Analyzing Data to Characterize Your Watershed

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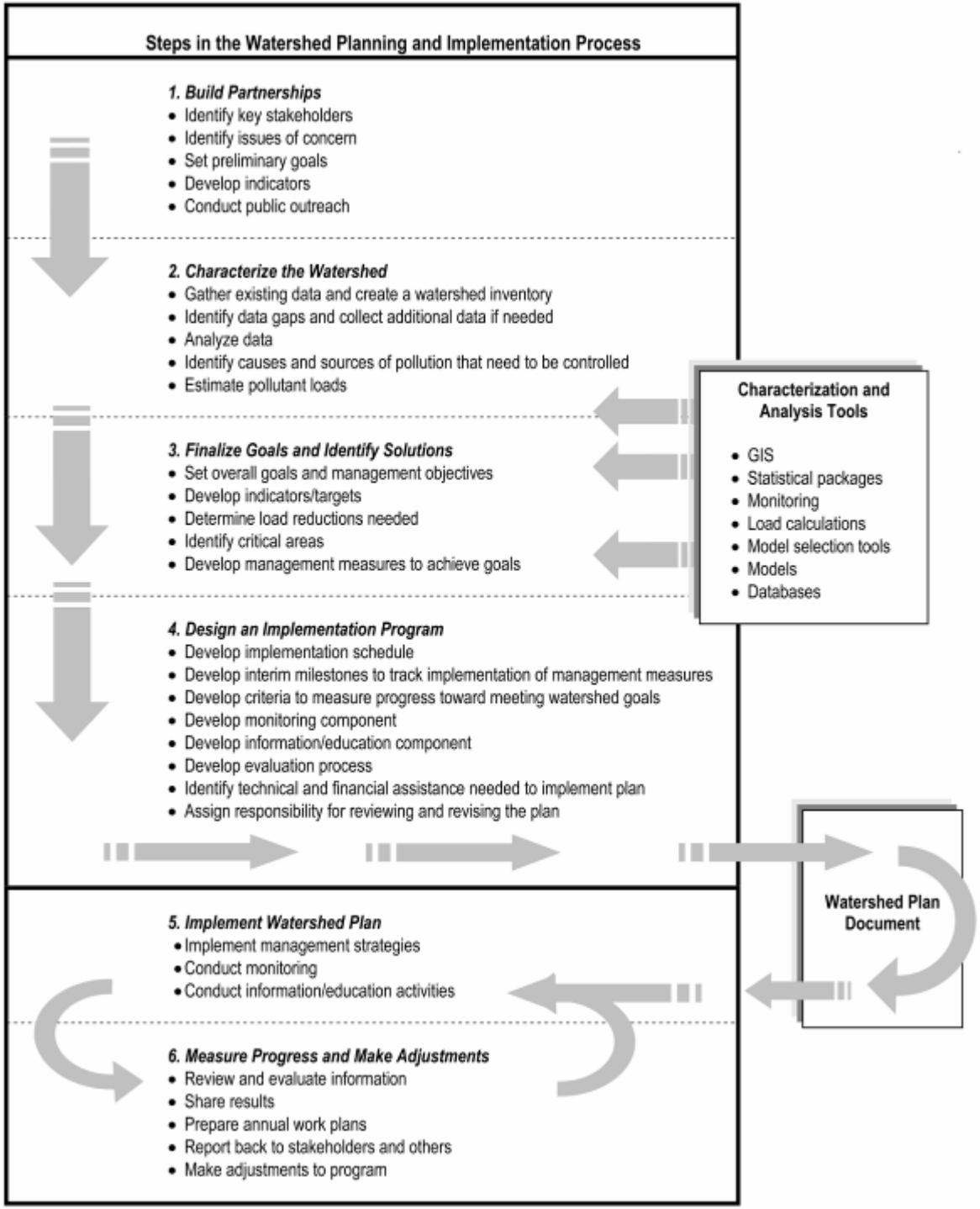
Steps in the Watershed Planning and Implementation Process



2. *Characterize the Watershed*

- Gather existing data and create a watershed inventory
- Identify data gaps and collect additional data if needed
- Analyze data
- Identify causes and sources of pollution that need to be controlled
- Estimate pollutant loads

3. *Finalize Goals and Identify Solutions*

- Set overall goals and management objectives
- Develop indicators/targets
- Determine load reductions needed
- Identify critical areas
- Develop management measures to achieve goals

Incorporation of the nine minimum elements

4. *Design an Implementation Program*

- Develop implementation schedule
- Develop interim milestones to track implementation of management measures
- Develop criteria to measure progress toward meeting watershed goals
- Develop monitoring component
- Develop information/education component
- Develop evaluation process
- Identify technical and financial assistance needed to implement plan
- Assign responsibility for reviewing and revising the plan

