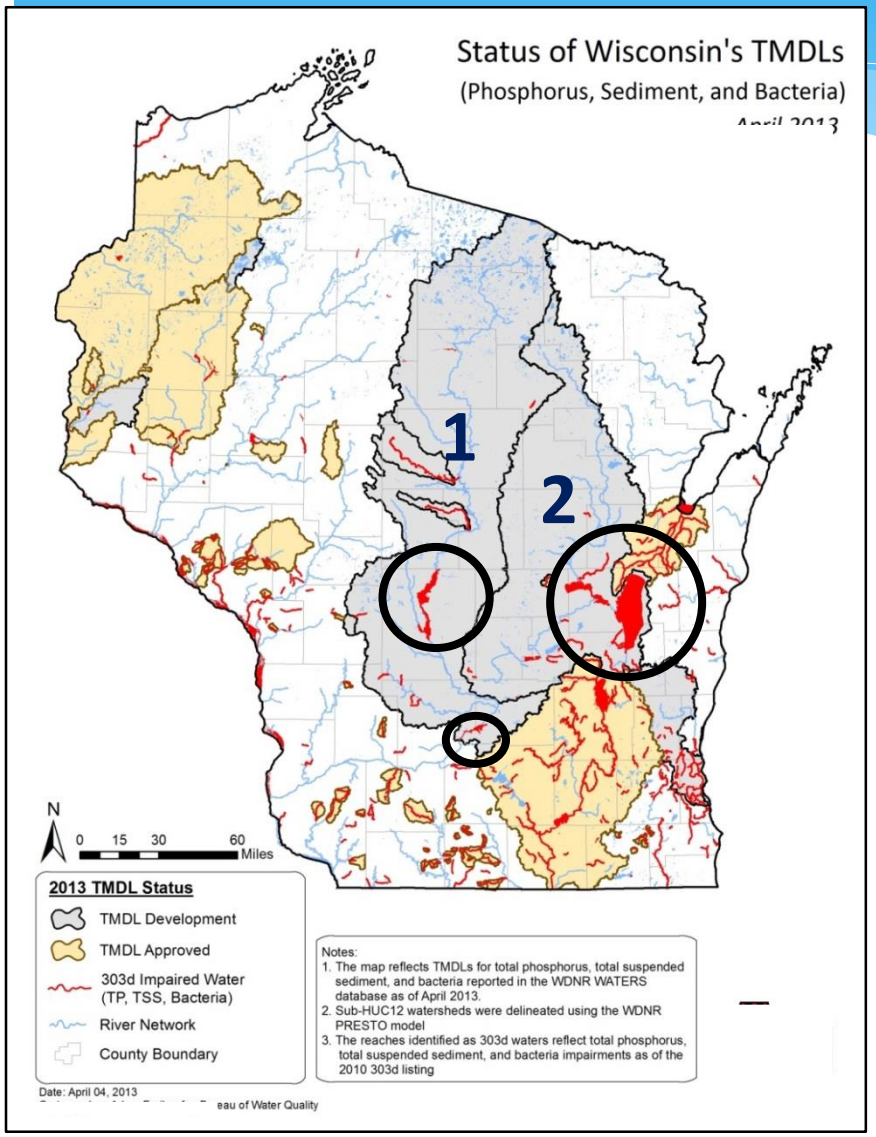
Nutrient TMDLS for Algae-related Impairments to Lakes

WISCONSIN
DEPT. OF NATURAL RESOURCES

Photo by Rhonda Cain-Carrell

TMDLs with Large Lakes or Reservoirs



1. Wisconsin River Basin - Castle Rock, Petenwell, and Lake Wisconsin

2. Upper Fox-Wolf Basin – Lake Winnebago and the pool lakes


Castle
Rock


Lake
Wisconsin


Lake
DuBay


Barnum Bay 2008
Petenwell


North End Winnebago Lake Aerial Photo

Water Quality Standards

* Designated Uses:
  * Fish & Aquatic Life
  * **Public Health** (Lake Winnebago)
  * **Recreation**

* Water Quality Criteria:
  * Numeric: dissolved oxygen, pH, bacteria, toxic substances, phosphorus, etc.
  * Narrative: "no objectionable deposits," "substances in concentrations or combinations shall not be harmful to humans, fish, plants, or other aquatic life."

* Per Wis. Stat. s. 281.15 water quality standards must be adopted by rule.

