Lake Pepin TMDL:

Total Maximum Daily Loads for Total Phosphorus

July 2026

Including Pierce, Pepin, and St. Croix counties, Wisconsin

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Acronym	Definition
303(d) List	List of Impaired Waters
9KEP	Nine Key Element Plan
AM	Wisconsin's Watershed Adaptive Management Option
BMPs	Best Management Practices
CAFO	Concentrated Animal Feeding Operation
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
DATCP	Department of Agriculture, Trade, and Consumer Protection
DO	Dissolved Oxygen
FAL	Fish and Aquatic Life
FSA	Farm Service Agency
LA	Load Allocation
LAL	Limited Aquatic Life
LWCD	Land and Water Conservation Department
LFF	Limited Forage Fish
LWRM	Land and Water Resources Management
mL	Milliliters
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
NCCW	Noncontact Cooling Water
NOD	Notice of Discharge
NPS Program	Nonpoint Source Pollution Abatement Program
NRCS	Natural Resources Conservation Service
PI	Phosphorus Index
WWTF	Publicly Owned Treatment Works
RC	Reserve Capacity
WinSLAMM	Source Loading and Management Model
SWAT	Soil and Water Assessment Tool
TBEL	Technology-Based Effluent Limit
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TRM	Targeted Runoff Management
TSS	Total Suspended Solids
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
Wisconsin DNR	Wisconsin Department of Natural Resources
WisCALM	Wisconsin Consolidated Assessment and Listing Methodology
WisDOT	Wisconsin Department of Transportation
WLA	Wasteload Allocation
WPDES	Wisconsin Pollutant Discharge Elimination System
WQBEL	Water Quality-Based Effluent Limit
WQT	Water Quality Trading
WWSF	Warm Water Sport Fish
WWTF	Wastewater Treatment Facility

1 INTRODUCTION

1.1 Background

Section 303(d) of the Federal Clean Water Act (CWA) requires states to identify waters within their boundaries that do not meet water quality standards. For these waterbodies, which are defined as "impaired", Section 303(d) further requires U.S. EPA and states to develop a Total Maximum Daily Load (TMDL) for the pollutant(s) violating or causing violations of water quality standards. A TMDL defines the assimilative loading capacity which is the maximum amount of pollutant that a waterbody can assimilate while continuing to meet water quality standards. A TMDL also allocates the maximum allowable pollutant load between point sources, expressed in the wasteload allocation, and nonpoint sources, expressed in the load allocation. Figure 1 shows the study area covered by this TMDL and the waterbodies listed as impaired as of Wisconsin's 2024 impaired waters list and the draft 2026 impaired waters list.

A TMDL provides a framework for U.S. EPA, states, and partner organizations to establish and implement pollution control and management plans, with the goal of achieving "water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water, wherever attainable (CWA § 101(a)(2))."

This report presents TMDLs for total phosphorus (TP) for Lake Pepin and surface waters in Wisconsin that drain to Lake Pepin, excluding the St. Croix River watershed. Lake St. Croix, the St. Croix River, and the associated watershed are addressed in the "Lake St. Croix Nutrient Total Maximum Daily Load", dated May 2012 and the associated "Implementation Plan for the Lake St. Croix Nutrient Total Maximum Daily Load", dated February 2013. Both reports can be found on the Wisconsin Department of Natural Resources (Wisconsin DNR) website.

This TMDL is designed to complement the TMDL submitted by the Minnesota Pollution Control Agency (MPCA) for Lake Pepin by addressing Wisconsin's portion of the Lake Pepin basin. The TMDL report, "Lake Pepin and Mississippi River

Eutrophication Total Maximum Daily Load Report" (2021 TMDL report) was approved by U.S. EPA on May 19, 2021, and can be found on MPCA's website. While Appendix E of the 2021 TMDL report includes an accounting of pollutant sources from Wisconsin that discharge to Lake Pepin, these loads were specifically excluded from U.S. EPA's approval. In addition, the 2021TMDL is set to meet water quality standards in Lake Pepin but the associated allocations do not necessarily address Wisconsin tributary waterbodies draining into Lake Pepin which may have more stringent water quality criterion or a smaller assimilative capacity than Lake Pepin.

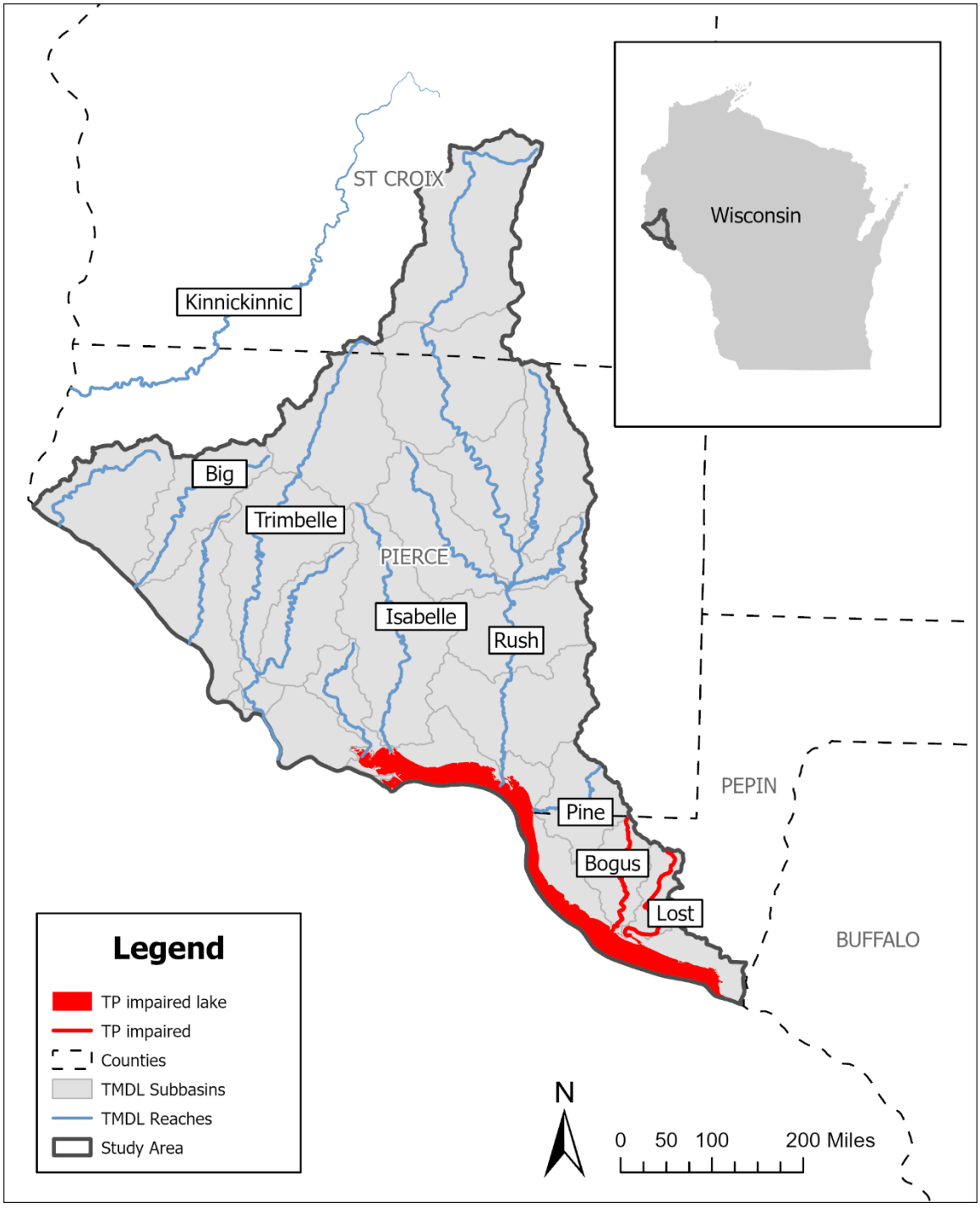

Figure 1 Location of waters impaired (303(d) Impaired Waters List for the year 2024) by phosphorus in the Lake Pepin study area.

1.2 Problem Statement

Lake Pepin is an impoundment of the Mississippi River along Wisconsin's western border. Lake Pepin and two small Wisconsin streams that drain directly to it, Lost and Bogus Creeks, are listed on Wisconsin's 303(d) list as impaired due to excessive phosphorus, which leads to nuisance algae growth, oxygen depletion, fish kills, reduced submerged aquatic vegetation, water clarity problems, and degraded habitat. These impairments can adversely affect fish and aquatic life, drinking water supplies, and recreation.

Although phosphorus is an essential nutrient for plant growth, excess phosphorus is a concern for most aquatic ecosystems. Under natural conditions where human activities do not dominate the landscape, phosphorus is generally in short supply and is a limiting factor for aquatic plant growth. As more phosphorus enters a waterbody, it acts to fertilize the aquatic system, allowing for more plant and algae growth. This condition of nutrient enrichment, and the subsequent transition from plants to algae-dominated primary production, is referred to as eutrophication. Eutrophication can alter the ecology of the waterbody and degrade the services it provides, including swimming, fishing, other recreational uses and supplies of clean drinking water.

A bloom of aquatic plants may also include cyanobacteria, also referred to as blue-green algae, which are harmful to fish and pose numerous health risks to humans. Concerns associated with blue-green algae include discolored water, reduced light penetration, taste and odor problems, dissolved oxygen depletions during die-off, and toxin production. Blue-green algal blooms (particularly surface scums) are unsightly and have unpleasant odors. Further, when algae die, decomposition of algae cells results in depletion of dissolved oxygen in the water, which suffocates fish and other aquatic life. Depending on the severity of the low dissolved oxygen event, large fish kills can occur. Lastly, blue-green algae blooms can result in the release of toxic substances (most notably, microcystin) which can be harmful to humans, and occasionally fatal to livestock and pets. The toxins it produces can cause numerous health issues including diarrhea, nausea, vomiting, skin irritations, allergic reactions or breathing difficulties, and more life-threatening conditions

including damage to the liver, kidneys, and nervous system which can lead to death. Nearly all these effects have economic impacts on local communities as well as state and federal governments.

1.3 Watershed Framework

The TMDLs presented in this report were developed using a watershed framework. Under a watershed framework, TMDLs are simultaneously completed for multiple water bodies within a TMDL study area.

The TMDL study area, the Wisconsin land area that drains into Lake Pepin, was divided into 18 subbasins based on drainage pathways. Individual TMDLs for phosphorus were developed for all 18 subbasins. Throughout this report, the 18 subbasins are referred to as TMDL subbasins. Federal 12-digit Hydrologic Units (HUC12) were used to delineate the TMDL subbasins except for two smaller phosphorus-impaired waterbodies, Bogus Creek and Lost Creek, which required their own smaller TMDL subbasins. A HUC12 is a standardized and geographically defined subwatershed that typically spans 10,000 to 40,000 acres. The TMDL subbasins are listed in Appendix A and mapped in Figure 2.

Each of these TMDL subbasins has an allocated load for TP based on Wisconsin's numeric water quality criteria phosphorus covering the waterbodies in that TMDL subbasin. The delineation of these TMDL subbasins often directly corresponds with the spatial extent of impaired river and stream segments or the contributory drainage areas of impaired lakes; however, TMDL subbasins were also delineated for waterbodies not listed as impaired. Thus, allocations are assigned to subbasins with listed and unlisted waterbodies. The resulting system of TMDL subbasin allocations ensure that allocated loads meet promulgated water quality criteria for all waterbodies within the TMDL subbasin as well as downstream waterbodies. If future monitoring determines that additional river or stream segments within a TMDL subbasin are impaired for TP, these impaired segments can be added to Wisconsin's future 303(d) Impaired Waters Lists under Category 4A (impaired waters with an approved TMDL or restoration plan) instead of Category 5 if the allocations contained in this TMDL allow attainment of water quality criterion for the proposed river or stream segment.

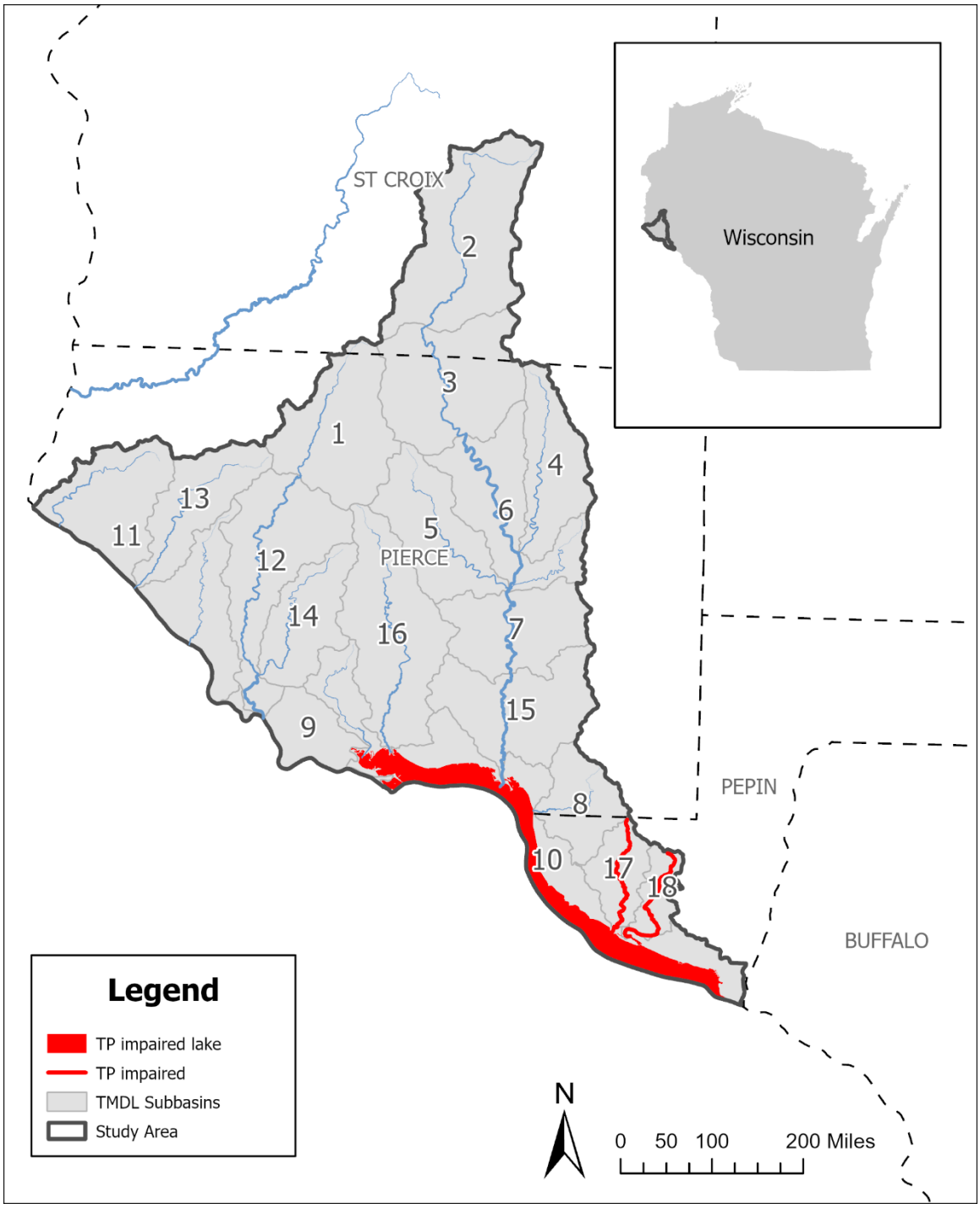

Figure 2 Map of subbasin IDs for the Wisconsin Lake Pepin TMDL area. The subbasin IDs also correspond to reach IDs in all subsequent tables in this report.

1.4 Report Organization

This report defines the TMDLs and allocations and outlines potential management actions that will help restore water quality for Lake Pepin and the Wisconsin streams tributary to it. The main body of the report identifies the waterbodies and impairments addressed by the TMDL, presents applicable water quality standards, assesses pollutant sources, summarizes the assimilative loading capacity and source allocation analysis, and discusses considerations for TMDL implementation. The main body of the report is supplemented with appendices with technical details on the analyses completed to develop the TMDLs along with detailed maps and tables.

2 APPLICABLE WATER QUALITY STANDARDS AND NUMERIC TARGETS

A TMDL defines the maximum amount of a pollutant a waterbody can assimilate while still meeting water quality standards. The purpose of this study is to complement the 2021 TMDL for Lake Pepin submitted by MPCA and approved by U.S. EPA, ensuring that phosphorus loads from Wisconsin meet applicable water quality criteria for Wisconsin tributaries flowing into Lake Pepin. This section summarizes applicable Wisconsin water quality standards and relevant narrative and numeric criteria.

2.1 Narrative Water Quality Criteria

All waters of the State of Wisconsin are subject to the following narrative water quality criterion established in Section NR 102.04(1) of the Wisconsin Administrative Code:

> "To preserve and enhance the quality of waters, standards are established to govern water management decisions. Practices attributable to municipal, industrial, commercial, domestic, agricultural, land development or other activities shall be controlled so that all waters including the mixing zone and the effluent channel meet the following conditions at all times and under all flow conditions: (a) Substances that will cause objectionable deposits on the shore or in the bed of a body of water, shall not be present in such amounts as to interfere with public rights in waters of the state, (b) Floating or submerged debris, oil, scum or other material shall not be present in such amounts as to interfere with public rights in waters of the states, (c) Materials producing color, odor, taste or unsightliness shall not be present in such amounts as to interfere with public rights in waters of the state."

Due to excessive phosphorus, the waterbodies listed in Appendix A do not meet Wisconsin's narrative water quality criterion. Excess phosphorus loading causes algal blooms, which may be characterized as floating scum, producing a green color, a strong odor, and an unsightly condition. Sometimes these algal blooms

contain toxins which limit recreational uses of the water bodies and poses a public health concern. Because of the low dissolved oxygen and degraded habitat impairments caused by excess phosphorus, designated fish and aquatic life uses are not fully supported in Lake Pepin and the 303(d) listed impaired waterbodies that drain to it.

2.2 Numeric Water Quality Criteria

In addition to narrative criteria, numeric water quality criteria for total phosphorus (TP) must be met in Lake Pepin and its Wisconsin drainage area. Numeric criteria for TP are defined in s. NR 102.06, Wis. Adm. Code (Table 1). The numeric criteria were adopted in 2010 and are based on relationships between TP and biological response indicators, as documented in Wisconsin Phosphorus Water Quality Standards Criteria: Technical Support Document (Wisconsin DNR, 2010). To be consistent with the criteria development methods, attainment of criteria for TP is assessed in streams as the median TP concentration during the growing season (May 1 through October 31) and in lakes as the mean TP concentration during the summer (June 1 through September 15). See WisCALM Guidance Document (Wisconsin DNR, 2026) for additional details.

Table 1 Numeric criteria for Total Phosphorus (TP) by waterbody type.

Water Type	TP Criteria
Large Rivers	100 µg/L
Other Rivers and Streams	75 µg/L
Non-Stratified Reservoirs (hydraulic residence time ≥ 14 days)	30 µg/L
Stratified Reservoirs (hydraulic residence time ≥ 14 days)	40 µg/L
Stratified, Two-Story Fishery Lakes	15 µg/L
Stratified Seepage Lakes	20 µg/L
Stratified Drainage Lakes	30 µg/L
Non-Stratified Lakes	40 µg/L

Lake Pepin serves as the boundary between Wisconsin and Minnesota. As such, the more stringent water quality criteria from either state are applied. In Wisconsin, Lake Pepin is considered an impounded flowing water under s. NR 102.06(3)(c), Wis. Adm. Code, meaning that Lake Pepin shall meet the river criterion that applies to the primary stream or river entering Lake Pepin. The water quality criterion for the Mississippi River under s. NR 102.06(3)(a)27, Wis. Adm. Code, is a total phosphorus criterion of 100 micrograms per liter (µg/L). MPCA conducted an extensive study titled “Lake Pepin Site Specific Eutrophication Criteria” (Minnesota Pollution Control Agency, 2011) to evaluate applicable criterion for total phosphorus and chlorophyll-a. Based on the research, MPCA recommended site-specific criteria for Lake Pepin of 100 µg/L for TP for the summer season (June 1 through September 30) and 28 µg/L for

chlorophyll-a. These criteria are consistent with Wisconsin's criteria and will provide protection of applicable designated uses. In June 2014, MPCA's recommended criteria were adopted as site-specific criteria by MPCA's Citizen' Board.

2.3 Designated Uses

Designated uses are the attainable condition specified in water quality standards for surface waters in Wisconsin. Designated uses are defined in Chapter NR 102 of Wisconsin Administrative Code. All waters of the state have the following designated uses: Fish and Aquatic Life, Recreation, Wildlife, and Public Health and Welfare. Wisconsin water quality standards establish criteria for water quality that correspond to attainment of these designated uses. The designated uses are subject to the narrative criteria described in Section 2.1 of this report.