Scales of Management

Scale

Decisions

Sub-Field

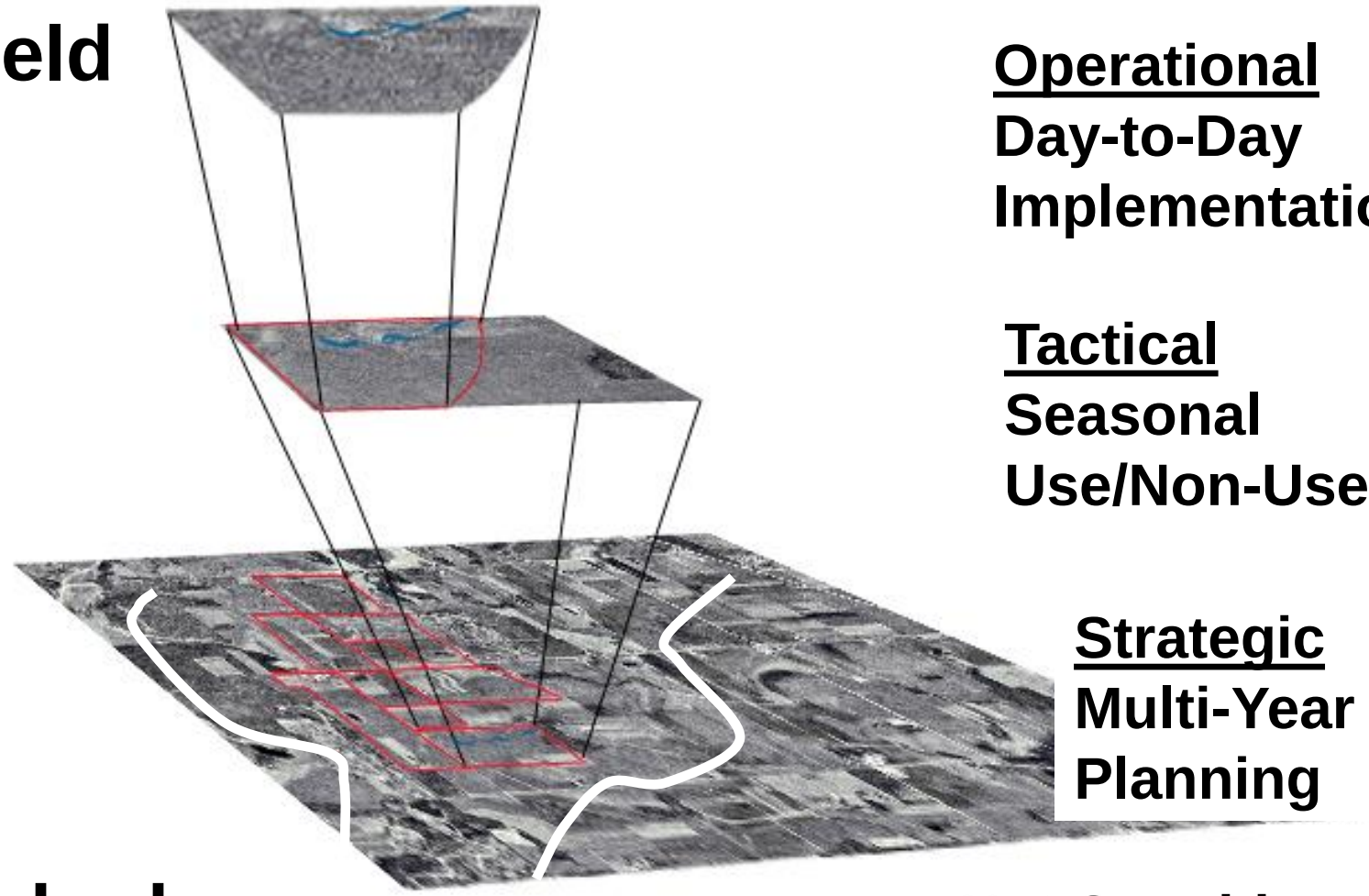
Operational
Day-to-Day
Implementation

Field

Tactical
Seasonal
Use/Non-Use

Farm

Strategic
Multi-Year
Planning



Watershed

Not Considered

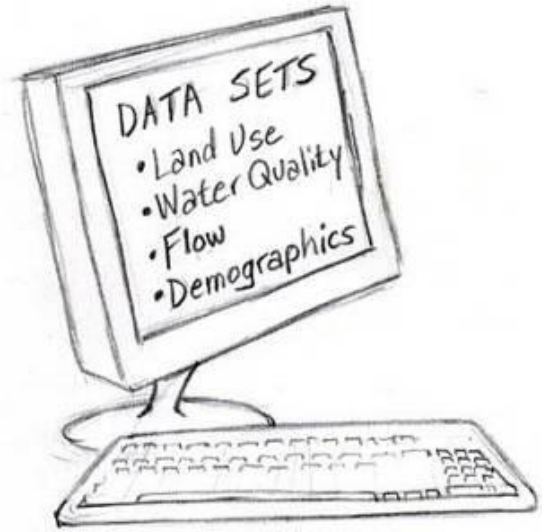
PLANNING

INPUTS	OUTPUTS		OUTCOMES		
Programmatic investments	Activities	Participation	Short	Medium	Long term

EVALUATION

Water quality info & analysis

- Water quality goals
  - Designated uses, WQ criteria
  - Restoration and protection goals
  - Flooding, aesthetics, others???
- Monitoring and assessment results
  - Desktop data mining, local monitoring results
  - ID impaired & threatened waters
- Key pollutants / stressors
  - Check 303(d); local monitoring/assessment
- Pollutant sources
  - From 303(d) or other assessment
- Current loads
  - Estimate, model, or otherwise quantify



Types of Data for Watershed Characterization

- **Physical and Natural Features**
  - Watershed boundaries
  - Hydrology (Seasonal, Peak Flow)
  - Topography
  - Soils
  - Climate
  - Habitat
  - Wildlife (turkey example)
- **Land Use and Population Characteristics**
  - Land use and land cover
  - Existing management practices
  - Demographics
- **Waterbody Conditions**
  - Water quality standards
  - 305(b) report
  - 303(d) list
  - TMDL reports
  - Source Water Protection Areas
- **Pollutant Sources**
  - Point sources
  - Nonpoint sources
- **Waterbody Monitoring Data**
  - Water quality data
  - Flow data
  - Biological data

Identification of causes & sources

- What “pollutants” are you dealing with?
  - Chemical or other stressors or causes of impairment
- How big is the problem for each?
- How do you know?
  - Did you “measure” them?
  - Did you estimate? How?
- Where are they coming from?
  - Can you put the info on a map?
- Can you estimate the % from each source?

