Fox Illinois River Basin TMDL Water Quality Modeling of Illinois' Chain O' Lakes

May 22, 2025

Online Webinar

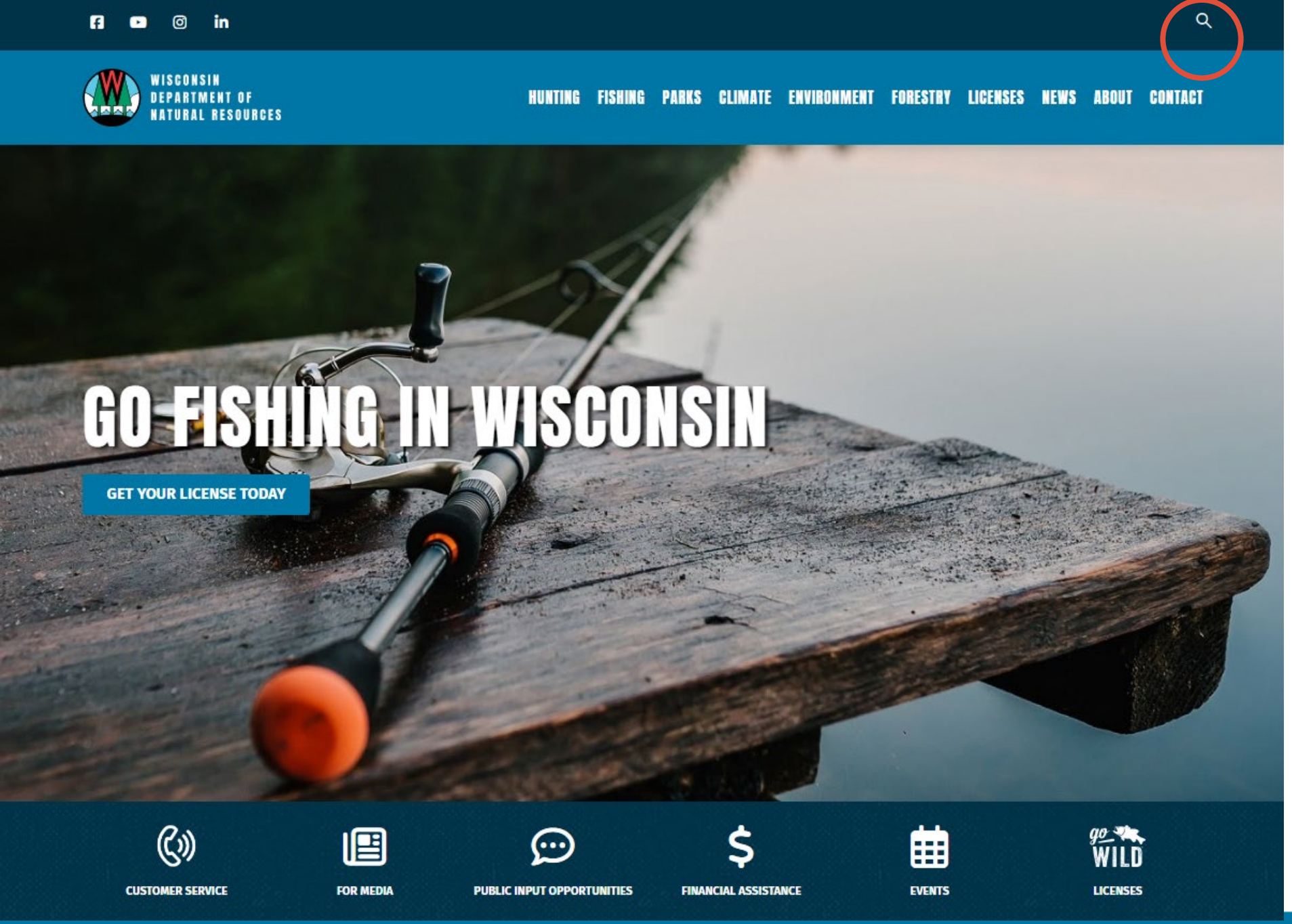
Today's Format

- Introductions
- Presentation covering Wisconsin's water quality modeling of Illinois' Chain O' Lakes TMDL
- Panel to address questions

- Both the recorded presentation and slides will be available on the DNR website

https://dnr.wi.gov/topic/TMDLs/FoxIllinois.html

or search "Fox Illinois River TMDL"



dnr.wi.gov

Click magnifying glass and type “Fox Illinois River TMDL” into the search bar

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

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» TOPIC » TMDLS

FOX ILLINOIS RIVER BASIN TMDL

A FRAMEWORK FOR WATER QUALITY IMPROVEMENT

Fox River at Waterford

Total Maximum Daily Loads (TMDLs)

- Overview
- TMDLs In Development
- Approved TMDLs
- Implementation
- Point Source
- Nonpoint Source
- Map and Projects

For more information, contact:

Eric Hettler
TMDL Modeler
Water Quality Program

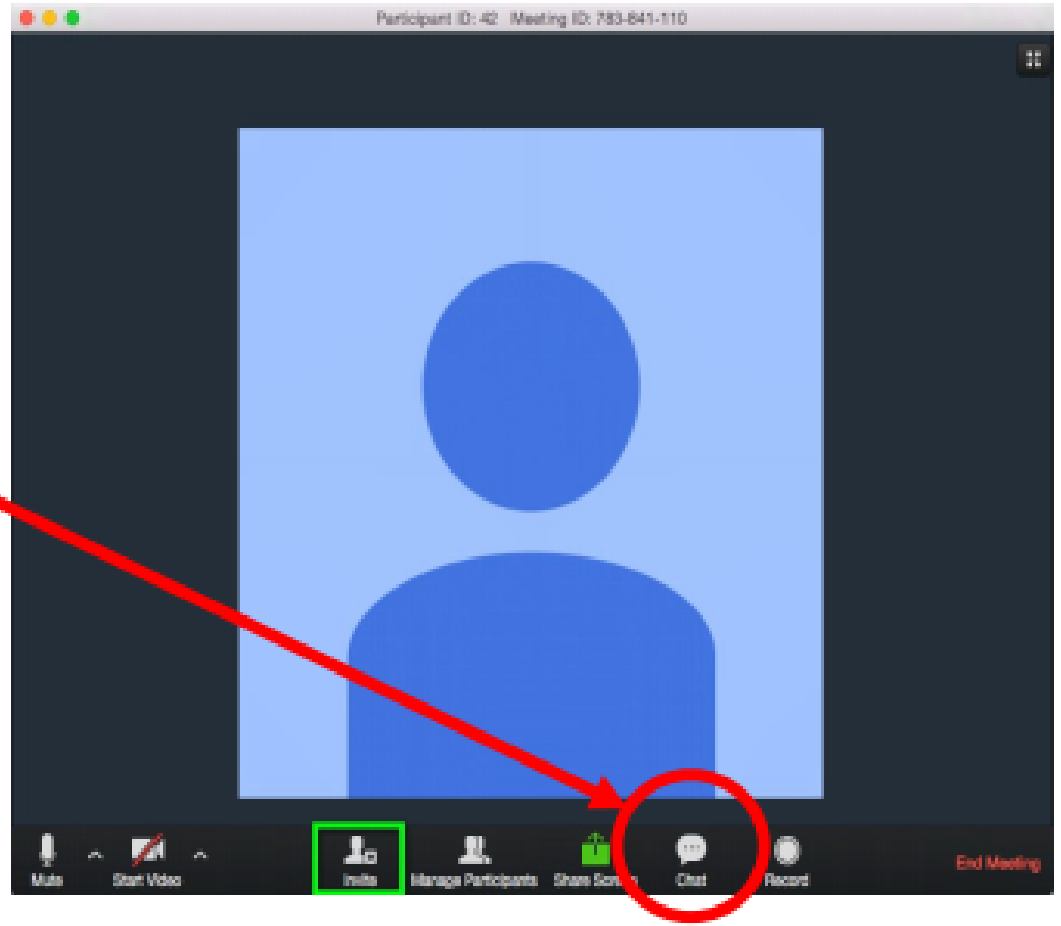
GovDelivery Sign-up

Subscribe to receive updates about the Fox Illinois River Basin TMDL.

Zoom

Click **Chat** in the meeting controls.

NOTE: If don't see controls, tap screen and they will pop up.



Kevin Kirsch
Statewide TMDL Coordinator

Eric Hettler, PE
TMDL Modeler

DNR Project Team and Sector Leads

Project Coordination: Eric Hettler[1] & Kevin Kirsch[1]

Monitoring: Rachel Sabre[1]

Wastewater: Nick Lent[1] & Nicole Krueger[1]

Stormwater: Samantha Katt[2] & Pete Wood[2]

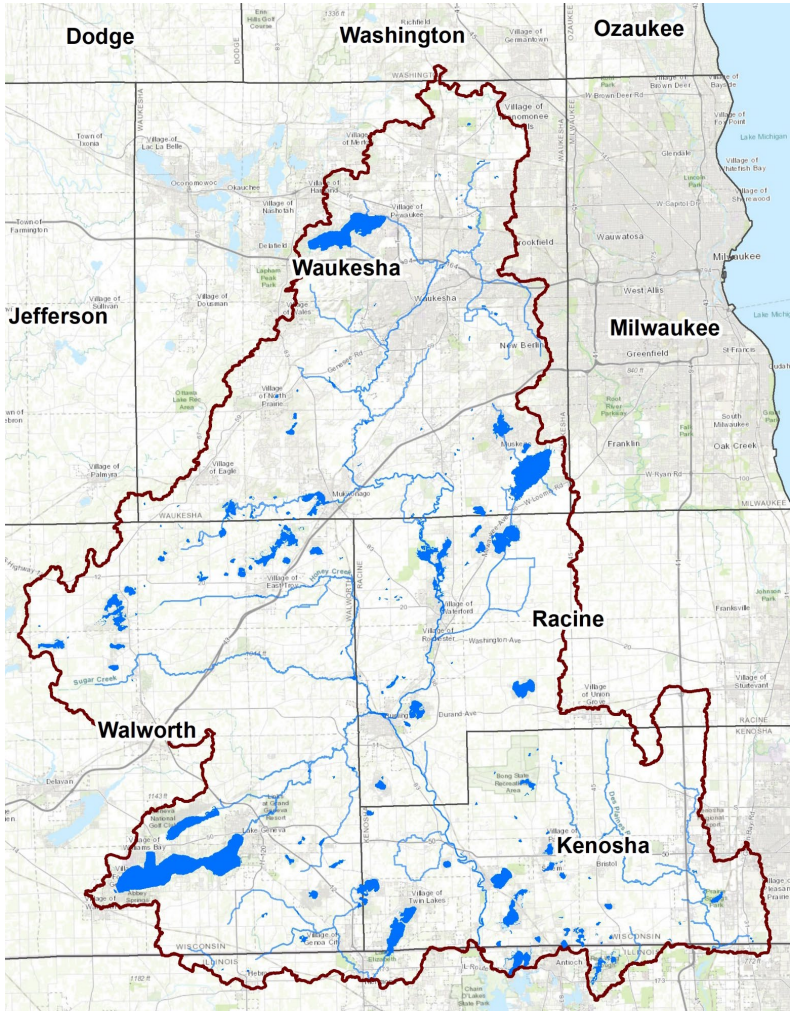
Agriculture & Urban Nonpoint: Jesse Bennett[2]

Modeling: Eric Hettler[1]

1. Bureau of Water Quality (WY)
2. Bureau of Watershed Management (WT)

Key Partners in the TMDL Development Process

SEWRPC
Serving the counties of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha



