

An Overview of External Phosphorus Loading to Lake Erie

**Ohio Lake Erie Phosphorus Task Force
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Outline: An Overview of Phosphorus

Phosphorus Sources: external and internal

Phosphorus Sources: point and nonpoint

Phosphorus Forms: dissolved and particulate

Phosphorus Bioavailability: high to low, positional

Phosphorus Inputs: pulsed and steady

Some Trends in the Above: an overview

Lake Erie Phosphorus Sources

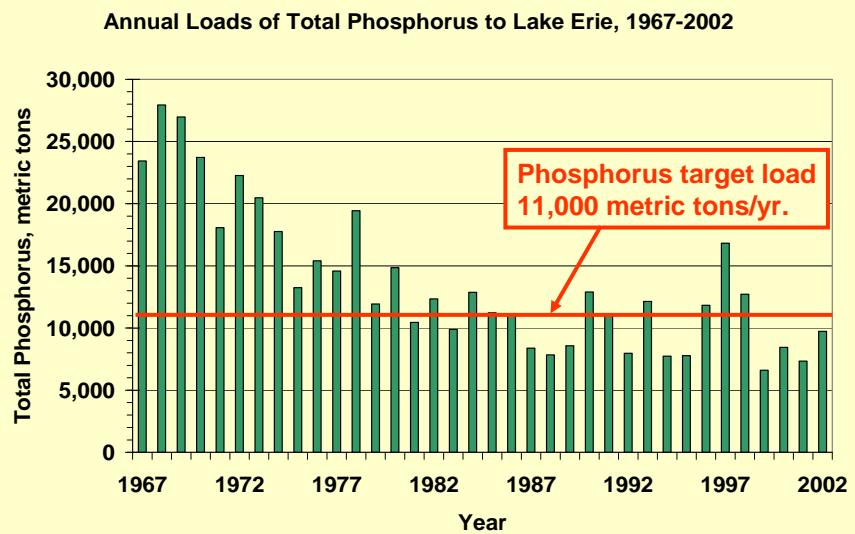
External Loads

Phosphorus that enters Lake Erie from the atmosphere, the Upper Lakes, or the Lake Erie watershed.

Internal Loads

Phosphorus released from bottom sediments, as mediated by chemical, physical and biological processes.

