DRAFT

Lake Pepin Watershed Phosphorus Total Maximum Daily Loads

MINNESOTA POLLUTION CONTROL AGENCY

LimnoTech

July 2019

wq-iw9-22b

Authors and contributors:

Text

Contents

List of Tables v

List of Figures vi

Acronyms viii

Executive Summary 1

1. Project Overview 1

1.1. Project Purpose and History 1

1.2. Identification of Waterbodies 3

1.3. Priority Ranking 7

2. Applicable Water Quality Standards and Numeric Water Quality Targets 8

2.1. State of Minnesota Designated Uses 8

2.2. State of Minnesota Water Quality Standards and Criteria for Listing 9

3. Watershed and Waterbody Characterization 12

3.1. Lake Pepin and Impaired Stream Reaches 12

3.2. Watershed Characteristics 14

3.2.1. Land Use 18

3.2.2. Hydrology 20

3.3. Historic and Current Water Quality Conditions of Impaired Waters 23

3.3.1. Mississippi River – Lake Pepin 23

3.3.2. Twin Cities Metropolitan Area 26

3.3.3. Minnesota River Basin 28

3.4. Phosphorus Source Summary 31

3.4.1. Municipal and Industrial Wastewater 33

3.4.2. Regulated Stormwater 37

3.4.3. Permitted Confined Animal Feeding Operations 39

3.4.4. Nonpoint sources 40

3.4.5. Natural Background 44

4. Modeling Approach 46

4.1. Water Quality Model 46

4.1.1. Baseline Loads 49

4.1.2. Scenario Development 50

4.1.3. Modeling to develop WLAs 53

4.2. Relationships to other TMDLs 53

5. TMDL Development 55

5.1. Loading Capacity 59

5.1.1. Lake Pepin and Pool 2 59
5.1.2. Impaired Stream AUID – Crow River to Upper St. Anthony Falls 59
5.2. Wasteload Allocation Methodology 61
5.2.1. Permitted Municipal and Industrial Wastewater 61
5.2.2. Regulated MS4 Stormwater 64
5.2.3. Regulated Construction and Industrial Stormwater 65
5.3. Load Allocation Methodology 65
5.4. Margin of Safety 66
5.5. Reserve Capacity 67
5.5.1. Minnesota Reserve Capacity 67
5.5.2. Wisconsin Reserve Capacity 69
5.6. Boundary Conditions 71
5.7. Application of Delivery Ratios 73
5.8. Seasonal Variation 74
5.9. Tribal Lands 74
6. Reasonable Assurance 75
6.1. Framework 75
6.2. Basin, Regional and Local Entities 79
6.3. Summary of Local Plans 83
6.4. Example Basin-wide Source Reduction Activities and Tools 84
6.5. Future Developments 96
7. Monitoring Plan 98
8. Implementation Strategy Summary 101
8.1. The Minnesota Nutrient Reduction Strategy 101
8.2. The Minnesota Watershed Approach 104
8.3. Permitted Sources 104
8.3.1. Construction Stormwater 104
8.3.2. Industrial Stormwater 105
8.3.3. MS4s 105
8.3.4. Wastewater 106
8.4. Non-Permitted Sources 106
8.5. Cost 107
8.6. Adaptive Management 108
9. Public Participation 110
9.1. Public Notice for Comments 113
10. Literature Cited 114

Appendices **117**
Appendix A – Impaired AUID Segments **118**
Appendix B – WWTP WLAs **121**
Appendix C – MS4 Entities Included in TMDLs **138**
Appendix D – Tribal Lands in Lake Pepin Watershed **144**
Appendix E – Wisconsin Loads accounted for in Lake Pepin TMDL **145**

List of **Tables**

Table 1. Impaired main-stem reaches on the Mississippi River in the Lake Pepin Watershed. 6
Table 2. Designated use classifications for impaired AUIDs. 9
Table 3. Water quality criteria for impaired AUIDs. 10
Table 4. Morphometric data for Lake Pepin, compared to lakes in the North Central Hardwood Forest (NCHF) and Western Corn Belt Plains (WCBP) ecoregions. 13
Table 5. AUID reach length and total contributing watershed area of impaired stream reaches. 14
Table 6. HUC-8 or HUC-10 watersheds within each of the major drainage basins in the Lake Pepin Watershed. 17
Table 7. Hydrologic summary for each major drainage basin. 20
Table 8. Hydrologic summary of each impaired AUID segment. 22
Table 9. Summary of water quality data for Lake Pepin. Data represent whole lake averages. 24
Table 10. Summary of water quality data for the impaired stream reaches in the Twin Cities Metropolitan Area. 27
Table 11. Summary of average summer water quality data for impaired AUIDs in the Minnesota River Basin. 28
Table 12. Estimates of nonpoint source contributions of phosphorus in the major basins during an average year. 42
Table 13. Summary of 21 Upper Mississippi River - Lake Pepin phosphorus load reduction scenarios. 52
Table 14. Summary of existing TMDLs in the Lake Pepin Watershed. 53
Table 15. Lake Pepin TMDL, AUID 25-0001-00. 56
Table 16. Mississippi River AUID 07010206-814 TMDL. 57
Table 17. Mississippi River AUID 07010206-805 TMDL. 58
Table 18. Calculation of loading capacity for the RES impaired AUID. 60
Table 19. Annual WLAs for municipal and industrial WWTPs in the Lake Pepin Watershed. 63
Table 20. Seasonal RES WLAs for municipal and industrial WWTPs in the Crow River Basin. 64
Table 21. Reserve Capacity for Replacing Septic Systems. 68
Table 22. Boundary condition loads. 72
Table 23. Watershed organizations in the Upper Mississippi River Basin. 82
Table 24. Watershed organizations in the Minnesota River Basin. 83
Table 25. Efforts providing Reasonable Assurance for phosphorus reductions across basins and sources. 85
Table 26. Lake Pepin and RES TMDLs chronology. 112

List of Figures

Figure 1. Lake Pepin Watershed and phosphorus impaired AUIDs on the main-stem Mississippi River and Minnesota River. 5
Figure 2. Map of Lake Pepin, with upper portion outlined in red, and lower portion outlined in green... 13
Figure 3. United States Level III Ecoregions within the Lake Pepin Watershed. 15
Figure 4. Map of the major drainage areas that make up the Lake Pepin Watershed (TCMA = Twin Cities Metro Area)........ 16
Figure 5. Land cover categories in the Lake Pepin Watershed (based on 2011 NLCD). 18
Figure 6. MCES assessment of median flows at gauges in the TCMA. 21
Figure 7. Lake Pepin and sampling locations used in water quality data analysis........ 24
Figure 8. Long term total phosphorus data summarized into a composite concentration from the four monitoring stations........ 25
Figure 9. Long term Chl-*a* data summarized into a composite concentration from the four monitoring stations........ 25
Figure 10. Mississippi River at Lock and Dam #3 – Total Phosphorus Load (Metric Tons). 26
Figure 11. Mississippi River at Lock and Dam #3 – Total Suspended Solids Load (Metric Tons). 26
Figure 12. Impaired river reaches in the Twin Cities Metropolitan Area. 27
Figure 13. Minnesota River Basin AUIDs........ 29
Figure 14. Annual summer total phosphorus concentrations on the Minnesota and Mississippi River from 2005 - 2017. 30
Figure 15. Annual summer Chl-a concentrations on the Minnesota and Mississippi River from 2005 - 2016. 30
Figure 16. Relative distribution of phosphorus loads in the Mississippi River Basin. 31
Figure 17. Relative distribution of phosphorus loads in the Minnesota River Basin. 32
Figure 18. Locations of NPDES wastewater facilities in the Lake Pepin Watershed. Note that only Minnesota facilities are shown. 34
Figure 19. Annual NPDES wastewater phosphorus loads in the Lake Pepin Watershed from 2000 – 2017 for municipal and industrial facilities........ 35
Figure 20. Annual NPDES wastewater phosphorus loads in the Upper Mississippi River Basin from 2000 – 2017 for municipal and industrial facilities........ 35
Figure 21. Annual NPDES wastewater phosphorus loads in the St. Croix River Basin from 2000 – 2017 for municipal and industrial facilities. 36
Figure 22. Annual NPDES wastewater phosphorus loads in the Minnesota River Basin from 2000 – 2017 for municipal and industrial facilities........ 36
Figure 23. Annual NPDES wastewater phosphorus loads in the Cannon River Watershed from 2000 – 2017 for municipal and industrial facilities........ 37
Figure 24. Locations of MS4 communities in the Lake Pepin Watershed. Note that only Minnesota MS4 communities are shown........ 38
Figure 25. Distribution of Animal Feeding Operations and Concentrated Animal Feeding Operations in the Lake Pepin Watershed. Note that only Minnesota facilities are shown. 40
Figure 26. Nonpoint sources of phosphorus in the Mississippi River Basin (Data Source: Minnesota Nutrient Reduction Strategy)........ 41

Figure 27. Year-to-year variability in total phosphorus loads to Lake Pepin. 49
Figure 28. Baseline annual total phosphorus loads to Lake Pepin. 49
Figure 29. Upper Mississippi River - Lake Pepin model Scenario 21 results showing phosphorus loadings from the major basins required to meet water quality standards. 52
Figure 30. Locations of USGS gauge station used in calculating the average June through September flow for the impaired stream AUID. 60
Figure 31. Map of boundary condition areas in the Lake Pepin Watershed. 73
Figure 32. Extent of State and basin strategies. 76
Figure 33. Status of WRAPS and 1W1P. 79
Figure 34. Buffer compliance estimates (map from BWSR 2017a). 88
Figure 35. Minnesota CREP map (BWSR 2017b). Map from http://www.bwsr.state.mn.us/crep/ 91
Figure 36. Mississippi River - Lake Pepin upland treatment map. 93
Figure 37. Trout Brook Subwatershed analysis (Dakota County SWCD 2016) 94
Figure 38. Forever Green logic model. 97
Figure 39. MPCA Intensive Watershed Monitoring and Assessment Map and Schedule. 100
Figure 40. Phosphorus loading trend in the Mississippi River at the state boundary. (source: The Minnesota Nutrient Reduction Strategy) 102
Figure 41. Priority watersheds for phosphorus reduction. (Source: The Minnesota Nutrient Reduction Strategy) 103
Figure 42. Minnesota's watershed approach. 104
Figure 43. Adaptive management iterative process. 109

Acronyms

AFO	Animal Feeding Operation
AUID	Assessment Unit ID
AWWDF	Average Wet Weather Design Flow
BC	Boundary Conditions
BMP	Best Management Practice
BWSR	Board of Water and Soil Resources
CAFO	Concentrated Animal Feeding Operation
cfs	cubic feet per second
Chl-*a*	Chlorophyll-*a*
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CRW	Cannon River Watershed
CWA	Clean Water Act
DNR	Minnesota Department of Natural Resources
ECOMSED	Estuarine and Coastal Ocean Model with Sediment
EPA	U. S. Environmental Protection Agency
FSA	Farm Service Agency
GIS	Geographic Information Systems
HSPF	Hydrologic Simulation Program-Fortran
HUC-8	hydrologic unit code
LA	Load Allocation
Lb	pound
kg/year	kilograms per year
L/gal	liters per gallon
LC	Loading Capacity
LTRMP	Long-Term Resource Monitoring Program
MCES	Metropolitan Council Environmental Services
MDA	Minnesota Department of Agriculture
MDF	Maximum Design Flow
mgd	Million gallons per day
mg/L	milligrams per liter
MOS	Margin of Safety
MPCA	Minnesota Pollution Control Agency
MRLP	Mississippi River-Lake Pepin
MS4	Municipal Separate Storm Sewer Systems
NLCD	National Land Cover Database
NPDES	National Pollutant Discharge Elimination System
NRS	Minnesota Nutrient Reduction Strategy
NWIS	National Water Information System
RC	Reserve Capacity
RCA	Row-Column AESOP

RES	River Eutrophication Standards
RFP	Request for Proposals
RIM	Reinvest in Minnesota
SAP	Science Advisory Panel
SDS	State Disposal System
SSTS	Subsurface Sewage Treatment Systems
SWCD	Soil and Water Conservation District
SWPPP	Stormwater Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TP	Total phosphorus
TSS	Total suspended solids
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WDNR	Wisconsin Department of Natural Resources
WLA	Wasteload Allocation
WPLMN	Watershed Pollutant Load Monitoring Network
WQBEL	Water Quality Based Effluent Limit
WMO	Watershed Management Organizations
WRAPS	Watershed Restoration and Protection Strategy
1W1P	One Watershed One Plan

Executive Summary

The Clean Water Act (CWA) of 1972 provides a framework for assessing water quality impairments in a comprehensive fashion called the Total Maximum Daily Load (TMDL). This process calls for:

- Monitoring surface waters;
- Identifying waterbodies that exceed state standards as being impaired;
- Determining the maximum loads of pollutants that can enter a water body and still meet standards;
- Calling for corresponding reductions in pollutant loads from the various sources.

The Minnesota Pollution Control Agency (MPCA) is committed to following this process to meet water quality standards and achieve broader improvements to aquatic ecosystems. This TMDL report addresses impairments caused by excessive phosphorus loads in the following waterbody assessment units:

- Lake Pepin (AUID 25-0001-00);
- The Mississippi River from Upper St. Anthony Falls to the St. Croix River (AUID 07010206-814); and
- The Mississippi River from the Crow River to Upper St. Anthony Falls (AUID 07010206-805).

The Lake Pepin TMDL effort began in 2002, when the state placed the lake on the impaired waters list for excess nutrients. Following the adoption of river eutrophication standards (RES) in 2014, the state placed reaches of the Mississippi River upstream of Lake Pepin on the impaired waters list for excess nutrients. High levels of total phosphorus (TP) in Lake Pepin and upstream rivers are causing excessive algal growth, which is detrimental to recreational uses such as boating and swimming, and also negatively impacts aquatic invertebrates and fish. During the TMDL development process, the MPCA and others discovered that roughly two-thirds of the algae in Lake Pepin are produced in upstream rivers and pools.

The MPCA and partners developed a water quality model to evaluate Upper Mississippi River sediment and nutrients from Lock and Dam 1 (Ford Parkway, Minneapolis, Minnesota) through Lock and Dam 4 (Alma, Wisconsin) below Lake Pepin. Once developed, the model was applied to support TMDLs to address the Total Suspended Solids (TSS) and nutrient impairments in Pools 2, 3, and 4 of the Upper Mississippi River. Mississippi River Pools are named in accordance with the designation of the Lock and Dam at their downstream boundary. Thus, Pool 2 extends from Lock and Dam 1 (Minneapolis) to Lock and Dam 2 (Hastings, Minnesota), Pool 3 extends from Lock and Dam 2 (Hastings, Minnesota) to Lock and Dam 3 (Welch, Minnesota), etc. After the model was completed in 2009, the MPCA put the issues of turbidity and eutrophication on separate tracks, starting with the development of site-specific standards, to be followed by TMDL documents.

The MPCA first developed a site-specific standard for TSS in 2010 for Pools 2 and 3. In 2011, following the recommendation of the Lake Pepin TMDL Science Advisory Panel (SAP), the MPCA published site-specific eutrophication criteria for Lake Pepin to provide protection of aquatic recreational uses: 100 µg/L TP and 28 µg/L Chlorophyll-*a* (Chl-*a)*. The MPCA Citizens' Board adopted the criteria in 2014, as part of an amendment to the state's water quality standards. The RES were developed and adopted in August 2014, and approved by the U.S. Environmental Protection Agency (EPA) in January 2015. Also in 2015, the MPCA issued the South Metro Mississippi River (SMMR) TSS TMDL, calling for large reductions in upstream sediment loads, primarily from the Minnesota River Basin, to decrease turbidity and improve aquatic life in Pool 2. With the site-specific nutrient criteria now in-place, and the SMMR TSS TMDL completed, the foundation has been laid for phosphorus TMDLs to protect Lake Pepin and the upstream impaired reaches of the Mississippi River.

The TMDLs addressed in this report need to be considered in a statewide watershed context. For Lake Pepin to meet its standards, phosphorus loads from upstream watersheds must be reduced. During high flows, sediment is the primary concern. The Lake Pepin watershed includes a number of sediment reduction goals at various scales including the South Metro TSS TMDL, the draft Minnesota River TSS TMDL, and numerous major watershed scale TSS TMDLs. Reducing algae during low flow conditions is the primary concern and the regulatory focus of the Lake Pepin and river eutrophication TMDLs. Meeting TSS and nutrient targets for the Cannon, Minnesota, Crow, and St. Croix rivers along with reductions in the Twin Cities Metropolitan Area will contribute to the achievement of water quality goals in Pool 2 and downstream through Lake Pepin during all flow conditions. Significant progress has already been made. Municipal and industrial wastewater dischargers in the Lake Pepin Basin have accomplished dramatic phosphorus load reductions over the past 15 years. Many wastewater facilities are already meeting their targets for local resources and Lake Pepin.

The TMDLs developed and presented in this report are consistent with other large scale projects in Minnesota calling for point source and nonpoint source pollutant loading reductions. Point sources have the potential to be a significant source of phosphorus during low-flow conditions, while nonpoint sources are a significant source following runoff events. Water quality data and modeling confirm that both point and nonpoint source reductions are required to meet the water quality standards. Due to the variability in weather and stream flows, the entire load reduction needed across all years could not be borne by either point or nonpoint sources alone. The selected model scenario that results in Lake Pepin meeting water quality standards calls for the following annual average TP load reductions from the major subbasins:

- 20% reduction in the Mississippi River at Ford Dam (Lock and Dam 1, Minneapolis)
- 50% reduction in the Minnesota River
- 20% reduction in the St. Croix River
- 50% reduction in the Cannon River
- 20% reduction in other tributaries

Within these subbasin reductions, a 70% reduction from previously permitted loads for WWTPs is called for, along with a 50% reduction in resuspension in Pool 2. RES impaired AUIDs on the Mississippi and Minnesota Rivers require reductions in ambient phosphorus concentrations ranging from around 10% to close to 70%.

The state developed the Minnesota Nutrient Reduction Strategy (NRS) to guide a holistic approach to reduce nutrient loading. The Lake Pepin Watershed Phosphorus TMDLs address watersheds that drain to the Minnesota River and Mississippi River, ultimately impacting the hypoxic zone in the Gulf of Mexico.

The NRS calls for 45% reduction in phosphorus (relative to a 1980 through 1996 baseline) by 2025. Given the well-matched scales of the NRS and the Lake Pepin watershed, the NRS provides a working goal and milestone timeline for the TMDL. The NRS will be revisited periodically (the first update is underway in 2018-2019) and thus will provide “check-in” points for progress, including progress specific to Lake Pepin. At such periodic intervals, changes in water quality, nutrient loading, and best management practice (BMP) implementation can be assessed and used to inform adaptive management of current programs. Significant reductions from nonpoint sources are needed. Identifying the best BMPs, providing means of focusing them, and supporting their implementation via state initiatives and dedicated funding is an on-going campaign undertaken at various scales.

The scale of the Lake Pepin Watershed Phosphorus TMDLs is extremely large. With a drainage area spanning approximately half of the state, involvement and support will need to come from all levels, with the expectation that new knowledge will lead to adaptive management. Minnesota’s Watershed Approach, consisting of a 10-year cycle of assessments, watershed restoration and protection strategy (WRAPS) development at the eight-digit HUC (hydrologic unit code) watershed level, and local water planning (e. g., One Watershed One Plan; 1W1P), will be critical to the success of attaining water quality standards and restoring aquatic recreation and aquatic life uses. As part of the NRS update, the MPCA is working to bring together the Lake Pepin and NRS technical work. This will include an examination of the compatibility of state-level strategy, Big River (e.g. Lake Pepin) and local watershed goals and approaches implemented through the WRAPS and 1W1P framework.

1. Project Overview

The State of Minnesota has designated beneficial uses for streams and lakes, such as supplying drinking water, supporting aquatic life, supporting recreation, and other uses. The state periodically assesses whether these waterbodies are attaining these uses. Under the federal CWA, states must conduct a TMDL study for each pollutant affecting an impaired water, which is a lake, river or stream that fails to meet its designated uses. A TMDL is a calculation of the maximum amount of pollutant that a water body can receive and still meet water quality standards and/or designated uses. The study identifies all pollutant sources and determines the allowable pollutant loading, and needed pollutant load reductions from each type of source to effectively restore water quality. State agencies, local groups and other stakeholders work together, using available data, computer modeling, and public input to develop TMDLs.

1.1. Project Purpose and History

The Lake Pepin Watershed Phosphorus TMDLs project addresses impairments caused by excess phosphorus in Lake Pepin and in impaired main-stem reaches in the Mississippi River upstream of Lake Pepin. TMDLs for impairments caused by excess phosphorus in the main-stem reaches of the Minnesota River will be addressed by the MPCA through other efforts. Excess phosphorus has led to eutrophication in the Minnesota River, portions of the Mississippi River and Lake Pepin. Both phosphorus and Chl-*a*, which is a measure of algal biomass, exceed applicable eutrophication standards for these surface waters. The symptoms of eutrophication may include: nuisance and harmful algal blooms; depletion of dissolved oxygen (DO) as plants and algae decay after consuming the excess nutrients; fish kills; reduction in species richness; and proliferation of more resilient and less desirable species (MPCA 2013a). Recreational uses and aquatic life uses in the waterbody may be impaired as a result.

The goal of this TMDL report is to quantify, where applicable, the allowable phosphorus loads that will attain water quality standards in the impaired reaches. The TMDLs included in this report establish, in accordance with Section 303(d) of the CWA, wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources in the watersheds of the impaired reaches. These allocations show the need for reductions from pollutant sources. The TMDLs also include a margin of safety (MOS) to account for uncertainty, and reserve capacity (RC) to account for potential future loading sources.

The MPCA has led the Lake Pepin Watershed Phosphorus TMDLs project. However, the Lake Pepin TMDL also has direct implications for Wisconsin, which shares a border with Minnesota on the Mississippi River at La Crosse, Wisconsin. The MPCA has consulted closely with the Wisconsin Department of Natural Resources (WDNR) on the project, as well as on broader issues of coordinating water quality assessments on the Mississippi River. As a result, WDNR and the MPCA agree on the site specific standard to protect Lake Pepin and the TMDL presented in this report.

The Lake Pepin Watershed Phosphorus TMDLs project builds on a foundation of studies carried out by multiple agencies and organizations over recent decades. The MPCA, Metropolitan Council Environmental Services (MCES), United States Geological Survey (USGS), University of Minnesota, Minnesota Department of Agriculture (MDA), Science Museum of Minnesota St. Croix Watershed Research Station, and WDNR, as well as numerous cities, counties, and watershed organizations, have all contributed significantly to the science and community engagement supporting the development of these TMDLs. Additional information is available in the following reports:

- Historical changes in sediment and phosphorus loading to the Upper Mississippi River: Mass-balance reconstructions from the sediments of Lake Pepin (St. Croix Watershed Research Station, Science Museum of Minnesota 2000)
- Lake Pepin Phosphorus Study, 1994-1998 (MCES 2002)
- Detailed Assessment of Phosphorus Sources to Minnesota Watersheds (Barr Engineering 2004)
- Lower Minnesota River DO TMDL (MPCA 2004)
- Upper Mississippi River – Lake Pepin Water Quality Model Development, Calibration, and Application (LimnoTech 2009a)
- Lake Pepin Site Specific Eutrophication Criteria (MPCA 2011)
- Draft - Minnesota River Turbidity TMDL (MPCA 2012a)
- Minnesota Nutrient Criteria Development for Rivers (MPCA 2013a)
- Byllesby Reservoir Phosphorus TMDL Report: Public Notice Draft (MPCA 2013b)
- Lake St. Croix Nutrient TMDL and Implementation Plan (MPCA 2012b and MPCA 2013c)
- Minnesota Nutrient Reduction Strategy (MPCA 2014)
- South Metro Mississippi River TSS TMDL (MPCA 2015a)
- Sediment Reduction Strategy for the Minnesota River Basin and South Metro Mississippi River (MPCA 2015b)
- Draft - Minnesota River and Greater Blue Earth River Basin TSS TMDL Study (MPCA 2019 – In Process)

The MPCA has already completed TMDLs that address phosphorus in the Lake Pepin Watershed in some of the contributing watersheds. The two largest phosphorus TMDLs include the Lake St. Croix Excess Nutrient TMDL and the Byllesby Reservoir Phosphorus TMDL. The allowable phosphorus loads specified in those two previous TMDLs are protective of Lake Pepin and, therefore, those areas are considered boundary conditions (i.e. excluded areas) in the Lake Pepin TMDL. Numerous other TMDLs developed for phosphorus in lakes have been developed throughout the Lake Pepin Watershed. WLAs for these smaller scale TMDLs may be more protective than the WLAs presented in this report. An entity with a WLA in this report as well as a WLA in other existing or future TMDLs for local water bodies will be required to meet the most stringent WLA to ensure protection of downstream uses.

A low DO TMDL for the lower Minnesota River established phosphorus allocations in the Minnesota River Basin (MPCA 2004), to protect the last 22 miles of the Minnesota River from excessive biological oxygen demand (BOD) loading during summer from the Minnesota River upstream of Jordan, Minnesota. Historically, the BOD loading was the result of algal production in the Minnesota River driven by elevated concentrations of TP.

The South Metro Mississippi River TSS TMDL (MPCA 2015a) includes the Upper Mississippi, Minnesota River, Cannon River, and St. Croix River basins, as well as small rivers and streams in southeast Minnesota that flow directly into the Mississippi River. Phosphorus is attached to soil particles in fields, ravines and stream banks. Soil particles become suspended solids during high flow conditions and are a major source of TP during high flows. The SMMR, from Fort Snelling in St. Paul to upper Lake Pepin downstream of Red Wing, is impaired due to high TSS (formerly turbidity impairments), which prevents sufficient sunlight from reaching the river bottom to allow the growth and maintenance of submersed aquatic vegetation. The South Metro Mississippi River TSS TMDL addresses the TSS impairment in addition to the accelerated in-filling of Lake Pepin with sediment. The TMDL is based on a site-specific standard of 32 mg/L TSS for the impaired reach. The draft Minnesota River and Greater Blue Earth River Basin TSS TMDL (MPCA 2019) covers TSS impairments along the Minnesota River and its tributaries. The project area covers the nine eight-digit hydrologic unit code (HUC-8) watersheds from the outlet of Lac qui Parle Lake to the mouth of the Minnesota River at the confluence with the Mississippi River at Fort Snelling. While the SMMR TSS TMDL and the Minnesota River and Greater Blue Earth River Basin TSS TMDL do not address phosphorus directly, loads of solids and phosphorus are highly correlated. The reductions in solids loadings from nonpoint sources needed to achieve the TSS TMDLs are expected to be greater than the phosphorus load reductions from nonpoint sources needed to meet the Lake Pepin Watershed Phosphorus TMDLs.

The MPCA developed the NRS to guide a holistic approach to reduce nutrient loading. The NRS calls for 45% reduction in phosphorus (relative to a 1980 through 1996 baseline) by 2025. Given the scale of the NRS encompasses the Lake Pepin watershed, the NRS provides a working goal and milestone timeline for the Lake Pepin TMDL. The NRS will be revisited periodically (the first update is underway in 2018-2019) and thus will provide “check-in” points for progress, including progress specific to Lake Pepin. At such periodic intervals, changes in water quality, nutrient loading, and BMP implementation can be assessed and used to inform adaptive management of current programs. Significant reductions from nonpoint sources are needed. Identifying the best BMPs, providing means of focusing them, and supporting their implementation via state initiatives and dedicated funding is an on-going campaign undertaken at various scales. As part of the NRS update, MPCA will examine the compatibility of state-level strategy, Big River (e.g. Lake Pepin) TMDLs, and local watershed goals and approaches implemented through the WRAPS and 1W1P framework.

1.2. Identification of Waterbodies

The contributing basins that make up the Lake Pepin watershed are comprised of seven major drainage areas:

- Upper Mississippi River Minnesota Basin (upstream of the Crow River);
- Crow River Watershed;
- Rum River Watershed;
- Twin Cities Metro Area;
- Minnesota River Basin;
- St. Croix River Basin; and

- Mississippi River/Lake Pepin (MRLP) direct tributaries (includes areas that drain directly to the Mississippi River downstream of Lock and Dam 2 in Hastings, Minnesota through Lake Pepin via tributary streams, including as the Cannon River, Vermillion River, and tributaries in Wisconsin.

These areas are presented in Figure 1. The Lake Pepin watershed phosphorus TMDL report addresses phosphorus impairments in 3 waterbody segments, or assessment units (referred to by assessment unit identification, or AUID). The impaired AUIDs are shown in Figure 1 and listed in Table 1. The impaired segments include:

- Lake Pepin (AUID 25-0001-00);
- The Mississippi River from Upper St. Anthony Falls to the St. Croix River (AUID 07010206-814); and
- The Mississippi River from the Crow River to Upper St. Anthony Falls (AUID 07010206-805).

Note that Pool 3 of the Mississippi River, between the St. Croix River and Lake Pepin, is not impaired by eutrophication. Also note that AUID 07010206-814 overlaps the site-specific AUID 07010206-806 from Ford Dam to Hastings Dam. AUID 07010206-806 was originally listed in 2016. The impairment for this site-specific reach has been assigned to the overlapping AUID from Upper St. Anthony Falls to the St. Croix River. The 2018 impaired waters list includes AUID 07010206-814 and notes that it was previously listed as AUID 07010206-806. Therefore, the TMDL presented in this report addresses both segments.

The figures in Appendix A present maps showing the previous segments and the new consolidated AUID segments. All previous segments within a new consolidated AUID segment are now listed due to listing of the new AUID segment.

Impaired AUIDs that border tribal lands are discussed in Section 5.9.

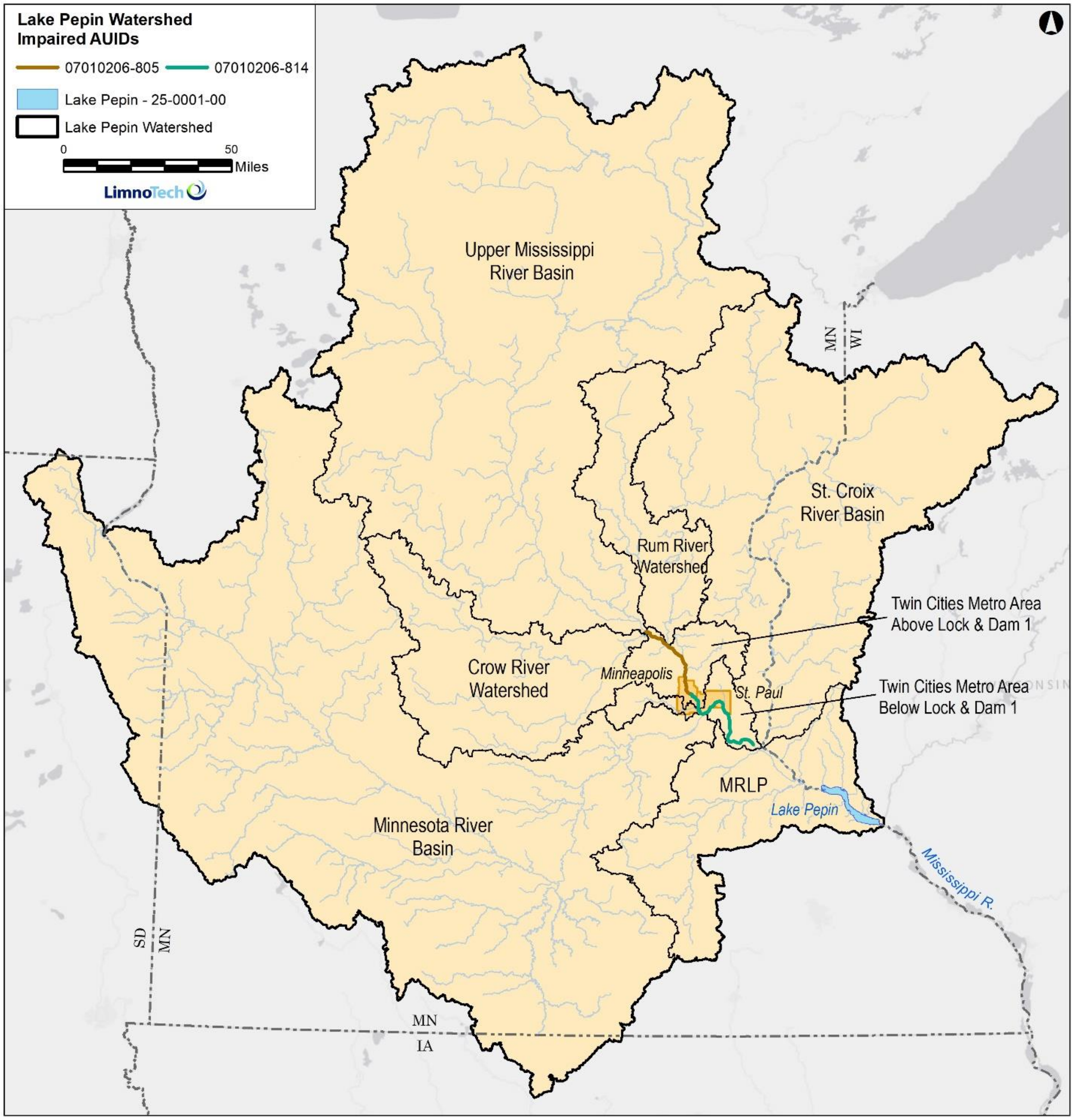


Figure 1. Lake Pepin Watershed and phosphorus impaired AUIDs on the main-stem Mississippi River and Minnesota River.

Table 1. Impaired main-stem reaches on the Mississippi River in the Lake Pepin Watershed.

Major Drainage Basins	Listed Waterbody Name	Location Description	Reach (AUID)	Impaired Use	Listed Pollutant	Listing Year
Mississippi River Basin	Lake Pepin	Mississippi River to Pool 4	25-0001-00	Aquatic Recreation	Phosphorus	2002
Mississippi River Basin	Mississippi River	Upper St. Anthony Falls to St. Croix River	07010206-814	Aquatic Life	Phosphorus	2018
Mississippi River Basin	Mississippi River	Crow River to Upper St. Anthony Falls	07010206-805	Aquatic Life	Phosphorus	2016

1.3. Priority Ranking

The MPCA's projected schedule for TMDL completions, as indicated on the 303(d) impaired waters list, implicitly reflects Minnesota's priority ranking of the TMDLs in this report. Ranking criteria for scheduling TMDL projects include, but are not limited to: impairment impacts on public health and aquatic life; public value of the impaired water resource; likelihood of completing the TMDL in an expedient manner, including a strong base of existing data and restorability of the waterbody; technical capability and willingness locally to assist with the TMDL; and appropriate sequencing of TMDLs within a watershed or basin.

The MPCA has aligned TMDL priorities with the watershed approach and WRAPS cycle. The schedule for TMDL completion corresponds to the WRAPS report completion on the 10-year cycle. The MPCA developed a state plan, Minnesota's TMDL Priority Framework Report, to meet the needs of EPA's national measure (WQ-27) under EPA's Long-Term Vision for Assessment, Restoration and Protection under the CWA section 303(d) program. As part of these efforts, the MPCA identified water quality-impaired segments that will be addressed by TMDLs by 2022. The waters of the Lake Pepin watershed addressed by the TMDLs in this report are part of that MPCA prioritization plan to meet the EPA's national measure.

The Lake Pepin TMDL effort began in 2002, when the state placed the lake on the impaired waters list for excess nutrients. MPCA conducted modeling studies and substantial public engagement to inform the development of a TMDL. Prior to completing a TMDL for Lake Pepin, the MPCA identified the need for site-specific criteria. The MPCA proceeded first with development of a site-specific standard for TSS in 2010 for Pools 2 and 3: 32 mg/L. In 2011, following the recommendation of the Lake Pepin TMDL SAP, the MPCA published site-specific eutrophication criteria for Lake Pepin to provide protection of aquatic recreational uses: 100 µg/L TP and 28 µg/L Chl-*a*. The MPCA Citizens' Board adopted the criteria in 2014 as part of an amendment to the state's water quality standards. The RES were developed and adopted in August 2014 and approved by the EPA in January 2015. Also in 2015, the MPCA issued the South Metro Mississippi River TSS TMDL, calling for large reductions in upstream sediment loads, primarily from the Minnesota River Basin, to decrease turbidity and improve aquatic life in Pool 2. With the site-specific nutrient criteria now in-place, and the South Metro Mississippi River TSS TMDL completed, the foundation has been laid for phosphorus TMDLs to protect Lake Pepin and the upstream impaired reaches of the Mississippi River.

2. Applicable Water Quality Standards and Numeric Water Quality Targets

Under the Federal CWA, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters. Water quality standards were first adopted in Minnesota in 1967 and have gone through numerous revisions. These standards represent a level of water quality that will support the CWA's goal of "fishable and swimmable" waters. Water quality standards consist of three components: beneficial uses, narrative and numeric criteria, and an antidegradation policy. Water quality standards can be found in Minn. R. ch. 7050. The Lake Pepin Watershed TMDLs have been developed to control phosphorus loads to prevent impairment of aquatic life and recreational uses in the main-stem Mississippi River resulting from eutrophication. Eutrophication is defined in Minn. R. ch. 7050.0150 subp. 4.L as:

> "Eutrophication" means the increased productivity of the biological community in water bodies in response to increased nutrient loading. Eutrophication is characterized by increased growth and abundance of algae and other aquatic plants, reduced water transparency, reduction or loss of DO, and other chemical and biological changes. The acceleration of eutrophication due to excess nutrient loading from human sources and activities, called cultural eutrophication, causes a degradation of water quality and possible loss of beneficial uses.

The Lake Pepin Watershed TMDLs have been developed to control phosphorus loads to prevent impairment of aquatic life and recreational uses in the main-stem Mississippi River resulting from eutrophication. The remainder of this section describes Minnesota's designated uses and criteria to support those uses as they apply to the Lake Pepin Watershed phosphorus TMDLs.

2.1. State of Minnesota Designated Uses

Lakes and streams in Minnesota have a Designated Use Classification defined by Minn. R. ch. 7050.1040, which sets the desired beneficial uses for a specific waterbody, describing the attainable aquatic life and recreational uses. Waters of Minnesota are assigned classes based on their suitability for the following beneficial uses:

1. Domestic consumption
2. Aquatic life and recreation
3. Industrial consumption
4. Agriculture and wildlife
5. Aesthetic enjoyment and navigation
6. Other uses
7. Limited resource value

The waterbodies addressed by the TMDLs in this report include one or more of the following use classifications: 1C, 2B or 2Bd, and 3C. Class 1C refers to domestic consumption uses (Minn. R. ch. 7050.0221, subp. 4). Class 3C refers to industrial consumption uses (Minn. R. ch. 7050.0223, subp. 4).

Classes 2B and 2Bd both refer to cool or warm water aquatic life and aquatic recreation uses. Class 2Bd distinguishes itself from Class 2B in that 2Bd waters are also protected as a source of drinking water. The impaired uses addressed by the TMDLs in this report pertain to the aquatic life and aquatic recreation uses for Class 2B and 2Bd waters. These uses are defined as follows:

- **Class 2B waters:** "The quality of class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm aquatic biota their habitats according to the definitions in subpart 4c. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface water is not protected as a source of drinking water." (Minn. R. ch. 7050.0222, subp. 4)
- **Class 2Bd waters:** "The quality of Class 2Bd surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface waters is also protected as a source of drinking water." (Minn. R. ch. 7050.0222, subp. 3)

Table 2 lists the applicable use classifications for each of the impaired AUIDs addressed in this TMDL report. The beneficial use subclass designator "g" is included with many of these uses. Class 2Bg and 2Bdg waters are protected for "general" cool and water water aquatic life and habitat (Minn. R. ch. 7050.0222, subp. 3c.C and Minn. R. ch. 7050.0222, subp. 4c.C)

Table 2. Designated use classifications for impaired AUIDs.

Impaired Waterbody Segment	AUID	Designated Use Classification
Lake Pepin	25-0001-00	2B
Mississippi River: Upper St. Anthony Falls to St. Croix River	07010206-814	2Bg
Mississippi River: Crow River to Upper St. Anthony Falls	07010206-805	2Bdg

2.2. State of Minnesota Water Quality Standards and Criteria for Listing

Minnesota's eutrophication standards, as defined in Minn. R. ch. 7050.0150, subp. 4.H, include a combination of indicators of enrichment, such as elevated phosphorus concentrations, and indicators of response, such as excessive algae growth. Minn. R. ch. 7050.0150, subp. 5 describes the type of enrichment and response indicators that can be applied to determine impairment of waters due to excess algae or plant growth.

Note that all impaired AUIDs addressed by the TMDLs in this report are considered rivers under MPCA rules, including Lake Pepin even though it has "lake" in its name. Narrative standards to protect against eutrophication in Class 2Bd waters are defined in Minn. R. ch. 7050.0222, subp. 3a and 3b. Class 2B narrative eutrophication standards are identical to those for Class 2Bd waters and are found in Minn. R. ch. 7050.0222, subp. 4a and 4b.

The MPCA has also developed and promulgated specific numeric criteria to supplement the narrative eutrophication standards to protect designated uses from detrimental impacts of excessive phosphorus concentrations and eutrophication. Exceedance of the indicator of enrichment, such as TP, and response, such as Chl-*a*, is required to indicate an impaired condition. The eutrophication criteria are applicable as a summer average during the summer season as defined in Minn. R. ch. 7050.0150, subp. 4:

- "Summer-average" means a representative average of concentrations or measurements of nutrient enrichment factors, taken over one summer season.
- "Summer season" means a period annually from June 1 through September 30.

A 10-year average of the summer averages is considered when making a determination of impairment. A timeframe of longer than 10 years may be used when modeling reduction targets for eutrophication standards. The eutrophication status of rivers and Lake Pepin can vary dramatically based on annual weather patterns. The Upper Mississippi-Lake Pepin (UMR-LP) model used for this TMDL has 22 years of output to cover a wide range of weather conditions.

The development of site-specific criteria for Lake Pepin and RES applicable to the TMDLs included in this report are briefly described below. A summary of specific numeric criteria applicable to the impaired AUIDs is presented in Table 3. These criteria are from Minn. R. ch. 7050.0222, subp. 3 for Class 2Bd waters and Minn. R. ch. 7050.0222, subp. 4 for Class 2B waters.

Table 3. Water quality criteria for impaired AUIDs.

Impaired Waterbody Segment	Use Class	Region	Total Phosphorus (µg/L)	Chl-*a* (µg/L)	BOD5 (mg/L)	DO Flux (mg/L/day)	pH
Lake Pepin: 25-0001-00	2B	Site-Specific	100	28	-	-	6.5-9.0
Mississippi River: Upper St. Anthony Falls to St. Croix River: 07010206-814	2Bg	Site-Specific	125	35	-	-	6.5-9.0
Mississippi River: Crow River to Upper St. Anthony Falls: 07010206-805	2Bdg	Central	100	18	2.0	3.5	6.5-9.0

Lake Pepin: Site-specific eutrophication standards for Lake Pepin are included in Minn. R. ch. 7050.0222, subp. 4:

- Phosphorus, total µg/L less than or equal to 100
- Chl-*a* (seston) µg/L less than or equal to 28

Development of the Lake Pepin site specific standards is described in *Lake Pepin Site Specific Eutrophication Criteria* (MPCA 2011). The role of upstream loadings of nutrients, solids, and algae were considered along with river flows and water residence time on the resulting level of algal production in Lake Pepin. These standards were established to provide protection of aquatic recreational uses for Lake Pepin and the downstream pools and should be applicable over the range of flows from which the criteria were developed. They are consistent with criteria for large rivers developed by Wisconsin.

Mississippi River Navigational Pool 2 (Upper St. Anthony Falls to St. Croix River): Site-specific eutrophication standards for Pool 2 are included in Minn. R. ch. 7050.0222, subp. 4:

- Phosphorus, total µg/L less than or equal to 125

- Chl-*a* (seston) µg/L less than or equal to 35

Development of the Pool 2 site specific standards is described in *Mississippi River Pools 1 through 8: Developing River, Pool, and Lake Pepin Eutrophication Criteria* (MPCA 2012c). The criteria are designed to protect aquatic life in rivers and pools, while also protecting downstream aquatic life and recreation in Lake Pepin. Proposed criteria consider linkages among rivers, pools, and Lake Pepin, downstream transport of TP and algae, TP and Chl-*a* relationships, and the desire to minimize the frequency of nuisance blooms (Chl-*a* > 50 µg/L).

River Eutrophication Standards: Eutrophication standards for Class 2Bd and 2B rivers and streams are included in Minn. R. ch. 7050.0222, subp. 3 and 4. Standards have been developed for North, Central, and South Regions. The Central Region criteria apply to the impaired reach of the Mississippi River from the Crow River to Upper St. Anthony Falls.

- Central River Nutrient Region
    - Phosphorus, total µg/L less than or equal to 100
    - Chl-*a* (seston) µg/L less than or equal to 18
    - Diel DO flux mg/L less than or equal to 3.5
    - Biochemical oxygen demand (BOD5) mg/L less than or equal to 2.0

Development of the RES is described in *Minnesota Nutrient Criteria Development for Rivers* (MPCA 2013a). The MPCA used several studies and collected extensive data to develop the criteria, using multiple lines of. MPCA was able to demonstrate significant relationships among several sensitive macroinvertebrate and fish metrics and TP, TN, Chl-*a*, and DO flux. The MPCA applied quantile regression and changepoint analyses using macroinvertebrate and fish data to determine biological thresholds for nutrients and associated stressors.

When MPCA promulgated RES, it also adopted some important rule language to guide the implementation of TP water quality based effluent limits (WQBELs) for eutrophication standards. Minn. R. ch. 7053.0205, subp. 7.C. contains the following text:

> *Discharges of total phosphorus in sewage, industrial waste, or other wastes must be controlled so that the eutrophication water quality standard is maintained for the long-term summer concentration of total phosphorus, when averaged over all flows, except where a specific flow is identified in chapter 7050. When setting the effluent limit for total phosphorus, the commissioner shall consider the discharger's efforts to control phosphorus as well as reductions from other sources, including nonpoint and runoff from permitted municipal storm water discharges.*

The intent of this language was to characterize the unique frequency and duration of eutrophication standards and to recognize the impact of other sources of TP to Minnesota's lakes and rivers. The consideration of reductions from other sources is very prevalent in phosphorus TMDLs.

Sources of TP vary greatly during different weather patterns common on any given summer in Minnesota. The RES TMDLs included in this report are focused on average seasonal loading capacity (LC), but the sources of TP vary considerably during different flow conditions in the river. Point sources, such as WWTPs, can be a much larger relative source at low flows when algal growth is at its highest.

3. Watershed and Waterbody Characterization

This section briefly describes the general characteristics of Lake Pepin and its watershed, water quality conditions in the impaired AUIDs, and the sources of phosphorus.

3.1. Lake Pepin and Impaired Stream Reaches

Lake Pepin is a natural lake on the Mississippi River. The lake formed about 10,000 years ago behind an alluvial fan at the mouth of the Chippewa River, which dammed the Mississippi after outflow from Glacial Lake Agassiz was diverted northward and ceased to scour sediments deposited by the Mississippi's tributaries (Wright et al. 1998). It has a surface area of about 40 square miles and a mean depth of 18 feet (Table 4). Lake Pepin is characterized by two somewhat distinct segments (Figure 2). The upper (inflow) segment accounts for about 40% of the lake by area (~10,700 acres), but only about 28% by volume because it is very shallow (mean depth 12 feet) and is more "river-like" in nature. The lower segment is somewhat deeper (mean depth 22 feet) and accounts for about 72% of the lake by volume; this segment is more "lake-like" as compared to the upper segment.