Recreational Use

Allowable phosphorus concentrations calculated to support recreational use by preventing excessive algae blooms.

(Chlorophyll *a* shall not exceed 20 µg/L more than 30% of days during July 15 – Sept 15).

Statewide Phosphorus Criteria

Rivers

100 µg/L

Streams [1]

75 µg/L

Reservoirs

- Not Stratified = 40 µg/L
- Stratified = 30 µg/L

Inland Lakes[2]

Ranges from 15-30 µg/L

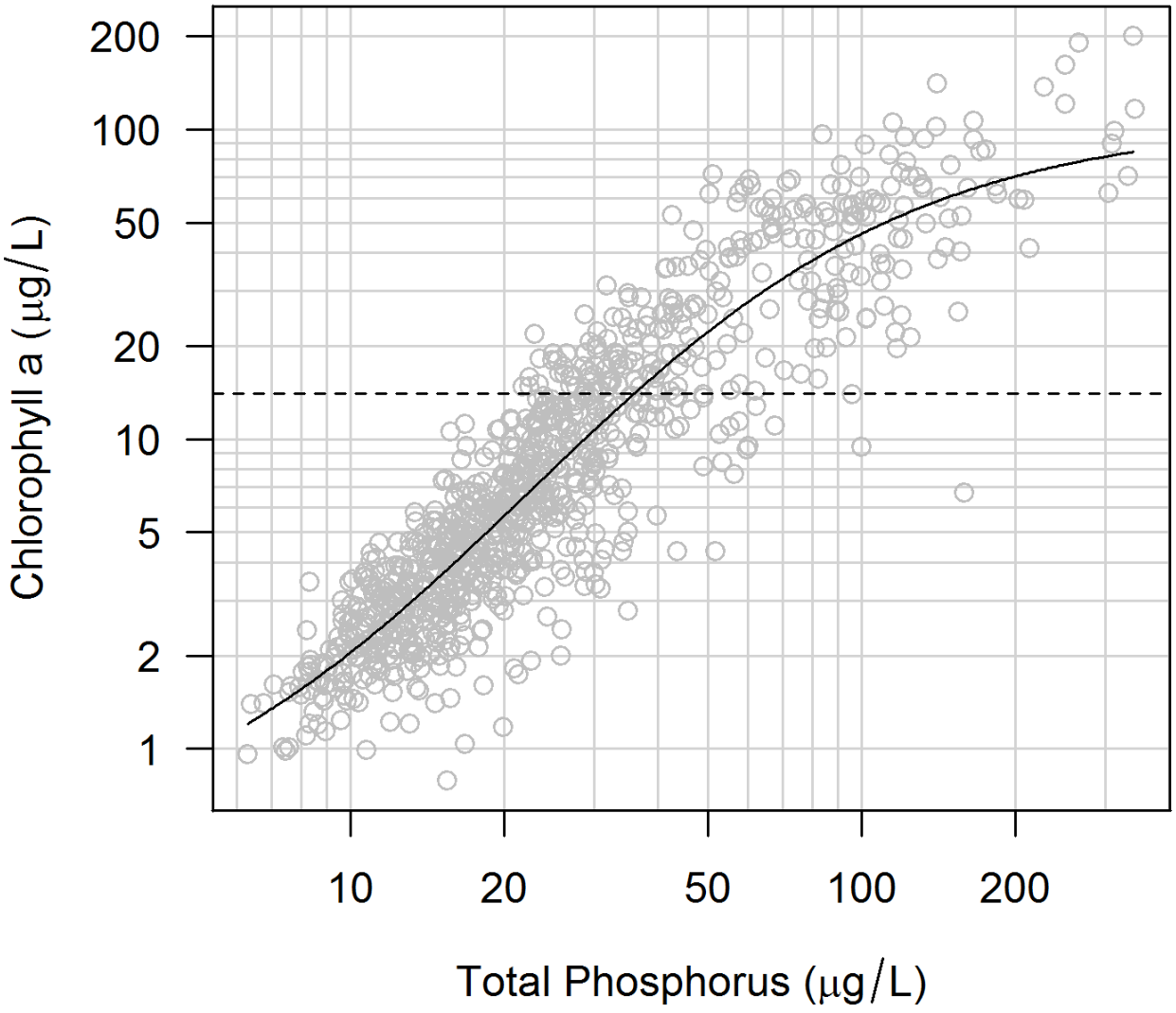
Great Lakes

- Lake Michigan = 7 µg/L
- Lake Superior = 5 µg/L

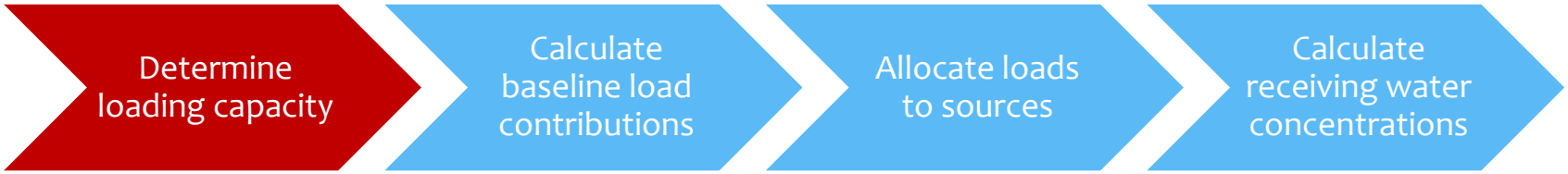
[1]All unidirectional flowing waters not in NR 102.06(3)(a). Excludes Ephemeral Streams.