Total External Phosphorus Loading to Lake Erie

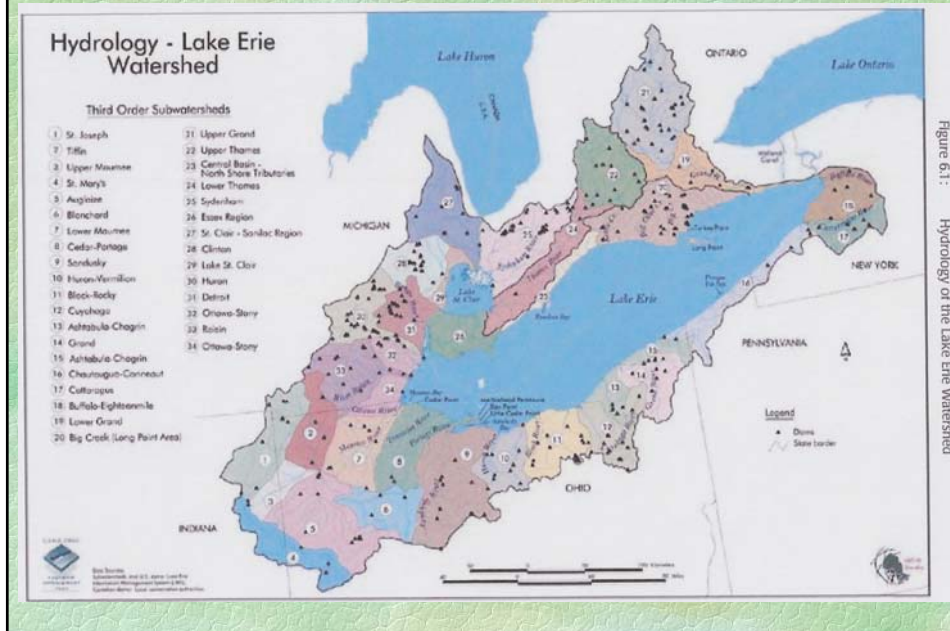


Lake Erie Phosphorus Sources

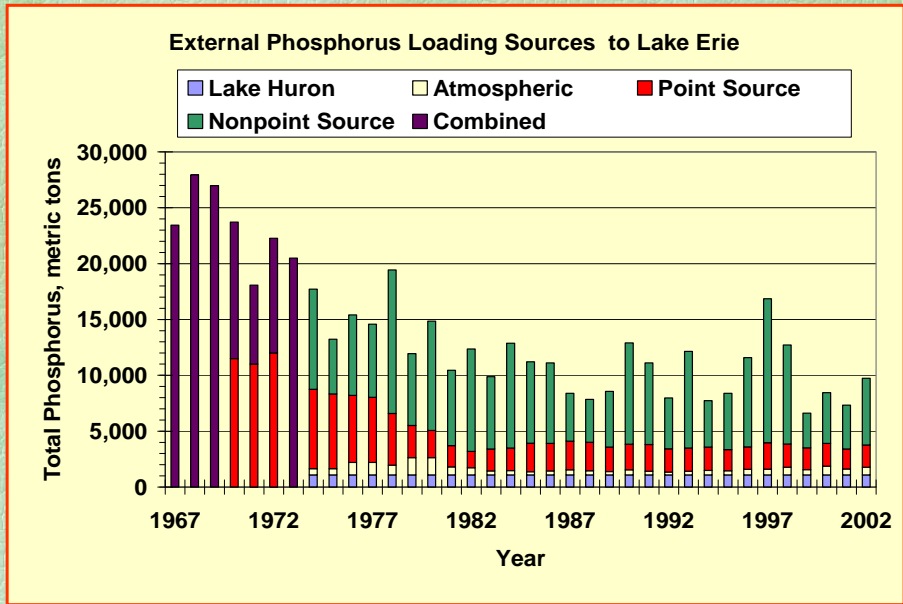
External Loads

1. Lake Huron output
 2. Atmospheric deposition
- (From Lake Erie Watershed)
3. Point Sources – associated with municipal and industrial water use
 4. Nonpoint Sources – associated with land use activities

Sources of External Phosphorus: The Lake Erie Watershed



External Phosphorus Loading by Source



How do we measure external phosphorus loading?

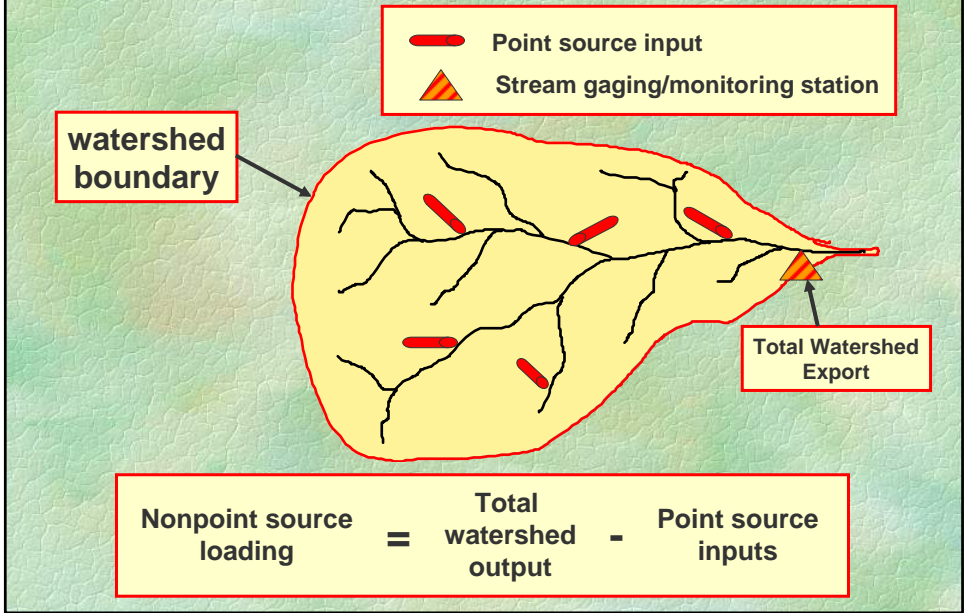
Lake Huron – outflow and concentration

Atmospheric Deposition – from deposition network

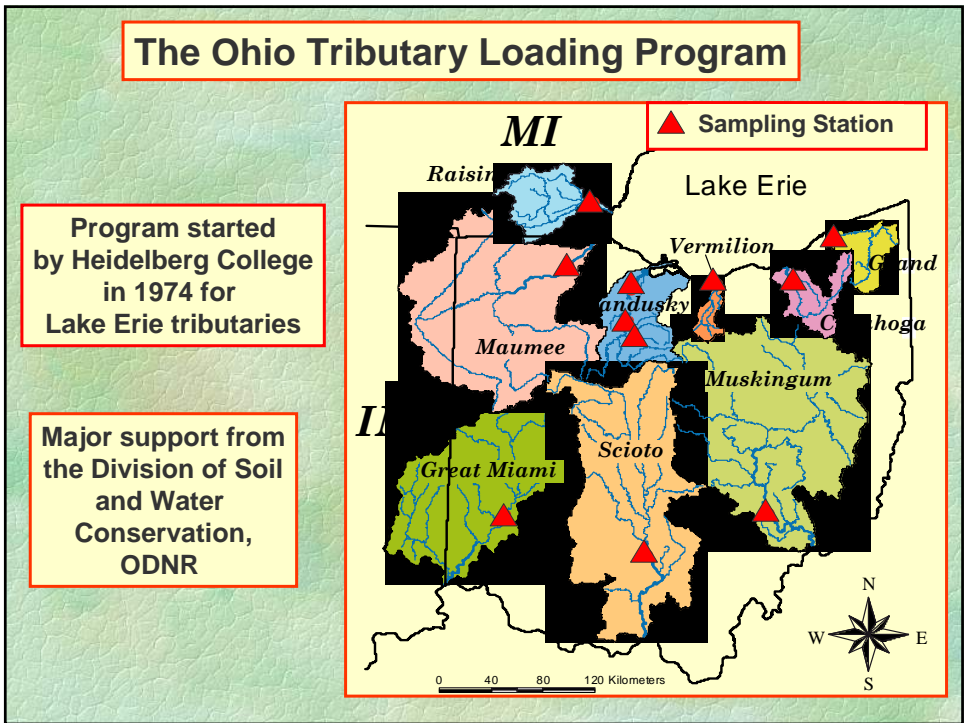
Point sources – from point source reporting systems
(NPDES permits in U.S.)