Lake Pepin's watershed is about 47,363 square miles and includes the Upper Mississippi, St. Croix, and Minnesota Rivers. The watershed drains about 48% of Minnesota and small portions of Wisconsin, Iowa, and South Dakota (Wright et al 1998). This results in a watershed-to-lake ratio of about 1,193:1. This large watershed area promotes short water residence times that range from six to 47 days, with an average of 16 days. Because of its shallowness, residence time in the upper segment is very short, often less than two to three days, which limits its potential to grow algae.

Physical and chemical properties of Minnesota lakes and rivers different upon where they are located across the state. Regions where lakes have similar patterns in numbers of lakes, water quality, morphometry and watershed characteristics are referred to as ecoregions. These characteristics form the basis for Minnesota's ecoregion-specific water quality standards. Ecoregion reference lakes provide a basis for placing Lake Pepin's morphometric and watershed characteristics in perspective (Table 4). With a surface area of almost 40 square miles, Lake Pepin is over 40 times larger than the typical lake in the North Central Hardwood Forest (NCHF) and Western Corn Belt Plans (WCBP) ecoregions, and is over twice as large as the largest reference lake (16 square miles). Lake Pepin's mean and maximum depths are similar to the typical range for the NCHF lakes, but because of its large surface area, its volume is much greater. The most significant factor that differentiates it from the reference lakes is its huge watershed and consequently large watershed-to-lake ratio (Table 4), which is much larger than the mean and maximum watershed-to-lake ratios for all reference lakes (8:1 and 56:1 respectively; Heiskary and Wilson 2008). Lake Pepin's large watershed:lake ratio results in extremely short water residence times (measured in days) as compared to the reference lakes (and other glacial lakes in Minnesota), which are measured in years. Extremely large watershed:lake ratios and short water residence times result in high water and nutrient loading rates, rapid flushing, and reduced sedimentation – all of which influence algal growth and the processing of phosphorus.

The relatively large surface area, fetch, and moderate depth of Lake Pepin (Table 4) often prevent stratification throughout the summer. High flows in May and June effectively "flush out" any cool water in the hypolimnion that could allow for stronger stratification. For example, a series of 1990 and 1991 summer DO and temperature profiles indicated no distinct thermal stratification and minimal difference in surface and bottom water temperature on all monitoring dates (Heiskary and Vavricka, 1993). The net result of the limited to ephemeral stratification of Lake Pepin is a deeper mixed layer, which suppresses algal growth. Thus, Lake Pepin mixes like a shallow lake, yet has the depth of what is typically considered a deep lake. These unique characteristics supported the need for a site-specific eutrophication criterion for Lake Pepin.

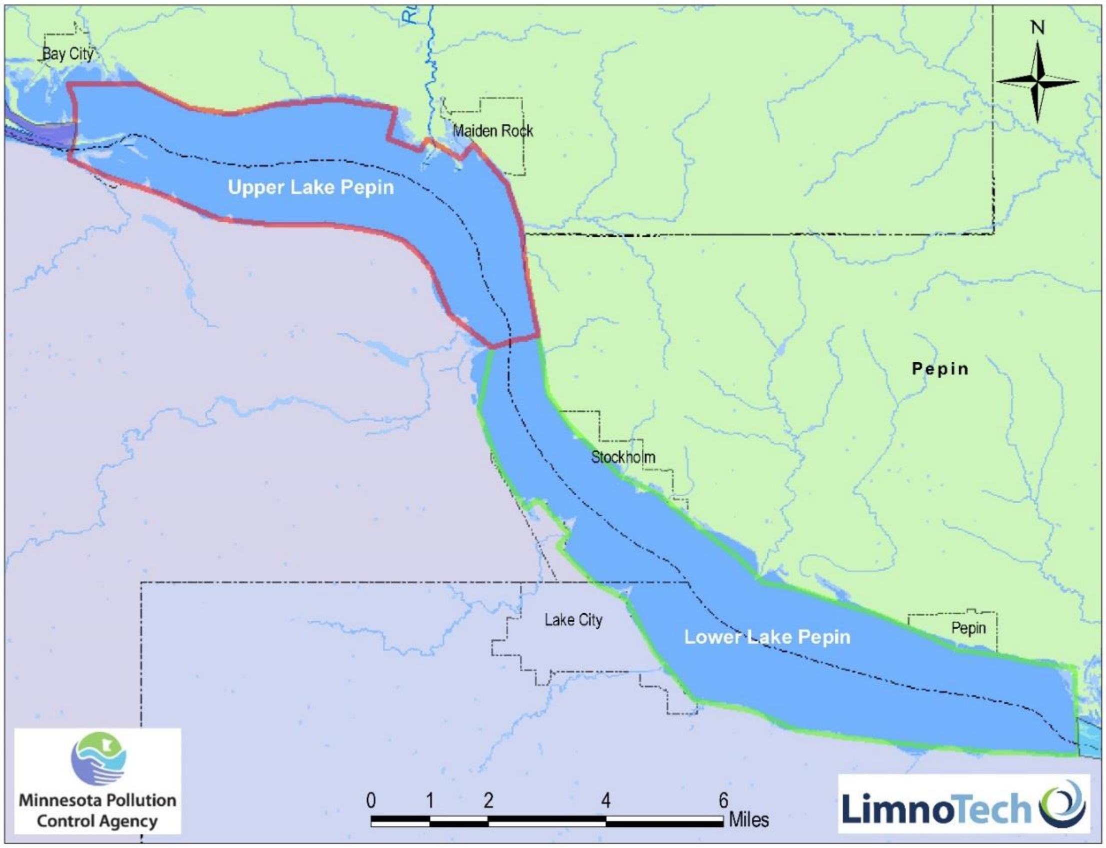


Figure 2. Map of Lake Pepin, with upper portion outlined in red, and lower portion outlined in green.

Table 4. Morphometric data for Lake Pepin, compared to lakes in the North Central Hardwood Forest (NCHF) and Western Corn Belt Plains (WCBP) ecoregions.

Parameter	Pepin*	NCHF (25^{th}-75^{th})**	WCBP (25^{th}-75^{th})**
Surface Area (*mi*^{2})	39.7	0.62 - 1.38	0.43 - 0.59
Mean depth (*ft*)	17.7	21 - 26	8 - 11
Maximum depth (*ft*)	56	43 - 73	10 - 27
Mixing depth (*ft*)	8 - 9	--	--
Maximum width (*mi*)	1 - 2	--	--
Maximum fetch (*mi*)	11.8	--	--
Length (*mi*)	20.8	--	--
Volume (*acre-ft*)	448,340	49,027 - 142,090	7,547 - 22,152
Watershed Area (*mi*^{2})	47,363	4 - 12	2 - 3
Watershed: lake surface area	1,193:1	6 - 9	4 - 7
Mean Hydraulic Retention Time	0.04 year (16 days)	9.3 years (mean)	4.8 years (mean)

*Data source: Heiskary and Varvricka, 1993

**Data source: Heiskary and Wilson 2008

In addition to Lake Pepin, the impaired stream reaches addressed in this TMDL are on the Minnesota River and Mississippi River. Table 5 summarizes contributing drainage areas for each AUID. Drainage areas were delineated from DNR watershed Geographic Information Systems (GIS) layers. Note that Pool 3 of the Mississippi River, between the St. Croix River and Lake Pepin, is not impaired by eutrophication.

Table 5. AUID reach length and total contributing watershed area of impaired stream reaches.

Impaired Waterbody Segment	AUID	AUID Length (miles)	Total Watershed Area (sq. mi)
Mississippi River: Upper St. Anthony Falls to St. Croix River	07010206-814	41.13	37,111
Mississippi River: Crow River to Upper St. Anthony Falls	07010206-805	25.81	19,640

3.2. Watershed Characteristics

Lake Pepin's watershed drains from several ecoregions (Figure 3). The Lake Pepin Watershed is composed of three major basins (Upper Mississippi, Minnesota, and St. Croix as shown in Figure 4) that are made up of 33 HUC-8 and an additional 10 HUC-10 basins. The major basins were delineated to best accommodate the development of the TMDLs in this report. Table 6 lists the HUC-8 and HUC-10 watersheds in each basin.

Tribal lands are included in the impaired watersheds. The TMDLs presented in this report do not address Tribal lands. Further discussion of Tribal lands is presented in Section 5.9. A map of tribal lands within the impaired watersheds is presented in Appendix D.

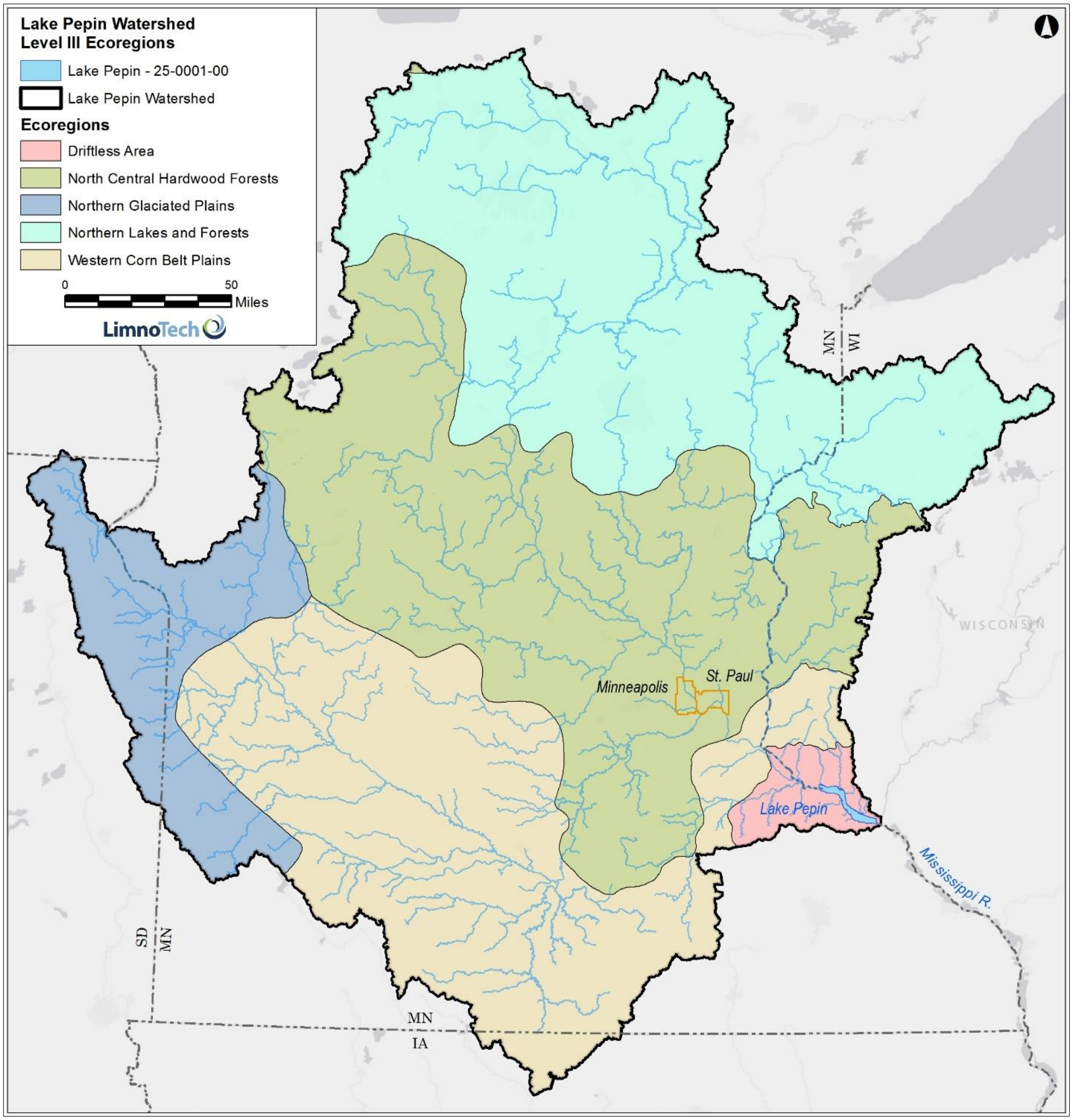


Figure 3. United States Level III Ecoregions within the Lake Pepin Watershed.

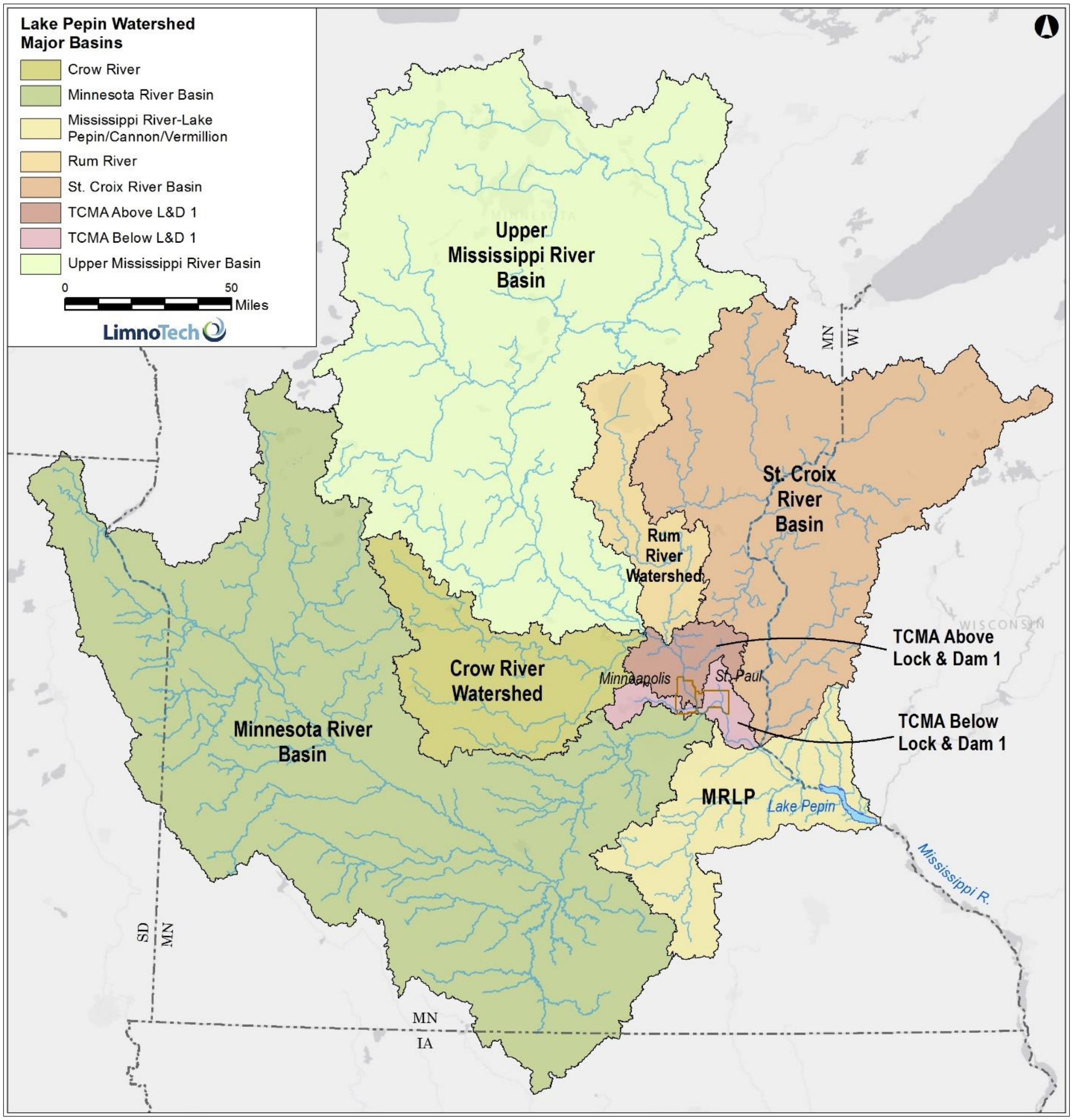


Figure 4. Map of the major drainage areas that make up the Lake Pepin Watershed (TCMA = Twin Cities Metro Area).

Table 6. HUC-8 or HUC-10 watersheds within each of the major drainage basins in the Lake Pepin Watershed.

<table>
<tr><th>Major Basin</th><th colspan="2">Contributing Watershed</th></tr>
<tr><td rowspan="11">Upper Mississippi River Basin</td><td rowspan="11">HUC-8</td><td>Mississippi River - St. Cloud 07010203</td></tr>
<tr><td>Sauk River 07010202</td></tr>
<tr><td>Mississippi River - Sartell 07010201</td></tr>
<tr><td>Mississippi River - Brainerd 07010104</td></tr>
<tr><td>Crow Wing River 07010106</td></tr>
<tr><td>Long Prairie River 07010108</td></tr>
<tr><td>Redeye River 07010107</td></tr>
<tr><td>Pine River 07010105</td></tr>
<tr><td>Mississippi River - Grand Rapids 07010103</td></tr>
<tr><td>Leech Lake River 07010102</td></tr>
<tr><td>Mississippi River - Headwaters 07010101</td></tr>
<tr><td>Rum River Watershed</td><td>HUC-8</td><td>Rum River 07010207</td></tr>
<tr><td rowspan="2">Crow River Watershed</td><td rowspan="2">HUC-8</td><td>North Fork Crow River 07010204</td></tr>
<tr><td>South Fork Crow River 07010205</td></tr>
<tr><td rowspan="5">St. Croix River Basin</td><td rowspan="5">HUC-8</td><td>Lower St. Croix River 07030005</td></tr>
<tr><td>Snake River 07030004</td></tr>
<tr><td>Upper St. Croix River 07030001</td></tr>
<tr><td>Kettle River 07030003</td></tr>
<tr><td>Namekagon River 07030002</td></tr>
<tr><td rowspan="12">Minnesota River Basin</td><td rowspan="12">HUC-8</td><td>Lower Minnesota River 07020012</td></tr>
<tr><td>Minnesota River - Mankato 07020007</td></tr>
<tr><td>Le Sueur River 07020011</td></tr>
<tr><td>Blue Earth River 07020009</td></tr>
<tr><td>Watonwan River 07020010</td></tr>
<tr><td>Cottonwood River 07020008</td></tr>
<tr><td>Redwood River 07020006</td></tr>
<tr><td>Minnesota River - Yellow Medicine River 07020004</td></tr>
<tr><td>Lac Qui Parle River 07020003</td></tr>
<tr><td>Minnesota River - Headwaters 07020001</td></tr>
<tr><td>Chippewa River 07020005</td></tr>
<tr><td>Pomme de Terre River 07020002</td></tr>
<tr><td rowspan="6">Twin Cities Metro Area Above Lock and Dam 1 (Minneapolis)</td><td rowspan="6">HUC-10</td><td>City of Minneapolis - Mississippi River 0701020607</td></tr>
<tr><td>Bassett Creek 0701020605</td></tr>
<tr><td>Rice Creek 0701020603</td></tr>
<tr><td>Shingle Creek 0701020604</td></tr>
<tr><td>Coon Creek 0701020602</td></tr>
<tr><td>Elm Creek 0701020601</td></tr>
<tr><td rowspan="4">Twin Cities Metro Area Below Lock and Dam 1 (Minneapolis)</td><td rowspan="4">HUC-10</td><td>Lock and Dam No 2 - Mississippi River - 0701020609</td></tr>
<tr><td>City of St. Paul - Mississippi River 0701020608</td></tr>
<tr><td>City of Minneapolis - Mississippi River 0701020607</td></tr>
<tr><td>Minnehaha Creek 0701020606</td></tr>
<tr><td rowspan="2">Mississippi River - Lake Pepin</td><td rowspan="2">HUC-8</td><td>Mississippi River-Lake Pepin, a.k.a. Rush-Vermillion 07040001</td></tr>
<tr><td>Cannon River 07040002</td></tr>
</table>

3.2.1. Land Use

Land use in Minnesota ranges across the state with northern Minnesota being dominated by natural hardwood forests and southern Minnesota dominated by cultivated crops. The National Land Cover Database (NLCD) of 2011 was used to determine predominant land use in each major basin. Figure 5 shows the land use categories in the Lake Pepin Watershed.

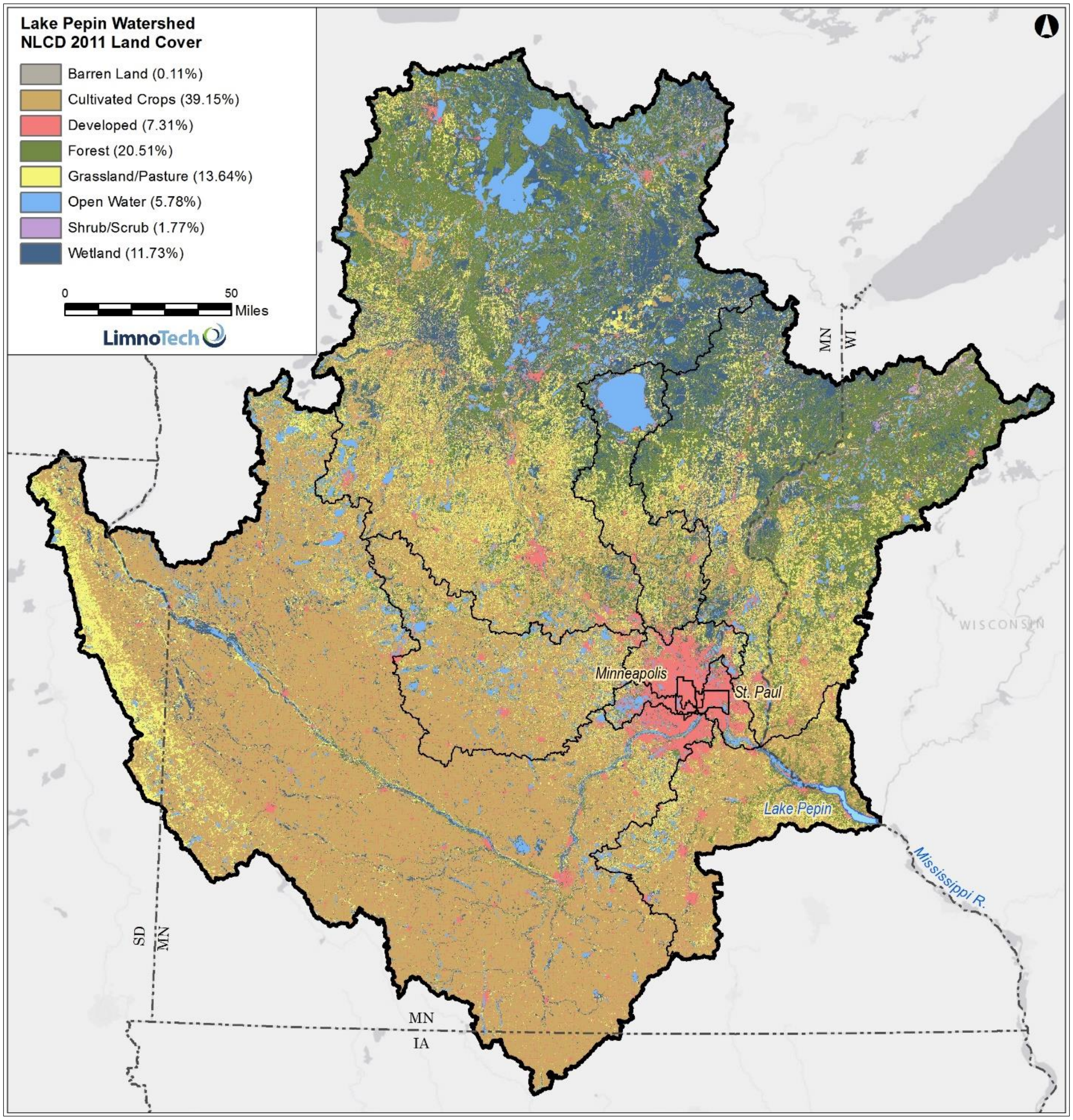


Figure 5. Land cover categories in the Lake Pepin Watershed (based on 2011 NLCD).

<u>Upper Mississippi River Basin</u>

The Upper Mississippi River Basin is composed of three major drainage basins: Upper Mississippi, Crow River, and Rum River. It is the largest drainage area contributing to Lake Pepin, approximately 40.3% of the total area. The predominant land uses for this region are cultivated crops, forests, and grassland/pastures, each contributing 21.6%, 29.2%, and 15.4% of the basin area, respectively. The northern most part of the watershed is heavily forested and designated as the Northern Lakes and Forests Ecoregion. Moving south through the watershed towards the Twin Cities there is an increase in cultivated cropland, which is a significant nutrient source to lakes and rivers.

St. Croix River Basin

The St. Croix River originates in Upper St. Croix Lake near Solon Springs, Wisconsin, from which it flows west and south more than 160 miles until it joins the Mississippi River at Prescott, Wisconsin. About 80% (129 miles) of the St. Croix River forms part of the boundary between Wisconsin and Minnesota. The upper 20% of the river is entirely within Wisconsin. The watershed covers about 4.9 million acres and extends from near Mille Lacs Lake in Minnesota on the west to near Clam Lake, Wisconsin, on the east. About 46% of the watershed is located in Minnesota. The St. Croix River Basin accounts for about 20% of the contributing area of the Lake Pepin Watershed.

The primary land uses in the St. Croix River Basin are forests and grassland/pasture at 42.5% and 17.1% respectively. Wetlands prevail throughout the north-northcentral region on the Minnesota side and in total make up 17.6% of the basin area.

Minnesota River Basin

The Minnesota River Basin is the second largest contributor to Lake Pepin in terms of drainage area. It makes up 35.9% of the total drainage area and is heavily farmed – 71.9% of the land use is cultivated crops. Phosphorus binds to soils and as such, TSS sources are positively correlated to phosphorus sources. In the lower precipitation area of the western basin, land use includes corn production, soybean production, wheat production and grazing of beef cattle. Runoff rates are relatively low, along with average TSS concentrations. Tributaries such as the Pomme de Terre River and Lac Qui Parle River continue to support fairly healthy beds of mussels, a sign of relatively good water quality.

As the river enters south-central Minnesota, higher average precipitation and rich, fine-textured soils favor the corn-soybean rotation, with some sugar beet production. Land drainage through surface ditches and pattern tiling is more intense here, and TSS concentrations of the main stem grow progressively higher as the river approaches the confluence with the Blue Earth River watershed. Here, TSS concentrations jump considerably in response to the extremely high sediment loads dumped into the river from the Le Sueur and Blue Earth Rivers, which discharge through a common outlet at Mankato.

From Mankato to St. Peter, TSS concentrations tend to remain high, fed by sediment-rich water discharged from small tributaries that comprise the Middle Minnesota River Watershed.

Twin Cities Metropolitan Area

The Twin Cities Metropolitan Area is comprised of two major drainage basins separated by Lock and Dam 1 (Minneapolis) on the Mississippi River. Roughly 54.2% of the total area is developed, and this area has the highest concentration of impervious surface in the Lake Pepin watershed. The urban areas in the metro area extend from heavily developed downtown Minneapolis and St. Paul to the lighter developed surrounding suburbs (greater Minneapolis). This area also contains the highest percentage of Municipal Separate Storm Sewer System (MS4) area coverage relative to the total drainage area, with dozens of cities and townships having an MS4 program. Beyond the extent of the greater Minneapolis area, land use shifts to a mix of forest, grass/pasture, and cultivated crops. Dozens of lakes and streams scattered throughout the metro area, including Lake Minnetonka in the western suburbs and the Mississippi River, make up 9.3% of the total area.

<u>Mississippi River-Lake Pepin Direct Tributaries</u>

The MRLP Watershed is a HUC-8 watershed that also includes the Cannon River Watershed (CRW) HUC-8 for this TMDL. The majority of the land use is cultivated crops (53.3%), followed by grass/pasture (15.8%) and forest (13.2%). Pool 3, Lake Pepin, Lake Byllesby, and several smaller lakes in the CRW comprise the 4.5% of open water.

3.2.2. Hydrology

A summary of the relative size of each major basin and the average flow contribution is presented in

Table 7.

Table 7. Hydrologic summary for each major drainage basin.

Major Basin	Watershed Area (mi2)	Percent of Contributing Area to Lake Pepin	Average Flow Contribution (cfs)	Percent of Contributing Flow to Lake Pepin
Upper Mississippi River	19,094	40.3%	9,674	38.7%
St. Croix River	7,671	16.2%	5,990	23.9%
Minnesota River	17,010	35.9%	7,003	28.0%
Twin Cities Metropolitan Area	1,007	2.1%	473	1.9%
Mississippi River-Lake Pepin Tributaries	2,581	5.5%	1,890	7.5%
Total Lake Pepin Watershed	47,363	-	25,029	-

The MCES also summarized flows at major USGS and U.S. Army Corps of Engineers gauging stations in their *Regional Assessment of River Water Quality in Twin Cities Metropolitan Area: 1976-2015* report (MCES Regional Assessment of River Quality, MCES 2018). Figure 6 presents median flows at these gauges in the TCMA.

Table 8 presents a general description of the impaired AUID segments including major tributary streams and dams within each of the segments. Maps of each impaired AUID are included in Appendix A. Note that Pool 3 of the Mississippi River, between the St. Croix River and Lake Pepin, is not impaired by eutrophication.

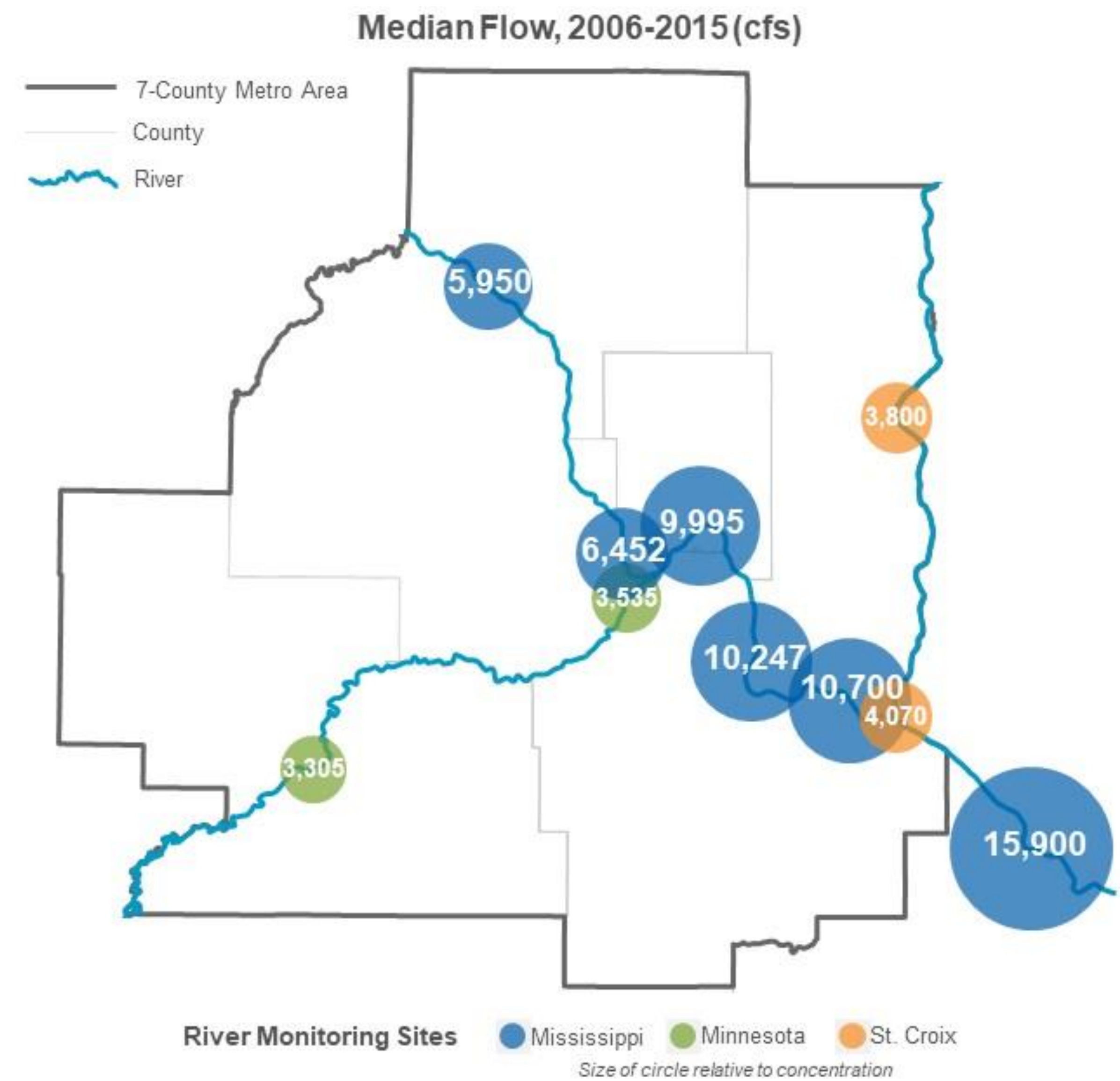


Figure 6. MCES assessment of median flows at gauges in the TCMA.

Table 8. Hydrologic summary of each impaired AUID segment.

Impaired AUID Segment	AUID	Upstream End	Downstream End	Major Tributaries	Dams & Pools within AUID
Lake Pepin	25-0001-00	Below Lock & Dam #3 at Red Wing, MN, where the Mississippi River widens to form Lake Pepin near Bay City, WI	Shortly upstream of the confluence with the Chippewa River on the Wisconsin side	Wells Cr., Gilbert Cr., and Miller Cr. on the Minnesota side; Isabelle Cr., the Rush River, Bogus Cr., and Lost Cr. on the Wisconsin side	Lock & Dam #3 is upstream of the upstream end of the AUID, Lock & Dam #4 is downstream of Lake Pepin. Lake Pepin comprises a significant portion of Pool 4
Mississippi River: Upper St. Anthony Falls to St. Croix River	07010206-814	Upper St. Anthony Falls in Minneapolis	Confluence with the St. Croix River	Stormwater drainage from Minneapolis and St. Paul, Minnehaha Cr., Minnesota River	Upper St. Anthony Falls Lock & Dam is the upstream boundary; Lower St. Anthony Falls Lock & Dam, Lock & Dam #1 (Ford Dam) and Lock & Dam #2 are all within the AUID. Pool 1 upstream of LD1 and Pool 2/Spring Lake upstream of LD2 are within the AUID
Mississippi River: Crow River to Upper St. Anthony Falls	07010206-805	Confluence with the Crow River	Upper St. Anthony Falls	Crow River, Rum River, Elm Cr., Coon Cr., Rice Cr., Shingle Cr., and Bassett Cr.	---

3.3. Historic and Current Water Quality Conditions of Impaired Waters

The MPCA placed Lake Pepin on the CWA Section 303(d) impaired waters list for excess nutrient (also called eutrophication) impairment in 2002 based on data collected from 1991 – 2000, expressed as June through September mean values:

- TP 198 (±4) ppb based on 160 observations
- Chl-*a* 25 (±1) ppb based on 158 observations
- Secchi 1.0 (±0.3) m based on 240 observations

Data sources included the U.S. Geological Survey's Long-Term Resource Monitoring Program (LTRMP) fixed site monitoring, MCES, and MPCA. These data were evaluated in the context of ecoregion mean values in accordance with MPCA guidance. TP and Chl-*a* were in excess of NCHF ecoregion thresholds, and water transparency readings (Secchi) were low. The MPCA recommended impairment listing based on these values.

3.3.1. Mississippi River – Lake Pepin

Figure 7 shows Lock and Dam 3, Lake Pepin and water quality sampling stations. Since the mid-1990s, the USGS LTRMP has been the principal source of data for Lake Pepin. Water quality data collected during 2007 through 2016 at four LTRMP sampling stations were used to characterize average TP and Chl-*a* concentrations for a 10-year period. This information is summarized in Table 9, Figure 8, and Figure 9. Over the most recent 10-year period, there is a decreasing trend in both TP and Chl-*a*. A detailed data and trend analysis through 2009 is provided in the Lake Pepin Site Specific Eutrophication Criteria Report (MPCA 2011).

Figure 10 presents TP loads at Lock & Dam 3 upstream of Lake Pepin. The data and calculated annual loads are provided by the MCES. This site is considered part of MPCA's Watershed Pollutant Load Monitoring Network (WPLMN). The recent 10-year average (2006 through 2015) of 2,702 metric tons per year is a 26% reduction from the baseline load of 3,676 metric tons per year (1980 through 1996). Much of this improvement can be attributed to reductions from WWTPs, as is shown in Section 3.4.1. Additional reductions are needed to attain the 2025 goal of 45% reduction. TSS loads at Lock and Dam 3 have also decreased in recent years, showing a 20% reduction from baseline loads as shown in Figure 11.

Note that the reach of the Mississippi River upstream of Lake Pepin, from the St. Croix River to Lake Pepin, is not impaired by phosphorus.

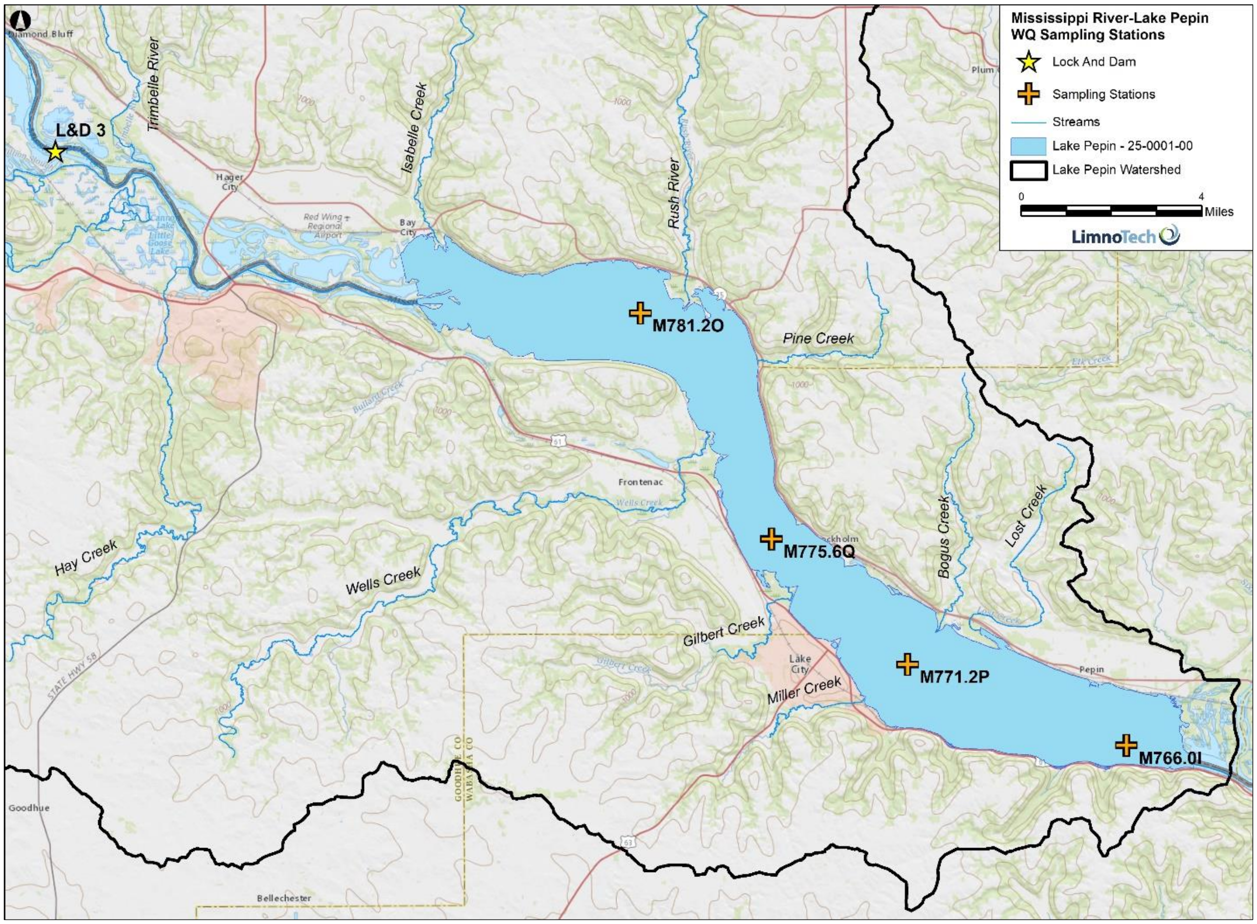


Figure 7. Lake Pepin and sampling locations used in water quality data analysis.

Table 9. Summary of water quality data for Lake Pepin. Data represent whole lake averages.

Listed Waterbody Name	Reach (AUID)	TP Standard (µg/L)	Average TP (µg/L)	Chl-*a* Standard (µg/L)	Average Chl-*a* (µg/L)	# Samples	Data Source
Lake Pepin	25-0001-00	100	153.75	28	28.8	74	LTRMP annual means 2007-2016

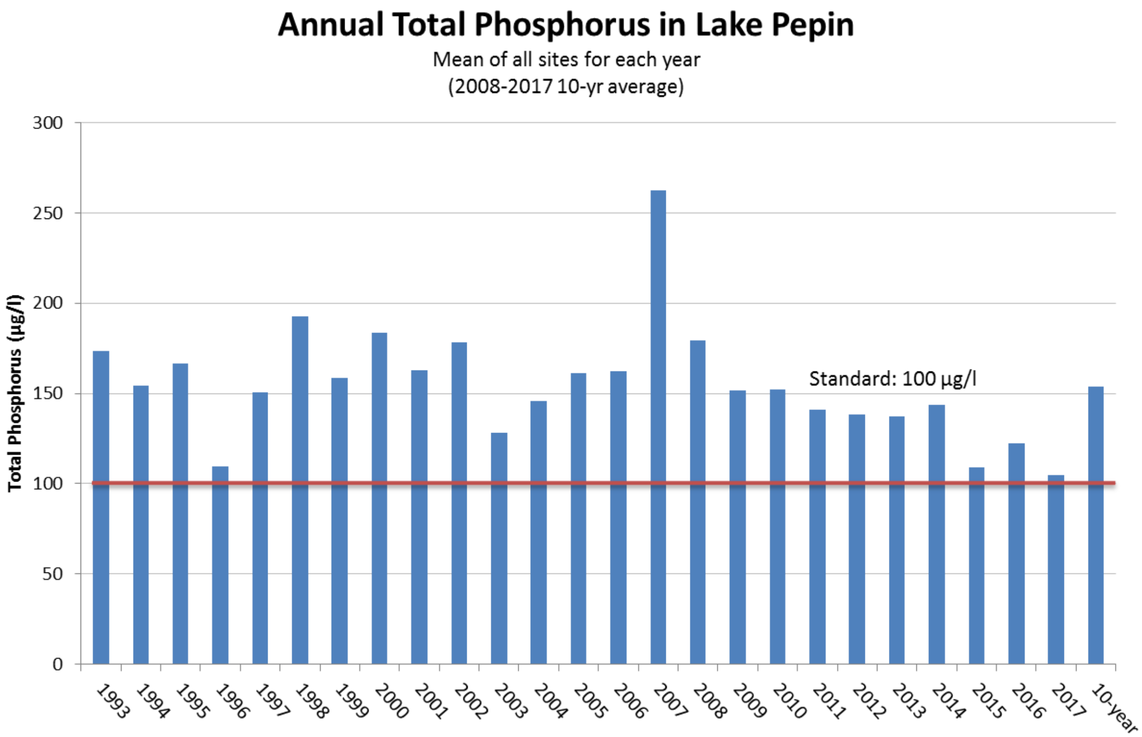


Figure 8. Long term total phosphorus data summarized into a composite concentration from the four monitoring stations.

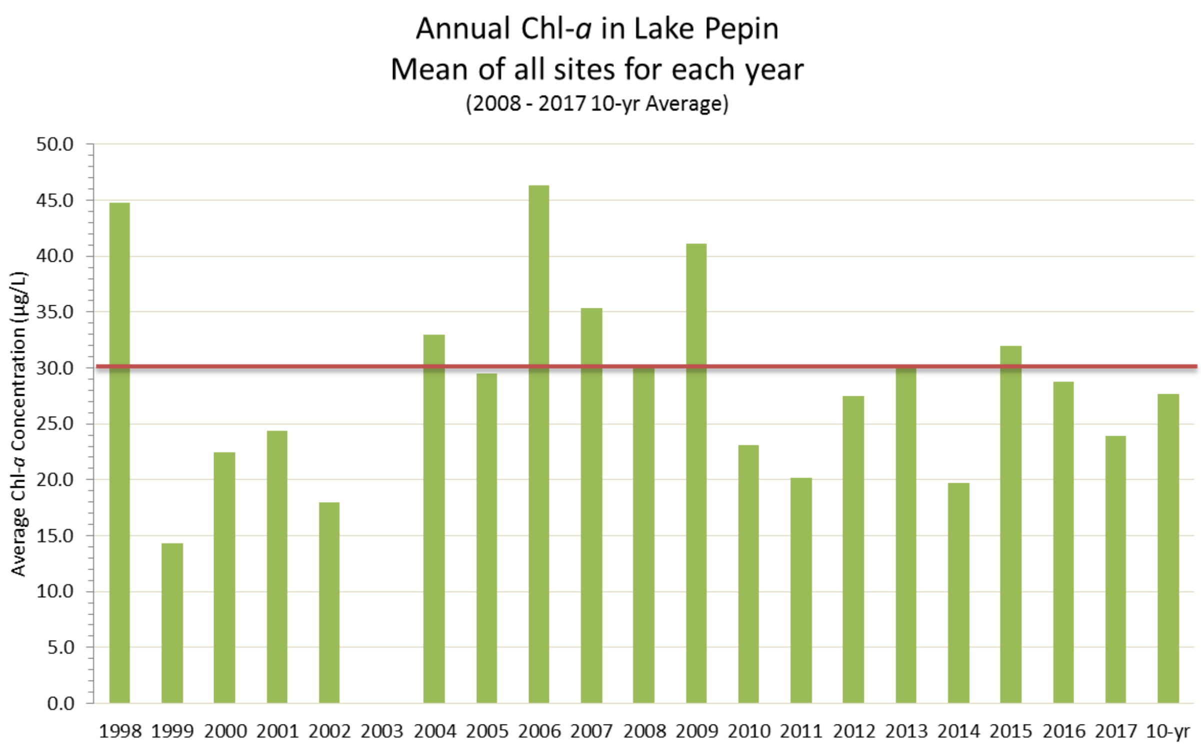


Figure 9. Long term Chl-*a* data summarized into a composite concentration from the four monitoring stations.

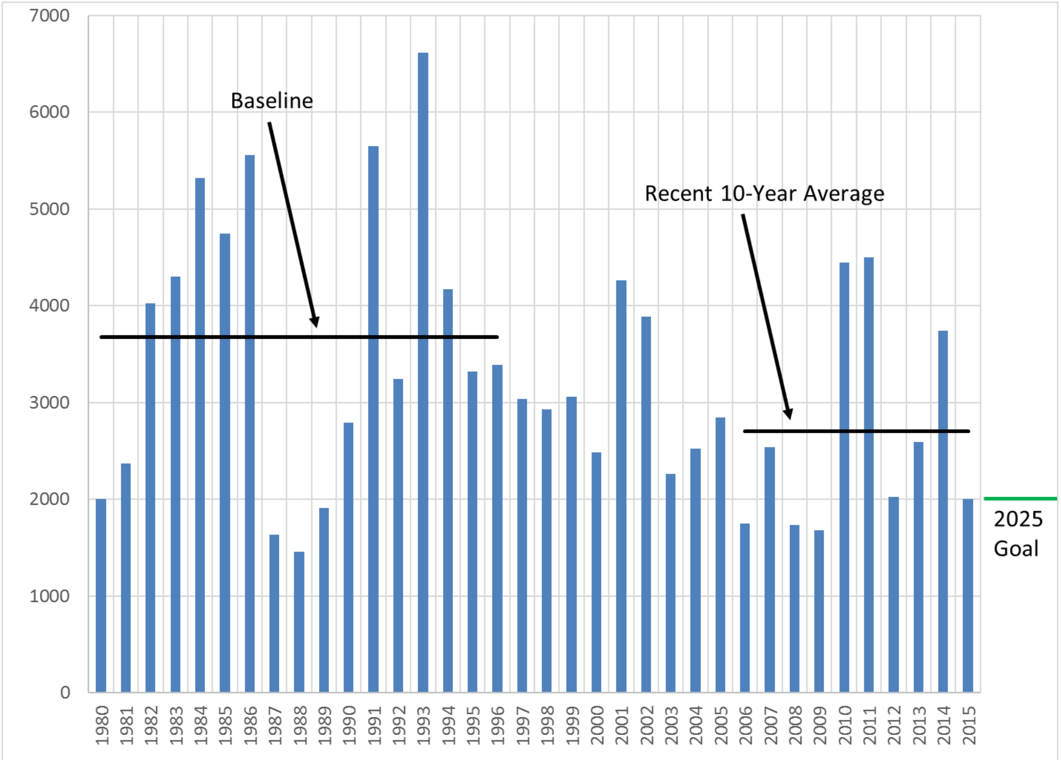


Figure 10. Mississippi River at Lock and Dam #3 – Total Phosphorus Load (Metric Tons).