Fox Illinois River Basin TMDL Water Quality Modeling of Illinois' Chain O' Lakes

Presentation Outline

Fox Illinois River Basin TMDL Background

Wisconsin's Obligations to Protect Illinois' Water Quality

Illinois Chain O' Lakes Background

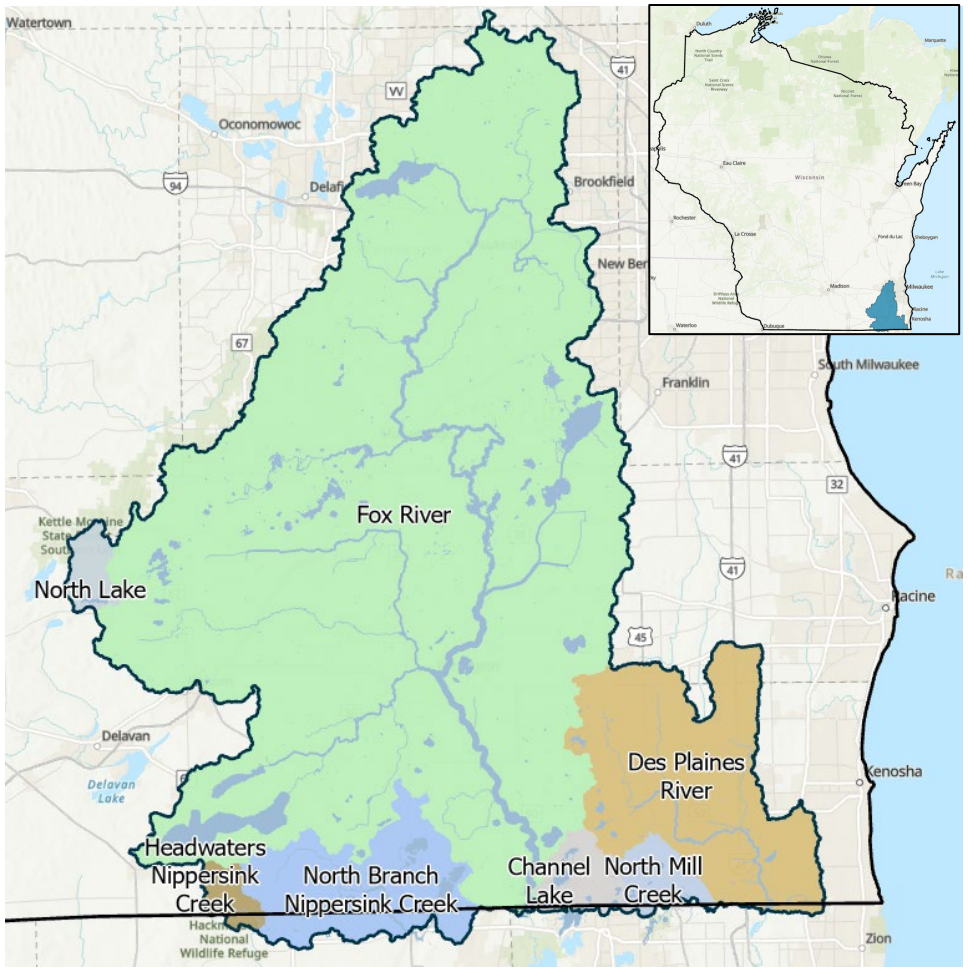
Grass Lake Modeling

- DNR Lake Modeling
- Model Inputs
- Model Calibration
- Reductions

Next Steps

Fox Illinois TMDL Project Background

FOXIL TMDL Project Extents

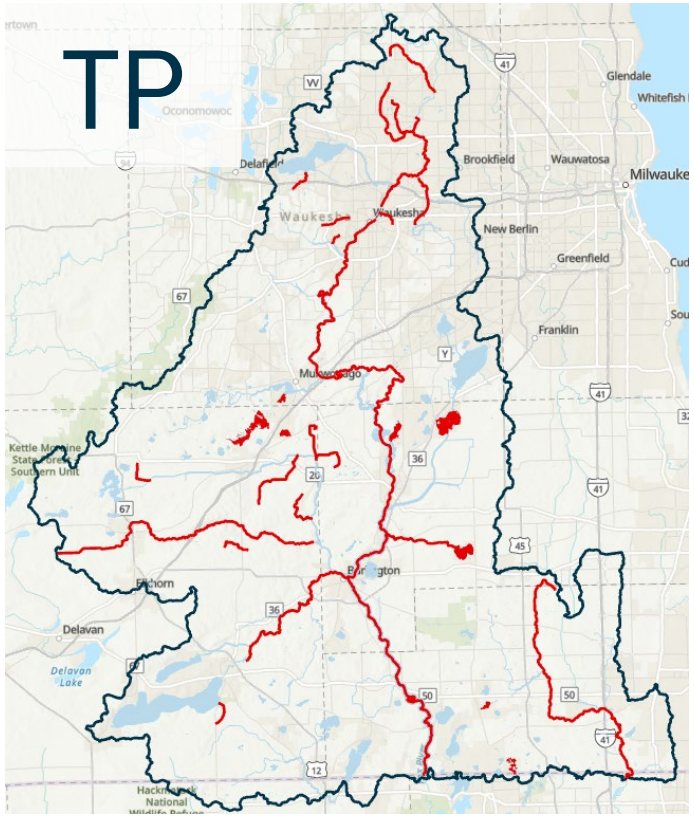


Located in Southeast Wisconsin

Seven Distinct Watersheds

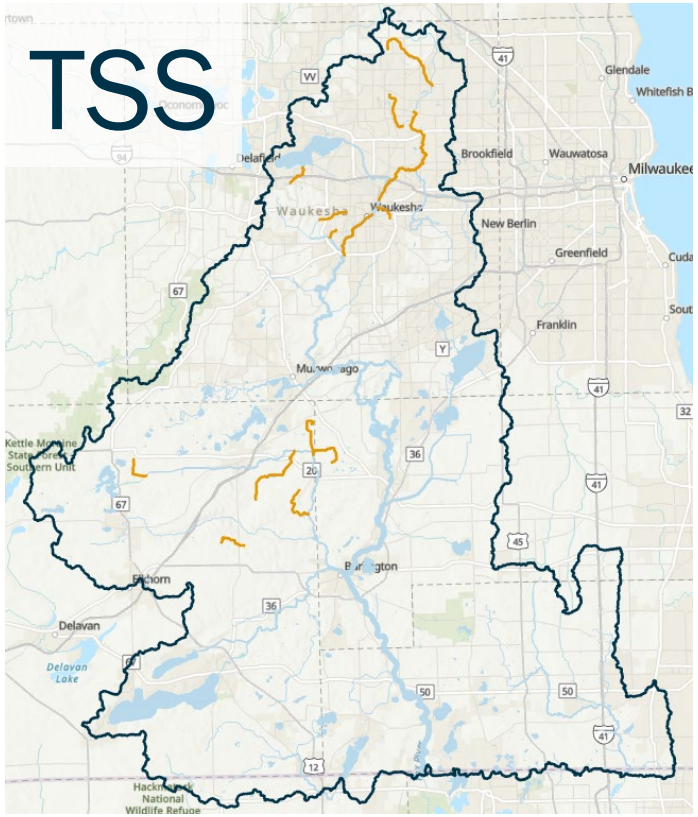
- Fox River
- Des Plaines River
- North Lake
- Headwaters Nippersink Creek North
- Branch Nippersink Creek
- Channel Lake
- North Mill Creek

TP & TSS Impairments – 303(d) List



11 named streams/rivers

9 lakes

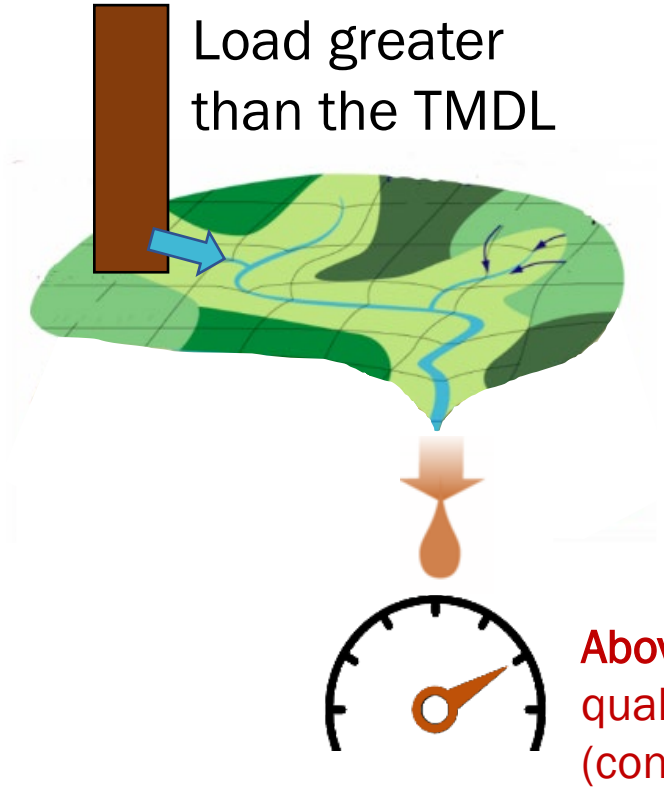


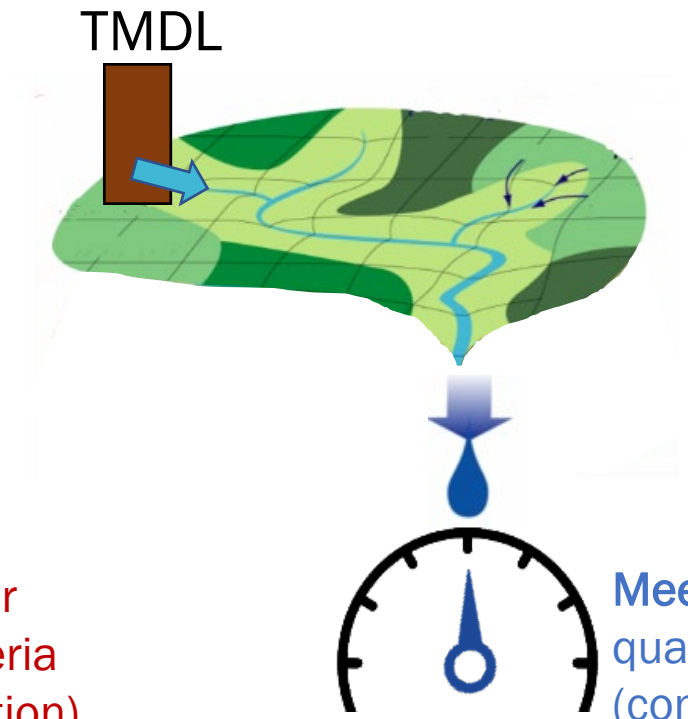
7 named streams/rivers

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

TMDL =

Load Allocation

Nonpoint loads

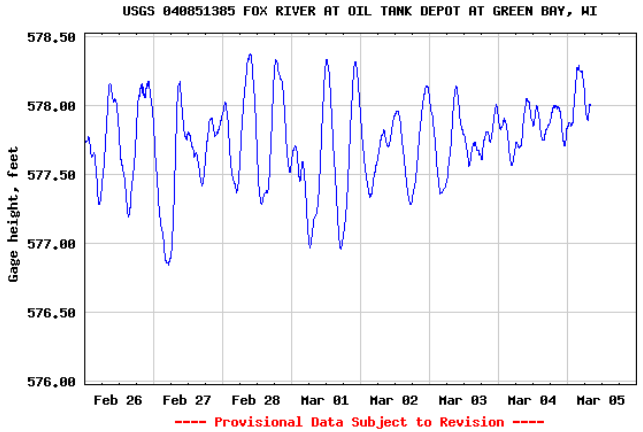
+

Wasteload Allocation

Permitted point sources

+

Margin of Safety



Modeling assumptions

Grass Lake Modeling Report

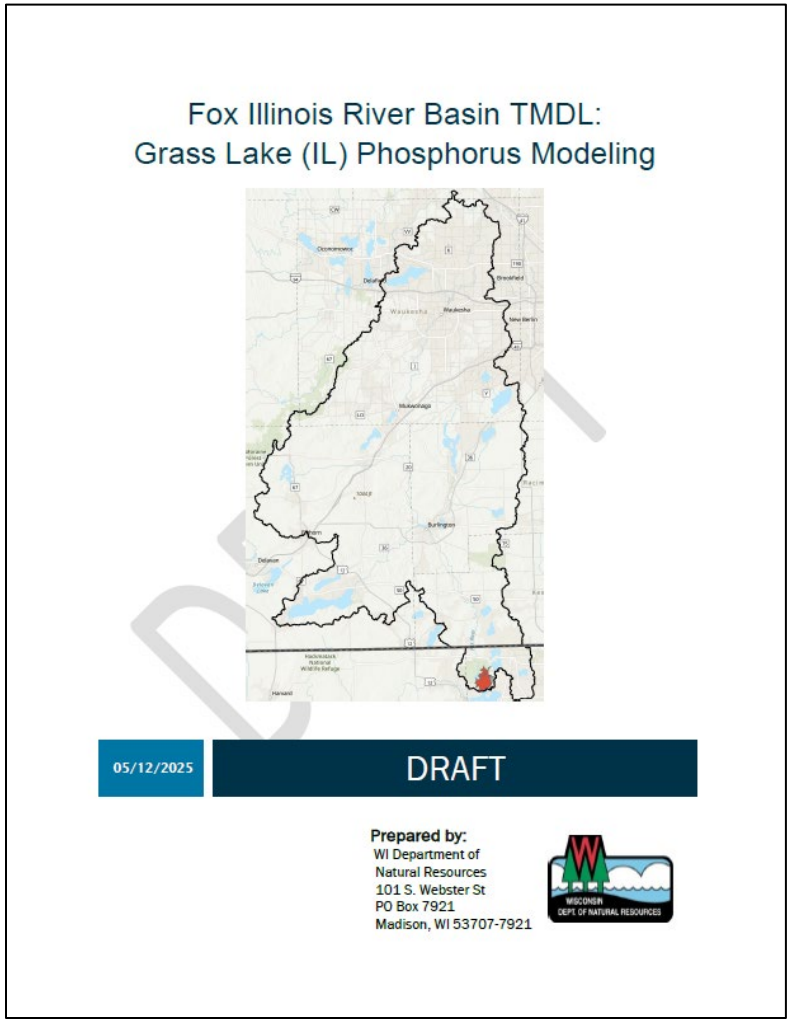
Grass Lake Modeling Report

Posted to FOXIL TMDL Website on May 14, 2025

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

Detailed explanation of lake modeling approach and results

Input accepted through June 20, 2025

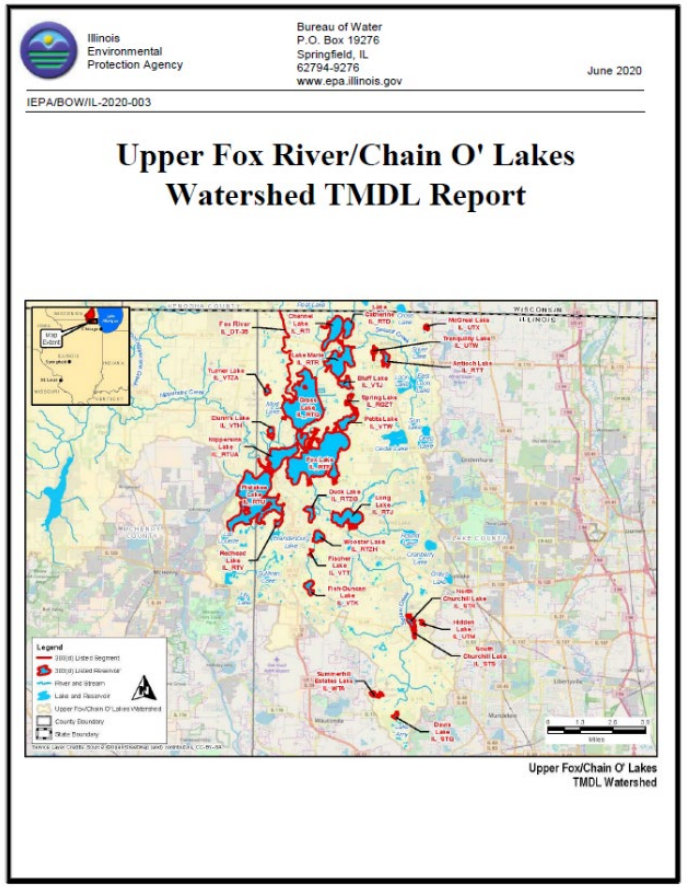


Wisconsin's Obligations to Protect Illinois' Water Quality

Section 2 of Report

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.