Nonpoint sources – watershed export/tributary monitoring programs
and extrapolations to unmonitored areas

The watershed approach for quantifying nonpoint phosphorus loading



The Ohio Tributary Loading Program



Phosphorus Forms: Dissolved and Particulate

Phosphorus Forms

Total Phosphorus (TP)

Dissolved Phosphorus

Particulate Phosphorus (PP)

Phosphorus Bioavailability

Phosphorus Forms

Total Phosphorus (TP) -

Dissolved Phosphorus

dissolved reactive phos. (DRP) --

dissolved hydrolyzable phos. (DHP) --

total dissolved phosphorus (TDP) --

dissolved organic phosphorus) -

Particulate Phos. (PP)-

NaOH extractible PP

Bioavailability varies among phosphorus forms and sources.

Bioavailability by Phosphorus Source

Point Sources (mostly municipal sources)

- Mostly dissolved reactive phosphorus
- Highly bioavailable

Nonpoint sources (mostly agricultural sources)

- Mostly particulate (attached to inorganic sediments)
- Particulate phosphorus ranges from 10-30% bioavailable
- Dissolved component is mostly dissolved reactive phosphorus and is highly bioavailable.

Timing of Phosphorus Inputs

Point sources

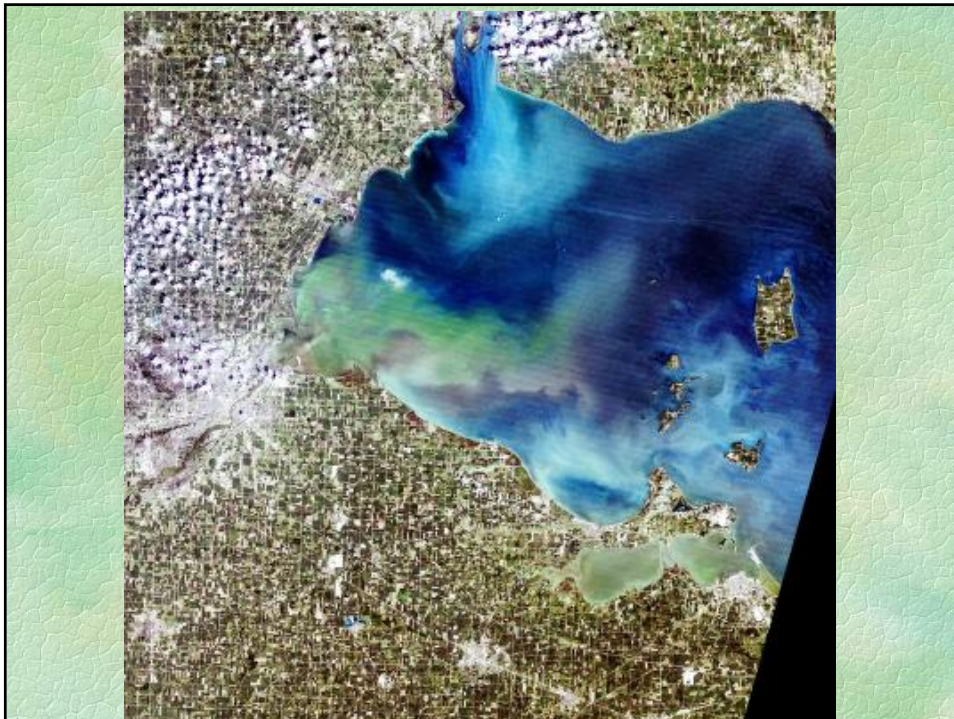
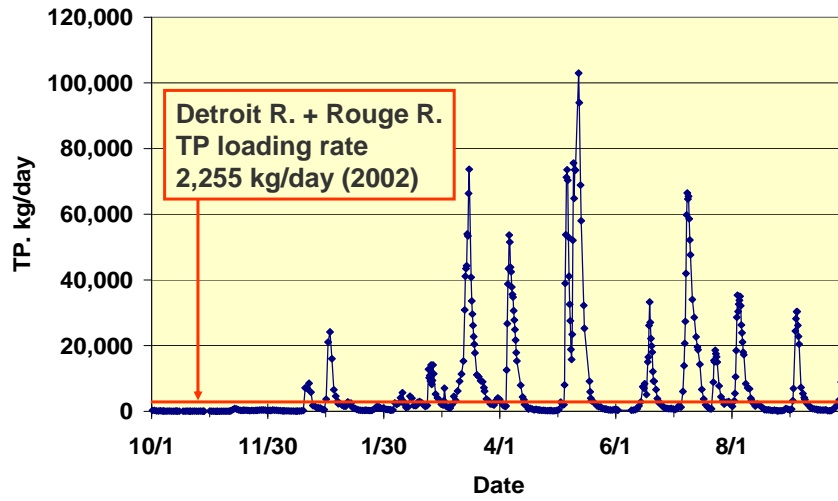
- Steady (approximately equal daily loading from waste treatment plants)