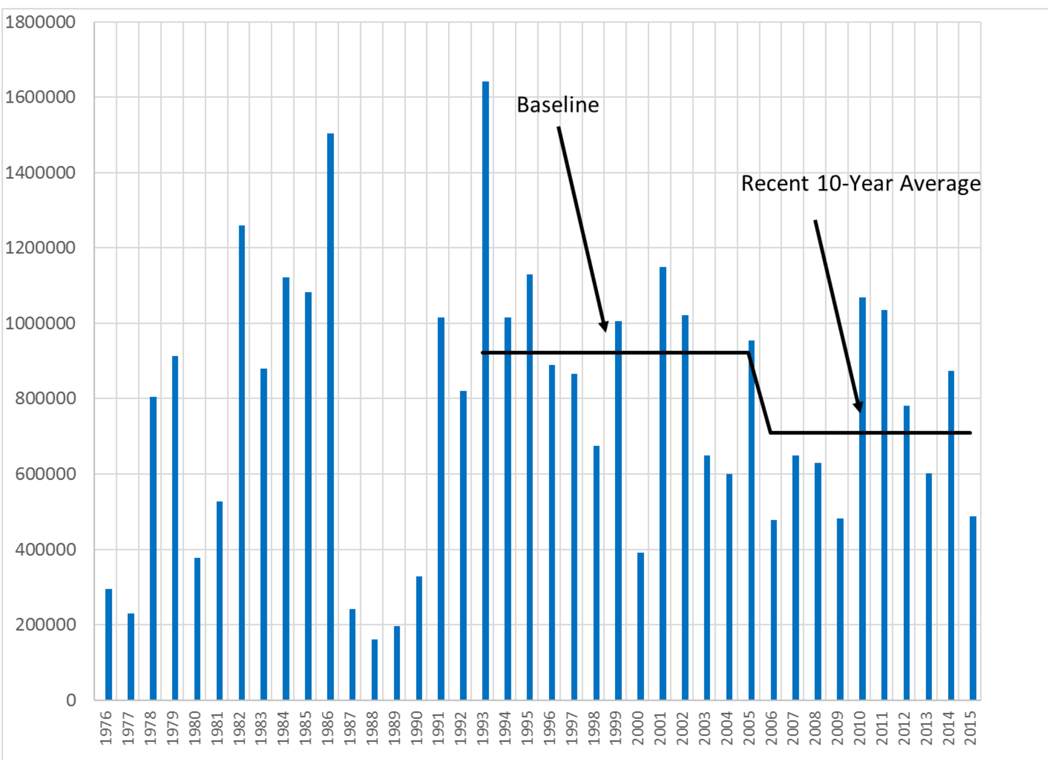


Figure 11. Mississippi River at Lock and Dam #3 – Total Suspended Solids Load (Metric Tons).

3.3.2. Twin Cities Metropolitan Area

Figure 12 shows the two impaired AUIDs on the Mississippi River upstream of Lake Pepin within the Twin Cities Metropolitan Area. Water quality data collected at MPCA sampling stations during the last

10 years were used to characterize average TP and Chl-*a* concentrations for each impaired reach. This information is summarized in Table 10. Note that the reach of the Mississippi River from the St. Croix River to Lake Pepin is not impaired by phosphorus.

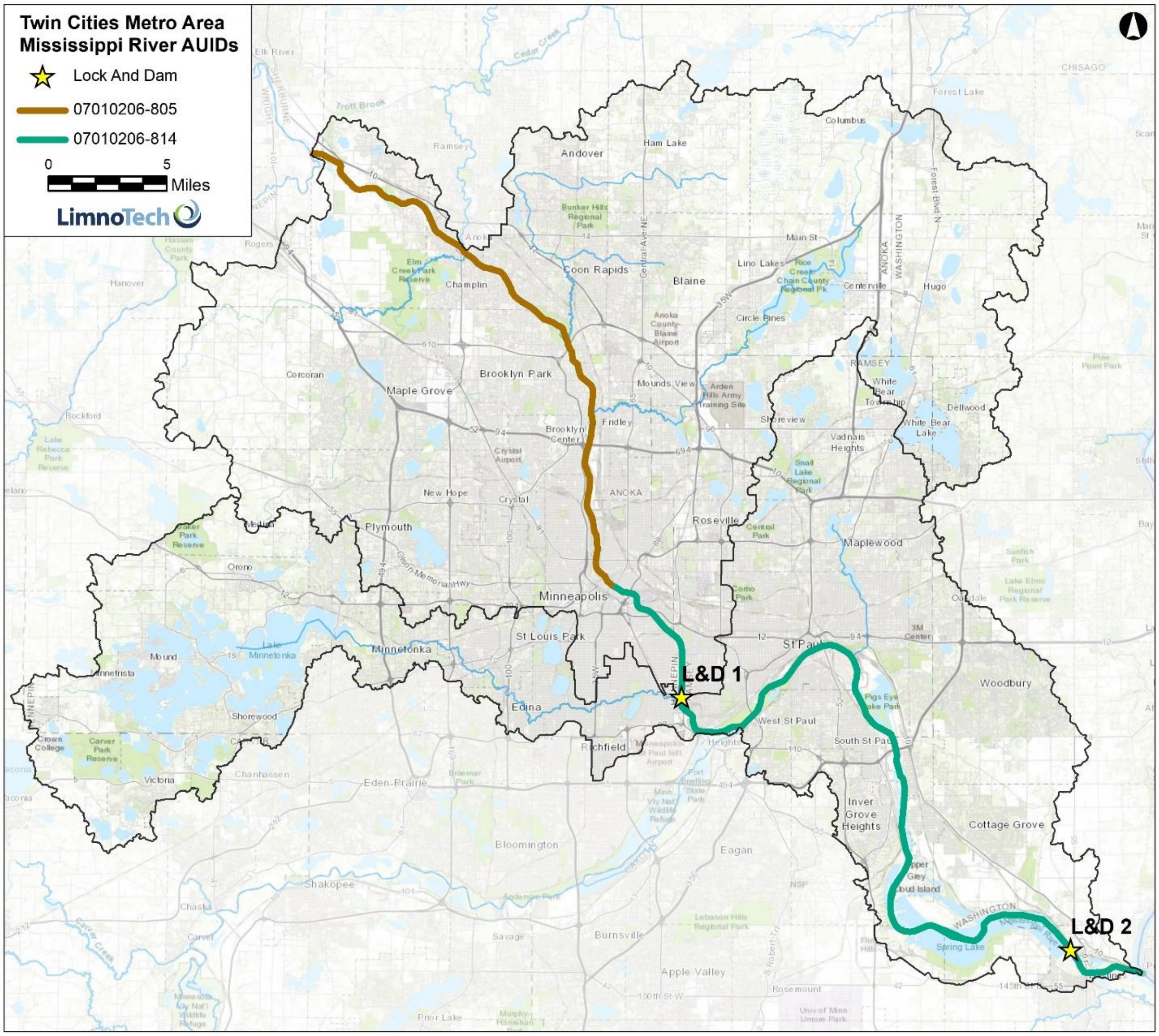


Figure 12. Impaired river reaches in the Twin Cities Metropolitan Area.

Table 10. Summary of water quality data for the impaired stream reaches in the Twin Cities Metropolitan Area.

Waterbody Name	Reach Description	Reach AUID	TP Standard (µg/L)	Average TP (µg/L)	Chl-*a* Standard (µg/L)	Average Chl-*a* (µg/L)	BOD Standard (mg/L)	Average BOD (mg/L)	# TP / Chl-*a* / BOD Samples	Sample Period
Mississippi River	Upper St. Anthony Falls to St. Croix River	07010206 -814	125	182.3	35	37.5	-	-	154 / 150/0	2004 - 2010
Mississippi River	Crow River to Upper St. Anthony Falls	07010206 -805	100	113.9	18	28.1	2.0	2.1	164 / 145/91	2006 - 2014

3.3.3. Minnesota River Basin

Figure 13 shows the AUIDs along the Minnesota River. Water quality data collected at MPCA sampling stations during summer (June through September) between 2006 through 2015 were used to characterize average TP, Chl-*a*, and BOD concentrations for each reach along the Minnesota River. Three reaches did not have data beginning in 2006, so the available period or record was used to characterized average TP, Chl-*a*, and BOD concentrations. This information is summarized in Table 11. Average concentrations of both TP and Chl-*a* in the most downstream reach of the Minnesota River are significantly higher than those observed in the Mississippi River reach from the Crow River to Upper St. Anthony Falls. The TP of 211.7 µg/L in the lower Minnesota River is 86% higher than the TP in the Mississippi River. Chl-*a* of 55.3 µg/L in the lower Minnesota River is 97% higher than the Chl-*a* in the Mississippi River. Figure 12 and Figure 13 compare the average summer TP and Chl-*a* concentrations by year in the Minnesota River and Mississippi River. More detailed assessments of water quality in the Minnesota River Basin can be found in the following sources:

- Lower Minnesota River Watershed Monitoring and Assessment Report

Table 11. Summary of average summer water quality data for impaired AUIDs in the Minnesota River Basin.

Reach Description	Reach AUID	Average TP (µg/L)	Average Chl-*a* (µg/L)	Average BOD (mg/L)	# TP / Chl-*a* / BOD Samples	Sample Period
River Mile 22 to Mississippi River	07020012-505	211.7	55.3	3.1	213 / 208 / 115	2006 - 2015
Carver Creek to River Mile 22	07020012-506	238.4	77.4	3.7	46 / 46 / 25	2006 - 2015
High Island Creek to Carver Creek	07020012-800	219.5	74.1	3.5	187 / 184 / 100	2006 - 2015
Cherry Creek to High Island Creek	07020012-799	182.2	67.4	4.1	26 / 26 / 12	2006 - 2015
Blue Earth River to Cherry Creek	07020007-723	248.6	61.7	4.5	169 / 106 / 13	2006 - 2015
Cottonwood River to Blue Earth River	07020007-722	231.5	59	4.1	164 / 79 / 11	2006 - 2015
Little Rock Creek to Cottonwood R	07020007-721	189.3	46.1	2.5	15 / 14 / 4	2014 - 2015
Beaver Creek to Little Rock Cr	07020007-720	250.2	57	4.5	150 / 22 / 11	2006 - 2015
Echo Creek to Beaver Creek	07020004-750	176.1	58.9	4.4	26 / 22 / 11	2006 - 2015
Yellow Medicine River to Echo Cr	07020004-749	164.8	45.2	2.7	16 / 14 / 3	2014 - 2015
Granite Falls Dam to Yellow Medicine R	07020004-748	219.8	40.9	2.9	92 / 14 / 46	2007 - 2015

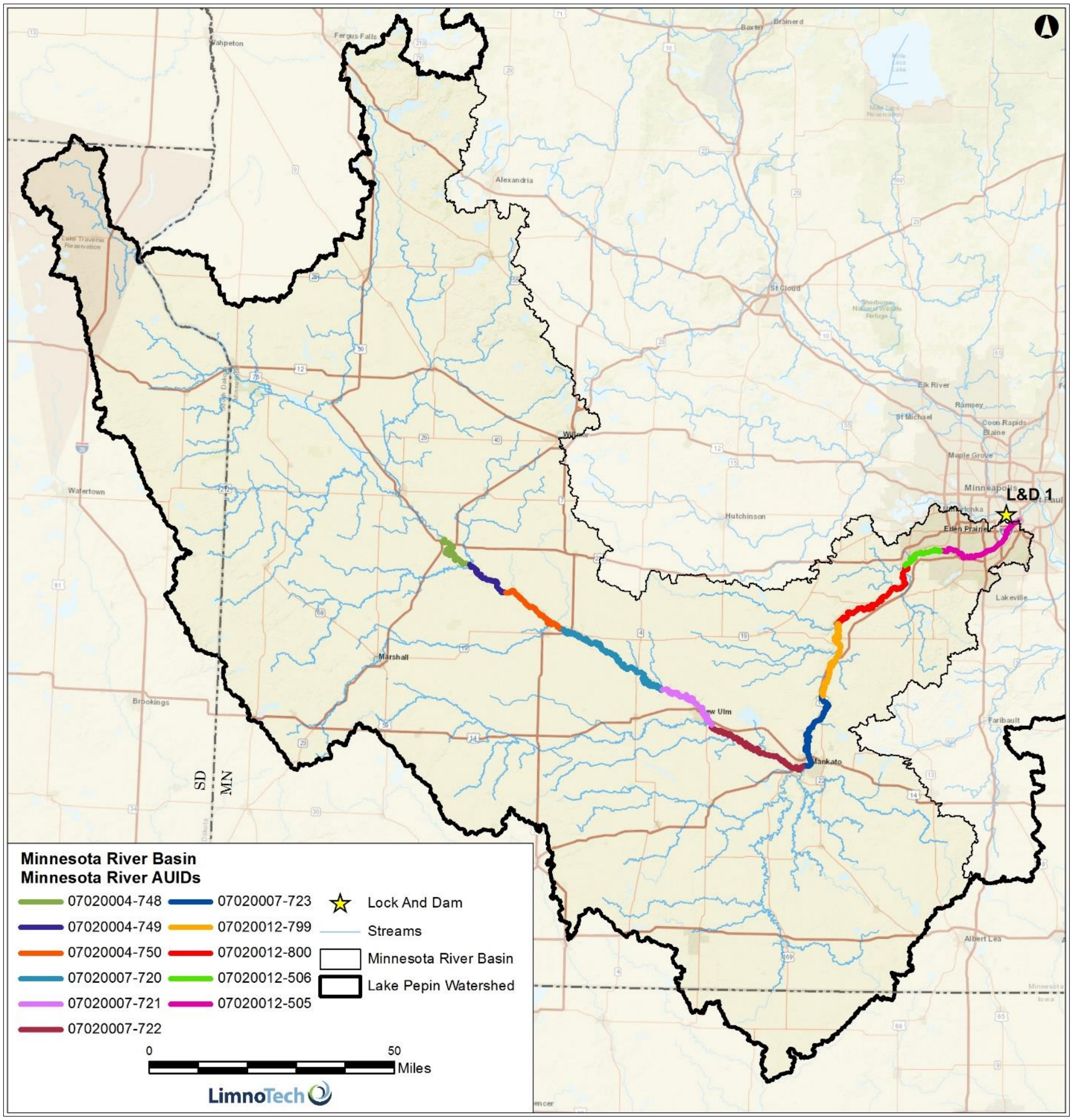


Figure 13. Minnesota River Basin AUIDs.

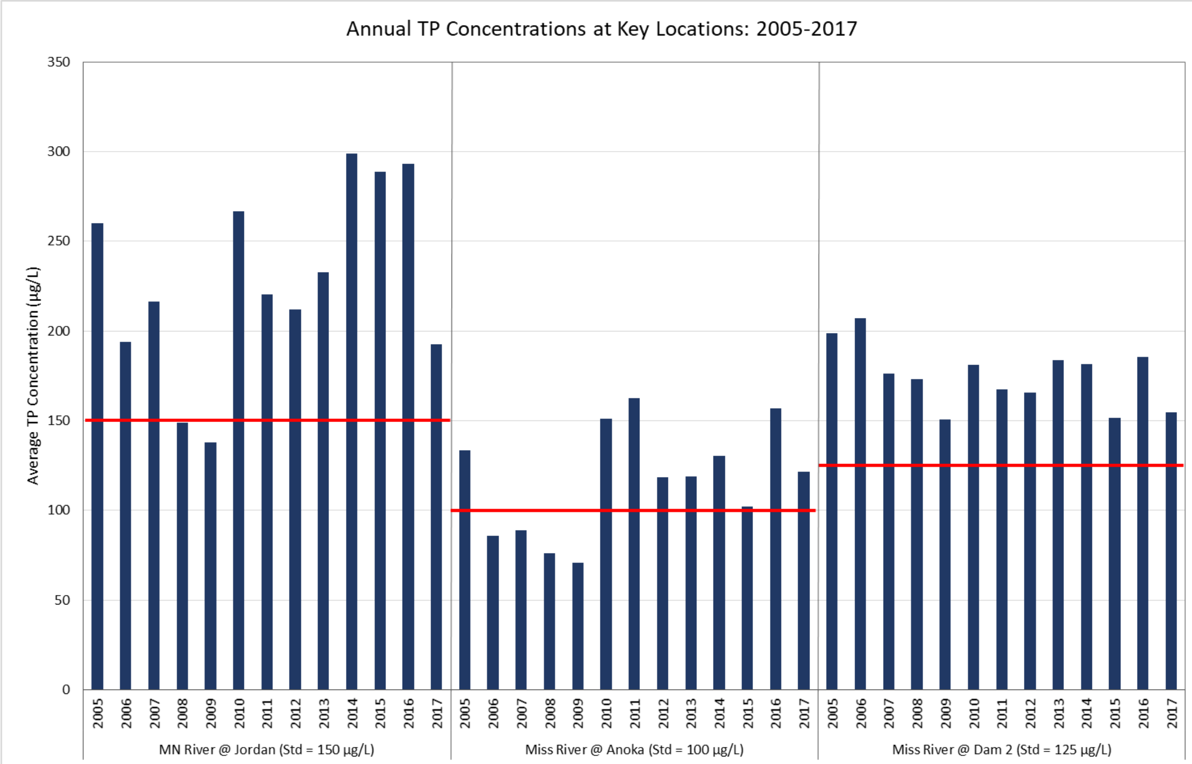


Figure 14. Annual summer total phosphorus concentrations on the Minnesota and Mississippi River from 2005 - 2017.

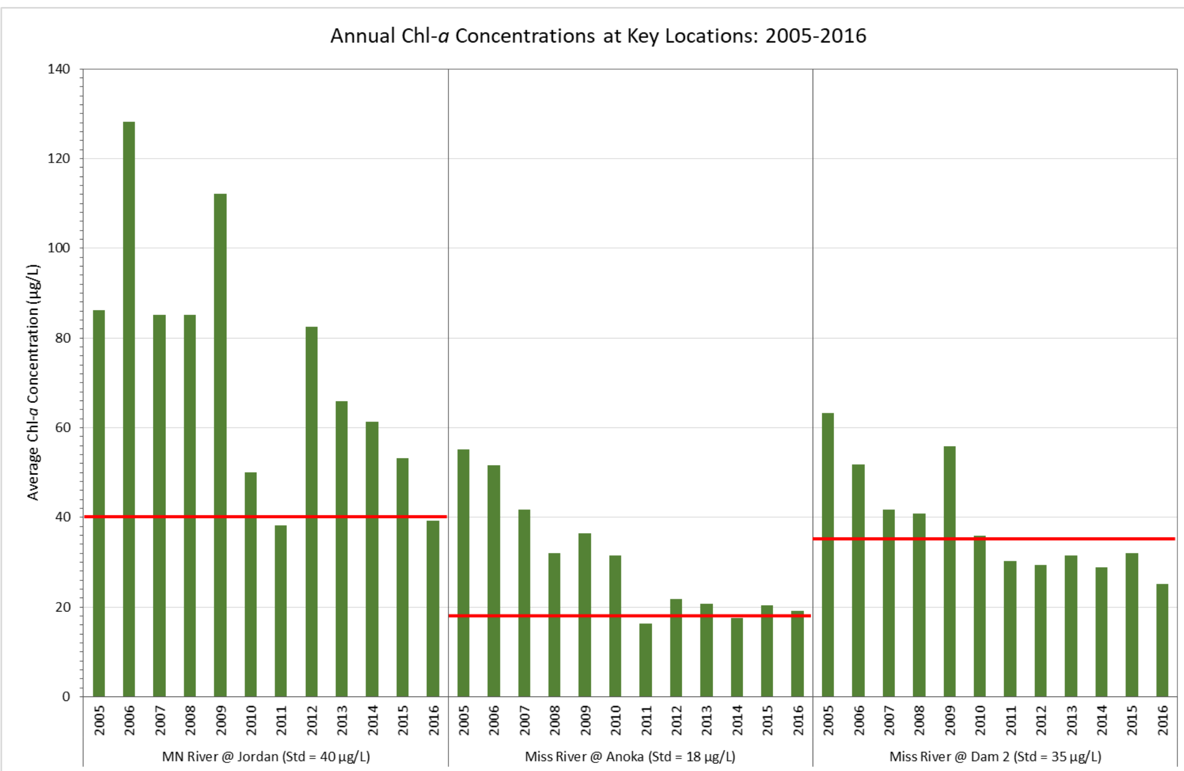


Figure 15. Annual summer Chl-a concentrations on the Minnesota and Mississippi River from 2005 - 2016.

3.4. Phosphorus Source Summary

This section provides a brief description of the sources in the watershed contributing to excess phosphorus in the impaired AUIDs. The [Minnesota NRS] summarizes phosphorus sources and transport in the state (MPCA 2014). MPCA has prepared an update to the NRS distribution of phosphorus sources. The MPA estimate of the phosphorus load distribution for the Mississippi River Basin upstream of the St. Croix River, but not including the Minnesota River Basin, is shown in Figure 16. The load distribution in the Minnesota River Basin is shown in Figure 17. Wastewater point source estimates are based on 2011 data. Key take-aways from these figures are listed below:

- Cropland and pasture runoff is the largest contributor of phosphorus in both basin at 30% in the Mississippi and 41% in the Minnesota. Another 10% is estimated to be contributed from cropland through tile drainage in the Minnesota Basin.
- Wastewater is the second largest source in the Mississippi Basin at 21%, while streambank erosion is the second largest source in the Minnesota Basin at 16%.
- Atmospheric deposition is significant contributor in both basins based on updated estimates in 2013.
- The differences in the distributions between the basins highlights the need to understand loads by basin.

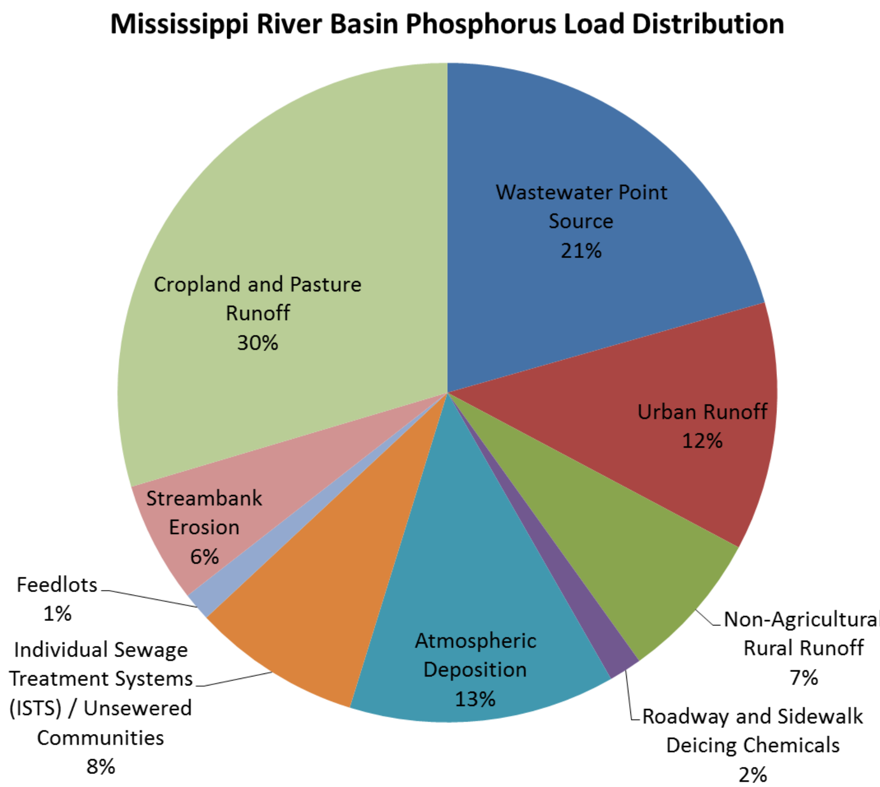


Figure 16. Relative distribution of phosphorus loads in the Mississippi River Basin.

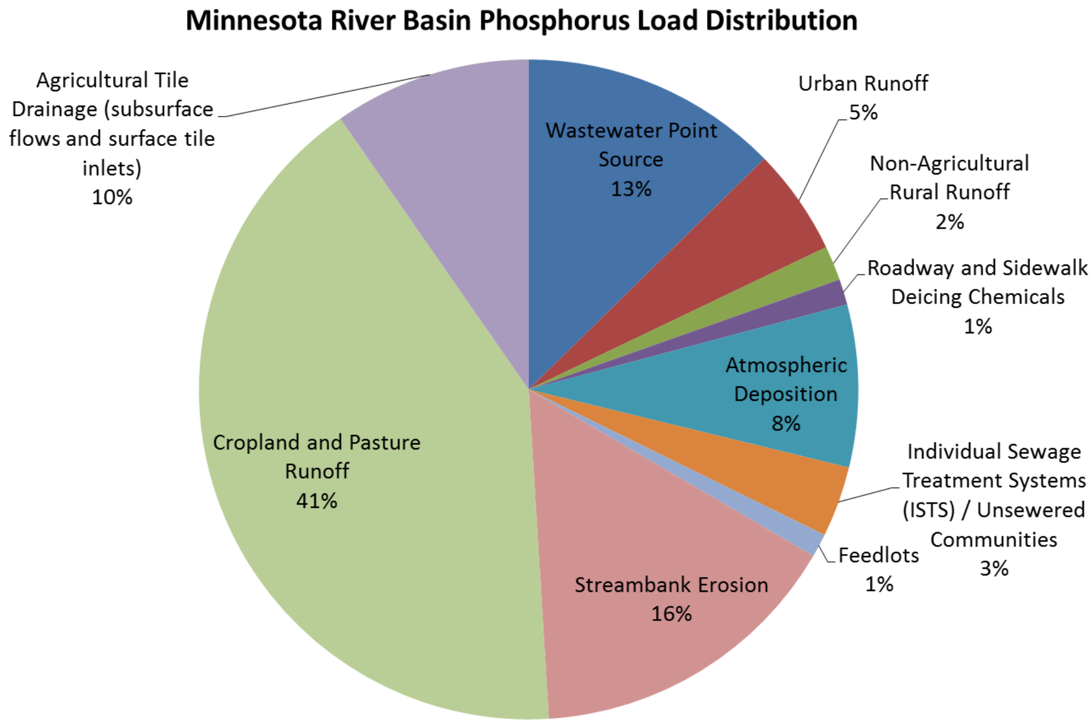


Figure 17. Relative distribution of phosphorus loads in the Minnesota River Basin.

Under the federal CWA, some sources can be regulated and require a permit that sets conditions for their discharges to the environment. These sources release pollutants from specific identifiable sources, such as discharge pipes, and are considered "point" sources. TMDLs include allowable LAs for the point sources in the watershed. Sources associated with large areas, rather than specific pipes, are considered "nonpoint" sources; these are exempt from regulation under the federal law. TMDLs include LAs for nonpoint sources, and natural background. The following are sources of phosphorus to lakes and streams:

- Point sources (regulated under the CWA)
  - Municipal and industrial wastewater dischargers
  - Regulated stormwater, or MS4
  - Permitted confined animal feeding operations (CAFOs)
- Nonpoint sources (exempt from regulation)
  - Cropland and pasture runoff
  - Agricultural tile drainage
  - Non-permitted feedlots
  - Streambank erosion
  - Nonagricultural rural runoff

- Individual sewage treatment systems
- Roadway deicing chemicals
- Atmosphere (including redeposited sediment from wind erosion)

- Natural background

The following sections discuss these sources of phosphorus.

3.4.1. Municipal and Industrial Wastewater

The CWA prohibits point source discharges to water of the United States, unless the discharge has a National Pollutant Discharge Elimination System (NPDES) permit. NPDES permits specify conditions and limitations for such discharges. There are approximately 500 active NPDES permitted wastewater facilities in the Lake Pepin Watershed, including city treatment plants, quarry dewatering pits, and process/contact wastewater used in industrial processes (Figure 18). This includes 29 facilities that discharge into the St. Croix River Basin and the MRLP on the Wisconsin side. A complete list of WWTPs addressed by the TMDLs in this report is provided in Appendix B. Starting in 2000, the MPCA's Citizens' Board adopted a strategy for addressing phosphorus in NPDES permits, which established a process for the development of 1 mg/L phosphorus limits for new and expanding WWTPs that had potential to discharge phosphorus in excess of 1,800 lbs/year. It also established requirements for other WWTPs to develop and implement phosphorus management plans. The MPCA's Phosphorus Strategy was formally adopted as Minn. R. 7053.0255, in 2008.

The data trend in Figure 19 shows TP loads decreasing over the last 15 years for both municipal and industrial dischargers in the Lake Pepin Watershed. TP loads from 2000 to 2015 have been reduced by 81%. Additional phosphorus loading trends from municipal and industrial discharges are plotted in Figure 20 to Figure 23 for the Upper Mississippi River Basin (including Crow River Watershed and Rum River Watershed), St. Croix River Basin, Minnesota River Basin, and CRW, respectively. All basins have experienced significant reductions in phosphorus loads from wastewater facilities.

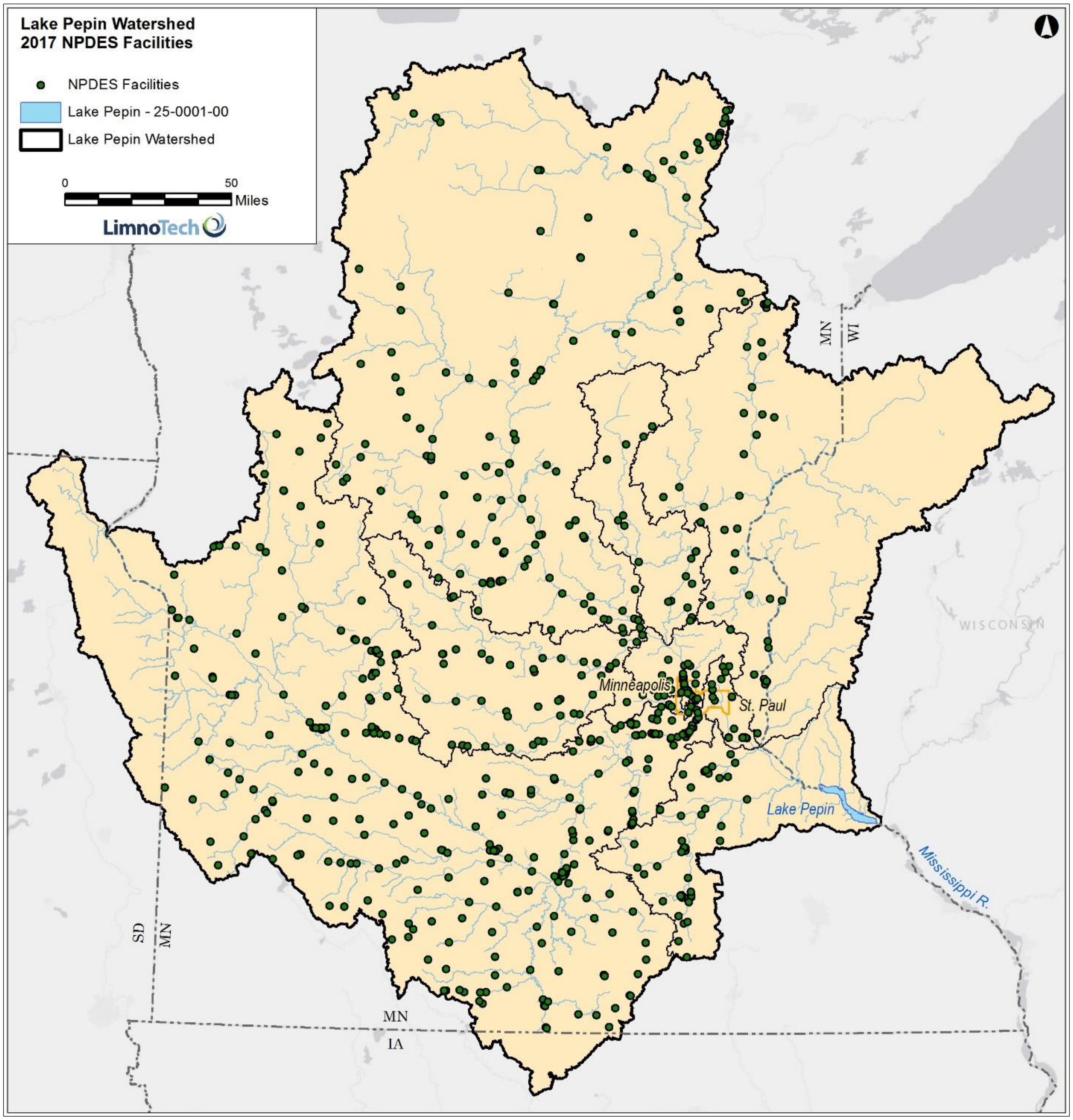


Figure 18. Locations of NPDES wastewater facilities in the Lake Pepin Watershed. Note that only Minnesota facilities are shown.

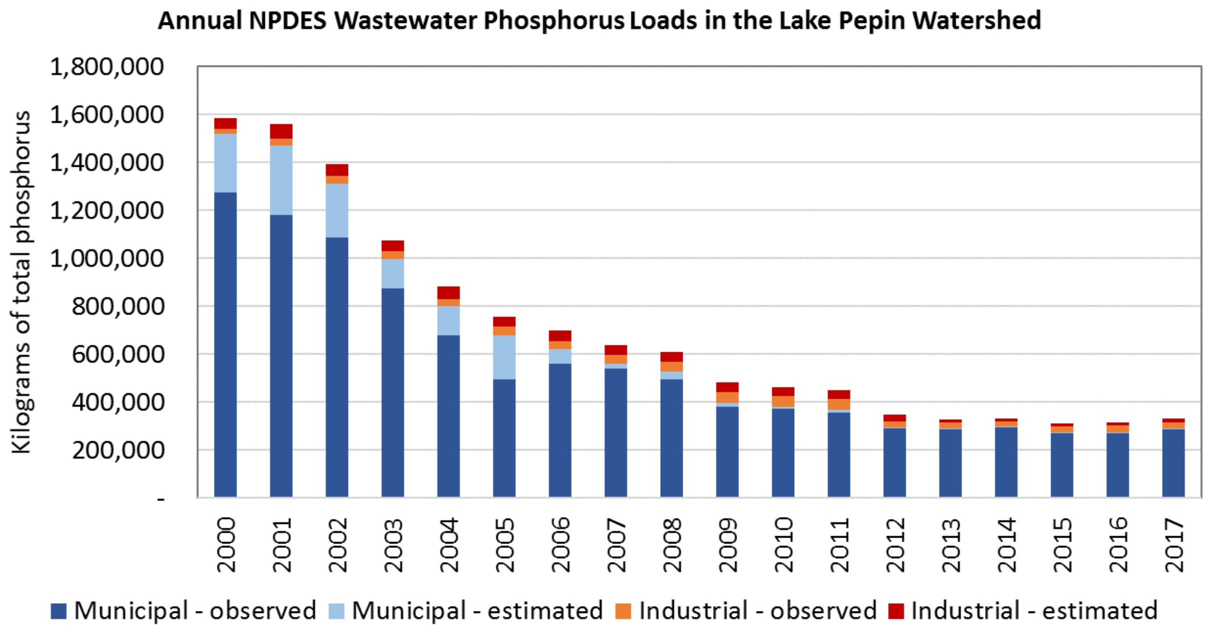


Figure 19. Annual NPDES wastewater phosphorus loads in the Lake Pepin Watershed from 2000 – 2017 for municipal and industrial facilities.

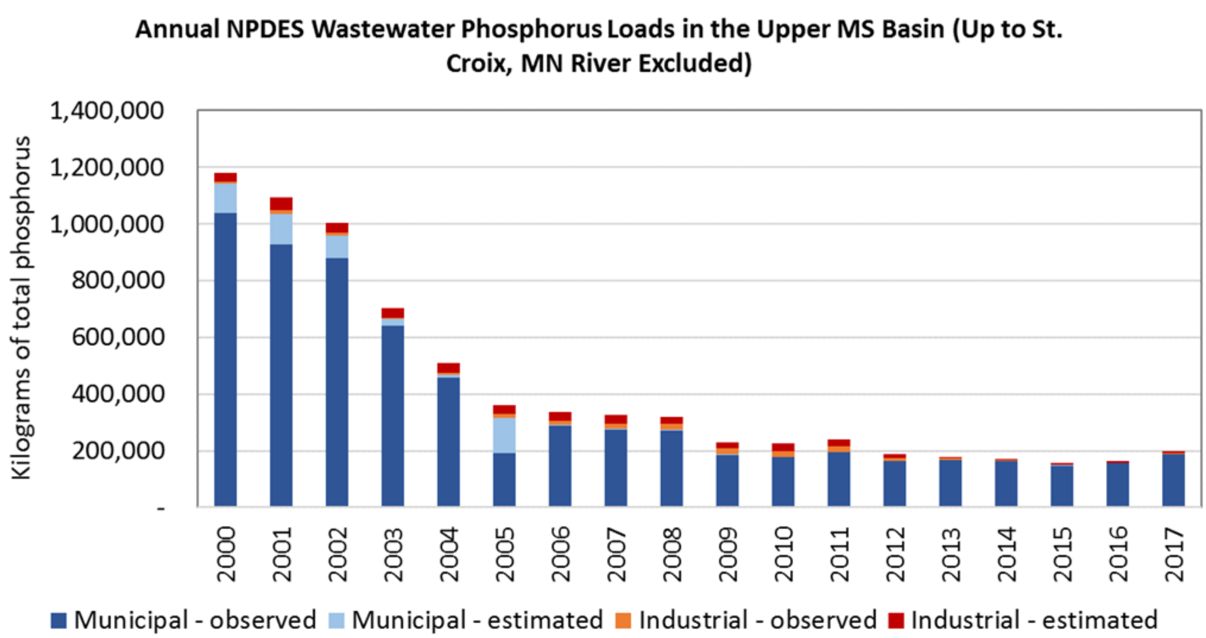


Figure 20. Annual NPDES wastewater phosphorus loads in the Upper Mississippi River Basin from 2000 – 2017 for municipal and industrial facilities.

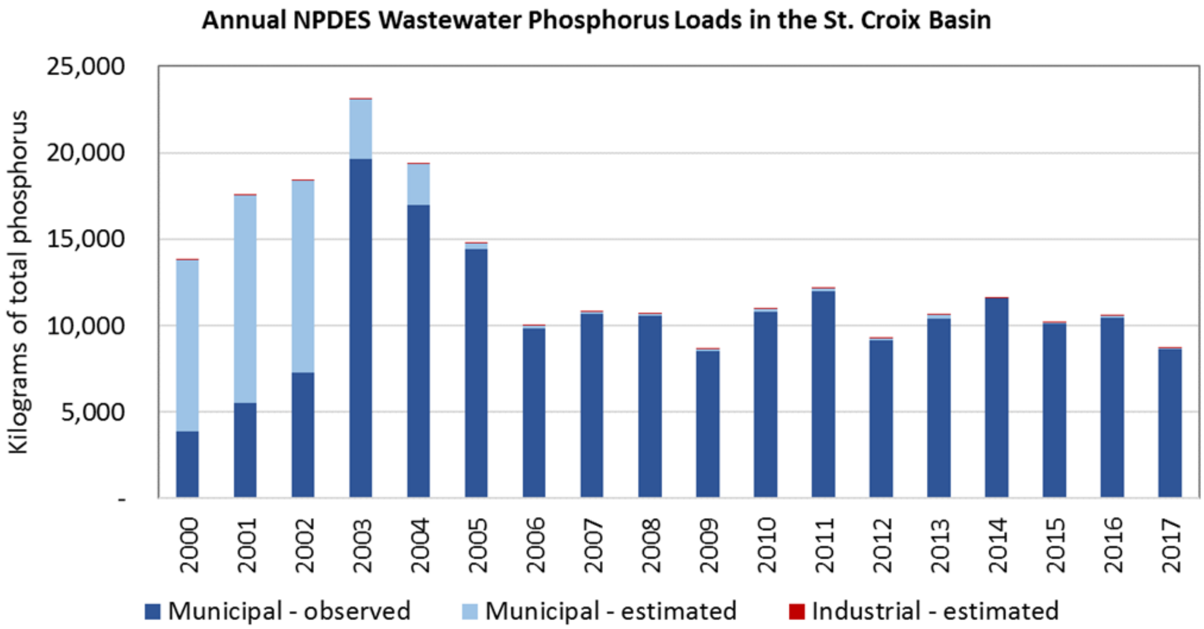


Figure 21. Annual NPDES wastewater phosphorus loads in the St. Croix River Basin from 2000 – 2017 for municipal and industrial facilities.

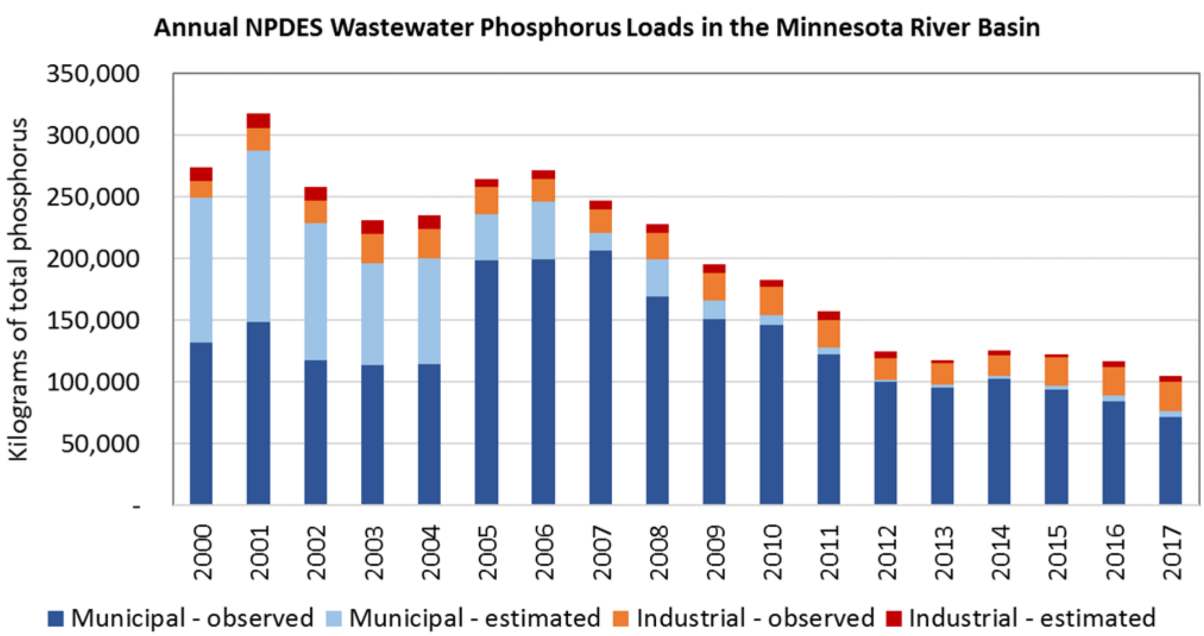


Figure 22. Annual NPDES wastewater phosphorus loads in the Minnesota River Basin from 2000 – 2017 for municipal and industrial facilities.

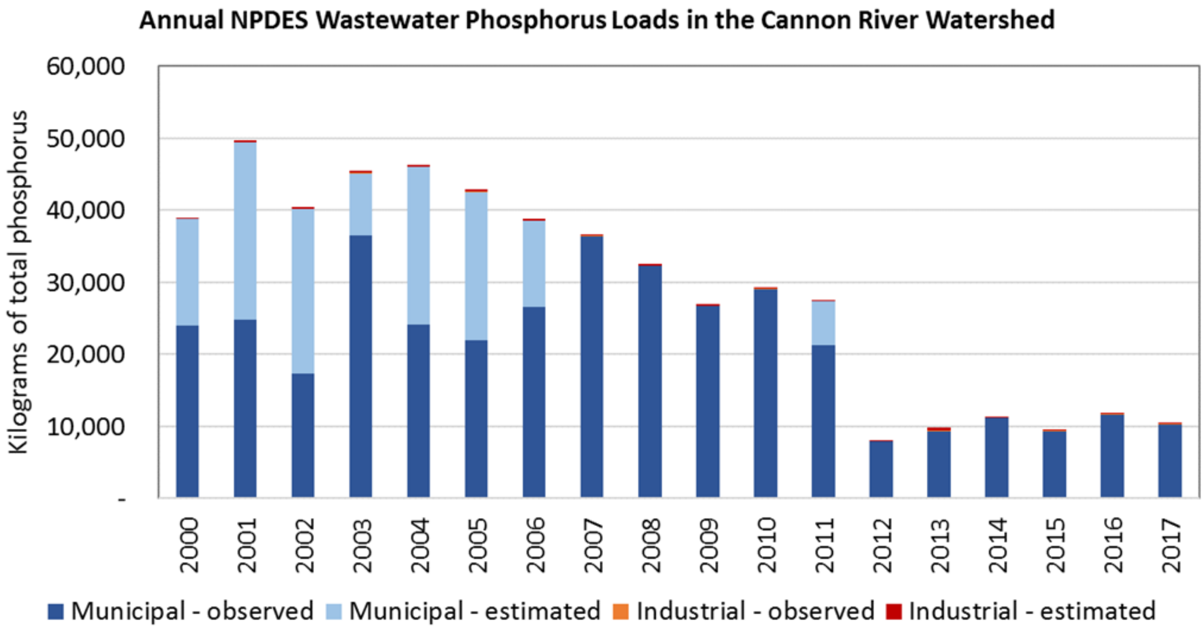


Figure 23. Annual NPDES wastewater phosphorus loads in the Cannon River Watershed from 2000 – 2017 for municipal and industrial facilities.

3.4.2. Regulated Stormwater

Other permitted sources of phosphorus in the Lake Pepin Watershed include stormwater runoff and discharge from MS4 communities, construction and industrial sites.

Sources of phosphorus in urban stormwater runoff include plant and leaf litter, soil particles, pet waste, road salt, fertilizer, and atmospheric deposition of particles. Lawns and roads account for the greatest loading, about 80% of total and dissolved phosphorus loading. Land use affects the contribution from different sources, with lawns and leaf litter being more important in residential areas and roads being more important in commercial and industrial areas. During precipitation or snowmelt events, runoff entrains phosphorus associated with particulate material and can also leach phosphorus from lawns, soils, and organic matter. Surface runoff may be conveyed to local waterbodies directly through the stormwater drainage and conveyance systems. Shallow groundwater or interflow through soil may also infiltrate into stormwater pipes. The stormwater conveyance system may include a variety of treatment practices to reduce phosphorus and other pollutants. Additional information on urban stormwater as a source of phosphorus can be found in Appendix J of MPCA's Detailed Assessment of Phosphorus Sources to Minnesota Watersheds (Barr 2004).