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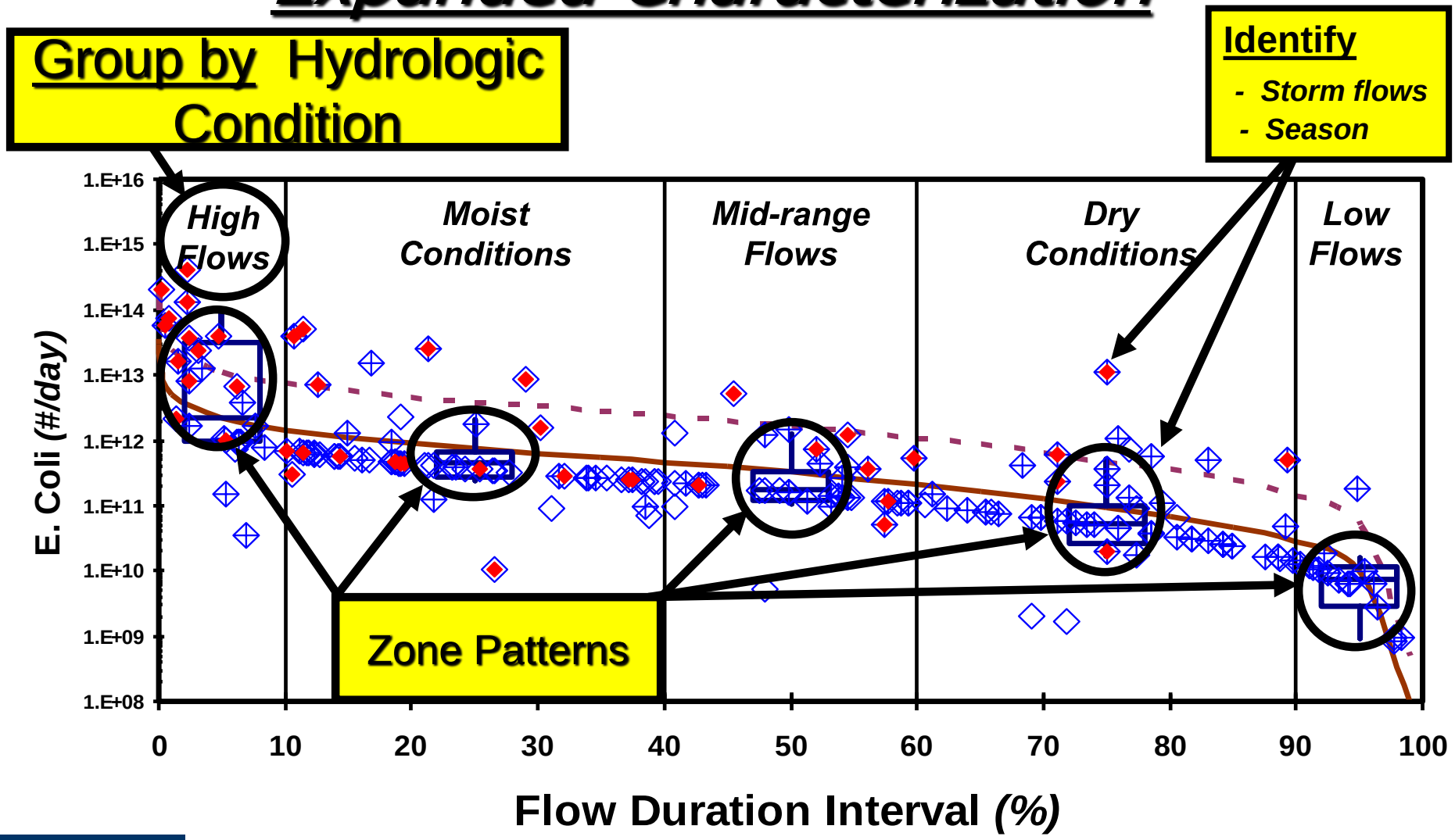
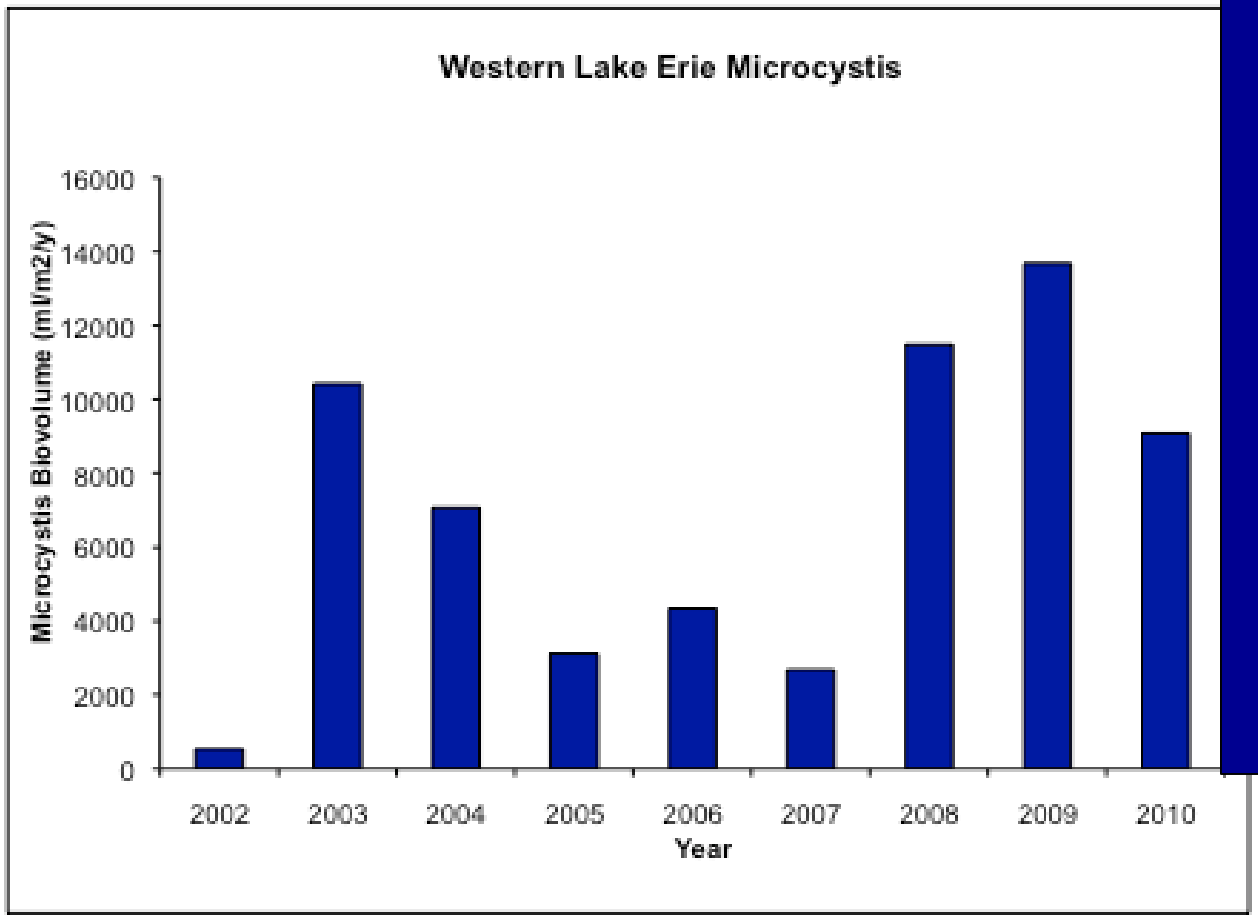
Hydrology-based Framework