The Fish and Aquatic Life use also includes the numeric criteria for phosphorus described in Section 2.2 of this report. Section NR 102.04(3) of the Wisconsin Administrative Code defines the Fish and Aquatic Life use and identifies five fish and aquatic life subcategories for surface water classification (cold water communities; warm water sport fish communities; warm water forage fish communities; limited forage fish communities; limited aquatic life). All fish and aquatic life subcategories are subject to attainment of the TP water quality criteria except for waters with a limited aquatic life designation.

2.4 Numeric Water Quality Targets

2.4.1 Total Phosphorus

The TMDL's water quality target is a numeric endpoint that represents the level of acceptable water quality to be achieved by implementing the TMDL. For phosphorus, the numeric targets for the TMDLs presented in this report are set equal to the numeric water quality criteria defined in s. NR 102.06, Wis. Adm. Code. The TP criteria for each TMDL reach are listed in Appendix A. To be consistent with the criteria development methods and procedures laid out in WisCALM, attainment

of criteria is assessed in streams as the median TP during the growing season (May 1 through October 31) and in lakes as the mean TP during the summer (June 1 through September 15).

2.4.2 Benefits of Achieving Numeric Targets

In addition to reduced TP concentrations in Lake Pepin and its Wisconsin tributaries, the expected water quality benefits from achieving the quality criteria, both narrative and numeric, include:

- Reduced density, frequency, and duration of nuisance algal blooms resulting in lowered health risks to humans and animals, especially pets;
- Increased dissolved oxygen concentrations that will support a more diverse and robust community of fish and other aquatic life;
- Increased water clarity/transparency due to the stabilizing effect of increased submerged aquatic vegetation;
- Improved biotic integrity index scores for fish and macroinvertebrate communities;
- Improved qualitative and quantitative aquatic habitat ratings;
- Reduced water temperatures;
- Improved pH levels;
- Increased numbers and safety of swimmers and recreational users.

3 WATERSHED CHARACTERIZATION

3.1 Watershed Setting

Lake Pepin is a natural lake on the Mississippi River. The lake formed about 10,000 years ago behind an alluvial fan of the Chippewa River. It has a surface area of about 40 square miles and an average depth of 18 feet. Lake Pepin is characterized by two distinct segments; the upper segment with average depth is approximately 12 feet and accounts for about 40% of the lake by area but only about 28% by volume. The lower segment has an average depth of approximately 22 feet and accounts for about 72% of the lake volume.

Lake Pepin's watershed is approximately 48,634 square miles and includes the Upper Mississippi, St. Croix, and Minnesota Rivers comprising about 48 percent of Minnesota and a portion of Wisconsin. The Wisconsin portion of Lake Pepin's watershed is about 514 square miles, extending from the confluence of the Mississippi and St. Croix Rivers to the confluence of the Mississippi and Chippewa Rivers. This section of the Mississippi River flows from the municipalities of Prescott to Pepin, encompassing portions of 3 counties (Pepin, Pierce, and St. Croix). The primary stream basins in the study area are the Rush River (215 square miles), the Trimbelle River (88 square miles), and Isabelle Creek (40 square miles). There are no inland lakes in this area other than Lake Pepin.

Land use and land cover in this area are relatively homogenous. A little under half of the TMDL study area is comprised of agriculture with crop rotations consistent with dairy, cash grain, and continuous corn. Another large portion of the TMDL study area is comprised of hay and pasture, which is ambiguously coincident with natural grasslands. The remainder of the TMDL study area is made up of mostly forested lands. A small portion of the TMDL study area has urbanized land uses. Notable municipal areas in the TMDL study area include Baldwin, Ellsworth, Prescott, Bay City, and Maiden Rock. None of the municipalities are permitted under ch. NR 216, Wis. Adm. Code. Table 2 provides a summary of land use classifications by TMDL subbasin and Figure 3 shows the distribution of land classifications across the TMDL study.

Table 2 Summary of Land Classifications by TMDL Subbasin

TMDL Subbasin	Urban (acres)	Agriculture (acres)	Grassland (acres)	Forest (acres)	Water (acres)	Wetland (acres)
1	141.3	6,647.7	7,585.3	5,960.7	5.1	486.3
2	1,541.5	15,764.0	8,982.3	1,831.7	13.3	534.4
3	151.7	8,641.0	8,717.7	5,841.8	-	412.1
4	115.4	6,721.1	4,729.2	2,361.0	-	121.7
5	114.1	8,618.0	4,862.7	2,906.8	2.0	115.0
6	137.2	8,006.5	4,808.2	5,515.3	2.0	310.2
7	156.4	7,843.0	2,667.3	5,180.6	19.6	250.0
8	35.8	5,397.2	1,288.6	3,185.9	6.0	112.3
9	966.7	1,945.8	748.8	1,379.1	2,098.6	1,600.8
10	1,328.7	7,178.5	2,835.0	8,309.4	13,907.9	2,421.1
11	1,282.4	13,751.5	5,479.3	7,100.3	1,133.4	1,242.6
12	599.8	8,972.9	5,192.2	7,148.0	78.7	719.0
13	156.6	5,104.9	4,571.5	3,555.2	2.0	80.3
14	187.9	6,311.8	2,870.3	3,261.9	0.7	90.5
15	86.1	8,679.8	3,040.0	7,153.9	5.8	393.6
16	615.8	12,494.9	5,283.0	6,882.3	-	304.3
17	31.1	2,615.4	1,400.1	2,961.0	6.2	53.2
18	33.6	1,406.6	1,191.6	2,050.1	-	91.1

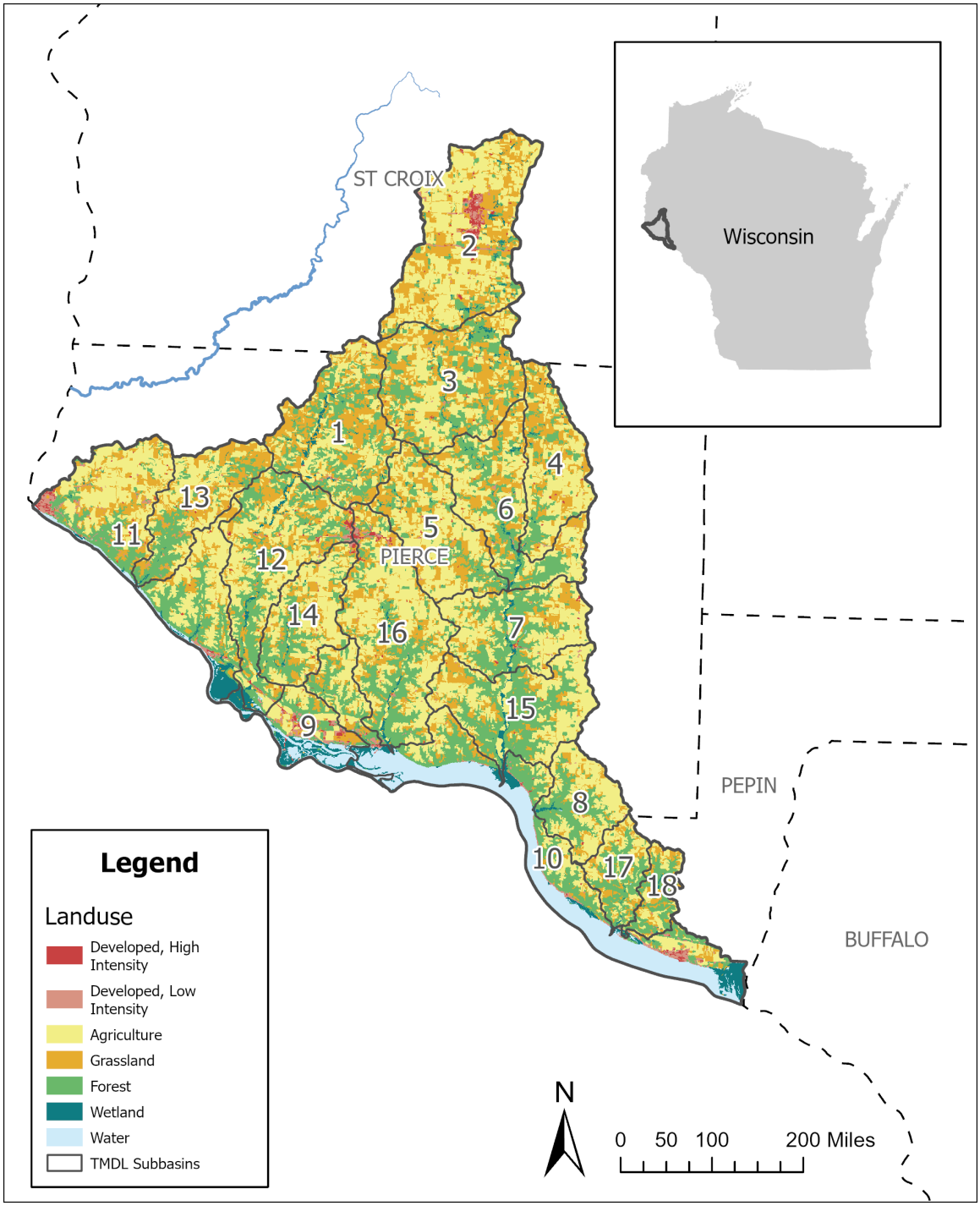

Figure 3 Land Use Classification and Distribution by TMDL Subbasin

3.2 Ecological Landscapes

The TMDL study area is bisected by two ecological landscapes: the Western Prairie and Western Coulees and Ridges. The primary difference between these two ecological landscapes is that although they are both characterized as hilly, the Western Prairie landscape tends to have less steep (i.e., more rolling) hills than the steep-sided valleys that characterize the Western Coulees and Ridges landscapes. Additionally, the natural landcover of the Western Prairie landscape tends toward natural grasslands, and the natural landcover of the Western Coulees and Ridges landscape tends toward forests. In the current land use of the region, these two distinctions are muted by the dominance of row-crop agriculture and pasture, except that more land area tends toward pasture in the Western Prairie area.

Although this region does not have a category explicitly associated with it, U.S. EPA's Ecological Landscapes GIS dataset, there is a region to the east of the Lake Pepin study area, which partially intersects with the Bogus and Lost Creek watersheds, that has notably different water chemistry characteristics than the rest of Wisconsin. This difference in water chemistry is attributed to a transition in the underlying bedrock with the topmost bedrock geological formation transitioning from Ordovician to Cambrian Periods. The transition from the Ordovician to Cambrian bedrock formations leads to higher natural phosphorus concentrations which have correlated with more water quality impairments due to phosphorus, even without a substantial increase in typically higher yielding sources of phosphorus such as agricultural land use, municipality size, or wastewater discharges. In the map in Figure 4, bright yellow streams denote impairments for phosphorus. In this map, impairments tend to be spatially correlated with red, green, and yellow bedrock geology polygons (Wonewoc, Tunnel City, and Trempealeau Groups) in the underlying bedrock geology map of West-Central Wisconsin (Brown, 1988). This natural background high-phosphorus concentration and bedrock geology correlation has been documented by researchers at Wisconsin DNR and USGS, with particularly strong associations with the Wonewoc formation (Miller & Kort, Wisconsin stream reference condition study summary, 2018; Miller, Kult, Robertson, & Saad, 2017). Research from UW-Eau Claire

indicates that anoxic (low oxygen) conditions in Cambrian bedrock groundwater can cause the release of phosphorus from iron-manganese oxides, which then flows into surface water. (Rayhorn, Palubicki, Vitale, Mahoney, & Mc Ellistrem, 2022).

Given the correlation with Cambrian bedrock and naturally elevated groundwater and surface water concentrations suggest that anthropogenic phosphorus may be pushing these naturally elevated phosphorus concentrations past the tipping point, leading to eutrophication. See Section 3.5.1.1 further discussion on specific methods related to naturally higher phosphorus concentrations in Lost and Bogus Creeks.

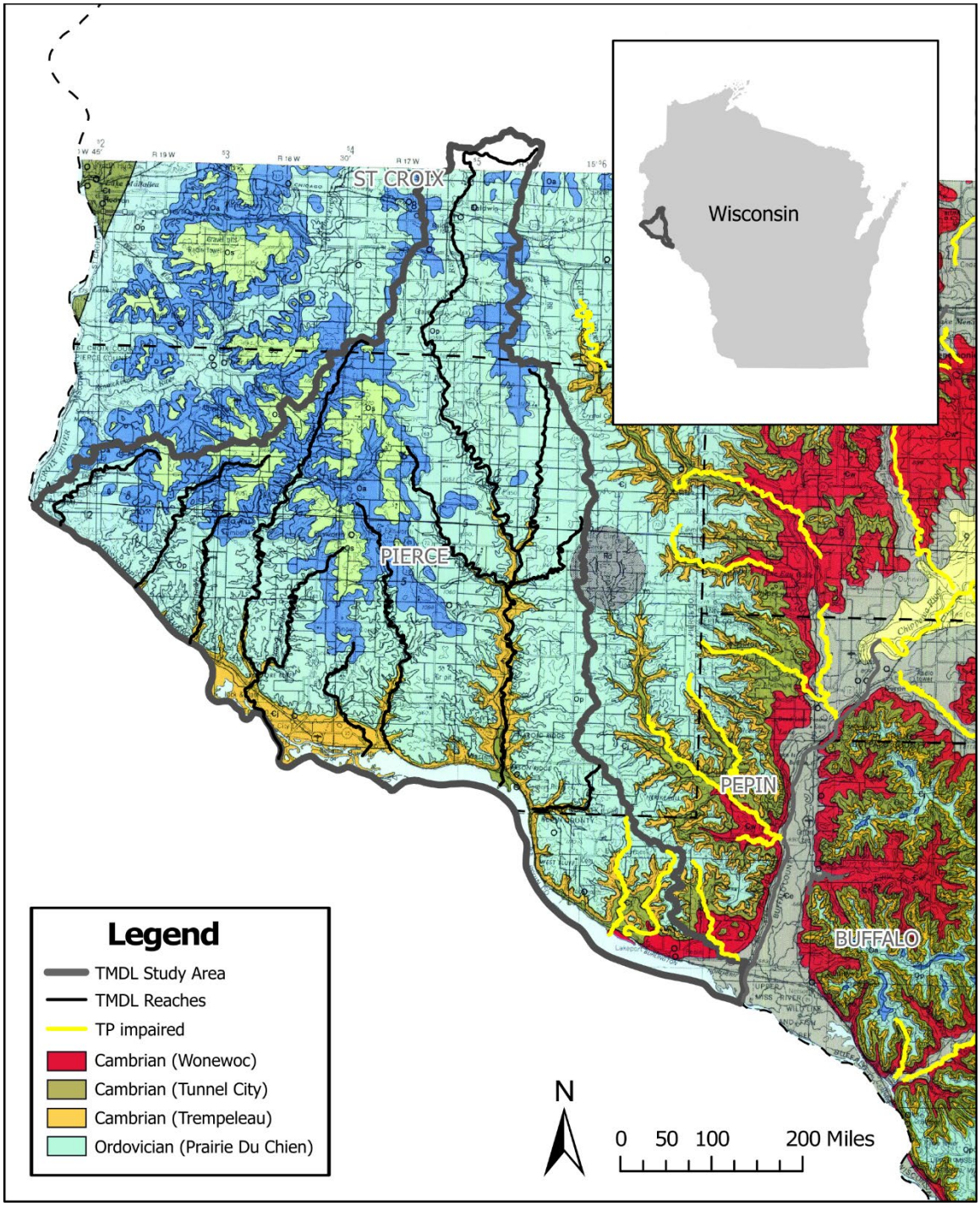

Figure 4 Geologic map describing the topmost layer of bedrock in West-Central Wisconsin (Brown, 1988). The transition from Ordovician Period layers (blue-green polygons) to Cambrian Period layers (red, green, and yellow polygons) is correlated with a higher density of streams impaired for phosphorus.

3.3 Water Quality

Phosphorus concentrations were sampled by Wisconsin DNR and partner groups as part of the Wisconsin DNR water quality monitoring program. The data summary is intended to provide a general overview of the range of observed and inferred water quality throughout the TMDL area.

Table 3 Water quality monitoring stations used to calibrate the TMDL load model for the Lake Pepin study area.

SWIMS station ID	Station Name	Number of TP samples	Time frame	Purpose
483080	Rush River - 385th St.	84	2000, 2006–2008, 2013–2015	Lake Pepin SWAT model calibration
10011512	Trimbelle River 1- 50' U.S. Of STH 35	6	2011	CWA assessment
483039	Isabelle Creek at STH 35	20	1990–1993	Citizen volunteer monitoring
483043	Rush River at Hwy N In El Paso	6	1990–1991	Ambient monitoring
483031	Kinnickinnic River - CTH F Bridge	113	2005–2006, 2010–2011, 2016–2018, 2020–2023	Lake St. Croix SWAT model
10008893	Lost Creek- Pepin	12	2021-2025	CWA Assessment and Ambient Monitoring
473020	Bogus Creek at STH 35	18	2015-2022	CBSM Pepin County Nutrient Monitoring and Citizen volunteer monitoring

Water Quality samples were collected specifically to calibrate a watershed model developed by the University of Minnesota and the MPCA. Sampling began in October 2006 and ended in September 2008. Only one monitoring station was established for SWAT calibration: Rush River at 385th St. (SWIMS station 483080). Monthly samples were collected for the following parameters: total phosphorus, dissolved phosphorus, nitrate-nitrite, total suspended solids, volatile suspended solids, and turbidity. Water quality sampling was also paired with daily streamflow monitoring for the purpose of estimating daily loads.

Monthly chemical sampling and daily streamflow monitoring only co-occurred for a total of 2 years, which is not long enough to provide confidence in calculating long term average loading rates. Therefore, an additional site located in the Kinnickinnic River watershed, which has similar watershed characteristics as the TMDL study watershed, was selected to augment the monitoring sites located in the TMDL study

area. The Kinnickinnic River watershed drains into the St. Croix watershed just north of this study area. It has similar land use composition and a similar watershed size to the Rush River. The downstream-most monitoring station (Kinnickinnic River - CTH F Bridge, SWIMS station 483031) has daily streamflow monitoring for the years 1998–2024 that coincided with water quality sampling during the years 2005–2006, 2010–2011, 2016–2018, and 2020–2023. Using both the Rush and Kinnickinnic River stations together, instead of just the Rush River, provided a better estimate of long term annual average phosphorus loads per unit area of watershed (Section 3.5.2.1).

The Rush River and Kinnickinnic River stations were the primary sites for model calibration, but water quality samples from multiple other sites located within the TMDL study area were used to validate the water quality model. These other sites were established for general 303(d) list assessment, volunteer monitoring, or other ambient water quality monitoring. These sites include the Trimbelle River (SWIMS station 10011512), Isabelle Creek (SWIMS station 483039), and the Rush River at Hwy N (SWIMS station 483043). In addition to the samples themselves, results from a separate model that estimates long-term growing season median concentrations (Phosphorus mixed-effects regression, or PhosMER, (see Section 3.5.2.3) were available at these three additional sites. The PhosMER model estimates were used to validate the TMDL loading model (see Section 3.5.2.3).