[2]Excludes wetlands and lakes less than 5 acres

Phosphorus Criteria Justification

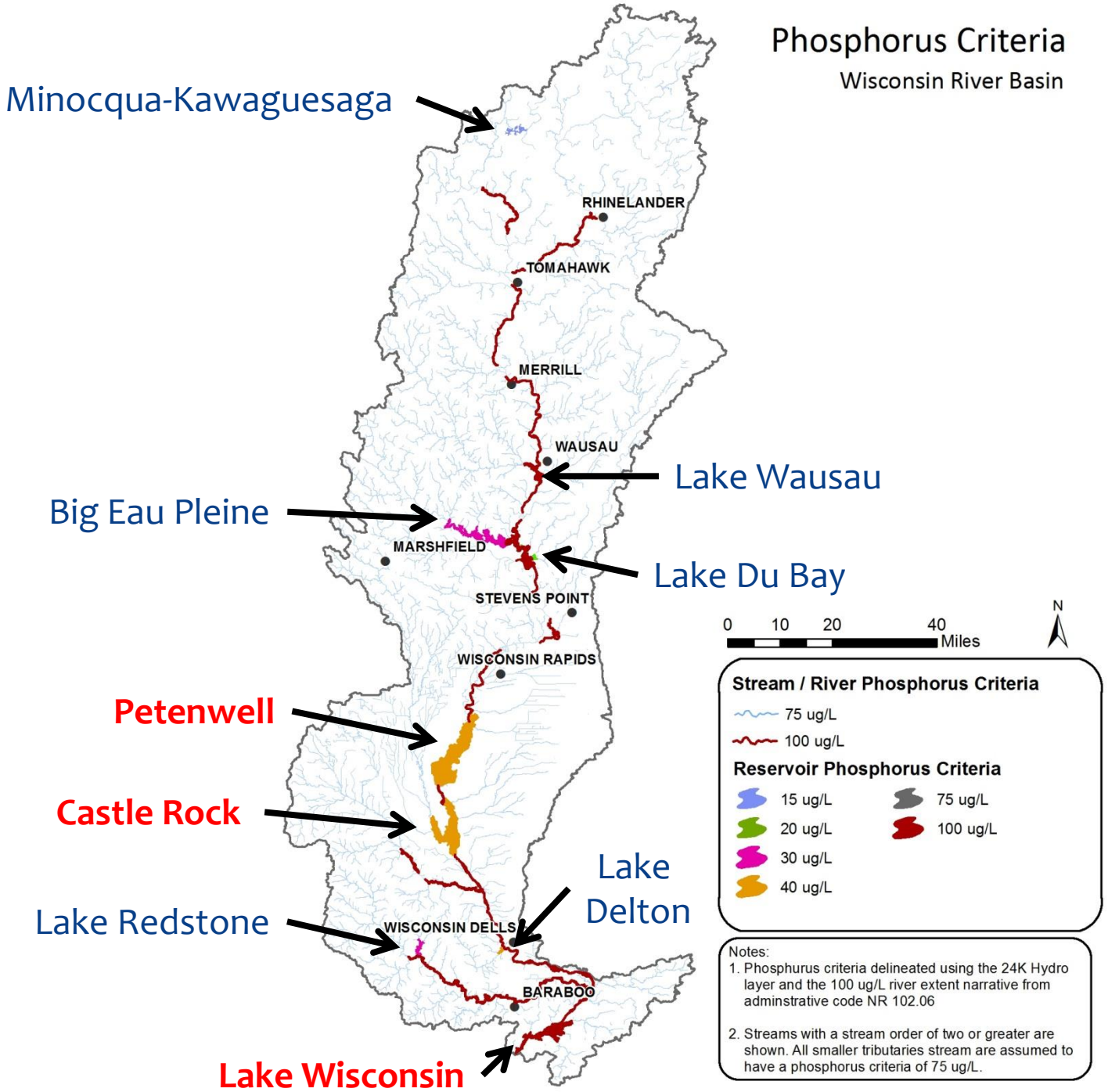


TMDL Development Process



* For river/stream reaches:
  * Loading capacity = Water Quality Target (criteria) * Flow

* For lakes and reservoirs a response model is needed to simulate loads based on waterbody characteristics to determine pollutant response (algal growth vs TP)