Illinois Environmental Protection Agency

Bureau of Water
P.O. Box 19276
Springfield, IL
62794-9276
www.epa.illinois.gov

June 2020

IEPA/BOW/IL-2020-003

Upper Fox River/Chain O' Lakes Watershed TMDL Report

Upper Fox/Chain O' Lakes TMDL Watershed

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

Title 40 —Protection of Environment
Chapter I —Environmental Protection Agency
Subchapter D —Water Programs
Part 131 —Water Quality Standards
Subpart B —Establishment of Water Quality Standards

Authority: 33 U.S.C. 1251 *et seq.*
Source: 48 FR 51405, Nov. 8, 1983, unless otherwise noted.

§ 131.10 Designation of uses.

(b) In designating uses of a water body and the appropriate criteria for those uses, the State shall take into consideration the water quality standards of downstream waters and shall ensure that its water quality standards provide for the attainment and maintenance of the water quality standards of downstream waters.

[1] The EPA interprets the term "downstream" to include both intra- and interstate waters, as well as waters that form a boundary between adjacent jurisdictions.

CWA Requirements for Downstream Waterbodies

OCTOBER TERM, 1991 91

Syllabus

ARKANSAS ET AL. *v.* OKLAHOMA ET AL.

CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE TENTH CIRCUIT

"In an opinion emphasizing EPA's discretion, Justice Stevens held that the Clean Water Act clearly authorized EPA to require that point sources in upstream states not violate the water quality standards in downstream states, and that the EPA's interpretation of those standards governed."

- February 27, 1992, memorandum from EPA Acting General Counsel

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 most be protective of the water quality criteria and standards of the Chain O'Lakes.

CWA Requirements for Downstream Waterbodies

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

but flow and associated phosphorus loadings entering the Chain O'Lakes from Wisconsin must allow attainment of water quality criterion in Grass Lake.

Illinois Chain O' Lakes Background

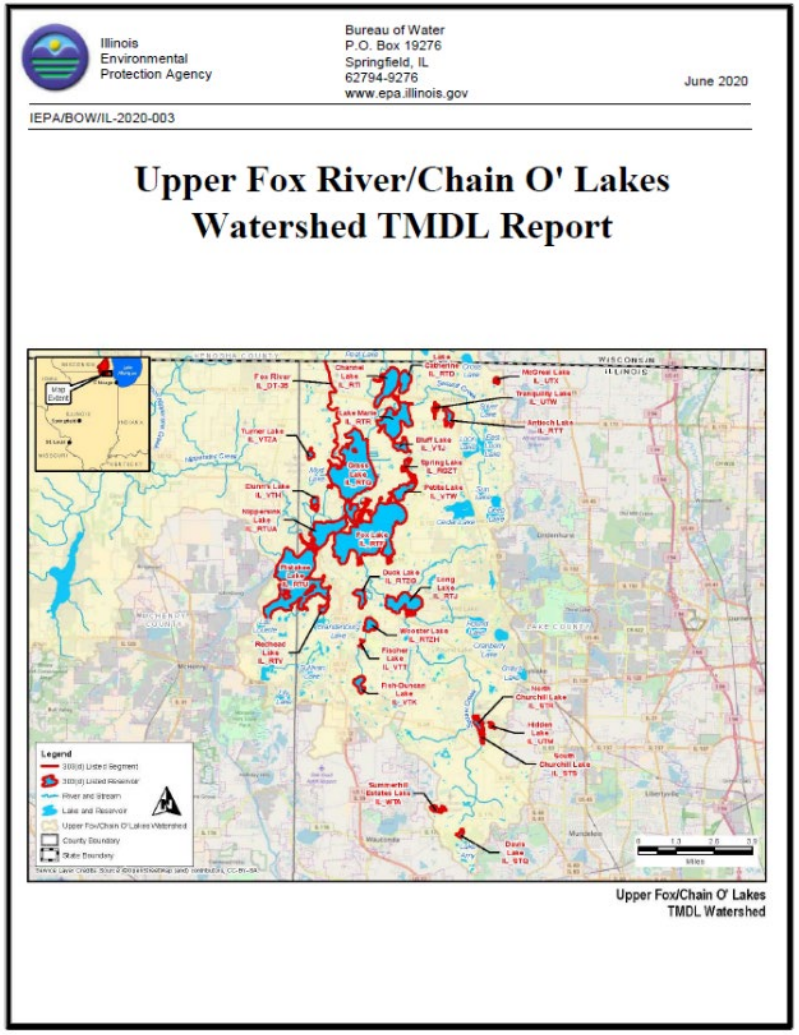
Section 2 of Report

Upper Fox River/Chain O' Lakes TMDL

Approved June 2020

TMDLs for 26 lakes having total phosphorus impairments (based on the 0.05 mg/L criterion)

Lakes evaluated using CDM Smith's Simplified Lake Analysis Model (SLAM)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Upper Fox River/Chain O' Lakes Watershed TMDL Report
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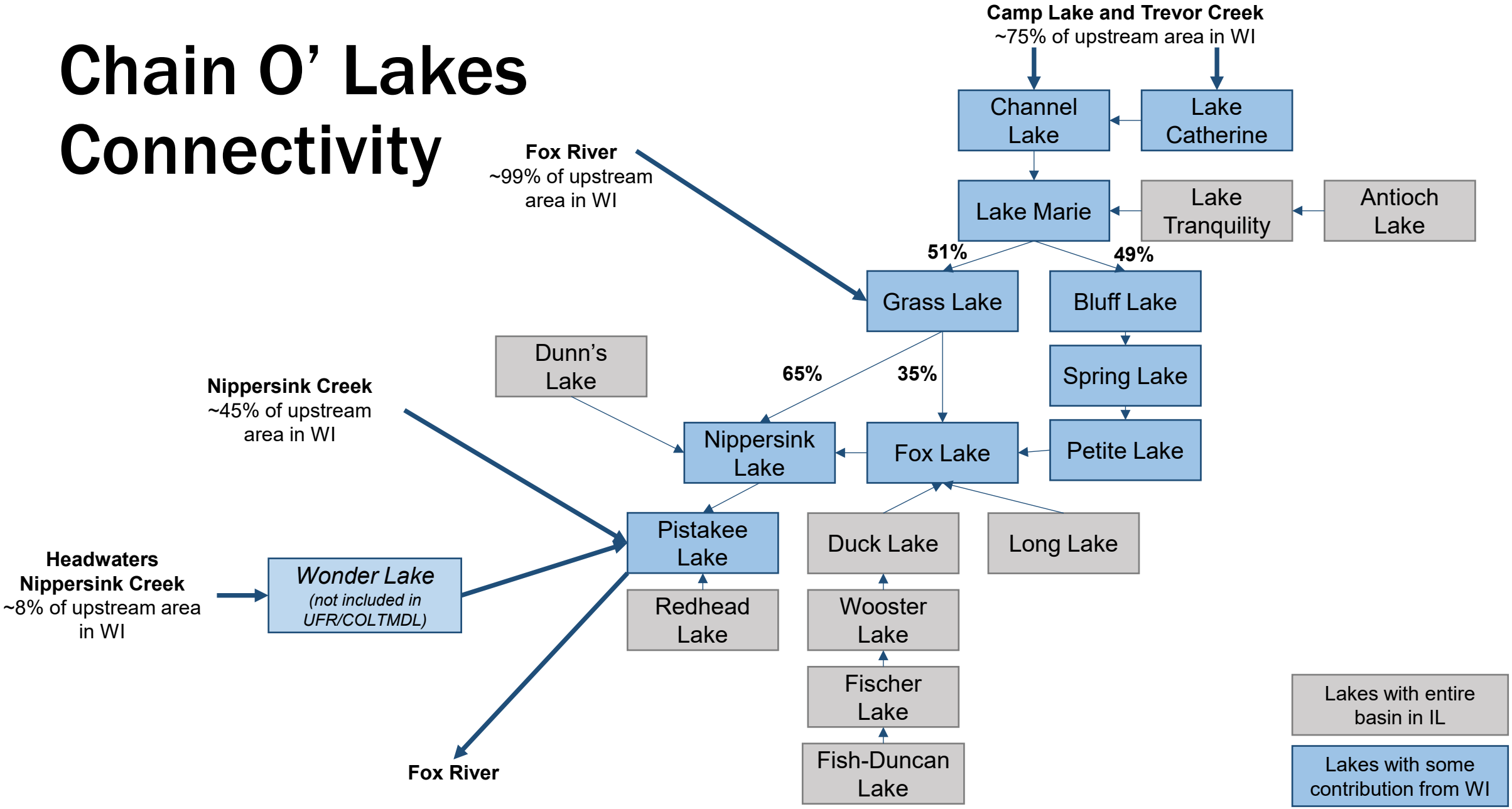
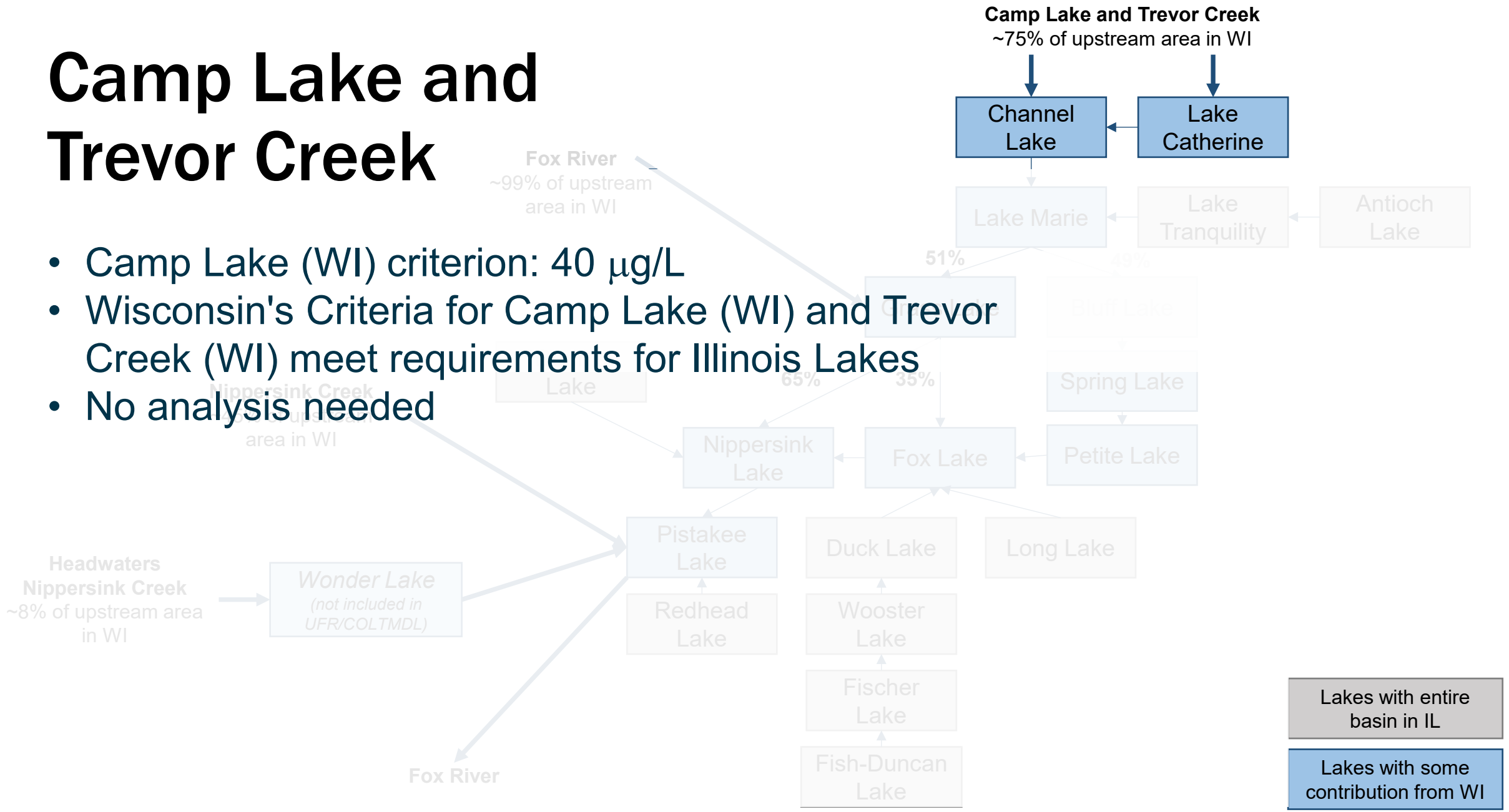
Chain O' Lakes Connectivity