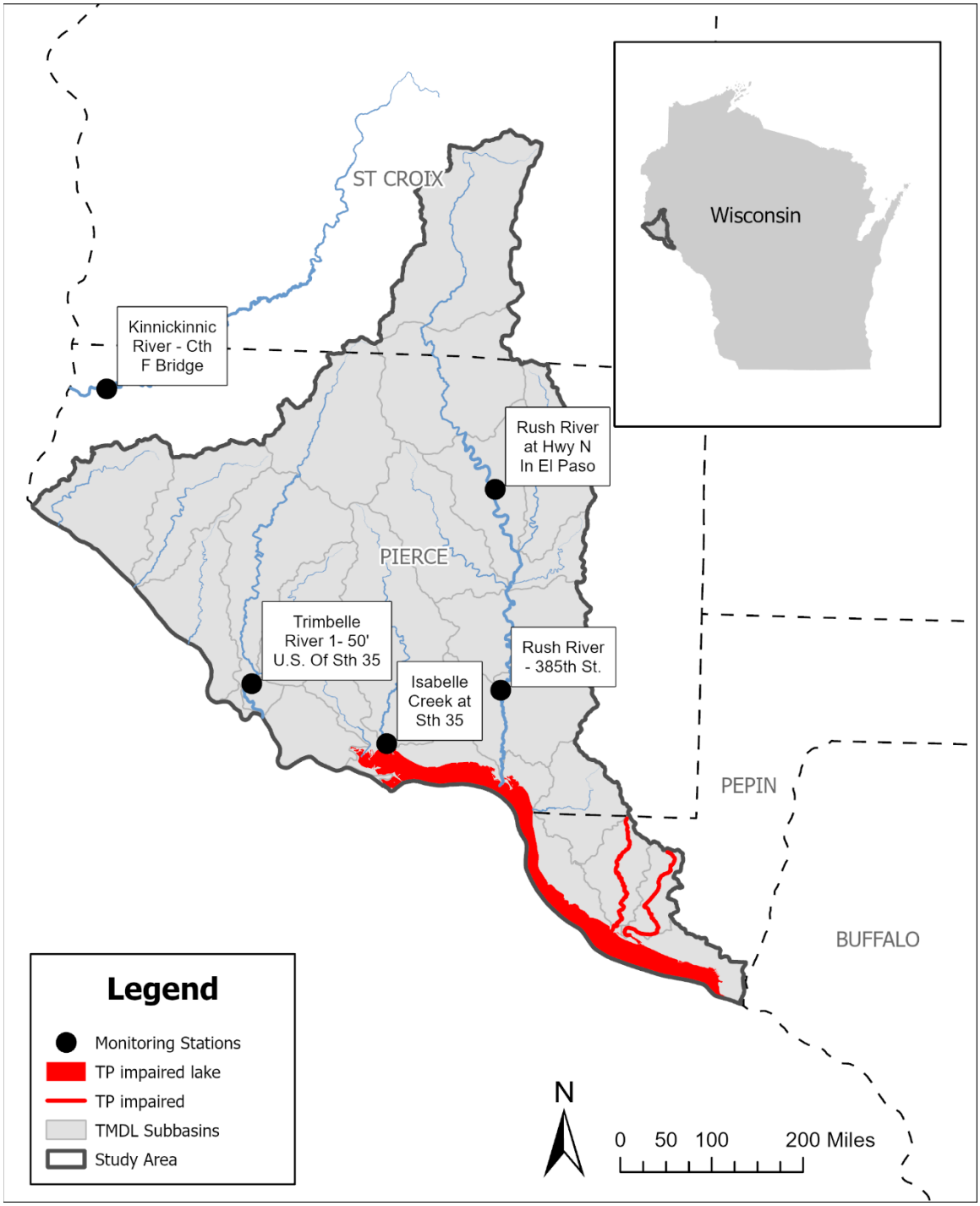

Figure 5 Map of monitoring stations used to calibrate a TMDL load model for the Lake Pepin study area.

3.4 Review of Phosphorus Sources

Two general types of water pollution sources exist: point source and nonpoint source. The Clean Water Act defines a point source of pollution as any discrete conveyance, such as a pipe or ditch, that discharges effluent from a permitted wastewater treatment facility (WWTF), stormwater runoff from a permitted municipal separate storm sewer system (MS4), or other permitted sources that discharge into a surface water. Nonpoint sources of pollution include any pollutant sources that are not permitted and include sources such as runoff from agricultural lands and non-permitted urban areas.

This section of the report provides a general description of point and nonpoint sources of phosphorus that discharge to surface waters in the Lake Pepin study area. Section 3.5 of this report provides further discussion of how phosphorus loads from each source were quantified for TMDL development. Additional information on sources of phosphorus to surface waters and loading mechanisms can be found in Carpenter et al. (1998), Sims (1998), and Steele et al. (2010).

3.4.1 Point Sources

Point sources of phosphorus discharge from a discrete conveyance and are regulated by Wisconsin DNR under the Wisconsin Pollutant Discharge Elimination System (WPDES) program. Point source outfalls that discharge to groundwater are excluded. Several subtypes of point sources are present and are described in the following paragraphs.

3.4.1.1 Publicly Owned Treatment Works

The term Publicly Owned Treatment Works (POTWs) refers to a sewage treatment plant that is owned and operated by a government entity, typically a city, town, or other local government or subject to chs. NR 110 and NR 210, Wis. Adm. Code. POTWs receive domestic and sometimes industrial wastewater via sewer systems, treat the wastewater to reduce or remove solid and chemical contaminants, and discharge treated effluent to surface waters. Raw, untreated municipal sewage

typically contains TP concentrations between 6 mg/L and 12 mg/L. Although these levels are reduced during treatment, rarely can all phosphorus be removed from the effluent.

3.4.1.2 Industrial Facilities

As part of their manufacturing process, many industrial facilities generate wastewater that contains phosphorus and is treated by the industry and discharged directly into a nearby surface water. Examples include wastewater generated during cheesemaking, power generation, equipment manufacturing, or canning fruits and vegetables.

3.4.1.3 Permitted Urban Stormwater

Urban stormwater refers to runoff that is generated from urbanized areas that have been affected by human development (e.g., parking lots, roads, lawns, exposed soils). These surfaces typically accumulate solid particles (dust, sediment, leaves, etc.) that are carried into waterbodies with stormwater. Some of these solid particles, such as sediment or leaves, also contain phosphorus. Other sources of phosphorus in stormwater can include pollen and pet waste.

Even though stormwater is driven by precipitation and fits the description of nonpoint source pollution, certain stormwater discharges to surface water are permitted under the WPDES program and are therefore considered point sources under the TMDL framework. Stormwater drainage systems (ditches, curbs, gutters, storm sewers, etc.) that are publicly owned and do not connect with a wastewater collection system are termed Municipal Separate Storm Sewer Systems (MS4s). Most MS4s that are in a federally designated Urbanized Area and serve populations of 10,000 or more are required to have a WPDES permit to discharge stormwater into surface waters. WPDES permits are also required for stormwater discharges from some construction sites and industrial sites. A Transportation Separate Storm Sewer System (TS4) permit has also been developed and was signed on June 30, 2018, covering Wisconsin Department of Transportation administered facilities within permitted MS4s.

3.4.1.4 Permitted Concentrated Animal Feeding Operations

A Concentrated Animal Feeding Operation (CAFO) is an agricultural operation that raises 1,000 or more animal units in confined areas. Wastewater that is generated by CAFOs is high in phosphorus from animal sewage and other animal production operations. Because of the potential water quality impacts from CAFOs, animal feeding operations with 1,000 animal units or more, CAFOs are required to have a WPDES CAFO permit. These permits are designed to ensure that operations use proper planning, construction, and manure management to protect water quality from adverse impacts.

WPDES permits for CAFO facilities cover the production area, ancillary service and storage areas, and land application areas. CAFOs must comply with all WPDES permit conditions which include the livestock performance standards and prohibitions contained in ch. NR 151, Wis. Adm. Code. Specific WPDES permit conditions for the production area specify that CAFOs may not discharge manure or process wastewater pollutants to navigable waters from the production area, including approved manure stacking sites, unless all the following apply:

- Precipitation causes an overflow of manure or process wastewater from a containment or storage structure.
- The containment or storage structure is properly designed, constructed, and maintained to contain all manure and process wastewater from the operation, including the runoff and the direct precipitation from a 25-year, 24-hour rainfall event for the CAFO's location.
- The production area is operated in accordance with the inspection, maintenance and record keeping requirements contained in s. NR 243.19, Wis. Adm. Code.
- The discharge complies with surface water quality standards including applicable water quality criteria.

For ancillary service and storage areas, CAFOs may discharge contaminated stormwater to waters of the state provided the discharge complies with groundwater and surface water quality standards. The permittee shall take

preventive maintenance actions and conduct periodic visual inspections to minimize the discharge of pollutants from these areas to surface waters. For CAFO outdoor vegetated areas, the permittee shall also implement the following practices:

- Manage stocking densities, implement management systems and manage feed sources to ensure that sufficient vegetative cover is maintained at all times over the entire area.
- Prohibit direct access of livestock or poultry to surface waters or wetlands located in or adjacent to the area unless approved by the Wisconsin DNR.,
- Provided manure, process wastewater, and associated nutrient applications conform with the requirements stipulated under s. NR 243.14(2)(b), Wis. Adm. Code, runoff from CAFO fields is considered an agricultural storm water discharge and is accounted for in the TMDL load allocation.

3.4.2 Nonpoint Sources

Nonpoint sources of pollution include any sources that do not meet the definition of a point source. Nonpoint source pollution is typically driven by runoff, or the movement of water over the land surface and through the ground into waterbodies, though other types of nonpoint source pollution exist. The following paragraphs describe nonpoint sources of phosphorus in the Lake Pepin study area.

3.4.2.1 Agricultural Runoff

High levels of phosphorus in agricultural runoff can stem from multiple sources. Chemical fertilizer and/or animal manure contains phosphorus, a critical plant nutrient, and are often applied to cropland to support crop growth. The phosphorus in chemical fertilizer and manure often becomes bound to soil particles. Because agricultural lands typically have lower vegetative cover than natural areas, they are prone to erosion during runoff events. Erosion from cropland not only carries sediment into nearby surface waters but also carries phosphorus from fertilizer and manure that is attached to soil particles. Alternatively, on cropland with phosphorus saturated soils or recent fertilizer/manure applications, phosphorus

can become dissolved in surface or subsurface runoff and wash into nearby waterbodies. The transport of dissolved phosphorus in subsurface agricultural runoff can also be accelerated on fields with tile drainage systems, which act as a conduit between subsurface water and adjacent drainage channels.

Phosphorus loading also occurs from areas where livestock are raised. As noted in Section 3.4.1.4, CAFOs are permitted under the WPDES program; however, runoff is covered in the TMDL through the load allocation. Smaller, nonpermitted animal feeding operations fall under the nonpoint source category and can contribute phosphorus to adjacent waters because of leakage of animal sewage from covered facilities and from sediment erosion or wash-off of manure from outdoor feedlots, barnyards, and grazing areas. Wisconsin's Nonpoint Source Program (NPS) has mechanisms through Wisconsin DNR, DATCP, and County Land and Water Departments in place to work with agricultural producers to reduce and minimize such discharges and focus on adoption of Nutrient Management Plans to reduce cropland erosion and nutrient losses.

3.4.2.2 Non-Permitted Urban Runoff

Developed areas are significant sources of phosphorus and sediment. Loading magnitudes typically increase with greater intensity of development. For example, runoff from areas with a high proportion of impervious surfaces tend to have phosphorus concentrations because any dust, leaves, pet/wildlife waste, or other material deposited on the surface is carried into nearby surface waters. Roads, driveways, rooftops, parking lots, and other paved areas in cities, suburban, and rural areas therefore all act as phosphorus sources. Other unpaved areas with disturbed soils (gravel or dirt roads, trails, paths, construction sites, etc.) can also contribute high levels of phosphorus to surface waters. Vegetated spaces such as lawns, golf courses, and parks typically have lower phosphorus loading than impervious areas since soil particles are held in place by plant roots and precipitation can infiltrate the soil. However, loading from these areas is generally still higher than undisturbed natural lands because of lower canopy densities and a minimal plant litter layer. Phosphorus loads can be particularly high from vegetated developed lands when plant fertilizers are applied.

3.4.2.3 Natural Background Sources

Phosphorus is a naturally occurring compound that is present in rocks, plant material, soils, and wildlife waste. Phosphorus loading is therefore expected from undisturbed forests, wetlands, and other natural areas. However, these areas contribute significantly lower loads per unit acre than agricultural and developed areas since runoff volumes are reduced with a more extensive plant canopy, leaf litter layer, and soil infiltration and percolation. These same factors also reduce soil erosion and sediment loading from undeveloped vegetated lands.

An additional background source of phosphorus loading to large, open waterbodies is atmospheric deposition. Dust and plant material in the atmosphere can be deposited to a lake or reservoir surface from the wind during dry periods or carried by precipitation. In developed watersheds, this typically represents a small fraction of phosphorus loading.

3.4.2.4 Stream Channels and Lakeshores

Under natural conditions, stream channels exist in dynamic equilibrium, with balanced erosion and deposition. Channel morphology (width, depth, slope, etc.) is in a stable state that is only altered with an extreme flow event or major disturbance to the landscape. In watersheds with urban or agricultural development, the equilibrium between channel erosion and deposition is disrupted due to altered streamflow and sediment loading patterns or artificial channel modifications. Because of these changes, the stream channel adjusts through transitional phases that can persist for years to centuries before again reaching a stable form. Channel downcutting and widening are two channel evolution phases that result in bed and bank erosion and contribute sediment and attached phosphorus to downstream waters. Conversely, when excess sediment enters a stream from the watershed or upstream reaches, sediment settles out of the water and the channel becomes increasingly shallow, which is a process known as aggradation.

Lakeshores typically exist in a similar state of equilibrium as stream channels under natural conditions, with significant erosion only occurring with extreme water level

changes or major disturbances to the landscape. Accelerated lakeshore erosion can occur when human activity removes trees and other deep-rooted vegetation from the nearshore area, when water levels are artificially manipulated, and/or when high wave action is generated from boats.

3.4.2.5 Lake Internal Sources

An additional category of nonpoint source loading in lakes is the release of phosphorus from sources that are internal to the water body. When phosphorus enters a lake from external sources (e.g., runoff or point source discharges), it cycles between inorganic and organic forms in the water column and bottom sediment. The net release of phosphorus from bottom sediments into the water column can be significant in lakes where several years of high external phosphorus loading have left a legacy of stored phosphorus. Release of phosphorus from bottom sediments can occur through a variety of processes, including aerobic and anaerobic decomposition of organic sediments, release of iron-bound phosphorus under anoxic conditions, simple diffusion due to sediment-water column concentration differences, or resuspension of phosphorus-laden sediment through wind and other disturbances.

It is important to note that bottom sediments should not be considered an independent source of phosphorus to a lake. A fundamental coupling exists between the loading of phosphorus from external sources and loading from bottom sediment. The magnitude of phosphorus loading from bottom sediment is largely determined by the amount held in storage in the lake due to historical external phosphorus loading.

3.5 Analysis of Phosphorus Loadings

An assessment of the magnitude of phosphorus loadings by pollutant source provides a foundation for TMDL implementation. It also provides an understanding of the relative contribution of each source to the overall total loading and establishes a starting point for the allocation of allowable pollutant loads to meet

associated assimilative capacities. This section describes the analysis of phosphorus loads completed for each of the sources described in Section 3.4.

This report uses the term "baseline load(s)" to refer to phosphorus loads that are used as the starting point for calculating TMDL allocations and potential reductions needed to meet the assimilative loading capacity of Wisconsin tributaries to Lake Pepin. While Lake Pepin has a criterion of 100 µg/L, the Wisconsin tributary waterbodies have a TP criterion of 75 µg/L which may necessitate additional reductions beyond the 20% reduction recommended in the 2021 TMDL report for Lake Pepin.

The baseline loads for point source dischargers were obtained from the estimated loads for Wisconsin contained in Appendix E of the 2021 TMDL report for Lake Pepin. Table 4 provides a summary of the estimated Wisconsin loads.

Table 4 MPCA's Estimated Loads from Wisconsin to meet the Loading Capacity for Lake Pepin

Wisconsin Loads Accounted for in MPCA's Lake Pepin TMDL		**kg/year**	**lbs./yr**	**kg/day**	**lbs./day**
		14,833	**32,701**	**40.6**	**89.5**
Wisconsin Point Source Loads	**Total Point Source Loads**	**4,295**	**9,469**	**11.8**	**26.0**
	Wisconsin WWTPs	3,925	8,653	10.8	23.8
	Construction and Industrial Stormwater	15	33	0.04	0.09
	Wisconsin General Permits	355	783	1.0	2.1
Wisconsin Nonpoint Source Loads	**Total Nonpoint Source Loads**	**9,600**	**21,164**	**26.3**	**58.0**
	Natural Background	8,160	17,990	22.0	48.5
Margin of Safety (MOS): Explicit 5% of LC		**742**	**1,636**	**2.0**	**4.4**
Reserve Capacity (RC)		**196**	**432**	**0.5**	**1.1**

Source: Values from Appendix E – Wisconsin Loads accounted for in Lake Pepin TMDL (MPCA, 2021)

The loads shown in Table 4 summarize the loads estimated for the Wisconsin portion of the Mississippi River-Lake Pepin/Cannon/Vermillion (MRLP) Basin shown in Figure 6.

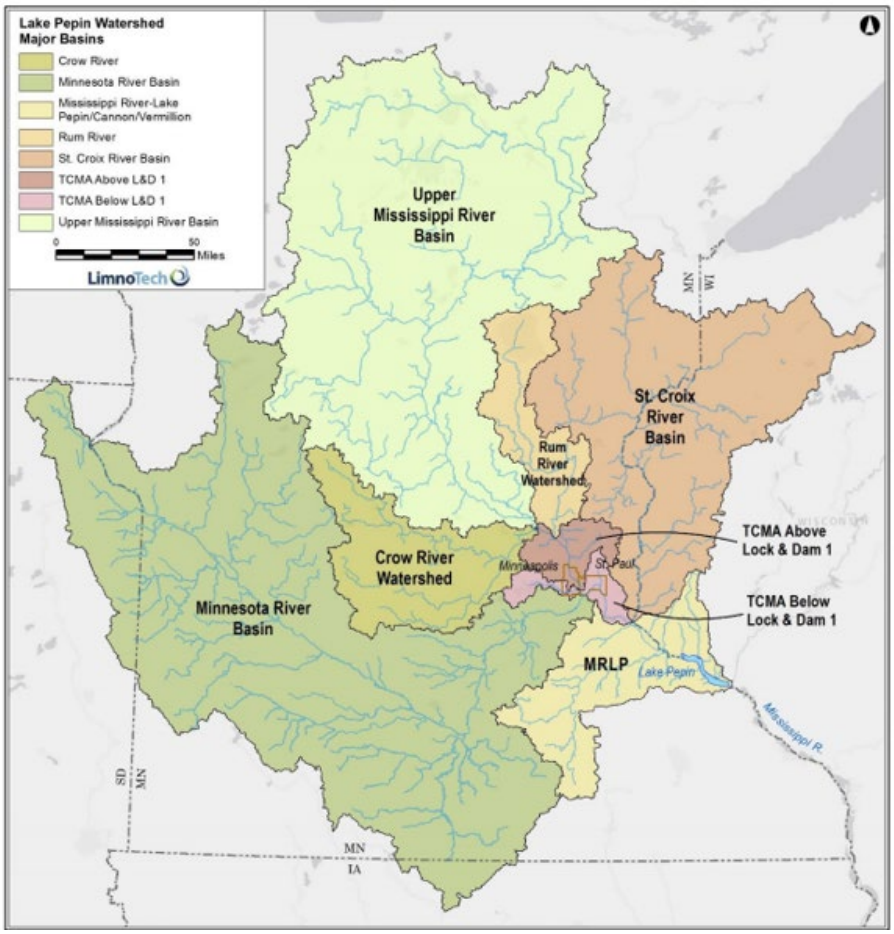

Figure 6 Map of Lake Pepin Watershed Major Basins. Source: Figure 4 of MPCA TMDL Report, 2021.

The estimated Wisconsin point and nonpoint source loads were identified to serve as a boundary condition for the overall TMDL for Lake Pepin and were included in the 2021 TMDL report by MPCA, in Appendix E, as informational. Nonpoint source loads, including the loads from Wisconsin, were estimated by running a watershed model for the 22-year simulation period spanning 1985 through 2006 and averaging the results over that period. The resulting loads were then reduced by 20%, consistent for the reductions assigned to the MRLP Basin.

While drafting its TMDL, the Wisconsin DNR reviewed the nonpoint loads included in the 2021 TMDL report and found that the estimated nonpoint load of 21,164 pounds of TP for Wisconsin tributaries to Lake Pepin reflects TP loading levels typically observed for forested watersheds and not consistent with a watershed

comprised of approximately 66% agricultural land use. This discrepancy in load can partly be attributed to an underrepresented contributory area; however, the 2021 TMDL report lacks the information necessary to reconstruct the original watershed modeling and a significant amount of time has passed since the modeling was conducted. Consequently, the Wisconsin DNR used updated data, including current agricultural management and cropping practices to recalculate the baseline nonpoint loads and provide a more granular breakdown of nonpoint loads by source area. The nonpoint loads were identified as stemming from either agricultural, non-permitted urban, and natural background source areas. To further aid implementation efforts, agricultural loads were also translated into edge-of-field targets compatible with SnapPlus software.

The Wisconsin DNR used a three-step modeling process to assess, calibrate, and validate nonpoint source loads. The details of this process are discussed in Section 3.5.1. The three main steps are outlined below:

1. Nonpoint source loadings from natural background sources, agricultural sources, and nonpermitted urban stormwater were estimated using a watershed model developed within the Wisconsin Lake Modeling Suite (WiLMS).

2. Overall watershed loadings were calibrated to site-specific load estimates at the Rush River 385th Street site. A modified version of the USGS LOADEST model was used to estimate total phosphorus loading at that site.

