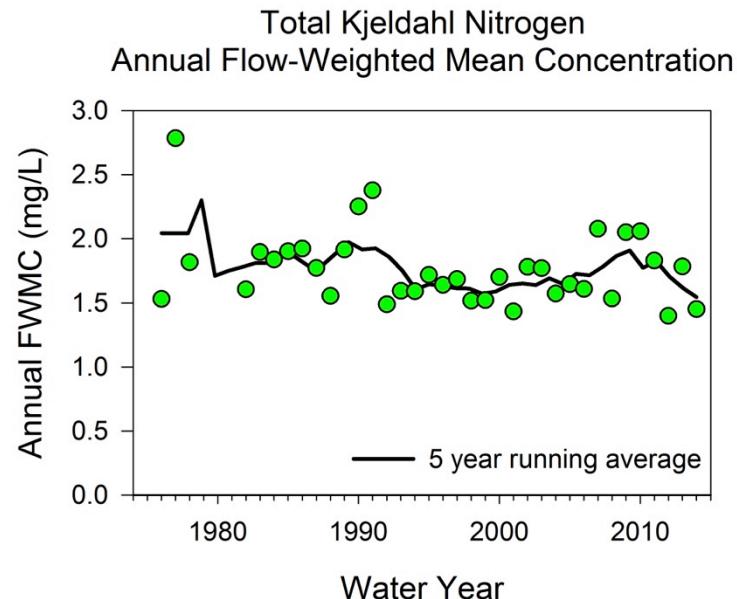
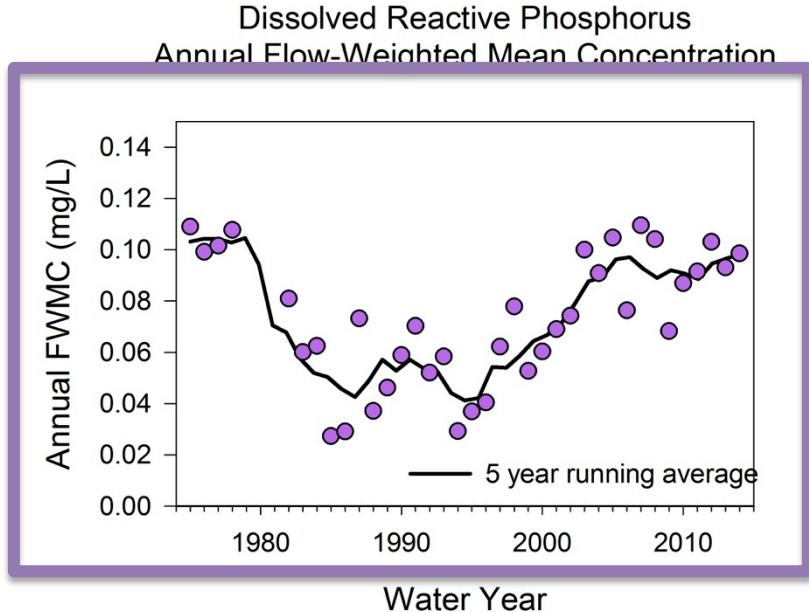
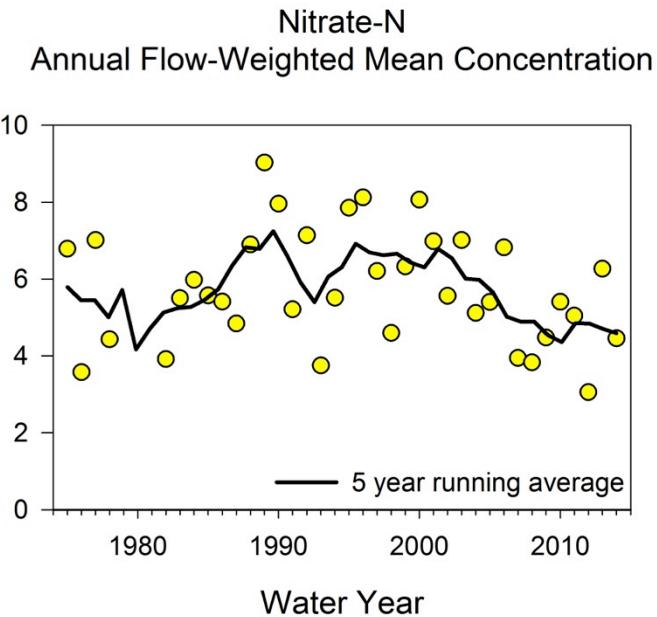
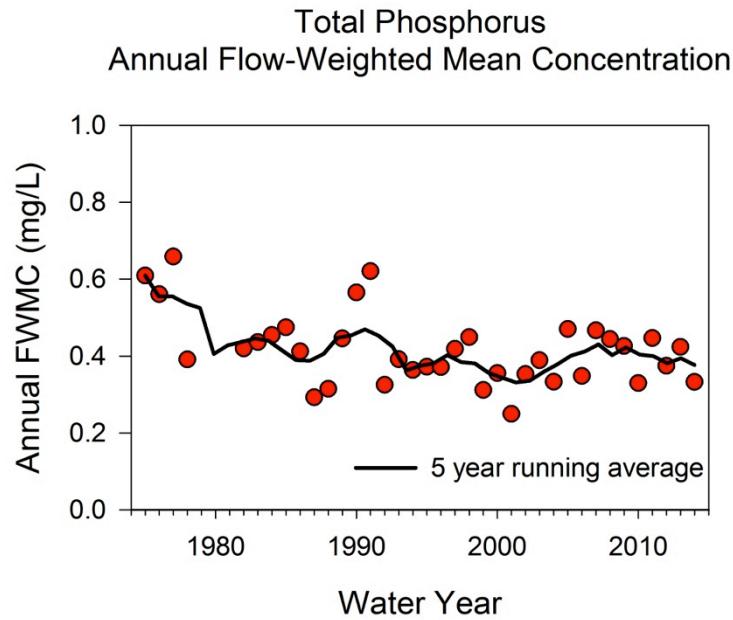