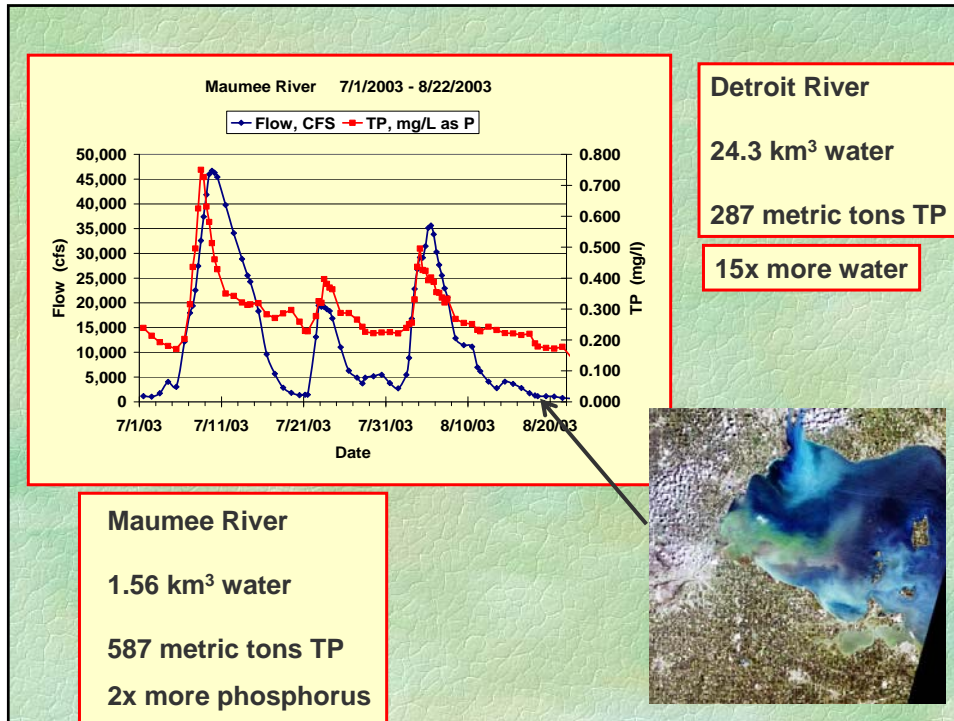
Nonpoint sources

- Pulsed inputs associated with rainfall/snowmelt runoff events
- High annual and seasonal variability

Maumee River, Phosphorus loading rate, 2003 water year

Maumee River, TP loading rate, 10/01/2002 - 09/30/2003





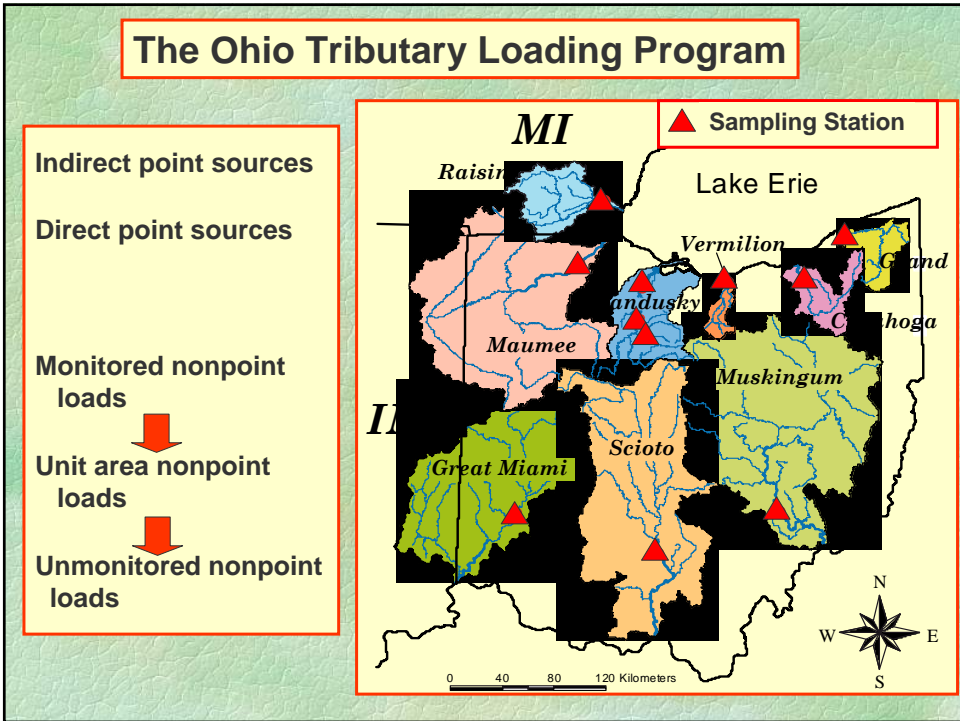
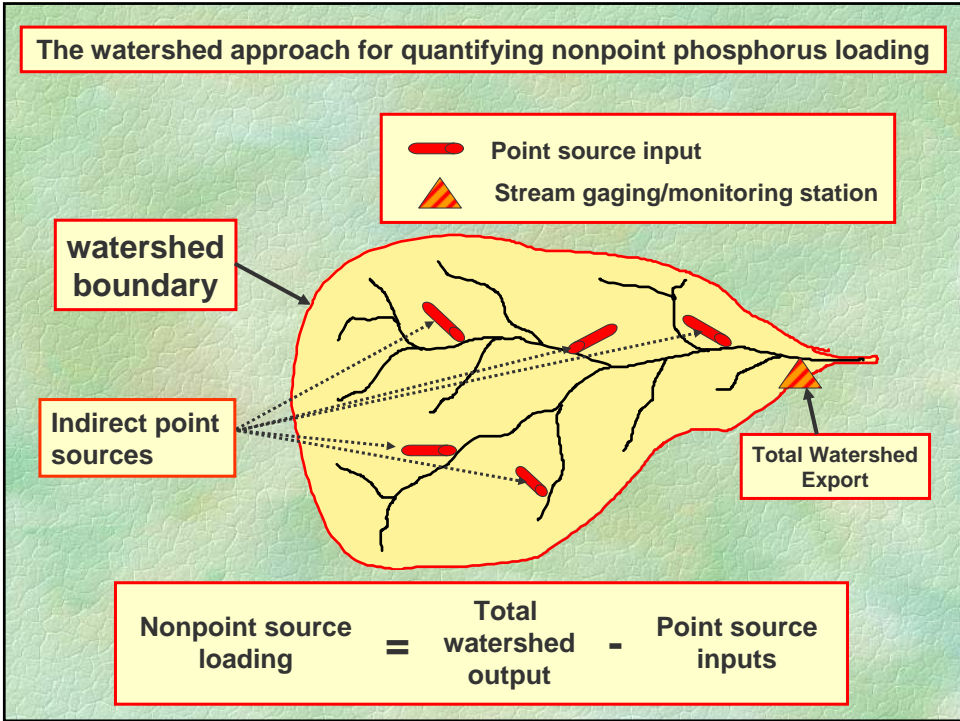
Additional definitions relative to Lake Erie loading calculations