MS4s are defined by the MPCA as conveyance systems owned or operated by an entity or public body having jurisdiction over discharge of stormwater or other wastes. The municipal stormwater permit holds permittees responsible for stormwater discharging from the conveyance system they own and/or operate. The conveyance system includes ditches, roads, storm sewers, and stormwater ponds. Stormwater runoff that falls under these permits is regulated as a point source and, therefore, must be included in the WLA portion of a TMDL. MS4 communities are permitted under the NPDES program and include cities, townships, watershed districts, and non-traditional communities such as hospitals, MnDOT roadways, correctional facilities, and universities/colleges. MS4 communities make up 5.85% of the geographic area of the total Lake Pepin Watershed (Figure 24). In Minnesota's portion of the Lake

Pepin Watershed there are a total of 206 MS4 communities addressed by the TMDLs in this report. An additional 11 cities with growing populations that exceed or are approaching 5,000 people are also addressed. The four MS4 communities in Wisconsin's portion of the watershed are all within the St. Croix River Basin. A complete list of MS4 communities addressed by the TMDLs in this report is provided in Appendix C. Industrial stormwater is regulated through an NPDES permit when stormwater discharges have the potential to come into contact with materials and activities associated with the industrial activity.

Untreated stormwater that runs off a construction site often carries sediment and other pollutants to surface water bodies. An NPDES permit is required for construction activity that disturbs one or more acres of soil or for smaller sites if the activity is part of a larger development. A permit also might be required if the MPCA or WDNR determines that the activity poses a risk to water resources. Coverage under the construction stormwater general permit requires sediment and erosion control measures that reduce stormwater pollution during and after construction activities.

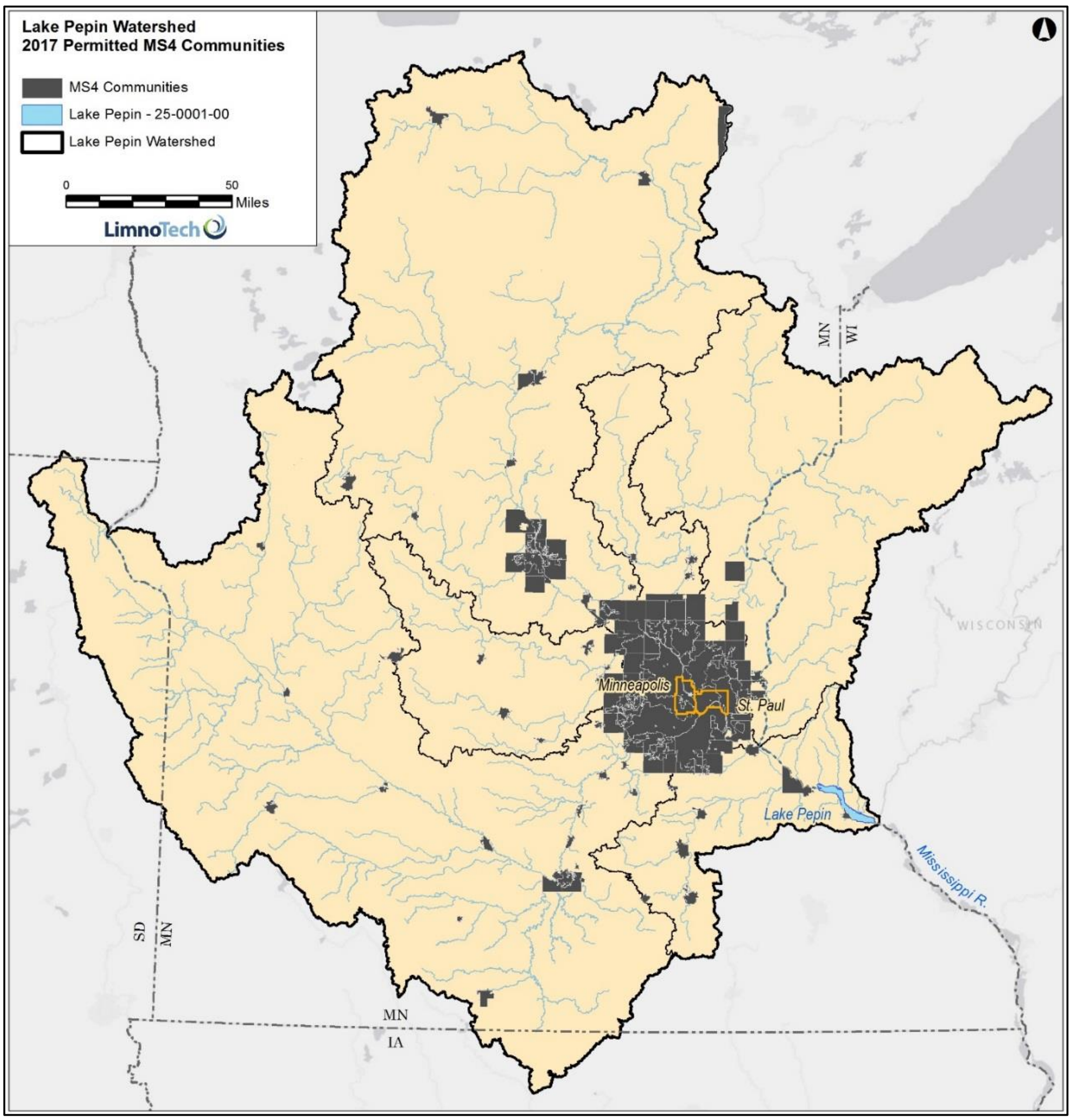


Figure 24. Locations of MS4 communities in the Lake Pepin Watershed. Note that only Minnesota MS4 communities are shown.

3.4.3. Permitted Confined Animal Feeding Operations

In Minnesota, animal feeding operations (AFOs) are required to register with their respective delegated county or the state if they are 1) an animal feedlot capable of holding 50 or more animal units (AU), or a manure storage area capable of holding the manure produced by 50 or more AUs outside of shoreland; or 2) an animal feedlot capable of holding 10 or more AUs, or a manure storage area capable of holding the manure produced by 10 or more AUs, that is located within shoreland. Further explanation of registration requirements can be found in Minn. R. 7020.0350.

Of the approximately of 11,686 AFOs in the Minnesota portion of the Lake Pepin Watershed, there are 914 NPDES permitted CAFOs. CAFOs are defined by the EPA based on the number and type of animals. For example, an operation with 2500 swine or 1000 cattle is designated as a CAFO, but a site with 2499 swine or 999 cattle is not considered a CAFO according to the EPA definition. The MPCA currently uses the federal definition of a CAFO in its permit requirements of animal feedlots along with the definition of an AU.

In Minnesota, the following types of livestock facilities are required to operate under a NPDES Permit or a state issued State Disposal System (SDS) Permit:

- all federally defined CAFOs that have had a discharge, some of which are under 1000 AUs in size; and
- all CAFOs and non-CAFOs that have 1000 or more AUs.

CAFOs and AFOs with 1,000 or more AUs must be designed to contain all manure and manure contaminated runoff from precipitation events of less than a 25 year - 24 hour storm event. In cases of excessive precipitation, these facilities may only discharge as authorized by their respective NPDES, SDS, or other applicable permit. Discharges from such overflows are allowable only if they do not cause or contribute to a violation of water quality standards. A current manure management plan which complies with Minn. R. 7020.2225 and the respective permit is required for all CAFOs and AFOs with 1,000 or more AUs.

CAFOs are inspected by the MPCA in accordance with the MPCA NPDES Compliance Monitoring Strategy approved by the EPA. All CAFOs (NPDES permitted, SDS permitted and not required to be permitted) are inspected by the MPCA on a routine basis with an appropriate mix of field inspections, offsite monitoring and compliance assistance.

For the Lake Pepin Watershed TMDLs, all NPDES and SDS permitted feedlots are designed to have zero discharge and as such, they do not receive a WLA. All other non-permitted feedlots and the land application of all manure are accounted for in the LA for nonpoint sources.

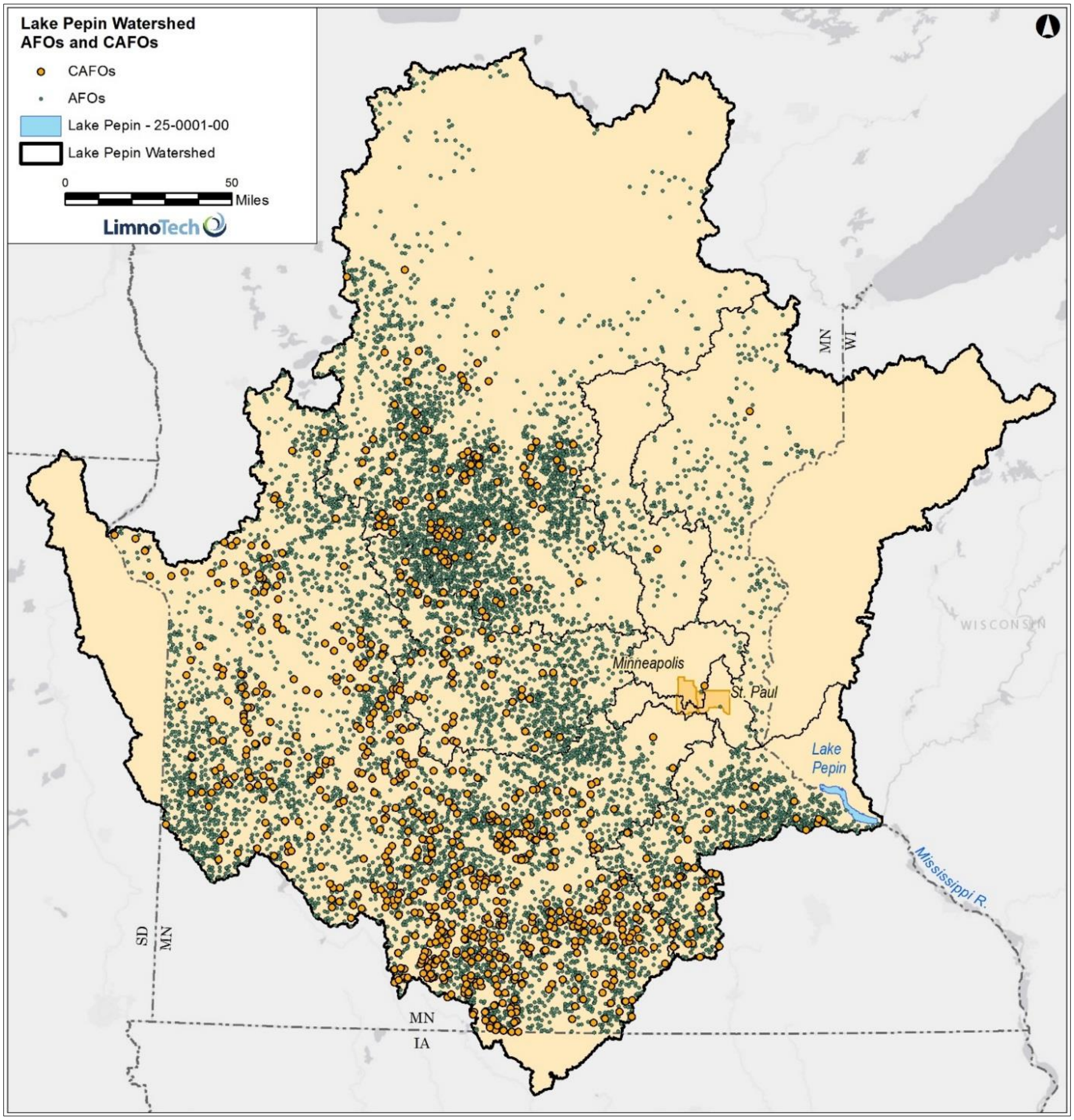


Figure 25. Distribution of Animal Feeding Operations and Concentrated Animal Feeding Operations in the Lake Pepin Watershed. Note that only Minnesota facilities are shown.

3.4.4. Nonpoint sources

The MPCA and partners have studied nonpoint sources of nutrients to Minnesota waters in depth and has made considerable effort to quantify the nutrient loads associated with different sectors and activities, as well as to quantify nutrient loads spatially throughout the state. The phosphorus source assessment summary developed in the Nutrient Reduction Strategy (NRS) is based on the Detailed Assessment of Phosphorus Sources to Minnesota Watersheds (Barr Engineering 2004, 2007). Figure 26 summarizes the relative distribution of major nonpoint sources contributing phosphorus to the Mississippi River in Minnesota. Cropland is estimated to contribute the largest percentage of phosphorus from nonpoint sources, 35%. Streambank erosion is estimated to be the second largest contributor at 17%. Other sources are all estimated to be less than 10%.

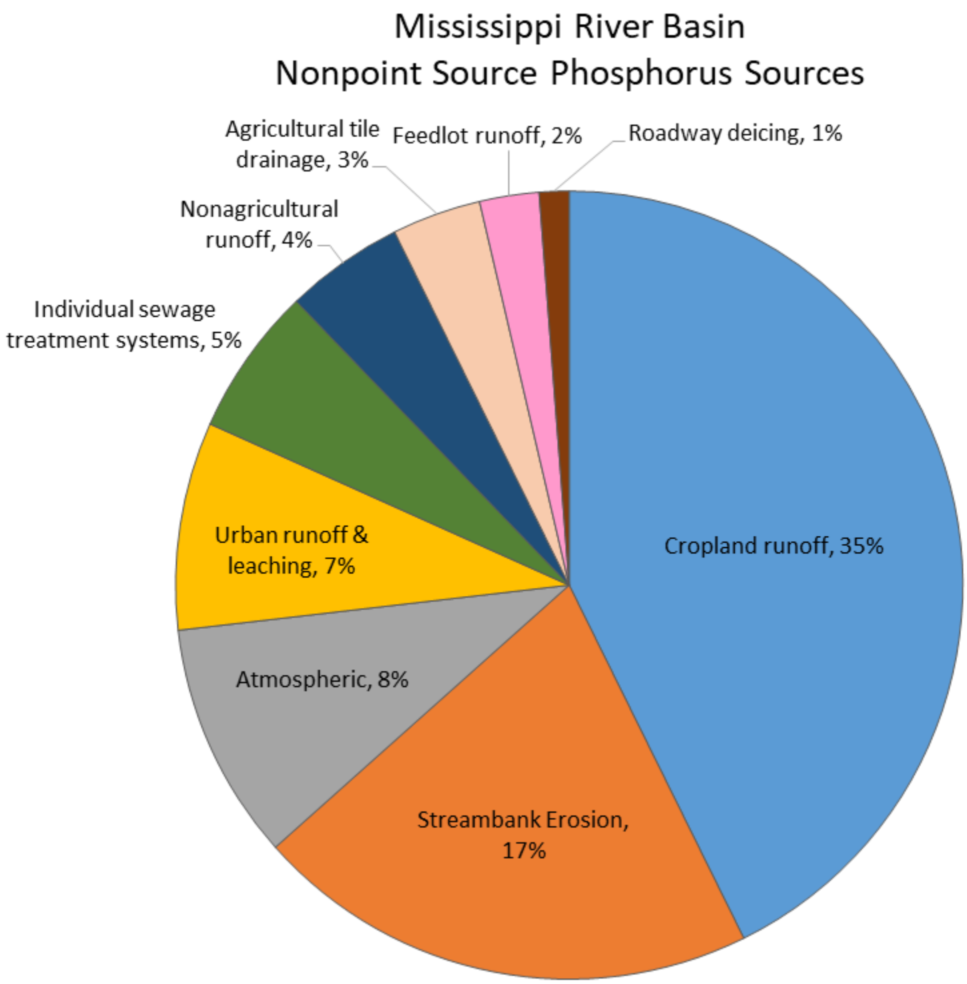


Figure 26. Nonpoint sources of phosphorus in the Mississippi River Basin (Data Source: Minnesota Nutrient Reduction Strategy).

Under average flow conditions the major phosphorus nonpoint sources to the major basins, as described in the Detailed Assessment of Phosphorus Sources to Minnesota Watersheds, are shown in Table 12. Cropland and pasture is the majority nonpoint source in the Upper Mississippi River Basin, the Minnesota River Basin, and the St. Croix River Basin. Streambank erosion is the majority source in the Lower Mississippi River Basin. Roadway deicing is a relatively small source in all basins.

Table 12. Estimates of nonpoint source contributions of phosphorus in the major basins during an average year.

Nonpoint Source	Total Phosphorus Load (kg/yr)				Percentage of Nonpoint Sources			
	Upper Mississippi River Basin	Minnesota River Basin	St. Croix River Basin	Lower Mississippi River Basin	Upper Mississippi River Basin	Minnesota River Basin	St. Croix River Basin	Lower Mississippi River Basin
Cropland & pasture	397,719	529,137	67,240	243,115	56%	65%	51%	40%
Septic systems	110,972	44,442	22,132	26,949	16%	5%	17%	4%
Streambank erosion	79,900	200,000	15,500	322,000	11%	25%	12%	53%
Roadway deicing	21,795	16,131	3,236	7,793	3%	2%	2%	1%
Non-agricultural rural runoff / non-permitted urban stormwater	98,615	21,645	23,308	13,363	14%	3%	18%	2%
Totals	709,001	811,355	131,416	613,220	100%	100%	100%	100%

Further descriptions of the major nonpoint sources is provided below.

Cropland and Pasture

Farmers apply commercial phosphorus fertilizers and manure to supplement the quantities available in the soil. Over-application can lead to the buildup of phosphorus in the soil. As the phosphorus levels build up in the soil, the potential for phosphorus in a soluble form increases (NRCS 2006). In pastures, phosphorus tends to be concentrated in areas where grazing animals spend more time such as travel lanes, ponds, shade and hay-feeding areas.

Generally, the transport mechanisms that cause phosphorus movement are erosion, surface water runoff from rainfall and irrigation, and leaching. Factors that influence the source and amount of phosphorus available to be transported are soil properties, and the rate, form, timing, and method of phosphorus applied. The phosphate ion attaches strongly to soil particles and makes up a part of soil organic particles. Any erosion of these particles will transport phosphorus from the site. Phosphorus can also be transported as soluble material in runoff and leaching water. When water moves over the soil surface, as it does in runoff events, or passes through the soil profile during leaching, soluble phosphorus will be transported with the water. Applying phosphorus fertilizer or manures on the soil surface will subject them to both runoff and erosion, particularly if the application takes place just before a rainfall, irrigation, or wind event that can carry the phosphorus material off site. If, however, the fertilizer or manure material is incorporated into the soil profile, it becomes protected from the transport mechanisms of wind and water. Leaching of phosphorus is at a higher risk through coarse textured soils or organic soils that have low clay content (NRCS 2006).

Phosphorus is primarily lost from farm fields through three processes: attached to the sediment that erodes from the field, dissolved in the surface water runoff, or dissolved in leachate and carried through the soil profile. On cultivated fields, most is lost through erosion, whereas on non-tilled fields most phosphorus losses are dissolved in surface water runoff or in leachate. Cultivated acres with phosphorus-rich soils, however, can also lose significant amounts of phosphorus dissolved in the runoff or the leachate (NRCS 2006).

Tile drainage creates a suitable environment for plant growth by removing excess water and improving infiltration and aeration. Tile drainage reduces runoff and increases water storage. While drainage has economic and environmental benefits, under some conditions excess nutrients from commercial fertilizers and livestock manure can quickly move to tile drains through preferential flow paths; cracks and fissures in the soil, worm holes, root channels and other macropores, and thereby escape from the field. In tile-drained fields, nearly 40% to 50% of both dissolved, “bioavailable” phosphorus and TP may leave fields via the tile system (King et al 2015 and Smith et al 2015).

Non-permitted Feedlots

A feedlot is defined as a lot or building or combination of lots and buildings intended for the confined feeding, breeding, raising, or holding of animals and specifically designed as a confinement area in which manure may accumulate. Or, where the concentration of animals is such that a vegetative cover cannot be maintained within the enclosure. Open lots used for the feeding and rearing of poultry (poultry ranges) shall be considered to be animal feedlots. Pastures are not considered to be animal feedlots. For the Lake Pepin Watershed TMDL, all NPDES and SDS permitted feedlots are designed to have zero discharge. All other non-permitted feedlots and the land application of all manure are accounted for in the LA for nonpoint sources. An owner is not required to apply for a permit for an animal feedlot with more than 10 but less than 50 AUs that is not in a shoreland area. Owners with fewer than 300 AUs are not required to have a permit for the construction of a new facility or expansion of an existing facility if construction is in accordance with the technical standards. Under MPCA rules, anyone who operates a feedlot must comply with all the provisions of the regulations, whether or not they have a permit. For more information, refer to the MPCA Feedlot Rules Overview:
https://www.pca.state.mn.us/sites/default/files/wq-f1-20.pdf

Streambank Erosion

Streambank erosion is a complex issue that is highly influenced by the dynamics of natural and anthropogenic disturbances. Under natural conditions, the processes of erosion and deposition result in changes to streams over long periods of time. The banks of streams may undergo erosion as a result of high shear stresses along the bank as well as mass failure or sloughing following erosion of the bank toe. These adjustments to stream channels can involve short term (days) and small spatial scales (a reach) or a longer time (hundred or more years) and larger extent (entire systems), depending on the magnitude and scale of disturbance. Human disturbances to floodplains and upland areas have resulted in accelerated channel erosion. The phosphorus attached to eroded streambank material is immediately delivered to the receiving water where it may ultimately become available for biologic uptake, re-deposited downstream, or transported with the flow out of the system. For more information, refer to Appendix G of the Detailed Assessment of Phosphorus Sources to Minnesota Watersheds:
https://www.pca.state.mn.us/sites/default/files/pstudy-appendix-g.pdf

Non-agricultural runoff / non-permitted urban stormwater

The non-agricultural rural land use components of watershed ecosystems includes native vegetation that still function at an ecosystem level in ways that are very similar to their undisturbed natural condition, as well as rural residential areas, transportation infrastructure, and other typically urban land uses such as residential and commercial developed areas outside the boundaries of MS4 areas. The sources and transport of phosphorus from non-agricultural runoff and non-permitted urban stormwater are similar to those described for regulated stormwater in Section 3.4.2. For more information, refer to Appendix I of the Detailed Assessment of Phosphorus Sources to Minnesota Watersheds: https://www.pca.state.mn.us/sites/default/files/pstudy-appendix-i.pdf

Septic Systems

Subsurface Sewage Treatment Systems (SSTS) – Of the approximate 450,000 septic systems across the state, slightly over 100,000 of them are estimated to be failing and could be sources of pollution to Minnesota's water resources. A failing system is one that does not provide adequate separation between the bottom of the drainfield and seasonally saturated soil. The wastewater in SSTS contains bacteria, viruses, parasites, nutrients and some chemicals. SSTS discharge treated sewage into the ground, ultimately traveling to the groundwater. Therefore, SSTS must be properly sited, designed, built and maintained to minimize the potential for disease transmission and contamination of groundwater and surface waters (MPCA 2013d). For more information, refer to Appendix H of the Detailed Assessment of Phosphorus Sources to Minnesota Watersheds: https://www.pca.state.mn.us/sites/default/files/pstudy-appendix-h.pdf

Roadway Deicing

The use of deicing chemicals has increased in the U.S. since the 1940s and 1950s to provide for safe and efficient winter transportation. While the majority of water quality concerns related to deicing materials is focused on chloride, phosphorus is also contained in deicing products at varying levels. Deicing agents derived from agricultural waste products have the highest concentrations of phosphorus, such as corn-based products. In most cases, the use of the deicing agents with the high phosphorus content is for the corrosion inhibition qualities. Roadway deicing as a phosphorus source is expected to be of greater concern in the highly urbanized portions of the impaired watersheds. For more information, refer to Appendix f of the Detailed Assessment of Phosphorus Sources to Minnesota Watersheds: https://www.pca.state.mn.us/sites/default/files/pstudy-appendix-f.pdf

3.4.5. Natural Background

Natural background is the landscape condition that occurs outside of human influence. Natural background sources are inputs that would be expected under natural, undisturbed conditions. Natural background sources can include inputs from natural geologic processes such as: soil loss from upland erosion and stream development; atmospheric deposition; groundwater discharge; wildlife; and loading from grassland, forests, and other natural land covers. Many of these source components may also be impacted by human activity.

Natural background is defined in both Minnesota rule and statute:

Minn. R. 7050.0150, subp. 4:

> "Natural causes" means the multiplicity of factors that determine the physical, chemical or biological conditions that would exist in the absence of measurable impacts from human activity or influence.

The Clean Water Legacy Act (Minn. Stat. § 114D.10, subd. 10):

> … characteristics of the water body resulting from the multiplicity of factors in nature, including climate and ecosystem dynamics that affect the physical, chemical or biological conditions in a water body, but does not include measurable and distinguishable pollution that is attributable to human activity or influence.

Engstrom and Almendinger (2000) developed an estimate of TP loads to Lake Pepin over time, based on analysis of Lake Pepin sediment core data. This work estimates a TP loading rate to Lake Pepin of 0.053 lb/acre/year circa 1830, prior to significant human impacts on the landscape. For detailed discussion on estimated increases in sediment and TP loading to Lake Pepin since European settlement, see Engstrom and Almendinger (2000), which can be found here. The value of 0.053 lb/acre/year compares to an estimated baseline load for 1994-1996 of 0.257, a five-fold increase. An estimate was also developed for the 1990s of 0.360 lb/acre/year, which includes the historic flood of 1993.

In comparison, phosphorus export from the St. Croix River to the Mississippi River has been estimated to have more than doubled from 127 tons per year (0.052 lb/acre/year) before 1850 to 285 tons per year (0.116 lb/acre/year) in the 1990s (Triplett et al 2009).

The natural background load is accounted for in the LAs in the TMDLs presented in this report. The natural background component of the LA was calculated using the 0.053 lb/acre/year value estimated by Engstrom and Almendinger (2000). The remaining LA can be considered to be the reducible portion of the LA.

4. Modeling Approach

A water quality model can be used in the TMDL process to link pollutant loads to water quality response. Such a model helps develop an understanding of existing conditions as well as assess the required reductions in pollutant loadings, or allowable pollutant loadings needed to attain water quality standards. Models can range in complexity to meet the specific management needs and characteristics of the waterbody.

For Lake Pepin and Pool 2, LimnoTech developed and applied a sophisticated water quality model, which is described in this section of the report. The MPCA used the results of this model to inform the site-specific criteria for Lake Pepin and Pool 2, as well as inform the development of WLAs for wastewater facilities throughout the watershed.

4.1. Water Quality Model

The Upper Mississippi River-Lake Pepin (MRLP) system requires a model that is complex in terms of process resolution and in terms of spatial and temporal resolution. The system stretches for about 90 Mississippi River miles (from Lock and Dam 1 in Minneapolis to the outlet of Lake Pepin) and consists of three morphometrically and hydraulically distinct pools, separated by lock and dam control structures. There is considerable variability both laterally and longitudinally in the system bathymetry, including channels, shoals, deltas, and impoundments. In addition, several islands throughout the system complicate the hydraulics.

To support the TMDLs for TSS and nutrient-Chl-*a* impairments in Pools 2, 3, and 4 (River Miles 848 to 765) of the Upper Mississippi River, the MPCA worked with the project's SAP and a consultant, LimnoTech, to develop a linked hydrodynamic-sediment transport-water quality model. This model, called the Upper MRLP Water Quality Model, applies to Upper Mississippi River from Lock and Dam 1 (Minneapolis) through Lock and Dam 4 below Lake Pepin.

LimnoTech adapted and upgraded a hydrodynamic water quality model developed by the MCES and HydroQual, Inc., in the 1990s. The Estuarine and Coastal Ocean Model with Sediment-RCA (ECOMSED) model was successfully calibrated and then used to evaluate the effect of specific load reductions on the TMDL endpoints including turbidity, phosphorus, Chl-*a*, and Secchi transparency. The model is central to the development of the TSS and eutrophication TMDLs. The main processes characterized in the model include:

- The growth and decay of algae in response to alternative nutrient inputs, temperature, flow, and light conditions; and
- The level of turbidity, TSS, sediment deposition, and Secchi transparency in the river as affected by loadings and resuspension of sediment and by growth cycles of algae.

Details of the model, its data set, and calibration can be found in LimnoTech's modeling report (LimnoTech 2009a).

The overall project approach followed the EPA's Draft Guidance on the Development, Evaluation, and Application of Regulatory Environmental Models (EPA 2003). Based on this guidance, the general approach to model development and application adhered to the following steps in the regulatory environmental modeling process:

1. Problem specification;
2. Model framework selection and formulation;
3. Model development;
4. Model evaluation; and
5. Model application.

An important component of this project was adhering to an open modeling process throughout the project that involved continual interaction with all stakeholders at each step in the process. Another important part of the open modeling approach was ongoing peer review of the entire modeling process by a SAP consisting of academic and government scientists and MPCA staff familiar with the system under study.

The Upper MRLP modeling framework consists of modified versions of two public domain models:

- ECOMSED hydrodynamic/sediment transport model; and
- Row-Column AESOP (RCA) water quality model.

The two models operate on the same computational grid, and hydrodynamic and sediment transport predictions from the ECOMSED model are linked directly to the RCA model to inform the water quality simulation. The "ECOM" component of the ECOMSED modeling framework is used to simulate three-dimensional and time-dependent hydrodynamic behavior in the Upper Mississippi River from Lock and Dam 1 (Minneapolis) to Lock and Dam 4 (Alma, Wisconsin). As a complementary module to the "ECOM" hydrodynamic module, the "SED" component of the overall ECOMSED framework is used to simulate the transport and fate of cohesive and non-cohesive sediments, which together constitute non-volatile suspended solids. Advective/dispersive transport and deposition and resuspension processes are simulated for cohesive sediments, which represent clays, fine and medium silts, and associated organic material. Likewise, transport and deposition/resuspension is simulated for a non-cohesive sediment class, which typically represents medium to coarse sands.

The basic RCA framework includes a suite of state variables to represent carbon, nitrogen, phosphorus, silica, oxygen, and algal dynamics, and it is configured to interface directly with the ECOMSED model, including linkage of hydrodynamic, water temperature, and sediment transport results. The RCA framework includes a simulation of water column processes affecting water quality. It also includes a coupled sediment diagenesis sub-model that simulates the cycling of detrital material and nutrients in the surface sediments and subsequent impacts on near-bed sediment oxygen demand and release of dissolved nutrients, including dissolved inorganic phosphorus.

The MPCA made every effort to incorporate all available data for the Upper Mississippi River system during the model development and calibration/confirmation process. The Upper Mississippi River system has a long history of abundant water quality and biological data collected by federal, state, and local government agencies. Within Pools 2 and 3, the MCES has collected a majority of the monitoring data, while the USGS through its LTRMP has collected a majority of the data in Pool 4. Other agencies that regularly collect data within the Upper Mississippi River system include the U.S. Army Corps of Engineers (USACE), the MPCA, the Minnesota Department of Natural Resources (DNR), and the WDNR.

With 22 years of data available for the Upper MRLP system, the MPCA and LimnoTech decided to use half of the data for model calibration and half for confirmation. LimnoTech calibrated the model using monitoring data for 1996 through 2006, and used the monitoring data from 1985 through 1995 as a confirmation dataset. Both the calibration and confirmation data sets included a low-flow and a high-flow year. The calibration period included:

- Intense low-flow monitoring program conducted in 2006 (10^{th} percentile summer flow, from June to September) at Lock and Dam 2 at Hastings, Minnesota.
- The 86^{th} percentile annual high flow at Lock and Dam 2 at Hastings, Minnesota in 2002.

The earlier confirmation period included:

- 1^{st} percentile summer flow in 1988.
- The highest annual flow on record in 1993.

It was important to test the model's ability to simulate the system response over the full range of flow conditions because high flows represent the critical conditions for TSS, while low flows represent the critical conditions for nutrient-stimulated phytoplankton growth.

Evaluation of this iterative calibration/confirmation process included:

- Complete listings of calibration parameters;
- Graphical presentations of the calibrated model;
- Comparison with system data along with a presentation of model-data comparisons for the confirmation period;
- Metrics used to quantitatively evaluate the model calibration/confirmation; and
- Diagnostic analyses of the modeling results with regard to important features of the system behavior.

The MPCA and LimnoTech found the overall model performance for the calibration period and confirmation periods to be quite good, especially given the complexity of the model framework and the extent of the model domain.

Once achieving the best possible model parameterization, LimnoTech conducted a suite of model application runs to provide a computation of the sediment and nutrient load-response relationships to support the TMDL process. LimnoTech developed a Management Analysis Tool to help the MPCA and stakeholders to visualize and compare the results of 21 different load reduction scenarios in relation to TMDL targets for Chl-*a*, TP, Secchi depth, and TSS.

A brief description of the scenarios is provided in the following section. Additional details on model development and application can be found in LimnoTech's modeling report (LimnoTech 2009a).

4.1.1. Baseline Loads

Baseline loads were developed by running the calibrated model for the entire 22 year simulation period (1985 through 2006) and averaging the results over that period. This included setting the discharge from the Metro WWTP and other WWTPs in the model domain at their previously permitted TP loads. This baseline scenario was entitled Scenario 2 – Historical Tributary Loads and WWTPs at Permitted Loads. As seen in Figure 27, the year-to-year variability can be significant and is largely correlated to flows in the system. Figure 28 presents the distribution of loads across the major basins and loading sources.

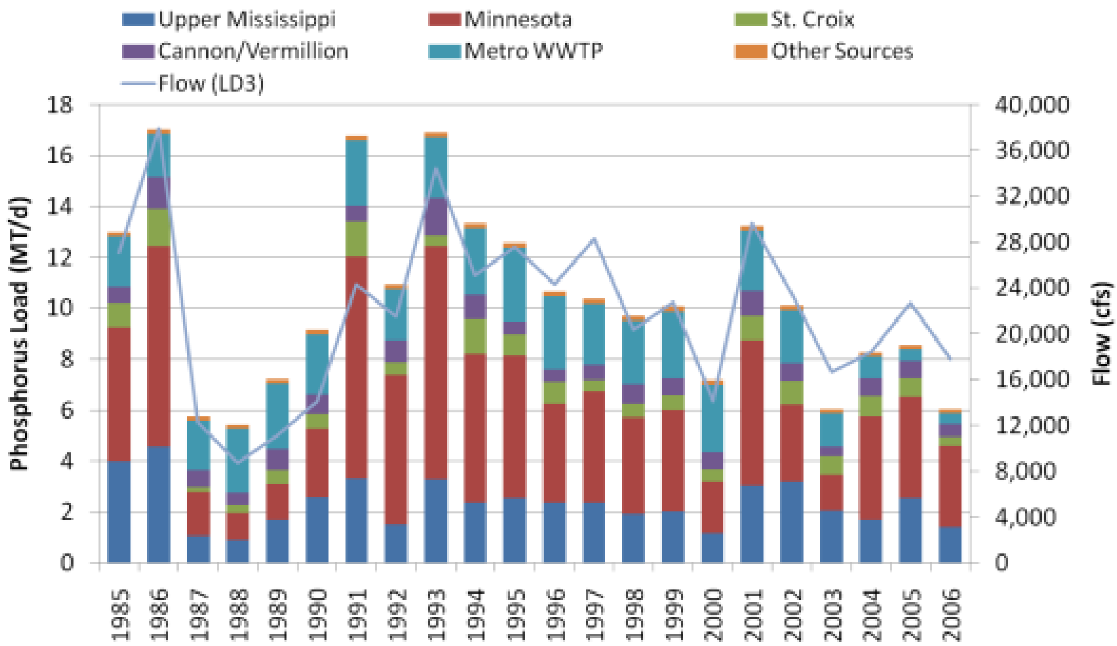


Figure 27. Year-to-year variability in total phosphorus loads to Lake Pepin.

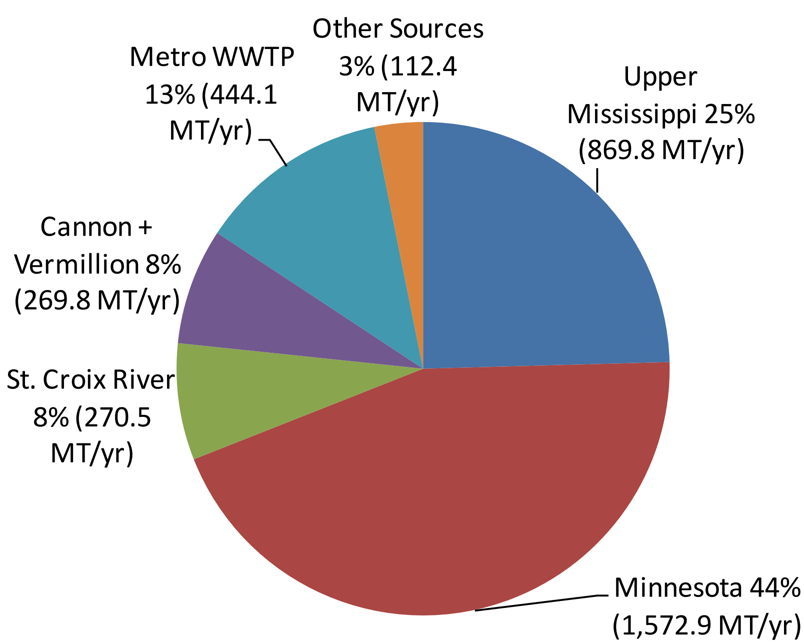


Figure 28. Baseline annual total phosphorus loads to Lake Pepin.

4.1.2. Scenario Development

Application of the Upper MRLP model to support the turbidity and eutrophication TMDLs could potentially include hundreds of simulations in order to evaluate the various combinations of TSS and TP loading reductions for each tributary's watershed pollutant loads and direct wastewater discharges. In order to simplify the model application, the initial set of load reduction scenarios applied the same relative percent reductions for suspended solids and phosphorus, including algal and zooplankton biomass.

The load reduction scenarios were designed in consultation with MPCA using the best information available in spring 2008. Separate studies for the St. Croix River and the Cannon River suggested that TSS and TP reductions of 20% and 50%, respectively, were reasonable for these watersheds. Therefore, all load reduction scenarios assumed these reductions. For simplicity, other minor tributaries were assumed to have a 20% reduction in TSS and TP loads. These tributaries included the Vermillion, Rush, and other minor tributaries. With the reductions for the St. Croix River and other smaller tributaries set at fixed percentages, it was possible to run a series of percent reduction combinations for the Minnesota River and the Upper Mississippi River at Lock and Dam 1 (Minneapolis). For the Minnesota River, reductions of 20%, 50%, and 80% were considered. For the Upper Mississippi River at Lock and Dam 1 (Minneapolis), which has significantly lower concentrations of TSS and TP relative to the Minnesota River, 50% was deemed to be the greatest reduction possible. Therefore, only 20% and 50% reductions were considered for the Upper Mississippi River at Lock and Dam 1 (Minneapolis). All tributary load reductions were made as a fixed percent reduction of the historical daily loading rates.

In total, 21 scenarios (Table 13) were modeled to evaluate in-lake phosphorus concentrations given various load reductions in tributaries and permitted wastewater facilities, while maintaining historical background conditions such as resuspension rates. Each of the initial 19 scenarios called for equal percent reductions of TSS, TP, and algae from the points of input to the model. These model scenarios do not account for possible interactions among the three variables in the tributaries as each is reduced, as might occur in practice, which would have required complex modeling of each tributary. In response to comments from the SAP, the MPCA conducted two additional model runs, using the output of a Minnesota River Basin model, to test the effect of seasonal variability in load reductions.

In scenarios 20-21, LimnoTech linked upstream modeling of the Minnesota River to the South Metro Mississippi modeling system. For these two scenarios, LimnoTech used the results of Scenario 4 from a Hydrologic Simulation Program Fortran (HSPF) model for the Minnesota River as input, at the Jordan monitoring station to a channel model (CE-QUAL-W2) developed by the U.S. Army Corps of Engineers for the lower segment of the Minnesota River from Jordan to Fort Snelling at the mouth of the Minnesota River. The results from CE-QUAL-W2 were subsequently fed into the ECOMSED RCA model developed by LimnoTech, to carry forward HSPF Scenario 4 and Scenario 11 loads of TP to the main stem Mississippi River. Scenario 4 and Scenario 11 of the HSPF model incorporated the following set of practices (Tetra Tech 2009):

- Increase perennial vegetation to 20% of the watershed, targeting erosive areas downstream of nick points in the Blue Earth River and Le Sueur River Watersheds, in particular.
- Implement conservation tillage on 75% of land with slopes greater than 3%, along with cover crops to reduce spring runoff.

- Eliminate all surface tile inlets.
- Follow University of Minnesota nutrient management recommendations.
- Use drop structures on ravines to achieve 30% to 40% sediment loading reduction.
- Use controlled drainage on cropland with less than 1% slope, along with two-stage ditch design, storing the first inch of field and urban runoff for at least 24 hours.
- Stabilize stream banks and bluffs by reducing stream flow and scour.
- Assume WWTPs with the potential to discharge above 1 mg/L TP were limited to 1 mg/L of phosphorus at current/historical flows. Stabilization pond facilities and facilities with TP consistently below 1.0 were included in HSPF scenario 4 at actual flows and concentrations if monitoring data was available.

The specific practices noted above and included in the Scenario 21 model simulation are not anticipated or expected to be the practices implemented to meet the reduction goals. Rather, Scenario 21 was chosen as one representation of phosphorus load reduction actions that results in meeting the site-specific water quality standard for both Lake Pepin and Pool 2, along with the RES for the lower Minnesota River. Figure 29 shows the contributing phosphorus loads to Lake Pepin from each major basin modeled in the Upper MRLP model under Scenario 21 from January 1985 through December 2006. The phosphorus loads for each basin calculated under Scenario 21 were used as the Loading Capacities for the Lake Pepin TMDL table found in Section 5.1. Two major basin values in the TMDL table for Lake Pepin, Twin Cities Metro downstream of Lock and Dam 1 (Minneapolis) and MRLP, differ from Scenario 21 results in Figure 29 due to how the basins were delineated by where the downstream pour point was placed. Therefore, loading capacities for the two basins were calculated using USGS gauge flow data adjusted for area and water quality standards.

Table 13. Summary of 21 Upper Mississippi River - Lake Pepin phosphorus load reduction scenarios.

Scen No.	Load Reduction Scenario	UMR / MR Load Reductions	Upper Miss. River					Minnesota River					St. Croix		Cannon		Other Tribs		WWTPs		
			Hist	20%	50%	80%	90%	Hist	20%	50%	80%	90%	Hist	20%	Hist	50%	Hist	20%	Hist	Permit	Reduced
1	Historical Tributary & WWTP Loads	Base	x					x					x		x		x		x		
2	Tributary Load Reductions with Permitted WWTP Loads	Base	x					x					x		x		x			x	
3		20% / 20%		x					x					x		x		x		x	
4		20% / 50%		x						x				x		x		x		x	
5		20% / 80%		x							x			x		x		x		x	
6		50% / 20%			x				x					x		x		x		x	
7		50% / 50%			x					x				x		x		x		x	
8		50% / 80%			x						x			x		x		x		x	
9	Tributary Load Reductions with Reduced WWTP Loads	Base	x					x					x		x		x				x
10		20% / 20%		x					x					x		x		x			x
11		20% / 50%		x						x				x		x		x			x
12		20% / 80%		x							x			x		x		x			x
13		50% / 20%			x				x					x		x		x			x
14		50% / 50%			x					x				x		x		x			x
15		50% / 80%			x						x			x		x		x			x
16	No P.S. Loads	90% / 90%					x					x		x		x		x			
17*	Reduced P.S.	20% / 50%		x						x				x		x		x			x
18*	Reduced P.S.	50% / 80%			x						x			x		x		x			x
19*	Reduced P.S.	90% / 90%					x					x		x		x		x			x
20	Scen 4 + HSPF/W2	20% / 50%		x						HSPF/W2				x		x		x		x	
21	Scen 11 + HSPF/W2	20% / 50%		x						HSPF/W2				x		x		x			x

*Reduced Resuspension

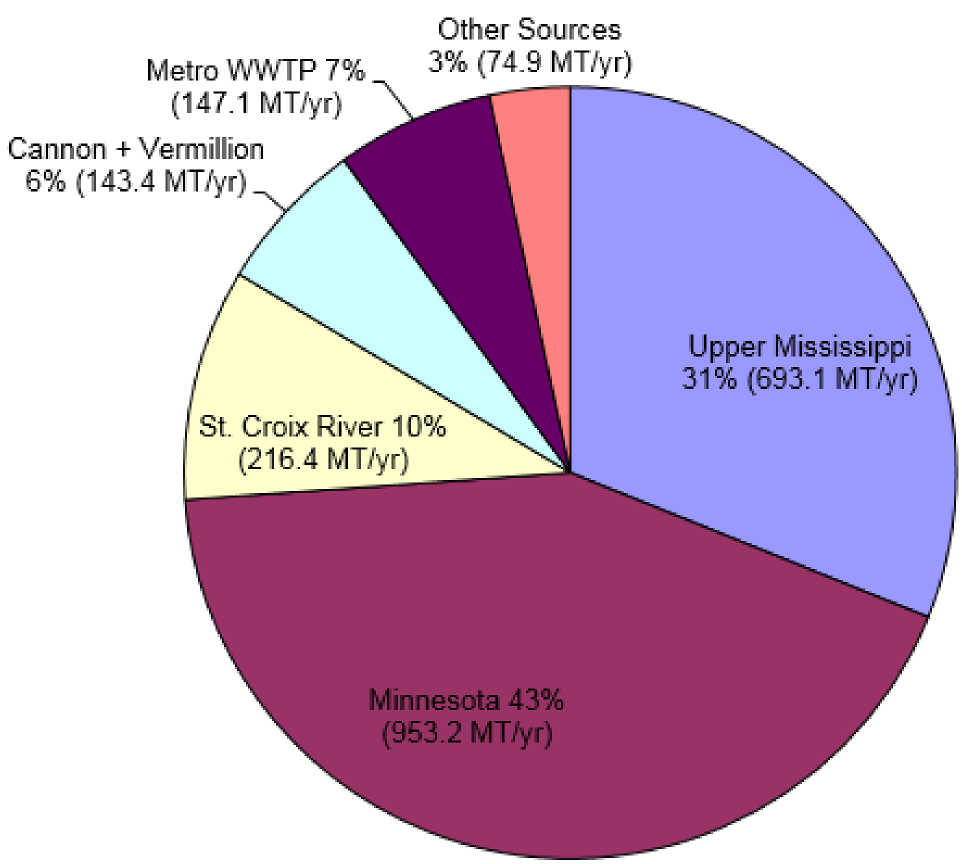


Figure 29. Upper Mississippi River - Lake Pepin model Scenario 21 results showing phosphorus loadings from the major basins required to meet water quality standards.

4.1.3. Modeling to develop WLAs

Additional modeling analyses were conducted by MPCA to support the development of WLAs for point source discharges to support the TMDLs in this report. The modeling analyses are described in two separate MPCA memoranda, one for the Minnesota River Basin and one for the Crow River Basin. The most recent versions of the memoranda can be obtained by contacting MPCA.

During the modeling process discussed previously for the Upper Mississippi River – Lake Pepin model, MPCA staff simultaneously developed draft WLAs compatible with scenario 21 reductions for all NPDES dischargers within the contributing watershed. A categorical approach was used to develop individual WLAs for the draft Lake Pepin TMDL. Calculations use the general formula below and further discussion is presented in Section 5.2.1.

Facility WLA = Average Wet Weather Design Flow or Max Design Flow x

categorical concentration mg/L TP x

3.785 L/gal x 365 days/yr.

RES WLAs in the Crow River Basin were developed with a load duration curve approach using flow data from the MPCA/USGS continuous flow monitoring database called HYDSTRA. A WLA of 7.95 kg/day was determined for the North Fork Crow River and 11.51 kg/day was determined for the South Fork Crow River**.** The combined WLA was categorically split among continuous facilities in the basin based on design flow. Further discussion is presented in Section 5.2.1.