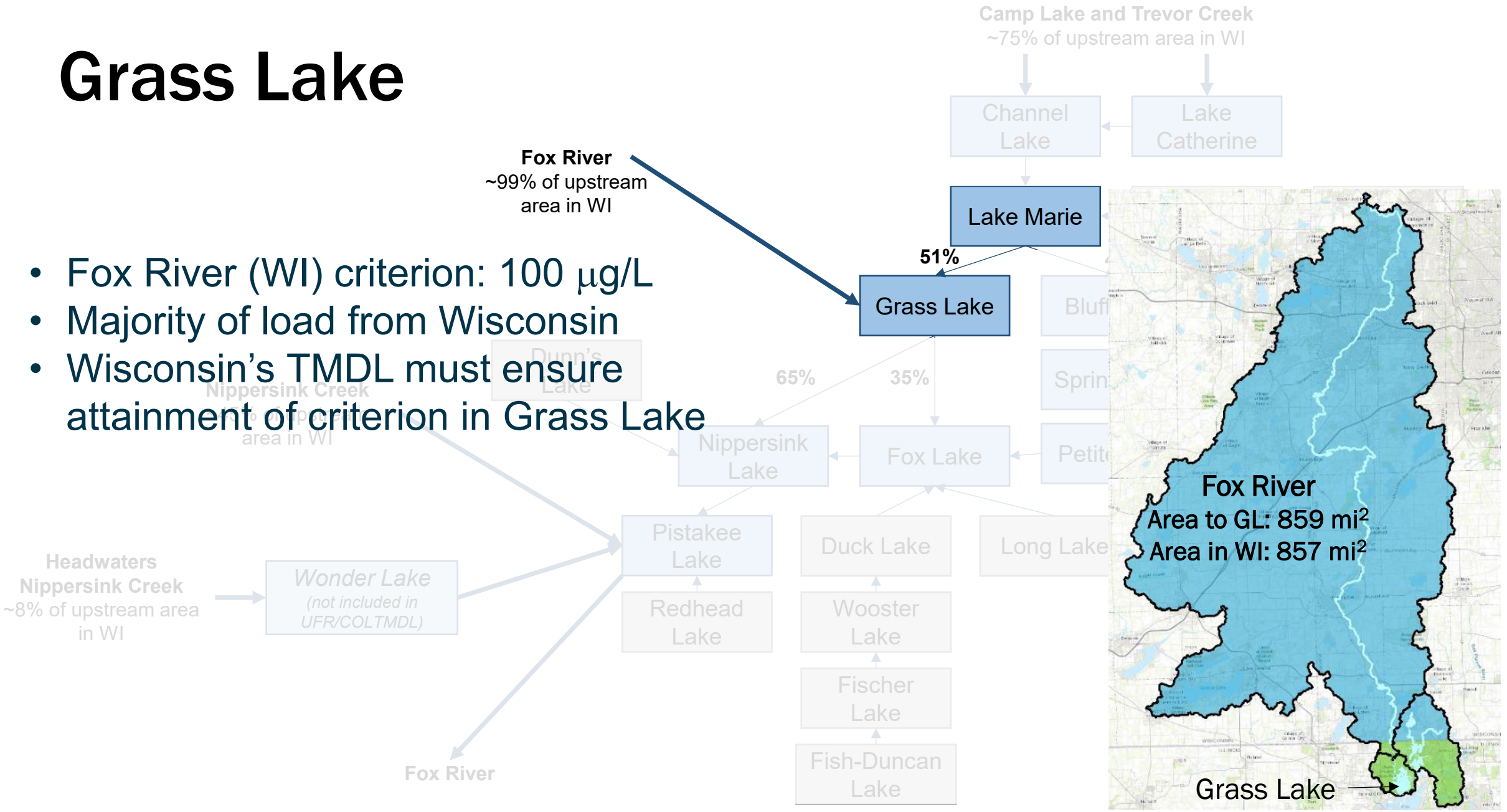
Camp Lake and Trevor Creek

- Camp Lake (WI) criterion: 40 μg/L
- Wisconsin's Criteria for Camp Lake (WI) and Trevor Creek (WI) meet requirements for Illinois Lakes
- No analysis needed

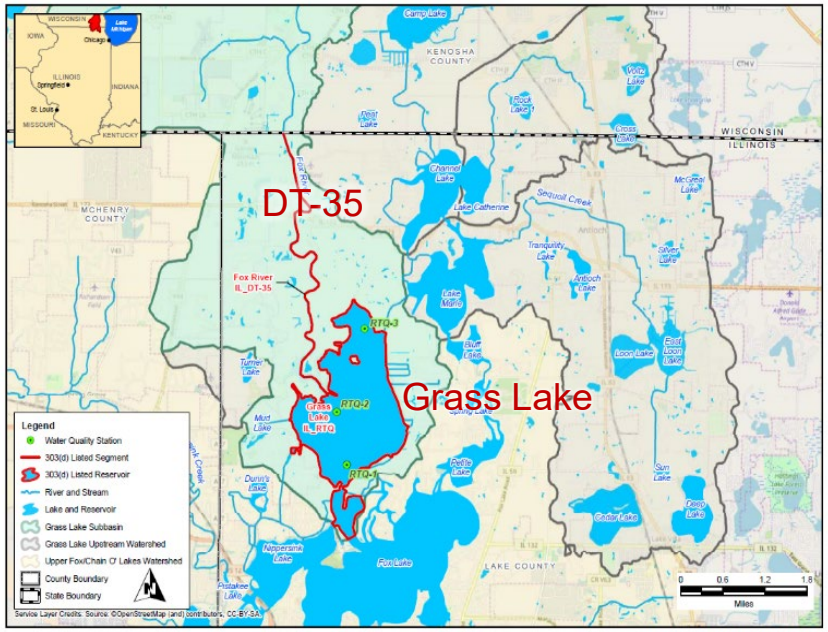


Grass Lake

- Fox River (WI) criterion: 100 μg/L
- Majority of load from Wisconsin
- Wisconsin's TMDL must ensure attainment of criterion in Grass Lake



Grass Lake TP Baseline and Allocations from Chain O' Lakes TMDL



CDM Smith

Upper Fox/Chain O' Lakes
Grass Lake Subbasin

FIGURE 1-13

Table 2-34 TMDL Summary for Grass Lake (RTQ)

Segment	Loading Source	LC (lbs/day)	WLA-MS4s (lbs/day)	WLA-Facilities (lbs/day)	LA (lbs/day)	MOS (10% of LC)	Current Load (lbs/day)	Reduction Needed (lbs/day)	Reduction Needed (Percent)
RTQ	Internal	22.1	-	-	19.9	2.21	29.4	7.30	25%
	External	79.0	0.002	-	71.1	7.90	395	316	80%
	Total	101	0.002	-	90.9	10.1	424	323	76%

Initial Review: Fox River from Wisconsin would need to be less than natural background concentration (<20 μg/L)

Conclusion: Need to revisit lake modeling to check modeling assumptions and ensure consistency with the Fox Illinois River Basin TMDL

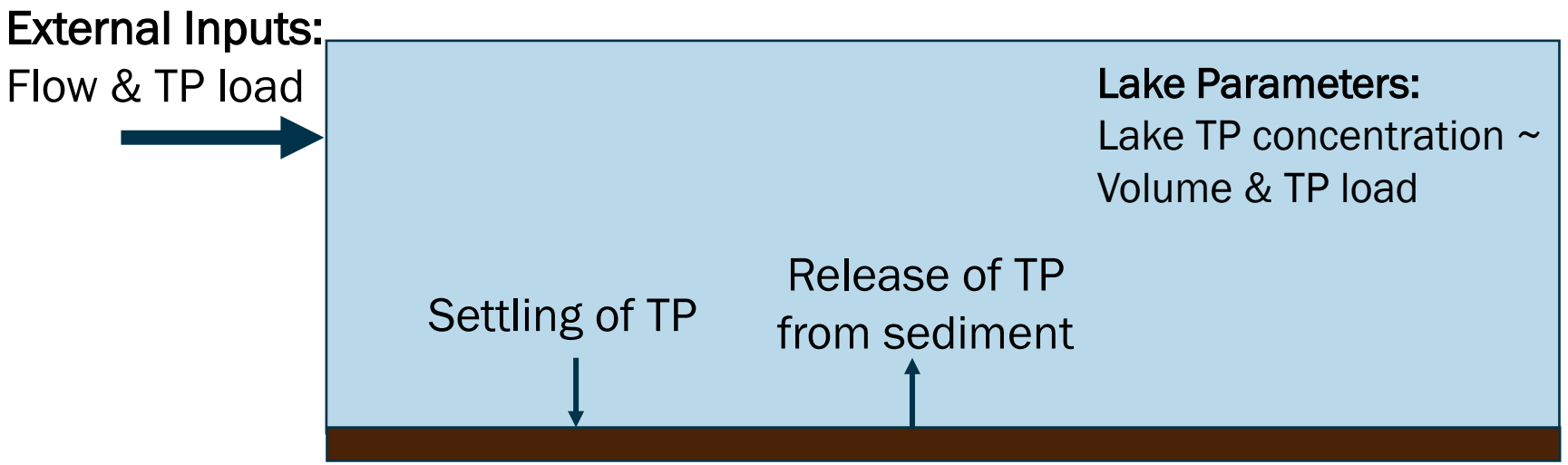
Justification for Updated Lake Modeling

1. Allocations Not Assigned for Wisconsin
2. Timeframe needs to be consistent with FOXIL TMDL
3. Baseline loads should be consistent with FOXIL TMDL SWAT+ model
4. Lake modeling approach should be consistent with Wisconsin's other TMDLs

DNR Lake Modeling

Section 3 and 4 of Report

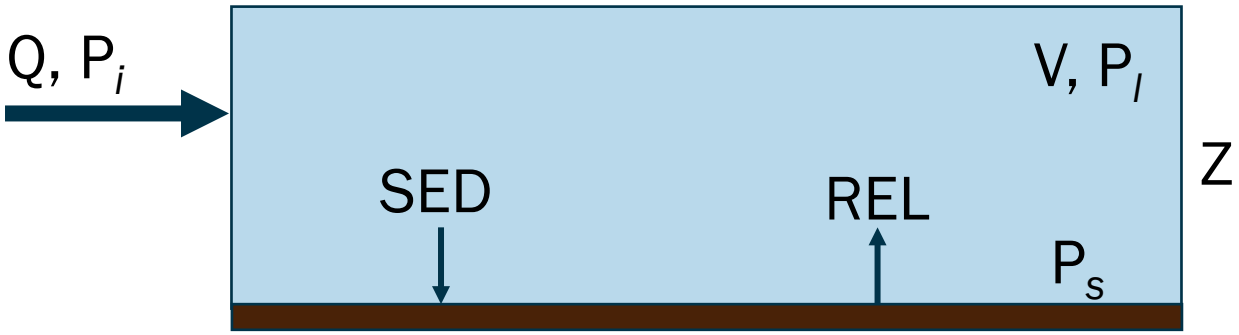
General Lake Modeling for TP



DNR Approach: Jensen (2006)

An empirical model describing the seasonal dynamics of phosphorus in 16 shallow eutrophic lakes after external loading reduction

Jens Peder Jensen,[1] Asger Roer Pedersen, Erik Jeppesen,[1] and Martin Søndergaard



$$\frac{dP_l}{dt} = \frac{Q}{V} \times (f_d \times P_i - P_l) - SED + REL$$

$$\frac{dP_s}{dt} = \frac{Q}{V} \times (1 - f_d) \times P_i + SED - REL$$

$$f_d = 1/(1 + \sqrt{V/Q/365})$$

$$SED = bS \times (1 + tS)^{T-20} \times \frac{P_l}{Z}$$

$$REL = bF \times (1 + tF)^{T-20} \times P_s$$

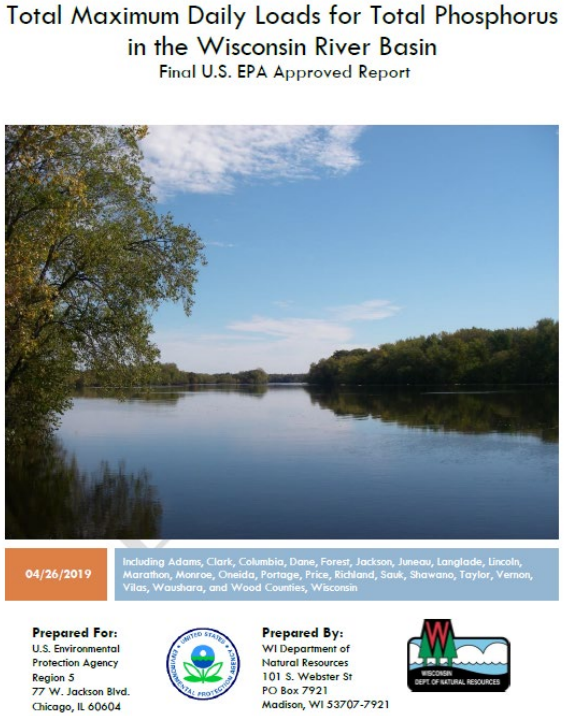
Q: Inflow volume
V: Lake volume
Z: Average lake depth

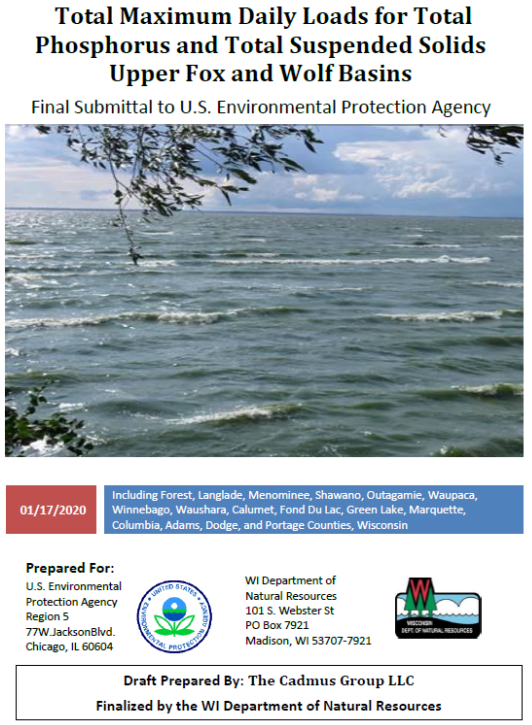
P_i: Inflow TP
P_l: In-Lake TP
P_s: Sediment TP

SED: TP sedimentation
REL: TP release

Wisconsin TMDLs with Downstream Waterbodies

- Wisconsin River Basin TMDL & Upper Fox-Wolf Basin TMDL both address downstream lakes or reservoirs with more stringent water quality criteria.

