

# Fox Illinois River Basin TMDL

TMDL for Total Phosphorus and Total Suspended Solids

Eric Hettler

Wisconsin Department of Natural Resources

August 21, 2025

# Today's Presenter



Eric Hettler, PE  
TMDL Modeler

# Today's Topics

Fox Illinois TMDL Background

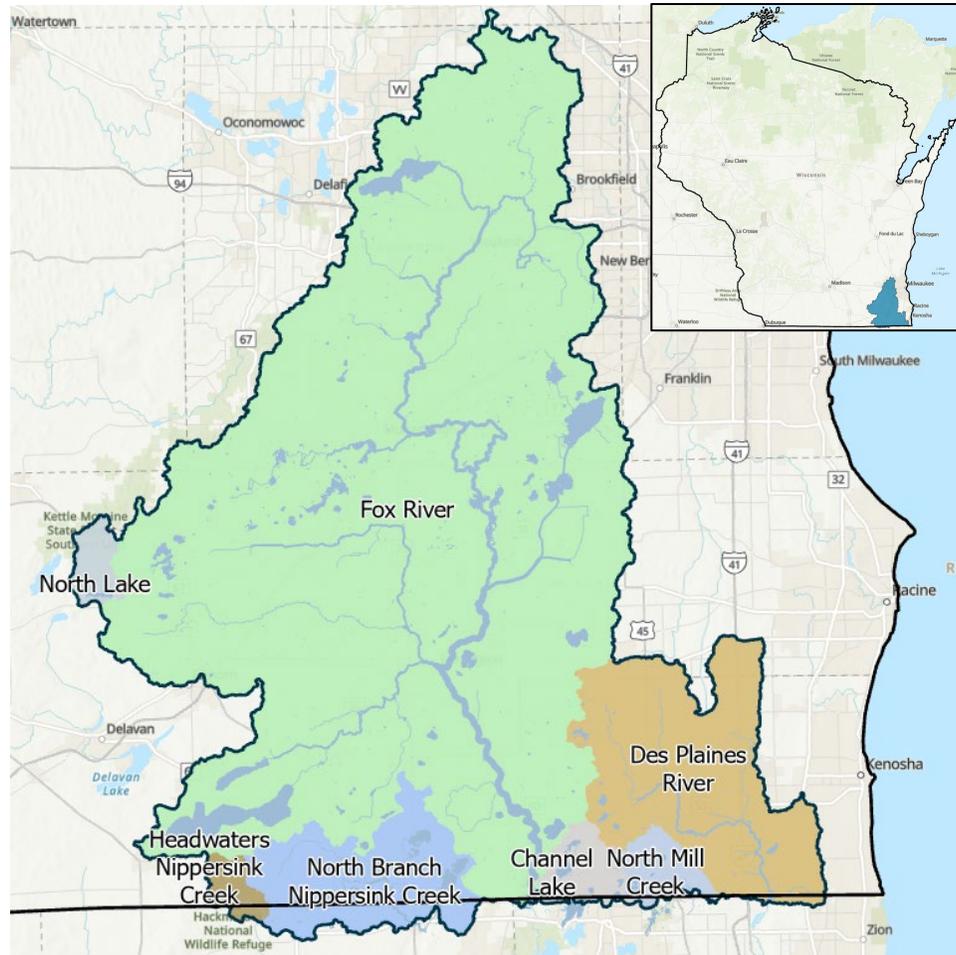
Fox Illinois TMDL Development

- Monitoring
- Conceptualization
- Modeling
- Allocations
- Implementation

Next Steps

# **Fox Illinois TMDL Project Background**

# FOXIL TMDL Project Extents



Located in Southeast Wisconsin

Seven Distinct Watersheds

Fox River

North Lake

Headwaters Nippersink Creek

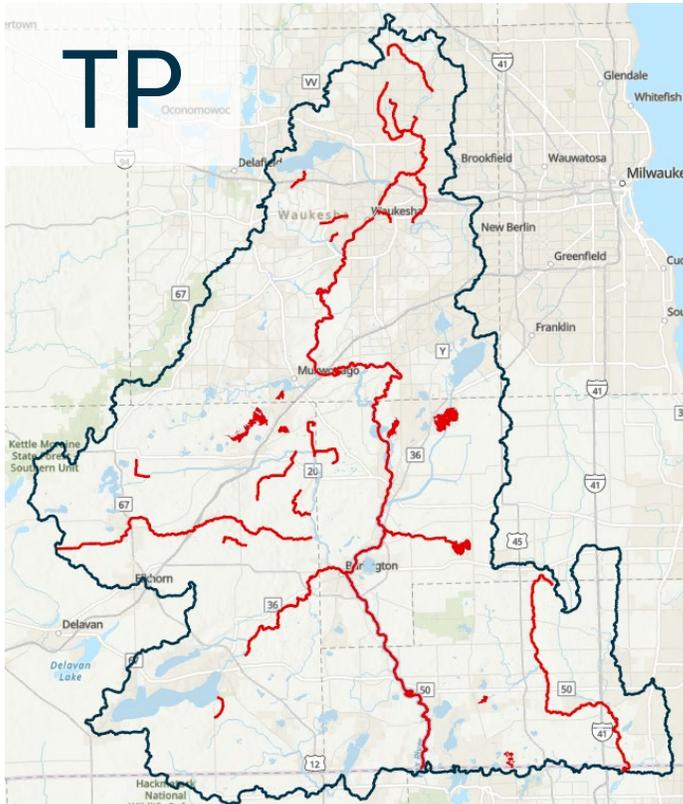
North Branch Nippersink Creek

Channel Lake

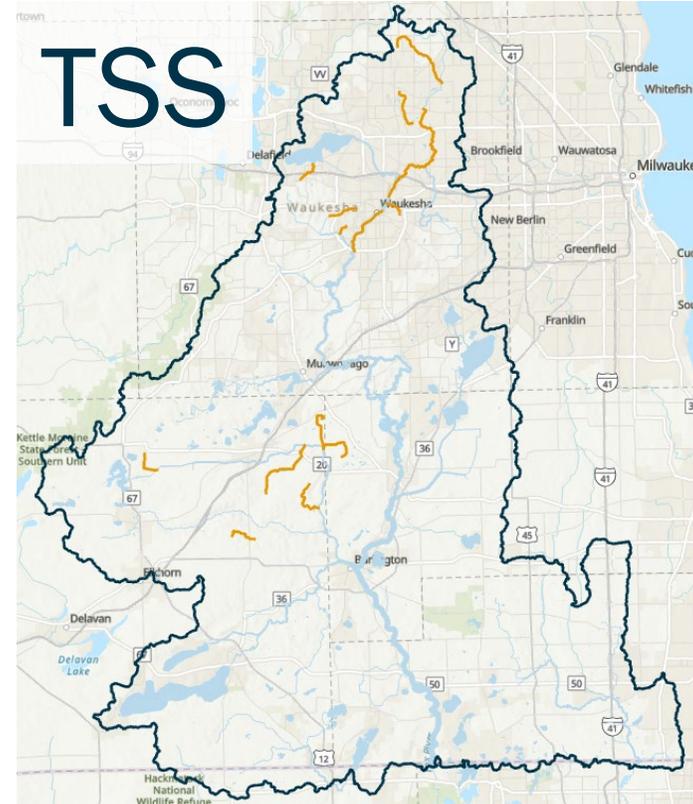
North Mill Creek

Des Plaines River

# TP & TSS Impairments – 303(d) List



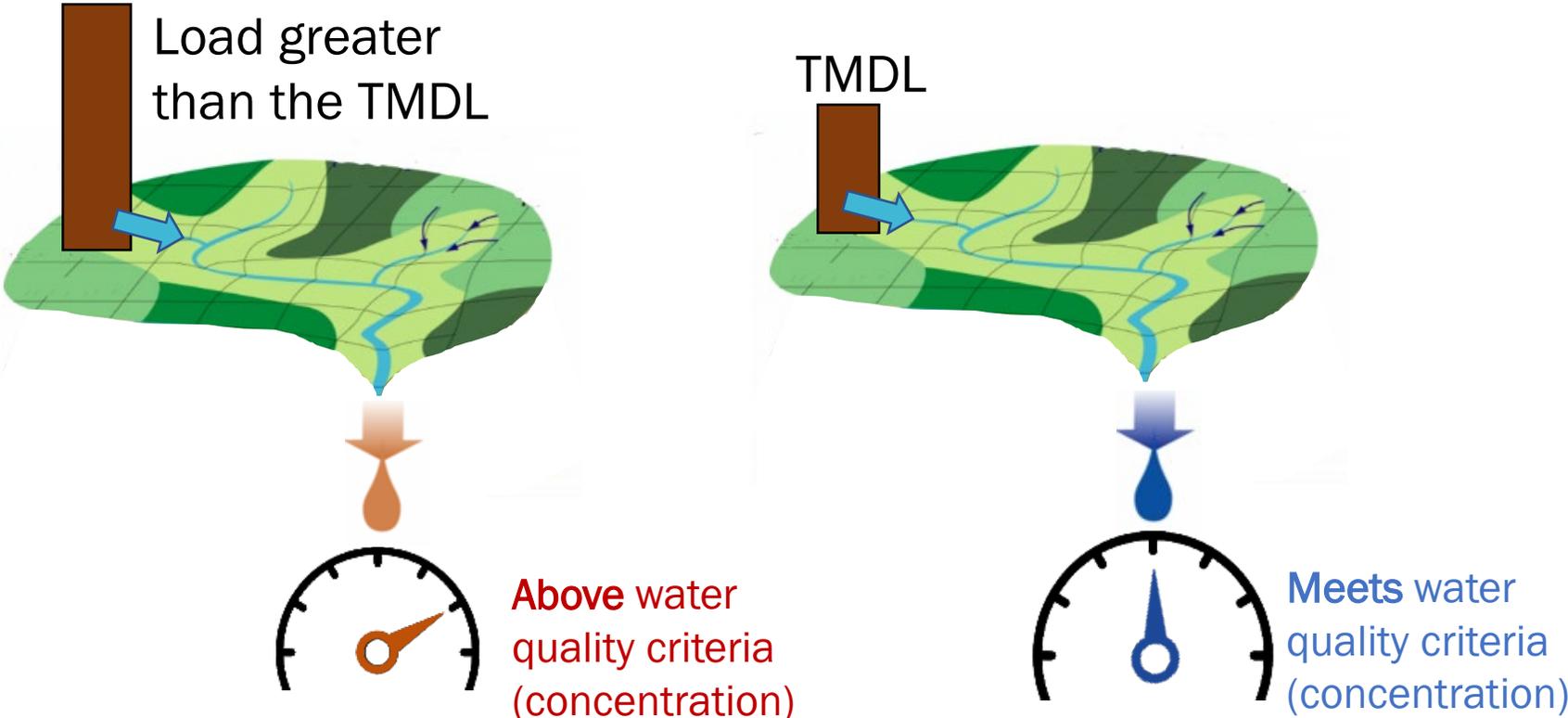
11 named streams/ivers  
9 lakes



7 named streams/ivers  
1 impoundment (Fox River)

# Total Maximum Daily Load (TMDL)

TMDL: Amount of a pollutant a waterbody can receive and still meet water quality standards