3. TP loadings were validated against site-specific loading estimates that were derived by multiplying estimates of annual average streamflow (Diebel, Ruesch, Menuz, Stewart, & Westenbroek, 2014) by an estimate of growing season median concentration adjusted to represent annual mean (see Section 3.5.2.3).

The results of Wisconsin DNR's analysis compared to the original estimated nonpoint source loads provided in the 2021 TMDL report are summarized in Table 5.

Table 5 Summary of 2021 TMDL Estimated Nonpoint Loads and Wisconsin DNR Nonpoint Source Baseline Loads

	2021 TMDL Loads		Wisconsin DNR Loads	
	lbs./yr	lbs./day	lbs./yr	lbs./day
Total Nonpoint Source Loads	21,164	58.0	100,212	274.3
Natural Background	17,990	48.5	19,661	53.8
Agricultural	Not Available		74,937	205.1
Non-permitted Urban	Not Available		5,614	15.4

The "2021 TMDL Loads" in Table 5 have a 20% reduction applied to them, while the Wisconsin DNR loads have not yet been reduced to reflect the 20% reduction baseline condition to meet the reduction goals necessary to meet Lake Pepin's assimilative capacity. Through the allocation process, Wisconsin DNR's baseline loads for agricultural and non-permitted urban sources will be reduced by 20%, to 84,102 pounds, and then reduced further as needed to meet the assimilative capacity of Wisconsin's tributary waterbodies. While the natural background loads between the 2021 TMDL Loads and Wisconsin DNR Loads are consistent with each other, there is a substantial difference in the total nonpoint source loads stemming from agricultural and non-permitted urban source areas with the majority stemming from agricultural sources. The difference in agricultural loads can be attributed to Wisconsin DNR's finer resolution under which the agricultural source areas were evaluated and that nonpoint loads were calibrated and validated against monitoring data specific to this portion of Wisconsin.

A summary of Wisconsin DNR's baseline loads by TMDL subbasin is provided in Section 3.6.

3.5.1 Nonpoint Source Baseline Loading Model

3.5.1.1 Land Use Specific Unit-Area Load Estimates

Watershed loads in WiLMS are derived from export coefficients (Table 6). Export coefficients are land use-specific unit-area loads calibrated to Wisconsin

landscapes (WDNR, Wisconsin Lake Modeling Suite, program documentation and user's manual, 2003; Panuska & Lilly, 1995). Export coefficients, in units of pounds per acre per year, were multiplied by their corresponding land use area in each watershed to calculate a land use-specific annual watershed load.

Land use areas were determined using the Wiscland 2.0 dataset, a remote sensing product developed collaboratively by the Wisconsin DNR and the University of Wisconsin. Wiscland 2.0 classifies Landsat 30-meter satellite imagery into four land use and land cover levels, with the most detailed level comprising 47 distinct categories. To align with the WiLMS export coefficient categories (Table 6), these categories were reclassified into the most appropriate corresponding WiLMS category. While most Wiscland 2.0 categories had a natural fit within WiLMS, shrublands (category 7000) and barren (category 8000) landcovers were reclassified into the most similar category: grasslands. All watershed loads were calculated using the same export coefficients except for Lost Creek and Bogus Creek, which did not fit well compared to the calibration dataset (Section 3.5.2.3). In the case of Lost and Bogus Creeks, a scalar value was applied until annual average model estimates matched annual average load estimates in the calibration dataset.

Table 6 Export coefficients (pounds per acre per year) used to calculate land use specific (Wiscland 2.0) phosphorus loads for each subbasin in the Lake Pepin study area. Export coefficients were adjusted in Lost and Bogus Creeks during the calibration process.

Land Use	Wiscland 2.0 category	Export coefficients (lb/acre/yr) [All (Lost, Bogus)]
Agriculture	2000	0.5 (1.7, 0.9)
Developed Urban High Intensity	1100	1.3 (4.3, 2.3)
Developed Urban Low Intensity	1200	0.4 (1.4, 0.8)
Forest	4000	0.1 (0.3, 0.1)
Grassland	3000, 7000, 8000	0.1 (0.3, 0.2)
Water	5000	0.3 (0.9, 0.5)
Wetland	6000	0.1 (0.3, 0.2)

3.5.2 In-Stream Loading Calibration

The Lake Pepin WiLMS model of watershed loading estimates was compared to multiple different calibration datasets to ensure they provided the most accurate possible estimates of phosphorus. Three datasets were used to provide calibration benchmarks for the WiLMS model:

1. Loading estimates from a modified version of the USGS LOADEST model (Section 3.5.2.1)
2. Streamflow estimates from the Wisconsin DNR natural community flow model (Section 3.5.2.2)
3. An alternative loading estimate calculated by multiplying streamflow from the natural community flow model by phosphorus concentration estimates from the Wisconsin DNR PhosMER model (Section 3.5.2.3).

3.5.2.1 Modified LOADEST Site-Specific Loading

Continuous daily phosphorus loads were estimated at the Rush River 385th St and Kinnickinnic River County Hwy H monitoring station. Load estimation was performed with a modified version of the methods that are associated with U.S. Geological Survey Fluxmaster and LOADEST software programs (Schwarz, Hoos, Alexander, & Smith, 2006). The purpose of these methods is to estimate constituent concentrations at a given site when water quality sampling frequency is insufficient for estimating continuous long-term loading. The methods are most effective for constituents that have a strong relationship with streamflow and exhibit cyclic variation with season (e.g., phosphorus concentrations tend to be higher in the summer). Additionally, a time variable allows TP concentrations to vary, linearly or quadratically, over the sampling period.

The first purpose of modifying the Fluxmaster/LOADEST method was to rectify issues with marginal sample sizes. Since the development of these tools, new statistical methods have become available that allow model coefficients to vary by a grouping factor (e.g., a monitoring site). Using each monitoring site as a grouping factor, a single model per constituent can be fitted without the loss of degrees of

freedom that would result from multiple independent models for each site using the regression methods implemented in Fluxmaster/LOADEST. The modeling framework chosen for model fitting was an implementation of linear mixed-effects models in the R programming language for statistical computing (R Core Team, 2020)—the library used in R software was the lme4 package (Bates, Maechler, Bolker, & Walker, 2015). Most of the same methods were used by adapting computer code from the rloadest R package (Runkel & De Cicco, 2017), except when model fitting was performed using lme4.

The second purpose of modifying the Fluxmaster/LOADEST method was based on initial findings that quickflow (the combination of surface runoff and shallow aquifer water yield) was a better predictor of TP than total discharge. To calculate quickflow for each site, we applied a baseflow separation routine based on wavelet transform (Nathan & McMahon, 1990) that is available in an R package called EcoHydRology. The recommended parameters (filter parameter = 0.925, passes = 3) were used. In model fitting for TP, quickflow was always used instead of total discharge. All quickflow values were translated by a value of positive 0.01 to prevent the log transformation of zero values during dry periods when baseflow accounted for all flow. Constituent concentration models were fitted using quickflow, however loading estimates were calculated by multiplying concentration predictions by *total* discharge. These methods are equivalent to those used in the Wisconsin Northeast Lakeshore TMDL.

The final model that was selected for load estimation can be described by the following equation:

Equation 1:

$$\ln(\boldsymbol{\rho}_m) = \beta_0 + [\beta_f] * \begin{bmatrix} \ln(\boldsymbol{Q_m}) \\ \ln(\boldsymbol{Q_m^2}) \end{bmatrix} + \gamma_0 + \boldsymbol{e}_m$$

In the above equation, m is one of the two monitoring sites (Kinnickinnic and Rush River), $\boldsymbol{\rho}$ is a matrix of TP concentrations, $\boldsymbol{Q}$ is a matrix of quickflow paired with $\boldsymbol{\rho}$, β is a fixed-effect coefficient, γ is a random-effect coefficient (the selected model only applies a random effect to the intercept for each monitoring sites), and $\boldsymbol{e}$ is

residual error. Models were evaluated using a combination of graphical and numerical methods (Table 7).

Table 7 Modified LOADEST numerical diagnostics. n is the sample size, BCF is the bias-correction factor, PBIAS is percent bias (negative means underprediction), and mNSE is Modified Nash Sutcliffe Efficiency.

Monitoring Station	n	BCF	PBIAS	mNSE	R^2
Rush River - 385th St.	76	-23.9	-23.9	0.78	0.81
Kinnickinnic River - Cth F Bridge	107	1.13	10.3	0.56	0.48

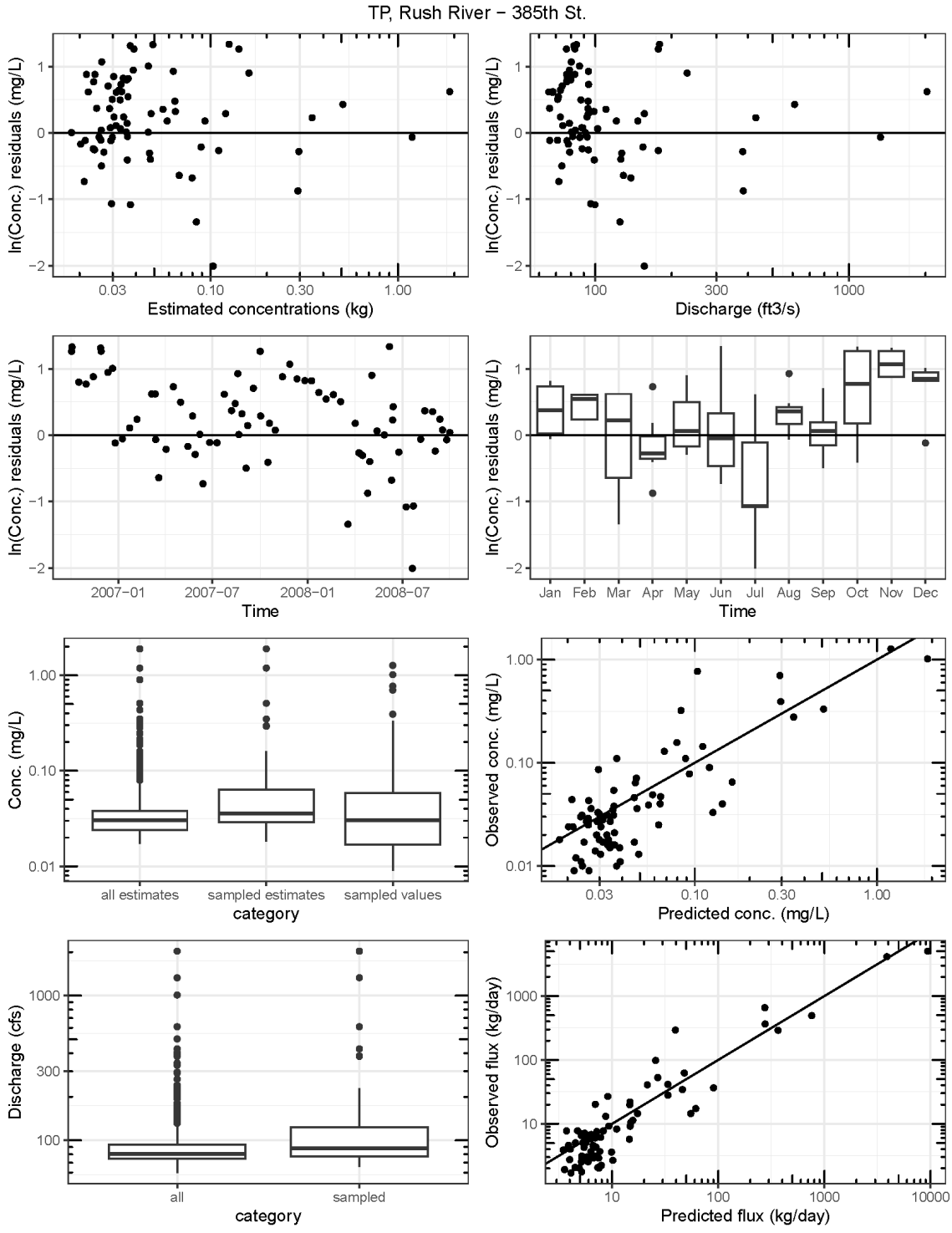

Figure 7 Diagnostic plots for the modified LOADEST site-specific loading model for the Rush River at 385th St.

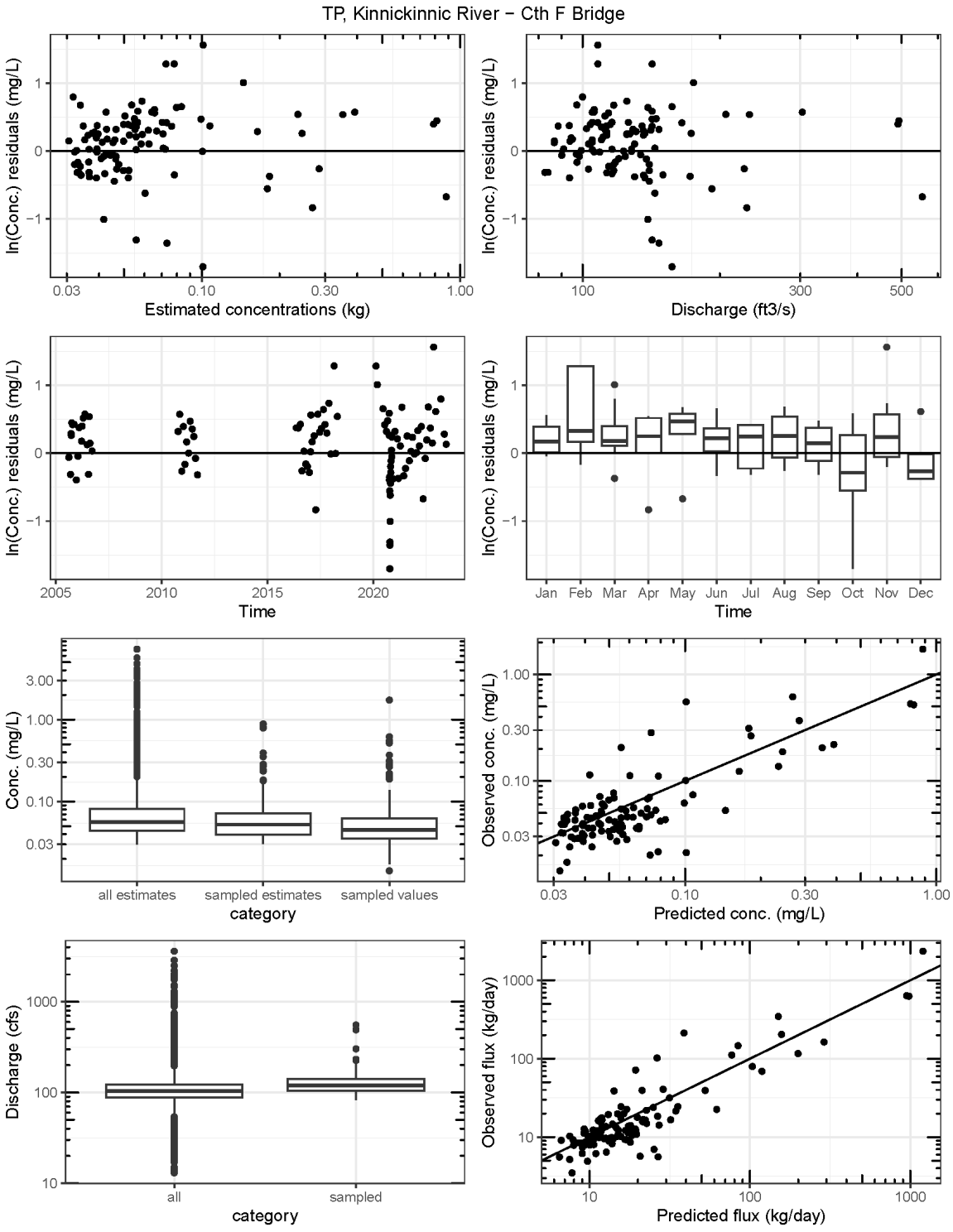

Figure 8 Diagnostic plots for the modified LOADEST site-specific loading model for the Kinnickinnic River County Hwy F.

3.5.2.2 Streamflow Estimation

Streamflow estimation is necessary for TMDL calculations for multiple reason. First, it is used to estimate the maximum allowable load for a waterbody (i.e., with more water, there is more assimilative capacity to dilute a pollutant). Second, if an estimate of pollutant loading is available, streamflow and baseline loading can be used to estimate concentrations.

For this TMDL, we used estimates of streamflow from the Wisconsin natural community set of flow models (Diebel, Ruesch, Menuz, Stewart, & Westenbroek, 2014). The natural community flow models estimate a variety of different annualized flow metrics including annual percentiles from the 5th to the 95th percentile flows, percentile flows by season including spring and fall, and the mean annual flow. For this TMDL, Wisconsin DNR used the mean annual flow estimate.

3.5.2.3 PhosMER Estimates

The PhosMER model was developed by Wisconsin DNR staff to improve confidence that a limited number of phosphorus samples would result in a good estimate of the true GSM (WDNR, 2021). The model uses antecedent precipitation (the depth of precipitation and snowmelt that occurred within a specified time frame prior to the sampling event) and various other watershed characteristics to predict daily TP concentrations. Because TP sampling can often be limited through time, but antecedent precipitation data is available for long-term periods of record, the PhosMER model can be used to hindcast the statistical distribution and uncertainty of daily TP concentrations over long periods of time.

3.5.2.4 Calibration results

The calibration results for the WiLMS-based TMDL loading model are presented in Table 8. In this table, the WiLMS-based concentration columns display phosphorus levels derived from the model described in Section 3.5.1.

To determine these values, the following calculations and adjustments were applied:

1. Flow-Weighted Mean (FWM) Concentrations: These were calculated by dividing the WiLMS-based load (annual average) by the Calibration streamflow (detailed in Section 3.5.2.2).
2. Existing Condition Adjustments: To transition from the MPCA baseline (Section 5.2) to a representation of current existing conditions, the annual average WiLMS-based phosphorus loads for agricultural and non-permitted urban land uses were increased by 20%.
3. Growing-Season Median (GSM) Concentrations: These were derived by applying the FWM/GSM ratio (Section 4.1) to the flow-weighted mean concentrations.

Finally, the WiLMS-based data were validated against estimates from either mLOADEST (Section 3.5.2.1) or PhosMER (Section 3.5.2.3). The specific model used for this comparison is identified in the Calibration Method column of the table.

*Table 8 Comparison of WiLMS-based phosphorus loading and concentration estimates against calibration values (mLOADEST and PhosMER). Estimates represent existing conditions adjusted for agricultural and non-permitted urban land uses. WiLMS-based concentrations include both flow-weighted means and growing-season medians derived via established FWM/GSM ratios. *Note that the streamflow derived from the natural community model was not used to in estimating the calibration concentration and load for the Rush River station at 385th St.*

Site	TMDL reach	WiLMS-based concentration estimate, flow-weighted mean (µg/L)	WiLMS-based concentration estimate, growing-season median (µg/L)	WiLMS-based load (lb)	Calibration method	Calibration streamflow (cfs, natural community model)	Calibration concentration (GSM)	Calibration Load (lb.)
Rush River at 385th St.	7	135.2	46.6	30,019	mLOADEST	112.8*	27.7	33,035
Rush River at El Paso	3	131.0	45.2	12,034	PhosMER	46.6	29.7	7,902
Trimbelle River	12	129.3	44.6	19,163	PhosMER	75.3	40.5	17,413
Isabelle Creek	16	261.1	90	10,899	PhosMER	21.2	74.1	8,969
Lost Creek	18	447.1	154.2	3,081	PhosMER	3.5	150.7	3,011
Bogus Creek	17	250.4	86.3	2,662	PhosMER	5.4	90.3	2,784

3.5.3 WWTF and Industrial Wastewater Dischargers

Baseline phosphorus loads for Wisconsin WWTF and industrial dischargers covered by individual WPDES permits dischargers were set equal to the estimated loads from Appendix E of the 2021 TMDL report. It is important to note that for wastewater dischargers, the estimated loads in the 2021 TMDL report were set equal to the design flow capacities of the WWTFs, which often account for wet weather peaking and future community growth, and either 1.0 mg/L, 3.5 mg/L, or current effluent concentrations for TP depending on the facility type and discharge flow rate. Table 9 summarizes the estimated wastewater loads from the 2021 TMDL report which served as baseline loads for Wisconsin's TMDL analysis to evaluate if reductions would be required to meet the assimilative loading capacity of Wisconsin's tributaries to Lake Pepin.

Table 9 Summary of Estimated Loads for Wisconsin WWTFs and Industrial Dischargers.