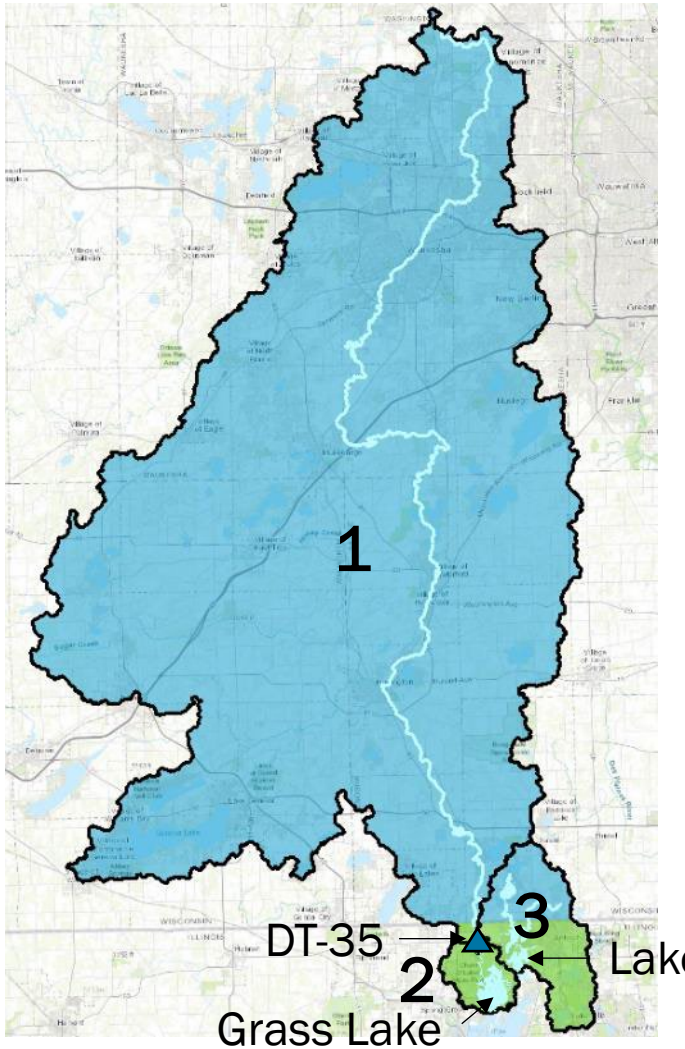




Grass Lake Model Inputs

Section 5 of Report

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)

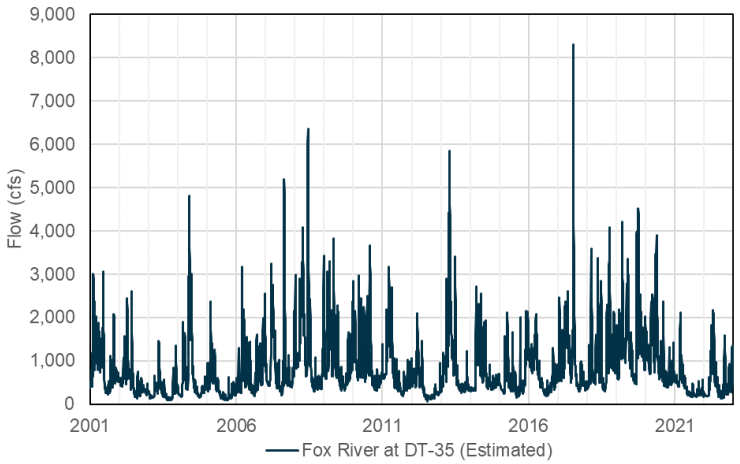
		Drainage Area (mi²)			% of Total	
ID	Waterbody	Wisconsin	Illinois	Total	Wisconsin	Illinois
1	Fox River to DT-35	857	2	859	99.8%	0.2%
2	Grass Lake Direct Drainage	0	11	11	0.0%	100.0%
3	Lake Marie to Grass Lake*	15	21	36	41.0%	59.0%
	Total to Grass Lake	**872**	**34**	**906**	**96.2%**	**3.8%**

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

Estimating TP Loads for Fox River at DT-35

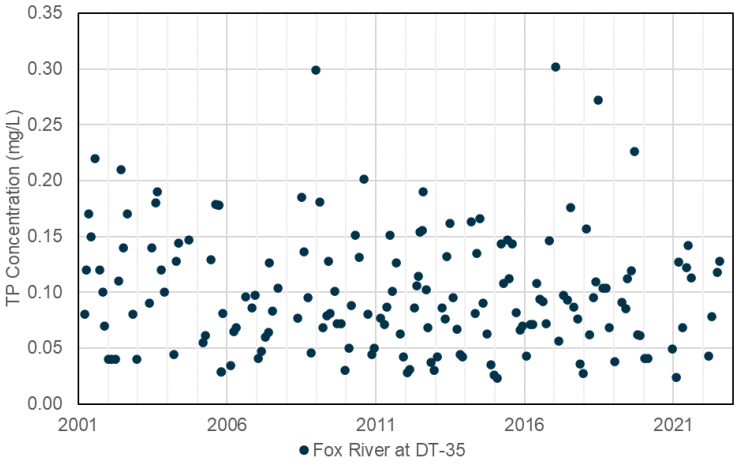
Flow Data:

Drainage-area ratio from USGS Fox River at New Munster

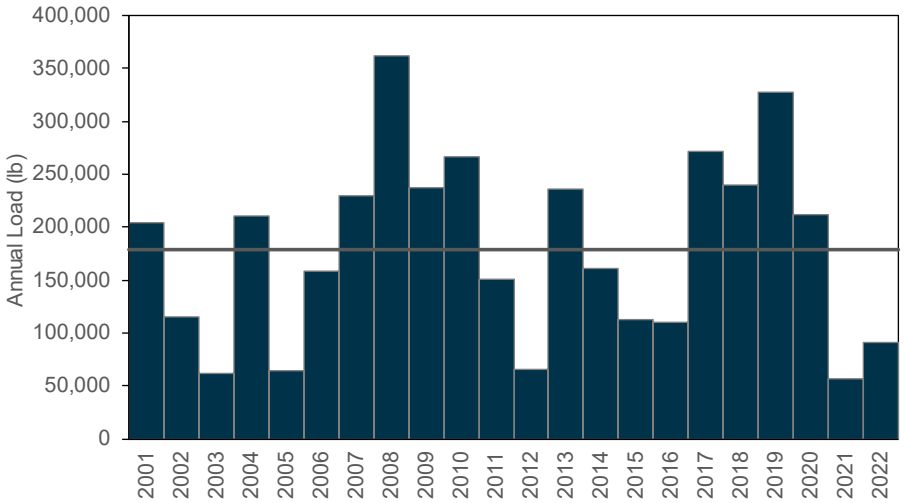


TP Data:

DT-35 from EPA's Water Quality Portal



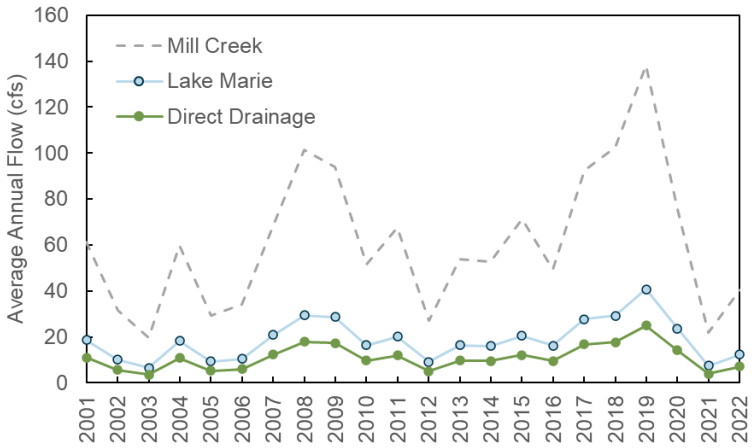
Load Data: Daily loads estimated from LOADEST



Estimating Flows and TP Loads from Lake Marie and Direct Drainage

Flow Data:

Drainage-area ratio from USGS at Mill Creek

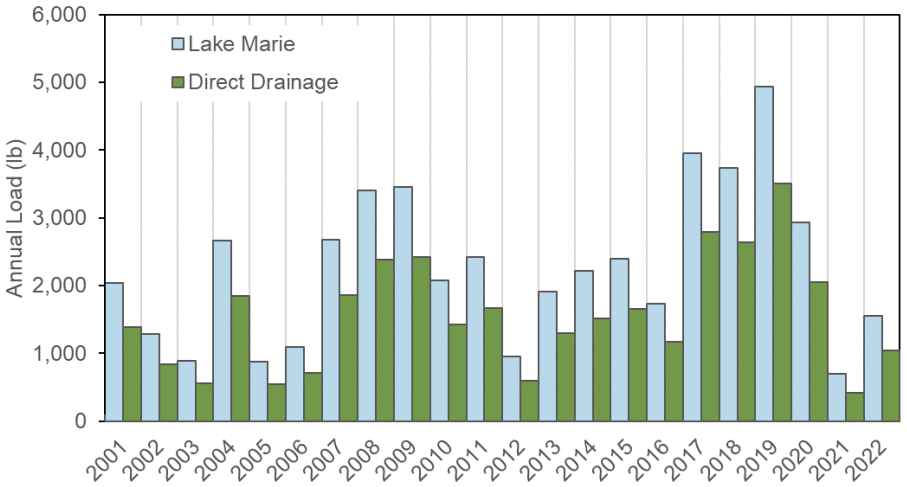


TP Data:

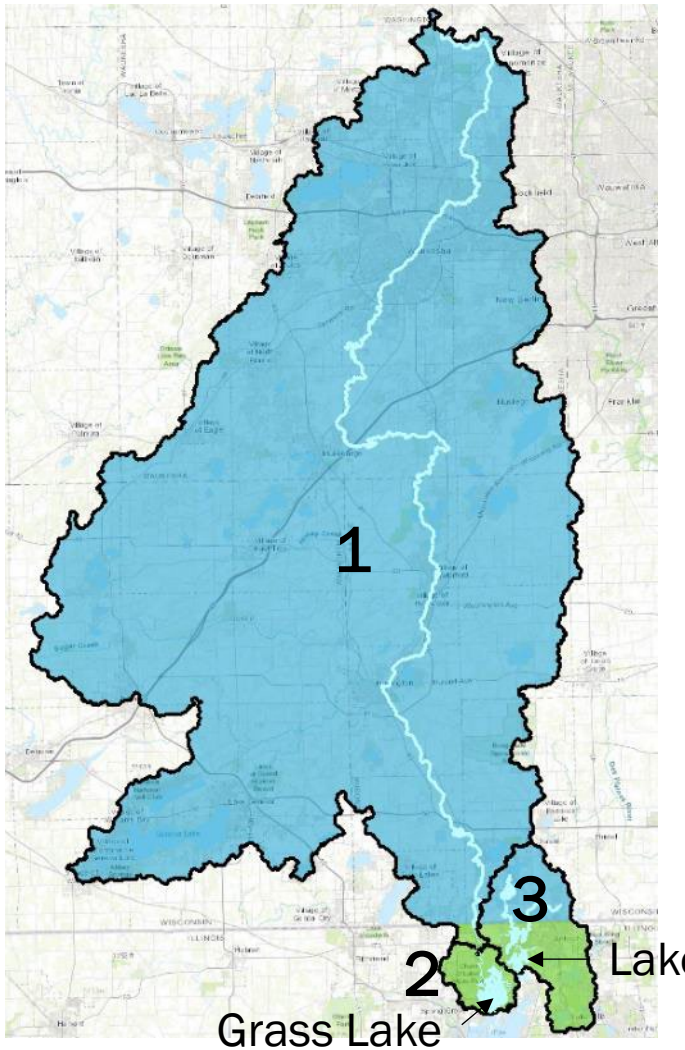
Annual average loads reported in Chain O' Lakes TMDL

Location	Annual Average Load (lb/yr)	Source
Lake Marie	2,273	CDM Smith Lake Model
Direct Drainage	1,563	Export coefficients

Load Data: Daily loads estimated from annual loads

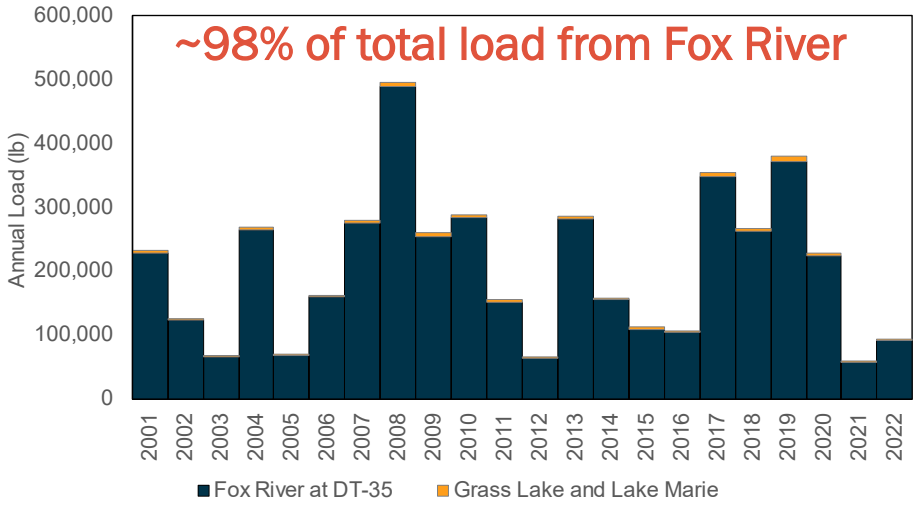


Summary of Grass Lake Loading



Map ID	Waterbody	2001-2022 Average Annual TP Load (lb)	% of Total
1	Fox River to DT-35	179,427	97.9%
2	Grass Lake Direct Drainage*	1,563	0.9%
3	Lake Marie*	2,273	1.2%
	Total to Grass Lake	**183,260**	**100%**