# Total Maximum Daily Load (TMDL)

EPA requires that waters listed as impaired on Wisconsin's 303d list have TMDLs developed

$$\text{TMDL} =$$

Load Allocation



Nonpoint loads

+

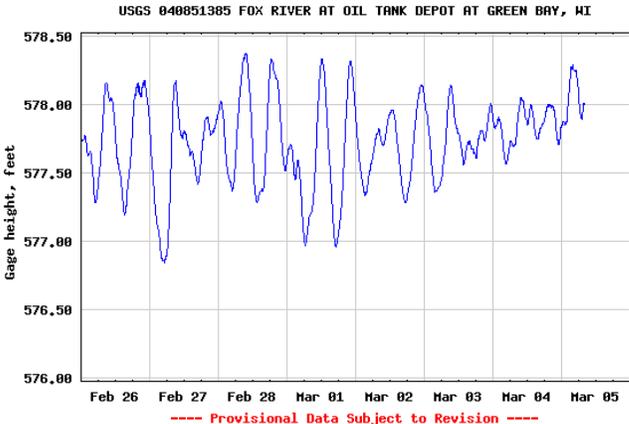
Wasteload Allocation



Permitted point sources

+

Margin of Safety



Modeling assumptions

# Des Plaines Watershed in Wisconsin

## Characteristics

121 square miles across two counties

4 HUC 12s watersheds

TP Impairment in Des Plaines River

6 WPDES permits



# Des Plaines River TP Water Quality

## Water Quality Monitoring

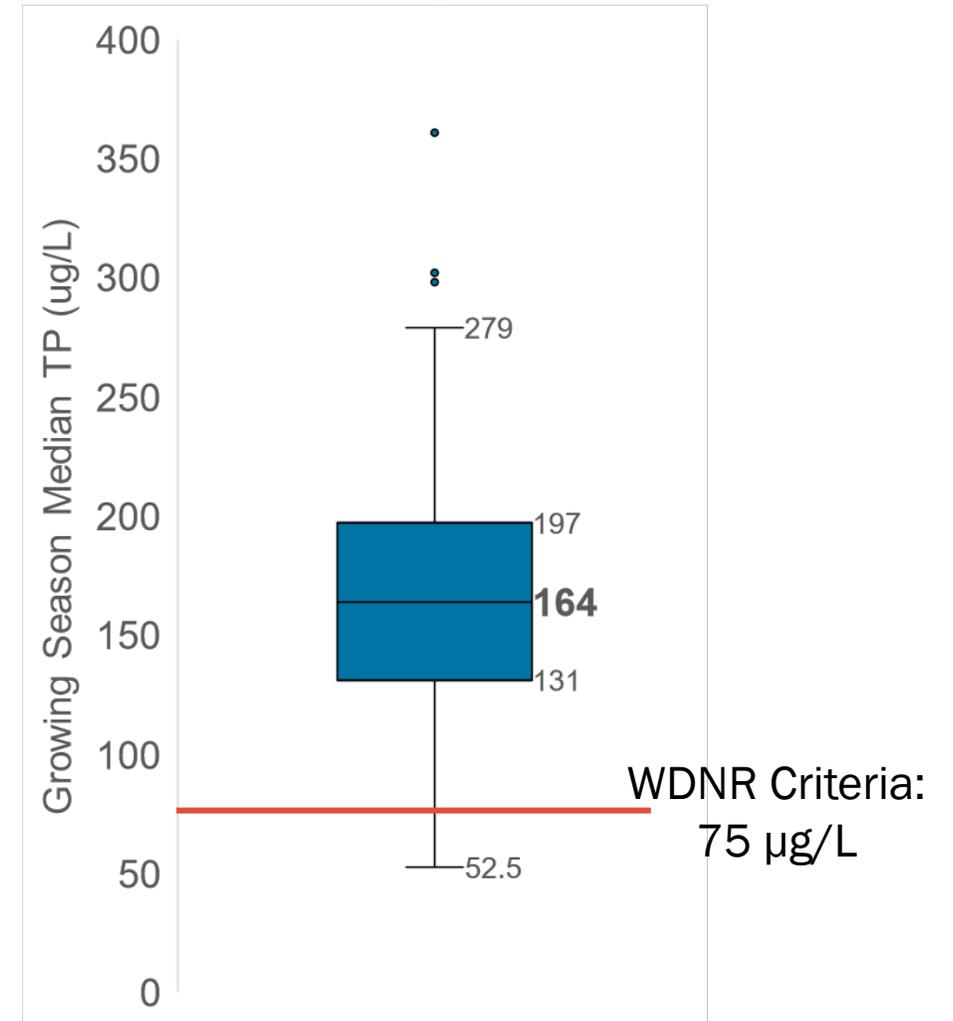
Des Plaines River at 122<sup>nd</sup> Street

February 2020 to May 2022

37 Samples

Growing Season Median: 164  $\mu\text{g/L}$

Growing Season May 1<sup>st</sup> through October 31<sup>st</sup>



# **FOXIL TMDL Development**

## Total Phosphorus and Total Suspended Solids

# TMDL Development Overview



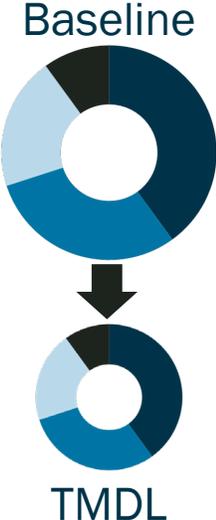
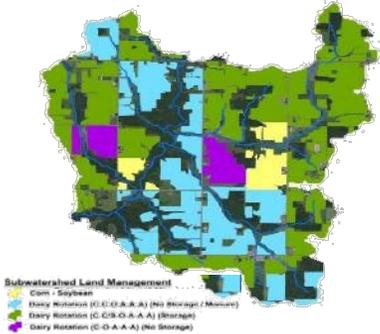
Monitoring  
Conceptualization



Modeling



Allocations  
Implementation



# TMDL Process: Monitoring



# TMDL Process: Monitoring



Monitoring Sites: 13 total

- *Chemistry (TP, TSS, Ortho-P)*
- *Flow (Stage and Discharge)*

Dates: late-2019 through mid-2022



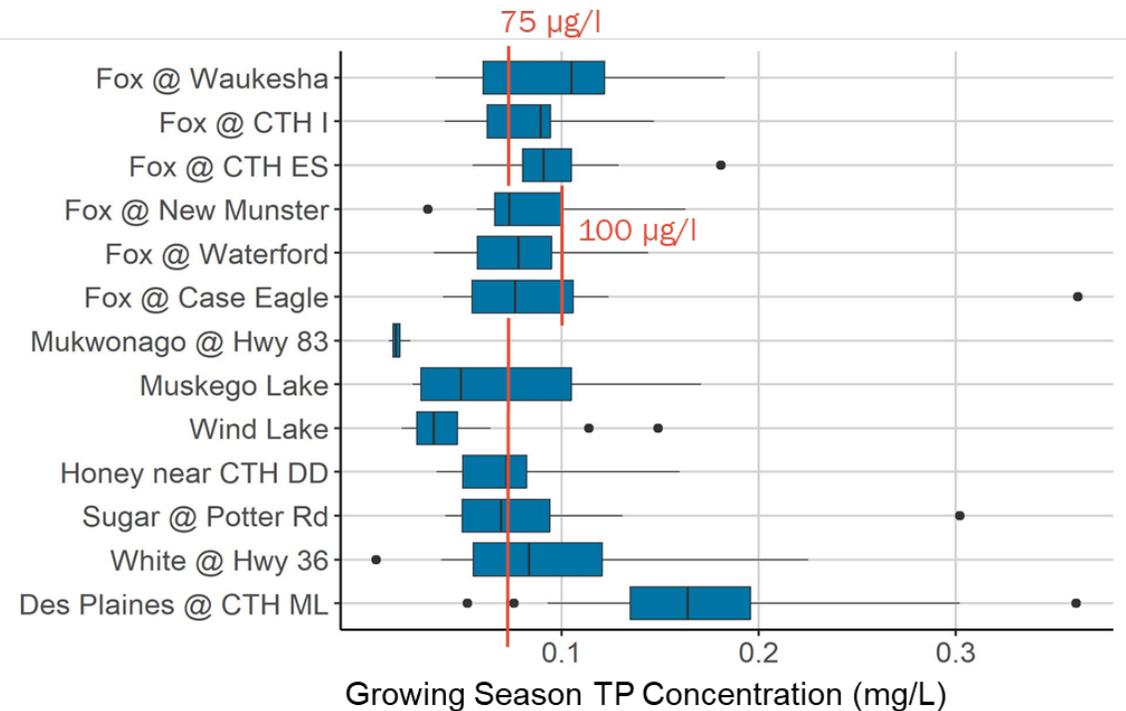
# TMDL Process: Monitoring



Monitoring Sites: 13 total

- Chemistry (TP, TSS, Ortho-P)
- Flow (Stage and Discharge)

Dates: late-2019 through mid-2022



# Monitoring: Resources



## Project Website:

<https://dnr.wisconsin.gov/topic/TMDLs/FOXIL>

### PAST WEBINARS

- ▼ [May 2025 Informational Webinar - May 22, 2025](#)
- ▼ [September 2024 Informational Webinar - Sept. 25, 2024](#)
- ▲ [October 2023 Informational Webinar - Oct. 31, 2023](#)

A public informational webinar was held to provide updates on the DNR-led water quality study titled “Total Maximum Daily Loads for Total Phosphorus and Total Suspended Solids in the Fox Illinois River Basin” (FOXIL TMDL). The informational webinar provided updates on the project including a summary of monitoring data collected for the project, an overview of agricultural land use and practices in the study area, a description of subbasin delineation for watershed modeling, and an outline of next steps for the project.

### REPORTS & SUPPLEMENTAL DOCUMENTATION

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- [SWAT Model Setup, Calibration and Validation for the Fox Illinois River Basin TMDL \[PDF\]](#)
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## Monitoring Results for the Fox Illinois River Basin TMDL



10/31/2023

Prepared by:  
WI Department of  
Natural Resources  
101 S. Webster St  
PO Box 7921  
Madison, WI 53707-7921



# TMDL Process: Conceptualization



# TMDL Process: Conceptualization



## What's happening in the watershed?

- Land use/management
- Climate
- Soils, topography, slope
- Hydrography & watershed delineation



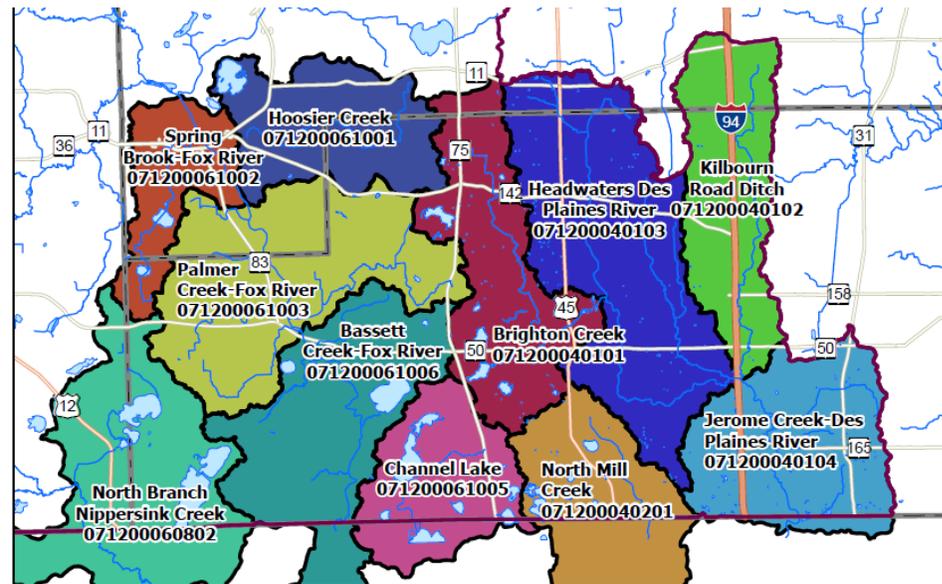
# Conceptualization



## Agricultural Surveys

- Crop rotations
- Tillage practices
- Fertilizer/manure applications
- Soil phosphorus
- Tile drainage

Fox-Des Plains TMDL:  
Agricultural Land Management Questionnaire for  
Kenosha County



# Conceptualization: Resources



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### Agricultural Survey Results for the Fox Illinois River Basin TMDL