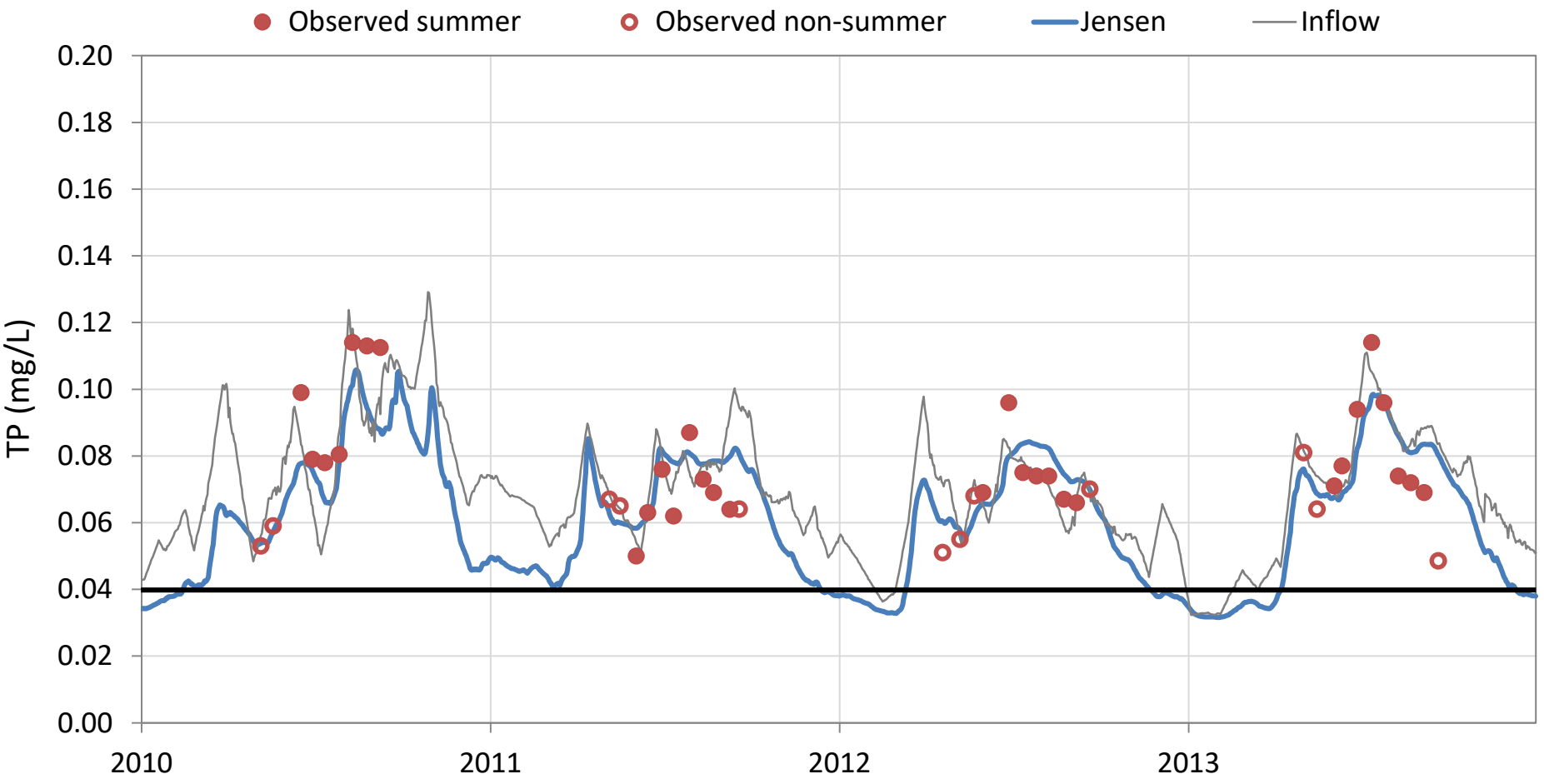

Phosphorus Criteria
Wisconsin River Basin
Minocqua-Kawaguesaga
RHINELANDER
TOMAHAWK
MERRILL
WAUSAU
Lake Wausau
Big Eau Pleine
MARSHFIELD
Lake Du Bay
STEVENS POINT
WISCONSIN RAPIDS
Petenwell
Castle Rock
Lake Delton
Lake Redstone
WISCONSIN DELLS
BARABOO
Lake Wisconsin
0 10 20 40
Miles
N
Stream / River Phosphorus Criteria
75 ug/L
100 ug/L
Reservoir Phosphorus Criteria
15 ug/L
20 ug/L
30 ug/L
40 ug/L
75 ug/L
100 ug/L
Notes:
1. Phosphurus criteria delineated using the 24K Hydro layer and the 100 ug/L river extent narrative from adminstrative code NR 102.06
2. Streams with a stream order of two or greater are shown. All smaller tributaries stream are assumed to have a phosphorus criteria of 75 ug/L.