Point Sources

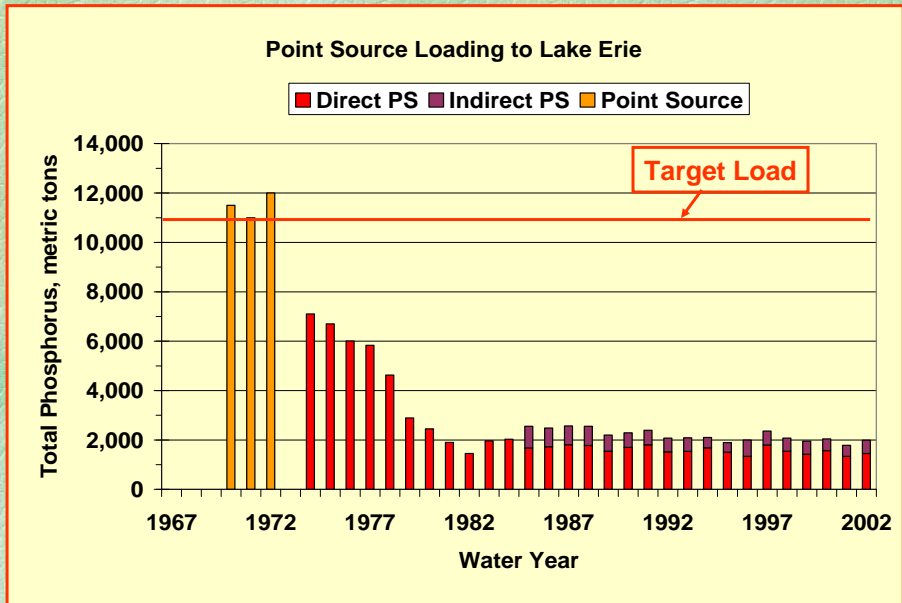
- A. Indirect – Point sources upstream from tributary loading stations
- B. Direct – All other point sources, i.e. point source that discharge into the lake, monitored tributaries downstream from the monitoring station or into any unmonitored stream.

Nonpoint Sources

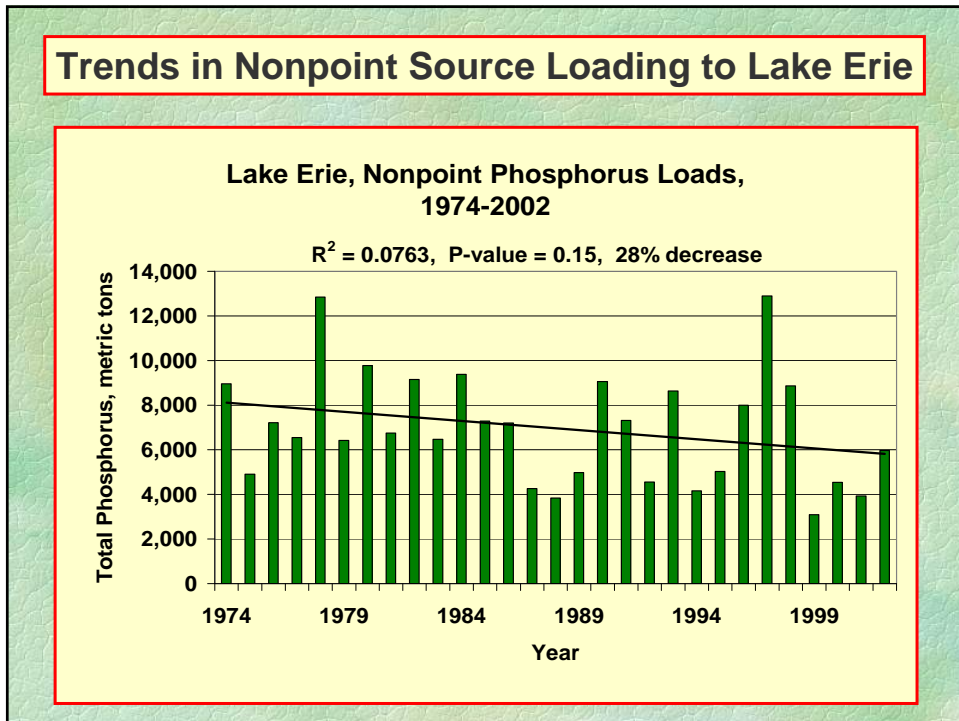
- A. Monitored
- B. Unmonitored (extrapolated from nearby monitored stations)