10/31/2023

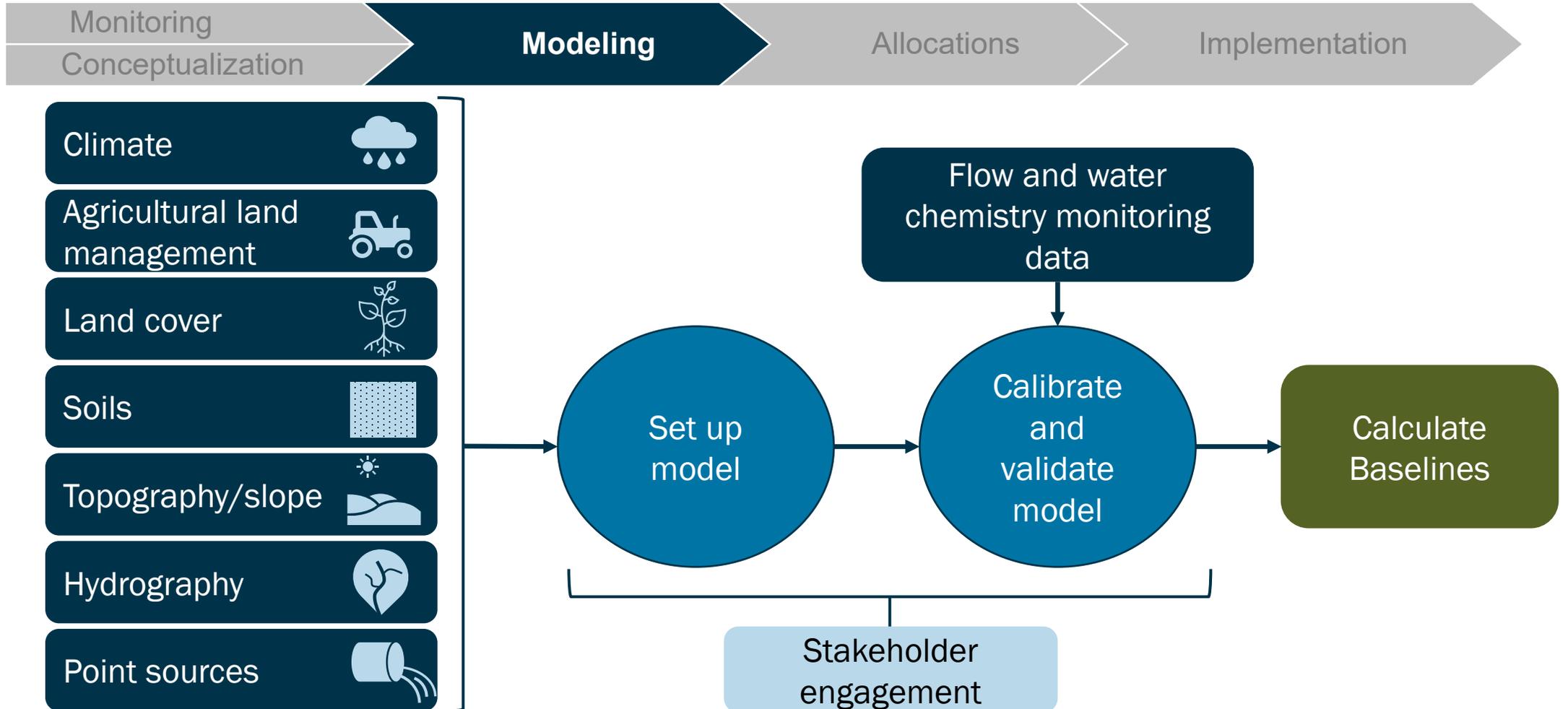
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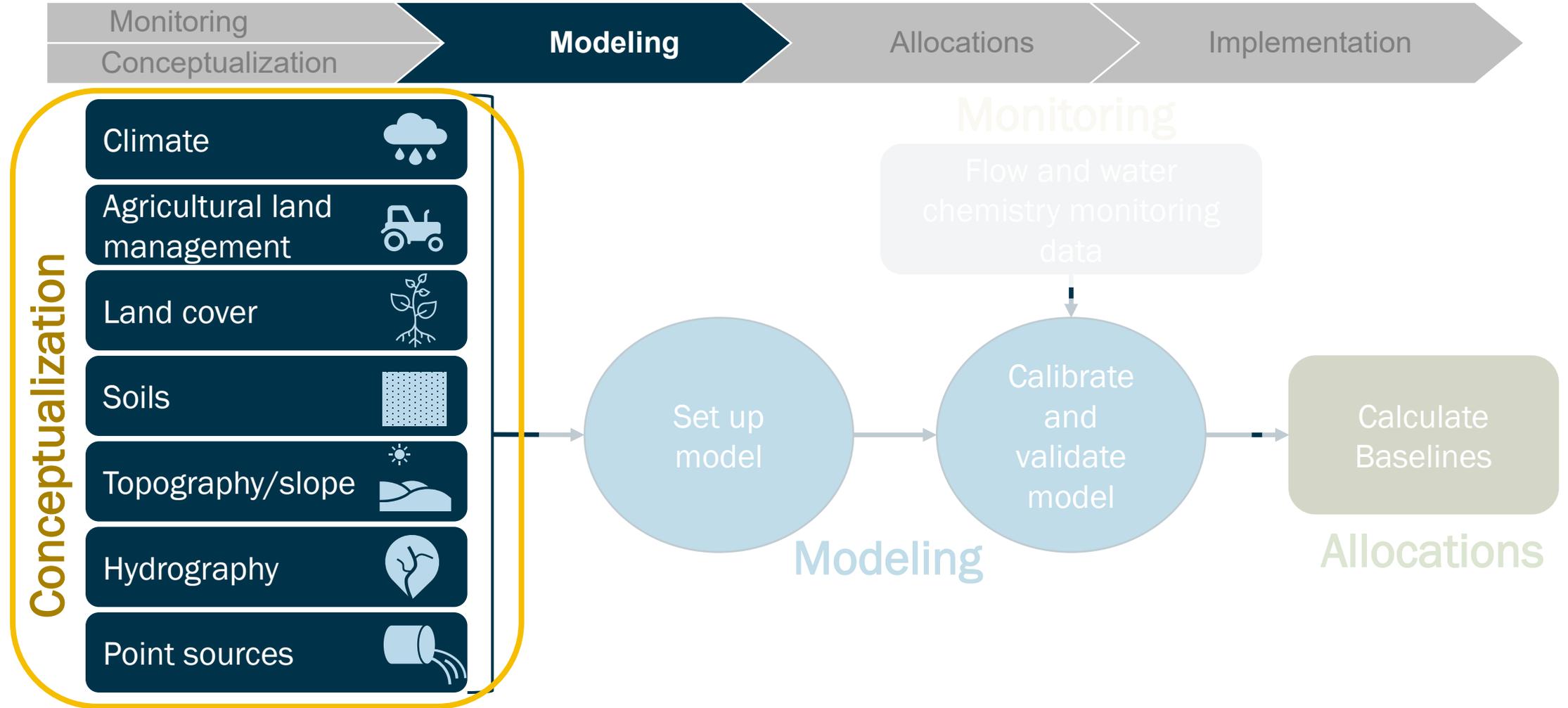
# TMDL Process: Watershed Modeling