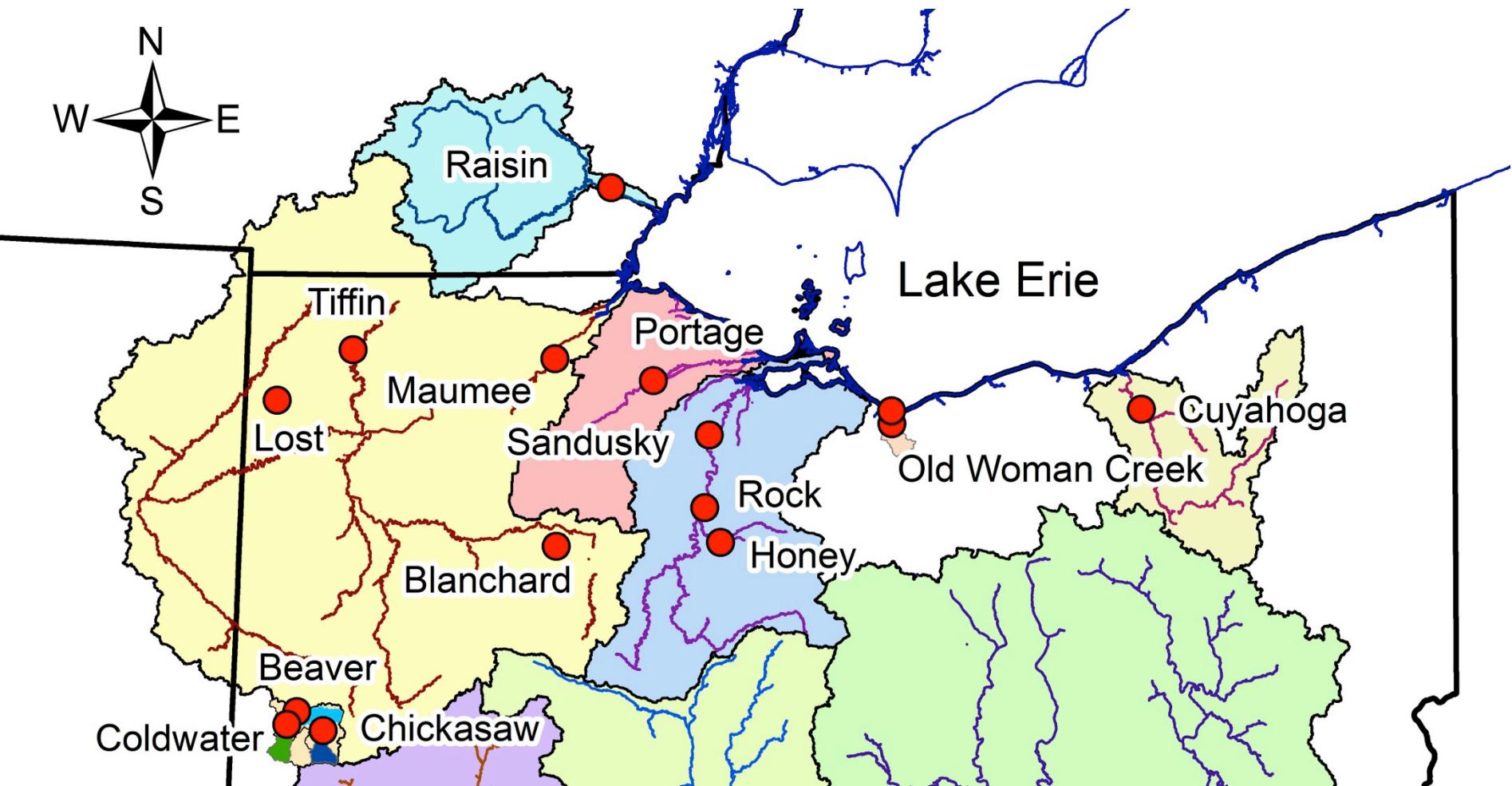
- No significant differences using a two-way ANOVA with river and sample type as factors ( $P=0.90$ )

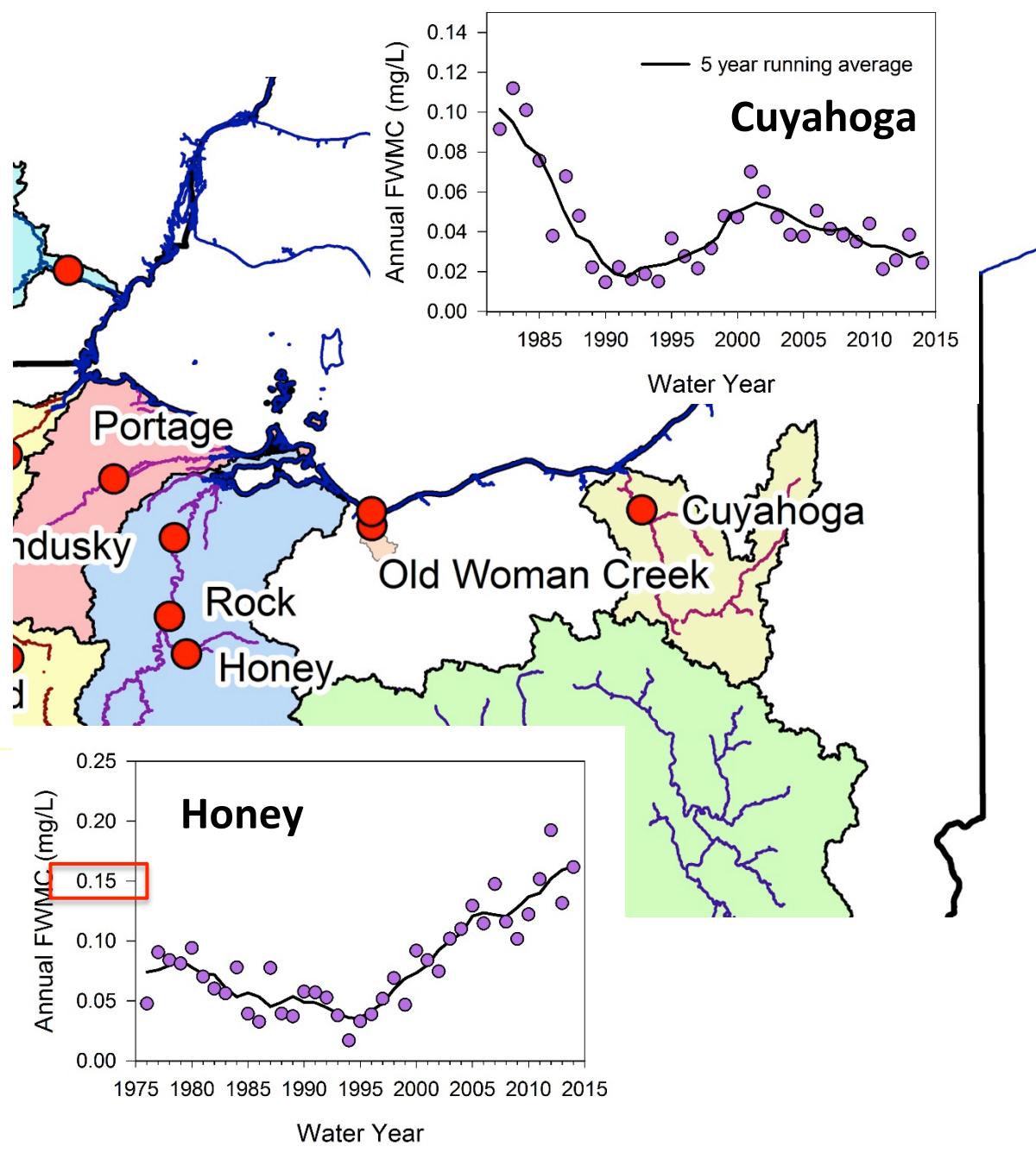
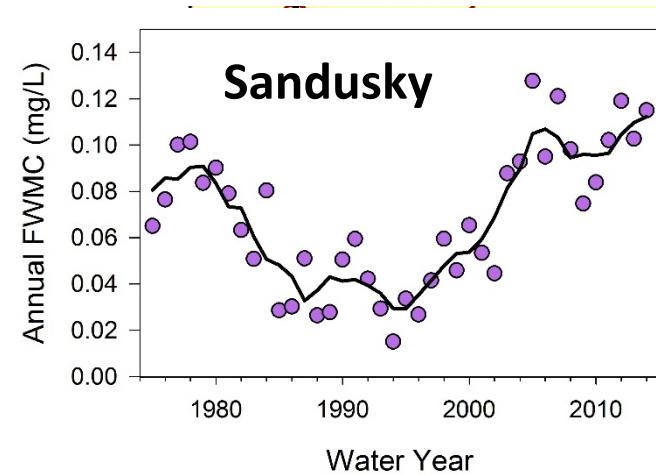
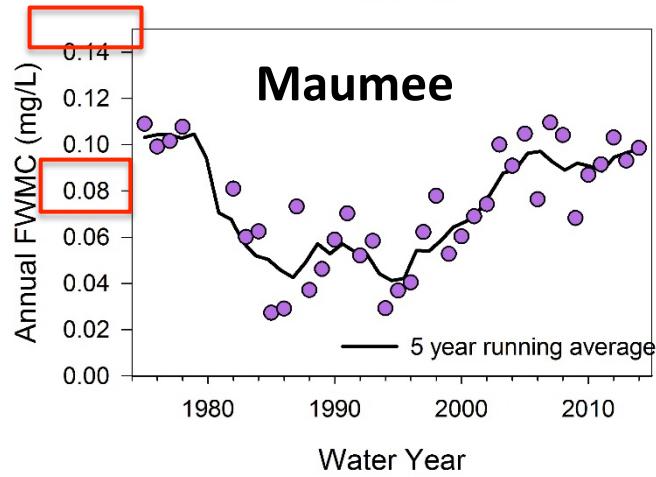
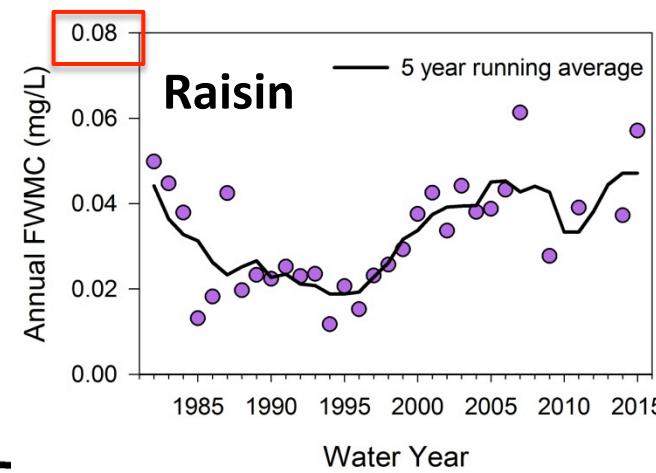