4.2. Relationships to other TMDLs

There are dozens of EPA approved TMDLs elsewhere in the major basins of the Lake Pepin Watershed addressing nutrient impairments. Each of those TMDLs have assigned WLAs for permitted wastewater facilities and MS4 communities. In some cases, these WLAs may be different than the WLAs assigned in this TMDL report. In these instances, the more restrictive WLA applies, in order to meet both the site-specific water quality standard in Lake Pepin and water quality standards in applicable TMDLs. All EPA approved WLAs are applicable. Where necessary, future permits will include WQBELs consistent with the assumptions and requirements of TMDL WLAs. A detailed list of these TMDLs can be found on the MPCA TMDL Projects website. A summary of the approximate number of approved phosphorus and TSS TMDLs in the Lake Pepin Watershed are presented in Table 14.

Table 14. Summary of existing TMDLs in the Lake Pepin Watershed.

Basin	Approved Phosphorus TMDLs		Approved TSS TMDLs
	Lake	Stream	Stream
Upper Mississippi River	192	15	20
Minnesota River	72	6	33
St. Croix River	45	3	2
Lower Mississippi River to Lake Pepin	40	0	19
Totals	349	24	74

*Numbers are approximate; stream phosphorus TMDLs include any with an identified phosphorus pollutant, e.g. dissolved oxygen.

Two larger scale phosphorus TMDLs have been completed in the Lake Pepin Watershed, the Lake St. Croix and Lake Byllesby TMDLs. The Lake St. Croix TMDL calls for reducing phosphorus load to the lake from 460 metric tons per year to 360 metric tons per year to meet the 40 µg/L target in the lake. Based on historical data, approximately 38% of the load to the lake is estimated to be retained in the lake, and 62% conveyed through the outlet. Therefore, approximately 223 metric tons per year is estimated to be discharged to the Mississippi River when the TMDL is met. The Lake Pepin TMDL is based on assumption that 216 metric tons per year will be discharged from the St. Croix Basin. These values are sufficiently close, only a 3% difference, to assume that attainment of the Lake St. Croix TMDL is sufficient to attain the Lake Pepin TMDL. Both TMDLs also include a MOS and RC.

The Lake Byllesby TMDL calls for meeting the site-specific 90 µg/L TP target in the lake. Attaining this target has been considered sufficient for the Lake Pepin TMDL and the in-lake target of 100 µg/L. The Lake Pepin TMDL calculations include loads from Lake Byllesby assuming 90 µg/L is met on an average annual basis.

5. TMDL Development

The phosphorus TMDLs for Lake Pepin, Pool 2, and the impaired AUIDs in the mainstem of the Mississippi River are presented in this section. The modeling methodologies discussed in Section 4 were used to develop these TMDLs.

The TMDL, which is represented as the total LC, is calculated using the following equation:

$$TMDL = \mathrm{LC} = \mathrm{WLA} + \mathrm{LA} + \mathrm{MOS} + \mathrm{RC} + \mathrm{BC}$$

Where:

Loading Capacity (LC): the maximum allowable pollutant load to a waterbody such that it will attain water quality standards.

Wasteload Allocation (WLA): the sum of point source pollutant loads requiring a permit under the NPDES program including industrial and municipal WWTPs, MS4 entities, regulated construction and industrial stormwater, and discharges covered by general NPDES permits.

Load Allocation (LA): the pollutant load that is allocated to nonpoint source loads that do not require a NPDES permit.

Margin of Safety (MOS): an accounting of uncertainty in the relationship between allowable pollutant loads and attainment of water quality standards.

Reserve Capacity (RC): pollutant load capacity set-aside for potential future loading sources.

Boundary Conditions (BC): areas within the impaired AUID watershed that do not require WLAs and LAs. BCs may include areas addressed by previously approved TMDLs that are sufficiently protective for this report's TMDLs, as discussed in Section 4.2. BCs may also include upstream areas that are currently meeting water quality standards and areas upstream of geographic barriers which are capable of trapping a significant mass of nutrients between the outfall and the impairment during most streamflow conditions. BCs are discussed in more detail in Section 5.6.

All TMDLs in this report were developed using TP as the target. The TMDLs, allocations, and margins of safety are expressed in kilograms of TP per day. The TMDLs for Lake Pepin and Pool 2 apply as annual average loads. The TMDL for the RES impairment of the Mississippi River, between the Crow River to Upper St. Anthony Falls, applies as a calendar month average load for June through September.

Land area in Wisconsin and discharges in Wisconsin contribute to the Lake Pepin Watershed and are accounted for in the TMDL. The relevant WLAs and LA for Wisconsin have been presented as separate loads. EPA cannot approve allocations for Wisconsin loads in a Minnesota TMDL.

The TMDLs for each impaired AUID are presented in Table 15 through Table 17. The remainder of this section, following the TMDL summary tables, discusses the development of the TMDL components for each impaired AUID. All values in the TMDL tables represent delivery of phosphorus to the impaired reach. The allowable load at the point of discharge may be greater. The development and application of phosphorus delivery ratios is discussed in Section 5.7.

Table 15. Lake Pepin TMDL, AUID 25-0001-00.

Lake Pepin TMDL, AUID 25-0001-00 TMDL (kg/year) = LC = WLA + LA + MOS + RC + BC = 2,218,436 = 609,805 + 1,089,195 + 110,922 + 27,454 + 381,060		Allowable TP Load kg/year	Allowable TP Load kg/day
Load Capacity (LC)		**2,218,436**	**6,078**
LC (excluding Boundary Conditions)		1,837,376	5,034
Major Basin Components	*Mississippi River at LD1*	*629,625*	*1,725*
	Minnesota River	*916,880*	*2,512*
	Twin Cities Metro Below LD1	*197,431*	*541*
	Mississippi River/Vermillion/Lower Cannon	*93,440*	*256*
Wasteload Allocation (WLA)	**Total WLA**	**609,805**	**1,671**
	WWTPs	***381,286***	***1,045***
	Mississippi River at LD1	*99,674*	*273*
	Minnesota River	*115,939*	*318*
	Twin Cities Metro Area Below LD1	*157,278*	*431*
	Mississippi River/Vermillion/Lower Cannon	*8,395*	*23*
	MS4s	***226,327***	***620***
	Mississippi River at LD1	*121,410*	*333*
	Minnesota River	*46,401*	*127*
	Twin Cities Metro Area Below LD1	*40,153*	*110*
	Mississippi River/Vermillion/Lower Cannon	*18,363*	*50*
	Construction and Industrial Stormwater	***1,837***	***5.0***
	Mississippi River at LD1	*630*	*1.7*
	Minnesota River	*917*	*2.5*
	Twin Cities Metro downstream of LD1	*197*	*0.5*
	Mississippi River/Vermillion/Lower Cannon	*93*	*0.3*
Load Allocation (LA)	**Total LA**	**1,089,195**	**2,984**
	Natural Background	*399,854*	*1,095*
Margin of Safety (MOS): Explicit 5% of LC		**110,922**	**304**
Reserve Capacity (RC)		**27,454**	**75**
Boundary Conditions (BC)	**Total BC**	**381,060**	**1,044**
	St. Croix River Basin	*216,445*	*593*
	Cannon River Upstream of Lake Byllesby	*64,970*	*178*
	Mississippi River Upstream of Aitkin	*63,510*	*174*
	Minnesota River Upstream of Lac Qui Parle Dam	*36,135*	*99*

Applicable total phosphorus criterion: 100 µg/L

Allowable TP loads applied as 12 month moving totals.

Note that multiplying kg/day values by 365 days do not exactly equal kg/year values due to rounding.

Wisconsin loads are not included other than in the boundary condition for the St. Croix Basin. See Appendix E for the loads from Wisconsin downstream of the St. Croix River that are accounted for in this TMDL.

Table 16. Mississippi River AUID 07010206-814 TMDL.

Mississippi River: Upper St. Anthony Falls to St. Croix River TMDL, AUID 07010206-814 TMDL (kg/year) = LC = WLA + LA + MOS + RC + BC		Allowable TP Load	
= 1,843,581 = 579,298 + 1,045,912 + 92,179 + 26,547 + 99,645		kg/year	kg/day
Load Capacity (LC)		**1,843,581**	**5,051**
LC (excluding Boundary Conditions)		1,743,936	4,778
Major Basin Components	*Mississippi River at LD1*	*629,625*	*1,725*
	Minnesota River	*916,880*	*2,512*
	Twin Cities Metro Below LD1	*197,431*	*541*
Wasteload Allocation (WLA)	**Total WLA**	**579,298**	**1,588**
	WWTPs	***369,918***	***1,014***
	Mississippi River at LD1	*99,674*	*273*
	Minnesota River	*115,939*	*318*
	Twin Cities Metro Area Below LD1	*154,305*	*423*
	MS4s	***207,636***	***569***
	Mississippi River at LD1	*121,410*	*333*
	Minnesota River	*46,401*	*127*
	Twin Cities Metro Area Below LD1	*39,825*	*109*
	Construction and Industrial Stormwater	***1,744***	***4.7***
	Mississippi River at LD1	*630*	*1.7*
	Minnesota River	*917*	*2.5*
	Twin Cities Metro downstream of LD1	*197*	*0.5*
Load Allocation (LA)	**Total LA**	**1,045,912**	**2,867**
	Natural Background	*388,979*	*1,066*
Margin of Safety (MOS): Explicit 5% of LC		**92,179**	**253**
Reserve Capacity (RC)		**26,547**	**73**
Boundary Conditions (BC)	**Total BC**	**99,645**	**273**
	Mississippi River Upstream of Aitkin	*63,510*	*174*
	Minnesota River Upstream of Lac Qui Parle Dam	*36,135*	*99*

Applicable total phosphorus criterion: 125 µg/L. This TMDL applies to AUID 07010206-814 and AUID 07010206-806
Allowable TP loads applied as 12 month moving totals.
Note that multiplying kg/day values by 365 days do not exactly equal kg/year values due to rounding.

Table 17. Mississippi River AUID 07010206-805 TMDL.

Mississippi River: Crow River to Upper St. Anthony Falls, 07010206-805 TMDL (kg/day) = LC = WLA + LA + MOS + RC + BC = 2,490 = 216 + 601 + 125 + 6 + 1,542		Allowable TP Load kg/day
Load Capacity (LC)		**2,490**
LC (excluding Boundary Conditions)		948
Major Basin Components	*Crow River*	*474*
	Twin Cities Metro Above St. Anthony Falls	*474*
Wasteload Allocation (WLA)	**Total WLA**	**216**
	WWTPs	***35***
	Crow River	*29*
	Twin Cities Metro Above St. Anthony Falls	*6*
	MS4s	***180***
	Crow River	*38*
	Twin Cities Metro Above St. Anthony Falls	*142*
	Construction and Industrial Stormwater	***1.0***
	Crow River	*0.5*
	Twin Cities Metro Above St. Anthony Falls	*0.5*
Load Allocation (LA)	**Total LA**	**601**
	Natural Background	111
Margin of Safety (MOS): Explicit 5% of LC		**125**
Reserve Capacity (RC)		**6**
Boundary Conditions (BC)	**Total BC**	**1,524**
	Mississippi River Upstream of Crow River	**1,327**
	Rum River	**215**

Applicable total phosphorus criterion: 100 µg/L

Allowable TP loads applied as calendar month averages, June through September. However, for the Twin Cities Metro Above Upper St. Anthony Falls WLAs, a 12 month moving total mass limit for Lake Pepin/Pool 2 is sufficient to address the RES impairment.

The Rum River Watershed is treated as a boundary condition for this RES TMDL because the Rum River is meeting the applicable RES standard of 100 µg/L.

5.1. Loading Capacity

The LC is equivalent to the TMDL, and is the maximum allowable pollutant load to a waterbody such that it will attain water quality standards. The LCs for Lake Pepin and Pool 2 were based on results of the Upper MRLP modeling efforts described in Section 4. The LC for the impaired stream AUID from the Crow River to Upper St. Anthony Falls was calculated based on typical flows in the river segment and the applicable RES criteria.

5.1.1. Lake Pepin and Pool 2

The LC for Lake Pepin and the Mississippi River from Upper St. Anthony Falls to St. Croix River reach was determined using the Upper MRLP model, which was discussed in Section 4.1. The model simulated 22 years, from 1985 through 2006. Multiple load reduction scenarios were simulated to determine the LC that would meet the site-specific criterion of 100 µg/L TP in Lake Pepin. A scenario was selected that achieved the criterion and included the following load reductions from the major subbasins, WWTPs, and internal loads caused by resuspension of sediment:

- 20% reduction in TP load from the Mississippi River at Ford Dam (Lock and Dam 1 (Minneapolis))
- 50% reduction in TP load from the Minnesota River
- 20% reduction in TP load from the St. Croix River
- 50% reduction in TP load from the Cannon River
- 20% reduction in TP load from other tributaries
- 70% reduction from previously permitted loads for WWTPs
- 50% reduction in resuspension in Pool 2

The results of this scenario also supported compliance with the site-specific 125 µg/L TP RES 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 (Welch, Minnesota) . A detailed description of how the model was developed, as well as the results of the reduction scenarios, is provided in the *Upper Mississippi River – Lake Pepin Water Quality Model* report (LimnoTech 2009a). The LCs for Lake Pepin and the Upper St. Anthony Falls to St. Croix River reach are summarized below and are based primarily on the results of the Upper MRLP model:

- Lake Pepin LC = 2,232,725 kg/year TP
- Mississippi River Upper St. Anthony Falls to St. Croix River LC = 1,843,270 kg/year TP

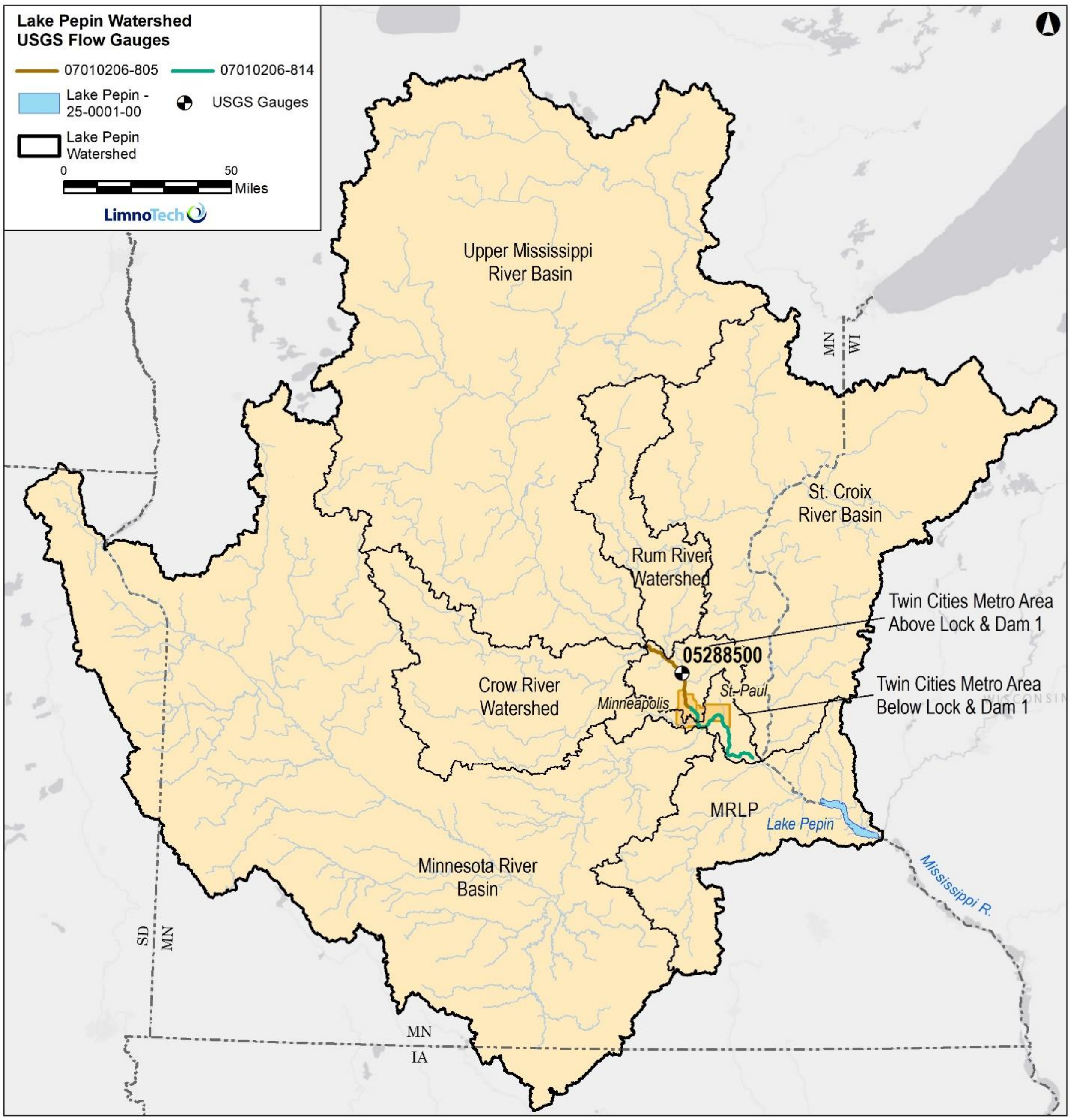
5.1.2. Impaired Stream AUID – Crow River to Upper St. Anthony Falls

The LC for the impaired stream AUID was determined through an analysis of historical flows from 1985 through 2015 and the applicable RES criteria. Flow data from USGS gauge stations along the Mississippi River closest to the impaired AUID were downloaded and an average June through September flow was calculated. Figure 30 shows the location of USGS gauge used in these calculations. A Drainage area ratio was applied to estimate flows when USGS gauge station locations did not match an AUID drainage area. The estimated average June through September flow was multiplied by the applicable TP RES criterion for the AUID to achieve a total allowable daily loading rate, or LC. The LC for the RES TMDL is summarized in Table 18 below.

Table 18. Calculation of loading capacity for the RES impaired AUID.

Listed Waterbody Name	Reach (AUID)	Applicable Total Phosphorus Criterion (µg/L)	Average June-September Flow (cfs)	Loading Capacity (kg/day TP)
Mississippi River: Crow River to Upper St. Anthony Falls	07010206-805	100	10,175	2,490

Figure 30. Locations of USGS gauge station used in calculating the average June through September flow for the impaired stream AUID.



5.2. Wasteload Allocation Methodology

The WLA is the sum of point source pollutant loads within the waterbody's drainage area, which includes NPDES permitted industrial and municipal WWTPs, MS4 communities, and regulated construction and industrial stormwater. The TMDLs in this report include WLAs for permitted entities throughout the watershed for each impaired AUID, with the exception that WLAs are not included in the Boundary Condition (BC) areas. These BC areas are discussed further in Section 5.6. The development of WLAs for each of the individual source categories is further described in the following sections.

5.2.1. Permitted Municipal and Industrial Wastewater

The MPCA's approach for determining whether permits must contain TP WQBELs is consistent with 40 CFR 122.44(d). The MPCA considers the development and implementation of WQBELs for each facility discharging TP concentrations in excess of the TP criterion upstream of a nutrient impaired waterbody. If a facility's discharge has a reasonable potential to cause or contribute to an excursion above a downstream water quality standard, the facility will receive a WQBEL in their discharge permit. The MPCA considers the presence of nutrient sinks between the discharge and the impaired waterbody when assessing reasonable potential. The MPCA also considers the attainment of water quality standards in water body reaches upstream of an impaired reach. .

The Upper Mississippi River Basin upstream of Aitkin and the Minnesota River Basin upstream of Lac Qui Parle Dam have significant lake or reservoir systems that function as nutrient sinks. The Mississippi River upstream of Aitkin is also at relatively low TP concentrations, approximately 50 µg/L. Therefore, wastewater dischargers within those BC areas do not require WLAs for the TMDLs in this report. Wastewater dischargers within the Lake St. Croix and Lake Byllesby watersheds have previously approved TMDLs and WLAs that are sufficiently protective of downstream impairments, as discussed in Section 4.2. Current loading capacities and WLAs in the existing TMDLs are sufficient to protect Lake Pepin. Therefore, wastewater dischargers within those watersheds do not require that WLAs be specified for the TMDLs in this report.

Remaining facilities discharging in the impaired watersheds are found to have reasonable potential for TP; and, therefore, are required to have a WLA to address the Lake Pepin and Pool 2 TMDLs in this report. For the RES impaired reach of the Mississippi River at the mouth of the Crow River (07010206-805), current loads in the Upper Mississippi River Basin above the Crow River and in the Rum River Basin are meeting RES criteria where they enter this impaired reach. Therefore, while a WLA for the Lake Pepin TMDL has been included for wastewater dischargers within those watersheds, separate RES WLAs have not been specified for the 07010206-805 TMDL. Seasonal WLAs have been specified for discharges in the Crow River Watershed to meet the RES TMDL. The Lake Pepin TMDL WLAs for the dischargers in the Upper Mississippi River Basin above the Crow River and the Rum River Watershed are sufficient to meet the 0701020-805 RES TMDL. Further discussion is provided in Section 5.6.

A total of 407 permitted municipal and industrial wastewater dischargers have been assigned a WLA in this TMDL report (Figure 19 and Appendix B). MPCA has developed an annual WLA for each of these facilities. Additionally, several seasonal WLAs for facilities within the RES impaired AUID have been developed that may be more restrictive than the annual WLAs to protect Lake Pepin. The development of these WLAs is documented in a series of MPCA memoranda. For the most current versions of these memoranda, the reader should contact the MPCA. The general methodology used to develop WLAs for wastewater dischargers is described below. Unique circumstances are noted in Appendix B.

The general approach for implementing WLAs in permits as WQBELs is described below for each type of WLA. However, the MPCA permit writers have discretion in how to implement WLAs as WQBELs in an individual permit. If the discharge is upstream of an impaired water other than those in this report, the discharge may be subject to a more restrictive WLA than what is presented in this report. Note that permit actions are not part of a TMDL and are reviewed and approved by EPA independently.

Annual WLAs to meet Lake Pepin and Pool 2 TMDLs

Categorical WLAs or WQBELs using average wet weather design flow (AWWDF) or maximum design flow (MDF) were developed for NPDES WWTPs in the Lake Pepin Basin using the general formula below.

> Facility WLA = AWWDF or MDF (mgd) x categorical concentration multiplier (mg/L TP) x 3.785 L/gal x 365 days/year

The categorical concentration multiplier is the allowable TP concentration for a category of facilities and is based on the size and type of facility. The multipliers were developed to allocate the overall WLA for the Lake Pepin TMDL. The categorical concentration multipliers were applied to design flows to derive annual WLAs for the Lake Pepin TMDL (Table 19 and Table 20). For larger WWTPS, greater than 20 mgd, the categorical concentration multiplier was the lowest at 0.3 mg/L TP. The highest categorical concentration multiplier of 3.5 mg/L TP was applied to facilities discharging less than 0.2 mgd. These WLAs are converted to a daily load by dividing by 365 days per year to satisfy EPA's requirements for daily loads in TMDLs. However, the WLAs are not intended to result in short duration permit effluent limits. The WLAs will be implemented in permits as 12-month moving total mass limits or WQBELs. These WQBELs will be evaluated on a monthly basis to ensure compliance.

Seasonal WLAs to meet RES TMDL

Some facilities within the Crow River Watershed were given a second WLA based on meeting the RES criteria in the downstream impaired AUID during the applicable months of June through September. These WLAs were developed, as needed, when the annual WLA to meet the Lake Pepin TMDL was not sufficient to meet the RES TMDL. More detail on the development of these RES WLAs for the Crow River Watershed can be found in the *Greater Crow River Watershed Phosphorus Effluent Limit Analysis* memorandum prepared by the MPCA. For the most current version of this memorandum, the reader should contact the MPCA. These seasonal WLAs will apply from June through September and are based on meeting RES criteria. They will be implemented in permits as calendar monthly average effluent limits by applying an effluent variability multiplier to the WLA. More restrictive TP WLAs and WQBELs may be assigned for local lakes and rivers in individual watershed reviews if these main-stem WLAs are not sufficient for local resources.

Facilities in the Upper Mississippi River Basin Watershed above the Crow River, the Rum River Watershed, and the Twin Cities Metro Area above Lock and Dam 1 (Minneapolis) were not assigned unique RES WLAs. For these facilities, the annual WLA established for the Lake Pepin TMDL is sufficient to support attainment of the RES in the Mississippi River segment. These watersheds attain the RES criteria upstream of the impaired reach in the Mississippi River (07010206-805, Crow River to Upper St.

Anthony Falls). The TMDL for 07010206-805 includes WLAs for these facilities at a value equal to the annual Lake Pepin WLA divided by 365 days.

WLAs for Stabilization Ponds

WLAs for stabilization ponds were developed to meet the Lake Pepin TMDL. Some of the WLAs require reductions in the annual TP load, while others require maintaining the existing load. When considering the RES TMDLs in this report, WLAs have been calculated for pond facilities to allow for a maximum of 16 days of discharge in the June through September timeframe at the maximum permitted daily discharge rate and a concentration of either 1.0 mg/L or 2.0 mg/L, depending on existing permit requirements. The 16 days of discharge is an assumption to illustrate the maximum for a pond in the June through September timeframe. Most ponds do not discharge for 16 days during this period. Additional consideration of the allowable TP load from these facilities may take place during local watershed reviews driven by local TMDLs or other watershed planning activities, such as WRAPS and 1W1P. The annual and daily WLAs presented in this TMDL report for stabilization ponds will generally be implemented as 12 month moving total mass permit limits.

Summary of Wastewater WLAs

A summary of WLA calculations is presented in Table 19 and Table 20. Seasonal RES WLAs for municipal and industrial WWTPs in the Crow River Basin. For all categories of TP dischargers. Not all individual WLAs included in the TMDLs in this report conform exactly to these general methodologies. Some site-specific considerations have been made in developing the individual WLAs. These site-specific considerations are noted along with the summary table of all individual WLAs included in Appendix B. Individual WLAs will be confirmed in individual TP WQBEL reviews or watershed reviews.

Table 19. Annual WLAs for municipal and industrial WWTPs in the Lake Pepin Watershed.

Facility Type and Flow (AWWDF or MDF*)	Annual WLA to meet Lake Pepin TMDL
Continuous > 20.0 mgd	AWWDF x 0.3 mg/L
Continuous 1.0 – 20.0 mgd	AWWDF x 0.8 mg/L
Continuous 0.2 – 1.0 mgd	AWWDF x 1.0 mg/L
Continuous <0.2 mgd	AWWDF x 3.50 mg/L or maintain current discharge
Stabilization ponds	AWWDF x 1.0 or 2.0 mg/L or maintain current discharge
WWTPs at conc. below RES	Maintain current discharge**
Industrial Discharge with concentration > 1.0 mg/L and MDF > 1.0 mgd	MDF x 1.0 mg/L
Industrial Discharge with concentration > 1.0 mg/L and MDF < 1.0 mgd	MDF x 1.0 mg/L
Industrial Discharge with concentration < 1.0 mg/L	Current load x 1.15
Other Industrial	Limits specified on a site specific basis

WLAs will be implemented as 12 month moving total mass limit
*MDF = Maximum Design Flow --> common value used to evaluate industrial discharges
**Expansion of these WWTPs may be permitted assuming effluent concentration remains below RES

Table 20. Seasonal RES WLAs for municipal and industrial WWTPs in the Crow River Basin.

Facility (AWWDF or MDF*)	Seasonal WLA to meet downstream RES TMDL in the Crow River Watershed
Lower Crow Watershed	
Continuous 1.0 – 20.0 mgd	70% AWWDF x 0.38 mg/L
Continuous 0.2 – 1.0 mgd	70% AWWDF x 0.48 mg/L
Continuous < 0.2 mgd	70% AWWDF x 1.67 mg/L
North Fork Crow Watershed	
Continuous > 1.0 mgd	70% AWWDF x 0.20 mg/L
Continuous 0.2 – 1.0 mgd	70% AWWDF x 0.30 mg/L
Continuous < 0.2 mgd	70% AWWDF x 0.47 mg/L
Industrial discharge with concentration < 1.0 mg/L	MDF x 1.0 mg/L
South Fork Crow Watershed	
Continuous > 3.0 mgd	70% AWWDF x 0.15 mg/L
Continuous 1.0 – 3.0 mgd	70% AWWDF x 0.25 mg/L
Continuous 0.2 – 1.0 mgd	70% AWWDF x 0.30 mg/L
Continuous < 0.2 mgd	70% AWWDF x 0.50 mg/L
Stabilization ponds	70% AWWDF x 0.95 mg/L
Industrial discharge with concentration > 1.0 mg/L	MDF x 0.150 mg/L
Other Industrial	Limits specified on a site specific basis

Implementation of Seasonal WLA as a monthly average limit during June through September will include a multiplier to account for effluent variability

*MDF = Maximum Design Flow --> common value used to evaluate industrial discharges

5.2.2. Regulated MS4 Stormwater

MS4 systems are designed to convey stormwater into a receiving waterbody and are permitted under an NPDES Permit. Permitted MS4s are included in the WLA. A MS4 TP unit area load or export coefficient was applied to MS4 areas to determine the WLA. Existing areas that are not currently part of a MS4 but become a new MS4 or join an existing MS4 are not included in the MS4 WLA. These areas are addressed in Section 5.5.1 of this TMDL report.

Several sources were reviewed to determine the appropriate unit area load or export coefficient to apply to the MS4 WLA. These sources included:

- Detailed Assessment of Phosphorus Sources to Minnesota Watersheds (Barr Engineering 2004)
- Lake St. Croix Nutrient TMDL (MPCA 2012b)
- Lake Byllesby TMDL (MPCA 2013b)
- Medicine Lake TMDL (MPCA 2010)
- Coon Creek TMDL (MPCA 2016b)
- Minnesota River DO TMDL (MPCA 2004)
- Upper Mississippi River – Lake Pepin Water Quality Model (LimnoTech 2009a)
- Cannon River HSPF Model (LimnoTech 2015).

TP export coefficients for MS4 “existing” conditions presented in the Detailed Assessment of Phosphorus Sources to Minnesota Watersheds were estimated to be approximately 0.5 lb/acre/year (Appendix J of the Detailed Assessment, Table 10 for average of loading rates for an average year for the Upper Mississippi River, Minnesota River, and Lower Mississippi River basins, and areas from Table 6). A 30% reduction, consistent with the reduction called for in the Minnesota River DO TMDL for MS4 areas results in 0.35 lb/acre/year. The Lake St. Croix TMDL called for a similar load from MS4s at 0.34 lb/acre/year based on a 40% reduction from an estimated 0.56 lb/acre/year existing condition estimate. The Lake Pepin model represented a 20% reduction in the MS4 load from the Twin Cities Metropolitan Area. Tributary monitoring conducted by MCES shows that many MS4 areas are already likely meeting 0.35 lb/acre/year as a 10-year average (Metropolitan Council 2014). Modeling by 30 MS4s as part of their evaluation of nondegradation showed that median loading rates were slightly below 0.35 lb/acre/year following implementation of BMPs. Based on literature review, available data, stakeholder input in past TMDL engagement, and agreement with existing basin-scale TMDLs, the WLA for each MS4 included in the TMDLs in this report is 0.35 lb/acre/year for the area served by the stormwater collection and conveyance system. The extent of reduction needed to achieve 0.35 lb/acre/year will vary by MS4.

If a phosphorus TMDL exists for a local lake or stream impairment, the local MS4 WLA will be more restrictive in most cases. In all cases, the more restrictive WLA will apply in order to meet both the local MS4 WLA and the WLA in this report. A summary table of the 206 MS4 entities addressed by the TMDLs in this report is included in Appendix C. An additional 11 cities that have grown or are growing and now have populations exceeding or approaching 5,000 are listed at the end of the table in Appendix C. These cities are also included in the MS4 WLAs in the TMDLs in this report. Estimated delivery ratios of TP from individual MS4s to the upstream end of the impaired AUID were applied to calculate the MS4 WLA included in the TMDL tables. The development and application of the delivery ratios is presented in Section 5.7.

5.2.3. Regulated Construction and Industrial Stormwater

A permit is required for any construction activities disturbing: one acre or more of soil; less than one acre of soil if that activity is part of a “larger common plan of development or sale” that is greater than one acre; or less than one acre of soil, but the MPCA determines that the activity poses a risk to water resources. A permit is also required for 11 categories of industrial activities that may discharge only industrial stormwater. A construction and industrial stormwater runoff WLA is needed to account for pollutant loading from these ongoing construction and industrial activities in the watershed. MPCA has established a WLA for construction and industrial stormwater of 0.1% of the Load Capacity, excluding Boundary Conditions, based on best professional judgment. This WLA was applied in each of the TMDLs.

5.3. Load Allocation Methodology

The LA is the pollutant load that is allocated to nonpoint source loads that do not require a NPDES permit. For the TMDLs presented in this report, the LA was calculated as the remaining portion of the LC after the WLAs, 5% MOS, RC and Boundary Conditions were subtracted. Nonpoint source loads can come from both natural background processes and anthropogenic, or human-made, influences. The LA includes a combination of these sources.

As discussed previously in Section 3.6.1.2, nonpoint anthropogenic sources of phosphorus include soil erosion or nutrient leaching from cropland, phosphorus in runoff from communities not covered by NPDES permits, and streambed and streambank erosion resulting from human-induced hydrologic changes and disturbance of stream channels and riparian areas. In addition, some phosphorus may leach into the reservoir or its upstream tributaries from poorly functioning septic systems.

The natural background component of the LA for each TMDL is presented in the TMDL tables and is intended to represent a rough estimate of the TP load prior to large-scale changes in the land use of the area. Natural background sources include atmospheric deposition and soil erosion from both stream channels and upland areas that would occur under "natural conditions." Engstrom and Almendinger (2000) developed an estimate of TP loads to Lake Pepin over time, based on analysis of Lake Pepin sediment core data. This work estimated a TP loading rate to Lake Pepin of 0.053 lb/acre/year circa 1830, prior to significant human impacts on the landscape. This value was used to estimate the natural background component of the LA.

Internal loads of phosphorus to the system are a component of the LA and were considered in the Lake Pepin and Pool 2 TMDLs. The model scenario used to establish the TMDLs for those AUIDs included a 50% reduction in the resuspension rate of bottom sediments throughout the Pool 2 reach. This corresponds to an approximate 2% reduction in the overall phosphorus load to Lake Pepin. Resuspension of sediments containing phosphorus is caused by high shear stresses on the bottom, driven by a variety of factors including currents and wind-wave action. Opportunities were identified to reduce resuspension in Pool 2 through restoration efforts, including establishment of islands to reduce wind fetch and wave action, specifically in shallow areas in and around Spring Lake. The model scenario supporting the TMDLs for Lake Pepin and Pool 2 accounts for the reduction in internal loading resulting from these restoration efforts, even though the TMDL tables do not include an explicit value for internal loads of phosphorus.

5.4. Margin of Safety

The applicable water quality standards and TMDLs designed to meet those standards have been developed using the best available information. Some uncertainty is inherent in this process, due to a variety of factors. Ultimately, continued monitoring and adaptive management are absolutely necessary to monitor the implementation of these TMDLs and the resulting improvements in water quality. The CWA requires each TMDL to include a MOS to account for lack of knowledge concerning the relationship between pollutant loading and resulting ambient water quality. Quantifying the uncertainty of the various assumptions made in defining the linkage between TP loads and resulting water quality and developing the TMDLs is challenging. Therefore, an explicit MOS equal to 5% of the LC was applied in the TMDLs, based on best professional judgment. The MOS is intended to acknowledge that there is uncertainty in the linkage between TP loads and resulting water quality.

This 5% MOS is considered to be sufficient given the robust datasets used and high quality of modeling conducted previously to support the Lake Pepin TMDL (LimnoTech 2009a). The overall modeling approach followed EPA's Draft Guidance on the Development, Evaluation, and Application of Regulatory Environmental Models (EPA 2003). An important overarching component of this project was the adherence to an open modeling process throughout the project that involved continual interaction with all stakeholders at each step in the process. Another important part of the open modeling approach was ongoing model peer review of the entire modeling process by a SAP, consisting of academic and government scientists and MPCA staff familiar with the system under study. Every effort was made to incorporate all of the available data for the Upper Mississippi River system during the model development and calibration/confirmation process. The Upper Mississippi River system has a long history of abundant water quality and biological data collected over the past 22 years (1985 through 2006) by federal, state, and local government agencies. The dataset includes 1,139,970 results from 109,458 samples collected at 7,056 stations (LimnoTech 2009a). The model was calibrated using monitoring data for 1996 through 2006, and the monitoring data from 1985 through 1995 were used as a confirmation dataset. Both the calibration and confirmation data sets included a low flow and a high flow year. The calibration period included the intense low-flow monitoring program conducted in 2006 (10th percentile summer (June through September) flow at Prescott) and the 86th percentile annual flow at Prescott in 2002. The earlier confirmation period included the 1% summer flow in 1988 and the highest annual flow on record in 1993. It was important to test the model's ability to simulate the system response over the full range of flow conditions because high flows represent the critical conditions for turbidity, while low flows represent the critical conditions for nutrient-stimulated phytoplankton growth.

Overall model performance for the calibration period and confirmation periods was found to be quite good, especially given the complexity of the model framework and the extent of the model domain. The median absolute relative error for TP predictions compared to measured data was approximately 12% at Lock and Dam 2 (Hastings, Minnesota), 15% at Lock and Dam 3 (Welch, Minnesota) , and 20% in Lake Pepin (LimnoTech 2009a).

5.5. Reserve Capacity

RC is included in TMDLs to represent a set-aside for potential future loading sources. States have flexibility in how RC is accounted for in TMDLs. The RC approaches taken by MPCA and WDNR for the TMDLs included in this report are discussed below.

5.5.1. Minnesota Reserve Capacity

The approach taken by MPCA to establish RC for wastewater and MS4 areas in the TMDLs in this report is discussed below.

Wastewater

The TMDLs in this report include a RC component to account for unallocated wastewater loadings to address industrial facilities without monitoring, such as gravel pits. Additionally, RC was included for errors and unknowns in future permitting. The RC to account for these issues was calculated as 5% of the total WWTP WLA for each TMDL.

As a result of population changes or increased contributions from industrial wastewater discharges, flows at some wastewater treatment facilities may increase over time. Any increase in discharge flow rate must maintain the WLA provided in this TMDL. A number of the WWTP WLAs presented in this TMDL are based on discharge flow rates that are higher than existing flow rates, allowing for growth within the existing WLA. Therefore, no RC is included in the TMDLs in this report for WWTP expansions.

However, in Minnesota, an additional RC component has been included for upgrading unsewered communities. RC is established for projects that address failing or nonconforming septic systems and "unsewered" communities, and will be made available only to new WWTPs or existing WWTPs that provide service to existing populations with failing or nonconforming systems. The potential need for RC for these situations has been estimated for Minnesota based on the assumption that 10% of the unsewered population within an impaired AUID drainage basin may discharge to WWTPs in the future. The potential TP load from future WWTPs serving these populations has been calculated based on an assumption of 0.8 kg/capita/year of TP load to the WWTP and a reduction efficiency of 80% at the WWTP, resulting in a load to the receiving water of 0.16 kg/capita/year (MPCA 2012b - Lake St. Croix Nutrient TMDL). Based on this loading rate, the potential RC needed is small relative to the overall TMDLs; it is approximately 1.2% (76 kg/day) of the Load Capacity for the Lake Pepin TMDL (6,118 kg/day). A summary of the RC calculated for replacing septic systems and for unallocated and unknowns is presented in Table 21 for each impaired watershed.

Table 21. Reserve Capacity for Replacing Septic Systems.

AUID	Unsewered Population Estimate*	10% Conversion Assumption	Reserve Capacity for Replacing Septic Systems (kg/yr)	Reserve Capacity for Unallocated and Unknowns (kg/yr)	Total Reserve Capacity (kg/yr)	Total Reserve Capacity (kg/day)
07010206-805	85,830	8,583	1,373	639	2,012	6
07010206-806/814	503,185	50,319	8,051	18,559	26,610	73
Lake Pepin	524,366	52,437	8,390	19,323	27,713	76

*Does not include boundary conditions areas

New or Expanding MS4

MS4 areas have been allocated a WLA based on a long-term average unit area load or export coefficient of 0.35 lb/acre/year for the TMDLs in this report. This WLA will apply to any new development that occurs within a regulated MS4. If one regulated MS4 acquires land from another regulated MS4, such as an annexation or highway expansions, there is no need to adjust the TMDL. In these cases, the MS4 WLA continues to be applied and no RC is needed in the TMDL.

If one or more non-regulated MS4s become regulated, the newly regulated MS4 area will become part of the MS4 WLA. These situations will require a transfer from the LA to the MS4 WLA, but are assumed to result in no net increase in TP loads to the impaired AUID. In the same context, if an expansion of a U.S. Census Bureau Urban Area encompasses previously non-MS4 areas and assigns these areas to an existing MS4 permittee, the MS4 WLA will continue to be applied to the MS4. Again, for this situation, a transfer from the LA to the WLA will be required but will assume no net increase in TP load to the impaired AUID. Finally, if a new MS4 or other stormwater-related point source is identified and is covered under a NPDES permit, the MS4 WLA will apply. In this situation, a transfer must also occur from the LA to the WLA. If a LA to WLA transfer is needed, the MS4 WLA will be increased by applying the long-term average unit area load of 0.35 lb/acre/year to the new MS4 area. The MS4 WLA will increase by this amount and the LA will decrease by this amount. In cases where transfers from the LA to the WLA are required, no RC is needed in the TMDL.

5.5.2. Wisconsin Reserve Capacity

The following text detailing the State of Wisconsin's approach to including RC was provided to MPCA by the WDNR. While the U.S. EPA will not review nor approve Wisconsin phosphorus loads for the Lake Pepin TMDL presented in this report, the TMDL accounts for phosphorus loads from Wisconsin, including an allowance for RC. RC is intended to provide WLA for new or expanding industrial, CAFOs, or municipal WPDES permit holders. The RC is not intended to be applied to general permits (exceptions discussed below), or permitted MS4s. For this TMDL, RC is assigned for phosphorus.

RC can be used to cover discharges from general permits if it is determined that the WLA set aside for general permits, as specified in the TMDL, does not adequately cover existing, new, or expanding discharges from general permits.

RC is calculated on a reach by reach basis, with 5% of a reach's available wastewater treatment plant WLA being set aside as RC. This proportion provides adequate RC for potential new or expanding dischargers in headwater sections of the basin. In addition, any unused RC accumulates from contributing reaches moving down through the basin, which cumulatively increases capacity available for dischargers located on larger downstream rivers. This approach affords dischargers greater flexibility with regard to where they can locate or expand, minimizes impacts on existing dischargers, and is consistent with the observed practice of larger dischargers locating on larger bodies of water.

If a permittee wishes to commence a new discharge or expand an existing discharge of a pollutant covered by the TMDL and the discharge is within the area covered by the TMDL, the permittee must submit a written notice of interest along with a demonstration of need to the WDNR. Interested dischargers will not be given RC unless they can demonstrate need.

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 RC is due to increasing production levels or industrial, commercial, or residential growth in the community.

If the WDNR determines that a new or expanding discharger qualifies for RC, the RC, if available, will be distributed using the procedures outline below:

New Discharger: For a new discharger, calculate the WQBEL per Administrative Code for the Wisconsin Department of Natural Resources (NR) 217 for phosphorus and NR 102 or NR 106 for other pollutants. If there is no WQBEL available for the pollutant, apply the TMDL reductions, consistent with the applicable reach, to the baseline condition used in the TMDL. 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 RC allocated to the discharger. If the discharger is unable to meet the limit with available technology, then more RC, 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 facility and treatment system.

Determination of the WLA 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 NR 207.03(3). 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 NR 207.03(4)(b). For all other new discharge situations the following procedures apply to determine the appropriate mass allocation:

a) Determine the mass of RC that is available in the given reach.

b) Calculate the WQBEL per NR 217.13(2)(a) and the associated mass limit per NR 217.14(3). Calculation should be based on current upstream water quality and for purposes of this calculation, any other discharges within the given reach may be ignored.

c) Calculate the mass load associated with the baseline condition (see Section 4) for the class of the new discharger. Then apply the TMDL reductions, consistent with the applicable reach, to the baseline condition to determine the resultant mass.

d) Set the WLA 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:

a) Determine the amount of RC that is available for the lake or reservoir. This can include unassigned RC from contributory reaches located upstream of the lake or reservoir.

b) Calculate the WQBEL per 217.13(3) and associated mass limit per NR 217.14(3).

c) Set the WLA equal to the more restrictive of the values determined by the above methods.

Expanding Discharger: For an expanding discharger, RC 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 Section 4, 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 RC, the difference between the mass discharged and their allocation can be made up through an off-set such as water quality trading. If there is not sufficient RC available, the discharge must be offset or the TMDL can be re-evaluated to determine if more assimilative capacity has become available since the original analysis.

RC should be taken equally from all reaches upstream of and in the reach which the discharger is located. As additional demands are placed on available RC, it may become necessary to shift the location that previously assigned RC was taken, provided the total LC for each reach is maintained. WDNR will maintain a database system to track assigned RC. Once RC reaches levels that it is no longer usable, 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.

RC is not required for new or expanding permitted MS4s. For new or expanding permitted MS4s, the mass associated with the LA for the nonpermitted, undeveloped, or agricultural land, that is now part of the permitted MS4, is transferred to the WLA 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 reach's watershed. Refer to "TMDL Guidance for MS4 Permits: Planning, Implementation, and Modeling Guidance" and corresponding Addendums for process details. Visit http://dnr.wi.gov to view and obtain current guidance documents.

For CAFOs, the TMDL assigns the production area a WLA of zero; however, RC is available to cover a new or expanding continuous or intermittent surface water discharge resulting from a manure treatment system. If RC is not available, the mass resulting from a treatment system discharge must be off-set through water quality trading. This off-set 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 from the CAFO are covered by the nonpoint LA.

Pursuant to 40 CFR 122.41(g) and NR 205.07(1)(c), Wisconsin Administrative Code, a WPDES permit does not convey any property rights of any sort nor any exclusive privilege. All proposed RC assignments are subject to WDNR review and approval and must be consistent with applicable regulations. RC 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.

5.6. Boundary Conditions

Specific areas are included as boundary conditions in the TMDLs in this report. The entire St. Croix River Basin and the CRW contributing to Lake Byllesby both have previously approved TMDLs that are sufficiently protective of Lake Pepin, as discussed in Section 4.2. The drainage area in the Upper Mississippi River Basin upstream of Aitkin is very low in TP, approximately 50 µg/L, and has a number of lakes on the river. The Minnesota River Basin upstream of the Lac Qui Parle Dam drains a reservoir system, dampening the downstream delivery of phosphorus. All four of these drainage areas are considered boundary conditions in the TMDLs for downstream impaired AUIDs. These boundary condition areas are presented in Figure 31. Also, in the case of the RES impaired segment of the Upper Mississippi River, AUID 07010206-805 (Crow River to Upper St. Anthony Falls), the Mississippi River Basin upstream of the impaired reach meets RES criteria. Therefore, specific to that TMDL, the Mississippi River upstream of AUID 07010206-805 was included as a boundary condition. The Rum River, a direct discharge to reach 07010206-805, also meets the applicable RES criterion of 100 µg/L. Therefore, the Rum River Watershed is also a boundary condition for that TMDL.

WLAs for permitted entities within these boundary condition areas were not developed for the applicable TMDLs. While no WLAs were calculated and included in the TMDLs, the TP load from these areas must still be considered in the downstream TMDLs. In the case of the St. Croix River Basin boundary condition, the Upper MRLP model output for Scenario 22 defined the boundary condition. Loadings from the other boundary condition areas were calculated using the long-term daily average flow rate from 1985 through 2015 at the outlet of the boundary condition area and a TP concentration representative of the boundary condition. Table 22 below summarizes the boundary conditions. Estimated delivery ratios of TP from individual boundary condition areas to the upstream end of the impaired AUID were applied to calculate the boundary condition included in the TMDL tables. The development and application of the delivery ratios is presented in Section 5.7.