Expanded Characterization



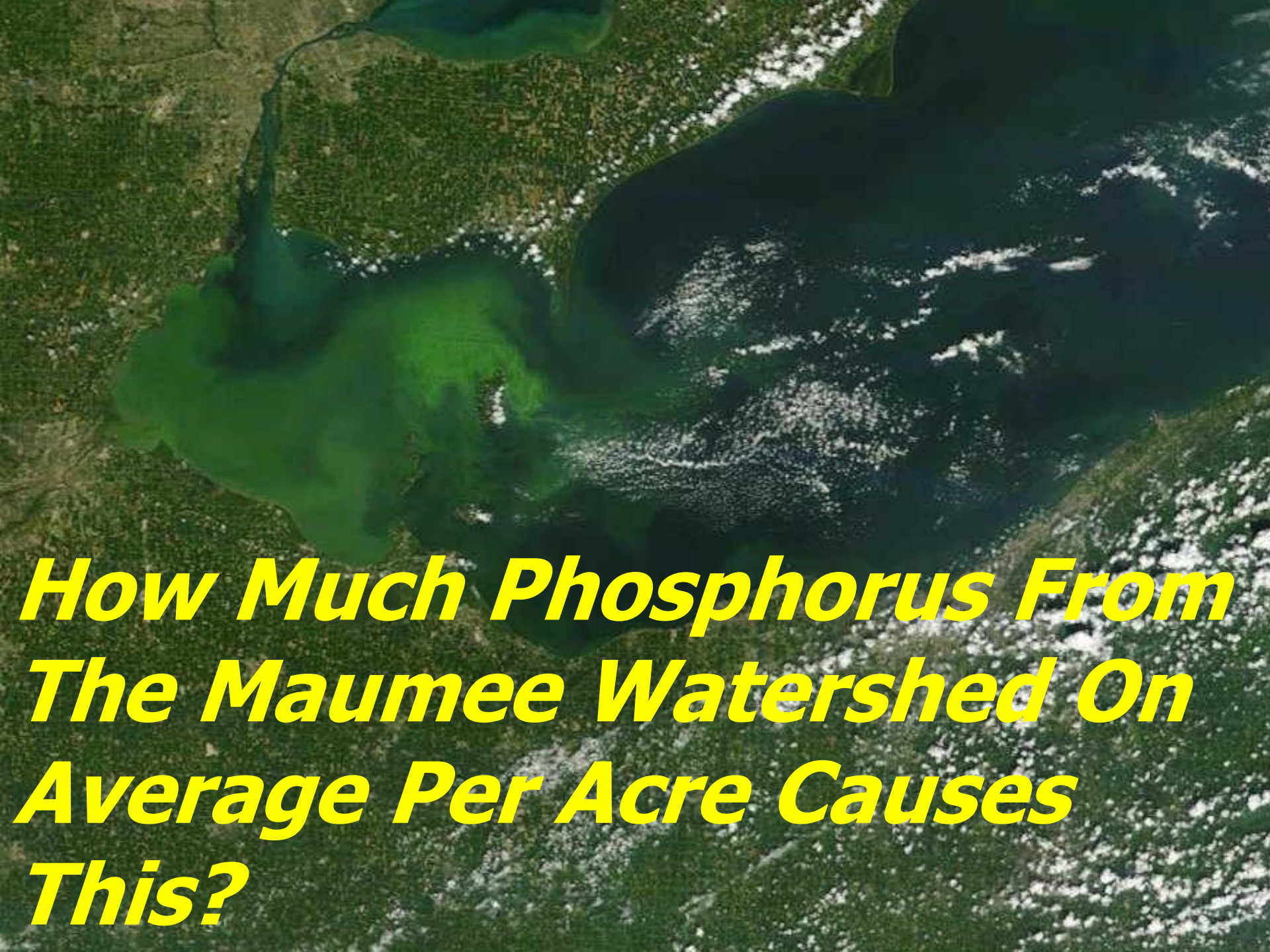
Microcystis in Lake Erie

- The Microcystis-Anabaena bloom of 2009 was the largest in recent years in our sampling region
- …until 2011



Is pollutant loading the problem?

- Data Driven
- Model



How Much Phosphorus From The Maumee Watershed On Average Per Acre Causes This?

3265 kilograms

4x4
453 kilograms

163 kilograms

21 kilograms

Average Annual Export From the Maumee WS is 1.2 kilograms of P per hectare (1.1 Pounds of P per acre) as measured through the Heidelberg Gage at Waterville.

What is a “load?”

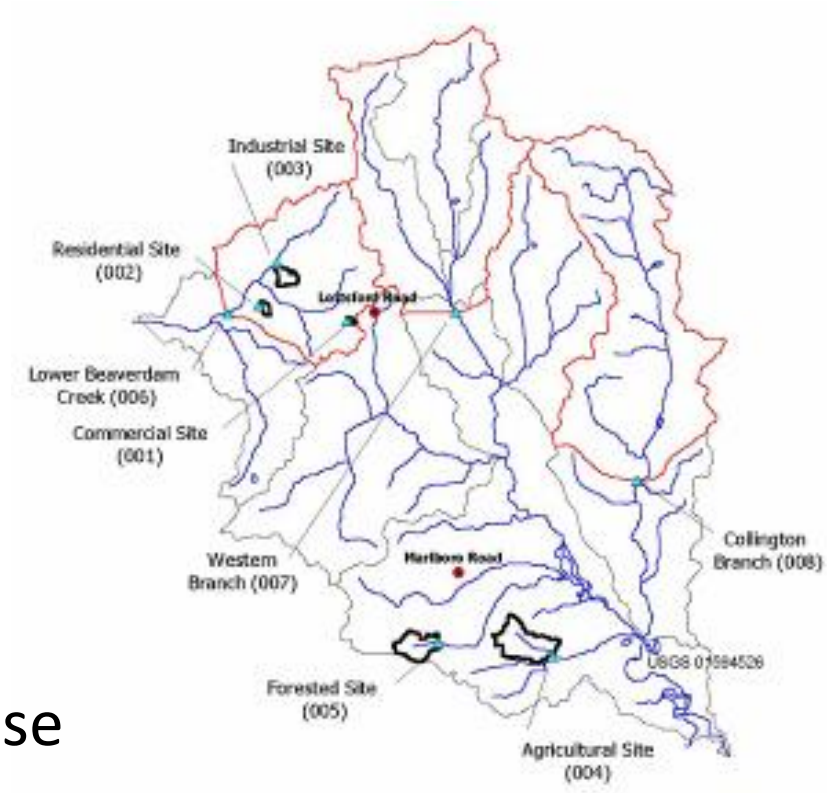
- Maybe measured by weight . . .
  - Kilograms per day
  - Pounds per week
  - Tons per month
- Maybe not . . .
  - Concentration-based expression of the “load” (e.g., milligrams per liter)
    - mg/L x L/day = mg/day [C = m/v]
  - # of miles of streambank needing stabilization or vegetation
  - # of AFOs requiring nutrient plans
  - % of urban area to be ‘perforated’

Existing loads come from:

- Point-source discharges (NPDES facilities)
  - Info is available on the discharges (DMRs, etc.)
  - Some are steady-flow, others are precip-driven
- Nonpoint sources (polluted runoff)
  - All are (mostly) precip-driven
  - Calculating the “wash-off, runoff” load is tough
  - Literature values can be used to estimate
  - Modeling gets you closer . . . . do you need it?
  - Can be significant in some locations

Data-driven Approaches

- Estimate source loads using:
  - Monitoring data
    - Periodic water quality concentrations and flow gauging data
    - Facility discharge monitoring reports
  - Literature
    - Loading rates, often by landuse (e.g., lbs/acre/year)
    - Typical facility concentrations and flow



Is a Data-driven Approach Appropriate?