Maumee is the largest tributary to any of the Great Lakes

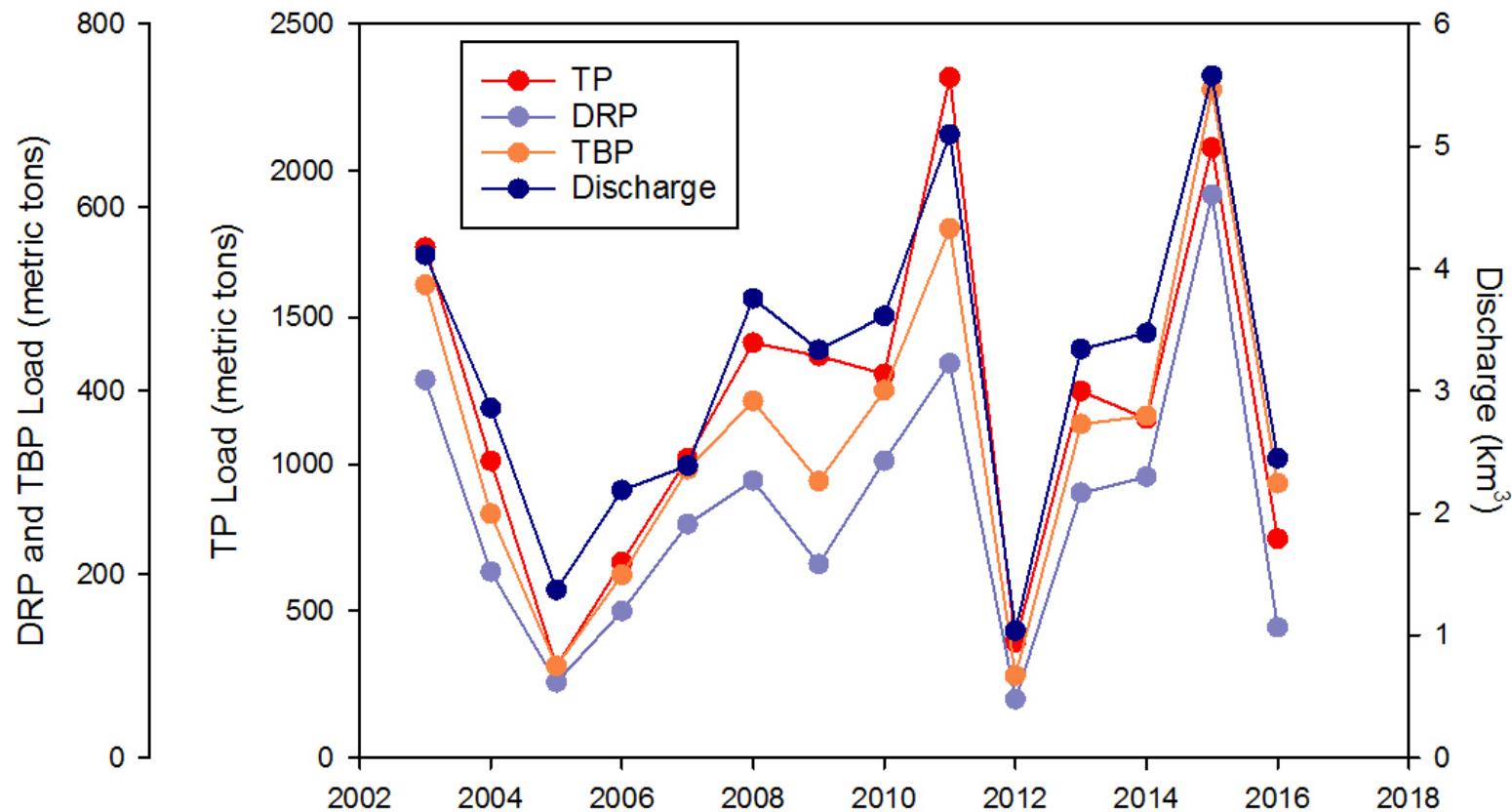
# Maumee River trends



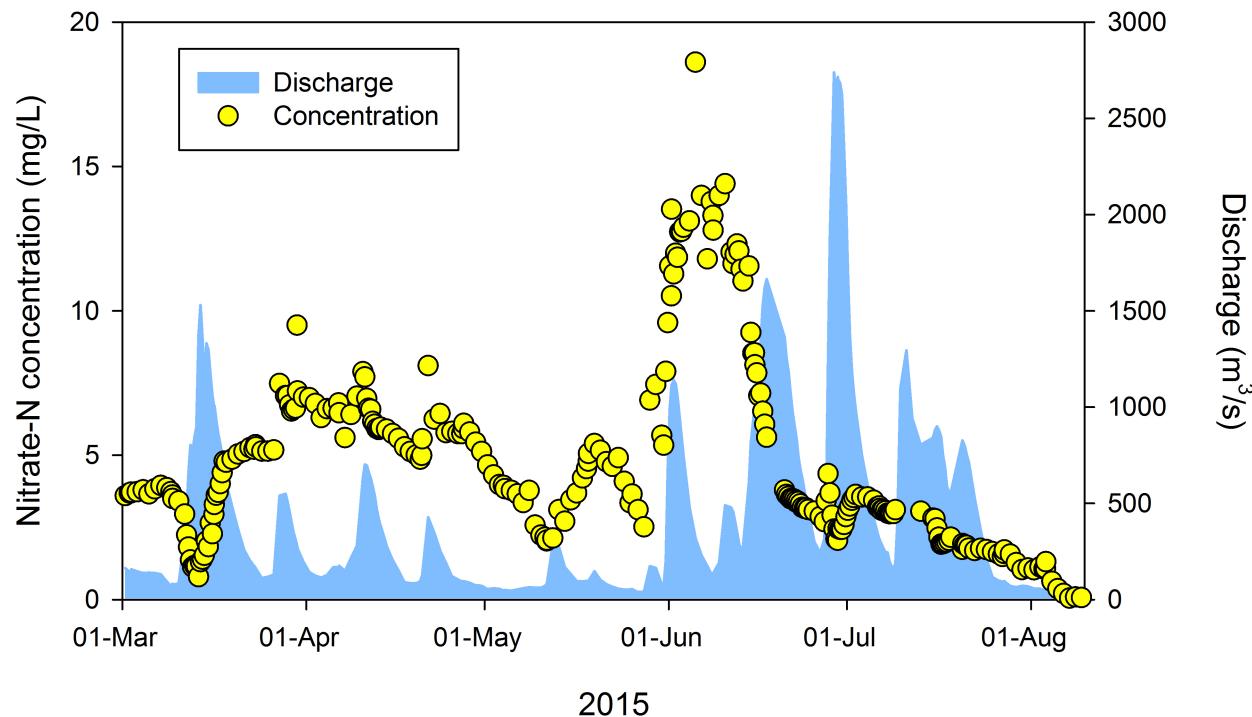


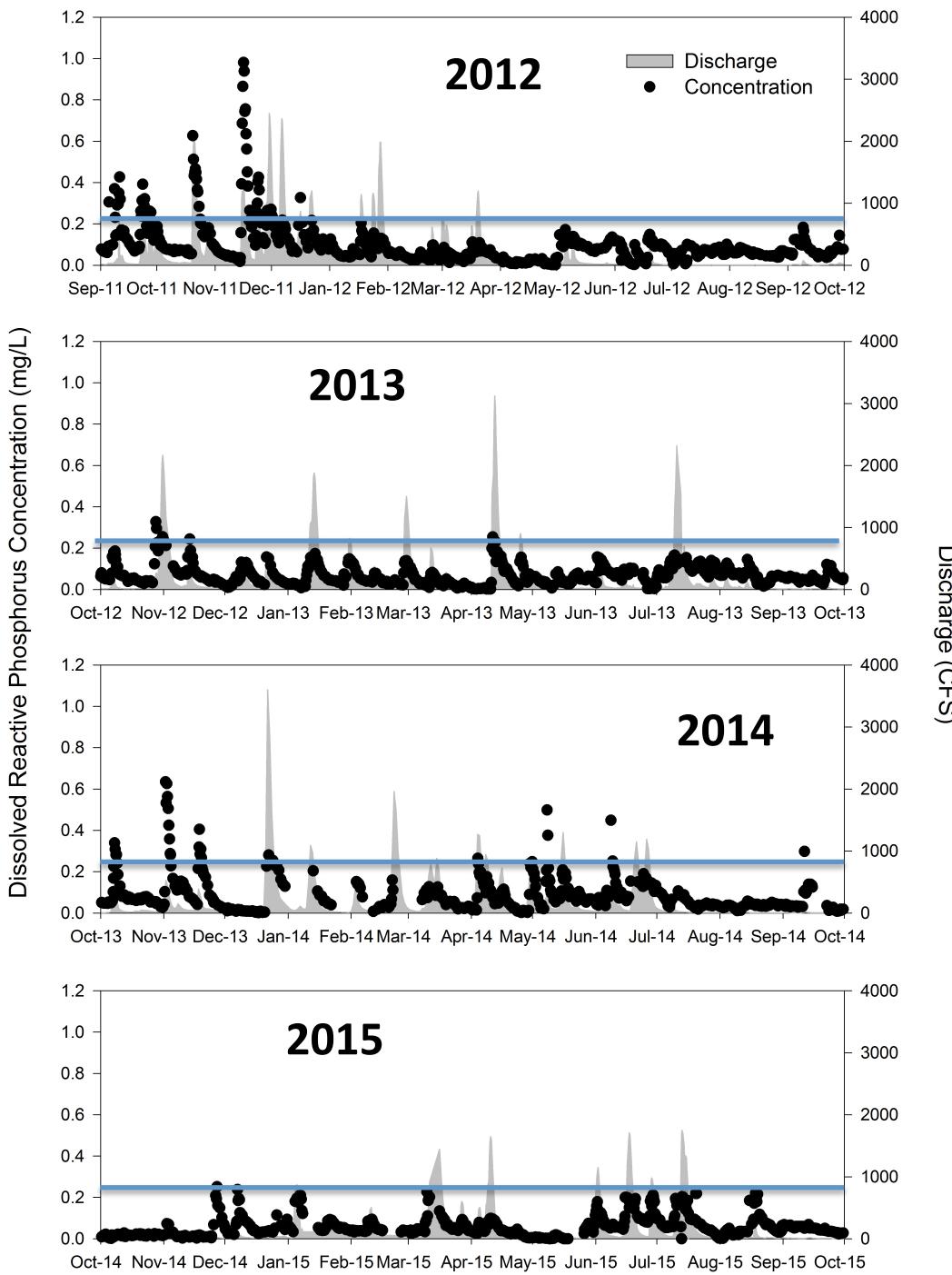


# Maumee River P loads vary with discharge indicating strong hydrologic control on