Lake Modeling

* Use the least complicated model that represents the answers the questions that need to be addressed

* **What's going on in the reservoir system?**
- Size, shape, depth, volume
- Hydrologic budget (rain, evaporation, inflow, outflow)
- Pollutant concentration
- Chemical conditions

Castle Rock (Main Body) Jensen Model



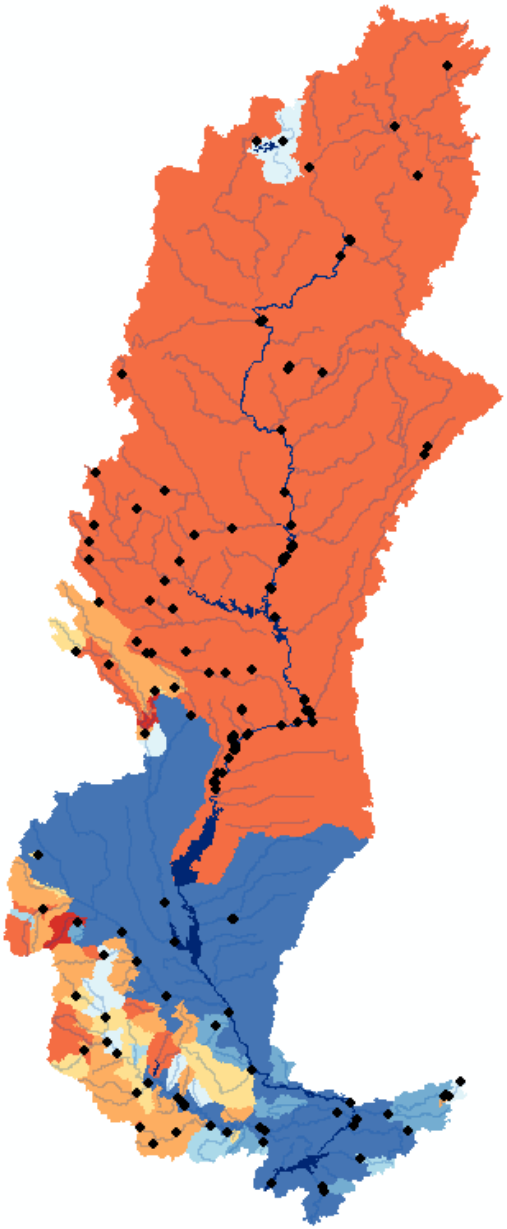
Jensen, J. P., Pedersen, A. R., Jeppesen, E., & Søndergaard, M. 2006. An empirical model describing the seasonal dynamics of phosphorus in 16 shallow eutrophic lakes after external loading reduction. Limnology and Oceanography 51 (1) 791-800.