* Loads from Chain O' Lakes TMDL



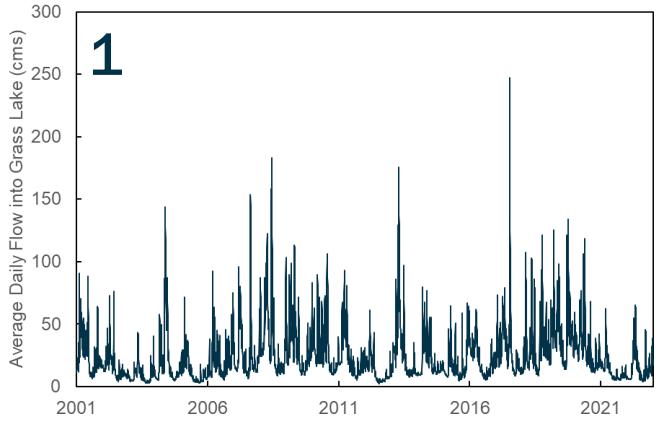
Grass Lake Jensen Model Inputs

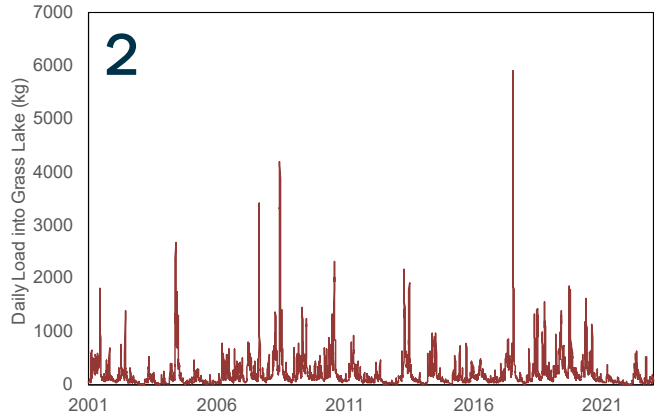
1. External flows into Grass Lake

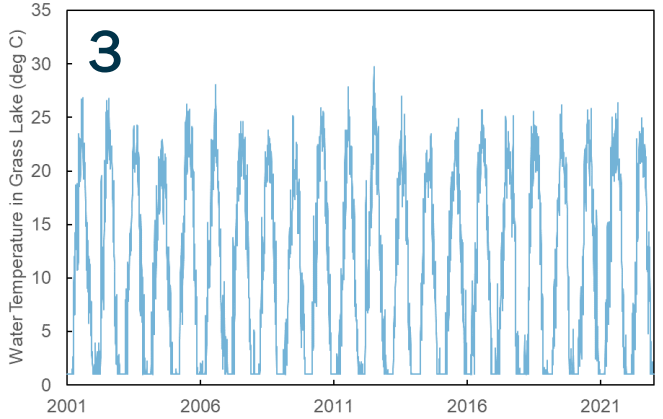
2. External TP loads into Grass Lake

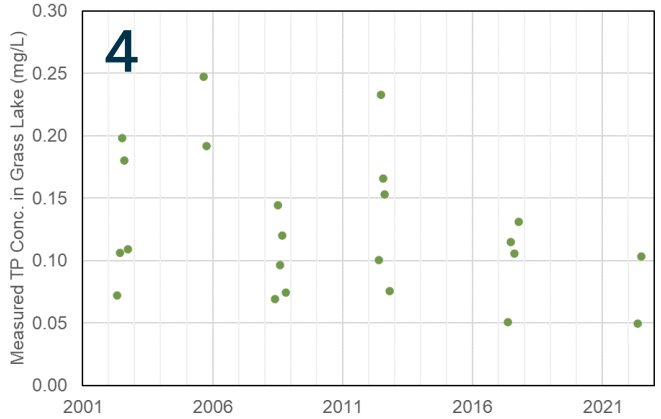
3. Temperature of water and sediment in Grass Lake

4. Measured TP concentrations in Grass Lake







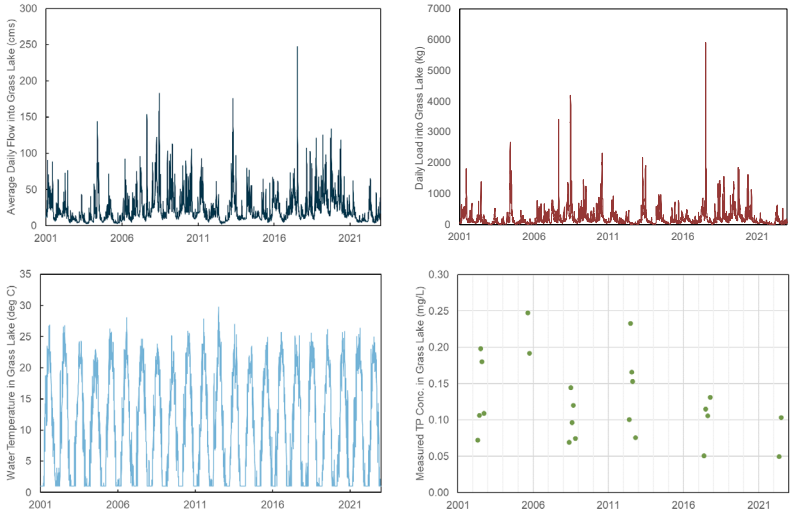


Grass Lake Model Calibration

Section 6 of Report

Grass Lake Jensen Model Procedure

Model Inputs



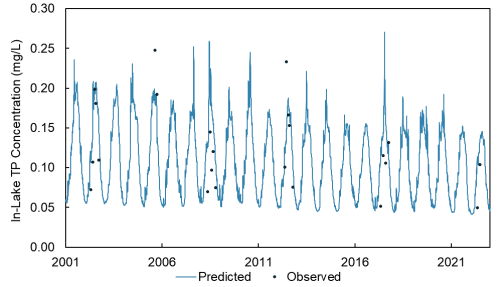
Jensen Model

Estimate lake *concentrations*

Model Parameters

P_s: Initial sediment P
bS: P sedimentation constant
tS: Temperature dependence of P sedimentation
bF: Sediment P release
tF: Temperature dependence of sediment P release

Compare modeled and observed concentrations



Revise parameters until model fit is maximized

Grass Lake Model Calibration Results

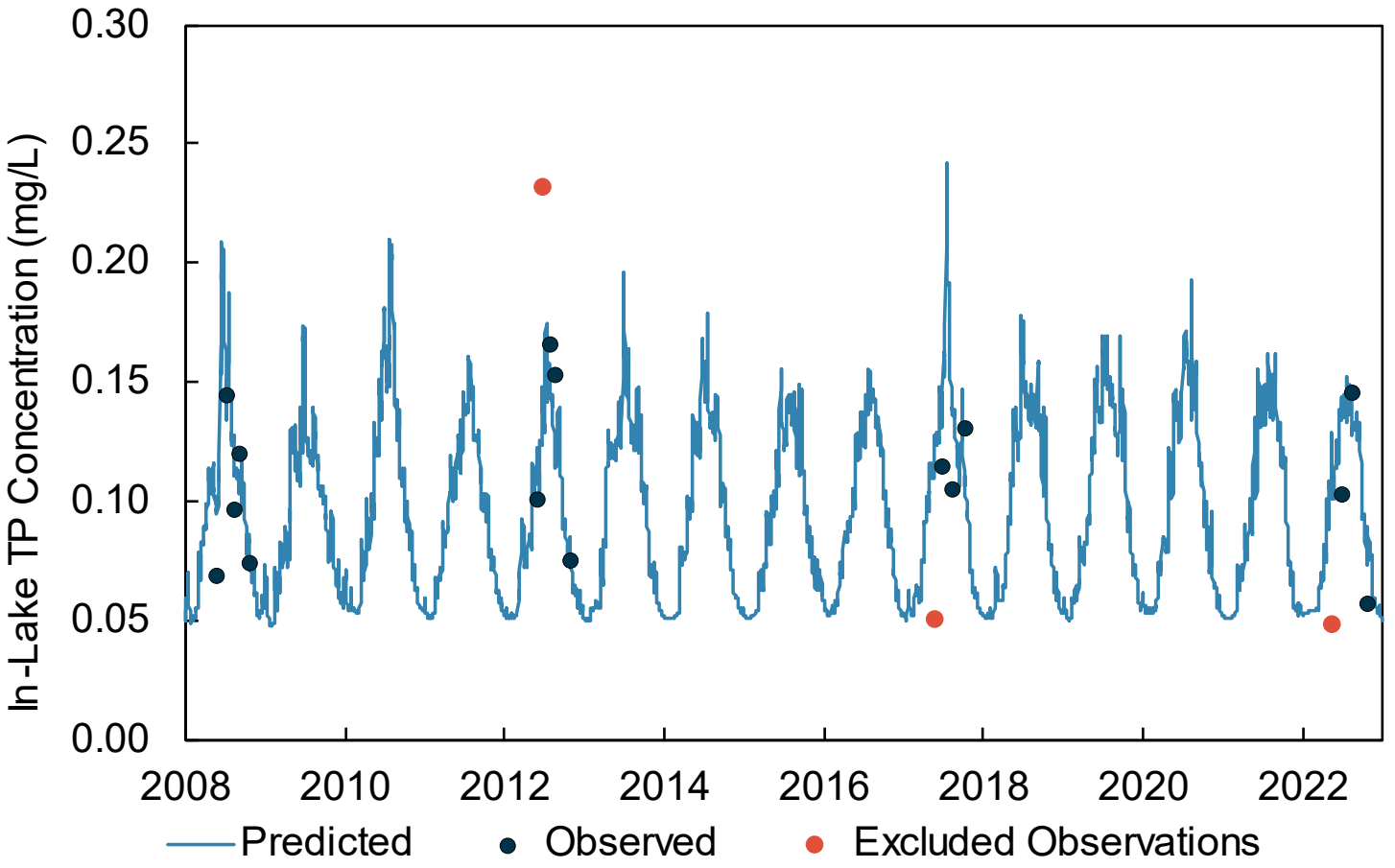
18 measurements: Every 3-4 years between 2008 and 2022

Three observations removed: Explanation in report

TP Concentration:

Observed: 0.111 mg/L

Predicted: 0.116 mg/L



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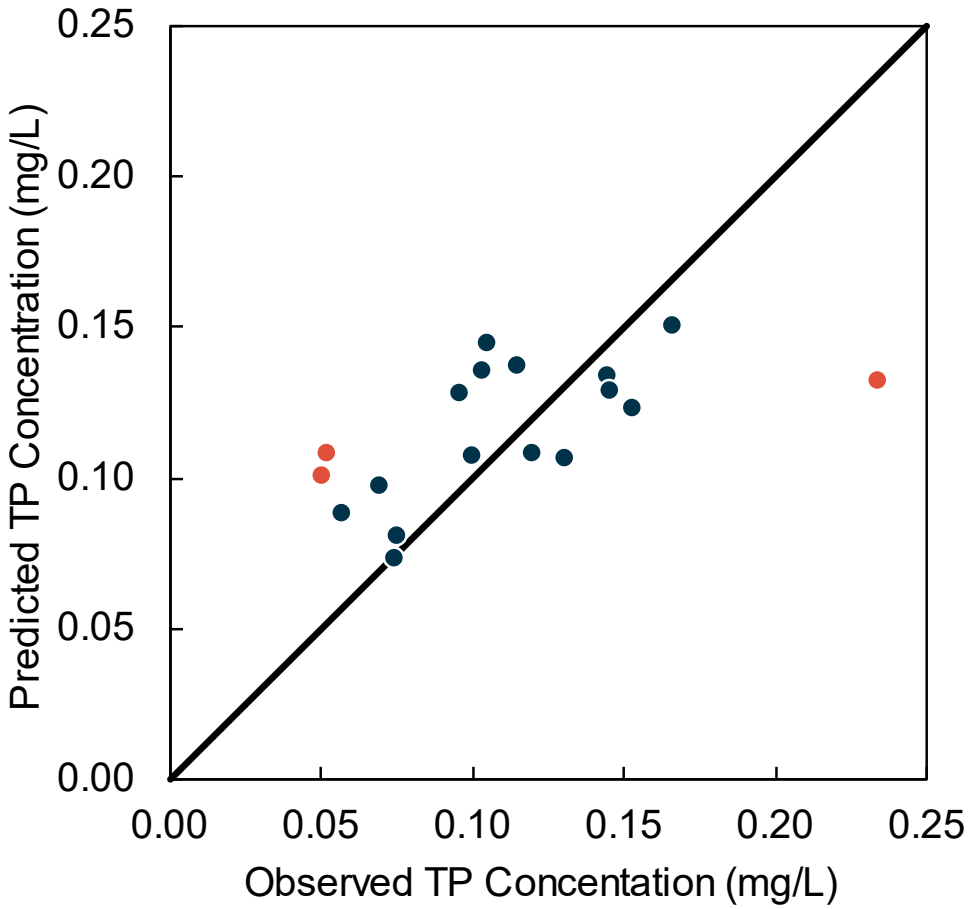
Observed: 0.111 mg/L