Table 22. Boundary condition loads.

Boundary Condition Area	Applicable TMDLs	Annual TP Load (kg/year)	Seasonal RES TP Load (kg/day)	Basis
St. Croix River Basin	25-0001-00	216,445	Not applicable, no RES TMDL downstream	Upper Mississippi River - Lake Pepin model results. Attainment of the Lake St. Croix Excess Nutrients TMDL will achieve this boundary condition load.
Cannon River Upstream of Lake Byllesby	25-0001-00	67,919	Not applicable, no RES TMDL downstream	Average flow out of Lake Byllesby and a site-specific TP criterion of 90 µg/L. Attainment of the Lake Byllesby TMDL will achieve this boundary condition load.
Mississippi River 21 miles Upstream of Aitkin	25-0001-00 07010206-814	129,681	Not applicable, the load from this area is included in the Mississippi River Upstream of Crow River for the 07010206-805 RES TMDL	Average flow at Aitkin and an observed TP conc. of 50 µg/L
Minnesota River Upstream of Lac Qui Parle Dam	25-0001-00 07010206-814	100,269	288	Average flow at Lac Qui Parle Dam and a site-specific TP criterion of 90 µg/L
Mississippi River Upstream of Crow River	07010206-805	Not applicable, this area is included in the 25-001-00 and 07010206-814 TMDLs	1,327	Average flow at upstream end of AUID and a TP conc of 75 µg/L (25% below upstream criterion of 100 µg/L, observed conc ~ 63 µg/L)
Rum River	07010206-805	Not applicable, this area is included in the 25-001-00 and 07010206-814 TMDLs	215	Average flow for Rum River Watershed and a TP criterion of 100 µg/L (observed conc ~ 85 µg/L

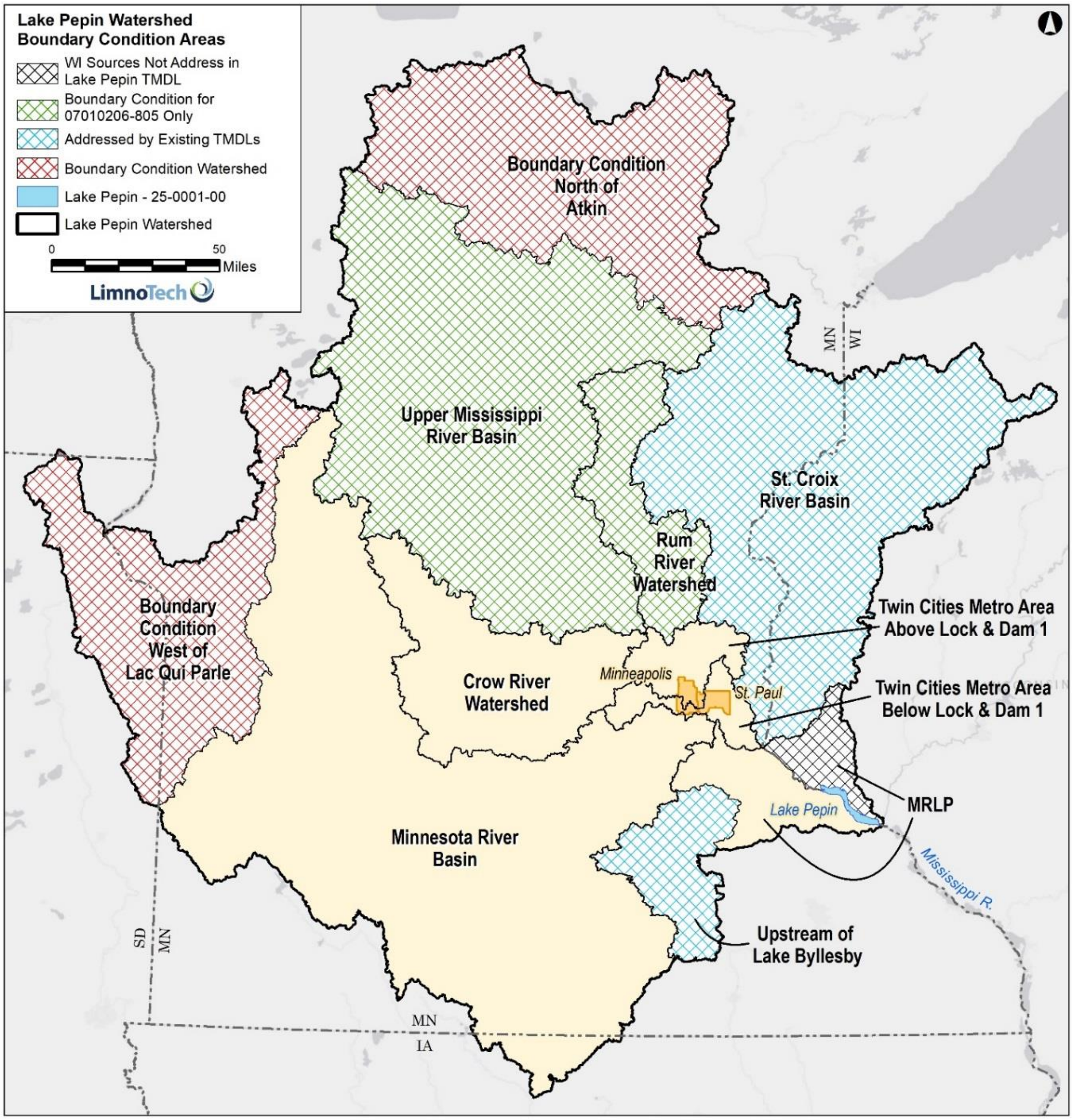


Figure 31. Map of boundary condition areas in the Lake Pepin Watershed.

5.7. Application of Delivery Ratios

A delivery ratio is the amount of phosphorus from a specific source that reaches a specific endpoint divided by the original amount of phosphorus loaded to the stream from that source. A delivery ratio accounts for losses of phosphorus during transport in a river system, such as settling and burial or biologic uptake and subsequent settling. Delivery ratios of TP from individual WWTPs, MS4s, and boundary condition loads to the upstream end of the impaired AUID for each TMDL were estimated and applied to these sources. Results from a MPCA model of the Upper Mississippi River from Brainerd to Lock and Dam 1 (Minneapolis) estimated the amount of phosphorus delivered to Lock and Dam 1 (Minneapolis) from various sources along the river (LimnoTech 2009b and 2009c). MPCA developed a linear regression equation using these model results to estimate TP delivery to Lock and Dam 1 (Minneapolis) from any distance upstream. The resulting equation is presented below:

$$Delivery\ Ratio = -0.0023 \times Distance\ (mi) + 1.0182\ [maximum\ of\ 1]$$

GIS tools were applied to calculate the distance from each WWTP, MS4, and boundary condition to the Upper MRLP model domain:

- Lock and Dam 1 (Minneapolis)
- Minnesota River confluence
- Mississippi River

Those distances were then used to calculate a delivery ratio for each source. The delivery ratio was applied to these loads prior to including them in the TMDL tables.

The application of the delivery ratios translates each source to a delivered load at upstream end of the impaired reach. The LAs in the TMDL tables all represented delivered loads to the impaired reach. Therefore, all values for WLAs and LAs in the TMDL tables are representative of delivered loads to the impaired reach. Actual loading at the source, whether an outfall pipe or edge of field, will be greater.

5.8. Seasonal Variation

The Lake Pepin site-specific eutrophication standards and the RES were set with annual and seasonal variability in mind. The TMDLs are designed so that the impaired AUIDs will attain the designated beneficial uses during the algal growing season of June through September over 10-year average conditions.

5.9. Tribal Lands

The MPCA uses a watershed approach to monitor the chemical and biological conditions of waters around the state. This approach includes working with tribes to develop a mutually agreeable and beneficial monitoring plan for waters that occur wholly or partially within the boundaries of tribal reservations. Following two years of watershed monitoring, the MPCA scientists strive to work with local resources managers, including tribal staff familiar with the monitoring efforts, to evaluate the data and determine if waters are meeting state water quality standards. The MPCA makes a draft impaired waters list available for public comment prior to submittal to EPA.

The MPCA recognizes that both states and tribes are invested in protecting and restoring all waters. The MPCA also recognizes that EPA has stated that its approval of the State's 303(d) impaired waters list does not extend to waters within reservations, and that EPA will take no action to approve or disapprove the list with respect to waters within reservations.

The MPCA includes waters throughout the state on the state's impaired waters list (MPCA 2016a), including waters that border reservations. The waters addressed by TMDLs in this report do not border reservations.

Tribal lands within the Lake Pepin Watershed Phosphorus TMDLs study area are shown in Appendix D. There are no tribal wastewater treatment facilities within the impaired watersheds addressed by this report. Tribal lands are less than 4% of the Lake Pepin Watershed area. If boundary condition areas (described in Section 5.6) are excluded, then tribal lands are less than 0.04% of the watershed. The TMDLs in this report do not allocate loads to any federally recognized Indian tribe. Should the need arise to compute WLAs for tribal facilities, MPCA will work with tribal authorities to develop a WLA.

6. Reasonable Assurance

A TMDL needs to provide reasonable assurance that water quality targets will be achieved through the specified combination of point and nonpoint source reductions reflected in the WLAs and LAs. According to EPA guidance (EPA 2002):

> When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint-source load reductions will occur ... the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. This information is necessary for the EPA to determine that the TMDL, including the LA and WLAs, has been established at a level necessary to implement water quality standards.

Regarding phosphorus load reductions within the Lake Pepin Watershed, including the RES TMDL on the Mississippi River main-stem, required point source controls will be effective in improving water quality if accompanied by considerable reductions in nonpoint source loadings. Reasonable assurance for permitted sources such as stormwater and wastewater is provided primarily via compliance with their respective NPDES permit programs. Reasonable assurance efforts to address nonpoint sources throughout the Lake Pepin Watershed, including the RES TMDL addressed in this report, are discussed in the remainder of this section. Concurrent efforts are also being carried out at large and small scales throughout the Lake Pepin Watershed that contribute to the nonpoint source reductions called for in this report. These include large scale efforts such as the statewide Nutrient Reduction Strategy, the Minnesota River Sediment Reduction Strategy, the South Metro Mississippi River TSS TMDL, the Minnesota River Turbidity TMDL, the Upper Mississippi River Bacteria TMDL, and the Minnesota 319 Nonpoint Source Management Program. Efforts at the HUC-8 level are also continuing with the development of WRAPS and 1W1P plans. Finally, smaller scale, local TMDL efforts are in-place and continue to develop.

6.1. Framework

EPA has defined components of reasonable assurance and a framework for implementation as part of the Chesapeake Bay TMDL project (EPA 2009):

- Revise tributary strategies to identify controls needed to meet the TMDL allocations.
- Evaluate existing programmatic, funding, and technical capacity to fully implement tributary strategy.
- Identify gaps in current programs and local capacity to achieve the needed controls.
- Commit to systematically fill gaps and build program capacity.
- Agree to meet specific, iterative, short-term (one to two year) milestones.
- Demonstrate increased implementation and/or pollutant reductions.
- Commit to measure and evaluate progress at set times.
- Accept contingency requirements if milestones are not met.

For the Lake Pepin and Pool 2 TMDLs, along with the RES TMDL addressed in this report, as well as the companion South Metro Mississippi TSS TMDL and Minnesota River Turbidity TMDLs, the MPCA has adopted the Chesapeake Bay Reasonable Assurance framework, with some modifications as follows:

- Utilize the phosphorus reduction strategies for the Mississippi River Basin included in the statewide *Nutrient Reduction Strategy*, the Minnesota River Basin Sediment Reduction Strategy, the Lower Minnesota River DO TMDL Implementation Plan, and the local watershed plans (and WRAPS) for the HUC-8 watersheds in the Lake Pepin drainage to meet TMDL allocations according to a phased schedule of implementation. Figure 32 shows the extent of these efforts across the state. Together, these strategies provide specific activities to be implemented at appropriate scales, both broad, basin-wide initiatives and more specific actions for major watersheds. MPCA staff are leading development of WRAPS and Minnesota Board of Water and Soil Resources (BWSR) is providing guidance and resources for local water planning, including 1W1P efforts.

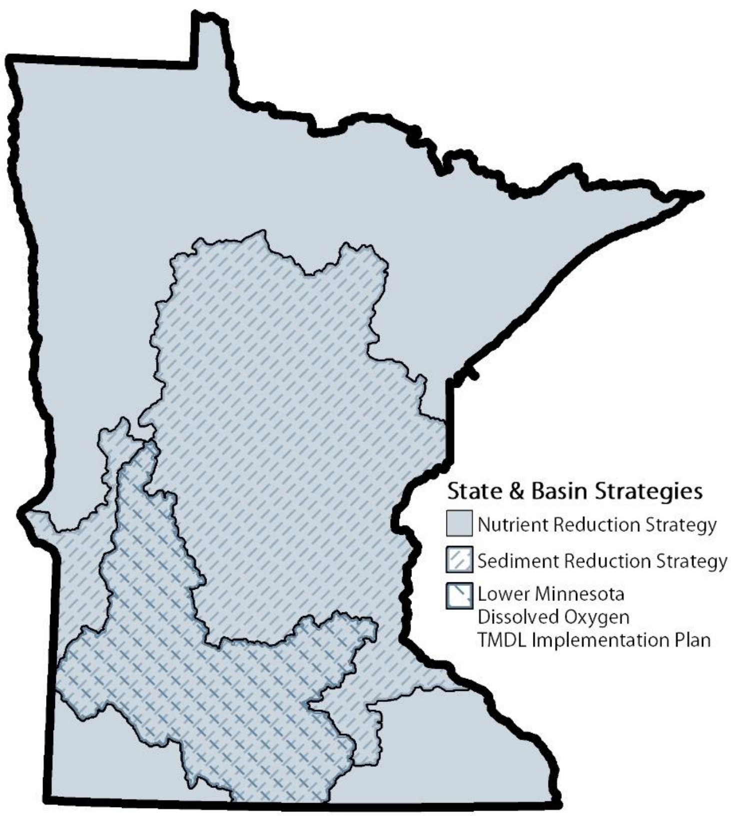


Figure 32. Extent of State and basin strategies.

- Evaluate existing programmatic, funding, and technical capacity to fully implement basin and watershed strategies. The NRS is a foundation for this evaluation and NRS updates will provide detail at regular intervals.

- Pursue specific, iterative, short-term milestones as described in the NRS and WRAPS documents. The NRS established a goal for 45% reduction in phosphorus loads from baseline conditions (1980 through 1996) by 2025. Minnesota is implementing a watershed approach that assesses, restores and protects waters under the umbrella of the Minnesota Water Management Framework. This approach sets milestones on a 10-year cycle including water assessments, WRAPS development at the HUC- 8 watershed level, and local water planning (e. g., 1W1P). The NRS provides the information and collective objectives needed to address watershed nutrient goals downstream of the HUC8 watersheds. These downstream objectives can then be integrated with needs and prioritized actions within the HUC8 watershed. HUC8 watershed goals and milestones are being developed so that cumulative reductions from all watersheds will achieve the goals and milestones in waters downstream. MPCA is currently conducting work to assess how well WRAPS and 1W1P are accounting for attainment of downstream goals, and will use the results to further guide and improve WRAPS and 1W1P with each 10-year cycle.

- Continuously monitor progress and consider adaptive management. Minnesota is a leader in tracking both BMP implementation and pollutant loading:
    - The Clean Water Legacy Act requires biennial reporting on the implementation of approved WRAPS and TMDL projects, including progress on BMP adoption and spending. Data for MPCA's BMP reporting are provided through BWSR's web-based conservation tracking system eLink, which tracks state-funded nonpoint source BMPs, including estimated load reductions. In addition, conservation easements associated with the Reinvest in Minnesota (RIM) Reserve program are tracked by BWSR. Implementation practices supported by the Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) are also made available at a HUC12 watershed scale. Regularly scheduled reporting allows state agencies to identify gaps in current programs, funding, and technical capacity to fully implement basin and watershed strategies. The MPCA Healthier Watersheds website also provides the following:
        - WRAPS status;
        - TMDL status for impaired lakes and streams;
        - Wastewater treatment plant pollutant loading reductions;
        - BMPs implemented by watershed (since 2004);
        - Local, state, and federal spending for implementation projects.
    - The wastewater phosphorus tool tracks loads and flow volumes for point source dischargers statewide: https://www.pca.state.mn.us/water/phosphorus-loads-and-flow-volumes
    - The WPLMN measures and compares data on pollutant loads from Minnesota's rivers and streams and tracks water quality trends.
- Accept contingency requirements if certain milestones are not on schedule. Regular evaluation of permitted discharges will continue, but as the *Nutrient Reduction Strategy* attests, future phosphorus load reductions should be focused on nonpoint sources. Contingency requirements to be implemented if nonpoint source targets are not met will focus on nonpoint sources themselves, and could take the form of a review of statewide nonpoint source control programs and policies by state agencies and their implementation by local agencies. NRS updates will provide an examination of the need for contingency requirements by way of regular review of statewide nonpoint source control programs and policies.

> A contingency requirement stated in the South Metro Mississippi TSS TMDLs – the buffer initiative– has already been implemented. Understanding the complexity of nonpoint sources is critical. Reductions will take time and will require a continued adaptive management approach. Minnesota's 10-year cycle for WRAPS and 1W1P supports this process well. As new understanding develops, each WRAPS and 1W1P cycle can account for lessons learned and refocus efforts to achieve the needed reductions.

The targeting of BMPs and ongoing measurement of the effectiveness of nonpoint source remediation measures also will provide some assurance of achieving the LAs in the TMDLs in this report. Minnesota has devoted significant time and resources to developing tools that support local government unit efforts to prioritize and target nonpoint source work. In addition, inter-agency work groups formed to direct the state's new Clean Water Fund will help to ensure that nonpoint source load reductions will be achieved. These groups will develop aids and guidance related to monitoring, implementation, research, and identification of measures and outcomes. Within this framework of implementation, reasonable assurance will be provided with regard to nonpoint sources through commitments of funding, watershed planning, and use of existing regulatory authorities.

The Clean Water Legacy Act (2006, subsequently amended with accountability language) provided the MPCA authority and direction for carrying out section 303(d) of the CWA, and has served to shape tool development and WRAPS content which support subsequent water planning and focusing of conservation monies. In November 2008, Minnesotans voted in support of the Clean Water, Land and Legacy Amendment to the state constitution. Through this historic vote, about $5.5 billion will be dedicated to the protection of water and land over the next 25 years. One third of the annual proceeds from sales tax revenue, an estimated $80 to $90 million, will be devoted to a Clean Water Fund to protect, enhance and restore water quality of lakes, rivers, streams, and groundwater. The Amendment specifies that this funding must supplement and not replace traditional funding. Approximately two-thirds of the annual proceeds will be earmarked for water quality protection and restoration.

Starting in 2008 with funding from the Legacy Amendment, the MPCA started a holistic approach to measure the health of the state's 80 major watersheds. This watershed approach greatly accelerated the state's assessment of lakes and streams while saving money, compared to the previous approach of studying one lake and one stream section at a time. It also puts focus on protecting healthy waters, a critical component missing from the previous approach of focusing only on impaired waters.

This watershed approach consists of four main steps on a 10-year cycle:

1. Intensive water monitoring and assessment to see if major rivers and lakes meet water quality standards
2. Identifying conditions that stress fish and bugs as well as healthy conditions that foster them
3. Developing WRAPS
4. Implementing changes to restore and protect waters through local water plans

Local partners, such as watershed partnerships and conservation districts, usually play a major role with the MPCA in the first three steps. They take the lead in the last step – implementation. Local partners and the MPCA seek input from citizens, landowners and others throughout the process. Together, they develop strategies based on local data and sound science that can lead to focused action to protect and restore Minnesota waters into the future. The current status and coverage of WRAPS and 1W1P are shown in Figure 33. For more information on WRAPS and updated status of their development across the State, go to [MPCA's website]() and [status page]().

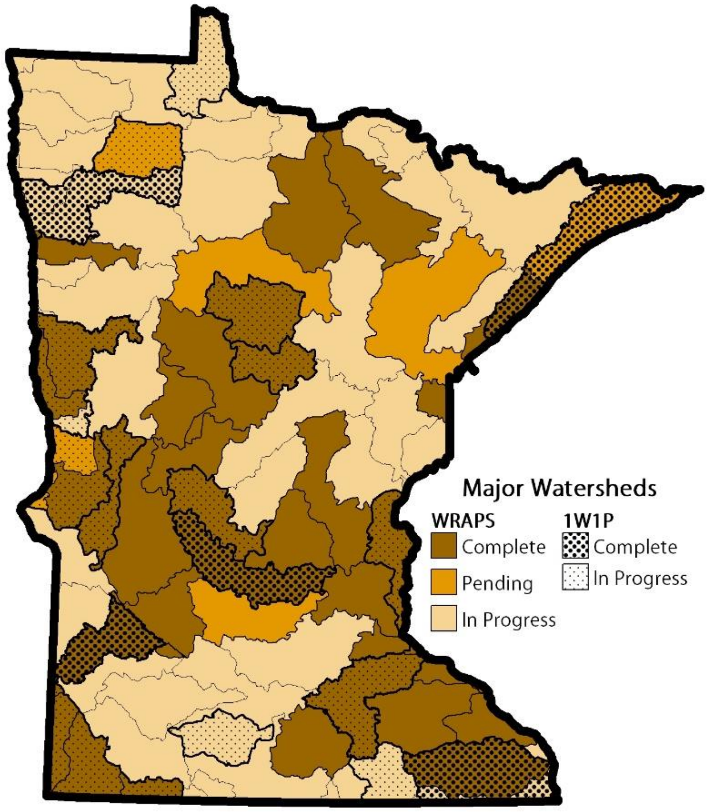


Figure 33. Status of WRAPS and 1W1P.

6.2. Basin, Regional and Local Entities

There are many local government units (LGUs) that play an important role in the planning and implementation of water quality improvement projects across Minnesota. The BWSR website includes a summary of these LGUs: http://www.bwsr.state.mn.us/partners/index.html. These LGUs include:

- Cities;
- Counties;
- Soil and Water Conservation Districts (SWCDs);
- Townships;
- Watershed Districts; and
- Watershed Management Organizations (WMOs).

SWCDs, Watershed Districts, and WMOs play an especially important role in terms of executing projects that will lead towards compliance with the TMDLs in this report. Minnesota's 90 SWCDs help direct and manage natural resource programs across the entire state. SWCDs work primarily on a one-on-one basis with landowners, aiming to connect landowners with the financial and technical resources they need to put conservation practices on the land. SWCDs also have various duties under the Wetland Conservation Act. Each SWCD is governed by a board of supervisors that develop policy for the district, develop plans and budgets, and empower and work with staff and represent their district at other meetings and functions. SWCDs work closely with a number of key partners, including:

- The USDA Natural Resources Conservation Service (NRCS), which often has field offices co-located with districts.
- BWSR, which provides administrative, financial and technical assistance to SWCDs. Local SWCDs implement a broad range of local, state and federal conservation programs, including the RIM Reserve conservation easement program, the State Conservation Cost-Share Program, and the Feedlot Water Quality Management Cost-Share Program.
- The University of Minnesota Extension Service has extension educators throughout the state who often work with SWCDs on educational and technical issues.

Watershed districts work to solve and prevent water-related problems with the idea that water management policies should be developed on a watershed basis, because water does not follow political boundaries. The boundaries of the districts follow those of a natural watershed. Minnesota has 46 watershed districts. Their specific duties of vary across the state -- some focus mainly on flood damage reduction, while others have a broad range of programs and services to protect and improve water quality. Each watershed district is governed by a board of managers appointed by the county boards of commissioners with land in the watershed district. Each watershed district is also required to have a citizen advisory committee to provide input to the managers on projects and activities. The statutory purposes of watershed districts are to conserve the natural resources of the state by land use planning, flood control, and other conservation projects by using sound scientific principles for the protection of public health and welfare and the provident use of natural resources. Watershed districts have been given broad authorities, including the authority to:

- Adopt rules with the power of law to regulate, conserve, and control the use of water resources within the district;
- Contract with units of government and private and public corporations to carry out water resource management projects;
- Hire staff and contract with consultants;
- Assess properties for benefits received and levy taxes to finance district administration;
- Accept grant funds, both public and private, and encumber debt;
- Acquire property needed for projects;
- Acquire, construct, and operate drainage systems, dams, dikes, reservoirs, and water supply systems; and
- Enter upon lands within and without the district to make surveys and conduct investigations.

Watershed Districts and WMOs have many similarities, including the requirement to conduct their activities according to an approved watershed management plan. Watershed districts and WMOs in the

Twin Cities Metro Area must also abide by Minn. R. ch. 8410, which spells out detailed plan requirements. WMOs differ from watershed districts in a number of ways:

- WMOs are mandatory, not voluntary;
- WMOs deal only with surface water, whereas watershed districts manage surface water and groundwater;
- WMOs do not have individual taxing authority, unless their joint powers agreement specifically grants this authority, and most are funded by the municipalities that make up their membership; and
- WMOs are governed by a board appointed by the member municipalities and townships.

All Watershed Districts and WMOs in the Twin Cities Metro Area are listed on MPCA's website: https://www.pca.state.mn.us/water/twin-cities-metropolitan-area-tcma-watersheds. The MCES is also a major contributor to water quality improvement projects in the metro (https://metrocouncil.org/Wastewater-Water/Services/Water-Quality-Management.aspx), as are county governments.

In addition to local governments, counties, SWCDs, state and federal agencies, and volunteer/nongovernmental organizations, there are numerous watershed groups in the Upper Mississippi River Basin (Table 23) and the Minnesota River Basin (Table 24). These watershed groups have different levels of organization and structure, but share a common goal to protect and improve water quality. They typically conduct watershed outreach and education activities, monitoring, research, and project planning and implementation. They are often the link between landowners and planning initiatives set on a watershed, region, or basin-wide scale. The level of activity being conducted by these organizations and available funding mechanisms such as the Clean Water Fund and CWA Section 319 grant programs to continue funding their work provide additional reasonable assurance that implementation will continue to occur to address nonpoint sources of phosphorus. For example, the Greater Blue Earth River Alliance has secured over $6 million in grant funds over the past 11 years to conduct research and implementation activities focused on water quality.

Table 23. Watershed organizations in the Upper Mississippi River Basin.

Watershed	Primary Partners	Website
Long Prairie River	Todd SWCD	https://www.co.todd.mn.us/divisions/soil-water-conservation-and-development/soil-and-water-conservation-district/
	Douglas SWCD	http://www.douglasswcd.com/
Sauk River	Sauk River Watershed District	http://www.srwdmn.org/
	Stearns SWCD	https://www.stearnscountyswcd.net/
	Stearns Environmental Services	https://co.stearns.mn.us/Government/CountyDepartments/EnvironmentalServices
Mississippi River	Aitkin SWCD	https://aitkincountyswcd.org/
	Morrison SWCD	http://morrisonswcd.org/
	Morrison County ESD	https://www.co.morrison.mn.us/index.asp?SEC={B3371DE6-EFB5-4CEF-BC66-DE6DBC38A696}
	Benton SWCD	https://www.soilandwater.org/
	Sherburne SWCD	http://www.sherburneswcd.org/
	Clearwater River Watershed District	http://crwd.org/
	Meeker County SWCD	http://www.co.meeker.mn.us/273/Soil-Water-Conservation
	Wright County SWCD	http://wrightswcd.org/
	City of St. Cloud	https://www.ci.stcloud.mn.us/
	Anoka Conservation District	https://www.anokaswcd.org/
	The Nature Conservancy	https://www.nature.org/en-us/
	Camp Ripley	http://minnesotanationalguard.ng.mil/crtc/
	Mille Lacs Band	https://millelacsband.com/
	White Earth	http://www.whiteearth.com/
	Crow Wing SWCD	https://crowwingswcd.org/
Pine River Watershed	Whitefish Property Owners Association	https://minnesotawaters.org/whitefishareapropertyowners/
	Pine River Watershed Alliance	http://www.prwa.us/
South Fork Crow River	Crow River Organization of Water	http://www.crowriver.org/
	Middle Fork Crow River Watershed District	http://www.mfcrow.org/
	North Fork Crow River Watershed District	https://www.nfcrwd.org/
North Fork Crow River	Stearns County SWCD	https://www.stearnscountyswcd.net/

Table 24. Watershed organizations in the Minnesota River Basin.

Watershed Organization	Website
Chippewa River Watershed Project	http://www.chippewariver.org/
Yellow Medicine River Watershed District	http://www.ymrwd.org/
Hawk Creek Watershed Project	https://www.hawkcreekwatershed.org/
Redwood–Cottonwood Rivers Control Area	http://www.rcrca.com/
Greater Blue Earth River Alliance	http://www.gberba.org/
Le Sueur River Watershed Network	http://lesueurriver.org
High Island Watershed District High Island Creek Watershed Project	
Lower MN River Watershed District	http://watersheddistrict.org/

Other organizations in the Minnesota River Basin that are supporting implementation include:

- Minnesota River Basin Data Center, Minnesota State University Mankato Water Resource Center (http://mrbdc.mnsu.edu/)—Providing basin-wide data management, coordination and a list of other organizations that are active in the Minnesota River Basin (https://mrbdc.mnsu.edu/get-involved).
- Minnesota River Watershed Alliance and Minnesota River Congress (http://watershedalliance.blogspot.com/)—Coordinating basin-wide governance and opportunities for stakeholders.
- Coalition for a Clean Minnesota River (http://www.ccmnriver.org/)—A grass-roots organization coordinating citizen and business interests in basin-wide efforts.

6.3. Summary of Local Plans

As discussed in Section 4.2, there are dozens of EPA approved TMDLs throughout the Lake Pepin Watershed addressing nutrient impairments, as well as sediment and bacteria. Each of those TMDLs have nonpoint source reductions required. A detailed list of these TMDLs can be found on the MPCA TMDL Projects website. Each TMDL also includes its own RA discussion. Some noteworthy elements from the RA discussion in TMDLs within the Lake Pepin Watershed include:

- Availability of reliable means of addressing pollutant loads (i.e. BMPs);
- A means of prioritizing and focusing management;
- Development of a strategy for implementation;
- Availability of funding to execute projects; and
- An adaptive management approach of tracking progress and monitoring water quality response.

Minnesota has a long history of water management by local government. 1W1P is rooted in this history and in work initiated by the Local Government Water Roundtable (Association of Minnesota Counties, Minnesota Association of Watershed Districts, and Minnesota Association of SWCDs). Roundtable members recommended that the local governments charged with water management responsibility should organize and develop focused implementation plans on a watershed scale.

The recommendation was followed by legislation that authorizes the Minnesota BWSR to adopt methods to allow comprehensive plans, local water management plans, or watershed management plans to serve as substitutes for one another; or to be replaced with one comprehensive watershed management plan. The legislation required BWSR to establish a suggested watershed boundary framework for these plans. This legislation is referred to as 1W1P (Minnesota Statutes §103B.101, Subdivision 14). Further legislation defining purposes and outlining additional structure for 1W1P, One Plan, officially known as the Comprehensive Watershed Management Planning Program (Minnesota Statutes §103B.801) was passed in May 2015.

BWSR's vision for 1W1P is to align local water planning on major watershed boundaries with state strategies towards prioritized, targeted, and measurable implementation plans – the next logical step in the evolution of water planning in Minnesota and an important component of the reasonable assurance framework (BWSR 2016b). BWSR updates the status of 1W1P, as shown in Figure 33, as watersheds enter into the 1W1P program. A current version can be found at the following link: https://bwsr.state.mn.us/one-watershed-one-plan-participating-watersheds

The transition to 1W1P will take time. Prior to full adoption of 1W1P, water planning continues to be done outside of the Twin Cities metropolitan area on a county basis, per the Comprehensive Local Water Management Act (Minn. Stat. § 103B.301) (see link for status of local water management plans). Within the metropolitan area, water planning is subject to Minn. R. ch. 8410 and is done on a watershed district or WMO basis. All local water plans incorporate implementation strategies aligned with or called for in TMDLs and WRAPS.

6.4. Example Basin-wide Source Reduction Activities and Tools

The modeling scenarios that describe goal attainment for Lake Pepin are based on an expectation of both point and nonpoint source reductions of phosphorus. The water quality data and modeling confirm that, in fact, both point and nonpoint reductions are required to meet the water quality standard, because phosphorus transport varies with weather and river flows. The entire load reduction requirement across all years could not be borne by either point or nonpoint sources alone, given the variability in weather and flows. As such, the model scenario that results in attainment of the site-specific Lake Pepin eutrophication criteria implemented annual average load reductions from the major subbasins, WWTPs, and internal loads caused by resuspension of sediment in Pool 2. These reductions and associated efforts to attain those reductions are presented in

Table 25. This is a large-scale effort that is founded upon cumulative achievement of smaller-scale reduction goals. The MPCA is currently conducting work to assess the linkage between smaller-scale goals for phosphorus or sediment reductions, such as local TMDLs, WRAPS or 1W1P, and larger basin-wide or statewide goals. The work focusses on integrating the state's statewide Nutrient Reduction Strategy into local watershed work by developing integrated load reduction goals and targets. Note that every upstream or local TMDL has its own RA discussion and the implementation efforts to meet the TMDLs in this report will build upon those currently in place. Also, additional smaller-scale or local TMDLs will continue to be developed and support downstream goals as well. Finally, MPCA is taking an adaptive management approach. As new understanding develops, each WRAPS and 1W1P cycle can account for lessons learned and refocus efforts to achieve the needed reductions.

Table 25. Efforts providing Reasonable Assurance for phosphorus reductions across basins and sources.

<table>
<tr><th>Phosphorus Source</th><th>Reduction Required</th><th>Large-scale basin-wide efforts</th><th>Other Efforts Supporting Reasonable Assurance</th></tr>
<tr><td>Upper Mississippi River Basin (Upstream of Ford Dam / Lock&Dam 1)</td><td>20%</td><td rowspan="5">Statewide Nutrient Reduction Strategy

Buffer Program

319 Nonpoint Source Management Program

Agricultural Water Quality Certification Program

Minnesota’s Soil Erosion Law

Conservation Reserve Enhancement Program

WRAPS and 1W1P at HUC8 scale and 10 year cycle

MPCA’s Subsurface Sewer Treatment System (SSTS) program</td><td>South Metro Mississippi River Total Suspended Solids TMDL,
Upper Mississippi River Bacteria TMDL,
Local TMDLs</td></tr>
<tr><td>Minnesota River Basin</td><td>~50%</td><td>Minnesota River Sediment Reduction Strategy,
South Metro Mississippi River Total Suspended Solids TMDL,
Minnesota River Turbidity TMDL,
Minnesota River Low Dissolved Oxygen TMDL,
Local TMDLs</td></tr>
<tr><td>St. Croix River Basin</td><td>20%</td><td>Lake St. Croix Nutrient TMDL,
Local TMDLs</td></tr>
<tr><td>Cannon River Basin</td><td>50%</td><td>Lake Byllesby TMDL,
Local TMDLs</td></tr>
<tr><td>Other Tributaries and Twin Cities Metropolitan Area below Ford Dam</td><td>20%</td><td>Watershed District Planning and Implementation Efforts,
MS4 Program,
Local TMDLs</td></tr>
<tr><td>Point Sources across all Basins</td><td>~70%</td><td>Statewide Nutrient Reduction Strategy</td><td>NPDES Program</td></tr>
<tr><td>Internal Load Reduction in Pool 2</td><td>50%</td><td>None applicable</td><td>South Metro Mississippi River Total Suspended Solids TMDL,
Lake Pepin Legacy Alliance</td></tr>
</table>

Identifying the best BMPs, providing means of focusing them, and supporting their implementation via state initiatives and dedicated funding is an on-going campaign undertaken at various scales. Minnesota’s *Nutrient Reduction Strategy* and many of the HUC-8 WRAPS in the Lake Pepin Watershed have engaged partners to arrive at reasonable examples of BMP combinations that attain pollutant reduction goals. Table 5-14 of the *Nutrient Reduction Strategy* presents a reasonable example of a scenario for achieving phosphorus goals through cropland BMPs in the Mississippi River Basin. This example scenario is summarized below.

- Efficient fertilizer use
  - 55% of cropland achieves target soil test phosphorus and uses subsurface banding (2.2 million new acres)
- Living cover
  - 78% adoption rate for riparian buffers (0.1 million new acres)

- 50% adoption rate for short season cover crops (0.3 million new acres)
    - 10% adoption rate for cover crops in grain, corn and soybeans (0.5 million new acres)
    - 3% adoption rate for conservation reserve (0.3 million new acres)
- Field erosion control
    - 72% adoption rate for conservation tillage (4.5 million new acres)

Minnesota is a leader in watershed planning, as well as monitoring and tracking progress toward water quality goals and pollutant load reductions. Various agencies and organizations have developed tools, programs, BMPs and restoration projects that have proven to be effective over time and/or will reduce phosphorus loads going forward. As stated by the State of Minnesota Court of Appeals in A15-1622 MCEA vs MPCA and MCES:

> *We conclude that substantial evidence exists to conclude that voluntary reductions from nonpoint sources have occurred in the past and can be reasonably expected to occur in the future. The NRS […] provides substantial evidence of existing state programs designed to achieve reductions in nonpoint source pollution as evidence that reductions in nonpoint pollution have been achieved and can reasonably be expected to continue to occur.*

The following examples describe large-scale programs that have proven to be effective over time and/or will reduce phosphorus and sediment loads going forward.

Buffer Program

The Buffer Law was first signed by Governor Dayton in June 2015, amended on April 25, 2016, and further amended by legislation signed by Governor Dayton on May 30, 2017. The Buffer Law requires the following:

- For all public waters, the more restrictive of:
    - a 50-foot average width, 30-foot minimum width, continuous buffer of perennially rooted vegetation, or
    - the state shoreland standards and criteria.
- For public drainage systems established under Minn. Stat. ch. 103E, a 16.5-foot minimum width continuous buffer.

Alternative practices are allowed in place of a perennial buffer in some cases. The amendments enacted in 2017 clarify the application of the buffer requirement to public waters, provide additional statutory authority for alternative practices, address concerns over the potential spread of invasive species through buffer establishment, establish a riparian protection aid program to fund local government buffer law enforcement and implementation, and allow landowners to be granted a compliance waiver until July 1, 2018, when they have filed a compliance plan with the SWCD.

The MPCA and University of Minnesota developed a phosphorus BMP spreadsheet tool to provide low-resolution estimates of phosphorus load reductions associated with full implementation of the 50 foot buffer law. The tool is being applied to support WRAPS efforts as well as estimate load reductions for major basins, as follows:

- Statewide: 13.2% reduction
- Upper Mississippi River Basin: 7.8 % reduction
- Minnesota River Basin: 14.2% reduction
- St. Croix River Basin: 1.3% reduction
- Cannon River Basin: 8.2% reduction

BWSR provides oversight of the buffer program; Figure 34 provides the preliminary assessment of compliance with the Buffer Law in the state.

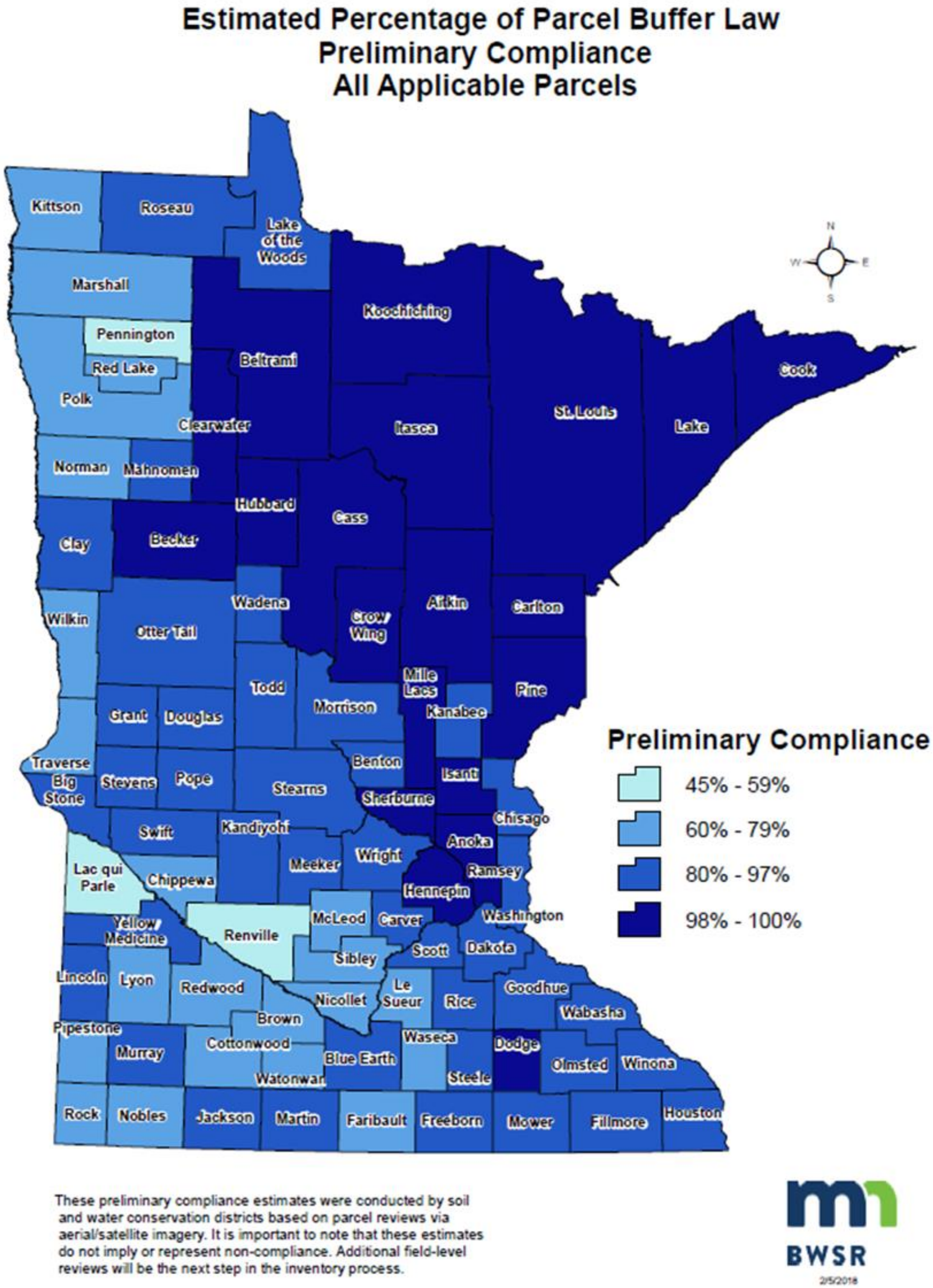


Figure 34. Buffer compliance estimates (map from BWSR 2017a).

319 Nonpoint Source Management Program

The federal CWA Section 319 (Section 319) grant program provides funding to states to address nonpoint source (NPS) water pollution in watersheds. The MPCA passes through approximately $2.6

million in Section 319 grants annually to local governments and organizations to implement BMPs and adopt strategies to mitigate NPS. The intent of the 319 Nonpoint Source Management Program is to make measurable progress for the targeted waterbodies in the 319 Focus Watersheds, ultimately restoring impaired waters and preventing degradation of unimpaired waters. The 319 Small Watersheds Focus Program provides sustainable, longer-term funding to a select number of Focus Watersheds. Selected watersheds will develop detailed Focus grant workplans following the EPA guidance, using existing local water plans and state reports. They will then be eligible to receive Section 319 grant funds to implement the workplan over the course of multiple grant cycles, for up to approximately sixteen years. The Focus Watersheds are selected to represent a cross-section of small watershed projects across the state that support local goals as expressed in local water plans, and the state's priorities (Nonpoint Source Funding Priority Plan, Nonpoint Source Management Program Plan, MPCA Strategic Plan, NRS, etc.). The funding pool is limited to these watersheds to provide a longer-term, stable funding source for staffing, local participation, and implementation of BMPs to achieve water quality goals.

The 319 Small Watersheds Focus Program selected 10 watersheds to be prioritized for funding in the 2020 competitive grant round. Of the initial 10 selected, four are in the Minnesota River Basin and one is in the Upper Mississippi River Basin, as listed below:

- Upper Mississippi River Basin
    - Rum River Watershed, middle subwatershed
- Minnesota River Basin
    - Martin SWCD, Fairmont Chain of Lakes/Dutch Creek
    - Redwood County SWCD, Plum Creek Watershed
    - Hawk Creek Watershed Project, Upper Hawk Creek/Wilmar Chain of Lakes
    - Scott County, Scott WMO, and SWCD, Sand Creek

Ten additional watersheds will be selected each year for funding beginning in 2021 to 2023 to form four groups of watersheds. More information about the Section 319 Small Watersheds Focus Program is found at https://www.pca.state.mn.us/ and entering "Section 319 Small Watersheds" in the search bar.

Agricultural Water Quality Certification Program

The Minnesota Agricultural Water Quality Certification Program is a voluntary opportunity for farmers and agricultural landowners to take the lead in implementing conservation practices that protect waters. Those who implement and maintain approved farm management practices will be certified and, in turn, obtain regulatory certainty for a period of 10 years.

Through this program, certified producers receive:

- **Regulatory certainty**: Certified producers are deemed to be in compliance with any new water quality rules or laws during the period of certification.
- **Recognition**: Certified producers may use their status to promote their business as protective of water quality.

- **Priority for technical assistance**: Producers seeking certification can obtain specially designated technical and financial assistance to implement practices that promote water quality.

Through this program, the public receives assurance that certified producers are using conservation practices to protect Minnesota's lakes, rivers, and streams.

Since the program's inception in 2014, 365 farms operating over 200,000 acres have been certified across Minnesota. As of April 11, 2017, certified farms have added 628 new conservation practices. The practices have kept more than 12.1 million pounds of sediment out of Minnesota rivers while saving nearly 17.4 million pounds of soil and 7,414 pounds of phosphorus.

Conservation Reserve Enhancement Program

Minnesota was awarded $500 million in Conservation Reserve Enhancement Program (CREP) funding, that when fully implemented will convert approximately 60,000 acres of land to perennial cover (perpetual easements) within 54 counties in western and southern Minnesota, including the Minnesota River Basin (Figure 35).

CREP is an offshoot of the Conservation Reserve Program (CRP), the country's largest private-land conservation program. Administered by the U.S. Department of Agriculture (USDA) Farm Service Agency (FSA), CREP targets state-identified, high-priority conservation issues. Five Minnesota state agencies have come together to support MN CREP, including BWSR, MDA, Department of Health, DNR, and MPCA. This project is a federal, state, and local partnership and will voluntarily retire environmentally sensitive land using the nationally recognized RIM Reserve program. This is accomplished through permanent protection by establishing conservation practices via payments to farmers and agricultural landowners. Enrollment began in 2017.