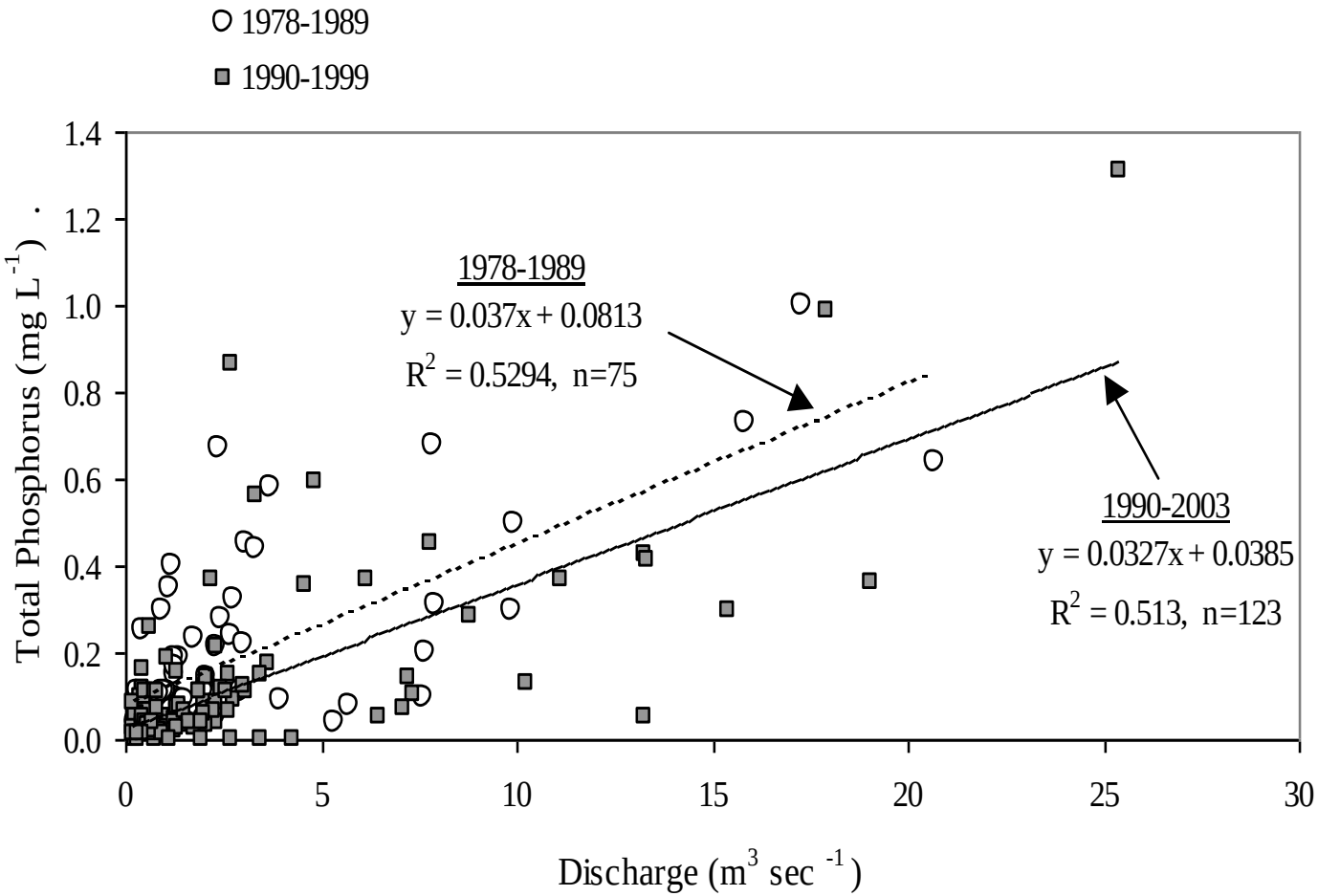
- Monitoring data
  - Does it represent most conditions that occur (low flow, storms, etc.)?
  - Does it represent the impairment?
  - Are spatial and source variability well-represented?
  - Have all parameters of interest been monitored?
  - Is there a clear path to a management strategy?

Load Estimates – Monitoring Data

- In simplest terms…

  load = flow x concentration
- Load duration curves
  - Flow-based presentation
- Statistical techniques
  - Relationships between flow and concentration to “fill in the blanks” when data aren’t available
  - Examples include:
    - Regression approach
    - FLUX

The reports also utilize monitoring data collected by DWQ. In this example, response was measured as a change in the slope of the TP/discharge relationship.



Load Estimates – Literature

- Landuse-specific loading rates (typically annual)
- Multiply loading rate by area:

$$load_{all} = (area_{lu1} \times loading\ rate_{lu1}) + (area_{lu2} \times loading\ rate_{lu2}) + \ldots$$

- Generally for landuse or watershed-wide analysis
- Many sources: Lin (2004); Beaulac and Reckhow (1982), etc.
- Use with caution (need correct representation for your local watershed)
  - Pollution sources
  - Climate
  - Soils

Example Load Estimation Based on Literature Values

Example of Pollutant Budget Estimation Using Export Coefficient Model

Land Use	Area (ha)	Nitrogen Export Coefficient (kg/ha/yr)	Total Nitrogen Load (kg/yr)	Percent of Nitrogen Load	Phosphorous Export Coefficient (kg/ha/yr)	Total Phosphorous Load (kg/yr)	Percent of Phosphorous Load
Forest	100	1.8	180	0.91	0.11	11	0.52
Corn	200	11.1	2220	11.24	2	400	18.95
Cotton	100	10	1000	5.6	4.3	430	20.37
Soybeans	20	12.5	250	1.27	4.6	92	4.36
Small Grain	50	5.3	265	1.34	1.5	75	3.55
Pasture	300	3.1	930	4.71	0.1	30	1.42
Feedlot or Dairy	5	2,900	14,500	73.39	220	1,100	52.11
Idle	30	3.4	102	0.52	0.1	3	0.14
Residential	20	7.5	150	0.76	1.2	24	1.14
Business	10	13.8	138	0.7	3	30	1.42
Industrial	5	4.4	22	0.11	3.8	19	0.9
Total	840	-	19,757	1	-	2,111	100

Note: Agricultural coefficients are from Reckhow et al. (1980), and urban coefficients are from Athayde et al. (1983).