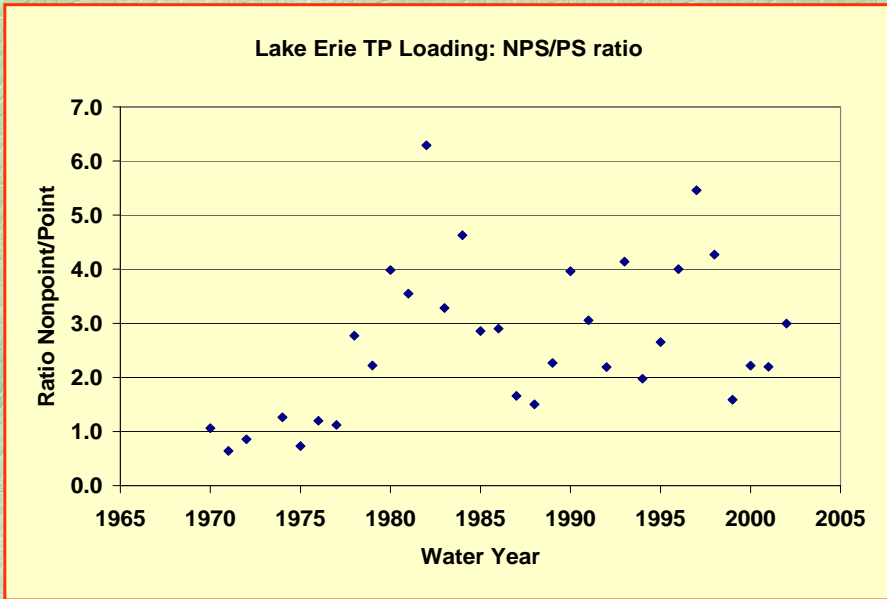
Trends in Point Source Loading to Lake Erie



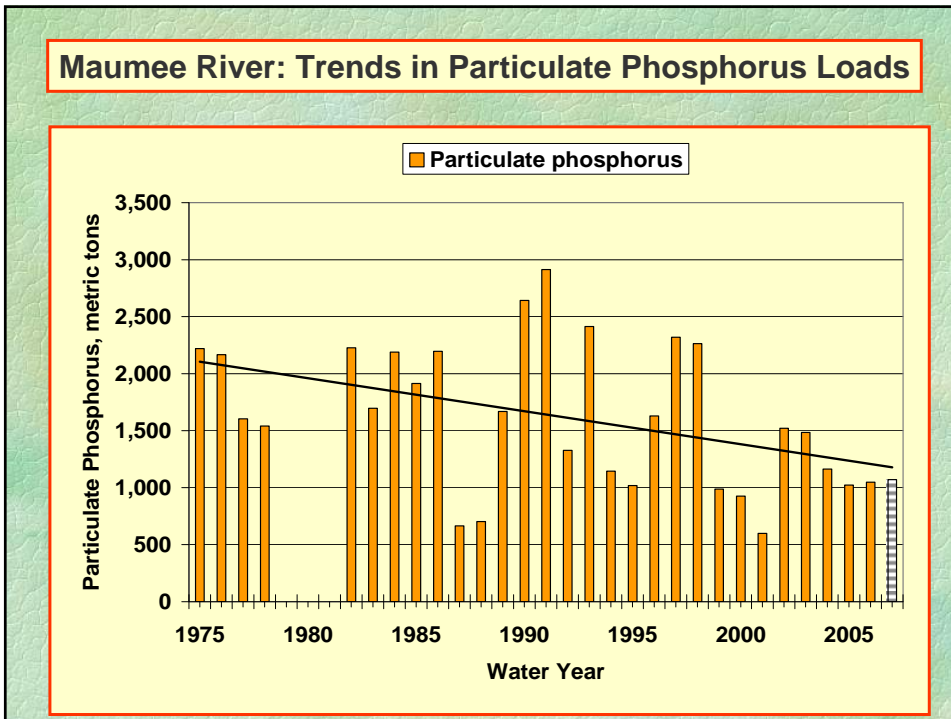
Trends in Nonpoint Source Loading to Lake Erie