Facility Name	Permit Number	kg/yr	lbs./yr
City of Prescott	WI0022403	703.0	1549.8
Ellsworth Co-op Creamery (Process)	WI0022942	419.0	923.7
Village of Baldwin	WI0026891	1,167.0	2572.8
Village of Bay City	WI0061255	202.0	445.3
Village of Ellsworth	WI0021253	794.0	1750.5
Village of Maiden Rock	WI0032361	64.0	141.1
Village of Pepin	WI0022811	576.0	1269.9
	Total	**3,925.0**	**8653.1**

Source: Values from Appendix E – Wisconsin Loads accounted for in Lake Pepin TMDL (Minnesota Pollution Control Agency, 2021)

3.5.4 Stormwater and Wastewater General Permits

Wisconsin DNR authorizes certain stormwater and wastewater discharges under a set of general WPDES permits. Unlike individual WPDES permits, the general permits are not written to reflect site-specific conditions of a single discharger but rather are issued to cover multiple dischargers with similar operations and types of discharges. These general permits vary in requirements for chemical monitoring,

inspection frequency, and plan development. Examples of discharges that can be covered by WPDES general permits include:

- Stormwater discharge from construction sites;
- Stormwater discharge from industrial sites;
- Discharge of noncontact cooling water from industrial facilities;
- Discharge of construction site pit and trench dewatering wastewater to surface waters or seepage systems;
- Discharge from facilities that wash equipment, vehicles and other objects outside.

Note that individual WPDES permits can be issued for the above examples if they are determined to be a significant source of pollution. A complete list of wastewater general permit categories can be found on the Wisconsin DNR Wastewater website[1].

Baseline loads for stormwater and general permits were set to the estimated loads provided in Appendix E of the 2021 TMDL report. This equates to 33 pounds per year for industrial and construction stormwater permits and another 783 pounds per year for general permits for a total of 816 pounds per year. This was distributed among the TMDL subbasins and is summarized in Section 3.6.

3.5.5 Permitted Concentrated Animal Feeding Operations

There are six CAFOs in the TMDL area that are covered under the WPDES general permit for CAFOs (Table 10; Figure 9). Runoff from CAFO land application activities is included as nonpoint source agricultural loads derived from the WiLMS model.

[1] https://dnr.wi.gov/topic/wastewater/generalpermits.html

Table 10 List of permitted CAFOs in the TMDL area.

CAFO Name	Permit No.	County
Steven Brand	65820	Pierce
Ridge Breeze Dairy	62928	Pierce
Jil Ro Sie Holsteins	66419	Pierce
Jon De Dairy Inc.	58408	St. Croix
Fetzer Farms Inc	65803	Pierce
Albedarned Dairy LLC	59102	St. Croix

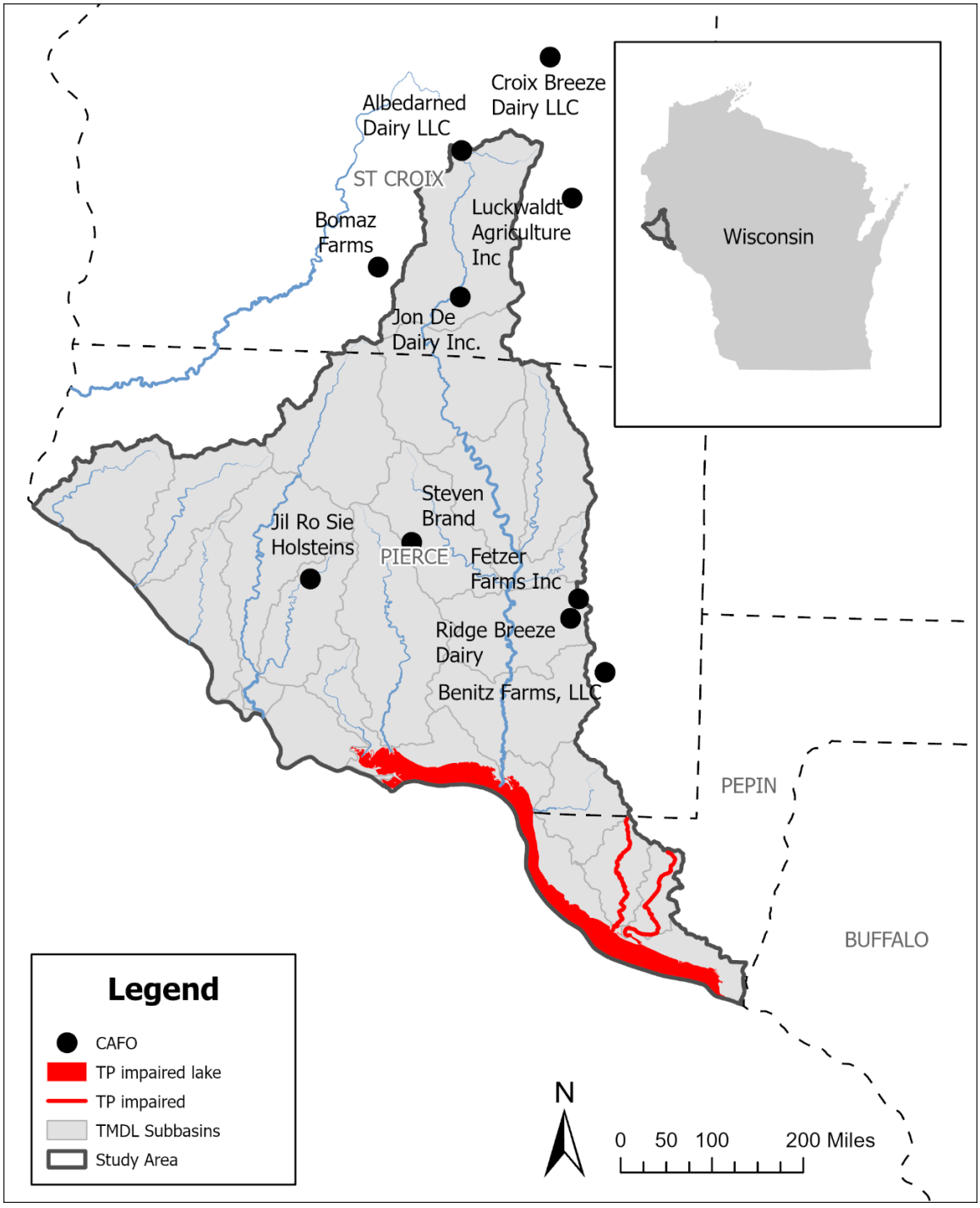

Figure 9 Concentrated Animal Feeding Operations (CAFOs) in the TMDL area (and 5 miles outside the watershed) that are covered under the WPDES general permit for CAFOs. Points on the map are an approximation of the operation's main location.

3.5.6 Stream Channels

The presence and magnitude of phosphorus loading from stream channel erosion is dependent on the amount of sediment and associated phosphorus entering a stream reach and local reach characteristics such as width, depth, and slope that determine whether channel aggradation or degradation occurs. In the TMDL model, stream channel loading was implicitly lumped into the overall loading total. Stream channel loading was not explicitly estimated.

3.6 Summary of Baseline Phosphorus Loads

Table 11 in this section provides a general summary of baseline TP loads in the TMDL area estimated from the methods described in the preceding sections. A map of the TMDL subbasins is provided in Figure 2.

Table 11 Summary of baseline annual total phosphorus loads by source for each subbasin. These baseline loads are incremental, meaning they exclude all incoming loads. Some source categories have been abbreviated for fit: NPU=non-permitted urban, IP=individual permit, GP=general permit

TMDL Subbasin	TMDL Subbasin Name	BG (lbs./yr)	Agric. (lbs./yr)	NPU (lbs./yr)	IP (lbs./yr)	GP (lbs./yr)	Total (lbs./yr)
1	Trimbelle River—mile 19 to headwaters	1,200	3,559	99	0	52	4,910
2	Rush River—mile 34.3 to headwaters	1,000	8,439	1,343	2,573	71	13,426
3	Rush River—mile 25.9 to mile 34.3	1,284	4,626	108	0	59	6,077
4	Cave Creek	622	3,598	92	0	35	4,347
5	Lost Creek (tributary to Rush River)	678	4,613	87	0	41	5,419
6	Rush River—mile 13.4 to mile 25.9	900	4,286	82	0	47	5,315
7	Rush River—mouth to mile 13.4	681	4,198	123	0	40	5,042
8	Pine Creek	382	2,889	22	0	25	3,318
9	Mississippi River	882	1,042	699	445	22	3,090
10	Lake Pepin	4,859	3,843	770	1,270	88	10,830
11	Mississippi River	1,473	7,361	856	1,550	74	11,314
12	Trimbelle River—mouth to mile 19	1,122	4,803	462	0	56	6,443
13	Big River	701	2,733	104	0	33	3,571
14	Little Trimbelle River	526	3,379	142	0	32	4,079
15	Rush River—mouth to mile 7.4	882	4,646	48	141	48	5,765
16	Isabelle Creek	1,051	6,689	485	2,674	63	10,962
17	Bogus Creek	526	2,100	36	0	18	2,680
18	Lost Creek (tributary to Lake Pepin)	892	2,133	56	0	12	3,093
	Totals:	19,661	74,937	5,614	8,653	816	109,683

4 DETERMINATION OF ASSIMILATIVE LOADING CAPACITY

The pollutant assimilative loading capacity of a waterbody is defined as the amount of a pollutant that the waterbody can assimilate and still meet water quality criteria and standards. By definition, a TMDL is a daily assimilative loading capacity; however, loading capacities can also be calculated for time periods other than daily if the effects of a pollutant manifest over longer periods.

This section describes how phosphorus loading capacities were calculated for the Wisconsin TMDL subbasins. The assimilative loading capacity for Lake Pepin and Pool 2 were set by MPCA at 4,894,304 pounds per year covering the simulation period of 1985 through 2006. This assimilative loading capacity meets the site-specific 125 µg/L TP for Pool 2 at Lock and Dam 2 (Hastings, Minnesota) that applies June through September, as well as the State of Wisconsin standard of 100 µg/L TP at Lock and Dam 3 (upstream of Red Wing, Minnesota). A detailed description of how the assimilative loading capacity was determined, as well as the results of the reduction scenarios, is provided in the Upper Mississippi River – Lake Pepin Water Quality Model report (Limno Tech, 2009a).

4.1 Phosphorus Assimilative Loading Capacity for Wisconsin Tributaries

Wisconsin's stream/river total phosphorus criteria are assessed as growing-season (May–October) median (GSM) concentrations (see Section 2.2). To establish annual TP loads that will meet GSM criteria, a method is required to translate GSM concentrations to flow-weighted mean (FWM) concentrations. FWM is higher than the GSM in streams where TP concentration increases with discharge and where there is little seasonal variation. In contrast, GSM may be higher than FWM in streams where TP exhibits a strong seasonal pattern that peaks in summer and is independent of discharge.

To determine appropriate FWM/GSM ratios for TMDL development, the FWM and GSM concentrations were calculated for the Rush River monitoring site at 385th St, where the highest quality and longest-term sampling and flow data were available.

At this site a daily concentration and load model was developed (Section 3.5.2.1) using the mLOADEST model framework. From this model, both FWM and GSM statistics can be extracted.

The mLOADEST model and associated FWM/GSM statistics were chosen as a means of applying an implicit margin of safety. To estimate the uncertainty of the GSM estimate, a statistical method called "bootstrapping" (a statistical procedure that resamples a single dataset to create many simulated samples for the purpose of estimating uncertainty) was used. The mLOADEST model was bootstrapped by refitting it 200 times—with each new iteration the model table was shuffled (resampling with replacement) to simulate slightly different conditions. Each iteration generated a new set of daily TP concentrations, and each time a new FWM/GSM ratio was calculated across those daily predictions. This process resulted in a distribution of FWM/GSM values at each site. The lower bound of the 80% confidence interval (the 10th percentile rank value) was chosen as the representation of the FWM/GSM ratio. The value used for all subbasins, derived from a combination of model results from the Kinnickinnic River CTH F Bridge and Rush River at 385th St. monitoring sites, was 2.9.

After determining appropriate FWM/GSM ratios, the phosphorus assimilative loading capacity was initially calculated for all TMDL reaches as:

Equation 2

$$Loading\ Capacity = Q_{mean} * TP_{crit} * (FWM/GSM)$$

where Q_{mean} is the mean annual flow in the subbasin (extracted from the WHDPlus model, same as the flow that was used in the WiLMS load model, referenced in Section 3.5.2.2), TP_{crit} is the total phosphorus criterion for the reach (75 µg/L for all reaches), and FWM/GSM is the conversion factor described in the preceding paragraphs. Phosphorus loading capacities for each TMDL subbasin are reported in Appendix B.

4.2 Critical Conditions

A TMDL must consider critical conditions for pollutant loading and their effects on water quality as part of the analysis of assimilative loading capacity. Wisconsin's phosphorus criteria are assessed during the growing season (May through October) in streams and rivers and the summer (June 1 through September 15) in lakes. These periods can be considered critical conditions for the water quality effects of phosphorus loading because they are times when the biological responses to excess phosphorus are strongest due to temperature, flow, and sunlight conditions that are conducive to excessive plant growth.

Although critical conditions for assessment of phosphorus occur during the summer and growing season, critical conditions for phosphorus loading include the entire year. The entire year is included because phosphorus entering a waterbody during non-growing season months can be stored over time and released during the growing season. Loading capacities and TMDL allocations for phosphorus were therefore calculated on an annual basis, with methods described in the preceding sections to translate annual loads to growing season or summer concentration targets (i.e., FWM/GSM ratios for stream and river reaches).

5 POLLUTANT LOAD ALLOCATIONS

The objective of TMDL studies is to allocate loads among pollutant sources so that appropriate control measures can be implemented, and water quality criteria can be achieved. Wasteload allocations (WLAs) are assigned to point source discharges regulated by WPDES permits and nonpoint source loads are assigned load allocations (LAs), which include both anthropogenic and natural background sources of a given pollutant.

TMDLs must also include a margin of safety (MOS) to account for the uncertainty in predicting how well pollutant reduction will result in meeting water quality standards, and account for seasonal variations. A reserve load capacity (RC) is also included in the TMDL to account for future discharges, changes in discharges, and other sources not defined through the TMDL study.

5.1 TMDL Equation

A TMDL is expressed as the sum of all individual WLAs for point source loads, LAs for nonpoint source loads, reserve capacity for future and increased discharges, and an appropriate MOS, which takes into account uncertainty:

$$TMDL = \sum WLA + \sum LA + MOS + RC$$

$\sum WLA$ is the sum of wasteload allocations (point sources), $\sum LA$ is the sum of load allocations (nonpoint sources), MOS is the margin of safety, and RC is the reserve capacity.

5.2 Allocation Approach

Load and wasteload allocations were developed for the following source types:

Load allocations:

- Natural background sources (e.g., forests and wetlands)
- Agricultural sources
- Non-permitted urban areas (NPUs)

Wasteload allocations:

- Individual WPDES permittees (WW, CAFO)
- General WPDES permittees (WW, stormwater, CAFO)

The 2021 TMDL for Lake Pepin established the maximum amount of TP that Lake Pepin can receive and allocated these TP loads to upstream sources in Minnesota and included estimated loads for sources in Wisconsin. However, the 2021 TMDL analysis is set to meet the 100 µg/L TP criterion for Lake Pepin. The applicable TP water quality criterion for Wisconsin's tributaries to Lake Pepin is 75 µg/L. This TMDL addresses that gap by integrating allocations and estimated nonpoint loads contained in the 2021 TMDL report, updating the estimated nonpoint loads, and assigning additional reductions, if needed, to ensure Wisconsin's stream TP criteria for its tributaries are successfully met. The integration process is as follows:

1. Set the baseline for the Wisconsin portion of the TMDL:
    a. For point sources covered by individual permits, use estimated loads contained in the 2021 TMDL report needed to achieve the Lake Pepin loading capacity.
    b. For non-point sources (agriculture and non-permitted urban), reduce the nonpoint loads calculated through Wisconsin DNR's analysis, summarized in Section 3.5, by the 20 percent as recommended in the 2021 TMDL report to achieve the Lake Pepin loading capacity.
    c. Distribute the total estimated general permit load allocation contained in the 2021 TMDL report to each Wisconsin subbasin and use these as the baseline general permit load:
        i. Sum the estimated loads for construction, industrial stormwater, and general permits (Table A.5.)
        ii. Calculate subbasin areas and distribute the load by the fraction of the total area for each subbasin.
    d. Distribute reserve capacity using the same area-weighted calculation as general permits.
2. Calculate allocations to meet Wisconsin phosphorus criteria (75 µg/L) for each "local" waterbody. Any additional reductions are applied to the baseline wasteload conditions and nonpoint sources.
3. Verify Wisconsin's phosphorus criteria are attained.

The specifics of determining the allocations for each source type are described in the following sections. Allocations for natural background sources were set equal to their baseline loads. Before allocating loads to other source types, the natural background load was subtracted from the total allowable reach load because it cannot likely be reduced further; the remaining load is considered "controllable".

The allocation process depends on whether the baseline reach load is greater than or less than the allowable reach load. Each case is presented below and visualized in Figure 9 and Figure 10.

Case 1: TMDL subbasin baseline load greater than the allowable load

Using the TMDL subbasin allowable load, the natural background load is first subtracted to derive the controllable load. The reserve capacity was set to the 2021 TMDL report's recommended value of 432 pounds and distributed proportionally within the 18 TMDL subbasins. After the reserve capacity is subtracted from the controllable load, the remaining controllable load is reduced so that the sum of natural background, controllable loads, and reserve capacity are equal to the TMDL load capacity. The GP load was set to the 2021 TMDL report's recommended wasteload allocation of 816 pounds and distributed proportionally within the 18 TMDL subbasins.

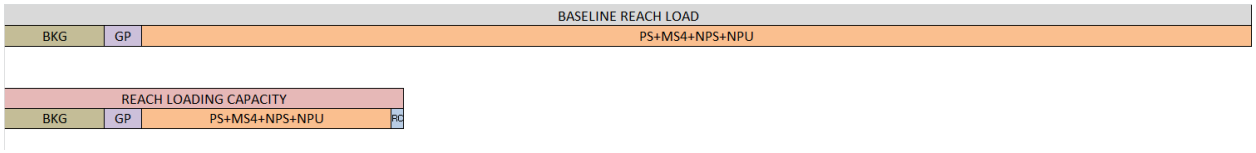

Figure 9 Allocation approach when baseline load is above allowable load.

Case 2: TMDL subbasin baseline load less than or equal to the allowable load

If the TMDL subbasin's baseline load is less than the reach allowable load, no load reductions are required to meet local water quality criteria. The reserve capacity was set to the MPCA recommended value of 432 pounds and distributed proportionally within the 18 TMDL subbasins and added to the baseline reach load. The GP load was set to the 2021 TMDL report's estimated load of 816 pounds and distributed proportionally within the 18 TMDL subbasins.

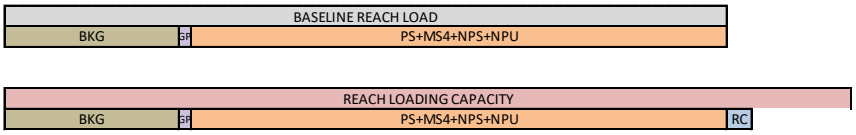

Figure 10 Allocation approach when baseline load is below allowable load.

5.3 Load Allocations

In general, the allocation process proceeds for each TMDL subbasin upstream to downstream. Controllable loads are reduced with equal percentage reduction across sources. Specifically, the fraction of the controllable load that is allocated to

each source category is equal to its fraction of the baseline load as calculated over the model simulation period. These fractions were calculated separately for each TMDL subbasin. This method assigns responsibility for attaining water quality targets in proportion to each source's current contribution to the excess load.

After load allocations are calculated for a TMDL subbasin, a check is done to determine if any of the permitted wastewater facilities have received an allocation that puts their equivalent effluent concentration below the local water quality criterion for TP.

Allocations must not exceed established regulations. CAFO wasteload allocations are set to zero because CAFOs must comply with all authorized discharge and overflow requirements described in the WPDES CAFO General and Individual Permits. In accordance with the CAFO General Permit, overflow events from CAFOs are allowable due to precipitation related overflows from CAFO storage structures which are properly designed, constructed, operated, and maintained in accordance with CAFO permits. Discharges from such overflows are allowable only if they do not cause or contribute to a violation of water quality standards. Discharges that do not meet the requirements outlined above are considered a permit violation and subject to stepped enforcement procedures.

Allocations were calculated separately for each source or source type in each TMDL reach on an annual basis. TP allocations by reach and source type are presented in Appendix B. Baseline TP loads are presented in Section 3.5.

5.3.1 Natural Background Sources

Loads from natural background sources (forest, grassland, and wetlands) were determined from the WiLMS model. Allocations for natural background sources are set equal to the baseline natural background load for that TMDL subbasin (i.e., no load reduction from baseline). Details regarding the modeling conditions used to determine baseline loads from natural background sources can be found in Section 3.5.