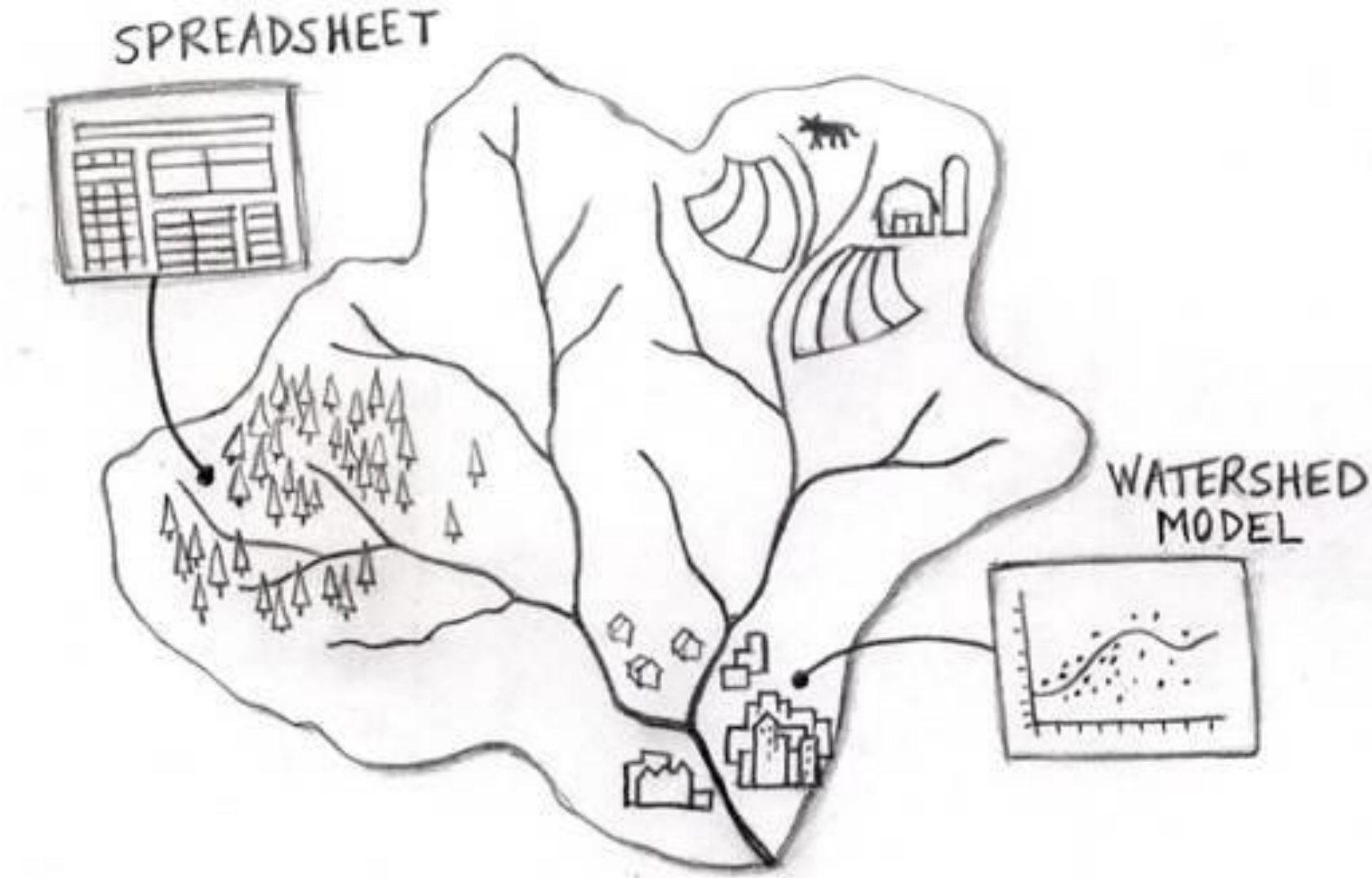
Limitations of Data-driven Approaches

- Monitoring data
  - Reflect current/historical conditions (limited use for future predictions)
  - Insight limited by extent of data (usually water quality data)
    - Often not source-specific
    - May reflect a small range of flow conditions
- Literature
  - Not reflective of local conditions
  - Wide variation among literature
  - Often a “static” value (e.g., annual)

What Tool Should I Select?

- Has a model already been used for load quantification?
- What scale is important?
- Is an annual load reduction estimate sufficient?
- Should individual storms be evaluated?
- Spreadsheet tools
  - Normally good for annual/overall reductions
  - Usually at a watershed scale – sometimes at the site scale
- Watershed models
  - Allow for continuous/long-term simulation
  - Often can be used for storm evaluation
  - Ability to function at all scales – site and watershed
- As these things increase:
  - Number of pollutants
  - Complexity of loads/stressors
  - Uncertainty regarding existing information
  - Expense involved in addressing problems
- The need for more sophisticated modeling also increases

How can we estimate loads?



Is a Model Necessary?

It depends what you want to know…

Probably Not

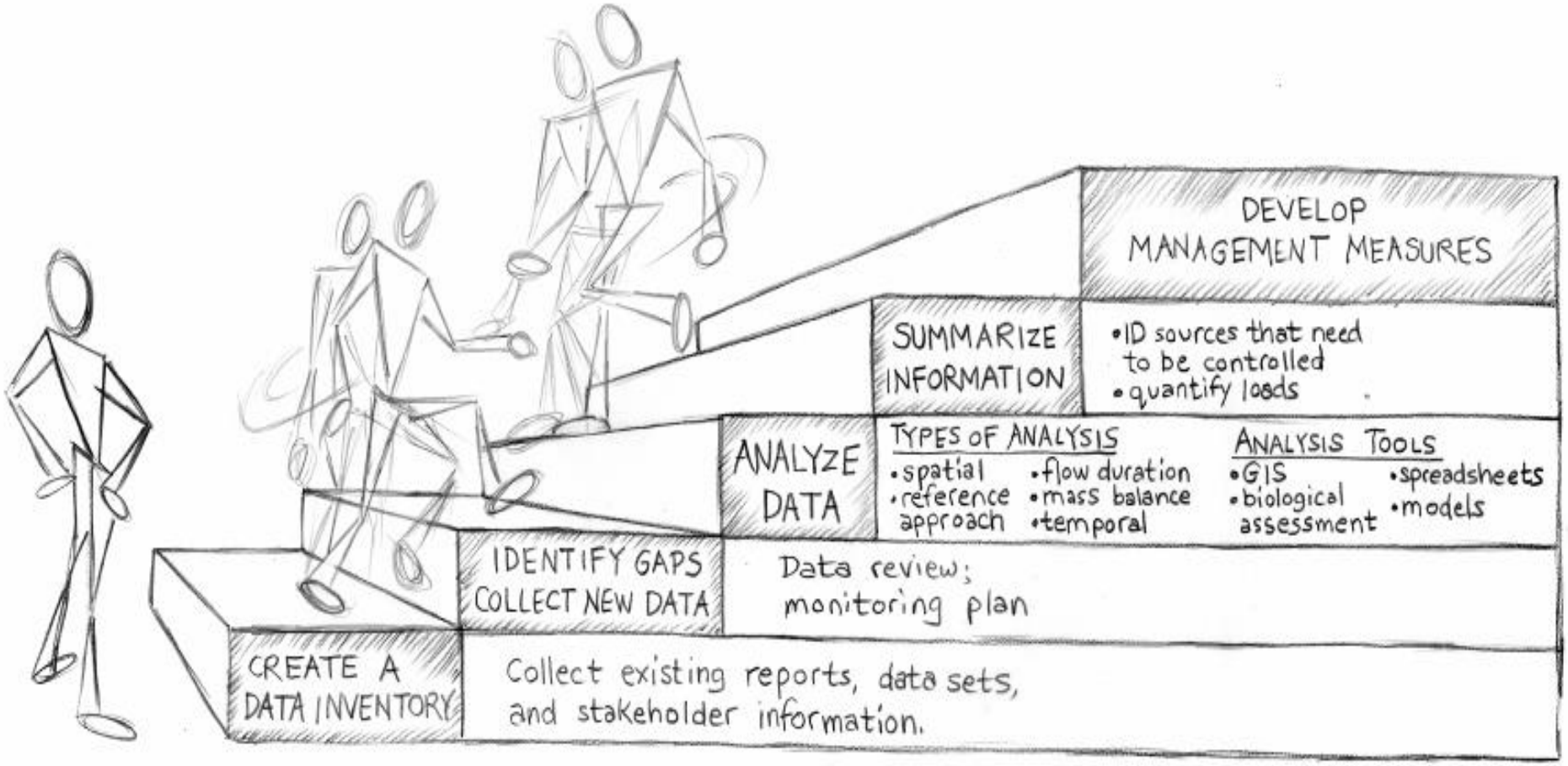
Probably

- What are the loads associated with individual sources?
- Where and when does impairment occur?
- Is a particular source or multiple sources generally causing the problem?
- Will management actions result in meeting water quality standards?
- Which combination of management actions will most effectively meet load targets?
- Will future conditions make impairments worse?
- How can future growth be managed to minimize adverse impacts?

Key Points:

- Approach depends on intended use of information
- Simplest approaches are literature-driven
- Watershed modeling is more complex and time-consuming
  - Can provide more insight into spatial and temporal characteristics
  - Can be useful for future predictions and evaluation of management options
- **One size doesn't fit all!**
- **DOCUMENT WHAT YOU DO**

Load assessment is is on ongoing learning process – iterative & creative!