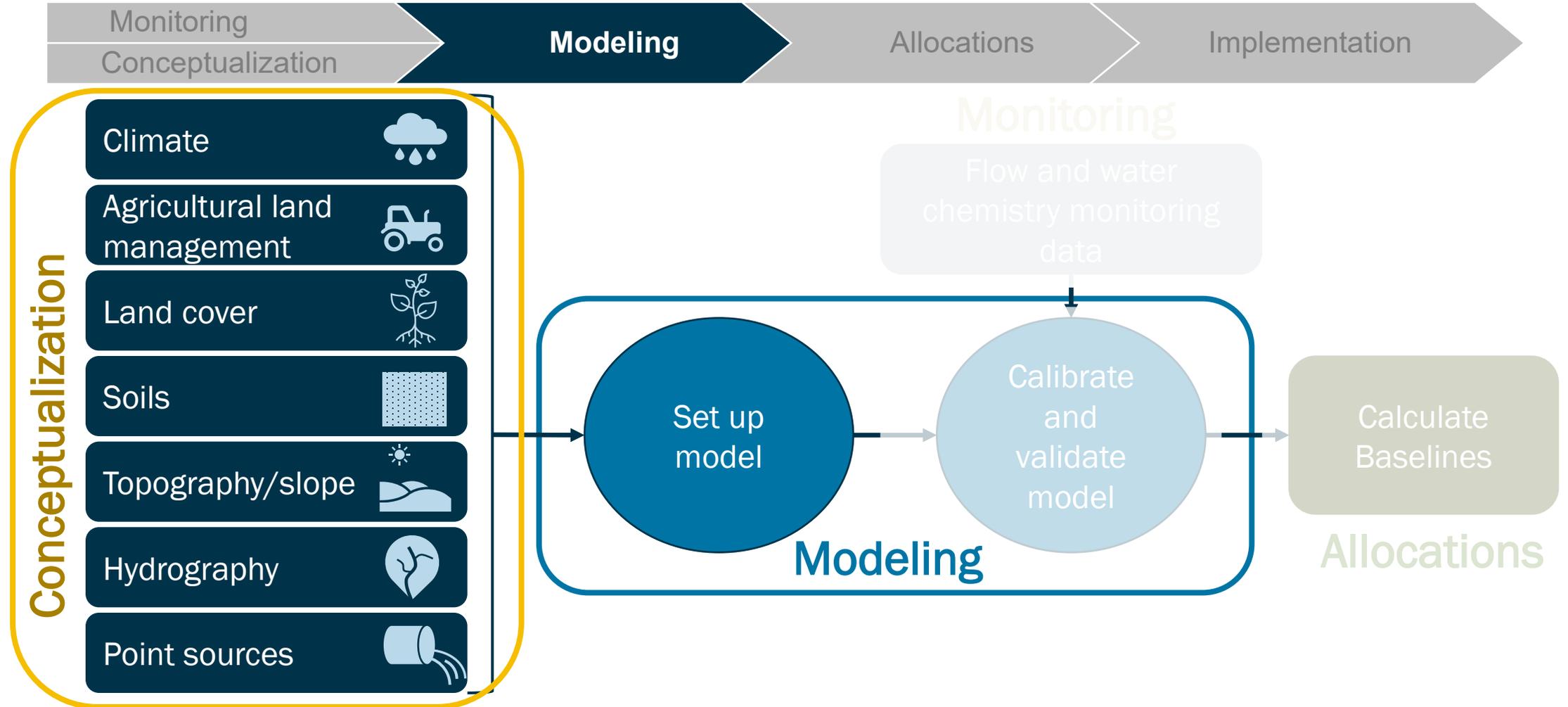
# TMDL Process: Watershed Modeling



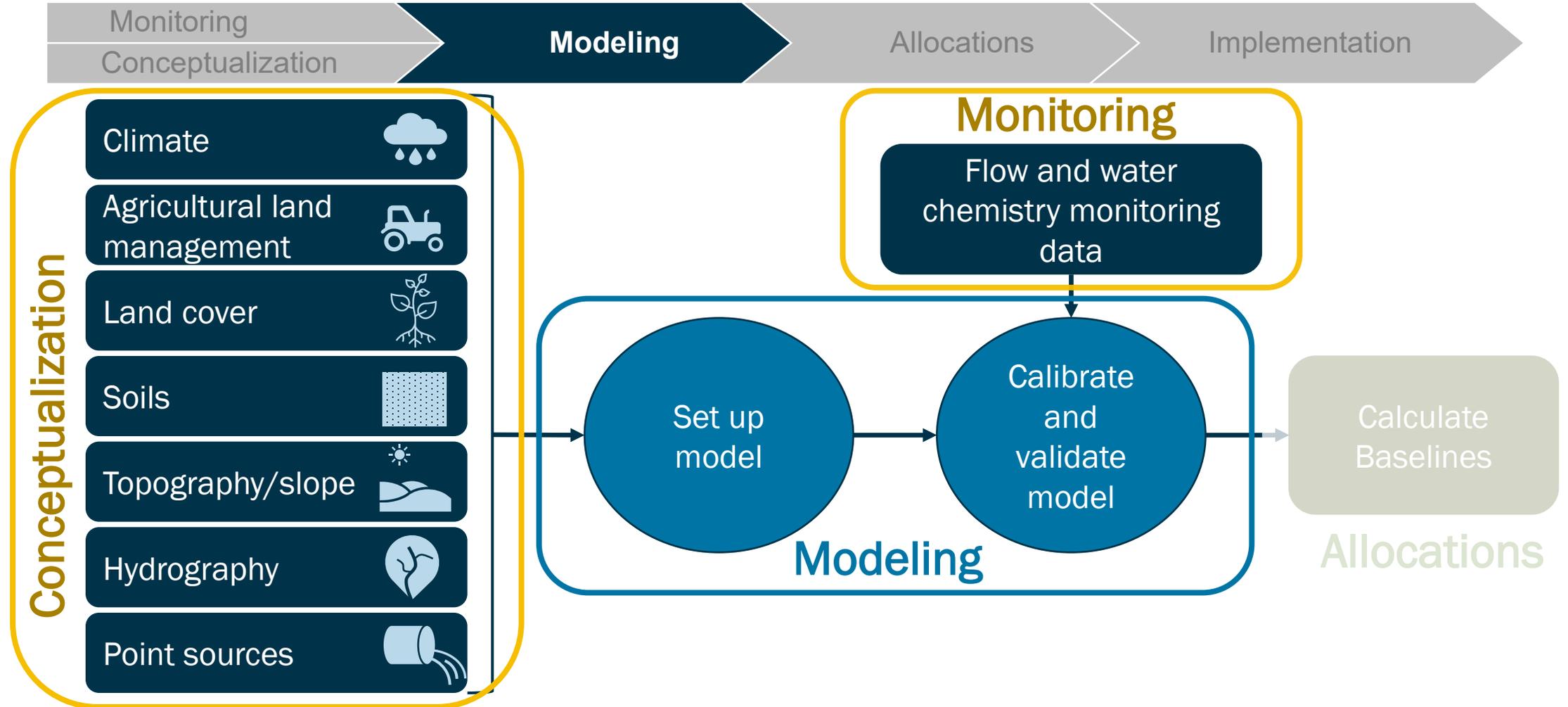
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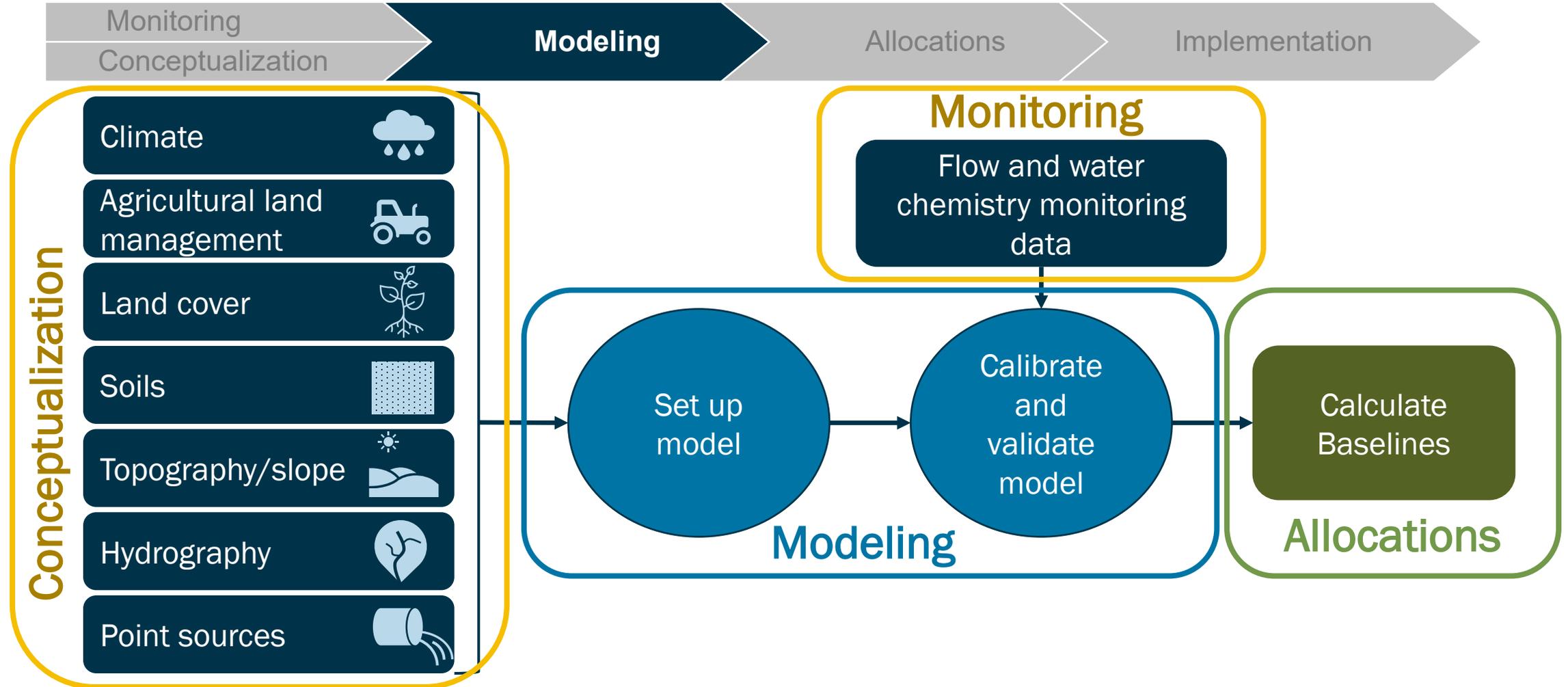
# TMDL Process: Watershed Modeling



# TMDL Process: Watershed Modeling



# TMDL Process: Watershed Modeling



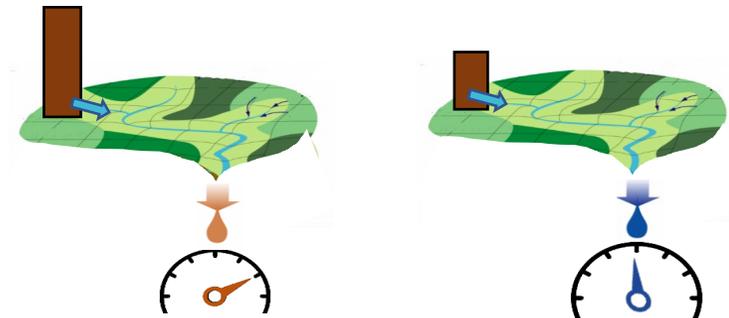
# Goals of Watershed Modeling

## Why do we develop a watershed model for TMDLs?

- Estimate flows and loads at ungauged and unmonitored locations
- Estimate flows and loads for a wide range of conditions
- Quantify loads from nonpoint and background sources

## How will results be used?

- Establish loading capacity
- Estimate baseline loads
- Determine allocations



# Soil and Water Assessment Tool (SWAT & SWAT+)

“The Soil & Water Assessment Tool is a small watershed to river basin-scale model used to simulate the **quality and quantity of surface and ground water** and predict the environmental impact of **land use, land management practices, and climate change**. SWAT is widely used in assessing soil erosion prevention and control, non-point source pollution control and regional management in watersheds.”

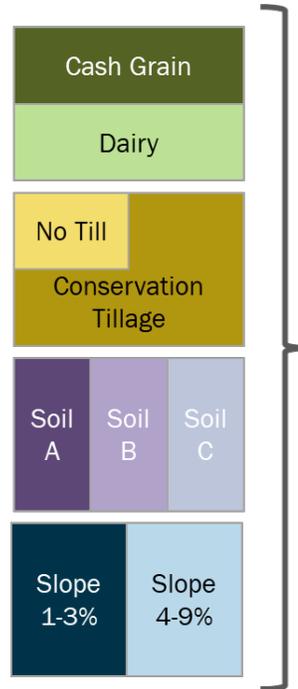


# SWAT+ Model Setup

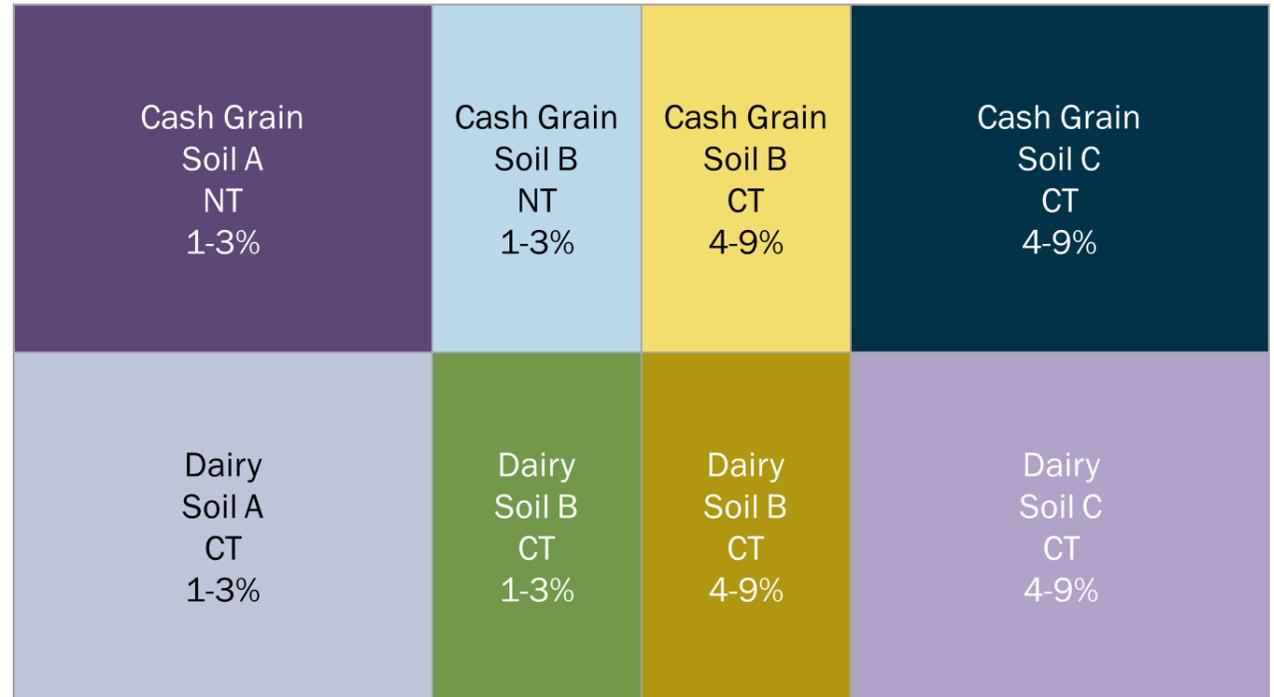
# Hydrologic Response Units (HRUs)

HRUs are a unique combination of

- Subbasin
- Land use
- Soils
- Slope



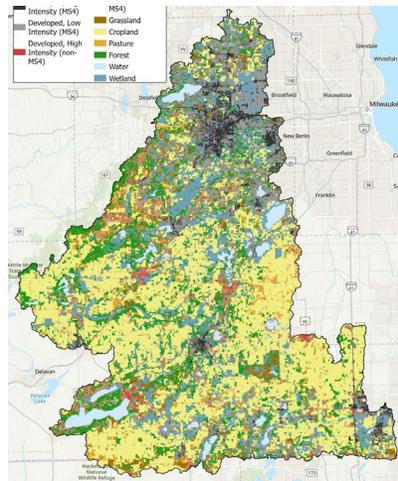
One subbasin



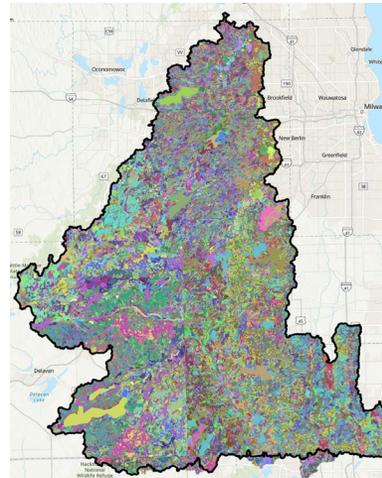
Eight unique combinations (HRUs)