runoff



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



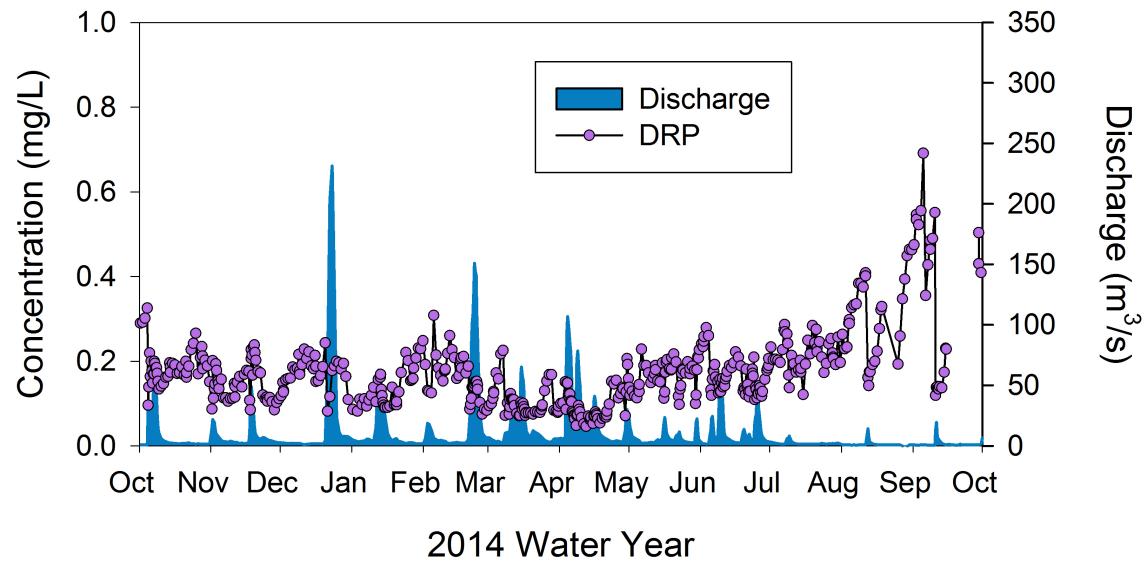


Chronic edaphic losses are prevalent

Honey Creek  
2012-2015

Indicates a large source in soils  
Either P stratification is prevalent  
OR  
STP recommendations are too high  
Or both!