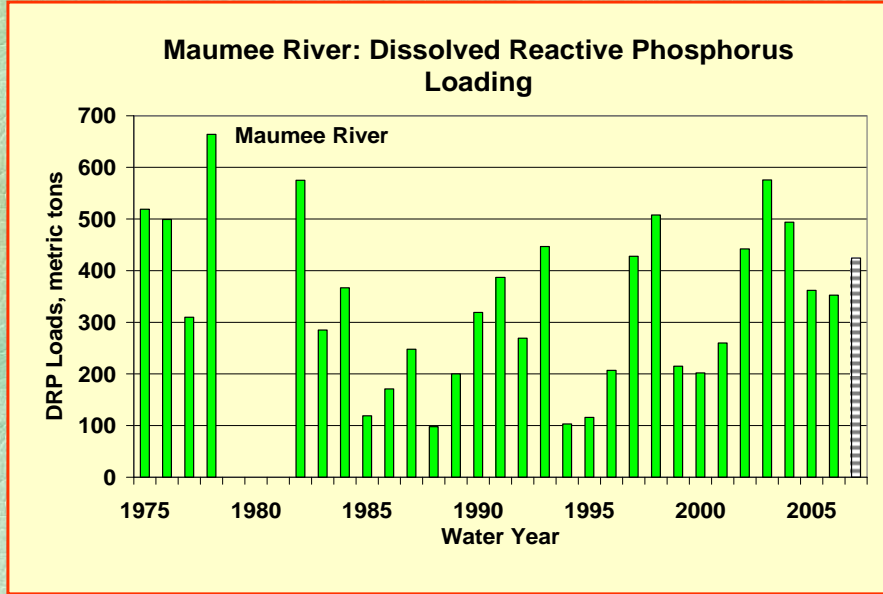
Trends in the ratio of nonpoint to point source loading



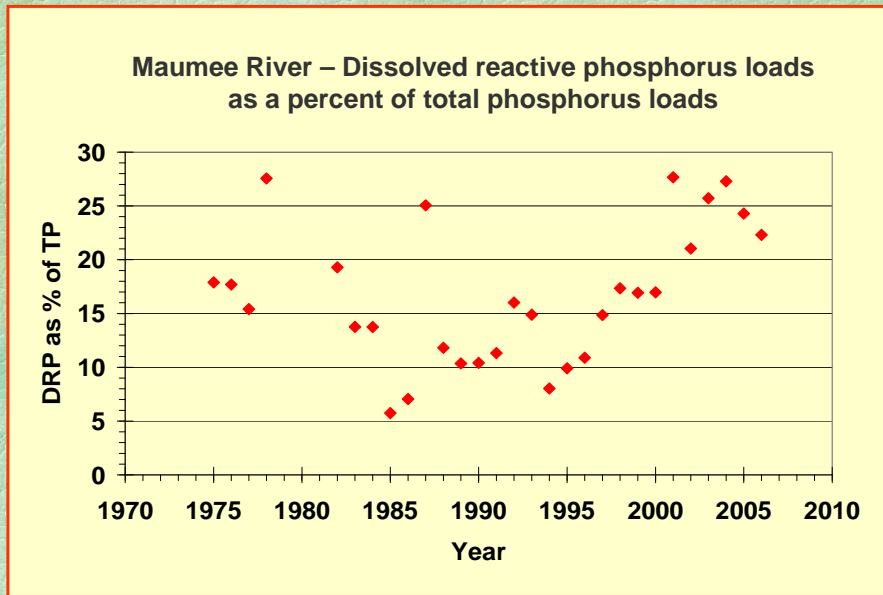
Maumee River: Trends in Particulate Phosphorus Loads



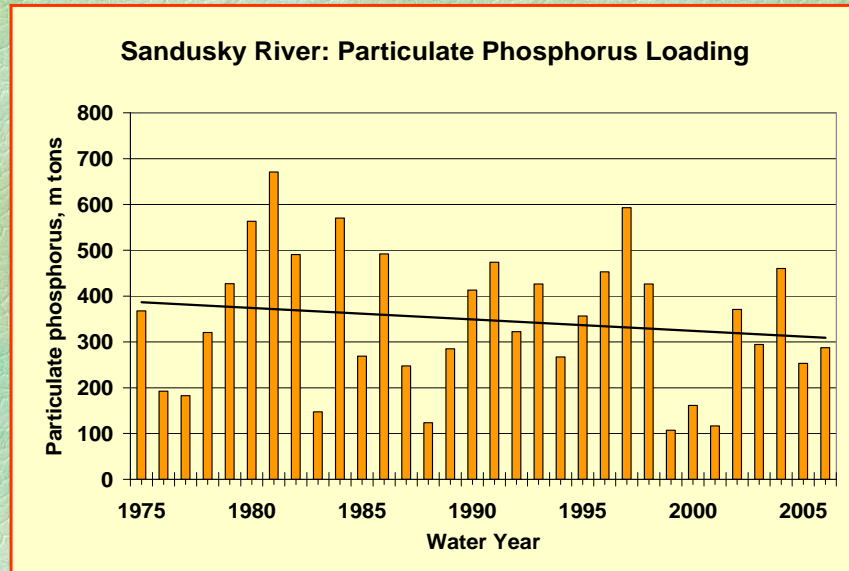
Maumee River: Trends in Dissolved Reactive Phosphorus Loads