# Initial HRU Definition

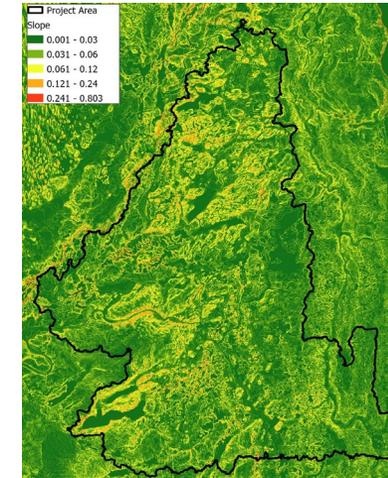
Land Use



Soils



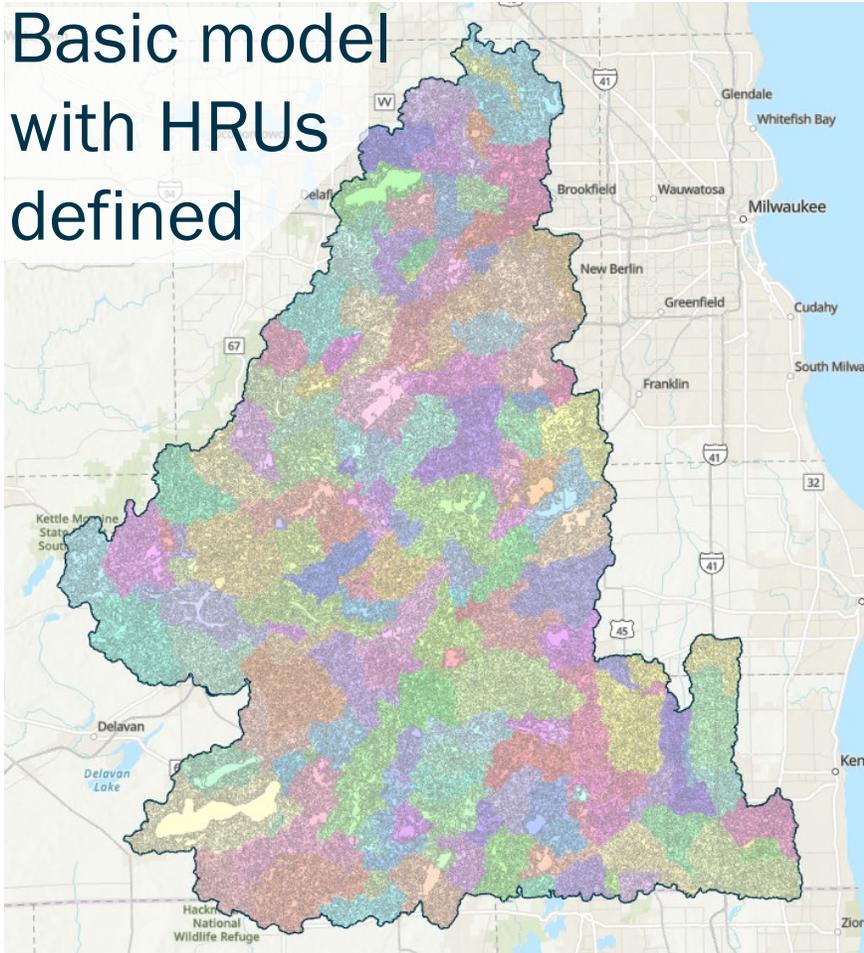
Slope



46,317 HRUs  
(reduced to 6,700)

# Additional Model Parameters

Basic model  
with HRUs  
defined



Weather



Point Sources



Management



Lake & reservoir properties



Aquifer properties



Channel properties

**P**

Soil phosphorus

# **SWAT+ Model Calibration/Validation**

# What is Model Calibration and Validation?

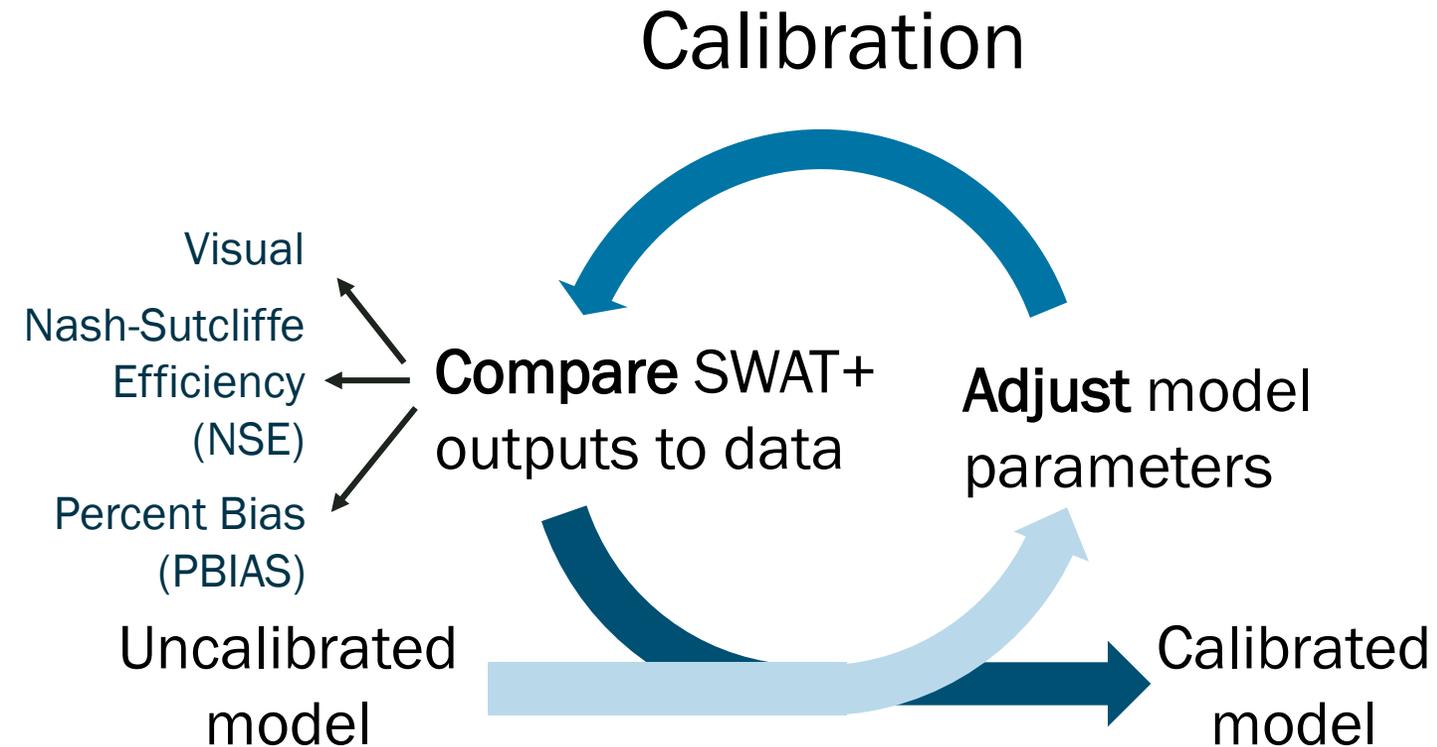
## Process

- Compare model results to fitted flow and load datasets
- Adjust model parameters until modeled results reasonably match fitted flow and load datasets

## Objective

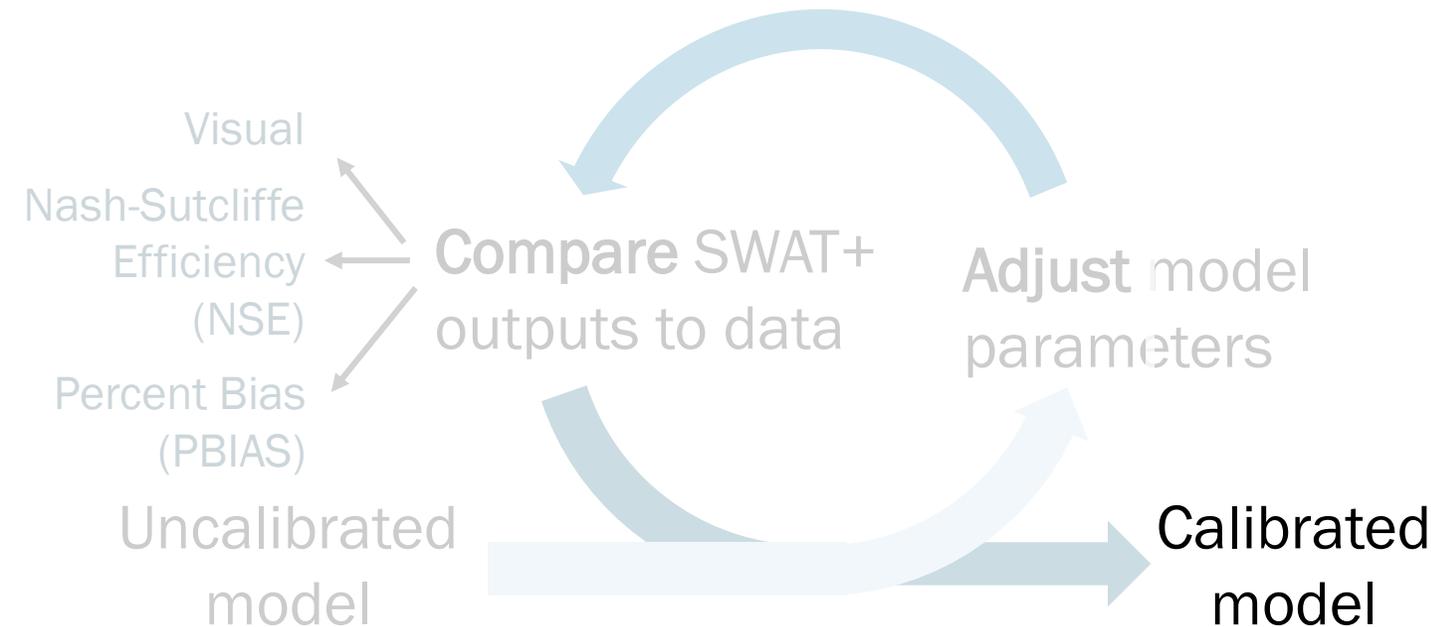
- Improve the agreement of modeled outputs and real-world measurements
- Increase confidence in model estimates in subbasins without monitoring data

# Calibration and Validation Process



# Calibration and Validation Process

## Calibration



## Validation

- Uses monitoring data not used for calibration
- Demonstrates that the model is accurately predicting through time



# SWAT+ Model Performance

# Calibration Steps

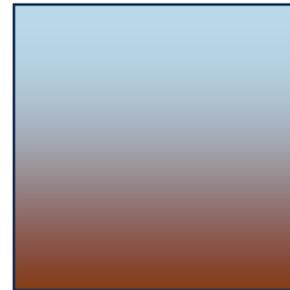
1. Crop Yield



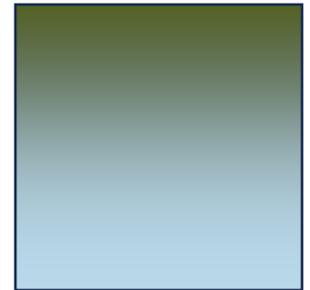
2. Flows



3. Sediment



4. Phosphorus



# Average Annual Crop Yield (2011-2022)

Crop Name	SWAT+ Yield (Mg/ha)	NASS Yield (Mg/ha)	% Difference
Corn	9.4	9.0	5%
Corn silage	15.7	15.2	3%
Soybean	2.6	2.8	-7%
Alfalfa, hay	6.0	6.4	-6%
Winter wheat	4.3	4.3	1%

# Performance Metrics for Model Fit

Moriasi et al. (2007)

**Percent Bias:** “Tendency of the simulated data to be larger or smaller than observations”

**Nash Sutcliffe Efficiency (NSE):**  
“Normalized statistic that determines the relative magnitude of residual variance”

Interpretation	Constituent	NSE	PBIAS
Very Good	Flow	0.75 or greater	±10 % or less
	TP	0.75 or greater	±15 % or less
	TSS	0.75 or greater	±25 % or less
Good	Flow	0.65 or greater	±15 % or less
	TP	0.65 or greater	±30 % or less
	TSS	0.65 or greater	±40 % or less
Satisfactory	Flow	0.5 or greater	±25 % or less
	TP	0.5 or greater	±55 % or less
	TSS	0.5 or greater	±70 % or less

# Performance: Flow

Calibration Site	Calibration		Validation	
	NSE	PBIAS	NSE	PBIAS
Fox River at Waukesha	0.89	-3.4	0.85	4.3
Fox River at CTH I	0.91	-7.6	0.89	1.2
Mukwonago River	0.84	1.0	0.65	11.0
Fox River at Waterford	0.94	-6.0	0.92	0.1
Muskego Lake	0.87	-1.2		
Wind Lake	0.65	-3.2		
Fox River at Rochester Dam	0.91	-10.4	0.87	-4.1
Honey Creek	0.74	-6.4		
Sugar Creek	0.73	0.7		
Lake Geneva	0.71	-13.1	0.60	6.5
White River	0.80	-14.8		
Fox River at New Munster	0.95	1.8	0.89	6.4
Fox River at WI Border	0.95	0.4	0.89	4.0
Des Plaines River	0.88	-1.1	0.84	4.6