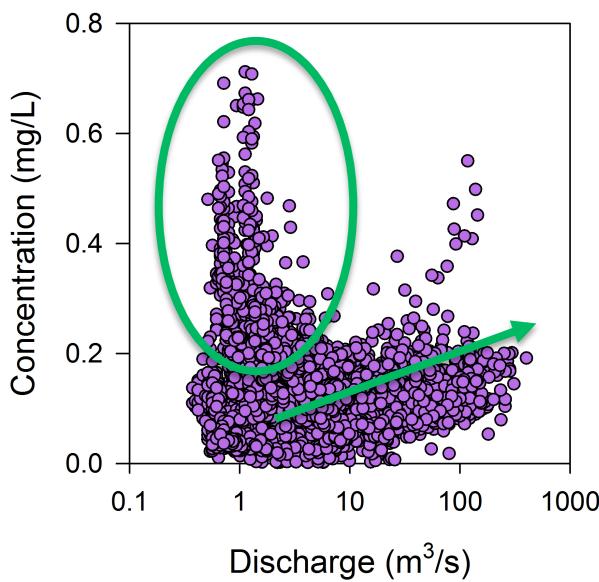
## Dissolved Reactive Phosphorus chemograph



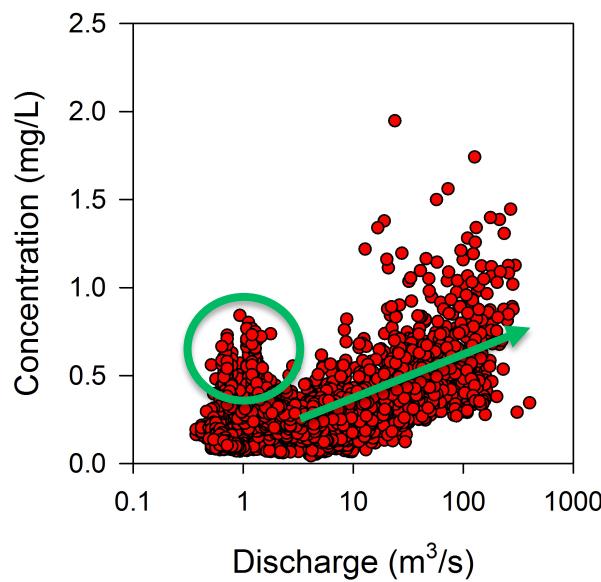
# Influence of point sources

*Blanchard River  
2014 WY*

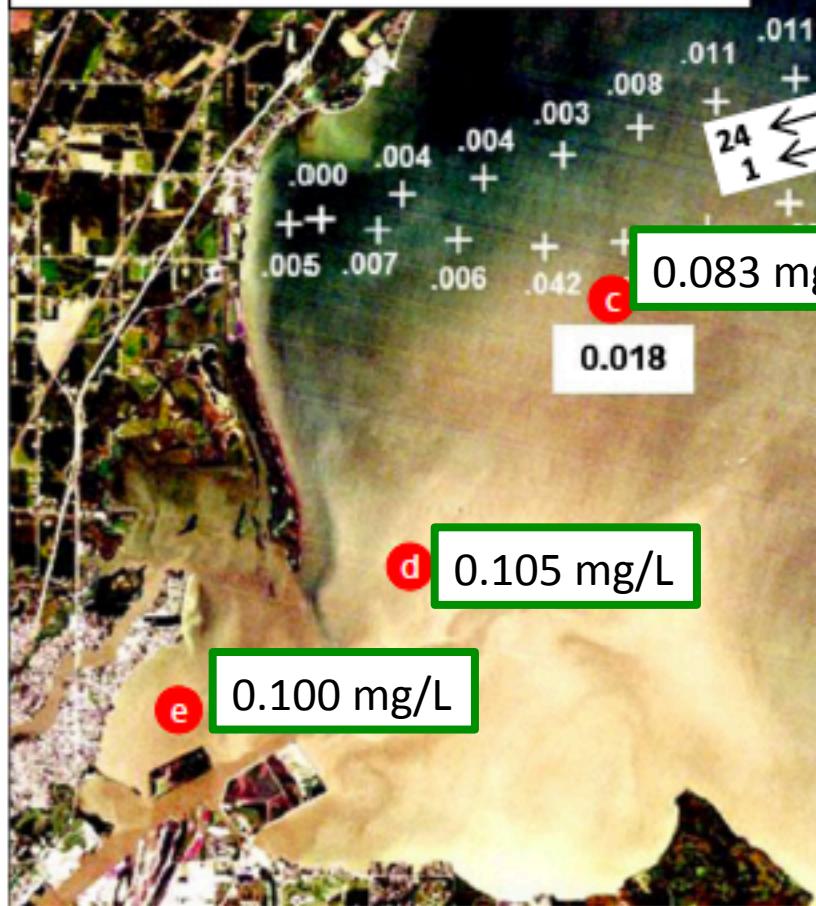
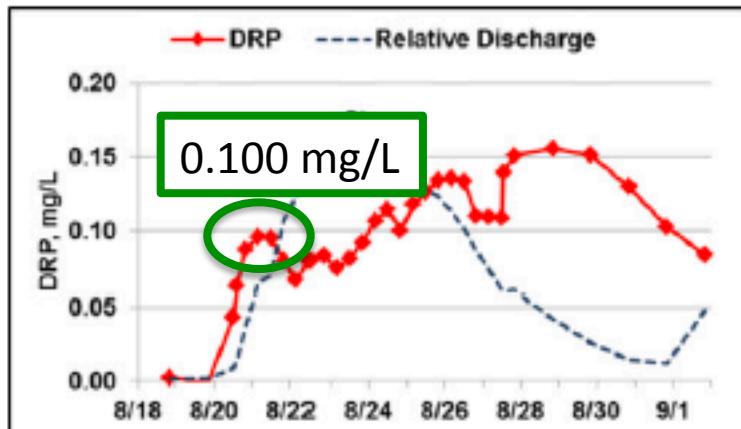
Dissolved Reactive Phosphorus



Total Phosphorus



But high concentrations are at low flow and contribute little to loads and is attenuated rapidly

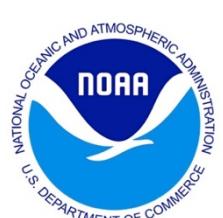


# Putting it all together

- We can measure DRP with the purpose of calculating loads
- DRP loads have been increasing in all HTLP monitoring agricultural Lake Erie watersheds
- Sources of DRP appear to be chronic indicating a large source pool
- The primary DRP source in urban areas is WWTP effluent, which attenuates rapidly downstream
  - More research is warranted in residential areas (and coming soon!)
- DRP in storm plumes do not appear to change until mixing with lake water in Maumee Bay, whereas a majority of PP settles

# Heidelberg Tributary Loading Program – Current Sponsors

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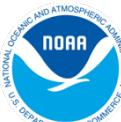
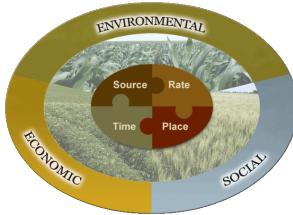