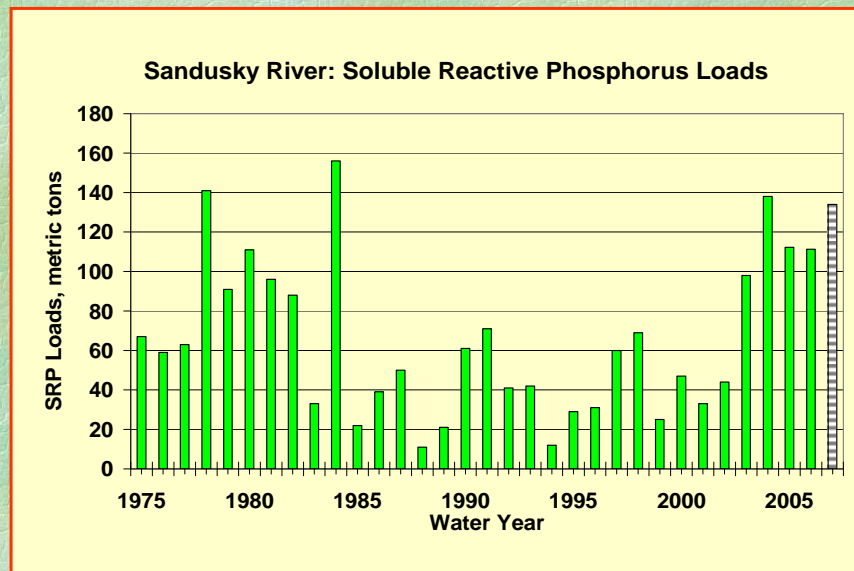
Maumee River – Trends in Dissolved Reactive Phosphorus as a percent of Total Phosphorus



Sandusky River – Trends in Particulate Phosphorus Loading

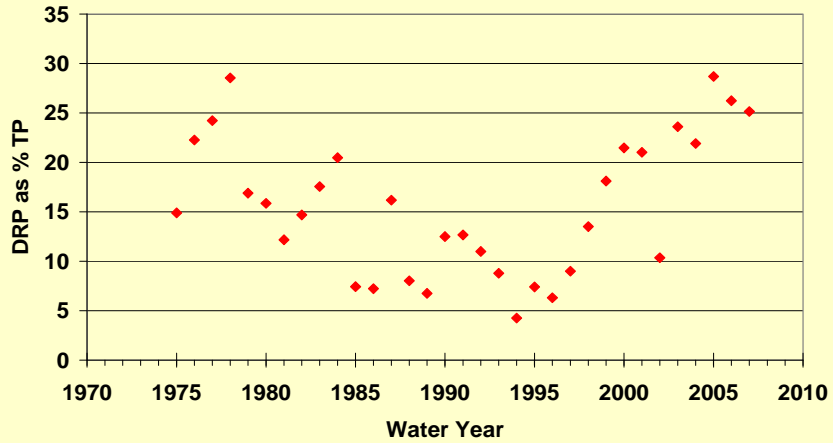


Sandusky River – Trends in Dissolved Reactive Phosphorus Loading



Sandusky River – Trends in Dissolved Reactive Phosphorus Loading as Percent of Total Phosphorus Loads

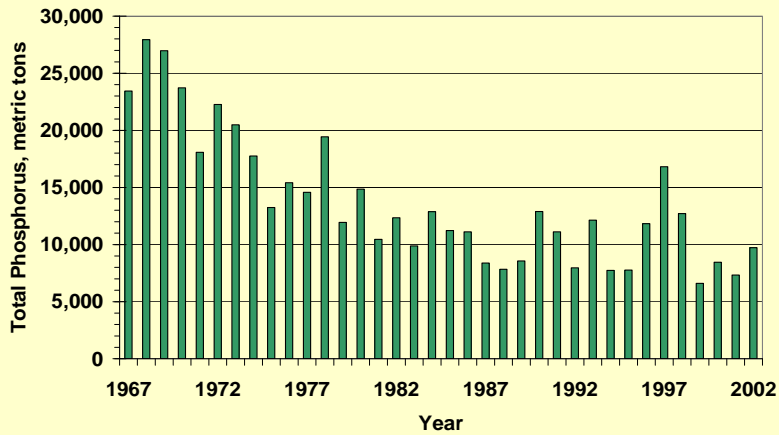
Sandusky River -- Dissolved Reactive Phosphorus as a Percent of Total Phosphorus



Some Conclusions

1. We probably need to look at more than simply total phosphorus loading to Lake Erie

Annual Loads of Total Phosphorus to Lake Erie, 1967-2002



2. Some of the changes in external loading

- a. Point sources had a rapid drop followed by slower declines.
- b. Total nonpoint loads have slowly declined since the late 1970s.
- c. The ratio of NPS to PS has increased greatly, as has the relative contributions of pulsed inputs.
- d. NPS particulate phosphorus has decreased slowly.
- e. NPS dissolved reactive phosphorus declined rapidly in the early years but has risen rapidly in recent years.
- f. In recent years tributary loads have a higher proportion of bioavailable phosphorus than in earlier years.

Questions

What do these changes in loading characteristics mean for Lake Erie?

Why has dissolved reactive phosphorus loading increased in recent years?

What can be done to reduce the dissolved reactive phosphorus loading... if it needs to be reduced?