5.3.2 Agricultural and Non-Permitted Urban Sources

Agricultural phosphorus loads were calculated for cropland areas using the WiLMS export coefficient method described in Section 3.5.1. These loads were then reduced by 20% to reflect MPCA's reductions necessary to meet Lake Pepin's water quality criteria. This resulting load served as a baseline and was reduced further, as needed, to meet the assimilative capacity for each of the 18 TMDL subbasins. Agricultural sources received allocations proportional to their contribution to the total controllable baseline load for each reach. Total annual phosphorus load allocations for agricultural sources can be found in Appendix B.

Loads for non-permitted urban areas were calculated from the non-background and non-agricultural land covers. These loads were then reduced by 20% to reflect reductions necessary to meet the Lake Pepin WQS. Non-permitted urban sources received allocations proportional to their contribution to the total controllable baseline load for each TMDL subbasin. Total annual phosphorus load allocations for non-permitted urban areas can be found in Appendix B.

5.4 Wasteload Allocations

5.4.1 Permitted Municipal and Industrial Wastewater Discharges

Wasteload allocations for municipal and industrial wastewater discharges covered by an individual WPDES permit were calculated from baseline loads and reductions determined using the steps described in Section 5.2. Wasteload allocations for municipal and industrial wastewater discharges covered by an individual WPDES permit are listed in Appendix B.

Section 40 CFR 122.45 (d), Fed. Reg., and s. NR 212.76 (4), and s. NR 205.065 (7), Wis. Adm. Code, specify that unless impracticable, effluent limits must be expressed as weekly and monthly averages for publicly owned treatment works and as daily maximums and monthly averages for all other continuous discharges. A continuous discharge is a facility that discharges 24 hours per day on a year-round basis except for temporary shutdowns for maintenance or other similar activities (s. NR 205.03 (9g), Wis. Adm. Code).

The Wisconsin DNR has demonstrated the impracticability of expressing WQBELs for TP as specified in 40 CFR 122.45(d)(2). The impracticability demonstration indicates that WQBELs for TP shall be expressed as a monthly average, if the TP WQBEL is equivalent to a concentration value greater than 0.3 mg/L, and as both a six-month average and a monthly average, if the TP WQBEL is equivalent to a concentration value less than 0.3 mg/L. In the latter case, the monthly average limit is three times the calculated six-month TP WQBEL. This will be implemented pursuant to the WPDES permit process.

For non-continuous discharges, methods for converting WLAs into permit limits should be determined on a case-by-case basis. For example, some discharges do not occur continuously and often vary from year to year, depending on weather conditions or production processes. In these cases, it may be appropriate to express limits by season or as a total annual amount. In many cases, using shorter term limits (daily, monthly) might have the effect of unduly limiting operational flexibility and, since TMDLs are required to be protective of critical conditions, a seasonal or annual limit would be consistent with the TMDL and protective of water quality. This will be implemented pursuant to the WPDES permit process.

Discharges covered by individual permits that have surface water intake structures are allowed to pass through the phosphorus that is present due to the water supply but are expected to remove any excess that is added or concentrated in their discharge to meet their wasteload allocation.

For phosphorus, the mass allocation contained in the TMDL will be expressed as a mass limit. In many cases, dischargers already have a concentration limit for phosphorus, based on the technology-based effluent limit (TBEL) requirements or a water quality-based effluent limit (WQBEL) required under ch. NR 217, Wis. Adm. Code. Concurrent with the TMDL mass limit, the TBEL concentration limits will be retained in subsequent WPDES permit reissuances. If the WQBEL limit has already taken effect in the permit, it may be replaced with a less stringent TMDL derived mass limit pursuant to the antidegradation procedures contained in ch. NR 207, Wis. Adm. Code.

5.4.2 General Permits

WPDES general permits address stormwater discharges from industrial facilities and construction sites and wastewater discharges that are considered to not be significant contributors of pollution. As described in Section 5.2, general permit allocations were distributed proportionately based on the TMDL subbasin's area. The wasteload allocations for these general permits were set aside with no reduction from baseline values.

5.4.3 Concentrated Animal Feeding Operations

The production area, storage areas, and ancillary service areas for CAFOs have been assigned a WLA of zero based on WPDES permit conditions that do not allow discharges that cause or contribute to a violation of water quality standards. In addition to the previously listed requirements, a CAFO may not discharge any pollutants from the production area to a 303(d)-listed surface water if the pollutants discharged are related to the cause of the impairment. For this TMDL study, this pollutant is phosphorus; however, surface waters may be listed as impaired for additional pollutants such as bacteria.

CAFOs must comply with all WPDES permit conditions which include the livestock performance standards and prohibitions in ch. NR 151, Wis. Adm. Code. These WPDES permit conditions have been translated into a WLA of zero. WPDES permit conditions for the production area specify that CAFOs may not discharge manure or process wastewater pollutants to navigable waters from the production area, including approved manure stacking sites, unless all of the following apply:

- Precipitation causes an overflow of manure or process wastewater from a containment or storage structure.
- The containment or storage structure is properly designed, constructed and maintained to contain all manure and process wastewater from the operation, including the runoff and the direct precipitation from a 25-year, 24-hour rainfall event for this location.

- The production area is operated in accordance with the inspection, maintenance and record keeping requirements in s. NR 243.19, Wis. Adm. Code.
- The discharge complies with surface water quality standards.

For ancillary service and storage area, CAFOs may discharge contaminated storm water to waters of the state provided the discharges comply with groundwater and surface water quality standards. The permittee shall take preventive maintenance actions and conduct periodic visual inspections to minimize the discharge of pollutants from these areas to surface waters. For CAFO outdoor vegetated areas, the permittee shall also implement the following practices:

- Manage stocking densities, implement management systems and manage feed sources to ensure that sufficient vegetative cover is maintained over the entire area at all times.
- Prohibit direct access of livestock or poultry to surface waters or wetlands located in or adjacent to the area unless approved by the Wisconsin DNR.

Provided manure, process wastewater, and associated nutrient applications conform with the requirements stipulated under s. NR 243.14(2)(b), Wis. Adm. Code, runoff from CAFO fields is considered an agricultural storm water discharge and is accounted for in the TMDL load allocation.

Reserve capacity, if available, and water quality trading can be used to offset phosphorus loads associated with a surface water discharge as part of an approved alternative manure treatment system.

5.5 Margin of Safety

The margin of safety (MOS) can be implicit (incorporated into the TMDL analysis through conservative assumptions) or explicit (expressed in the TMDL as a portion of the loading capacity) or a combination of both. This TMDL has both an explicit MOS for Lake Pepin and an implicit MOS for the Lake Pepin tributary waterbodies.

MPCA established a 5% explicit MOS based on Lake Pepin's loading capacity for its portion of the TMDL. Wisconsin DNR's TMDL for Lake Pepin is designed to align with these requirements; by adopting MPCA's estimated loadings from permitted sources, reserve capacity, and the 20% reduction targets for nonpoint loads, thus the MOS established by MPCA is inherently accounted for in Wisconsin DNR's allocations for Lake Pepin.

An implicit MOS has been incorporated into the TMDLs addressing Wisconsin's tributaries to Lake Pepin. The primary means of applying the implicit MOS was by setting FWM/GSM ratios used for assimilative loading capacity analysis (Section 4.1) to conservative values as described below. GSM concentrations were estimated using the PhosMER model that predicts daily phosphorus concentrations. Confidence in PhosMER model estimates can be calculated through statistical cross-validation. An estimate of the FWM/GSM ratio at the lower 90% confidence limit of bootstrapped predictions was chosen (i.e., the implicit margin of safety is set to a value that gives us 90% certainty that FWM load estimates from the WiLMS loading model will result in meeting water quality criteria). Section 3.5.6 notes that TP loading from streambank erosion is not explicitly modeled in this study but is factored into baseline loading estimates for other nonpoint source categories (agriculture, urban, etc.). This approach represents an implicit margin of safety in nonpoint source allocations because Wisconsin DNR plans to encourage practices specifically aimed at reducing streambank erosion while also attaining allocations for land-based sources.

5.6 Reserve Capacity

Reserve capacity is a means of setting aside a portion of the assimilative loading capacity to allow for future growth. Inclusion of reserve capacity in a TMDL is optional but history has shown it to be sound public policy. Reserve capacity for Lake Pepin was included in the MPCA TMDL (Minnesota Pollution Control Agency, 2021) to account for future discharges, changes in current discharger loadings, and other sources not defined through TMDL development. To calculate the reserve capacity in each TMDL subbasin, the total reserve capacity assigned by MPCA for Lake Pepin was distributed among the Wisconsin 18 TMDL subbasins.

This approach provides reserve capacity for potential new or expanding dischargers in headwater sections of the basin. In addition, reserve capacity accumulates from contributing subbasins moving down through the basin making more available for dischargers located on larger downstream rivers. This approach affords dischargers greater flexibility in where they can locate, minimizes impacts on existing dischargers, and is consistent with the observed practice of larger dischargers locating on larger bodies of water.

Reserve capacity is intended to provide wasteload allocation for new or expanding wastewater (industrial or municipal) dischargers, GPs that may be switched to individual permits, and CAFOs that add a surface water outfall as the result of a manure treatment system. Reserve capacity may be applied to general permittees if it is determined, through analysis of discharge monitoring data, that the amount set aside for GPs is not sufficient to cover the actual discharge amount from existing, new, or expanding discharges. Refer to "TMDL Implementation Guidance for Wastewater Permits" (WDNR,2024) for process details.

Reserve capacity is not required for new or expanding permitted MS4s. For new or expanding permitted MS4s, the mass associated with the load allocation for the nonpermitted, undeveloped, or agricultural land, that is now part of the permitted MS4, is transferred to the wasteload allocation with a percent reduction in pollutant load assigned to the new or expanding permitted MS4 area consistent with the reductions stipulated in the TMDL for the subbasin. Refer to "TMDL Guidance for MS4 Permits: Planning, Implementation, and Modeling Guidance" (WDNR, 2014) and corresponding addendums for process details.

For CAFOs, TMDLs assign the production area a wasteload allocation of zero; however, reserve capacity may be available to cover a new or expanding surface water discharge resulting from a manure treatment system. If reserve capacity is not available, the mass resulting from a treatment system discharge must be offset through water quality trading. This offset can be generated through reductions in pollutant loads associated with modifications in manure applications to fields resulting from the treatment system or changes in the CAFO's operation. Fields

receiving manure and process wastewater from the CAFO are covered by the nonpoint load allocation.

If a municipality, CAFO, or industry wishes to commence a new or increased discharge of a pollutant covered by the TMDL and within the area covered by the TMDL, the permittee must submit a written notice of interest for reserve capacity along with a demonstration of need to Wisconsin DNR. Interested dischargers will not be given a portion of the reserve capacity unless they can demonstrate a need for a new or increased wasteload allocation. Examples of point sources in need of WLA would include those that are a new discharge or those that are significantly increasing their current discharge and would be unable to meet current WLAs despite optimal operation and maintenance of their treatment facility.

A demonstration of need should include an evaluation of conservation measures, recycling measures, and other pollution minimization measures. New dischargers must evaluate current available treatment technologies and expanding dischargers should evaluate optimization of their existing treatment system and evaluation of alternative treatment technologies. In addition to evaluation of treatment options, an expanding discharger must demonstrate that the request for reserve capacity is due to increasing productions levels or industrial, commercial, or residential growth in the community.

If the Wisconsin DNR determines that a new or expanding discharger qualifies for reserve capacity, the reserve capacity, if available, will be distributed using the procedures outline below.

New Discharger: For a new discharger, calculate the water quality-based effluent limit (WQBEL) per ch. NR 217 for phosphorus and chs. NR 102 or NR 106, Wis. Adm. Code, for other pollutants. If there is no water quality-based effluent limit available for the pollutant, apply the TMDL reductions consistent with the applicable subbasin to the baseline condition used in the TMDL. Baseline conditions, consisting of concentration and flows, are set for different pollutants and classes of dischargers. If the discharger can meet the resulting limit with available technology, then the limit is translated into a mass, and this mass becomes the amount of

reserve capacity allocated to the discharger. If the discharger is unable to meet the limit with available technology, then more reserve capacity, up to a maximum cap, can be allocated to the discharger. The maximum cap is calculated based on the facility's flow and the highest concentration for a similar type of facility and treatment system.

Determination of the wasteload allocation available to a new discharge will depend on the type and condition of the immediate receiving water. Limitations for new discharges to Outstanding Resource Waters shall be based on s. NR 207.03(3), Wis. Adm. Code. Limitations for new discharges to Exceptional Resource Waters which are not needed to prevent or correct either an existing surface or groundwater contamination situation, or a public health problem shall be based on s. NR 207.03(4)(b), Wis. Adm. Code. For all other new discharge situations, the following procedures apply to determine the appropriate mass allocation:

- Determine the mass of reserve capacity that is available in the given subbasin.
- Calculate the WQBEL per s. NR 217.13(2)(a) and the associated mass limit per s. NR 217.14(3), Wis. Adm. Code. Calculation should be based on current upstream water quality and for purposes of this calculation any other discharges within the given subbasin may be ignored.
- Calculate the mass load associated with the MPCA baseline condition (see Section 3.5) for the class of the new discharger. Then apply the TMDL reductions, consistent with the applicable subbasin, to the baseline condition to determine the resultant mass.
- Set the wasteload allocation equal to the most restrictive of the values determined by the above methods.

For a new discharge directly to a lake or reservoir, use the following procedure to determine the appropriate mass allocation:

- Determine the amount of reserve capacity that is available for the lake or reservoir. This can include unassigned reserve capacity from contributing subbasins located upstream of the lake or reservoir.

- Calculate the WQBEL per s. NR 217.13(3) and associated mass limit per s. NR 217.14(3), Wis. Adm. Code.
- Set the wasteload allocation equal to the more restrictive of the values determined by the above methods.

Expanding Discharger: For an expanding discharger, reserve capacity will be allocated to cover the increased mass attributed to the facility expansion, measured as the increase in flow over the flow assumed in the TMDL baseline (see Table 11 in Section 3.6), minus any reductions that can be realized through optimization or economically viable treatment technologies.

If a new or expanding discharger requires more mass than what was allocated through reserve capacity the difference between the mass discharged and their allocation can be made up through an offset such as water quality trading. If there is not sufficient reserve capacity available, the discharge must be off set through a water quality trade.

Reserve capacity should be taken equally from all subbasins upstream and in which the discharger is located. As additional demands are placed on available reserve capacity, it may become necessary to shift the location that previously assigned reserve capacity was taken, provided the total assimilative loading capacity for each subbasin is maintained. Wisconsin DNR will maintain a system to track assigned reserve capacity and Wisconsin DNR will notify U.S. EPA in writing of reserve capacity assignments. Once reserve capacity is no longer available, the TMDL will need to be re-evaluated to see if additional assimilative capacity has become available since the original TMDL analysis due to changes in flow or implementation of the reductions prescribed in the TMDL. This can be a very lengthy process and may not result in additional allocations.

Wisconsin DNR will use the information provided by the permittee to determine if reserve capacity is available and then issue, reissue, or modify a WPDES permit to implement a new WLA based on application of reserve capacity. The new WLA will be used as the basis for effluent limits in the WPDES permit. U.S. EPA will be notified if a new or expanded WLA is developed.

Pursuant to s. 40 CFR 122.41(g), Fed. Reg., and s. NR 205.07(1)(c), Wis. Adm. Code, a WPDES permit does not convey any property rights of any sort nor any exclusive privilege. Distribution of reserve capacity does not require re-opening of the TMDL; rather, the permit process can be used for reserve capacity assignments. All proposed reserve capacity assignments are subject to Wisconsin DNR review and approval and must be consistent with applicable regulations. Reserve capacity decisions and related permit determinations are subject to public notice and participation procedures as well as opportunities for challenge at the time of permit modification, revocation and reissuance, or reissuance under Chapter 283, Wis. Stats.

5.7 Seasonal Variation

TMDLs must consider seasonal variation in environmental conditions. Critical conditions for phosphorus impairments generally occur during the growing season and summer months when temperature, flow, and sunlight conditions are conducive to excessive plant growth. However, phosphorus loadings can occur throughout the entire year and contribute to high phosphorus concentrations during this critical period since phosphorus stored in stream channels and lakes can be released during the summer months.

The method used in this TMDL to link TP concentration targets to loading capacities is based on observed FWM/GSM ratios, which describe the relationship between annual loads and growing season (i.e., critical condition) concentrations (see Section 4.1). Variable allocations by season or month were therefore not required to be developed under this TMDL study.

The allocation methods used for TMDL development assume that the seasonal pattern of phosphorus and sediment loads under the allocated condition will be like the existing seasonal pattern. For nonpoint sources, this means that actions implemented to reduce loads are assumed to be effective throughout the year. While this may not be true for any individual practice, it is anticipated that a broad suite of practices will be required to meet the necessary reductions from nonpoint sources, and that the collective efects of this system’s approach of management

practices, at the watershed scale, will meet this assumption. Discharges from point sources have much less seasonal variation, and it is expected that any required reductions will be uniformly distributed seasonally.

5.8 Climate Change

Projections of precipitation patterns and temperatures are highly variable by location, and individual climate models. The ensemble of climate model projections for Wisconsin generally shows more annual precipitation with precipitation patterns shifting toward drier summers and wetter springs and falls accompanied overall with more intense storms. The updated GLISA/NOAA predictions shows by mid-century, assuming the RCP8.5 high emissions scenario which is the highest baseline emissions scenario corresponding with a continued rise in emissions throughout the twenty-first century, a decrease in summer precipitation amounts for the northeast portion of Wisconsin ranging between zero and 1.0 inches per season and an increase in the numbers of days with over 1-inch of precipitation from zero to 1.5 days. NOAA is currently engaged in a multi-year process to update Atlas 14 with nonstationary approaches and statistics to project changes in rainfall design storms such as the 1-year design storm, 25-year design storm, etc. NOAA is also evaluating downscaled global models' ability to mimic extreme precipitation events at both the temporal and spatial scales. This information is not yet available.

After consultation with climate change researchers at UW-Madison, the approach that has been recommended for TMDL development is to use a weather dataset from the most current climate normal period. NOAA calculates Climate Normals every 10 years covering a 30-year period. The 1991-2020 U.S. Climate Normals are the latest series of decadal Normals going back to 1950. Consistent with this approach, the Wisconsin DNR utilized the most current dataset.

6 IMPLEMENTATION AND REASONABLE ASSURANCE

6.1 Implementation Planning

Wisconsin DNR has initiated an implementation planning process, which builds on both previous and ongoing planning and implementation efforts to control or reduce nutrient pollution in the Wisconsin Lake Pepin TMDL area. The implementation process will develop strategies to use most effectively existing federal, state, and county-based programs to achieve wasteload and load allocations outlined in the TMDL. The planning process will build upon recommendations and ongoing efforts to reduce nonpoint source pollution sources, which are discussed in more detail below.

6.1.1 Nonpoint Implementation

Implementation of the load allocations are implemented through ch. NR 151, Wis. Adm. Code. Implementation of the load allocations that exceed the current performance standards in subchs. III and IV of ch. NR 151, Wis. Adm. Code, is voluntary unless adopted through s. NR 151.005, Wis. Adm. Code.

As discussed below under Reasonable Assurance, both state and local government agencies are obligated to continue and maintain existing conservation activities and programs, including Farmland Preservation Program (administered by DATCP), NR151 agricultural performance standards, Targeted Runoff Management and Notice of Discharge grant programs (administered by Wisconsin DNR). These programs are instituted by state statutes and administrative codes.

In addition to these existing conservation programs, the Wisconsin DNR will assist partners with implementation activities and focus additional conservation and watershed conservation activities, including Nine Key Element Plans (9KEP). As of July 2025, there are three 9KEPs under development within the Lake Pepin TMDL area (all within Pierce County) that contain milestones to meet the nonpoint load allocations within the Lake Pepin TMDL report over a ten-year period.

Table 12 Nine-key Element Plans in development as of July 2025.