Performance Metrics
Very Good
Good
Satisfactory
Not Satisfactory

# Performance: Sediment

Calibration Site	Calibration		Validation	
	NSE	PBIAS	NSE	PBIAS
Fox River at Waukesha	0.63	4.8		
Fox River at CTH I	0.53	-13.6	0.53	-1.1
Fox River at Waterford	0.54	-8.9	0.45	7.5
Fox River at Rochester Dam	0.59	-12.6	0.61	-3.1
Honey Creek	0.82	-8.8		
Sugar Creek	0.63	0.1		
White River	0.85	-10.2		
Fox River at New Munster	0.75	-4.1	0.88	3.4
Des Plaines River	0.78	-1.3	0.55	-6.3

Performance Metrics
Very Good
Good
Satisfactory
Not Satisfactory

# Performance: Sediment and Phosphorus

Calibration Site	Calibration		Validation	
	NSE	PBIAS	NSE	PBIAS
Fox River at Waukesha	0.59	-2.7		
Fox River at CTH I	0.53	-6.5	0.65	3.7
Mukwonago River	0.65	-3.6	0.52	11.0
Fox River at Waterford	0.56	18.4	0.58	20.0
Muskego Lake	0.83	-12.1		
Wind Lake	0.80	4.0		
Fox River at Rochester Dam	0.70	-9.4	0.65	-8.7
Honey Creek	0.81	2.5		
Sugar Creek	0.59	-7.9		
Lake Geneva	0.58	-11.6	0.43	-21.7
White River	0.77	-6.7		
Fox River at New Munster	0.78	-1.2	0.75	-4.4
Fox River at WI Border	0.85	-1.0	0.86	4.4
Des Plaines River	0.72	0.9	0.79	14.8

Performance Metrics
Very Good
Good
Satisfactory
Not Satisfactory

# Modeling: Resources



## Project Website:

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▼ [May 2025 Informational Webinar - May 22, 2025](#)

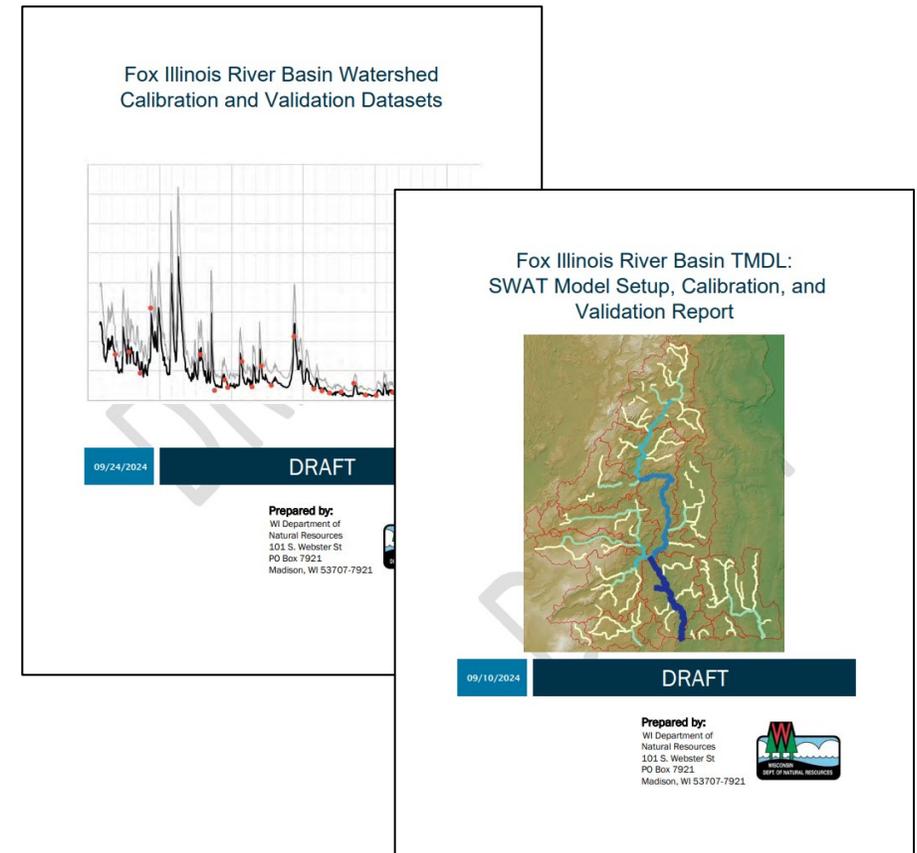
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- Recorded presentation: [September 2024 Informational Webinar](#)
- [Webinar presentation slides \[PDF\]](#)

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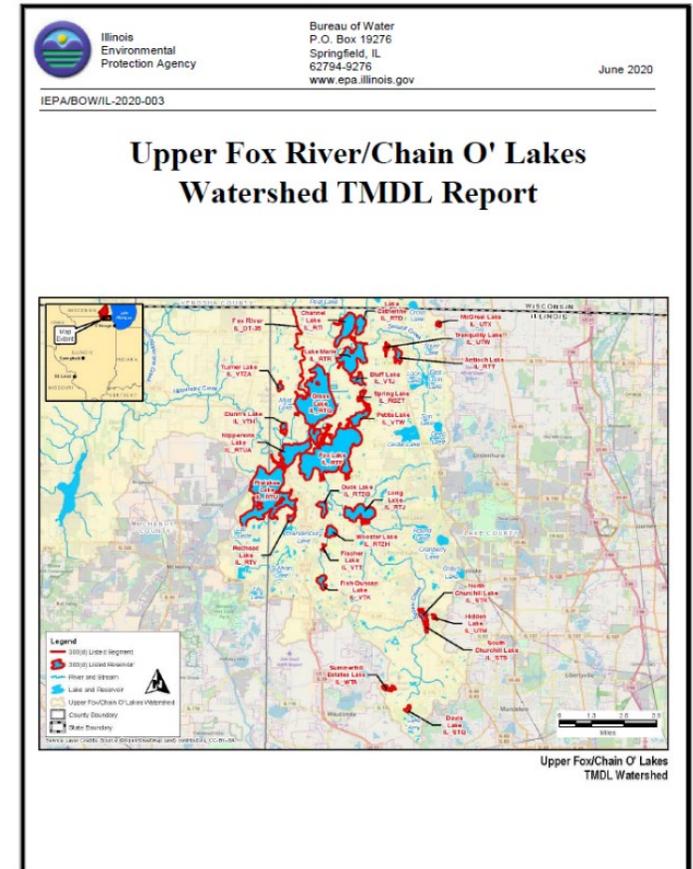
# Grass Lake in Illinois

# Upper Fox River/Chain O' Lakes TMDL

The TMDL was Approved June 2020 covering 26 lakes listed as impaired for total phosphorus based on Illinois' 0.05 mg/L criterion.

## Section 302.205 Phosphorus

Phosphorus (STORET number 00665): After December 31, 1983, Phosphorus as P shall not exceed 0.05 mg/l in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more, or in any stream at the point where it enters any such reservoir or lake. For the purposes of this Section, the term "reservoir or lake" shall not include low level pools constructed in free flowing streams or any body of water which is an integral part of an operation which includes the application of sludge on land. Point source discharges



# CWA Requirements for Downstream Waterbodies

*“It is clear that the central goal of the CWA and EPA’s implementing regulations is to ensure that downstream States/Tribes are not subjected to pollutant loads from upstream or adjacent jurisdictions that cause or contribute to the impairment of downstream waters.”*

USEPA, Considerations for the Development of Multijurisdictional TMDLs, 2012



## Key Requirements:

1. IEPA cannot assign allocations or percent reductions to Wisconsin dischargers.
2. A TMDL developed by Wisconsin must be protective of the water quality criteria and standards of the Chain O'Lakes.

# CWA Requirements for Downstream Waterbodies

*"It is clear that the central goal of the CWA and EPA's implementing regulations is to ensure that downstream States/Tribes are not subjected to pollutant loads from upstream or adjacent jurisdictions that cause or contribute to the impairment of downstream waters."*

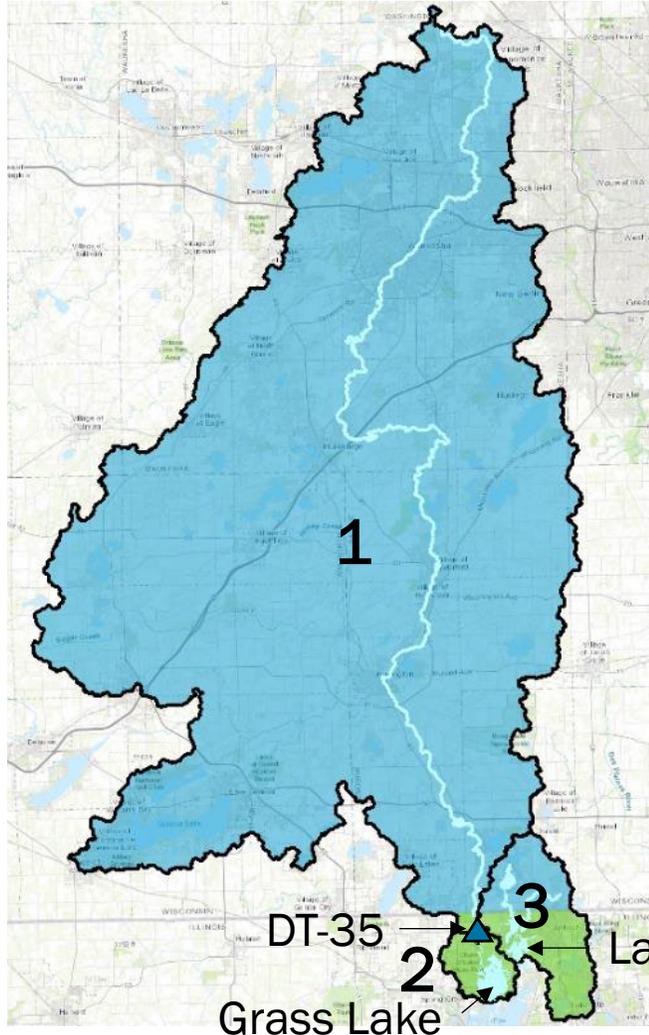
Allocations and loading capacities outlined in IEPA's Chain O' Lakes TMDL are not applicable to Wisconsin...

Key Requirements:

1. IEPA cannot assign allocations or percent reductions to Wisconsin dischargers. **Chain O' Lakes.**
2. A TMDL developed by Wisconsin must be protective of the water quality criteria and standards of the Chain O'Lakes.