What the approach needs to support:

Sources change over time

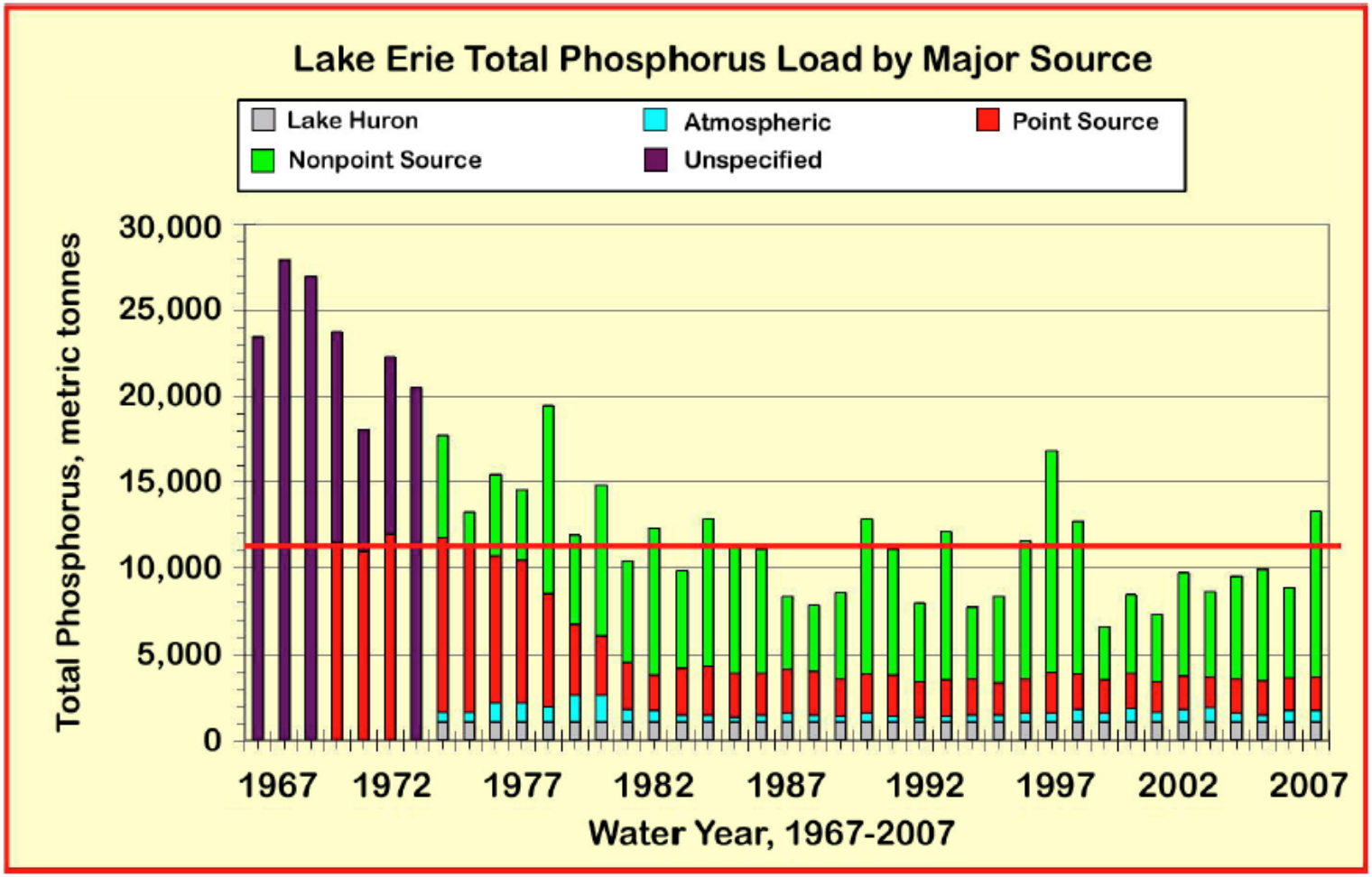


Figure 3— Annual loading of total phosphorus to Lake Erie, 1967 – 2007.
(Historical data from David Rockwell, U.S.EPA and David Dolan, University of Wisconsin Green Bay. Data from 2002-2007 are based on personal communication from David Dolan to David Baker, Heidelberg University. Graph prepared by David Baker)

2. What is the problem?

Particulate Phosphorus

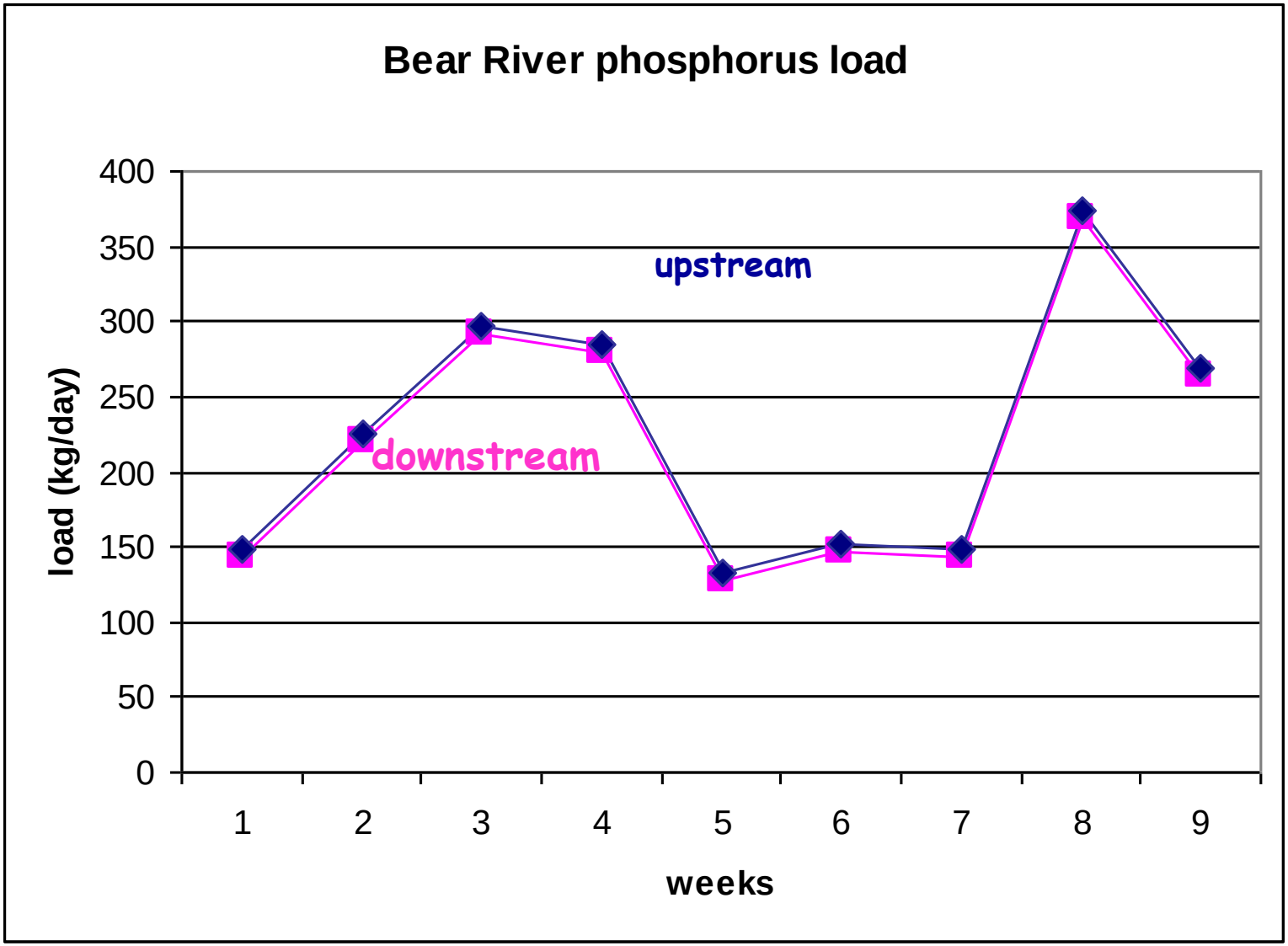
- ~ 30% bioavailable to algae
- Tends to settle out of water column with sediment
- Loads have decreased as a result of agricultural erosion control programs.