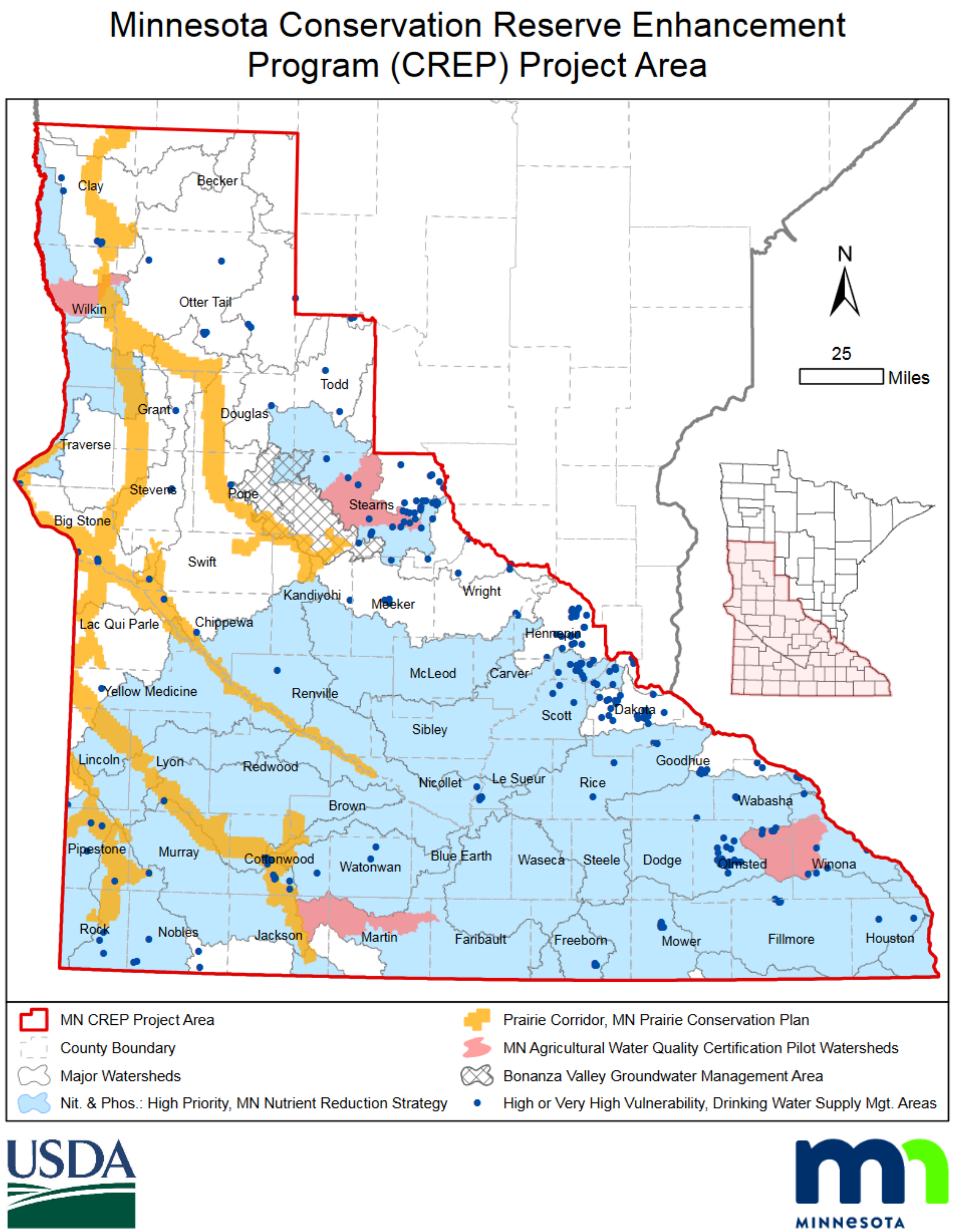


Figure 35. Minnesota CREP map (BWSR 2017b). Map from http://www.bwsr.state.mn.us/crep/

The basin, regional, and local entities described in Section 6.2 are the entities that wield the program and grant funds to do conservation work that will contribute to attainment of the TMDLs presented in this report. Following are a few recent representative brief descriptions of efforts that are examples of the type of work being done.

Local tool development in the Mississippi River - Lake Pepin (direct tributaries) Watershed: The SWCDs in the MRLP Watershed have mapped structural BMPs and delineated the drainage areas treated by each (Figure 36). This planning tool serves to confirm the work completed to date and provide guidance regarding focus areas for new BMPs, as well as potential BMP maintenance/cleanout needs. This tool has already leveraged $484,000 for structural BMPs that will reduce sediment and phosphorus loading in the watersheds of the streams that drain directly to Lake Pepin and the Mississippi River (e.g. Wells Creek).

Local tool development and implementation in Cannon River Watershed (CRW): The CRW is a HUC-8 watershed that joins the Mississippi River just upstream of Lake Pepin. The *Subwatershed Analysis for Trout Brook*, funded by a grant from the Clean Water Fund and prepared by the Dakota County SWCD, provides a tool for prioritizing for sediment and phosphorus reduction at a subwatershed scale (Figure 37). This work is a replicable example of tool development equipping LGUs to focus best use of resources in pursuit of pollutant load reductions

HSPF SAM tool implementation across the state: SAM (Scenario Application Manager) is a graphical interface to the HSPF model applications. It uses agreed-upon practitioner's language and expands the state's investment in HSPF to a broader audience to support the development of TMDLs and WRAPS. The SAM decision-support tool provides a user-friendly, comprehensive approach to identify means for achieving the water quality improvement goals that were set by TMDL assessments, protection strategies and watershed restoration programs. SAM assists in understanding watershed conditions and identifying priority areas and BMPs that will provide the greatest water quality benefit for each dollar invested. SAM simplifies complex hydrologic and water quality model applications into transparent estimates of the significant pollutant sources in a watershed. Users apply their knowledge and expertise of BMP implementation with the tool's interpretation of HSPF model results.

The 'ANALYZE' feature in SAM allows the user to display a wide range of baseline model conditions, as well as results from user-built scenarios. The data types available for display include basic water quality estimates (e.g. reach concentration and reach load) as well as pollutant loading rates broken out by specific subwatershed and/or land use type. Common pollutants available for display in SAM include TSS, TP and TN among others. The ANALYZE feature produces output in three different formats (table, plot or map) and enables export of these output formats to mainstream software packages (e.g. Excel or ArcMap) for further analysis or sharing of data.

The 'DESIGN' feature allows the user to design and build a model scenario that can include any combination of land use change, pre-specified BMPs, user defined point source alternatives, and climate change predictions. If a user has a well-defined plan to address water quality, the user can input the details of that plan into SAM and, in less than 20 minutes, be able to explore the effect of their strategy on water quality using the ANALYZE feature in SAM.

The 'TARGET' feature allows the user to set pollutant concentration or pollutant load targets at a specific location in a watershed, and select from a list of BMPs that could be used to meet those targets. The user-defined water quality targets can take the form of a percent reduction in pollutant load, a concentration threshold, or even an exceedance-based water quality goal. The TARGET feature takes into account the effectiveness and cost of selected BMPs to provide the most cost-effective (i.e. cost-optimized) plan for achieving the user-defined water quality target. The tools in this tab also provide an option to set an annual budget, which will constrain the optimization within a specified budget. The tools in the TARGET feature only work on BMPs and do not consider land use changes or point-source modifications.

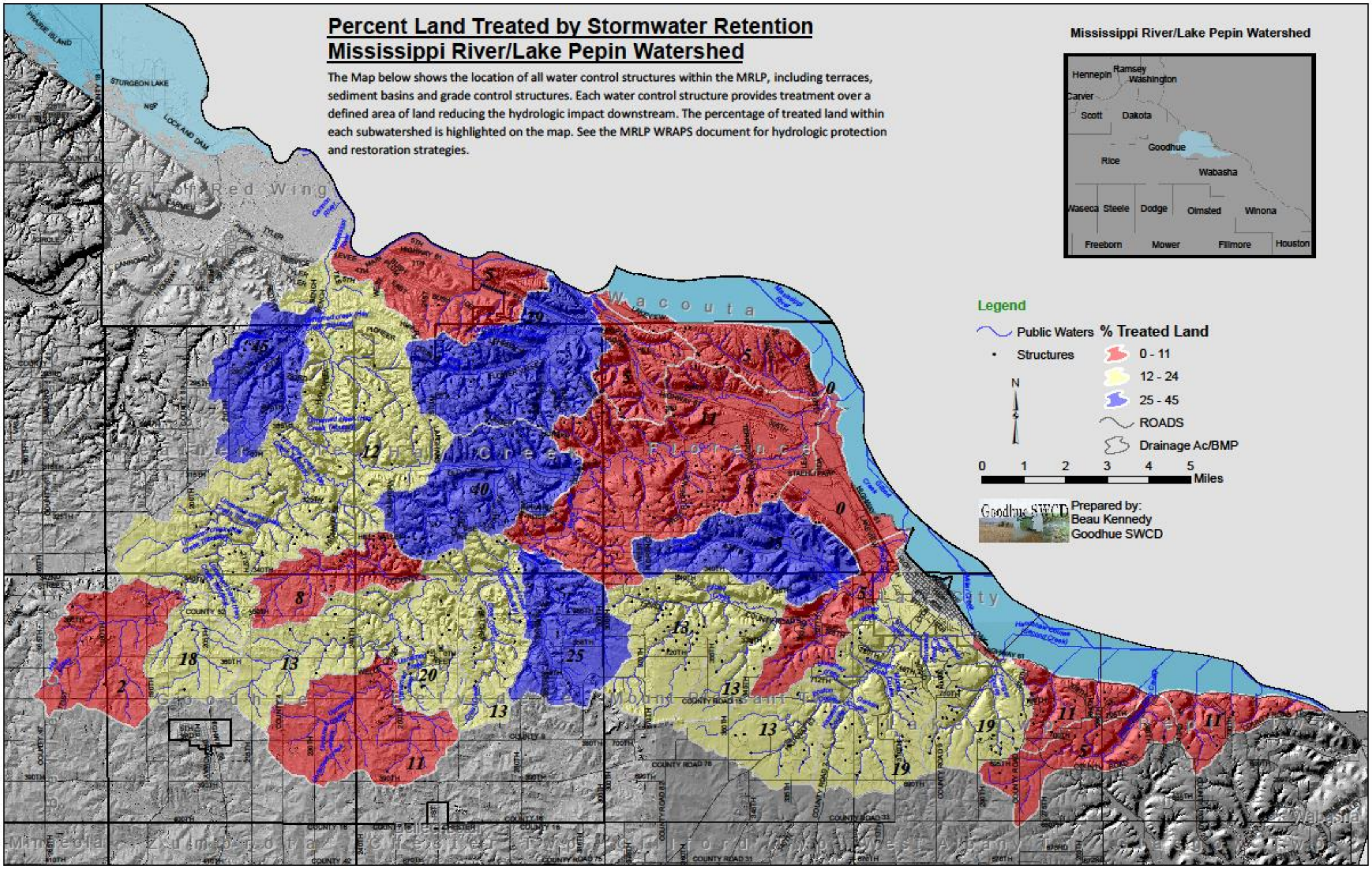


Figure 36. Mississippi River - Lake Pepin upland treatment map.

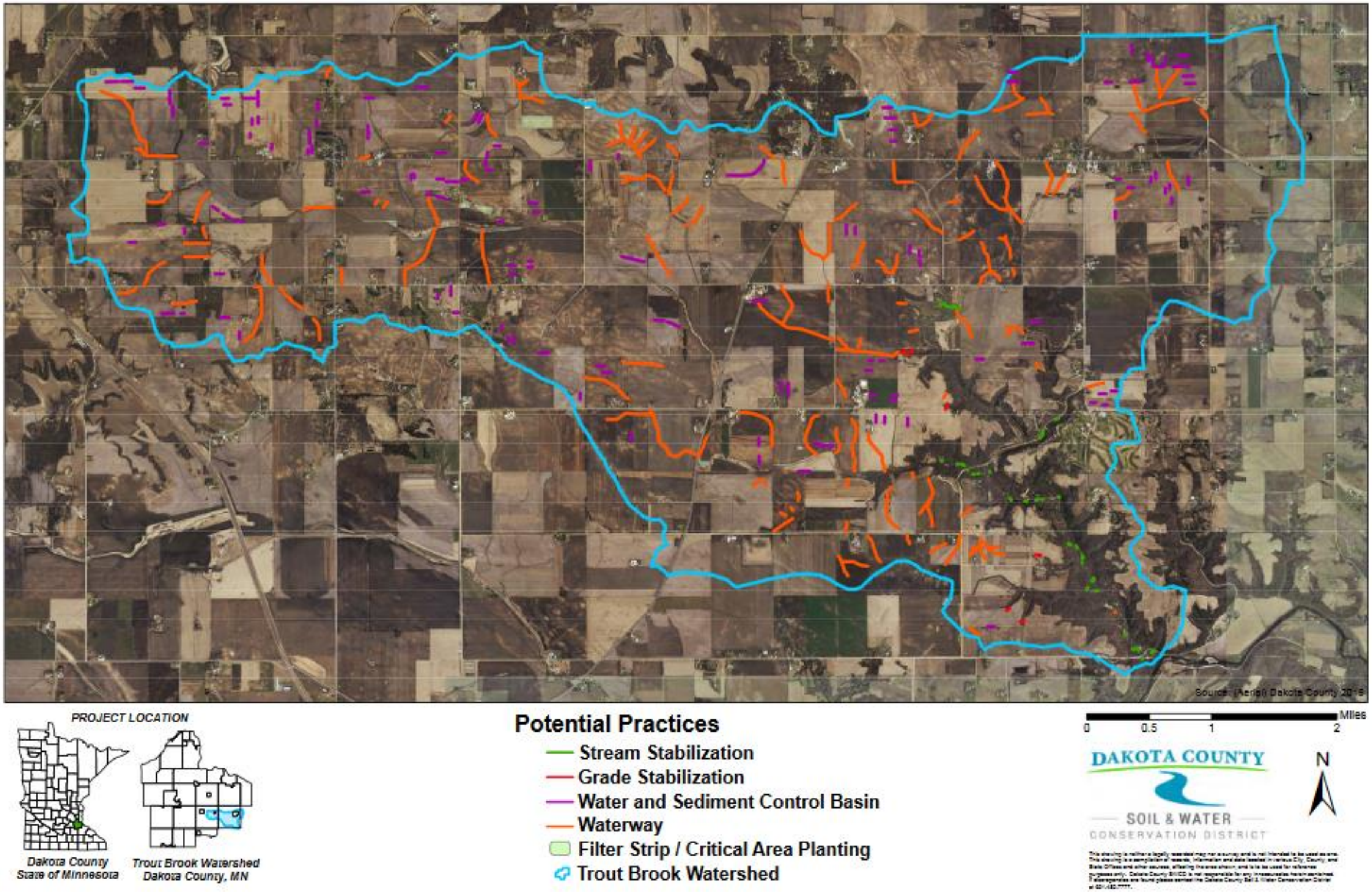


Figure 37. Trout Brook Subwatershed analysis (Dakota County SWCD 2016)

Septic Systems

The MPCA's Subsurface Sewer Treatment System (SSTS) program protects public health and the environment by ensuring SSTS's (or septic systems) effectively treat wastewater. The MPCA rules govern how septic systems are designed, installed, and managed. The rules are implemented and enforced through local ordinances by counties, cities, and townships. Local units of government—including cities, counties, townships, and others—enforce Minnesota SSTS rules through ordinances and issue permits for systems designed for flows up to 10,000 gallons per day.
https://www.pca.state.mn.us/water/subsurface-sewage-treatment-systems

Internal Load in Pool 2

Internal loads of phosphorus to the system are a component of the nonpoint source LA and were considered in the Lake Pepin and Pool 2 TMDLs. Solids depositing in the wide lower Pool 2 during the summer are much more flocculent and do not consolidate at the sediment surface as well as more inorganic solids deposited at other times of the year. Therefore, the surface sediments in this part of the system are more amenable to wind-driven resuspension during the summer and early fall. The model scenario used to establish the TMDLs for those AUIDs included a 50% reduction in the resuspension rate of bottom sediments throughout the Pool 2 reach. The 50% reduction in resuspension in this reach corresponds to an approximate 2% reduction in the overall phosphorus load to Lake Pepin. Resuspension of sediments containing phosphorus in Pool 2 is caused by shear stresses on the bottom, driven by a variety of factors including currents and wind-wave action. Opportunities were identified to reduce resuspension in Pool 2 through restoration efforts, including establishment of islands to reduce wind fetch and wave action, specifically in shallow areas in and around Spring Lake. The model scenario supporting the TMDLs for Lake Pepin and Pool 2 accounts for the reduction in internal loading resulting from these restoration efforts.

The Mississippi TSS TMDL sets the stage for reducing internal loads of sediment caused by wind and wave action through island-building and other river management practices undertaken by State and Federal partners working to restore the ecosystem of the Upper Mississippi River. Because of its importance in achieving the TSS water quality goal, internal loading is among the sources receiving priority attention in restoration funding programs. The MPCA, DNR, WI DNR, U.S. Army Corps of Engineers, and U.S. Fish and Wildlife Service are involved in plans and efforts to decrease internal loading from wind and wave resuspension by 50% by building islands and periodic water level draw-downs. Boating restrictions also have been considered. Islands in shallower areas with wide expanses of open water, such as lower Pool 2, can reduce wind fetch in order to cut down on sediment re-suspension. Draw-downs of the water level in a navigation pool expose the bottom sediment in shallow floodplains and areas near islands, allowing the sediment to dry and consolidate. Exposure also facilitates the growth of rooted vegetation, which reduces wind and wave erosion. Detailed plans for this work are provided in the Mississippi Makeover Project.

Additional in-lake restoration projects are being supported by the Lake Pepin Legacy Alliance (LPLA). LPLA has spearheaded a large-scale restoration project to rejuvenate the areas most impacted by sediment. The project aims to improve water clarity, create fish and wildlife habitat, and increase recreational access in Upper Lake Pepin. It will also provide a beneficial use for the dredge material in Lower Lake Pepin, which is suitable for the construction of new islands designed to redirect sediment flows and reduce overall impact. The Army Corps of Engineers is leading implementation and funding

65% of the costs, but LPLA is responsible for fundraising the local cost-share, estimated to be $3.5 million. LPLA applied for $750,000 through the Lessard Sam's Outdoor Heritage Council in the summer of 2018. The proposal to fund Lake Pepin Restoration is now included in the Council's final recommendation to the Minnesota Legislature. The Minnesota Legislature needs to approve the funding during their next session, but LPLA is hopeful that the full $750,000 will be awarded. Last year, LPLA raised an anticipated $867,500 through grants and municipal pledges, which could be enough to start construction in 2020. The WI DNR and LPLA also successfully applied for a pilot program that will direct more federal funds to the project.

6.5. Future Developments

Minnesota's *Nutrient Reduction Strategy* describes the need to "step up" agricultural BMP implementation in order to meet nutrient reduction goals. Section 6.3.1 of the *Nutrient Reduction Strategy* discusses the need for private industry to drive landscape changes, and notes specifically that a barrier to realizing impactful vegetative changes in cropping systems is "finding markets to create economic incentive for growing cover crops and perennials." Point source phosphorus reductions and soil conservation have resulted in positive changes for the waters of Minnesota (and downstream: the *Nutrient Reduction Strategy* estimates a 33% reduction of our state's phosphorus load since the mid-1990s). Going forward, further significant reduction will likely need to happen via profound landscape changes.

The Forever Green Initiative at the University of Minnesota (https://www.forevergreen.umn.edu/) is advancing the idea that agriculture can be the long-term solution to nutrient loading issues in the state. The basic logic model of the Forever Green Initiative is presented in Figure 38. The Initiative is positioned to develop new winter annual and perennial crops, with associated efficient farming systems, that will lead to improved water quality and management of water quantity, while bolstering the rural and agricultural economy with high-value, commercially marketable food, feed, and fuel products. Perennial and winter-annual crops—working in tandem with summer annuals—can capture solar energy, water and nutrients with very high efficiency. Specifically, these production systems can:

- Diversify economic opportunities for Minnesota's farmers, through the production of new sources of food, feed, and high-value biomaterials, without interfering with current annual production systems.
- Provide ecosystem services such as clean water, healthy soil, pollinator forage and habitat.
- Enable abundant production despite climate variability and new pest and disease pressures.
- Enhance rural communities by creating new industries based on renewable agricultural resources and employment opportunities.
- Attract high quality talent to the University of Minnesota to meet the future workforce needs of the agriculture, food, energy and natural resource based industries in Minnesota.

The Minnesota Clean Water Council has recommended $3.3 million of support for the Forever Green Initiative (Minnesota Clean Water Council 2018). This is an example of the State's commitment to supporting bigger picture thinking and placing more perennial crops on the land.

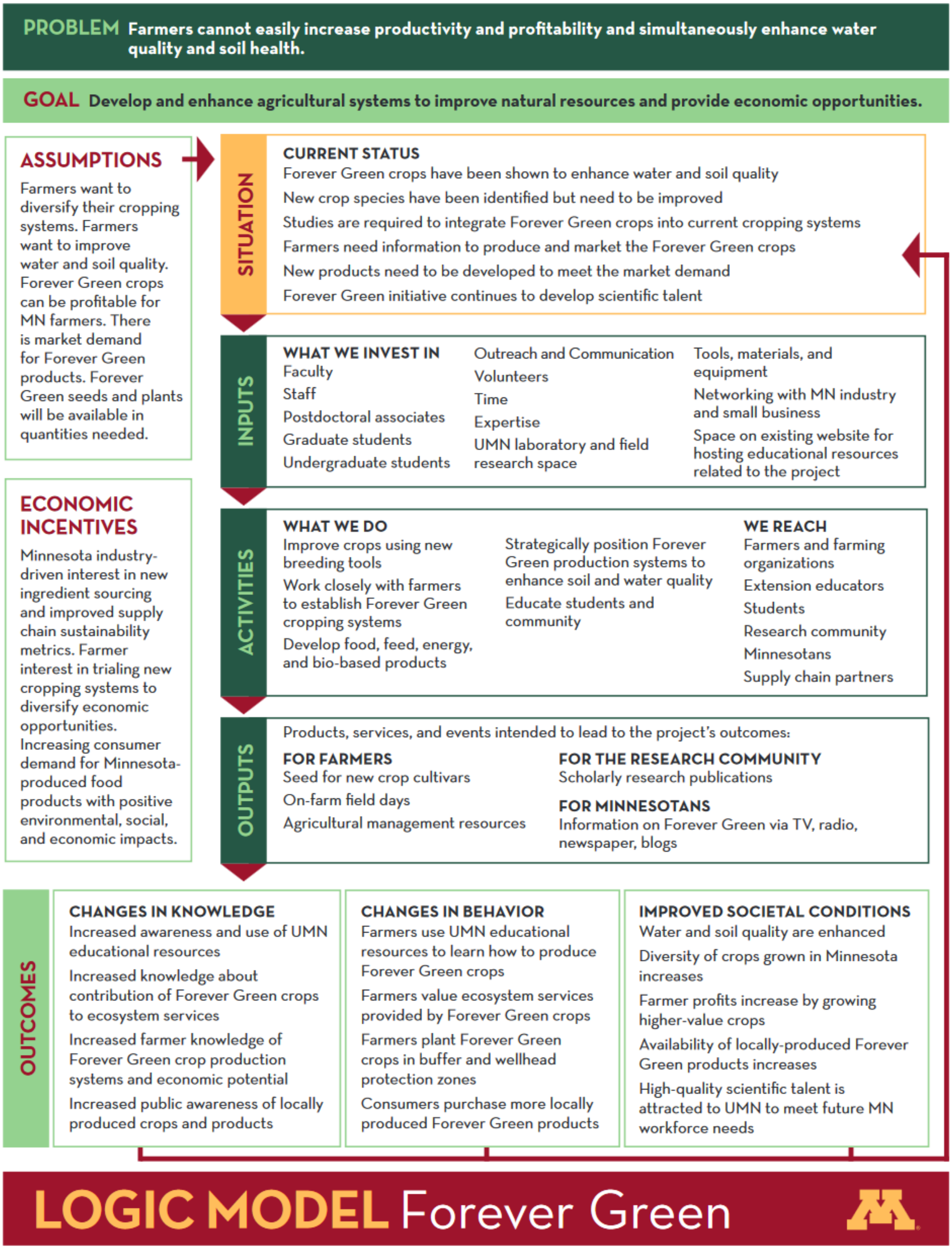


Figure 38. Forever Green logic model.

7. Monitoring Plan

A monitoring plan is a required component of a TMDL and is intended to assist in determining whether implementation of the TMDL has attained water quality standards, and to support revisions to the TMDL through an adaptive management approach. Specifically, EPA guidance (EPA 1999) suggests a monitoring plan should:

- Determine the effectiveness of the implementation actions by measuring ambient water quality improvements.
- Determine whether allocations are met.
- Determine whether allocations are sufficient to attain water quality standards.
- Determine whether implementation actions, including interim milestones, are occurring as planned.
- Assess the effectiveness of BMPs and control actions for reducing loads from nonpoint sources.

This section provides an overview of the key monitoring programs in-place at many scales in multiple watersheds and by multiple agencies and organizations within the Lake Pepin Watershed. Several types of monitoring will be important for guiding and assessing successful implementation of the TMDLs in this report and attainment of water quality standards. For the TMDLs in this report, the focus will be on monitoring TP and appropriate response variables such as Chl-*a*, BOD, and DO flux, and pH.

- MPCA Intensive Watershed Monitoring: The MPCA carries out a program of intensive chemical, biological, and physical monitoring and assessment at the HUC-8 scale as part of Minnesota's watershed approach to managing water quality. This monitoring effort is the first step in a 10-year cycle for each HUC-8. MPCA determines the overall health of the watershed and identifies impaired waters. Results of monitoring that other state, federal, and local organizations have performed for various purposes are included in the process. Additional information is collected on the watershed's physical characteristics, including land use, topography, soils, and pollution sources. The MPCA water quality specialists evaluate the data to:
    - determine whether or not water resources meet water quality standards and designated uses
    - identify waters that do not meet water quality standards and list them as impaired waters
    - identify waters that should be protected
    - identify stressors affecting aquatic life in streams.

  Outcomes of this step include the creation of a Monitoring and Assessment Report and a Stressor Identification Report on the watershed's biota (fish, bugs, etc.).

  Ten years later, the watershed is monitored again to determine its condition and to detect changes and the effects of implementation activities. A map of the watersheds and schedule for intensive monitoring and assessment is presented in Figure 39. The most recent map can be found on MPCA's website by searching for "watershed approach."

- MPCA WPLMN: The WPLMN measures and compares data on pollutant loads from Minnesota's rivers and streams and tracks water quality trends. WPLMN data are used to assist with assessing impaired waters, watershed modeling, determining pollutant source contributions, developing watershed and water quality reports, and measuring the effectiveness of water quality restoration efforts. Data are collected along major river main-stems, at major watershed (i.e., HUC-8) outlets to major rivers, and in several subwatersheds. This long-term monitoring program began in 2007, and is a cooperative effort among the MPCA, MDNR, USGS, and many local units of government.
- MCES Stream Monitoring and Assessment program: MCES, with assistance from local partners, operates long-term, automated stream monitoring stations. MCES currently collects both water quality and stream flow information at 22 stream sites, and biological information on macroinvertebrates at 14 of those sites. The sites include tributaries to the Mississippi River, the Minnesota River, and the St. Croix River in the Twin Cities metropolitan area. Water quality information collected by the Stream Monitoring Program is intended to help determine compliance with water quality standards, to determine the extent of nonpoint source pollution, to help with the development and implementation of TMDLs, and to measure progress toward attainment of water quality standards as BMPs are implemented. MCES produces and makes available annual reports documenting the assessment of the data.
- Minnesota DNR supports a Cooperative Stream Gauging network with MPCA. Continued quantification of flows in main-stem and tributary streams is critical for understanding pollutant loads.
- The USGS Minnesota Water Science Center continuously monitors surface water, ground water, and water quality parameters across the state. Monitoring sites are operated in cooperation with various local, State, or Federal agencies. Minnesota provides real-time water-stage, streamflow and precipitation data at 149 sites across the state. Water-quality conditions are continuously monitored by the USGS at 11 sites across the state of Minnesota. The National Water Information System (NWIS) Mapper displays all Minnesota surface-water sites, groundwater sites, and more.
- Discovery Farms Minnesota is a farmer-led program that collects farm- and field-scale monitoring data under real-world conditions. The program is coordinated by the Minnesota Agricultural Water Resource Center in partnership with the MDA and the University of Minnesota Extension.
- Implementation monitoring is conducted by both BWSR (i.e., eLink) and USDA. Both agencies track the locations of BMP installations. Tillage transects and crop residue data are collected periodically and reported through the Tillage Transect Survey Data Center.
- Discharges from permitted municipal and industrial wastewater sources are reported through discharge monitoring records. These records are used to evaluate compliance with NPDES permits, including the WLAs required by TMDLs. Summaries of discharge monitoring records are available through the MPCA's Wastewater Data Browser.

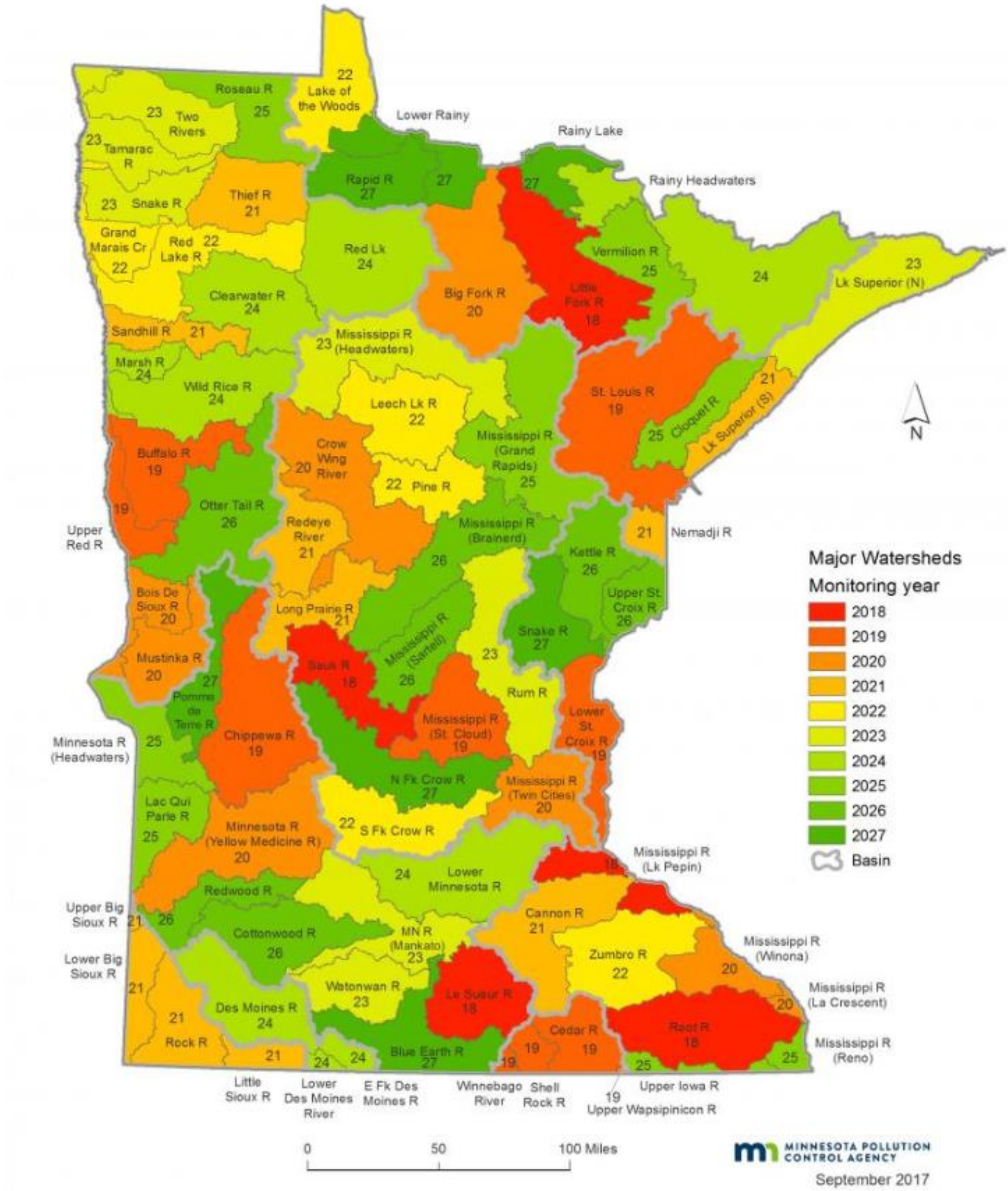


Figure 39. MPCA Intensive Watershed Monitoring and Assessment Map and Schedule.

8. Implementation Strategy Summary

The goals, timelines, and strategies for phosphorus load reductions in the impaired waters addressed in this TMDL report are set in a greater context of statewide work to reduce phosphorus loads from both point and nonpoint sources in the Lake Pepin Watershed and beyond. Additionally, the efforts to reduce phosphorus from nonpoint sources are directly related to efforts to reduce sediment loads in the Minnesota River Basin. To accomplish these goals, the MPCA has set in motion a number of interrelated efforts including:

- Minnesota Nutrient Reduction Strategy (statewide)
- Sediment Reduction Strategy for the Minnesota River Basin and South Metro Mississippi River
- South Metro Mississippi River Turbidity TMDL
- Minnesota River Basin TSS TMDLs
- Lake St. Croix Excess Nutrients TMDL and Implementation Plan
- Lake Byllesby Phosphorus TMDL

8.1. The Minnesota Nutrient Reduction Strategy

The primary implementation strategies to achieve the phosphorus load reductions required by the TMDLs in this report are described in the Nutrient Reduction Strategy (NRS; MPCA 2014). The Nutrient Reduction Strategy is intended to guide the state in reducing excess nutrients in waters so that in-state and downstream water quality goals are ultimately met. Successful implementation of the NRS will require broad support, coordination, and collaboration among agencies, academia, local government, private industry, and citizens. The theme of the NRS is *A Path to Progress in Achieving Healthy Waters,* and highlights a multi-faceted approach to nutrient reduction that focuses on the following:

- **Progress goals for downstream waters.** The strategy includes clear, meaningful and achievable nutrient loading reduction targets and interim milestones.
- **Progress on in-state nutrient criteria.** The strategy complements existing planning efforts to make progress toward meeting in-state nutrient criteria for impaired waters and provides protection to lakes and streams not yet assessed, or assessed as threatened or unimpaired by nutrients.
- **Prioritize and target watersheds.** The strategy helps to prioritize watersheds relative to nutrient loads and impacts, and target implementation activities to ensure efficient use of resources.
- **Build from existing efforts.** Many ongoing efforts are moving the state in the right direction. The strategy unifies and organizes information to align goals, identify the most promising strategies, and coordinate activities.
- **Local implementation.** The goal is for agencies and organizations to focus and adjust programs, policies, and monitoring efforts.

The NRS includes a goal for reducing phosphorus in the Mississippi River by 45% from average 1980 through 1996 conditions by 2025. This goal applies where the Mississippi River leaves Minnesota boundaries. The NRS estimates that a 31% reduction of phosphorus in the Mississippi River at Red Wing, the upstream end of Lake Pepin, had been achieved by 2014 largely as a result of reductions in point sources.

While the TMDLs in this report require varying levels of phosphorus reduction, similar strategies will be applied across the Lake Pepin Watershed. Figure 40 presents the estimated past and planned future phosphorus loading trends in the Mississippi River at the state boundary.

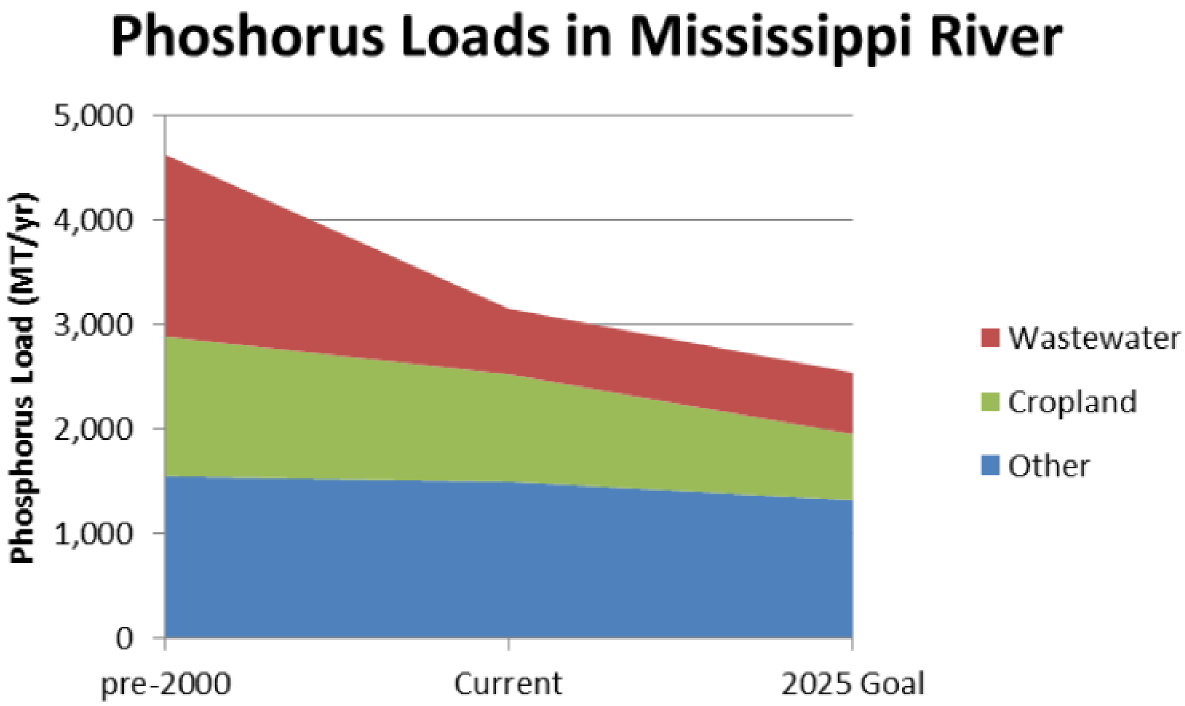


Figure 40. Phosphorus loading trend in the Mississippi River at the state boundary. (source: The Minnesota Nutrient Reduction Strategy)

Priority sources of phosphorus targeted in the NRS for reduction include cropland runoff, wastewater point sources, and streambank erosion. Priority watersheds for phosphorus reduction were also identified in the NRS and many of these are in the Lake Pepin Watershed (Figure 41). Priority watersheds have the highest nutrient yields (loads normalized to area), and also include watersheds with high phosphorus levels in rivers. Watershed prioritization for phosphorus is based on a Spatially Referenced Regressions on Watersheds (SPARROW) model that combined nutrient loads leaving the HUC-8 watershed with a comparison to the (at the time pending) RES for that reach, and computed a yield reaching the state border. HUC-8 watersheds with a higher yield reaching the state border were assigned a higher priority ranking. This ranking process did not factor in the potential capacity for lakes to intercept phosphorus.

The NRS points out that there is no single solution for achieving the level of phosphorus reductions required. Many different types of actions and BMPs will be needed over large areas of the state. To support this widespread change, the NRS includes two overarching strategies:

- **Develop a Statewide NRS Education/Outreach Campaign,** integrated with other efforts to promote statewide stewardship of water resources. The campaign will be responsible for raising general public and agricultural producer awareness about the need to reduce nutrients in

Minnesota waters and will support education activities intended to lead to expanded BMP implementation. Partnerships with and efforts by agricultural business and producer groups are key to success.

- **Integrate Basin Reduction Needs with Watershed Planning Goals and Efforts.** WRAPs and accompanying comprehensive watershed management plans (e.g., 1W1P) should be developed to not only have the goal of protecting and restoring water resources within the watershed, but to also contribute to nutrient reductions needed for downstream waters both within Minnesota and those downstream of the state border. The Minnesota Nutrient Planning Portal was developed for accessing watershed nutrient-related information. It includes information on phosphorus conditions and trends in local waters, modeling, local water planning, and other information. Information from this portal can be used when developing local plans and strategies to reduce phosphorus losses to local and downstream waters.

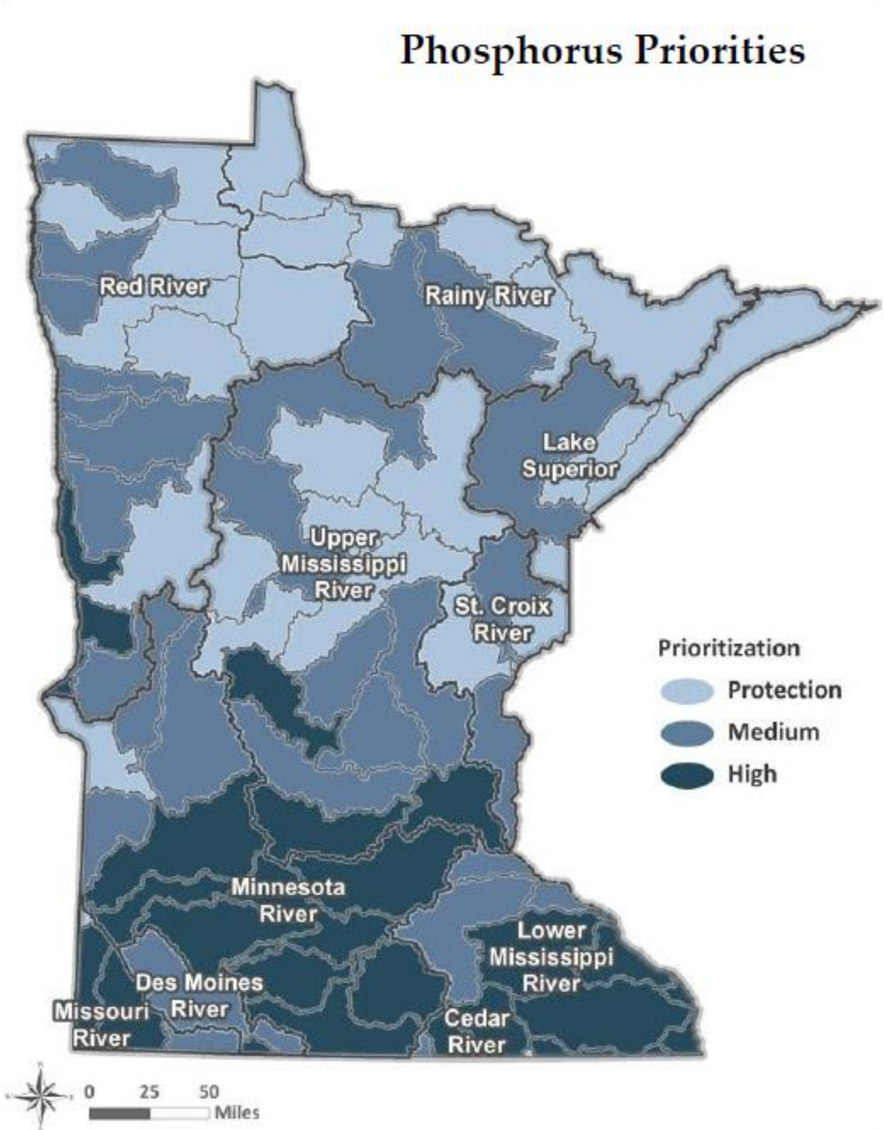


Figure 41. Priority watersheds for phosphorus reduction. (Source: The Minnesota Nutrient Reduction Strategy)

8.2. The Minnesota Watershed Approach

Detailed implementation planning for phosphorus reductions in the Lake Pepin Watershed will occur at the individual major watershed (i.e., HUC-8) level as part of Minnesota's watershed approach to restoring and protecting water quality. This watershed-level planning occurs on a 10-year cycle beginning with intensive watershed monitoring and culminates in local implementation (Figure 42). A WRAPS report is produced as part of this approach and produces strategies for restoration of impaired waters and protection of unimpaired waters in each HUC-8 watershed. The WRAPS for each HUC-8 watershed includes elements such as implementation strategies, timelines, interim milestones, and responsible governmental units for achieving the needed pollutant reductions. These high-level strategies are then used to inform watershed management plans (e.g., 1W1P) that focus on local priorities and knowledge to identify prioritized, targeted, and measurable actions and locally based strategies. These plans further define specific actions, measures, roles, and financing for accomplishing water resource goals.

The remainder of this section discusses briefly the strategies for reducing phosphorus from specific point and nonpoint sources.

Figure 42. Minnesota's watershed approach.

8.3. Permitted Sources

8.3.1. Construction Stormwater

A permit is required for any construction activities disturbing: one acre or more of soil; less than one acre of soil if that activity is part of a "larger common plan of development or sale" that is greater than one acre; or less than one acre of soil, but the MPCA determines that the activity poses a risk to water resources. WLAs have been included in the TMDLs in this report to account for pollutant loadings from these ongoing construction activities. The BMPs and other stormwater control measures that should be implemented at construction sites are defined in MPCA's NPDES/SDS General Stormwater Permit for Construction Activity (MNR100001). If a construction site owner/operator obtains coverage under the NPDES/SDS General Stormwater Permit and properly selects, installs and maintains all BMPs required under the permit, including those related to impaired waters discharges and any applicable additional requirements found in Appendix A of the Construction General Permit, the stormwater discharges would be expected to be consistent with the WLAs in the TMDLs in this report. All local construction stormwater requirements must also be met.

8.3.2. Industrial Stormwater

WLAs have been included in the TMDLs in this report to account for pollutant loadings from industrial stormwater. The BMPs and other stormwater control measures that must be implemented at the industrial sites are defined in the MPCA's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) or facility specific Individual Wastewater Permit (MN00XXXXX) or NPDES/SDS General Permit for Construction Sand & Gravel, Rock Quarrying and Hot Mix Asphalt Production facilities (MNG490000). These NPDES/SDS permit requirements may or may not identify specific limits, BMPs and/or implementation activities regarding industrial stormwater that apply when a TMDL is approved.

The TMDLs in this report do not identify nor trigger additional limits, BMPs and/or implementation activities for industrial stormwater. While industrial stormwater discharges may exceed the applicable downstream water quality criterion, they do not substantially contribute to violations of standards since they constitute a *de minimis* fraction of the overall pollutant load compared to the LA, MS4 WLA and WWTP WLA.

If a facility owner/operator obtains stormwater coverage under the appropriate permit and properly selects, installs, and maintains all BMPs required under the permit, the stormwater discharges would be expected to be consistent with the WLAs in the TMDLs in this report. All local stormwater management requirements must also be met.

8.3.3. MS4s

There are 206 regulated MS4 entities in the Lake Pepin Watershed that are addressed by the WLAs included in the TMDLs in this report. An additional 11 cities that are growing and have populations that exceed or are approaching 5,000 are also included. The list of these entities is included in Appendix C. The WLA for all MS4 entities is the equivalent of 0.35 lb/acre/year of TP for stormwater discharging from the conveyance system they own and/or operate. Section 5.2.2 describes the approach used in arriving at this loading rate. MS4 permittees are required to document compliance with WLA(s) over time as part of their MS4 Stormwater Pollution Prevention Plan (SWPPP). MS4s must determine if they are currently meeting their WLA(s) and, if not, provide a narrative strategy and compliance schedule to meet the WLA(s). Since many stormwater BMPs reduce both TP and TSS loading to a receiving water body, MS4 permittees will be able to report progress on multiple TMDLs with individual stormwater BMPs (e.g. Lake Pepin Watershed TMDL, South Metro Mississippi River TSS TMDL, etc.).

The MPCA's MS4 program provides guidance for addressing TMDL requirements in MS4 General Permit applications and SWPPP documents. In addition, the MPCA has developed guidance to assist permittees with meeting reporting requirements in the permit. This guidance includes detailed discussion of appropriate models and other approaches for estimating loads associated with implementation of stormwater BMPs.

For new development projects, MPCA's current phase II MS4 general permit requires no net increase from pre-project conditions (on an annual average basis) of stormwater discharge volume, stormwater discharges of TSS, and stormwater discharges of TP. For re-development projects, the MPCA's current Phase II MS4 General Permit requires a net reduction from pre-project conditions (on an annual average basis) of stormwater discharge volume, stormwater discharges of TSS, and stormwater discharges of TP. These provisions in the MS4 permits will prevent increases in loading.