# Grass Lake Connectivity



Three drainage areas: 1. Fox River upstream of Station DT-35\*, 2. direct drainage to Grass Lake, and 3. Lake Marie

*Note: Illinois maintains a long-term water quality monitoring station on the Fox River between the Wisconsin Border and Grass Lake (DT-35)*

ID	Waterbody	Drainage Area (mi <sup>2</sup> )			% of Total	
		Wisconsin	Illinois	Total	Wisconsin	Illinois
1	Fox River to DT-35	857	2	859	99.8%	0.2%
2	Grass Lake Direct Drainage	0	11	11	0.0%	100.0%
3	Lake Marie to Grass Lake*	15	21	36	41.0%	59.0%
<b>Total to Grass Lake</b>		<b>872</b>	<b>34</b>	<b>906</b>	<b><u>96.2%</u></b>	<b>3.8%</b>

\*Note: ~49% of flow from Lake Marie is diverted to Bluff Lake

# Grass Lake Modeling Modeling

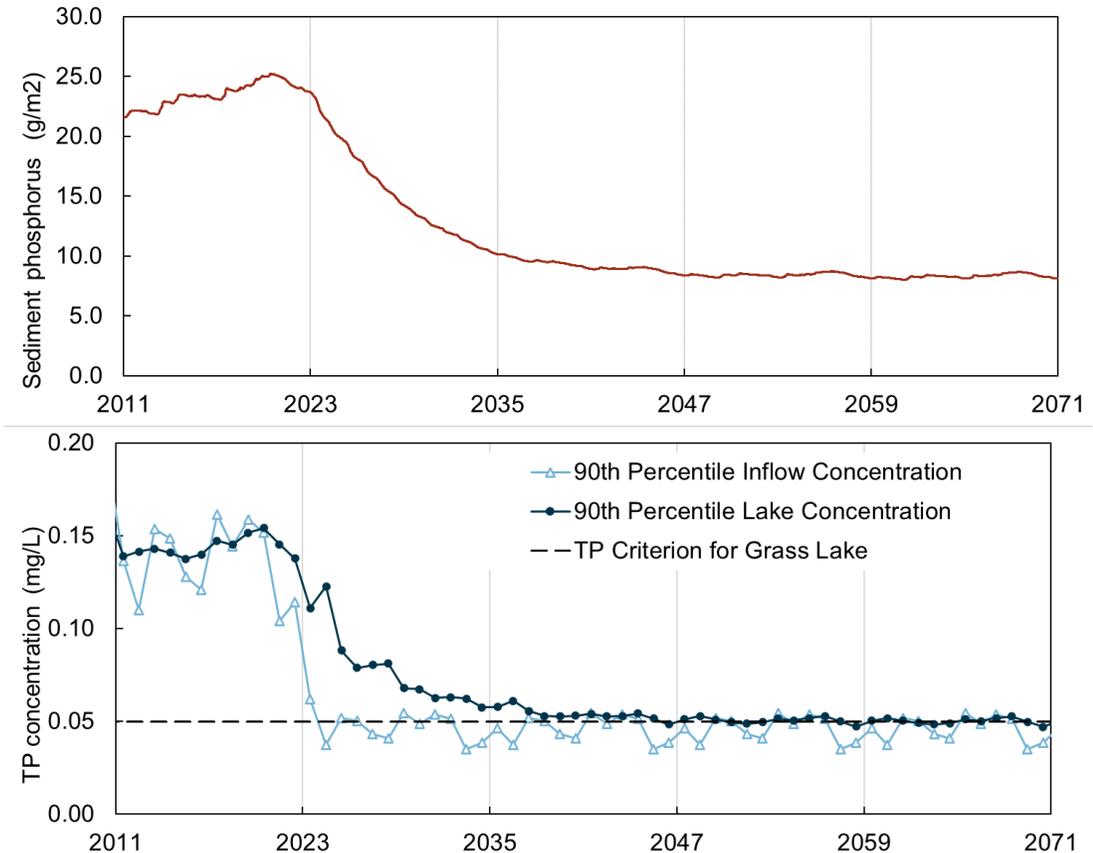
## External Loading

Baseline (2011-2022): 173,917 lb/yr

Loading Capacity: 58,784 lb/yr

## Reduction in External Loads: 66.2%

*Note: Phosphorus criterion for 90<sup>th</sup> percentile reached ~40 years after reductions*



# Grass Lake: Resources



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- Recorded presentation: [May 2025 Informational Webinar](#)

### MODELING REPORTS

A draft report was developed to detail Wisconsin’s water quality modeling of the Illinois Chain O’ Lakes. We are accepting input on the draft reports until June 20, 2025. Please send all written feedback to Eric Hettler at [eric.hettler@wisconsin.gov](mailto:eric.hettler@wisconsin.gov).

[Chain O’ Lakes/Grass Lake \(IL\) Phosphorus Modeling Report \[PDF\]](#)

### Fox Illinois River Basin TMDL: Grass Lake (IL) Phosphorus Modeling



05/12/2025

DRAFT

Prepared by:  
WI Department of  
Natural Resources  
101 S. Webster St  
PO Box 7921  
Madison, WI 53707-7921



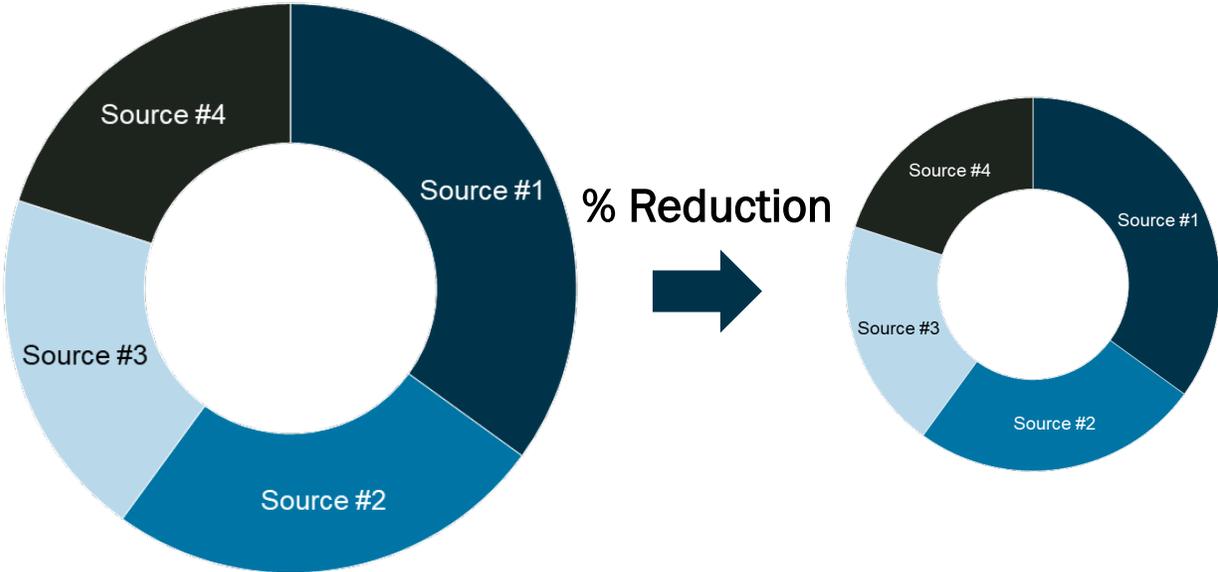
# Next Steps: Allocations

# Allocations



Baseline Load Model

Allowable Load Criteria and Flows Reduction



# Step 1: Calculate Allowable Load

**Allowable Load:** Amount of pollutant a waterbody can receive without exceeding criteria (TMDL); expressed as lbs/yr or lbs/day

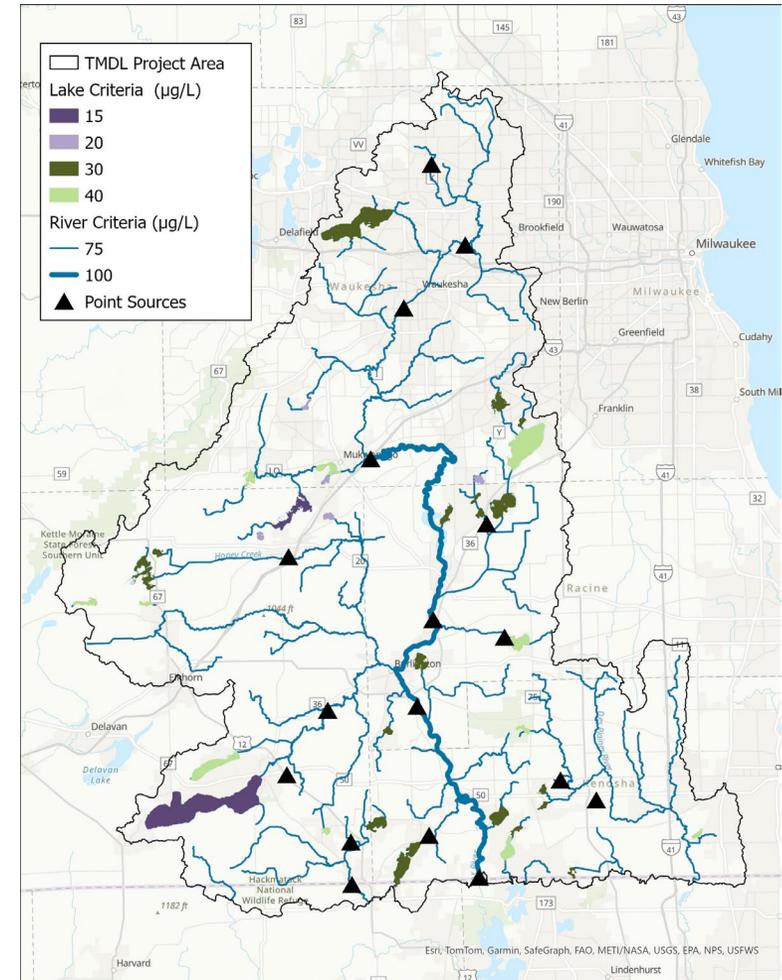
## Stream/River Allowable Load

$$\text{Allowable Load} = \text{Flow} * \text{Criteria}$$

*Note: Wisconsin uses GSM for criteria, so an adjustment factor is used to translate annual loading*

## Lake Allowable

Calculated from SWAT+ model or Grass Lake model



# Step 2: Calculate Baseline Loads

**Baseline Load =**  
Nonpoint sources +  
Point sources +  
Reserve Capacity +  
Margin of Safety

## Nonpoint Sources (SWAT+ model)

Natural/Background

Agriculture

Non-permitted urban

## Point Sources

General permits

MS4s (SWAT+ Model)

Permitted dischargers(set at 1 mg/L and DAF)

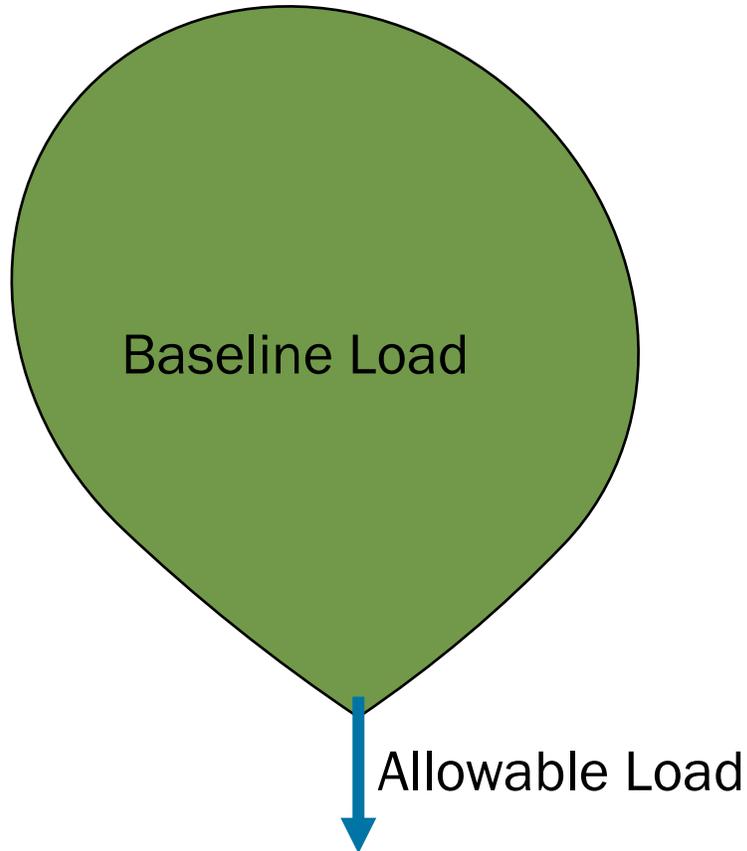
## Other Components

Reserve Capacity

Margin of Safety (implicit or explicitly)