Site-Specific Total Phosphorus Criteria for Petenwell Flowage, Castle Rock Flowage, and Lake Wisconsin

Reservoir	Existing TP Criterion (µg/L)	Recommended Site-Specific TP Criterion (µg/L)
Petenwell Flowage	40	53
Castle Rock Flowage	40	55
Lake Wisconsin	100	47

Calculated to support recreational use by preventing excessive algae (Chlorophyll a shall not exceed 20 µg/L more than 30% of days during July 15 – Sept 15)

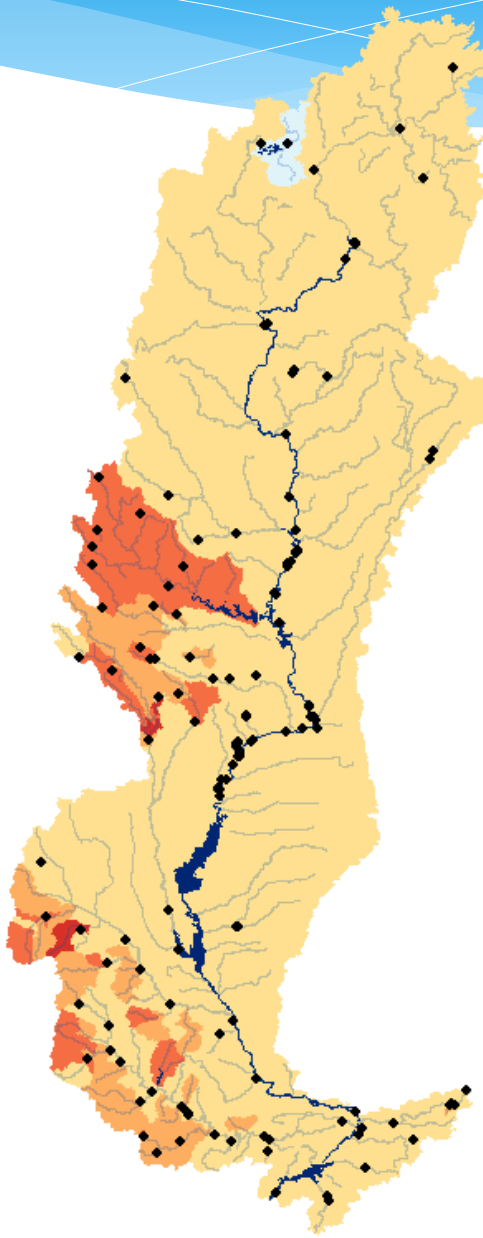
Percent Reduction Maps



Current Criteria

Percent Reduction
- 0%
- 1 - 25%
- 25.1 - 50%
- 50.1 - 60%
- 60.1 - 70%
- 70.1 - 80%
- 80.1 - 90%
- 90.1 - 93%