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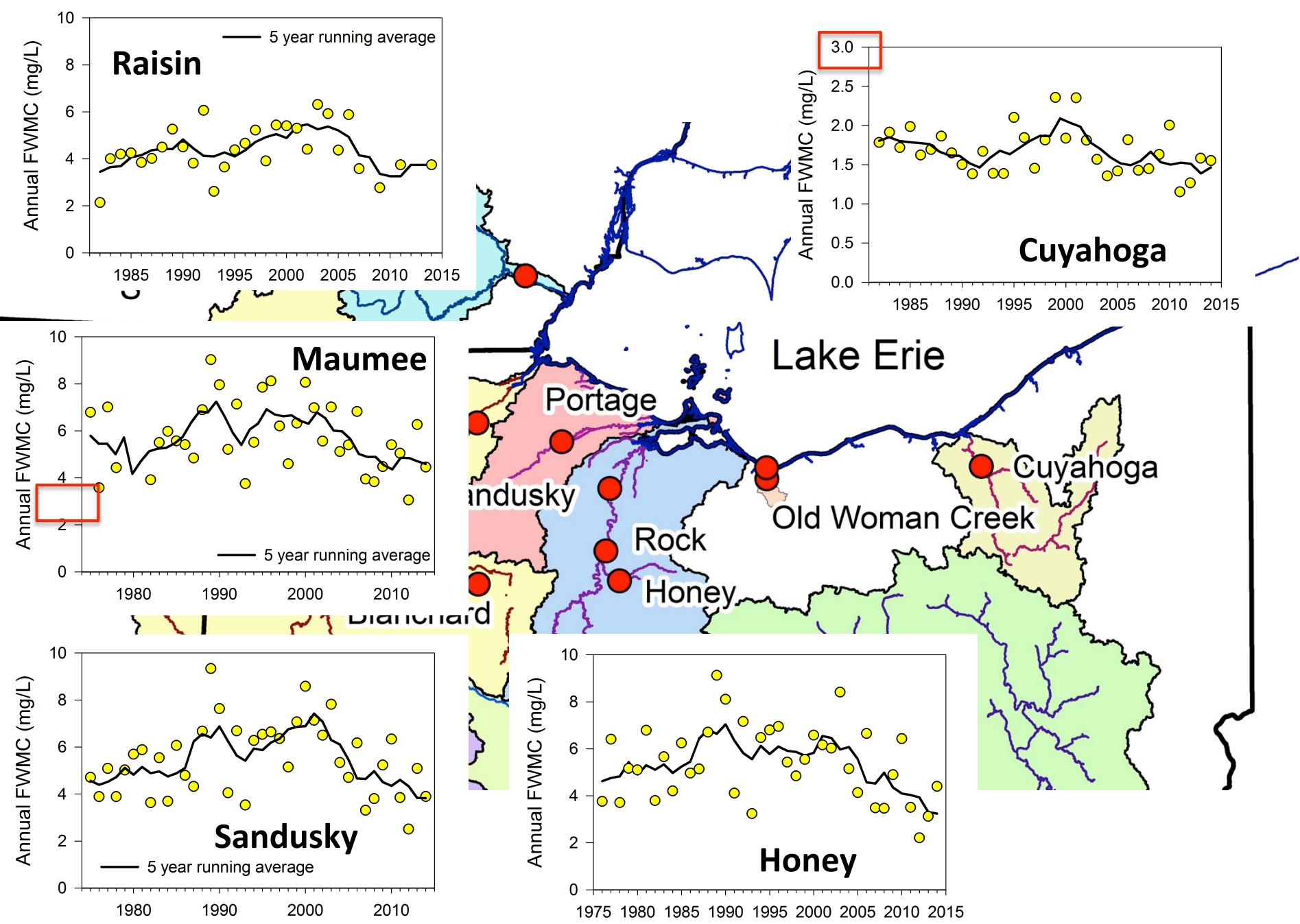
Or contact me at [ljohnson@heidelberg.edu](mailto:ljohnson@heidelberg.edu)



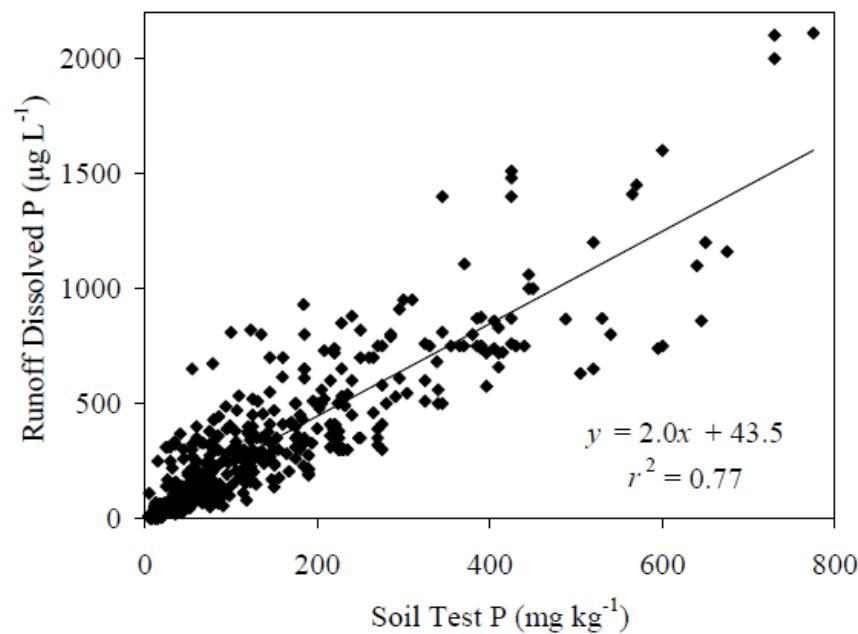
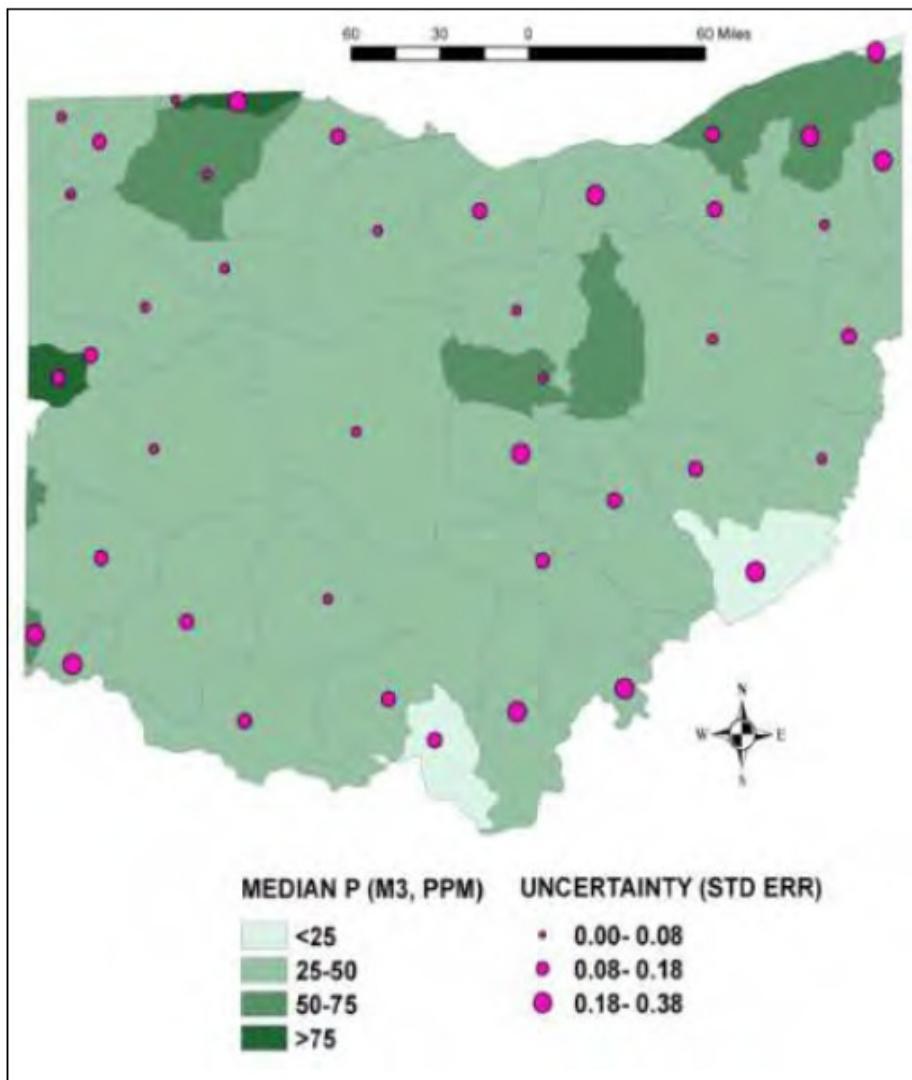
<http://www.facebook.com/NCWQR>

Questions?