# Step 3: Calculate Reductions to Meet Wisconsin Water Quality Criteria

If baseline load > allowable load, reductions required



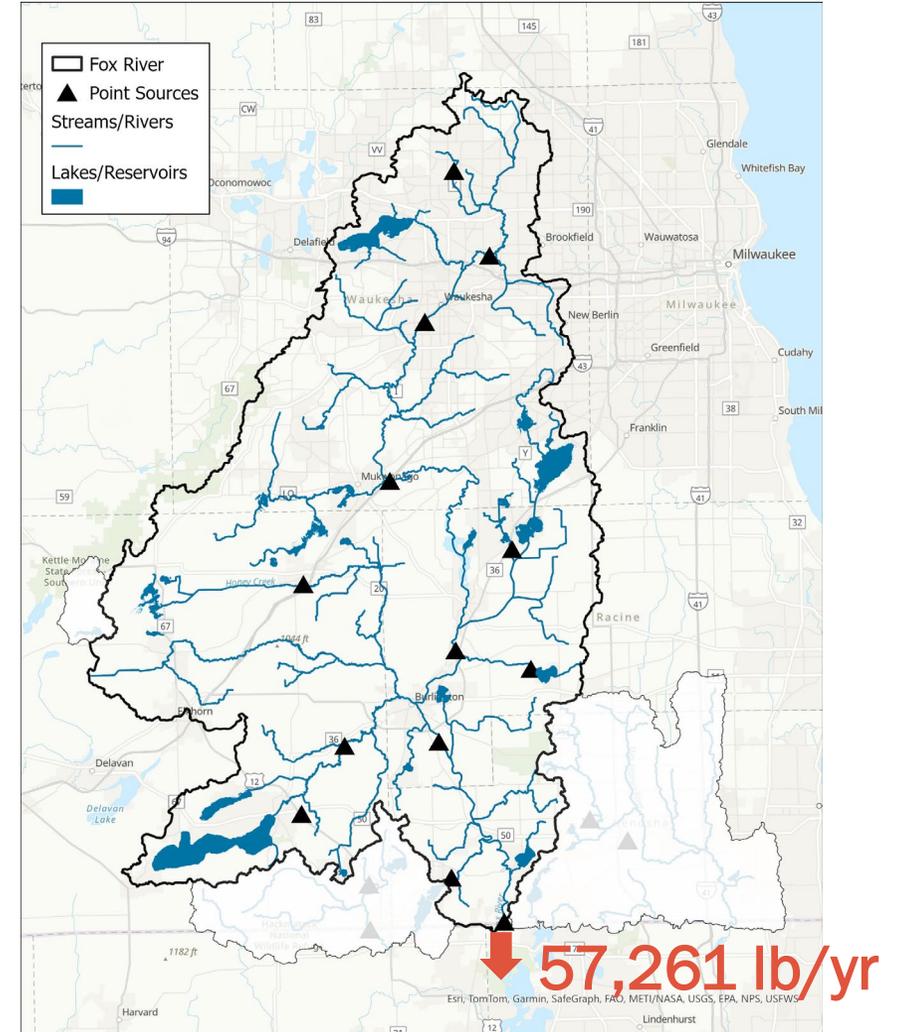
$$\% \text{ Reduction} = \frac{\text{Baseline Load} - \text{Allowable Load}}{\text{Baseline Load}}$$

# Step 4: Calculate Additional Reductions to Meet Grass Lake Criterion

Allowable Load from Fox River in Wisconsin:

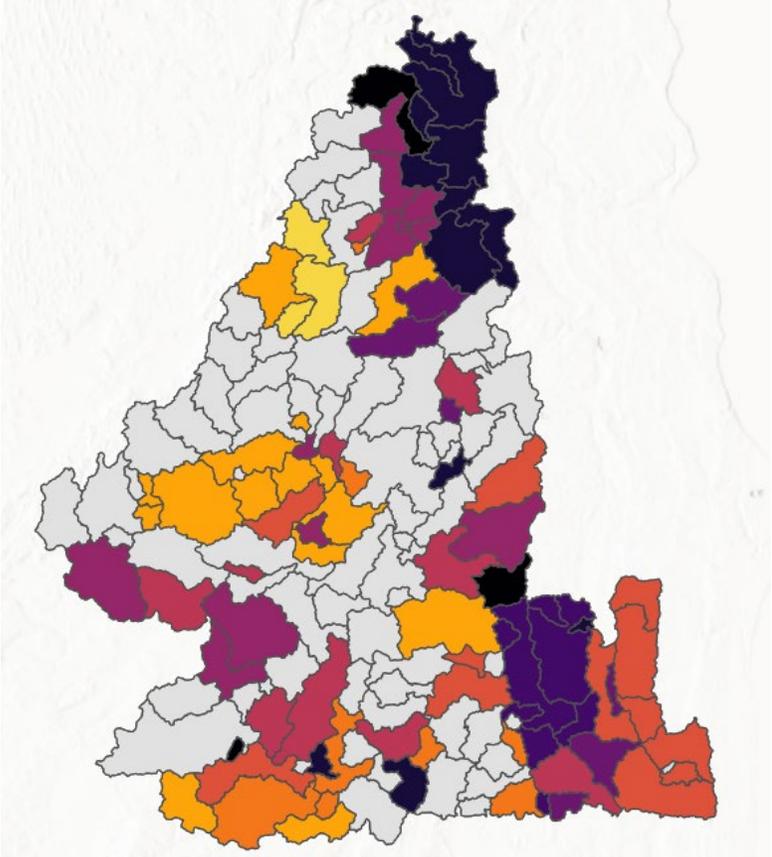
57,261 lb/yr

Reduce loads beyond what is required to address Wisconsin criterion

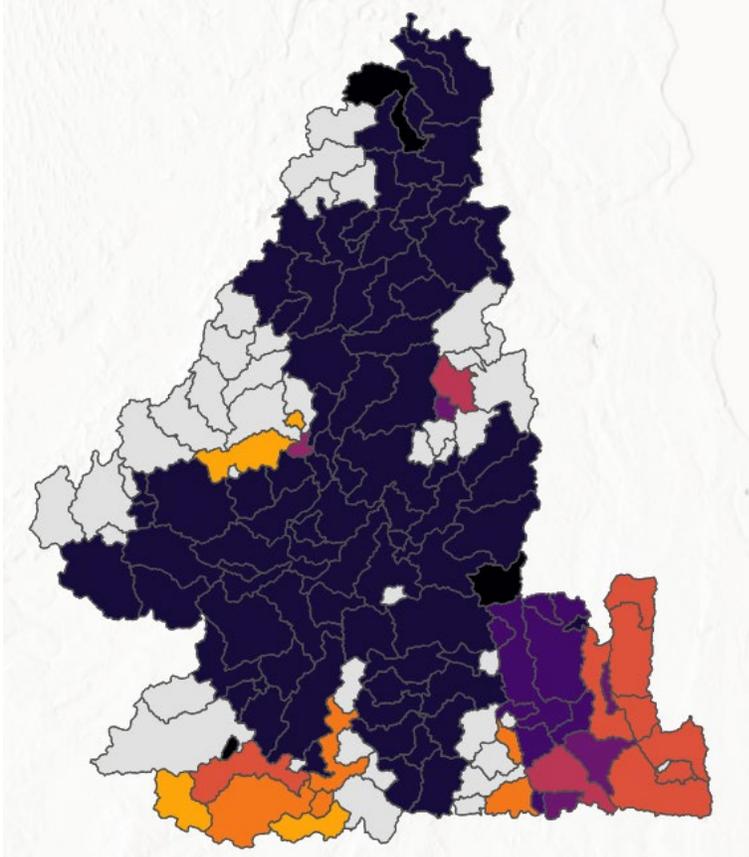


# Allocation Output: Percent Reductions

Meeting Wisconsin Criteria



Meeting Grass Lake Criterion



# Allocation Output: TMDL Tables

## TMDL Tables: Load allocations by source

### Total Phosphorus Annual Allocations

Table K.K.1. Annual total phosphorus load allocations by TMDL reach. Some column names have been abbreviated to fit: Load cap. = loading capacity, LA = load allocation (background, agriculture, non-permitted urban), WLA = wasteload allocation (general permits, MS4s, individual permits), RC = reserve capacity, BG = background load, Agric. = agriculture allocation, NPU = non-permitted urban allocation, GP = general permits, IP = individual permits.

Rch	Total (LA+WLA+RC) (lbs/year)	LA (BG+Ag+NPU) (lbs/year)	BG (lbs/year)	Agric. (lbs/year)	NPU (lbs/year)	WLA (GP+MS4+IP) (lbs/year)	GP (lbs/year)	MS4 (lbs/year)	IP (lbs/year)	RC (lbs/year)
K1	1,354	1,239	230	985	24	59	11	47	0	56
K2	3,392	3,162	219	2,921	22	72	32	40	0	159
K3	2,595	2,455	269	2,169	18	23	23	0	0	116
K4	2,799	2,653	357	2,268	28	24	24	0	0	122
K5	1,354	1,292	317	968	7	10	10	0	0	52
K6	271	257	40	216	2.1	2.3	2.3	0	0	12
K7	1,750	1,652	113	1,532	7.1	16	16	0	0	82

# Implementation



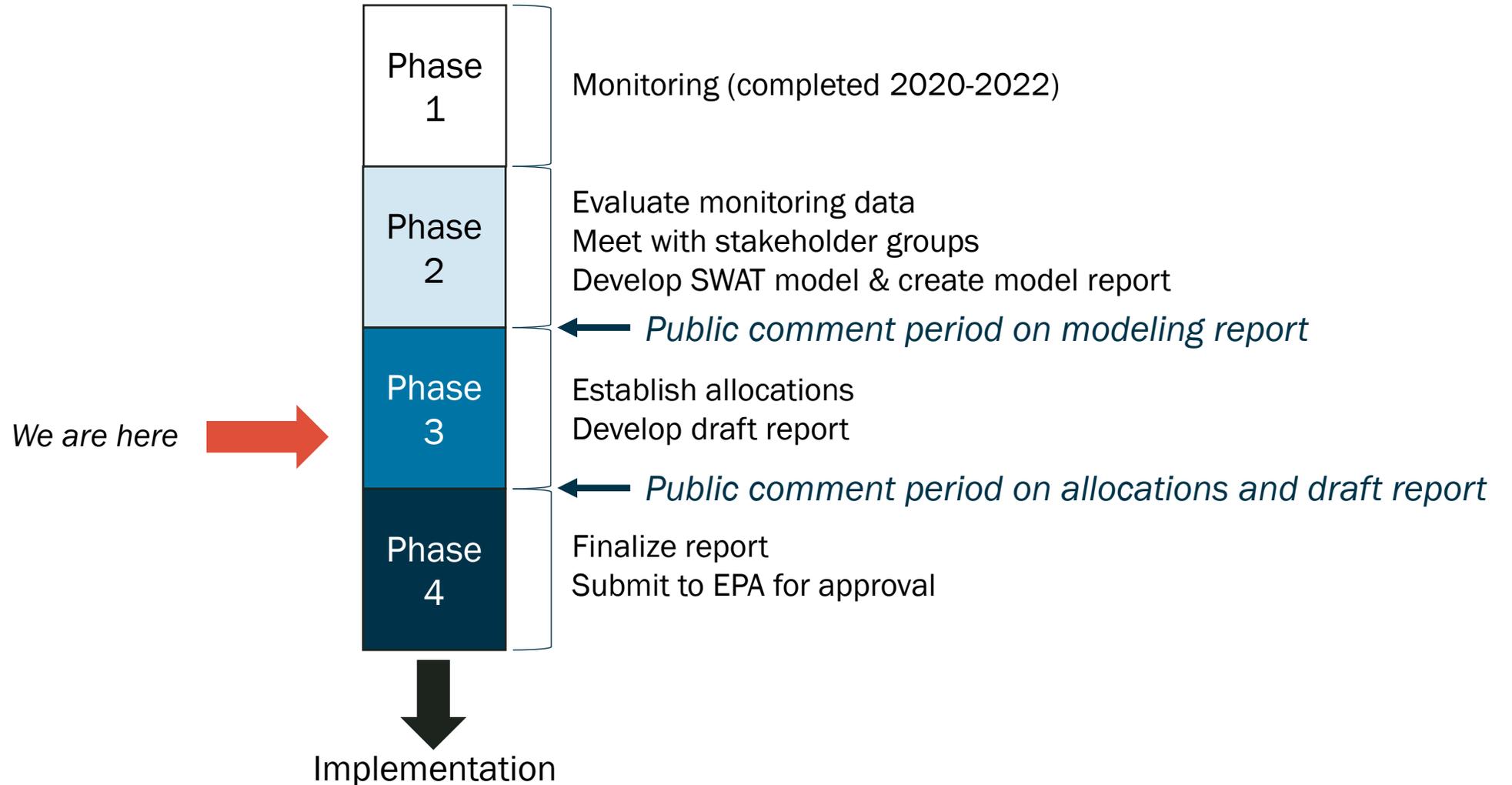
# Implementation



## Framework for Implementing Management Practices

- Incorporate TMDL wasteload allocations into permit limits
- Provide additional support and context for existing implementation plans
- Identify high-loading watersheds & locations

# Summary of Next Steps



# Staying Connected

[dnr.wisconsin.gov/topic/TMDLs/FOXIL](https://dnr.wisconsin.gov/topic/TMDLs/FOXIL)

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