Outfalls



SSC

Evaluation of Historic TP Concentrations

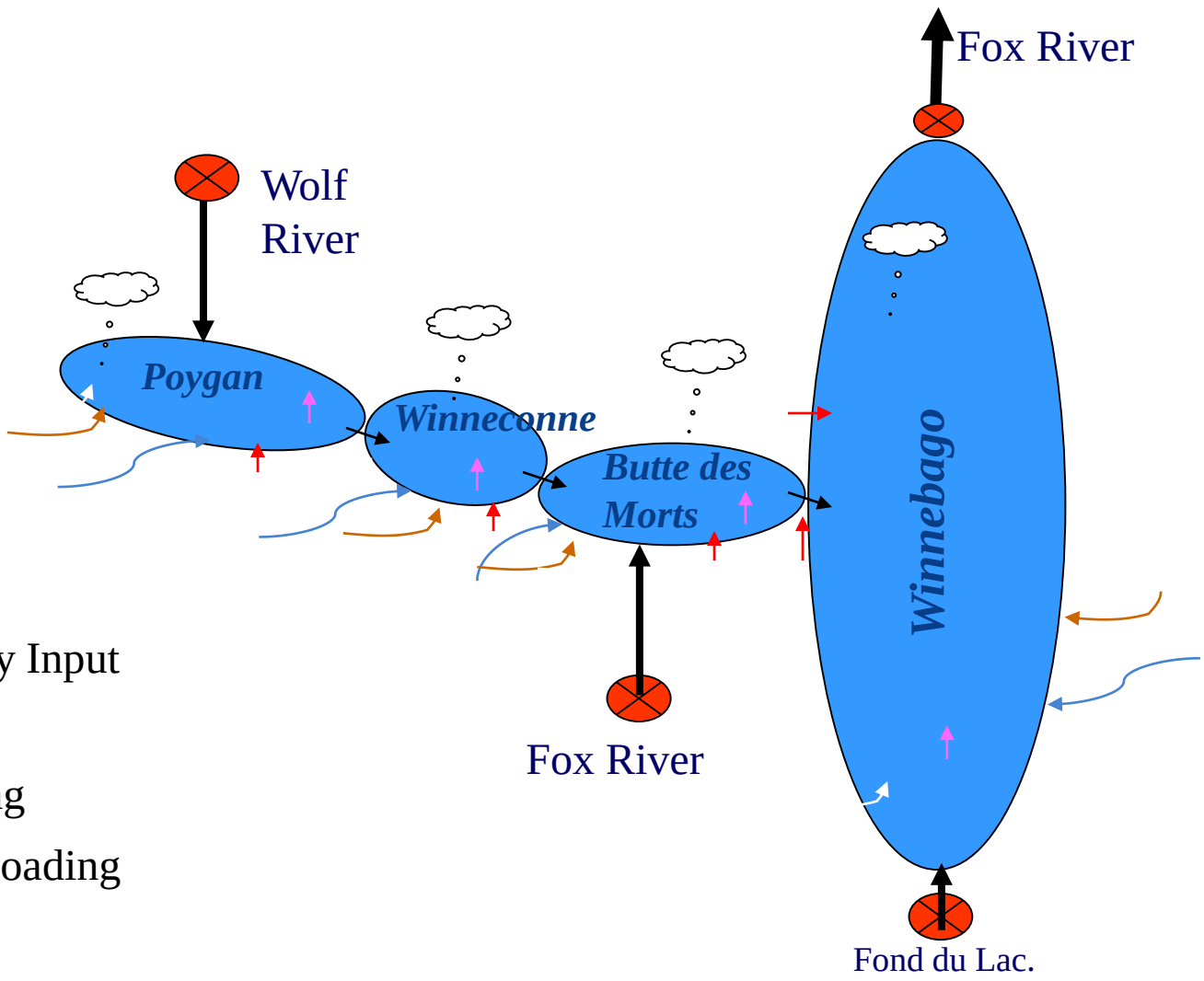
Onterra, LLC
Lake Management Planning

* Cores were collected at two sampling sites and dated with sedimentation rates determined.

* Diatoms were collected from the cores at the top and bottom of the cores to evaluate current and historic phosphorus concentrations (µg/L).

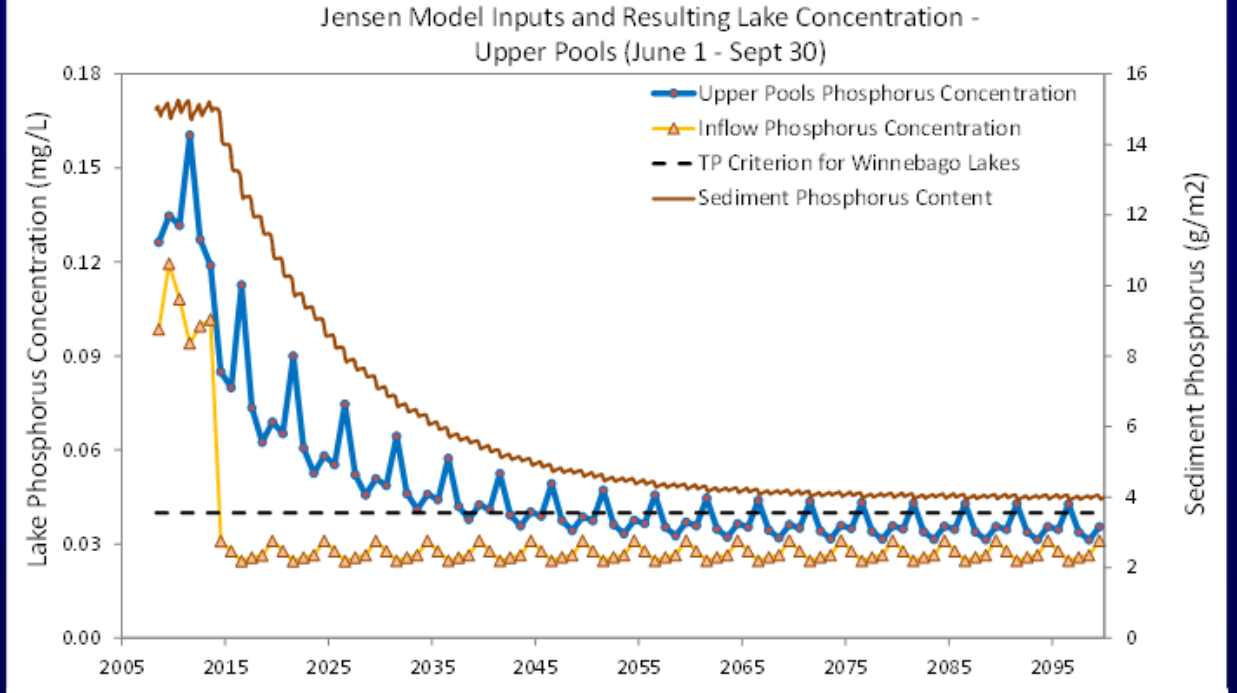
	Top	Bottom
North Basin	108	40
South Basin	94	47