LAKE ERIE ALGAE.COM



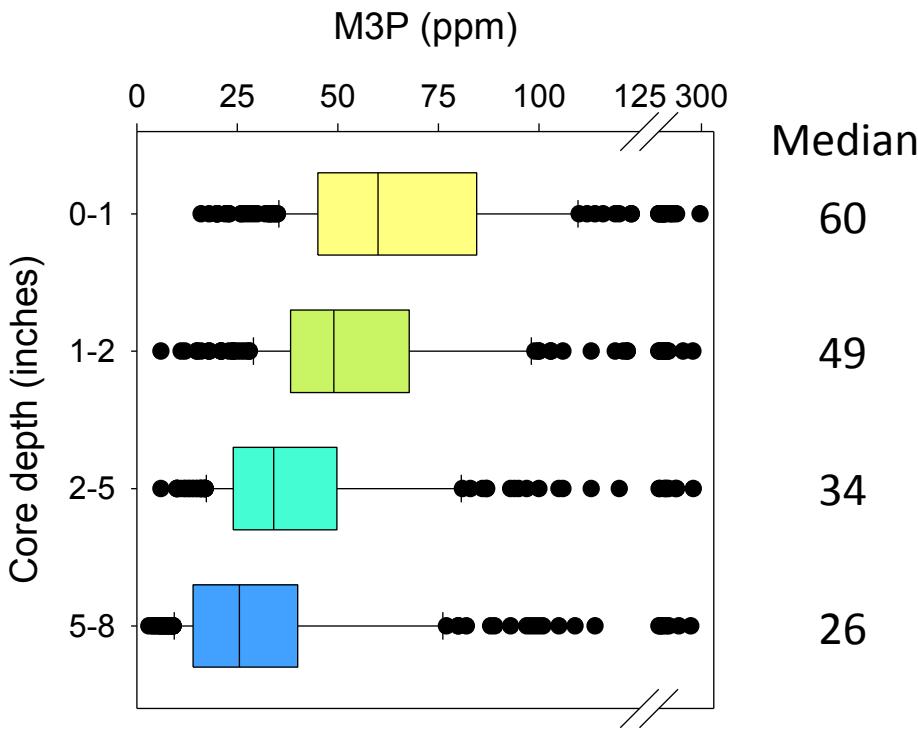
# Is soil P high indicating over application of fertilizer or manure?