Predicted: 0.116 mg/L



Grass Lake TP Reductions

Section 7

Approach for Applying IL Standard

Illinois Administrative Code tit. 35, § Section 302.205

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

Chain O' Lakes TMDL Section 2.3.1.1

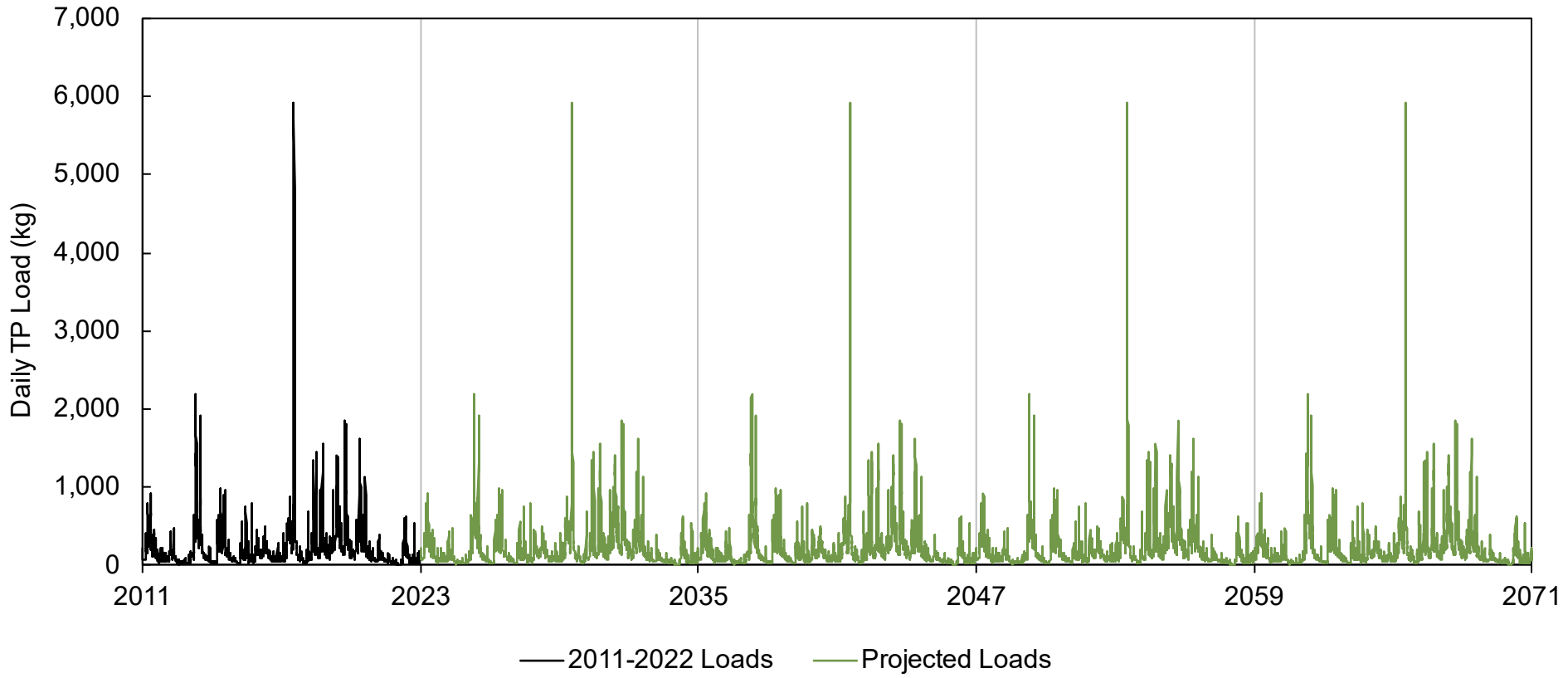
The current calculated loads from internal and external sources were then iteratively reduced in the model until the water quality standards were met by the 90th percentile of all projected daily concentrations within a lake. The

TP Criterion: 0.05 mg/L

Meet at 90th percentile of all daily concentrations

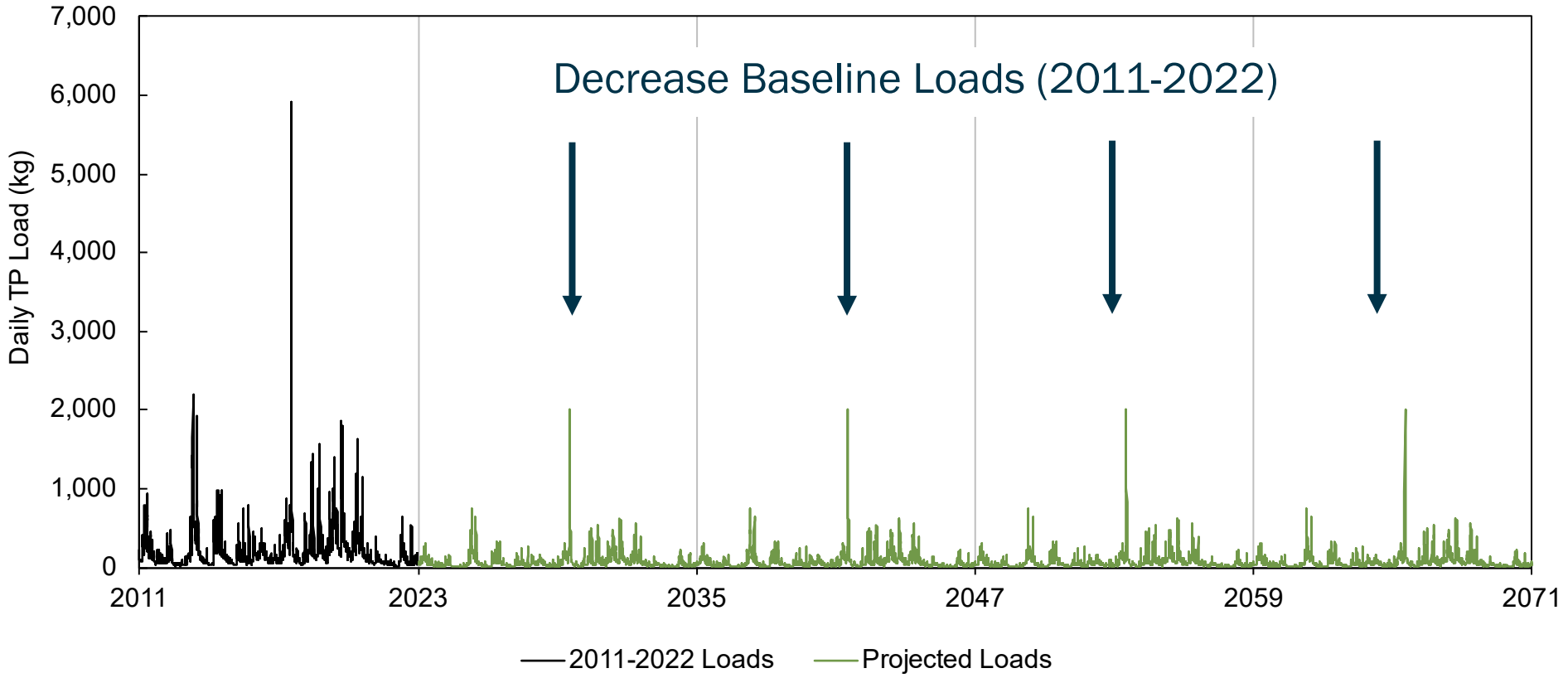
Projection of External TP Loads

Repeat existing flows and TP loads from 2011-2022 into the future



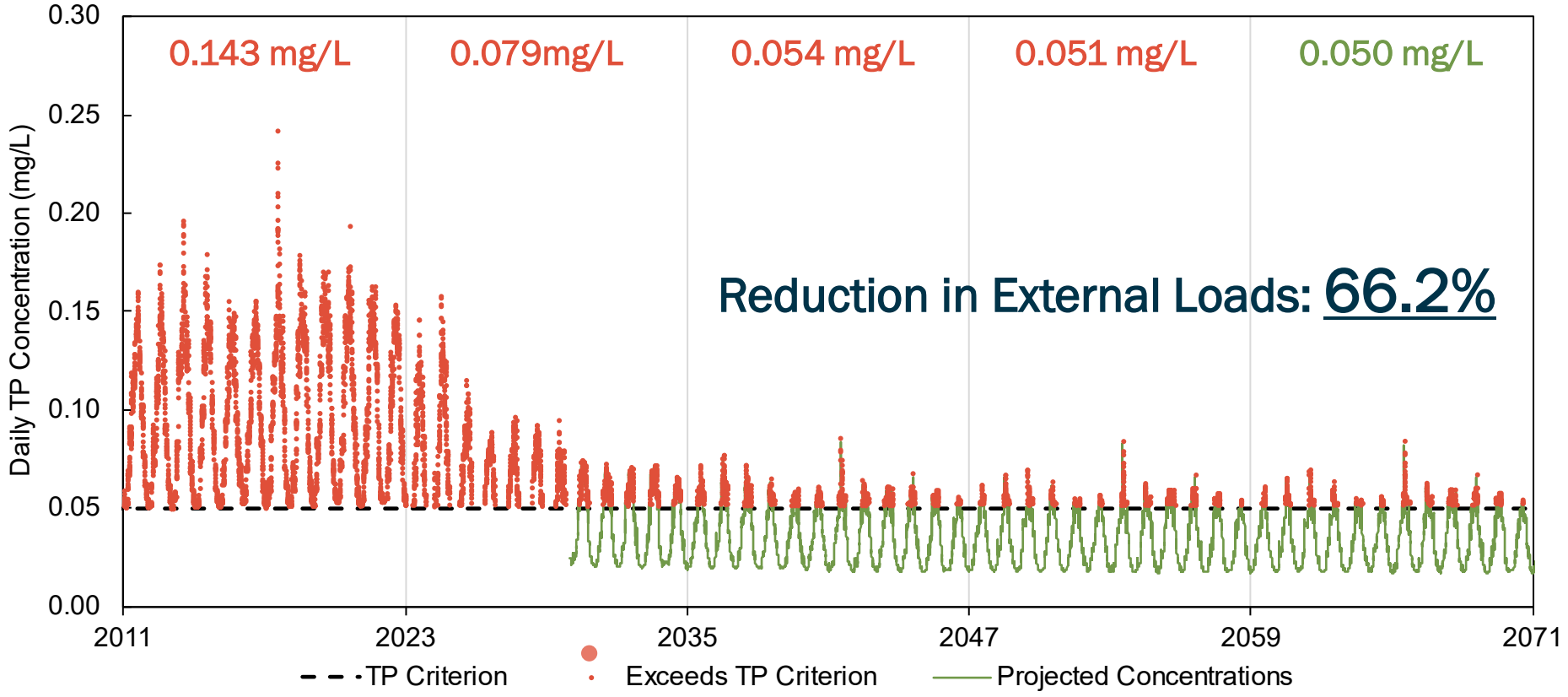
Reduction of Projected External TP Loads

Reduce projected TP loads to account for reductions in internal loading



Results from the Reduction of External TP Loads

Adjust external loads until 90th percentile of daily concentration in Grass Lake is below TP criterion



Summarized Results from Lake Modeling

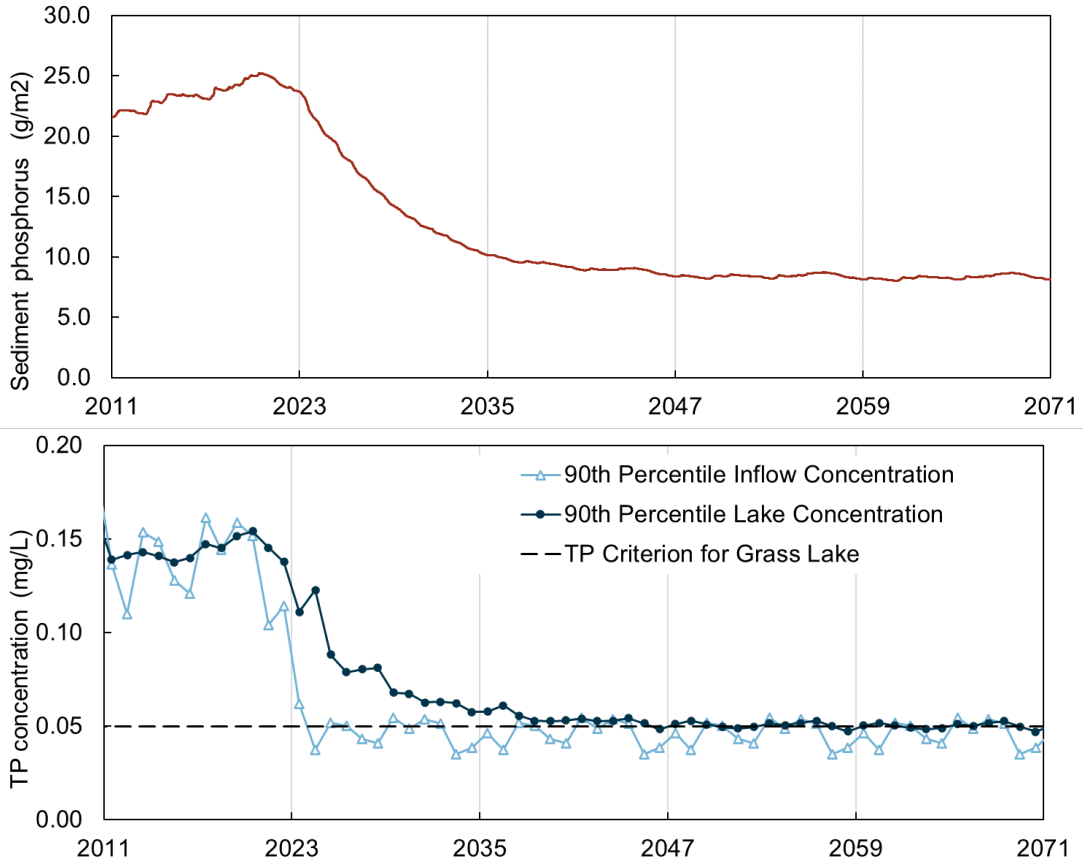
External Loading

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

Loading Capacity: 58,784 lb/yr

Reduction in External Loads: 66.2%

Note: Phosphorus criterion for 90th percentile reached ~40 years after reductions