Dissolved Phosphorus

- ~90% is dissolved reactive phosphorus (DRP)
- DRP is 100% bioavailable.
- Cropland runoff of DRP has increased dramatically in last 15 years.
- These increases have been linked to a return of blue green algal problems in Lake Erie.

The obvious needs to be looked at - upstream/downstream monitoring capture the impacts of this activity?

Loading from large feeding operation swamped by the large loads carried by the Bear River.



Maumee Storm Runoff Statistics (1960-2010)

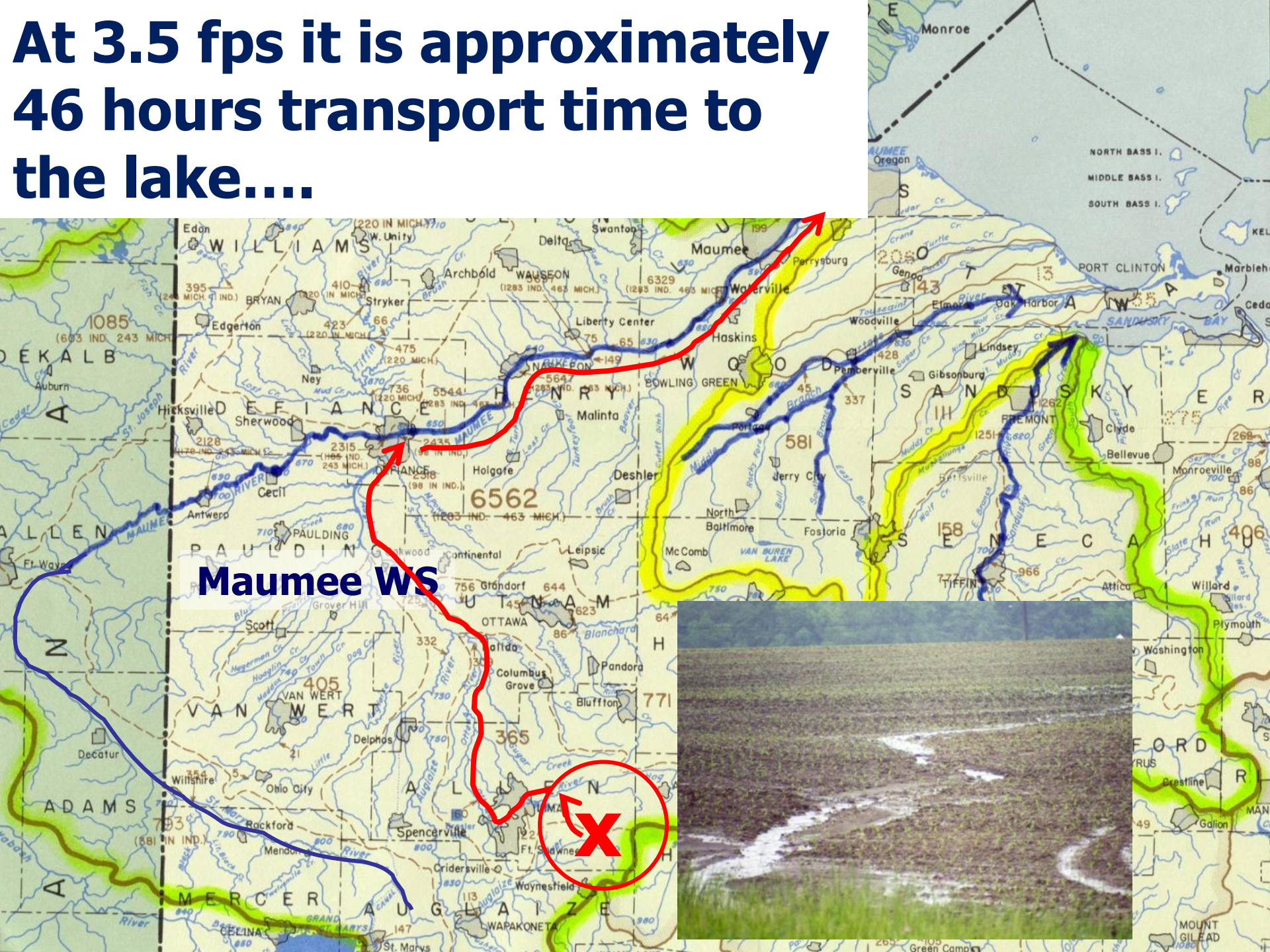
- **Statistically significant increases:**
  - **Number of storm runoff events per year (67% increase)**
  - **Number of spring runoff events (40%)**
  - **Number of winter runoff events (47%)**
  - **Annual storm discharge (53%)**
  - **Summer storm discharge (27%)**

- **Other seasonal comparisons show increases but they are not significant**

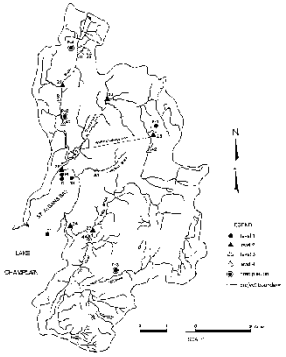
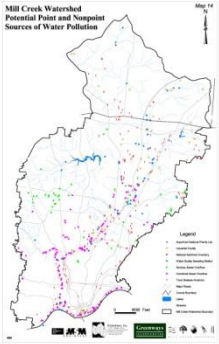
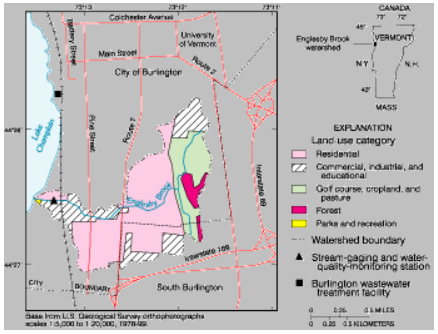
- **Rapid increases 1960-1970, slower increases since**

Dr Pete Richards – Heidelberg Data

At 3.5 fps it is approximately 46 hours transport time to the lake….



Remember: Monitoring data and planning

Several major watershed monitoring projects have reported difficulty in obtaining quality water quality to use watershed plan development:

- Uncooperative weather
- Insufficient monitoring time frame
- Mistakes in understanding of pollution sources
- Poor experimental design
- Lag time