Name	HUC 12	TMDL Reach
Goose Creek	070400010301	1
Little Trimbelle River	070400010302	14
Spring Creek	070400010303	12

Focused watershed implementation projects and activities are defined in each 9KEP and include prior agricultural field erosion risk/rankings and agricultural pollutant load modeling results completed by Tetra Tech contractor for the Lake Pepin TMDL area. Once the plans are complete, the Wisconsin DNR will offer NPS staff and financial support for the implementation of these 9KEPs, including assistance with grant applications, implementing other existing nonpoint source reduction actions and programs to meet NR 151 standards and prohibitions and water quality monitoring after substantial adoption of conservation practices within a 9KEP watershed. Wisconsin DNR will also collaborate with County land conservation partners and agricultural producers to focus on reviewing nutrient management plans and meeting the agricultural edge of field targets in Appendix C

In 2022 and 2023, Wisconsin DNR executed a contract with Tetra Tech in which the following materials were prepared to support Lake Pepin TMDL implementation activities:

a. Based on the WiscLand 2.0 (Wisconsin Department of Natural Resources, 2016) landcover map and NRCS SSURGO soils (Natural Resources Conservation Service), the Wisconsin DNR developed edge-of-field agricultural baseline phosphorus loading estimates, and edge-of-field targets expressed in lbs./acre/year based on the reductions needed for each subbasin For the subbasins with the highest unit area phosphorus loading, an EVAAL (Wisconsin Department of Natural Resources) model was developed to identify the agricultural fields that are most susceptible to erosion, and within those fields the portions most prone to sheet, rill, and gully erosion. Identified fields can then be prioritized for the installation of cropland BMPs achieving greater reductions.

b. For the subbasins with the highest unit area phosphorus loading, an EVAAL (Wisconsin Department of Natural Resources) model was developed to identify the agricultural fields that are most susceptible to erosion, and within those fields the portions most prone to sheet, rill, and gully erosion. Identified fields can then be prioritized for the installation of cropland BMPs achieving greater reductions.
c. Wisconsin DNR updated the Watershed Restoration Viewer with the most recent Wisconsin Lake Pepin TMDL data. This is a web-based program that allows users to quickly identify TMDL data in relation to watershed location.

6.1.2 Point Source Implementation

The Wisconsin Lake Pepin TMDL expresses wasteload allocations for TP as maximum annual loads (pounds per year) and maximum daily loads (pounds per day), which equal the maximum annual loads divided by the number of days in the year. As described in the "TMDL Implementation Guidance for Wastewater Permits" (WDNR,), total phosphorus WQBELs for wastewater discharges covered by the Wisconsin Lake Pepin TMDL should be derived in a similar manner as methods used for the Northeast Lakeshore, Lower Fox, Wisconsin River, and Upper Fox and Wolf River Basin TMDL discharges. That is, consistent with the impracticability demonstration, TP limits should be expressed as a monthly average when wasteload allocations equate to a TP effluent concentration greater than 0.3 mg/L, and as a six-month average and monthly average equal to 3 times the six-month average when WLAs equate to a TP effluent concentration equal to or less than 0.3 mg/L.

This TMDL establishes TP wasteload allocations to reduce the loading in the entire watershed including WLAs to meet water quality standards for tributaries. Therefore, WLA-based WQBELs are protective of immediate receiving waters and limit calculators will not need to include TP WQBELs derived according to s. NR 217.13, Wis. Adm. Code.

Since wasteload allocations are expressed as annual loads (lbs./yr.), permits with TMDL-derived monthly average permit limits should require the permittee to calculate and report rolling 12-month sums of total monthly loads for TP. Rolling 12-month sums can be compared directly to the annual wasteload allocation.

The above guidance for expressing TMDL wasteload allocations as permit limits is based on U.S. EPA's statistical method for deriving water quality-based effluent limits as presented in 5.4 and 5.5 of the Technical Support Document for Water Quality-based Toxics Control (EPA, 1991).

Required by the Clean Water Act, reasonable assurances provide a level of confidence that the wasteload allocations and load allocations in TMDLs will be implemented. This TMDL will be implemented through enforcement of existing regulations, financial incentives, and various local, state, and federal water pollution control programs. The following subsections describe some of the activities, programs, requirements, and institutional arrangements that will provide reasonable assurance that this TMDL will be implemented and that the water quality goals should be achieved.

6.2 Reasonable Assurance for Point Sources

Wisconsin DNR regulates point sources through the WPDES permit program. Individual permits are issued to municipal and industrial wastewater discharges. General permits are issued to some classes of industries or activities that are similar in nature, such as noncontact cooling water and certain stormwater discharges. After the WLAs presented in this report have been approved by Wisconsin DNR and U.S. EPA, reissued permits must contain conditions consistent with the wasteload allocations.

Individual permits issued to municipal and industrial wastewater discharges will include discharge limits consistent with the approved wasteload allocations. For phosphorus, the mass allocation contained in the TMDL will be expressed as a mass limit. In cases where the resulting mass limit is equivalent to a concentration approaching the criteria of the waterbody itself (0.3 mg/L or less), the discharge

limit will be expressed as both a monthly average and a six-month average. In many cases, discharges will also continue to receive a concentration limit for TP, based on the TBEL requirements in ch. NR 217, Wis. Adm. Code.

Dischargers with general WPDES permits will be evaluated to determine if additional requirements are necessary to ensure that discharges remain consistent with TMDL goals. This could include issuing individual WPDES permits to facilities that currently hold general permits.

Wisconsin DNR regulates stormwater discharges from certain MS4s, industries, and construction sites under WPDES permits issued pursuant to chapter NR 216, Wis. Adm. Code. Wisconsin DNR also established developed urban areas, construction site, and post-construction performance standards under ch. NR 151, Wis. Adm. Code, which are implemented through stormwater MS4 and construction site permits. When the TMDL WLAs have been approved by Wisconsin DNR and U.S. EPA, Wisconsin DNR will incorporate permit conditions into stormwater permits consistent with the TMDL WLAs. Existing programs that detect and eliminate illicit discharges will continue to be implemented by municipalities. WPDES permit conditions already require monitoring and elimination of discovered discharges.

Wisconsin DNR and appropriate state agencies will monitor and enforce CAFO permit requirements so that CAFOs are operated and maintained to prevent discharges as required by their WPDES permit.

6.3 Reasonable Assurance for Nonpoint Sources

To attain the TMDL reduction goals, management measures must be implemented and maintained over time to control phosphorus loadings from nonpoint sources of pollution. Wisconsin's Nonpoint Source Pollution Abatement Program (NPS Program), described in the state's Nonpoint Source Program Management Plan (WDNR, 2021), outlines a variety of financial, technical, educational, and enforcement programs, which support implementation of management measures to address nonpoint source pollution. Wisconsin DNR and the Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) coordinate

statewide implementation of the NPS Program. The NPS Program includes core activities and programs, which are a high priority and the focus of Wisconsin DNR and DATCP's efforts to address NPS pollution; these programs include those described in the following sections.

6.3.1 Statewide Agricultural Performance Standards & Manure Management Prohibitions

Adopted in 2002 and updated in 2010, Chapter NR 151, Wis. Adm. Code, establishes runoff management performance standards and prohibitions for agricultural and non-agricultural facilities and practices. These standards and prohibitions are intended to be minimum standards of performance necessary to achieve water quality standards, as described in section 281.16, Wis. Stat. Implementing the performance standards and prohibitions on a statewide basis is a high priority for the NPS Program and requires having adequate Wisconsin DNR staff and financial resources to meet the NR 151 implementation and enforcement procedures (NR 151.09 and 151.095). Widespread implementation and, when necessary, enforcement of agricultural performance standards and manure management prohibitions, listed below, throughout the TMDL area will be critical to achieve the necessary nonpoint source load reductions. Such effort will require having adequate amounts of Wisconsin DNR staff and/or cost share funding to cover the required cost for agricultural operations to meet the NR 151 standards. Wisconsin DNR also relies on LWCDs to help implement NR 151 locally, which requires LWCDs having adequate staffing and financial support to fund staff.

d. Tillage setback: A setback of 5 feet from the top of a waterbody channel for the purpose of maintaining stream bank integrity and avoiding soil deposits into state waters. Tillage setbacks greater than 5 feet but no more than 20 feet may be required, if necessary, to meet the standard. Harvesting of self-sustaining vegetation within the tillage setback is allowed.
e. Phosphorus Index (PI): A limit on the amount of phosphorus that may run off croplands and pastures as measured by a phosphorus index with a maximum of 6, averaged over an eight-year accounting period, and a PI

cap of 12 for any individual year. The PI is measured in pounds per acre per year.

f. Process wastewater handling: a prohibition against significant discharge of process wastewater from milk houses, feedlots, and other similar sources.
g. Meeting TMDLs: A standard that requires crop and livestock producers to reduce discharges, if necessary, to meet a load allocation specified in an approved TMDL by implementing targeted performance standards specified for the TMDL area using best management practices specified in ch. ATCP 50, Wis. Adm. Code. If a more stringent or additional performance standard is necessary to meet water quality standards, it must be promulgated by rule before compliance is required. Before promulgating targeted performance standards to implement a TMDL, the Wisconsin DNR must determine, using modeling or monitoring, that a specific waterbody or area will not attain water quality standards or groundwater standards after substantial implementation of the existing NR 151 performance standards and prohibitions.
h. Sheet, rill, and wind erosion: All cropped fields shall meet the tolerable (T) soil erosion rate established for that soil. This provision also applies to pastures.
i. Manure storage facilities: All new, substantially altered, or abandoned manure storage facilities shall be constructed, maintained, or abandoned in accordance with accepted standards, which includes a margin of safety. Failing and leaking existing facilities posing an imminent threat to public health or fish and aquatic life or that violate groundwater standards shall be upgraded or replaced.
j. Clean water diversions: Runoff from agricultural buildings and fields shall be diverted away from contacting feedlots, manure storage areas and barnyards located within water quality management areas (300 feet from a stream or 1,000 feet from a lake or areas susceptible to groundwater contamination).
k. Nutrient management: Agricultural operations applying nutrients to agricultural fields shall do so according to a nutrient management plan.

Each nutrient management plan must be designed to limit or reduce the discharge of nutrients to waters of the state for the purpose of complying with state water quality standards and groundwater standards. In addition, for croplands in watersheds that contain impaired surface waters, a plan must be designed to manage soil nutrient concentrations so as to maintain or reduce delivery of nutrients contributing to the impairment of impaired surface waters. ATCP 50.04 contains additional requirements for all nutrient management plans. This standard does not apply to applications of industrial waste, municipal sludge or septage permitted under other Wisconsin DNR programs provided the material is not commingled with manure prior to application.

l. Manure management prohibitions:

- No overflow of manure storage facilities
- No unconfined manure piles in a water quality management area
- No direct runoff from feedlots or stored manure into state waters
- No unlimited livestock access to waters of the state in locations where high concentrations of animals prevent the maintenance of adequate or self-sustaining sod cover.

Wisconsin DNR, DATCP, and the county Land and Water Conservation Departments (LWCDs) will work with landowners to implement agricultural and non-agricultural performance standards and manure management prohibitions to address sediment and nutrient loadings in the TMDL area.

Some landowners voluntarily install BMPs to help improve water quality and comply with the NR 151 performance standards and prohibitions. Cost-sharing funds, provided via state or federal funds, may or may not be available for many of these BMPs. Wisconsin statutes, and the NR 151 implementation and enforcement procedures of s. NR 151.09 and 151.095, Wis. Adm. Code, require that farmers in noncompliance with the agricultural performance standards must be offered at least 70% cost-sharing funds for BMP installation before they can be required to

comply with the agricultural performance standards and prohibitions. If cost share money is offered, those in violation of the standards are obligated to comply with the rule. The amount of cost sharing funds available for use by LWCD's, DATCP and Wisconsin DNR will require implementing the performance standards and prohibitions throughout the TMDL area over time. DATCP's Farmland Preservation Program requires that any agricultural land enrolled in the program must be determined to comply with the performance standards by no later than 2020 to continue receiving tax credits associated with the program.

6.3.2 Wisconsin DNR Cost-Sharing Grant Programs

The counties and other local units of government in the TMDL area may apply for grants from Wisconsin DNR to control NPS pollution and, over time, meet, or exceed, the NR 151 standards and Lake Pepin TMDL load allocation. The Wisconsin DNR supports NPS pollution abatement by administering and providing cost-sharing grants to fund BMPs through various grant programs, including, but not limited to:

- The Targeted Runoff Management (TRM) Grant Program
- The Notice of Discharge (NOD) Grant Program
- The Urban Nonpoint Source & Storm Water Management Grant Program
- The Lake Planning Grant Program
- The Lake Protection Grant Program
- The River Planning & Protection Grant Program

Under the recently adopted ch. NR 193, Wis. Adm. Code, the lake planning, lake protection and river planning, and protection grant programs have all been rolled

into one "Surface Water Grant"—more information can be found on the Wisconsin DNR Surface Water Grant web page[2].

Many of the counties and municipalities in the TMDL area have a track record of participating in these NPS related grant programs.

6.3.3 Targeted Runoff Management (TRM) Grant Program

Targeted Runoff Management (TRM) grants are provided by the Wisconsin DNR to control nonpoint source pollution from both urban and agricultural sites. A combination of state General Purpose Revenue, state Bond Revenue, and federal Section 319 Grant funds is used to support TRM grants. The grants are available to local units of government (typically counties) and targeted at high-priority resource problems. TRM grants can fund the design and construction of agricultural and urban BMPs. Some examples of eligible BMPs include livestock waste management practices, some cropland protection, and streambank protection projects. These and other practices eligible for funding are listed in s. NR 154.04, Wis. Adm. Code.

Revisions to ch. NR 153, Wis. Adm. Code[3], which governs the program, took effect on January 1, 2011, and modified the grant criteria and procedures, increasing the state's ability to support performance standards implementation and TMDL implementation. Since the calendar year 2012 grant cycle, projects may be awarded in four categories:

[2] https://dnr.wisconsin.gov/aid/SurfaceWater.html or search "WDNR Surface Water Grants"
[3] http://legis.wisconsin.gov/rsb/code/nr/nr153.pdf

	TMDL	Non-TMDL
Small Scale	TMDL implementation Agricultural or urban focus	Implements NR 151 performance standards Agricultural or urban focus
Large Scale	TMDL implementation Agricultural focus only	Implements NR 151 performance standards Agricultural focus only

Section 281.65(4c), Wis. Stats., defines additional priorities for Targeted Runoff Management Projects as follows:

1. TRM projects must be targeted to an area based on any of the following:
    a. Need for compliance with established performance standards.
    b. Existence of impaired waters.
    c. Existence of outstanding or exceptional resource waters.
    d. Existence of threats to public health.
    e. Existence of an animal feeding operation receiving a Notice of Discharge.
    f. Other water quality concerns of national or statewide importance.
2. Projects are consistent with priorities identified by Wisconsin DNR on a watershed or other geographic basis.
3. Projects are consistent with approved county land and water resource management plans.

The maximum cost-share rate available to TRM grant recipients is up to 70 percent of eligible costs (maximum of 90% in cases of economic hardship), with the total of state funding not to exceed established grant caps. TRM grants may not be used to fund projects to control pollution from sources permitted under Wisconsin law. Grant application materials are available on the Wisconsin DNR web site[4].

6.3.4 Notice of Discharge (NOD) Grants Program

Notice of Discharge (NOD) Project Grants, also governed by ch. NR 153, Wis. Adm. Code, are provided by Wisconsin DNR and DATCP to local units of government (typically counties). A combination of state General Purpose Revenue, state Bond Revenue, and federal Section 319 Grant funds are used to support NOD grants. The purpose of these grants is to provide cost sharing to farmers who are required to install agricultural management practices to comply with Notice of Discharge requirements. Notices of Discharge are issued by the Wisconsin DNR under ch. NR 243, Wis. Adm. Code, (Animal Feeding Operations - https://docs.legis.wisconsin.gov/code/admin_code/nr/200/243), to small and medium animal feeding operations that pose environmental threats to state water resources. The project funds can be used to address an outstanding NOD, or an NOD developed concurrently with the grant award.

Both state agencies work cooperatively to administer funds set aside to make NOD grant awards. Although the criteria for using agency funds vary between the two agencies, Wisconsin DNR and DATCP have jointly developed a single grant application that can be used to apply for funding from either agency. The two agencies jointly review the project applications and coordinate funding to ensure the most cost-effective use of the available state funds. Funding decisions must consider the different statutory and other administrative requirements each agency operates under. Grant application materials are available on the Wisconsin DNR web site at: http://dnr.wi.gov/Aid/NOD.html.

[4] http://dnr.wi.gov/aid/targetedrunoff.html

6.3.5 Surface Water Grants: Lake Management Planning

The Wisconsin DNR provides grants to eligible parties to collect and analyze information needed to protect and restore lakes and their watersheds and develop lake management plans. Section 281.68, Wis. Stats., and ch. NR 193 Wis. Adm. Code, provide the framework and guidance for Wisconsin DNR's Lake Management Planning Grant Program. Grant awards may fund up to 66% of the cost of a lake planning project. Grant awards cannot exceed $25,000 per grant for large-scale projects. Eligible planning projects include:

- Gathering and analysis of physical, chemical, and biological information on lakes.
- Describing present and potential land uses within lake watersheds and on shorelines.
- Reviewing jurisdictional boundaries and evaluating ordinances that relate to zoning, sanitation, or pollution control or surface use.
- Assessments of fish, aquatic life, wildlife, and their habitats. Gathering and analyzing information from lake property owners, community residents, and lake users.
- Developing, evaluating, publishing, and distributing alternative courses of action and recommendations in a lake management plan.

Grants can also be used to investigate pollution sources, including nonpoint sources, followed by incorporation into the lake management plan of strategies to address those sources. Investigation can involve many types of assessment, including determining whether the water quality of the lake is impaired. A plan approved by Wisconsin DNR for a lake impaired by NPS pollution should incorporate the U.S. EPA's "Nine Key Elements".

6.3.6 Surface Water Grant Program for Lakes and Rivers

The Wisconsin DNR Surface Water Grant Program provides cost-sharing grants for surface water protection and restoration. Sections 281.68, 281.69 and 281.70, Wis. Stats., and ch. NR 193, Wis. Adm. Code, provide the framework and guidance for the Surface Water Grant Program.

Grant deadlines, program guidance, and application materials are available on the Wisconsin DNR website[5].

6.3.6.1 Lake Planning and Management Program Overview

The Wisconsin DNR provides grants to eligible organizations for lake and watershed planning and management.

Lake planning grants may fund up to 67 percent of project costs and include education activities (maximum grant amount of $5,000) and planning activities like developing or updating a management plan and other projects that lay the groundwork to protect or improve surface water (maximum grant amount of $10,000).

Lake management grants may fund up to 75 percent of project costs. Grant categories and eligible projects include:

- Lake and Watershed Management Plan Implementation (maximum grant amount of $200,000) - Projects recommended in a management plan that have been determined by Wisconsin DNR to be eligible to compete for a grant. These projects may include watershed best management practices (BMPs), in-lake restoration activities, or other projects that will protect or improve lakes.

[5] http://dnr.wi.gov/Aid/SurfaceWater.html

- Land Acquisition (maximum grant amount of $200,000) - Purchase of land or conservation easements that will significantly contribute to the protection or improvement of the natural ecosystem and water quality of a lake.
- Surface Water Restoration (maximum amount of $50,000) - Restoration practices that will protect a lake's water quality or its natural ecosystem.
- Ordinance Development (maximum grant amount of $50,000) - Development of local regulations or ordinances to protect lakes.
- Wetland Restoration Incentives (maximum grant amount of $10,000) - Special wetland incentive grants of up to $10,000 are eligible for 100 percent state funding if the project is identified in the sponsor's comprehensive land use plan.

6.3.6.2 River Planning and Management Program Overview

The Wisconsin DNR provides grants to eligible organizations for river planning and management.

River planning grants may fund up to 67 percent of project costs for education (maximum grant amount of $5,000) and planning (maximum grant amount of $10,000) activities. Eligible planning projects include:

- Developing the capacity of river management organizations
- Collecting information on riverine ecosystems
- River system assessment and planning
- Increasing local understanding of the causes of river problems
- Design activities necessary for the implementation of a management project

River management grants may fund up to 75 percent of project costs. Grant categories and eligible projects include:

- River Management Plan Implementation (maximum grant amount of $50,000) - Projects recommended in a management plan that have been determined by Wisconsin DNR to be eligible to compete for a grant. These projects may include in-stream restoration activities, or other projects that will protect or improve rivers.

- Land Acquisition (maximum grant amount of $50,000) - Purchase of land or conservation easements that will significantly contribute to the protection or improvement of the natural ecosystem and water quality of a river.

- Surface Water Restoration (maximum amount of $25,000) - Restoration practices that will protect a river's water quality or its natural ecosystem.

6.3.7 DATCP Soil & Water Resource Management Program

DATCP oversees and supports county conservation programs that implement the state performance standards and prohibitions and conservation practices. DATCP's Soil and Water Resource Management (SWRM) Program requires counties to develop Land and Water Resource Management (LWRM) Plans to identify conservation needs. Each county Land and Water Conservation Department in the TMDL area developed an approved plan for addressing soil and water conservation concerns in its respective county. County LWRM plans to advance land and water conservation and prevent NPS pollution by:

- Inventorying water quality and soil erosion conditions in the county.

- Identifying relevant state and local regulations, and any inconsistencies between them.