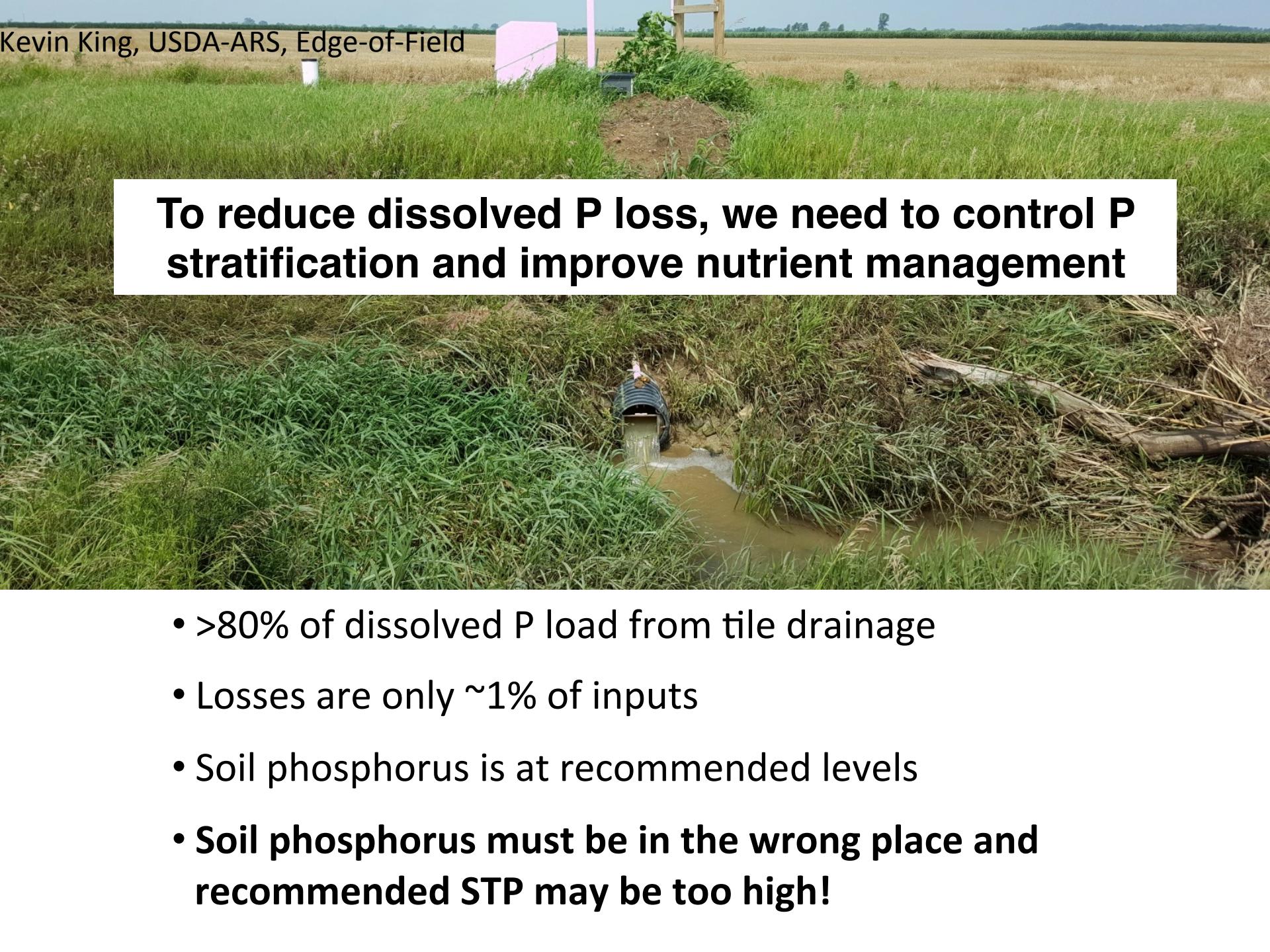
*From Vadas et al. 2005*



# Soil test P at varying depths across the Sandusky River watershed



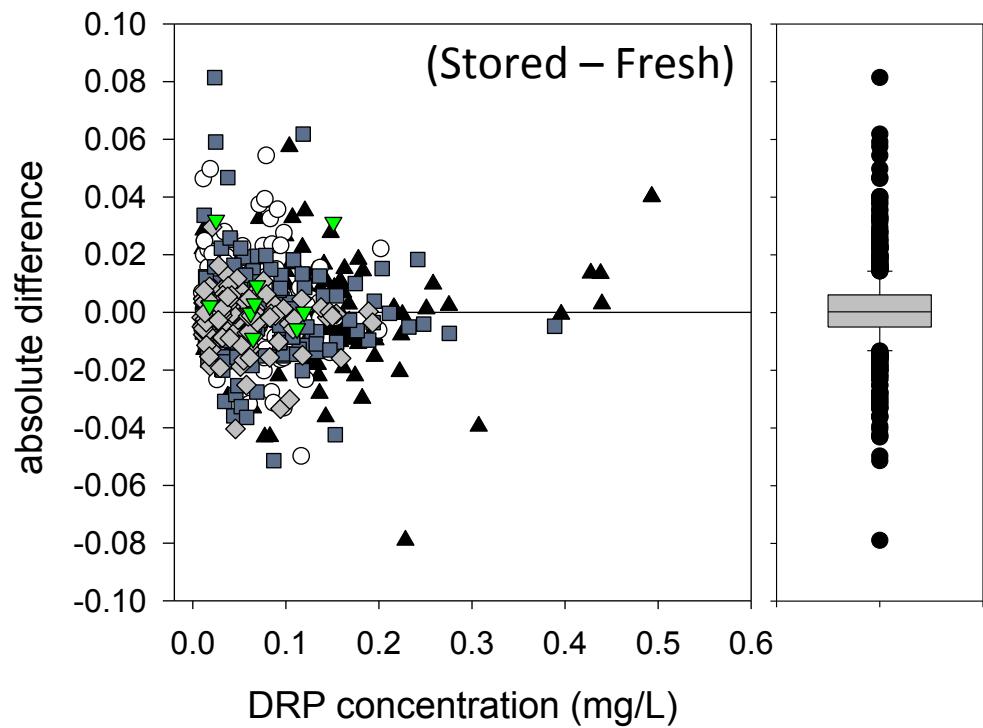
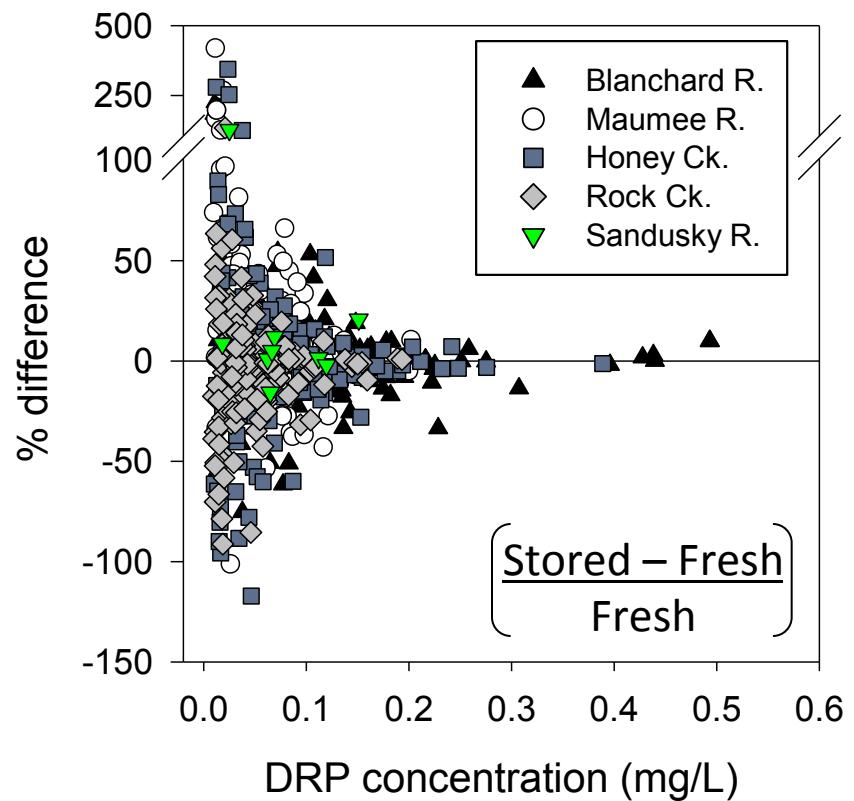
- Stratification evident even in the top 1" of soil (ANOVA,  $P<0.001$ ,  $n=232$ )
- If we reduced the top 2" to the mean of the 8" core, we'd reduce the risk for runoff by 28%



To reduce dissolved P loss, we need to control P stratification and improve nutrient management

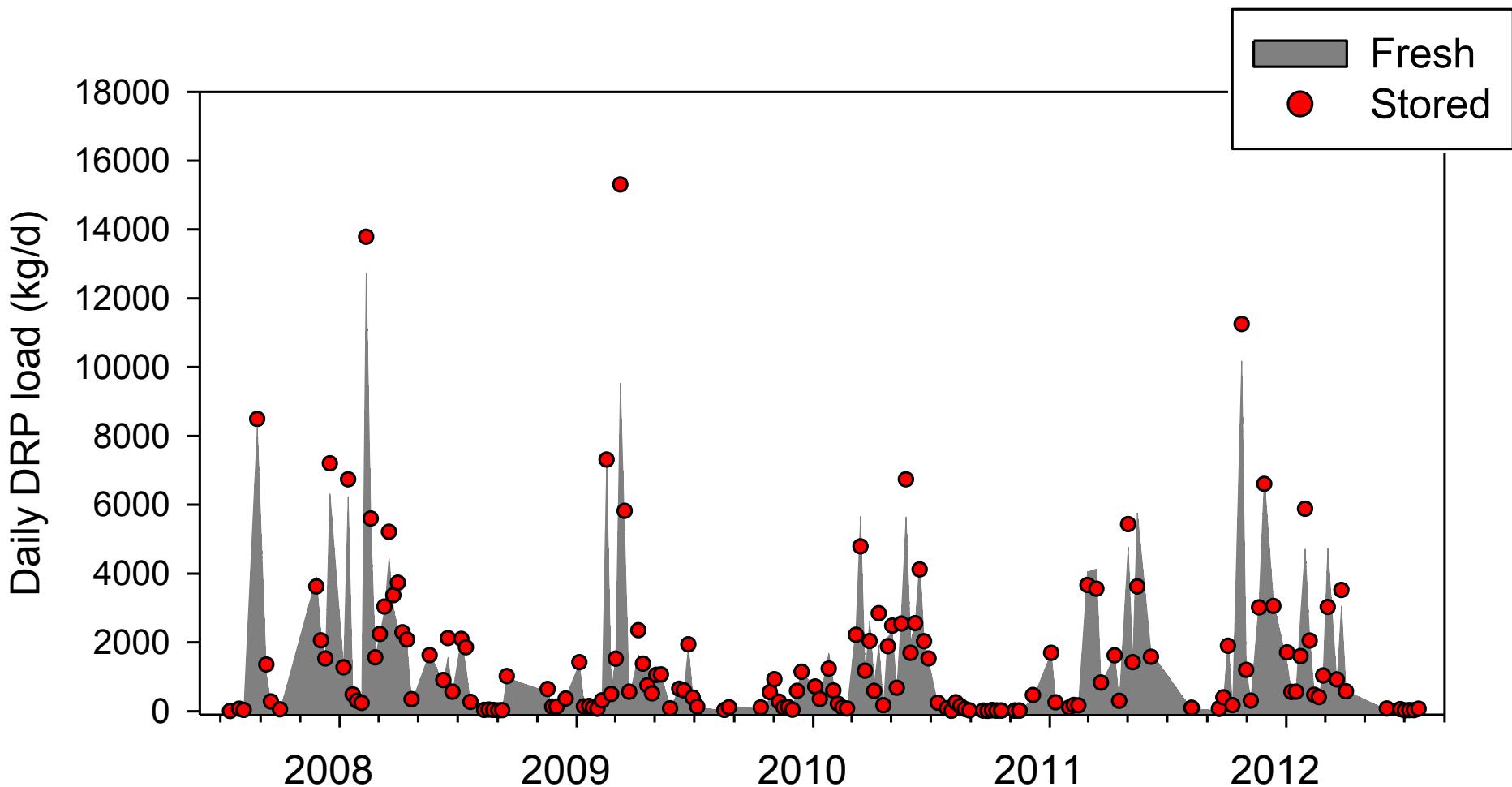
- >80% of dissolved P load from tile drainage
- Losses are only ~1% of inputs
- Soil phosphorus is at recommended levels
- **Soil phosphorus must be in the wrong place and recommended STP may be too high!**

# DRP concentration



- Largest deviations are when concentrations are low
- 80% of the data are within 0.02 mg/L

# Daily DRP load in the Maumee



# There are instances of acute runoff *Honey Creek in Fall 2011*