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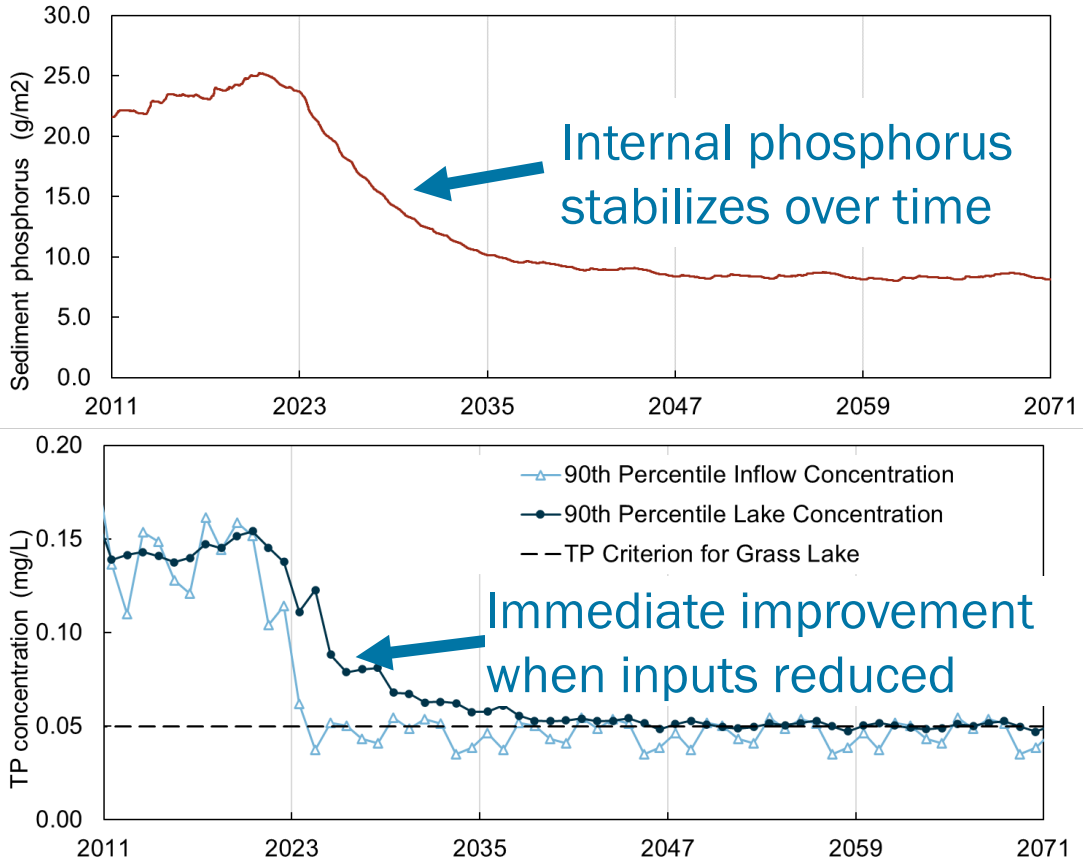


Grass Lake Loading Capacity: Comparison to Chain O' Lakes TMDL

Grass Lake: Illinois Chain O' Lakes TMDL

Loading Source	LC (lb/day)	Current Load (lbs/day)	Reduction Needed (lbs/day)	Reduction Needed (Percent)
Internal	22.1	29.4	7.3	25%
External	79.0	395.0	316.0	80%
Total	**101.0**	**424.0**	**323.0**	**76%**

Reduction in external loads to Grass Lake

Grass Lake: Wisconsin DNR Analysis

Loading Source	LC (lb/day)	Current Load (lbs/day)	Reduction Needed (lbs/day)	Reduction Needed (Percent)
Internal	9.2	20.1	10.9	54.1%
External	160.9	476.2	315.2	66.2%
Total	**170.2**	**496.3**	**326.1**	**65.7%**

Reduction in external loads to Grass Lake

Next Steps: Allocations

Step 1: Identify Reductions to Meet Wisconsin Water Quality Criteria

Stream/River TP Criteria

Streams: 75 µg/L

Rivers: 100 µg/L

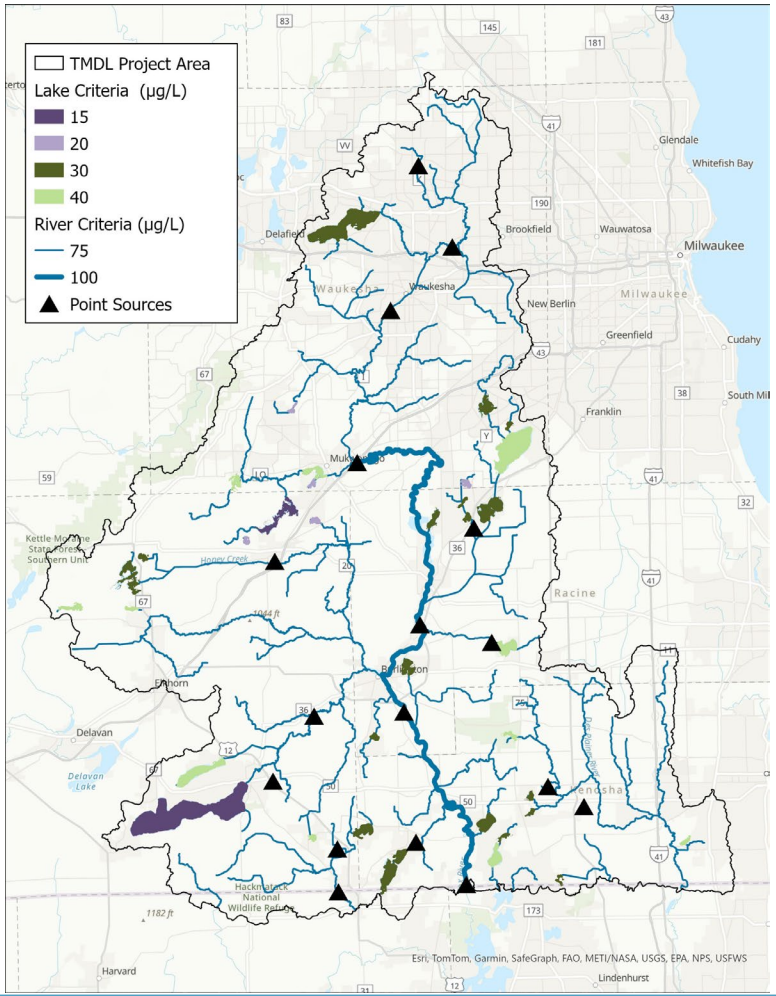
Lake TP Criteria

Shallow Headwater: 40 µg/L

Deep Headwater: 30 µg/L

Deep Seepage: 20 µg/L

Two-Story Fishery: 15 µg/L

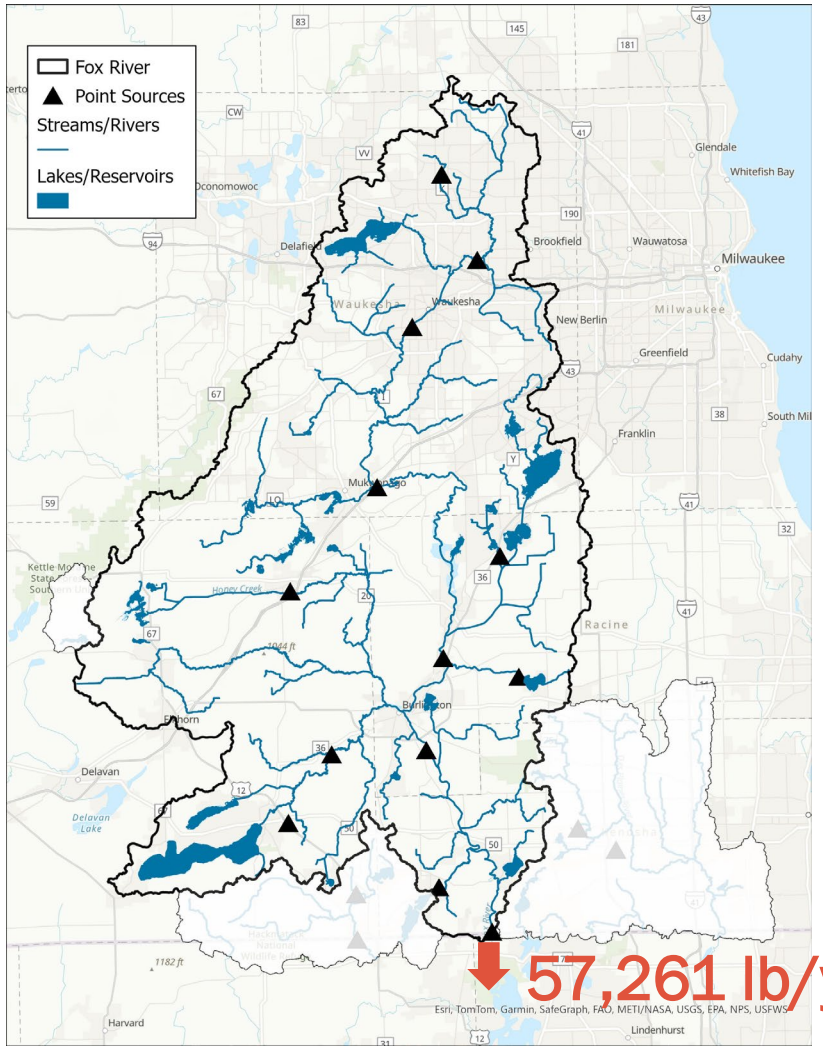


Step 2: Identify Additional Reductions to Meet Grass Lake Criterion

Allowable Load from Fox River in Wisconsin:

57,261 lb/yr

Reduce loads beyond what is required to address Wisconsin criterion



Next Steps: Input

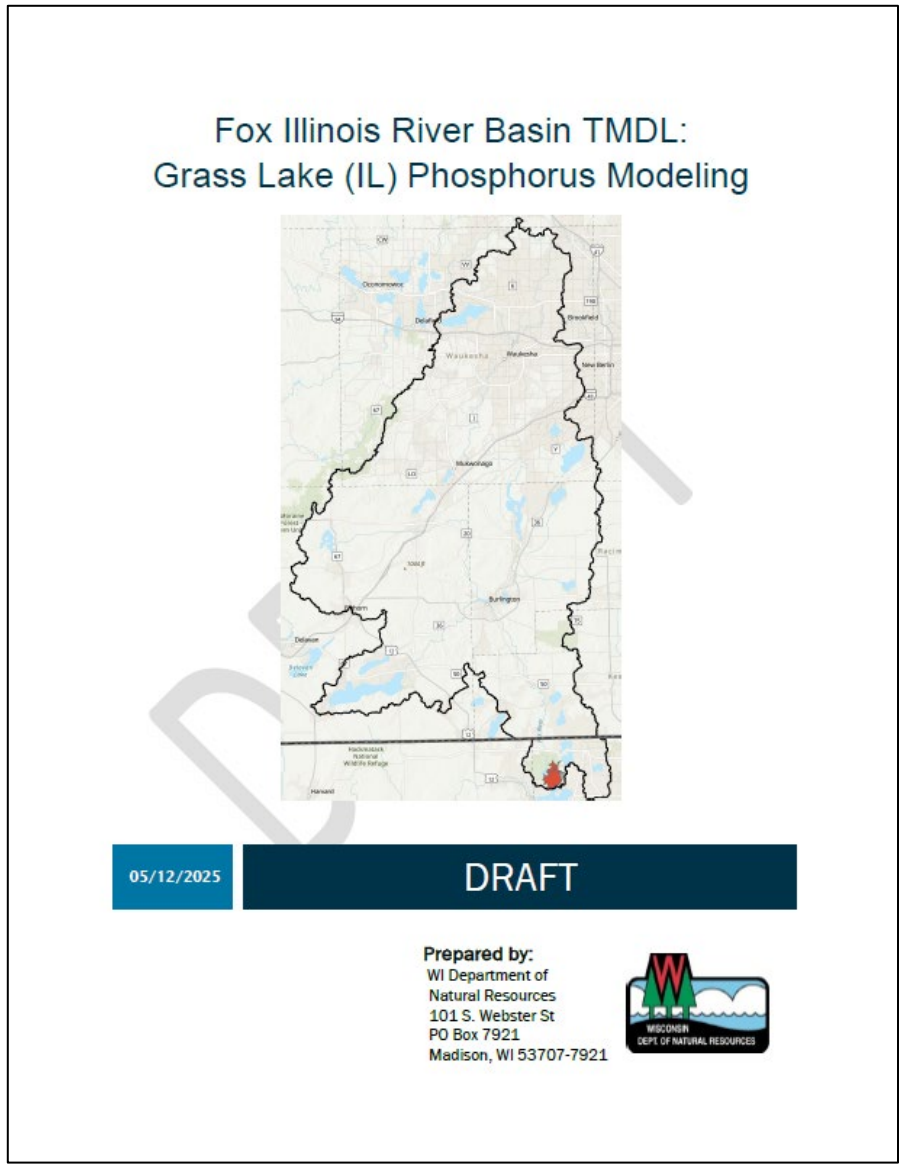
Modeling Report

Posted to FOXIL TMDL Website on May 14, 2025

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

Detailed explanation of lake modeling approach and results

Input accepted through June 20, 2025



CONNECT WITH US

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Project Website:
https://dnr.wisconsin.gov/topic/TMDLs/FOXIL

or search for “Fox Illinois TMDL” on dnr.wi.gov

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OFF THE RECORD"