- Setting water quality goals in consultation with the Wisconsin DNR.

- Identifying key water quality and soil erosion problems, and practices to address those problems.

- Identifying priority farm areas using a range of criteria (e.g., impaired waters, manure management, high nutrient applications).
- Identifying strategies to promote voluntary compliance with statewide performance standards and prohibitions, including information, cost-sharing, and technical assistance.
- Identifying enforcement procedures, including notice and appeal procedures.
- Including a multi-year work plan to achieve soil and water conservation objectives.

Counties must receive DATCP's approval of their plans to receive state cost-sharing grants for BMP installation. DATCP is also responsible for providing local assistance grant funding for county conservation staff implementing NPS control programs included in the LWRM plans. This includes local staff support for DATCP and Wisconsin DNR programs.

This TMDL provides County Land and Water Conservation Departments with the data necessary to identify and prioritize pollutant sources so that strategies can be developed and applied to reduce pollutant loads in the TMDL area over time more effectively.

6.3.8 DATCP Producer Led Watershed Protection Grants Program

To improve the quality of Wisconsin's waterways, DATCP developed and launched the first Producer Led Watershed Protection Grants Program in 2016. The grant program is designed to give financial support to farmers willing to lead conservation efforts in their own watersheds. The DATCP grants to eligible producers provide support to farmer groups to deliver cost share programs, on-farm demonstration and research projects, and education and outreach efforts on conservation systems and on innovative practices that improve water quality. In 2025, 49 producer-led groups were awarded grants, with a max award of $40,000 per group. As of 2025, there is one producer led group active in the TMDL study area, the

Western Wisconsin Conservation Council (WWCC) with two more groups, the South Kinni Farmer-Led Watershed Council and the Dry Run Farmer-Led Watershed Council in watersheds immediately adjacent to the TMDL study area.

6.3.9 Federal Programs

Numerous federal programs are also being implemented in the TMDL area and are expected to be an important source of funds for future projects designed to control phosphorus loadings. A few of the federal programs include:

- Environmental Quality Incentive Program (EQIP). EQIP is a federal cost-share program administered by the Natural Resources Conservation Service (NRCS) that provides farmers with technical and financial assistance. Farmers receive flat rate payments for installing and implementing runoff management practices. Projects include terraces, waterways, diversions, and contour strips to manage agricultural waste, promote stream buffers, and control erosion on agricultural lands.

- Conservation Reserve Program (CRP). CRP is a voluntary program available to agricultural producers to help them safeguard environmentally sensitive land. Producers enrolled in CRP plant long-term, resource conserving covers to improve the quality of water, control soil erosion, and enhance wildlife habitat. In return, the Farm Service Agency (FSA) provides participants with rental payments and cost-share assistance.

- Conservation Reserve Enhancement Program (CREP). CREP provides annual rental payments for up to 15 years for taking cropland adjacent to surface water and sinkholes out of production. A strip of land adjacent to the stream must be planted and maintained in vegetative cover consisting of certain mixtures of tree, shrub, forbs, and/or grass species. Cost-sharing incentives and technical assistance are provided for planting and maintenance of the vegetative strips. Landowners also receive an upfront, lump sum payment for enrolling in the program, with the amount of payment dependent on whether they enroll in the program for 15 years or permanently.

- Regional Conservation Partnership Program (RCPP) promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. NRCS provides assistance to producers through partnership agreements and through program contracts or easement agreements RCPP combines the authorities of four former conservation programs – the Agricultural Water Enhancement Program, the Chesapeake Bay Watershed Program, the Cooperative Conservation Partnership Initiative and the Great Lakes Basin Program. Assistance is delivered in accordance with the rules of EQIP, CSP, ACEP and HFRP; and in certain areas the Watershed Operations and Flood Prevention Program.

6.3.10 Water Quality Trading & Adaptive Management

Water Quality Trading (WQT) and Adaptive Management (AM) may be used by eligible municipal and industrial wastewater dischargers to demonstrate compliance with TMDL WLAs. Both compliance options provide a unique watershed-based opportunity to reduce pollutant loading to streams, rivers, and lakes through point and nonpoint source collaboration. AM and WQT may also provide a new source of funding for local assistance and implementation of management measures to address nonpoint source pollution and improve water quality. The Wisconsin DNR web site provides more details about water quality trading[6] and adaptive management[7].

6.3.11 Phosphorus Multi-discharger Variance (MDV)

The statewide multi-discharger variance (MDV) for phosphorus (s. 283.16, Wis. Stat.) extends the timeline for wastewater dischargers that must comply with low-level phosphorus limits. In exchange, point sources commit to stepwise reductions of phosphorus in their effluent as well as helping to address nonpoint sources of

[6] https://dnr.wisconsin.gov/topic/Wastewater/WaterQualityTrading.html
[7] https://dnr.wisconsin.gov/topic/Wastewater/AdaptiveManagement.html

phosphorus from farm fields, cities, or natural areas to implement projects designed to improve water quality.

Wisconsin's phosphorus MDV was approved by U.S. EPA on September 3, 2025, and is set to expire in 2035. Wisconsin DNR is working with dischargers to promote the adoption of alternative compliance options prior to the 2035 expiration. MDV implementation guidance [1] is available to provide details about MDV eligibility and programmatic requirements.

If a facility meets the eligibility requirements and requests and gets approval for the MDV, the WPDES permit will be modified or reissued with the following requirements:

- Reductions of effluent phosphorus: Point sources are required to reduce their phosphorus load each permit term of MDV coverage.
- *Implement a watershed project*: Point sources must implement one of the following watershed project options to help reduce nonpoint source of phosphorus pollution:
    - Implement a watershed project directly;
    - Work with a third party to implement a watershed project; or
    - Make payments to a county (or counties) to be used for nonpoint source pollution control activities.

6.4 Follow-up Monitoring

A post-implementation monitoring effort will determine the effectiveness of the implementation activities associated with the TMDL. Wisconsin DNR and/or its partners will monitor the waters of this TMDL based on the rate of management practices installed and tracked through the implementation of the TMDL, including sites where Wisconsin DNR, DATCP, and NRCS grants are aimed at mitigating

[1] https://dnr.wisconsin.gov/topic/Wastewater/phosphorus/StatewideVariance.html

phosphorus loading. Monitoring will occur as staff and fiscal resources allow until it is deemed that stream quality has responded to the point where it is meeting its codified designated uses and applicable water quality standards.

In addition, waterbodies in the TMDL area may be monitored on a rotational basis as part of Wisconsin DNR's statewide water quality monitoring strategy to assess current conditions and trends in overall stream quality. That monitoring consists of collecting data to support a myriad of metrics contained in Wisconsin DNR's baseline protocol for wadeable streams, such as the index of biological integrity (IBI), the Hilsenhoff Biotic Index (HBI), a habitat assessment tool, and several water quality parameters determined on a site-by-site basis.

Wisconsin DNR will work in partnership with local citizen monitoring groups to support monitoring efforts which often provide a wealth of data to supplement Wisconsin DNR data. All other quality-assured available data in the basin will be considered when looking at the effectiveness of the implementation activities associated with TMDLs.

Watershed specific surface water monitoring will be conducted in the TMDL study area as warranted. Based on the information/data received from participating implementation partners, the Wisconsin DNR will track the level of implementation occurring throughout the TMDL study area. By tracking the amount of implementation activities occurring, the Wisconsin DNR can effectively plan the use of existing state resources and/or apply for external funds [i.e., grants] if available for monitoring activities, including staff for sample collection and/or laboratory analyses of the samples. As total phosphorus reductions are achieved, the Wisconsin DNR will develop and implement a watershed specific monitoring plan to evaluate water quality in relation to water quality criteria.

The Wisconsin DNR will be responsible for delisting any 303d waterbodies in accordance with WisCALM (https://dnr.wisconsin.gov/topic/SurfaceWater/WisCALM.html) listing and delisting requirements. Typically, these watershed specific evaluations conducted by the Wisconsin DNR are known as Targeted Watershed Assessments (TWA).

6.4.1 Statewide Tracking Database

Tracking the implementation of nonpoint source pollution reduction practices on the landscape is an important but often challenging component of TMDL implementation tracking and assessment. To assist in the tracking and reporting of this data the BMP Implementation Tracking System (BITS) was developed (https://dnr.wisconsin.gov/topic/nonpoint/bmptracker). BITS is a web portal that efficiently facilitates this data submission and analysis, including the spatial component. It also allows the Wisconsin DNR to better track and demonstrate progress towards reaching nutrient reduction goals related to TMDLs, Statewide Nutrient Reduction Strategy, and other Wisconsin DNR and U.S. EPA reporting requirements. BITS contains five separate modules with additional modules planned to accommodate other programs.

- Multi-Discharger Phosphorus Variance (MDV): Last updated in December of 2022, this module is for submitting information regarding nonpoint projects installed as part of the MDV program including plans and annual reports (https://dnr.wisconsin.gov/topic/Wastewater/phosphorus/StatewideVariance.html).

- Agricultural Targeted Runoff Management (TRM): This module was relapsed in March of 2021 and is used to submit final reports for TRM Grants (https://dnr.wisconsin.gov/aid/TargetedRunoff.html).

- Notice of Discharge (NOD): This module was released in August of 2021 and is used to submit final reports for NOD Grants (https://dnr.wisconsin.gov/aid/NOD.html).

- Urban Nonpoint Source Construction (UNPS-C): This module was released in September of 2022 and tracks final reports for UNPS Construction Grants (https://dnr.wisconsin.gov/aid/UrbanNonpoint.html).

Urban Targeted Runoff Management (Urban TRM): The Urban Targeted Runoff Management (Urban TRM) module was released on Sept. 26, 2022. Use this module to submit final reports for Urban TRM grants (https://dnr.wisconsin.gov/aid/UrbanNonpoint.html).

7 PUBLIC PARTICIPATION

U.S. EPA expects full and meaningful public participation in the TMDL development process, and TMDL regulations require that states must provide opportunities for public review consistent with its own continuing planning process (40 C.F.R. §130.7(c)(1)(ii)). U.S. EPA is required to publish a notice seeking public comment when it establishes a TMDL (40 C.F.R. §130.7(d)(2)).

Wisconsin DNR believes that public outreach and meaningful stakeholder engagement throughout the TMDL development, TMDL implementation planning, and TMDL implementation process results in better outcomes and overall TMDL success. With this in mind, the Wisconsin DNR has provided many ways for stakeholders to learn about the TMDL development process.

7.1 Public Informational Meeting and Comment Period

Per s. NR 212.77 Wis. Adm. Code, on April 27, 2026, the Wisconsin DNR conducted a public informational meeting and hearing followed by a comment period. Written comments were accepted beginning April 16, 2026, through May 15, 2026. Verbal comments received during the public hearing, and written comments received prior to the close of the comment period were considered prior to making a final approval and submittal of the TMDL study to U.S. EPA. Written and verbal comments carry the same weight.

The hearing notice was sent out via GovDelivery and posted on the Wisconsin DNR website and public hearings calendar. A copy of the official public notice is included below.

By the close of business May 15, 2026, no written comments were received. During the public informational meeting, some clarifying questions were asked regarding the presentation; however, no verbal comments were submitted.

Copy of Public Notice for Informational Hearing:

STATE OF WISCONSIN DEPARTMENT OF NATURAL RESOURCES
PUBLIC NOTICE OF INFORMATIONAL HEARING FOR
THE LAKE PEPIN TOTAL MAXIMUM DAILY LOAD STUDY

Date: April 27, 2026

Time: 1:00 pm

Location: Virtual

Pre-registration is required. To attend, register online via ZOOM.

Contact: Kevin Kirsch, Kevin.Kirsch@wisconsin.gov

Details: The Wisconsin Department of Natural Resources is conducting a public informational hearing to provide an overview and receive comments on the draft "The Lake Pepin TMDL: Total Maximum Daily Loads for Total Phosphorus" (TMDL Study). The public informational hearing will be held via Zoom and will be recorded. A copy of the public hearing version of the TMDL Study is available for review on the DNR website. The public informational hearing will include a presentation outlining the TMDL Study and discuss implementation planning and monitoring considerations. Written comments will be accepted through May 15, 2026.

Written comments can be submitted via e-mail: Kevin.Kirsch@wisconsin.gov or regular mail:

Wisconsin Department of Natural Resources
Attn: Kevin Kirsch
101 S. Webster St., P.O. Box 7921
Madison, WI 53707-7921

Reasonable accommodation, including the provision of informational material in an alternative format, will be provided for qualified individuals with disabilities upon request.

8 BIBLIOGRAPHY

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software, 67*(1), 1-48.

Brown, B. A. (1988). Bedrock geology of Wisconsin, West-Central sheet. Madison, WI: Wisconsin Geological and Natural History Survey. Retrieved from https://wgnhs.wisc.edu/catalog/publication/000416/resource/m104

Carpenter, S. R., Caraco, N. F., Correll, D. L., Howarth, R. W., Sharpley, A. N., & Smith, V. H. (1998). Nonpoint Pollution of Surface Waters with Phosphorus and Nitrogen. *Ecological Applications, 8*(3), 559-568.

Chenevert, J., Shupryt, M., Kult, J., & Fisch, A. (2018). *Guidelines for Developing Flow Rating Curves for Estimation of Continuous Discharge*. Madison, WI: WI Dept. of Natural Resources.

Diebel, M. W., Ruesch, A. S., Menuz, D., Stewart, J., & Westenbroek, S. M. (2014). *Ecological limits of hydrologic alteration in Wisconsin streams*. Madison, WI: Wisconsin DNR. Retrieved from https://digital.library.wisc.edu/1711.dl/V4GAXIASV2NYA8Y

EPA. (1991). *Technical Support Document for Water Quality-based Toxics Control*. Washington, D.C.: U.S. EPA. Retrieved from https://www3.epa.gov/npdes/pubs/owm0264.pdf

Miller, M. A., & Kort, B. (2018). Wisconsin stream reference condition study summary. Madison, WI: Wisconsin Dept. of Natural Resources.

Miller, M. A., Kult, J., Robertson, D. M., & Saad, D. A. (2017). *Development of ecological expectations for Wisconsin streams*. Madison, WI: Wisconsin Dept. of Natural Resources.

Minnesota Pollution Control Agency. (2011). *Lake Pepin Site Specific Eutrophication Criteria*. St. Paul, MN. Retrieved from https://www.pca.state.mn.us/sites/default/files/wq-s6-10.pdf

Minnesota Pollution Control Agency. (2021). *Lake Pepin and Mississippi River Eutrophication Total Maximum Daily Load Report.* St. Paul, MN. Retrieved from https://www.pca.state.mn.us/sites/default/files/wq-iw9-22e.pdf

Nathan, R. J., & McMahon, T. A. (1990). Evaluation of automated techniques for base flow and recession analysis. *Water Resources Research, 26*(7), 1465-1473.

Natural Resources Conservation Service. (n.d.). Soil Survey Geographic (SSURGO) Database. Retrieved from https://sdmdataaccess.sc.egov.usda.gov/?referrer=Citation.htm-SSURGOLink

Neitsch, S. L., Williams, J. R., Arnold, J. G., & Kiniry, J. R. (2011). *Soil and Water Assessment Tool Theoretical Documentation Version 2009.* College Station, TX: Texas Water Resources Institute.

Newcombe, C. P., & Jensen, O. J. (1996). Channel Suspended Sediment and Fisheries: A Synthesis for Quantitative Assessment of Risk and Impact. *North American Journal of Fisheries Management, 16*(4), 693-727.

Panuska, J. C., & Lilly, R. A. (1995). *Phosphorus loadings from Wisconsin watersheds: recommended export coefficients for agricultural and forested watersheds.* Madison, WI: WDNR.

PRISM Climate Group. (n.d.). PRISM Gridded Climate Data. Corvallis, OR: Oregon State University. Retrieved December 2020, from https://prism.oregonstate.edu/

R Core Team. (2020). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/

Rayhorn, B., Palubicki, M., Vitale, S., Mahoney, B., & Mc Ellistrem, L. (2022). Lake eutrophication: natural vs anthropogenic phosphorus? *Phosphorus Conference.* Madison, WI.

Robertson, D. M., Weigel, B. M., & Graczyk, D. J. (2008). *Nutrient Concentrations and Their Relations to the Biotic Integrity of Nonwadeable Rivers in Wisconsin*. Reston, VA: U.S. Geological Survey.

Runkel, R., & De Cicco, L. (2017). rloadest: river load estimation.

Schwarz, G. E., Hoos, A. B., Alexander, R. B., & Smith, R. A. (2006). *The SPARROW surface water quality model: theory, application, and user documentation*. Reston, VA: U.S. Geological Survey.

Sharpley, A. N., Chapra, S. C., Wedepohl, R., Sims, J. T., Daniel, T. C., & Reddy, K. R. (1994). Managing Agricultural Phosphorus for Protection of Surface Waters: Issues and Options. *Journal of Environmental Quality, 23*(3), 437-451.

Sims, J. T. (1998). Phosphorus Loss in Agricultural Drainage: Historical Perspective and Current Research. *Journal of Environmental Quality, 27*(2), 277-293.

Steele, M. K., McDowell, W. H., & Aitkenhead-Peterson, J. A. (2010). *Chemistry of Urban, Suburban, and Rural Surface Waters*. Madison, WI: SA Inc., CSA Inc., SSSA Inc.

WDNR. (2003, October). Wisconsin Lake Modeling Suite, program documentation and user's manual. Madison, WI. Retrieved from https://dnr.wisconsin.gov/sites/default/files/topic/Lakes/WiLMSDocumentation.pdf

WDNR. (2003). *Wisconsin Lake Modeling Suite: Program Documentation and User's Manual, Version 3.3 for Windows*. Madison, WI: WI Dept. of Natural Resources. Retrieved from https://dnr.wisconsin.gov/topic/Lakes/Model

WDNR. (2010). *Wisconsin Phosphorus Water Quality Standards Criteria: Technical Support Document*. Madison, WI: WI Dept. of Natural Resources. Retrieved from https://dnr.wi.gov/water/wsSWIMSDocument.ashx?documentSeqNo=130570791

WDNR. (2014). *TMDL Guidance for MS4 Permits: Planning, Implementation, and Modeling Guidance*. Madison, WI: WI Dept. of Natural Resources. Retrieved from https://dnr.wisconsin.gov/topic/Stormwater/standards/ms4_modeling.html

WDNR. (2020). *TMDL Implementation Guidance for Wastewater Permits*. Madison, WI: WI Dept. of Natural Resources. Retrieved from https://dnr.wisconsin.gov/topic/TMDLs/Implementation.html

WDNR. (2021). *Waterbody Assessments Rule Package: Technical Support Document, Revisions to Ch. NR 102, Wis. Adm. Code, Rule No. WY-23-13, Appendix B*. Madison, WI: WI Dept. of Natural Resources.

WDNR. (2021). *Wisconsin's Nonpoint Source Program Management Plan*. Madison, WI: WI Dept. of Natural Resources. Retrieved from https://dnr.wisconsin.gov/topic/Nonpoint/aboutNPSprogram.html

WDNR. (*Wisconsin Consolidated Assessment and Listing Methodology (WisCALM)*. Madison, WI: WI Dept. of Natural Resources. Retrieved from https://dnr.wi.gov/topic/SurfaceWater/Assessments.html

Wisconsin Department of Natural Resources. (2016). *Wiscland 2 Land Cover User Guide*. Madison, WI. Retrieved from https://p.widencdn.net/8ghipa/Wiscland_2_User_Guide_September_2016

Wisconsin Department of Natural Resources. (2019). *Total Maximum Daily Loads for Total Phosphorus in the Wisconsin River Basin*. WDNR, Bureau of Water Quality, Madison, WI. Retrieved from https://dnr.wisconsin.gov/sites/default/files/topic/TMDLs/WRBApprovedTMDL20190426.pdf

Wisconsin Department of Natural Resources. (2020). *Total Maximum Daily Loads for Total Phosphorus and Total Suspended Solids Upper Fox and Wolf Basins*. WDNR, Bureau of Water Quality, Madison, WI. Retrieved from

https://dnr.wisconsin.gov/sites/default/files/topic/TMDLs/UFWB_TMDL_Report_US_EPA_Final.pdf

Wisconsin Department of Natural Resources. (2023). *The Northeast Lakeshore TMDL: Total Maximum Daily Loads for Total Phosphorus and Total Suspended Solids*. WDNR, Bureau of Water Quality, Madison, WI. Retrieved from https://dnr.wisconsin.gov/sites/default/files/topic/TMDLs/NEL_TMDL_report_approved.pdf

Wisconsin Department of Natural Resources. (n.d.). Erosion Vulnerability Assessment for Agricultural Lands (EVAAL). Madison, WI. Retrieved from https://github.com/dnrwaterqualitymodeling/EVAAL