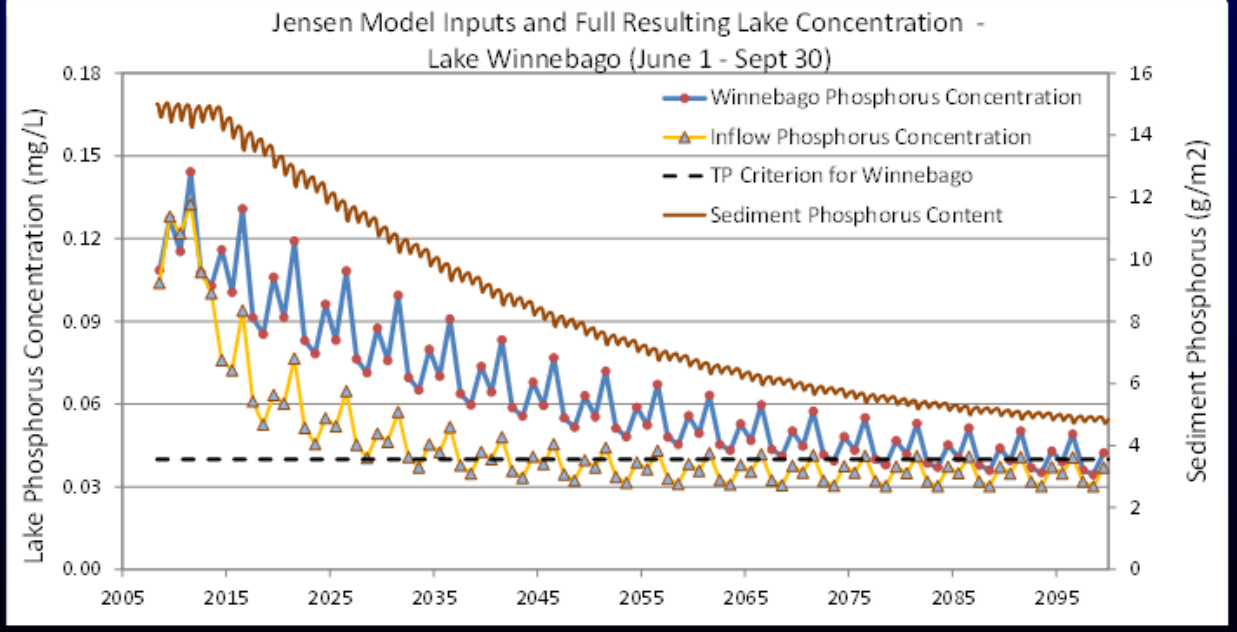
Schematic for the Eutrophication Model Bathtub (Simulations of Winnebago Pools)



Simulation of a 75% Reduction in all external loading to the Upper Fox/Wolf Basin

The BATHTUB model shows that a 73% reduction in external load is needed to meet 0.04mg/L.





Upper Pools need about a 70% Reduction in Loading & 40 yrs to Reach 0.04 mg/L
Winnebago needs about a 75% Reduction in Loading & 75 yrs to Reach 0.04 mg/L

Historical Comparison of Butte des Morts

Estimated internal load during the growing season accounts for **56%** of the total growing season phosphorus load to Lake Winnebago (2009-2011) compared to 15% for Lake Poygan, 14% for Lake Butte des Morts, and 3% for Lake Winneconne.

Restoration of Aquatic Plants