8.3.4. Wastewater

Municipal and industrial wastewater treatment facilities are regulated through NPDES permits. A total of 407 permitted municipal and industrial wastewater dischargers have been assigned a WLA in this TMDL report. An annual WLA for each of these facilities has been developed by MPCA to protect Lake Pepin. The approach and methodology for determining annual WLAs can be found in Section 5.2.1. The annual WLAs to protect Lake Pepin, which have been determined to also protect RES criteria in Pool 2, will be implemented in permits as 12 month rolling total kg/day mass limits or WQBELs. These WQBELs will be evaluated on a monthly basis to ensure compliance.

Additionally, some facilities within the Crow River Watershed were given a second WLA based on meeting the RES criteria in the downstream impaired AUID during the applicable months of June through September. These WLAs were developed, as needed, when the annual WLA to meet the Lake Pepin TMDL was not sufficient to meet the RES TMDL. More detail on the development of these RES WLAs for the Crow River Watershed can be found in the *Greater Crow River Watershed Phosphorus Effluent Limit Analysis* memorandum prepared by MPCA. For the most current version of this memorandum, the reader should contact MPCA. These seasonal WLAs will apply from June through September and are based on meeting RES criteria. They will be implemented in permits as monthly average limits by applying an effluent variability multiplier. More restrictive TP WLAs and WQBELs may be assigned for local lakes and rivers in individual watershed reviews if these main-stem WLAs are not sufficient to protect local resources.

8.4. Non-Permitted Sources

A key point of focus in the NRS to addressing nonpoint source/non-permitted sources is through BMP implementation and the needed community education and support to promote widespread effective BMP use. The NRS identifies key strategies for implementing agricultural BMPs as follows:

- Work with private industry to support nutrient reduction
- Increase living cover crops
- Improve soil health
- Establish riparian buffers
  - Minnesota 50-ft Buffer Law along public waters was implemented on November 1, 2017.
  - Public ditches are required to have 16.5-ft buffer beginning on November 1, 2018.
- Efficient fertilizer use

- Reduced tillage and soil conservation
- Drainage water retention and treatment.

Paramount to the success of BMP implementation will be garnering support from both the public and private sectors. The NRS calls for developing demonstration projects at the watershed and field scales. These demonstration projects could be used for public outreach and education as well as research opportunities in testing BMP effectiveness. The Sediment Reduction Strategy (MPCA 2015b) outlines similar implementation strategies to address nonpoint sources and required reductions.

The NRS also outlines implementation strategies for miscellaneous sources such as SSTSs, or septic systems, as well as feedlots. The SSTS Program is underway with a 10-year plan to upgrade systems and reduce the percentage of failing systems from 39% to <5%.

8.5. Cost

TMDLs are required to include an overall approximation of implementation costs (Minn. Stat. 2007, § 114D.25). Estimating the cost to achieve the TMDLs in this report is a very difficult exercise. Given that this TMDL is largely an overlay TMDL with several other TMDLs nested within it, it is perhaps most helpful to look at the costs estimated in the component TMDLs, as reported in either the TMDL reports themselves or the accompanying implementation plans. For example, the estimated cost for implementation of the Byllesby Reservoir Phosphorus TMDL is $170 to $180 million, with further capital improvement and maintenance costs taken on by three largest municipal phosphorus dischargers (Faribault, Northfield, and Owatonna).

Cost analyses for both wastewater nutrient removal and agricultural BMP implementation were provided in the Minnesota Nutrient Reduction Strategy (MPCA 2014). The reader is referred to the NRS for more details beyond the summary information included here. Costs for the vast majority (over 90%) of residents receiving municipal wastewater treatment range from $7 to $11 per pound of phosphorus removed to reach 1 mg/L concentration phosphorus in the effluent. However, removal costs escalate sharply with declining effluent concentration targets. Costs range from $39 to $175 per pound for removal to a 0.8 mg/L concentration and $91 to $344 per pound for removal to a 0.1 mg/L concentration. These phosphorus removal cost estimates represent chemical phosphorus treatment by mechanical municipal wastewater treatment facilities only. Stabilization pond and industrial WWTP phosphorus removal costs are not included in these estimates. Dividing these dollars per pound totals by the total population served by wastewater treatment facilities that discharge to surface waters (approximately 3.86 million) yields the following:

- Cost for phosphorus removal to a 1 mg/L concentration = $10/capita/year
- Cost for phosphorus removal to a 0.8 mg/L concentration = $14/capita/year
- Cost for phosphorus removal to a 0.1 mg/L concentration = $34/capita/year

The cost-benefit results for agricultural BMPs were estimated on an annual basis by calculating the net present value of the monetary costs and benefits associated with each practice from the producer's point of view. Costs included up-front establishment and operation costs. Benefits included any increases in production or cost savings to the producer gained by implementing the practice. The annualized value represents the net cost (or benefit in some cases) for the practice if it were paid in constant annual payments for the lifetime of the practice. The annualized value provides a means for comparing practices with different timing of costs and benefits (e.g., more up-front, less operation costs versus less up-front, more operation costs) or different time periods. The annualized values per acre were applied to the acres of BMPs to calculate the cost per year to achieve the goals and milestone. For the Mississippi River major basin, the cost of agricultural BMPs was estimated to be $51,100,000 - $136,500,000 per year. Costs estimates will vary considerably with changing technologies, changing markets, new information and other changes. In the Mississippi River major basin, the cost savings from the increased fertilizer use efficiency and conservation tillage BMPs greatly offset the net costs of the other BMPs. Please refer to Section 3.2 for descriptions of major basins.

The Lake Pepin Full Cost Accounting Project attempted to analyze the environmental and economic effects of actions to improve water quality by reducing phosphorus and sediment loads. Key findings included:

- Modest gains in water quality are possible without reducing economic returns. Relative to current levels, phosphorus may be reduced by from roughly 20% to 32%.
- 50% reductions in sediment and phosphorus are possible in the Seven Mile Creek and West Fork Beaver Creek watersheds, but this level of reduction requires moving substantial acreage out of row crops into winter annual or perennial vegetation. Utilizing existing, or creating new, markets for either practice may help dampen the effects of any reduced economic returns as a result of the transition out of row crops.
- When the value of non-market ecosystem services is incorporated into the economic accounting, 50% reductions of sediment and phosphorus occur at low costs to society.
- BMPs for achieving water quality goals will not by themselves be sufficient to achieve water quality goals, and incur higher than necessary cost relative to economic returns. Employing conventional BMPs alone only achieves modest reductions in sediment and phosphorus (<20% reductions). In order to work towards a goal of 50% reduction in phosphorus, conventional BMPs must be accompanied by transition of key landscape segments from row crops to winter annual or perennial vegetation that will lead to improved water quality and management of water quantity..

8.6. Adaptive Management

The successful implementation of efforts to attain the TMDLs in this report will require an adaptive management approach. Incorporating flexibility and adaptability within implementation planning will facilitate more efficient and cost effective nutrient reduction planning efforts over time.

The NRS also recognized the need for adaptive management. Progress towards goals and milestones needs to be tracked over time to determine if strategies are successful and where additional work is needed. To understand the level of phosphorus reduction progress being achieved and ensure that on-the-ground implementation is on pace with goals and milestones, it is important to evaluate both changes in the adoption of BMPs and water quality monitoring information. The basic components of the NRS's adaptive management plan are as follows:

- Identify data and information needed to track progress toward NRS goals and milestones.

- Create a system or approach for collecting data and information needed to track progress toward NRS goals and milestones.
- Evaluate trends as well as relationships between actions and outcomes.
- Adjust the NRS as necessary.

Within these goals are strategies and tools to be utilized in an effort to track, evaluate, and communicate the progress and effectiveness of nutrient reduction BMPs. These efforts include regional scale programs, such as the WPLMN, and more local efforts outlined in WRAPS. Implementation efforts to achieve the TMDLs in this report will be frequently evaluated and periodically updated using an iterative process of planning, implementing, assessing and adapting (Figure 43).

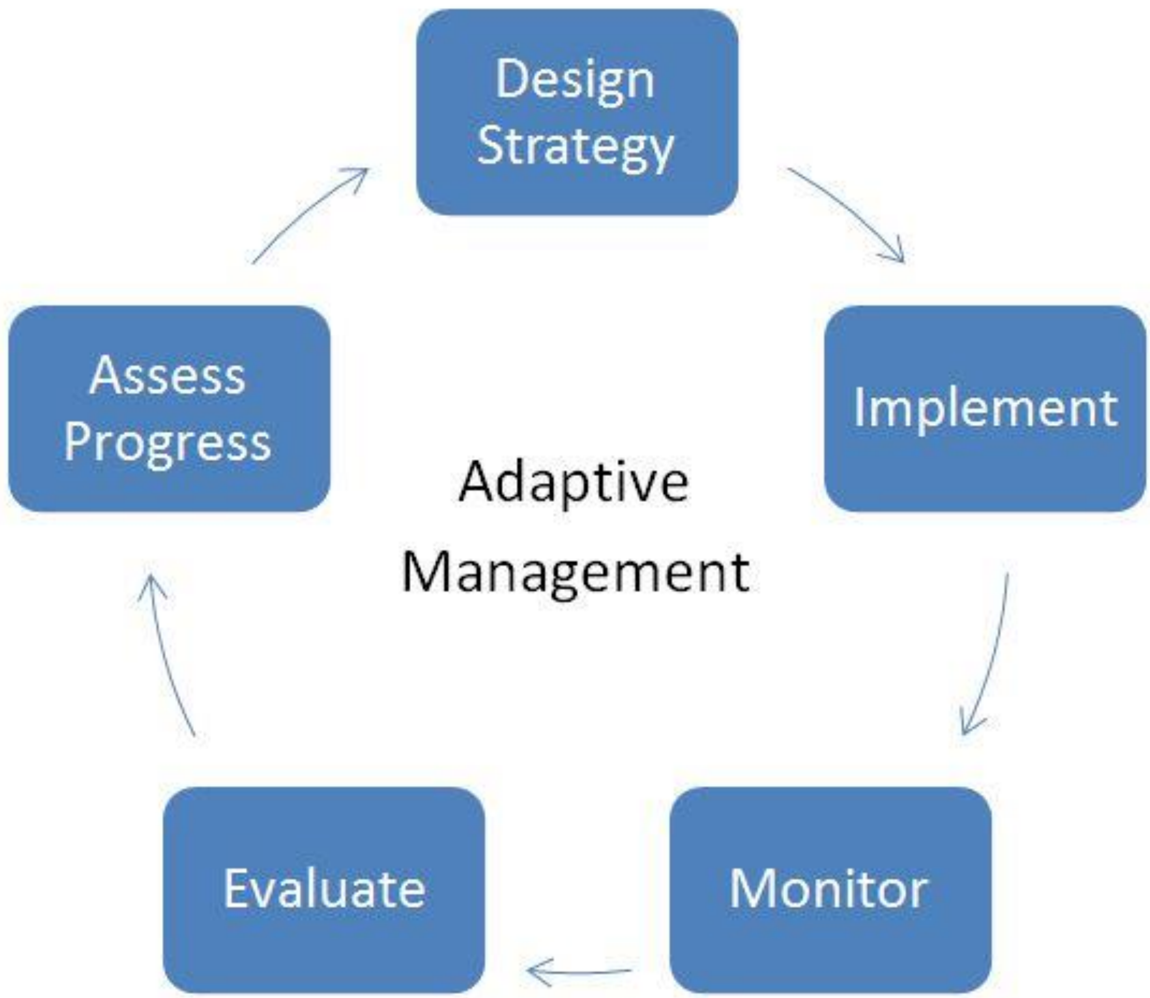


Figure 43. Adaptive management iterative process.

9. Public Participation

This section describes the stakeholder involvement processes conducted as part of development of the Lake Pepin TMDL. The process has spanned well over a decade, largely due to the need for additional scientific work on the appropriate water quality standards for the lake, RES development, and the overall size and complexity of the effort. Many other TMDL and watershed planning and implementation efforts in the greater watershed have continued throughout this time, making progress toward addressing the Lake Pepin and Mississippi River impairments. Stakeholders have been involved and engaged throughout.

The process began in approximately 2004. The MPCA invited a representative group of individuals to the first Stakeholder Advisory Committee in October 2004. This group has been involved in discussions ever since. MPCA engaged the committee in the development of two successive TMDL work plans – the first one to guide water quality assessment, and the second to guide watershed analysis. The MPCA promptly posted both on its web site. The MPCA has also posted presentations given at committee meetings on its web site.

The Lake Pepin TMDL SAP was established in February 2005, in consultation with the Stakeholder Advisory Committee and the University of Minnesota. The first task undertaken by the SAP was to advise the MPCA on the development of a Request for Proposals (RFP) for Lake Pepin (including the South Metro Mississippi) TMDL modeling. A sub-group worked on details of the RFP work plan, which the entire SAP reviewed before the draft was finalized. The SAP met subsequently on occasion to review and comment on modeling results, the last such meeting being on October 8, 2008. Frequently members offered a variety of perspectives on technical issues. In addition to attendance at meetings, several SAP members contributed technical information as well as many hours to discussion and analysis of technical issues that arose during the development and application of the Upper MRLP model.

The MPCA held three sector-specific meetings to review the findings of the modeling in summer 2008 with groups representing:

- Agriculture;
- Conservation and environmental protection; and
- Municipal wastewater and stormwater.

As a follow-up to the municipal sector meeting, an MS4 stakeholder advisory group was formed and met three times, with considerable email correspondence. This group includes representatives from MS4s, their consultants, and the MPCA. About 60 people were involved in the kickoff meeting, where 13 members were selected for the advisory group. Meetings typically had 8-10 attendees. This group focused on choosing a strategy for linking the permit to the TMDL and setting allocations.

In addition to the stakeholder committee and science advisers, the MPCA has involved the broader public through annual forums and conferences. Three annual technical conferences on the Lake Pepin TMDL also were held in 2006, 2007, and 2008 – the first two in the Twin Cities, and the third in Mankato – for two days. The MPCA held three Lake Pepin Forums between 2007 and 2009 in Red Wing, Minnesota, to engage stakeholders and citizens. The MPCA staff members have also made presentations on the Lake Pepin TMDL for many organizations and audiences, including the Minnesota Association of

Watershed Districts, Minnesota Association of SWCDs, Upper Mississippi River Basin Association, Upper Mississippi River Conservation Committee, and others.

In order to further strengthen local and regional ties to this large, complex TMDL project, the MPCA contracted with Dakota County and Dakota County SWCD to coordinate “Mississippi Makeover,” a project to coordinate both local land use planning and Mississippi River management with the TMDL. A stakeholder group formed for Mississippi Makeover has developed a list of environmental indicators for the project. A technical committee chaired by the DNR developed metrics, or quantitative targets, for each of these indicators. The result will be an adaptive management approach to integrating the TMDL with river management and local land use planning.

After MPCA determined in 2010 that a site-specific standard would be required for Lake Pepin, public participation shifted away from TMDL meetings. As summarized in the following table, subsequent engagement was focused on developing the lake standard and the RES. Concurrent related project work on the NRS and many HUC-8 WRAPS also required significant public engagement.

Groups beyond MPCA have also had a major impact on public education and outreach related to Lake Pepin. The Lake Pepin Legacy Alliance is a great example. The Alliance is a citizen-driven organization bringing together education, science, and collaborative action to sustain Lake Pepin's ecosystem for the long-term.

The River Connections newsletter has provided on-going news and updates to stakeholders regarding Lake Pepin and related subject matter. In March 2015 the newsletter was combined with another (Watershed Network News) and continues to provide a news channel for Lake Pepin and Big River projects.

Table 26. Lake Pepin and RES TMDLs chronology.

Original Project Genesis	
1990s	Extensive collaborative WQ studies
2002	Lake Pepin 303(d) listing
2004	TMDL development initiated
2005	Water Resources Center invited to lead Science Advisory Panel
2007-2008	LimnoTech develops Upper Mississippi River - Lake Pepin model framework
2010	Draft site specific standard for Lake Pepin
Engagement shifts to river eutrophication, site specific standards for Lake Pepin and pools	
June 2012	Request for Comment on proposed river & site specific WQS
November 2013	Proposed WQS in State Register
January 2014	Hearing on proposed WQS
February 2014	Comment period closed
June 2014	Petition seeking administrative stay of rules
July 2014	MPCA Citizen Board denies stay
August 2014	WQS became effective in Ch7050
December 2014	MESERB files suit in Appeals Court
January 2015	USEPA approved WQS
July 2015	Oral arguments
August 2015	Rules declared valid by Appeals Court
October 2017	Minnesota River Basin RES meeting in Mankato
May 2018	Crow River Basin RES meeting in Delano
Concurrent project work and milestones related to nutrient and sediment reduction in the Lake Pepin watershed	
2005	Lake Pepin draft WLA based permit limits implementation begins
2006	Lower Minnesota River Basin DO TMDL
2010	TSS standard replaces turbidity for South Metro Mississippi
2012	Lake St. Croix Phosphorus TMDL
2014	Minnesota Nutrient Reduction Strategy
2014	MPCA begins approving WRAPS at the HUC-8 scale
2015	Sediment Reduction Strategy (for MN River Basin and South Metro Mississippi River)
2015	South Metro Mississippi TSS TMDL
2015	North Fork Crow Watershed WRAPS & TMDLs
2016	Cannon River WRAPS & Byllesby Reservoir Phosphorus TMDL
TMDL Development Resumes	
2016-2017	LimnoTech retained to draft TMDLs document for Lake Pepin and Great River eutrophication TMDLs, integrating related projects, Nutrient Reduction Strategy, coordinating with Minnesota River TSS TMDLs
2019	Draft TMDLs document available for review

9.1. Public Notice for Comments

An opportunity for public comment on the draft TMDL report was provided via a public notice in the *State Register* from [XXX] to [XXX]. There were xxx comment letters received and responded to as a result of the notice.

10. Literature Cited

Barr Engineering. 2004. Detailed Assessment of Phosphorus Sources to Minnesota Watersheds. Prepared for the Minnesota Pollution Control Agency. https://www.pca.state.mn.us/water/phosphorus

Barr Engineering. 2007. Detailed Assessment of Phosphorus Sources to Minnesota Watersheds – Atmospheric Deposition: 2007 Update. Prepared for the Minnesota Pollution Control Agency. https://www.pca.state.mn.us/sites/default/files/pstudy-2007updatememo.pdf

Dakota County SWCD. 2016. Subwatershed Analysis for Trout Brook. http://www.dakotacountyswcd.org/pdfs/Trout%20Brook%20SWA.pdf

Engstrom, D. R. and J. E. Almendinger. 2000. Historical changes in sediment and phosphorus loading to the Upper Mississippi River: Mass-balance reconstructions from the sediments of Lake Pepin. Final Research Report prepared for the Metropolitan Council Environmental Services. St. Croix Watershed Research Station, Science Museum of Minnesota, Marine on St. Croix, Minnesota.

Environmental Protection Agency (EPA). 1999. Protocol for Developing Nutrient TMDLs.

Environmental Protection Agency (EPA). 2002. Guidelines for Reviewing TMDLs under Existing Regulations issued in 1992. https://www.epa.gov/sites/production/files/2015-10/documents/2002_06_04_tmdl_guidance_final52002.pdf

Environmental Protection Agency (EPA). 2003. Draft Guidance on the Development, Evaluation, and Application of Regulatory Environmental Models. EPA – Office of Science Policy and Office of Research and Development, Council for Regulatory Environmental Modeling. Washington, D.C.

Environmental Protection Agency (EPA). 2009. The Next Generation of Tools and Actions to Restore Water Quality in the Chesapeake Bay, A Draft Report Fulfilling Section 202(a) of Executive Order 13508. Washington, DC. September 9, 2009. http://executiveorder.chesapeakebay.net/file.axd?file=2009%2f9%2f202(a)+Water+Quality+Draft+Report.pdf

Heiskary, S.A. and Vavricka, M. 1993. Lake Pepin Water Quality: 1976 – 1991 Section 3. Mississippi River Phosphorus Study. MPCA, St. Paul Minnesota.

Heiskary, S. and B. Wilson. 2008. Minnesota's approach to lake nutrient criteria development. Lake Reserv. Manage. 24:282-297.

King, K. W., M. R. Williams, and N. R. Fausey. 2015. Contributions of Systematic Tile Drainage to Watershed-Scale Phosphorus Transport. J. Environ. Qual. 44:486-494. doi:10.2134/jeq2014.04.0149

LimnoTech Inc. 2009a. Upper Mississippi River – Lake Pepin Water Quality Model Development, Calibration, and Application. Prepared for the Minnesota Pollution Control Agency. Prepared by LimnoTech. July 2009.

LimnoTech Inc. 2009b. Memorandum: Initial Development and Calibration of a Water Quality Model for the Upper Mississippi River. Prepared for the Minnesota Pollution Control Agency. Prepared by LimnoTech. July 2009.

LimnoTech Inc. 2009c. Memorandum: Estimation of Upper Mississippi River Phosphorus Delivery Ratios. Prepared for the Minnesota Pollution Control Agency. Prepared by LimnoTech. July 2009.

LimnoTech Inc. 2015. Cannon River Watershed HSPF Model Development Project. Minnesota Pollution Control Agency, One Water Program. Prepared for the Minnesota Pollution Control Agency. Prepared by LimnoTech. January 15, 2015.

Metropolitan Council Environmental Services (MCES). 2002. Lake Pepin Phosphorus Study, 1994-1998.

Metropolitan Council Environmental Services (MCES). 2014. Technical Executive Summary. Comprehensive water quality assessment of select metropolitan area streams.

Metropolitan Council Environmental Services (MCES). 2018. Regional Assessment of River Water Quality in the Twin Cities Metropolitan Area 1976-2015. (link to report website)

Minnesota Board of Water and Soil Resources (BWSR). 2016b. One Watershed, One Plan fact sheet. http://www.bwsr.state.mn.us/planning/1W1P/1W1P_Factsheet.pdf

Minnesota Board of Water and Soil Resources (BWSR). 2017a. Buffer web page. http://www.bwsr.state.mn.us/buffers/

Minnesota Board of Water and Soil Resources (BWSR). 2017b. CREP web page. http://www.bwsr.state.mn.us/crep/

Minnesota Clean Water Council. 2018. FY 20-21 Clean WaterFund and Policy Recommendations Report. Biennial Report to the Legislature. November 30, 2018
https://www.pca.state.mn.us/sites/default/files/lr-cwc-1sy18.pdf

Minnesota Pollution Control Agency (MPCA). 2004. Lower Minnesota River Dissolved Oxygen TMDL. https://www.pca.state.mn.us/sites/default/files/tmdl-final-lowermn-doreport.pdf

Minnesota Pollution Control Agency (MPCA). 2010. Medicine Lake Excess Nutrients TMDL. https://www.pca.state.mn.us/sites/default/files/wq-iw8-19e.pdf

Minnesota Pollution Control Agency (MPCA). 2011. Lake Pepin Site Specific Eutrophication Criteria. https://www.pca.state.mn.us/sites/default/files/wq-s6-10.pdf

Minnesota Pollution Control Agency (MPCA). 2012a. Draft - Minnesota River Turbidity TMDL. https://www.pca.state.mn.us/sites/default/files/wq-iw7-32b.pdf

Minnesota Pollution Control Agency (MPCA). 2012b. Lake St. Croix Nutrient TMDL. https://www.pca.state.mn.us/sites/default/files/wq-iw6-04e.pdf

Minnesota Pollution Control Agency (MPCA). 2012c. Mississippi River Pools 1 through 8: Developing River, Pool, and Lake Pepin Eutrophication Criteria. https://www.pca.state.mn.us/sites/default/files/wq-s6-09.pdf

Minnesota Pollution Control Agency (MPCA). 2013a. Minnesota Nutrient Criteria Development for Rivers. https://www.pca.state.mn.us/sites/default/files/wq-s6-08.pdf

Minnesota Pollution Control Agency (MPCA). 2013b. Byllesby Reservoir Phosphorus TMDL Report: Public Notice Draft. https://www.pca.state.mn.us/sites/default/files/wq-iw9-10b.pdf

Minnesota Pollution Control Agency (MPCA). 2013c. Implementation Plan for the Lake St. Croix Nutrient TMDL. https://www.pca.state.mn.us/sites/default/files/wq-iw6-04c.pdf

Minnesota Pollution Control Agency (MPCA). 2013d. Minnesota's Nonpoint Source Management Program Plan. https://www.pca.state.mn.us/sites/default/files/wq-cwp8-15.pdf

Minnesota Pollution Control Agency (MPCA). 2014. Minnesota Nutrient Reduction Strategy. https://www.pca.state.mn.us/sites/default/files/wq-s1-80.pdf

Minnesota Pollution Control Agency (MPCA). 2015a. South Metro Mississippi River Total Suspended Solids TMDL. https://www.pca.state.mn.us/sites/default/files/wq-iw9-12e.pdf

Minnesota Pollution Control Agency (MPCA). 2015b. Sediment Reduction Strategy for the Minnesota River Basin and South Metro Mississippi River. https://www.pca.state.mn.us/sites/default/files/wq-iw4-02.pdf

Minnesota Pollution Control Agency (MPCA). 2016a. Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List. https://www.pca.state.mn.us/sites/default/files/wq-iw1-04i.pdf

Minnesota Pollution Control Agency (MPCA). 2016b. Coon Creek Watershed District TMDL. https://www.pca.state.mn.us/sites/default/files/wq-iw8-44e.pdf

Minnesota Pollution Control Agency (MPCA). 2019. Minnesota River and Greater Blue Earth River Basin Total Suspended Solids Total Maximum Daily Load Study – Draft Report – In Process.

NRCS. 2006. Model Simulation of Soil Loss, Nutrient Loss, and Change in Soil Organic Carbon Associated with Crop Production. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_012874.pdf

Smith, D. R., K. W. King, L. Johnson, W. Francesconi, P. Richards, D. Baker, and A. N. Sharpley. 2015. Surface Runoff and Tile Drainage Transport of Phosphorus in the Midwestern United States. J. Environ. Qual. 44:495-502. doi:10.2134/jeq2014.04.0176

TetraTech. 2009. Minnesota River Basin Turbidity TMDL and Lake Pepin Excessive Nutrient TMDL, Model Calibration and Validation Report. Prepared for Minnesota Pollution Control Agency. June 5, 2009.

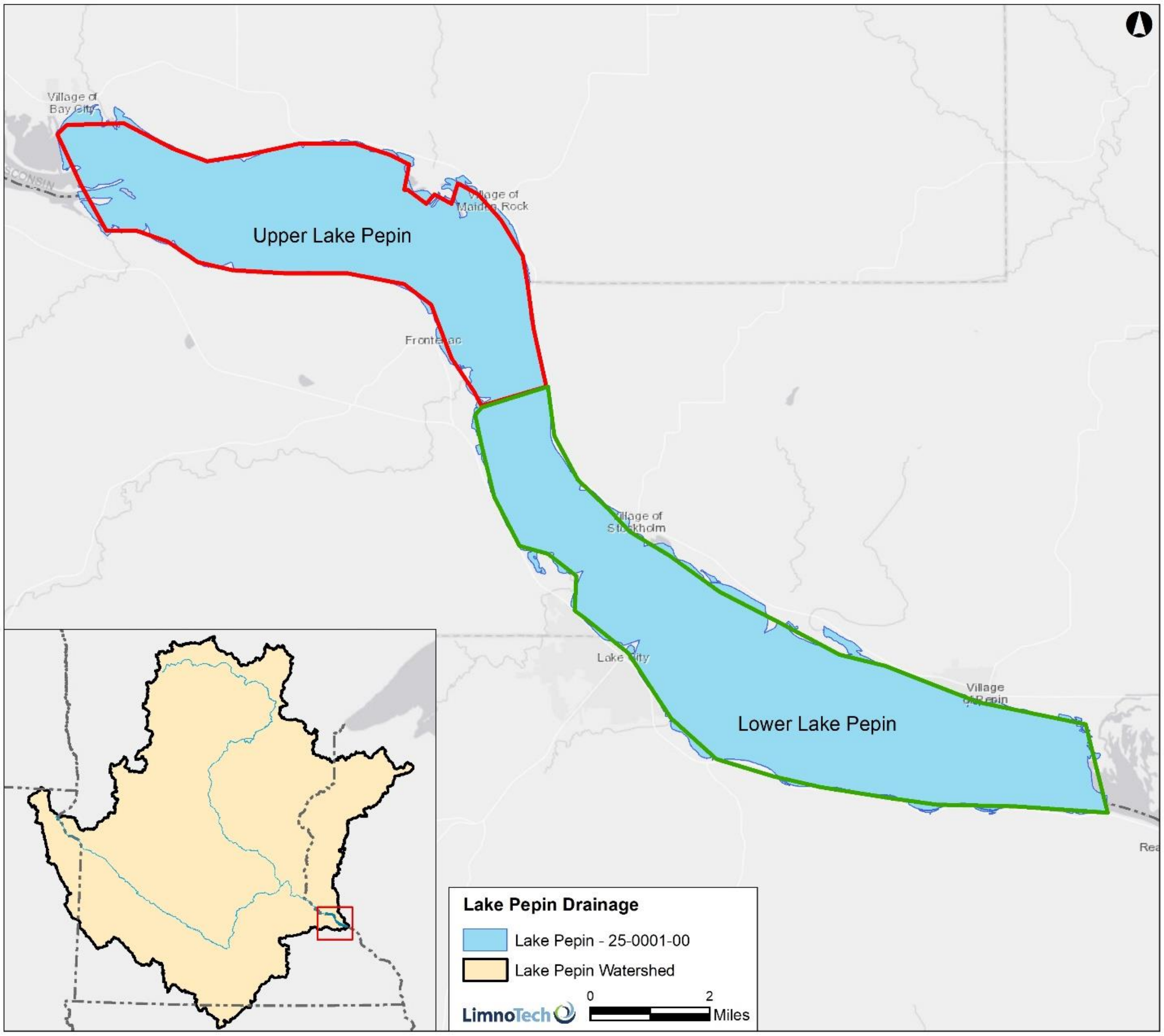
Triplett, Laura & R. Engstrom, Daniel & Edlund, Mark. 2009. A whole-basin stratigraphic record of sediment and phosphorus loading to the St. Croix River, USA. Journal of Paleolimnology. 41. 659-677. 10.1007/s10933-008-9290-7.

University of Minnesota. 2016. Forever Green two page summary. http://forevergreen-umn.info/Forever_Green_2page_040816.pdf

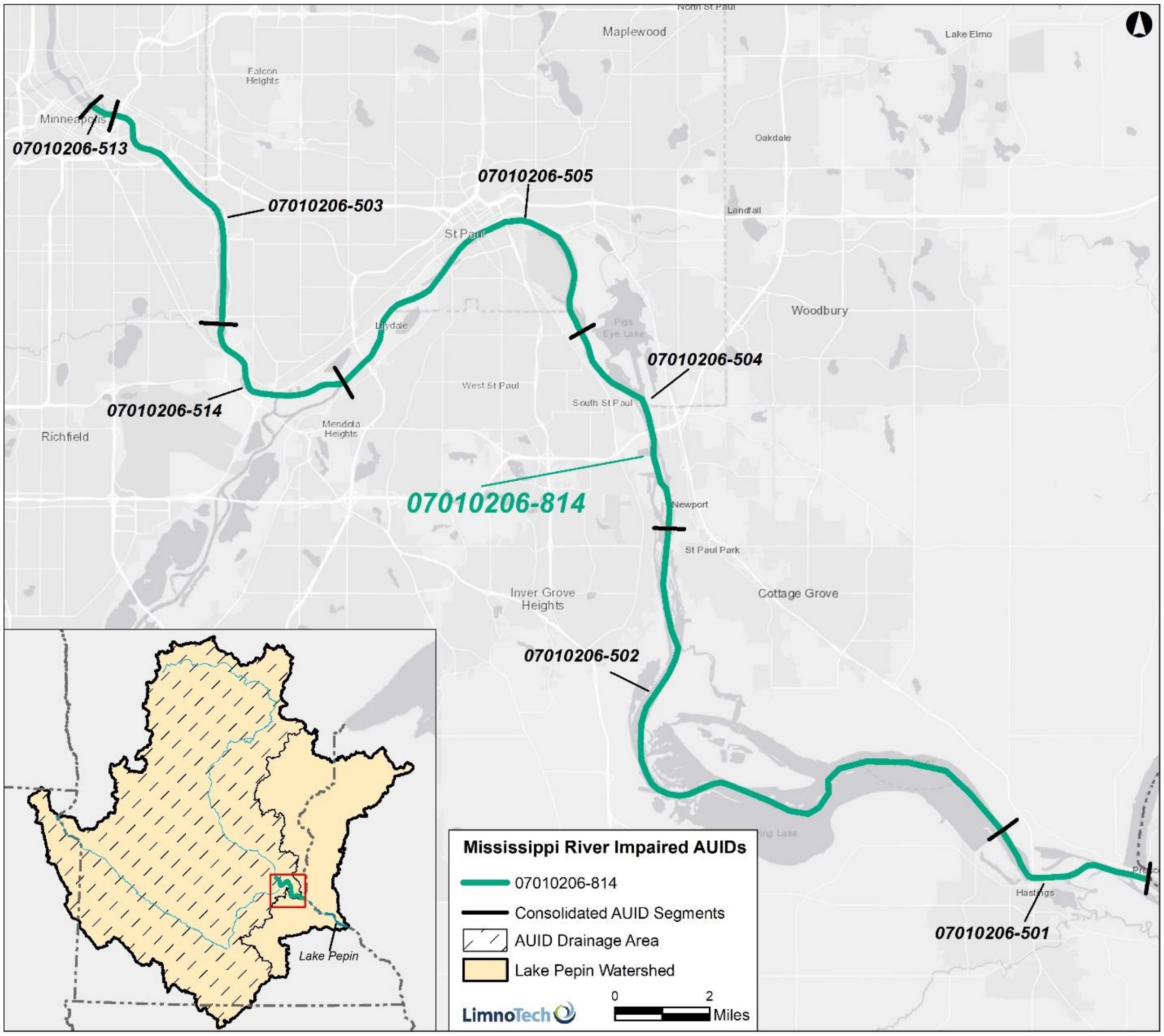
Wright, H. E., K. Lease and S. Johnson, 1998. Glacial River Warren, Lake Pepin, and the environmental history of southeastern Minnesota. In C.J. Patterson (Ed), Contributions to Quaternary Studies in Minnesota. Minnesota Geological Survey Report of Investigations 49, Minneapolis, MN: 131-140.

Appendices

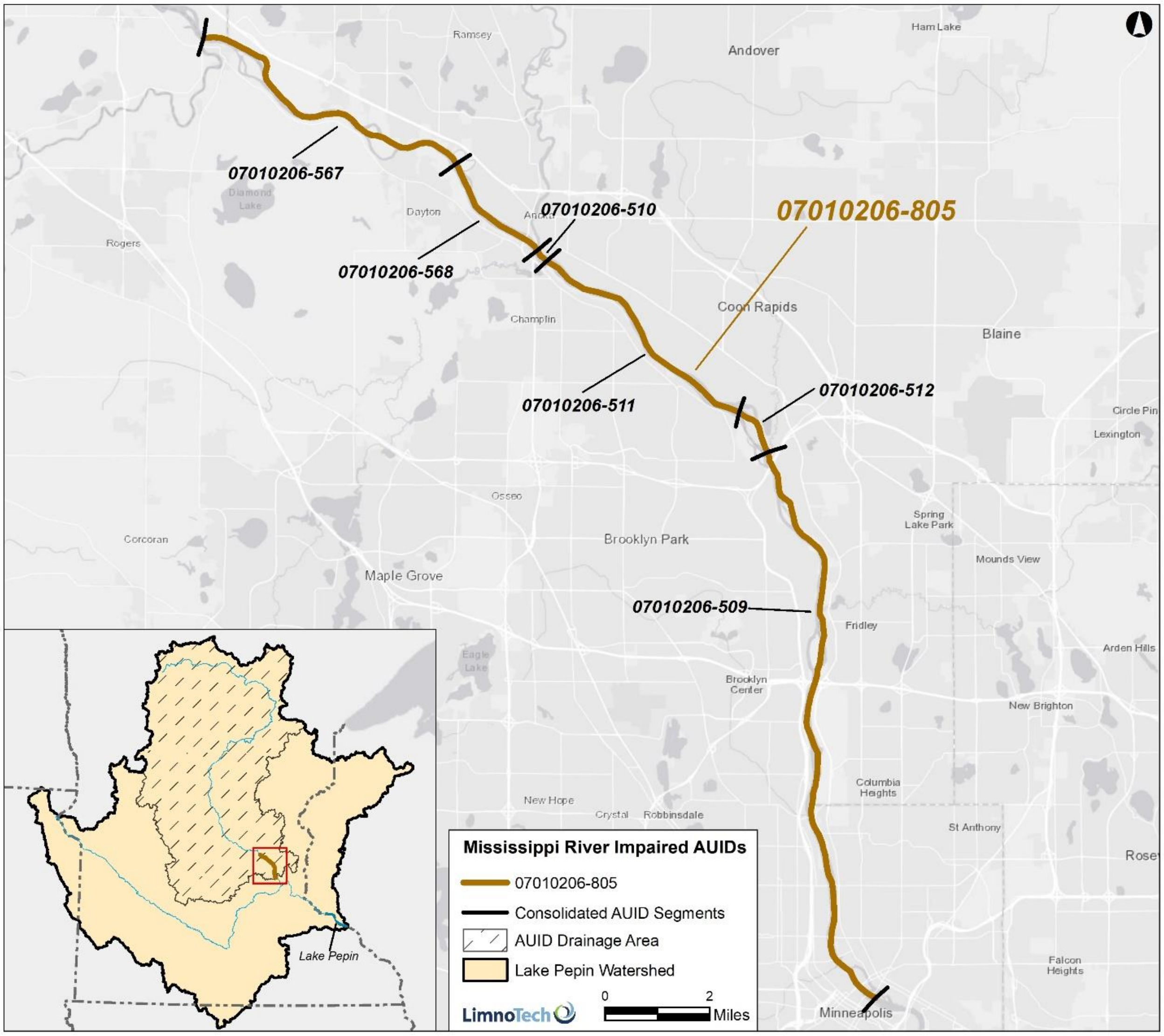
Appendix A – Impaired AUID Segments



Impaired AUID 25-0001-00 Lake Pepin.



Impaired AUID Reach 07010206-814 Mississippi River Pool 2 Upper St. Anthony Falls to St. Croix River.



Impaired AUID Reach 07010206-805 Mississippi River Crow River to Upper St. Anthony Falls.

Appendix B – WWTP WLAs

Facility Name	Permit Number	Lake Pepin WLA		RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs			Notes
					kg/yr		kg/day	
		12 Month Moving Total (kg/yr)	(kg/day)		25-0001-00	07010206-806/814	07010206-805	
Mississippi River/Lake Pepin Direct Tributaries								
ADM - Red Wing	MNG250009	29	0.079		29			
City of Prescott	WI0022403	703	1.926		703			
Ellsworth Co-op Creamery (Process)	WI0022942	419	1.148		407			
Federal-Mogul Corp	MN0001147	179	0.490		179			
Lake City WWTP	MN0020664	1,680	4.603		1,680			
Red Wing WWTP	MN0024571	4,421	12.112		4,421			
Village of Baldwin	WI0026891	1,167	3.197		1,054			
Village of Bay City	WI0061255	202	0.553		202			
Village of Ellsworth	WI0021253	794	2.175		772			
Village of Maiden Rock	WI0032361	64	0.175		64			
Village of Pepin	WI0022811	576	1.578		576			
Xcel Energy - Prairie Island Nuclear Plant	MN0004006	300	0.822		300			
Xcel Energy - Red Wing Generating Plant	MN0000850	11	0.030		11			
Cannon River Watershed below Byllesby								
Cannon Falls WWTP	MN0022993	1,271	3.482		1,223			
Vermillion River Watershed								
Hampton WWTP	MN0021946	279	0.764		260			
Kemps Culture Facility	MNG250109	207	0.567		191			
Vermillion WWTP	MN0025101	261	0.715		248			
Twin Cities Metro Area Below Lock & Dam 1								
3M - Cottage Grove	MN0001449	6,253	17.132		6,253	6,253		
Aggregate Industries Inc - Larson	MN0030473	448	1.227		448	448		

Facility Name	Permit Number	Lake Pepin WLA		RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs			Notes
					kg/yr		kg/day	
		12 Month Moving Total (kg/yr)	(kg/day)		25-0001-00	07010206-806/814	07010206-805	
Aggregate Industries Inc - Nelson Plant	MN0001309	1,382	3.786		1,382	1,382		
Boomerang Laboratories Inc	MN0066508	37	0.101		35	35		
Captain Ken's Foods Inc	MN0059765	7.3	0.020		7.3	7.3		
CF Industries Sales LLC - Pine Bend Terminal	MN0069418	6.6	0.018		6.6	6.6		
Flint Hills Resources Pine Bend Refinery	MN0000418	2,644	7.244		2,644	2,644		
HB Fuller Co - Willow Lake	MN0051811	122	0.334		120	120		
Met Council - Empire WWTP	MN0045845	11,858	32.488		11,858	11,858		
Met Council Eagles Point WWTP	MN0029904	8,220	22.521		8,220	8,220		
Met Council Hastings WWTP	MN0029955	2,973	8.145		2,973			
Met Council Metropolitan WWTP	MN0029815	120,553	330.282		120,553	120,553		
NEA Galtier LLC	MN0062031	15	0.041		15	15		
Pearson Candy Co	MNG255066	14	0.038		14	14		
Saint Louis Park GWP - Reilly Tar Site	MN0045489	104	0.285		103	103		
Saint Paul Park Refining Co LLC	MN0000256	1,515	4.151		1,515	1,515		
Saint Paul Regional Water Services	MN0045829	622	1.704		622	622		
Saputo Dairy Foods USA LLC	MNG255067	373	1.022		363	363		
SIGH Properties LLC	MN0054577	1.8	0.005		1.8	1.8		
St Louis Park WTP	MNG640084	18	0.049		18	18		
United & Children's Hospital	MN0002968	25	0.068		25	25		
USCOE Lock & Dam 2 WTP	MNG640113	0.41	0.001		0.41	0.41		
Xcel Energy - High Bridge Generating Plant	MN0000884	100	0.274		100	100		
Twin Cities Metro Area Above Lock & Dam 1								
AaCron Inc	MNG250002	137	0.375	0.38	132	132	0.38	Note 1
BAE Systems Land & Armaments LP	MNG255087	85	0.233	0.23	84	84	0.23	Note 1
Calco of Minneapolis	MN0059960	15	0.041	0.041	15	15		Note 1

Facility Name	Permit Number	Lake Pepin WLA		RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs			Notes
		12 Month Moving Total (kg/yr)	(kg/day)		kg/yr 25-0001-00	kg/yr 07010206-806/814	kg/day 07010206-805	
Covanta Hennepin Energy Resource Co LP	MN0057525	258	0.707	0.71	258	258	0.71	Note 1
Cummins Power Generation	MNG255029	17	0.047	0.047	17	17	0.047	Note 1
Electric Machinery Co Inc/WEG Group	MN0054771	16	0.044	0.044	16	16		Note 1
Forest Lake WTP	MNG640118	3.6	0.010	0.010	3.3	3.3	0.010	Note 1
Former Naval Industrial Reserve Ordinance Plant	MNG790159	99	0.271	0.27	98	98	0.27	Note 1
Fridley Locke Park Filtration WTP	MN0043664	28	0.077	0.077	28	28	0.077	Note 1
GAF Materials Corp	MN0002119	229	0.627	0.63	228	228	0.63	Note 1
Hennepin County Energy Center	MN0057509	108	0.296	0.30	108	108		Note 1
Hiawatha Metalcraft Inc	MNG250061	36	0.099	0.10	36	36		Note 1
Honeywell - Aerospace Minneapolis	MN0042641	386	1.058	1.06	386	386		Note 1
Honeywell International Inc	MNG255088	359	0.984	0.98	353	353	0.98	Note 1
International Paper - Fridley	MNG255038	1.5	0.004	0.004	1.5	1.5	0.004	Note 1
Magellan Pipeline Co LP - Saint Paul Terminal	MN0045896	97	0.266	0.27	93	93	0.26	Note 1
Maple Hill Estates	MN0031127	42	0.115	0.12	39	39	0.11	Note 1
Medivators	MN0063541	41	0.112	0.11	40	40	0.11	Note 1
Metal-Matic Inc	MNG255065	21	0.058	0.06	21	21		Note 1
Minneapolis Water Works - Fridley	MN0003247	373	1.022	1.02	370	370	1.02	Note 1
New Brighton WTP - Wells 10 & 11	MNG640068	3.2	0.009	0.0088	3.1	3.1	0.0087	Note 1
Nilfisk-Advance Inc	MN0066648	20	0.055	0.05	19	19	0.05	Note 1
Owens Corning - Minneapolis Plant	MN0048810	8.7	0.024	0.024	8.5	8.5	0.024	Note 1
Robinson Rubber Products Co Inc	MNG250048	8.0	0.022	0.022	7.8	7.8	0.022	Note 1
Saint Anthony WTP	MNG640081	55	0.151	0.15	54	54		Note 1
Saint Croix Forge Inc	MN0069051	11	0.030	0.03	10	10	0.03	Note 1
Tekna Seal LLC	MNG255036	1.4	0.004	0.004	1.4	1.4	0.004	Note 1
U of M - Civil Engineering Bldg 156	MN0058882	3.1	0.008	0.008	3.1	3.1		Note 1

Facility Name	Permit Number	Lake Pepin WLA		RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs			Notes
		12 Month Moving Total (kg/yr)	(kg/day)		kg/yr		kg/day	
					25-0001-00	07010206-806/814	07010206-805	
Vision-Ease LP dba Vision-Ease Lens	MN0065501	3.5	0.010	0.010	3.3	3.3	0.010	Note 1
WestRock MN Corp	MN0048984	138	0.378	0.38	138	138		Note 1
Xcel Energy - Fifth Street Substation	MN0003301	40	0.110	0.11	40	40		Note 1
Xcel Energy - Riverside Generating Plant	MN0000892	200	0.548	0.55	199	199	0.55	Note 1
Rum River Watershed								
Braham WWTP	MN0022870	553	1.515		457	457		Note 4
Cambridge WWTP	MN0020362	2,122	5.814		1,831	1,831		Note 4
Castle Towers WWTP	MN0042196	166	0.455		149	149		Note 4
Foreston WWTP	MNG580017	135	0.370		97	97		Note 4
Great River Energy - Cambridge	MN0068098	1.6	0.004		1	1		Note 4
Isanti Estates LLC	MN0054518	97	0.266		86	86		Note 4
Isanti WWTP	MN0023795	908	2.488		799	799		Note 4
Kraemer Mining & Materials - Mille Lacs	MN0067806	520	1.425		333	333		Note 4
MDNR Father Hennepin State Park	MN0033723	12	0.033		7	7		Note 4
Milaca WWTP	MN0024147	938	2.570		667	667		Note 4
Onamia WWTP	MNG580050	580	1.589		371	371		Note 4
Pease WWTP	MNG580167	108	0.296		78	78		Note 4
Premier Products Inc	MNG250082	0.30	0.001		0	0		Note 4
Princeton WWTP	MN0024538	1,862	5.101		1,436	1,436		Note 4
Saint Francis WWTP	MN0021407	746	2.044		680	680		Note 4
Crow River Watershed								
AB Mauri Food Inc dba Ohly Americas	MNG250099	622	1.704	1.70	459	459	1.38	
Annandale/Maple Lake/Howard Lake WWTP	MN0066966	1,309	3.586	0.63	1,064	1,064	0.56	
Associated Milk Producers - Paynesville	MN0044326	16	0.044		10	10	0.031	Note 1
Atwater WWTP	MN0022659	553	1.515	0.25	351	351	0.18	

Facility Name	Permit Number	Lake Pepin WLA		RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs			Notes
					kg/yr		kg/day	
		12 Month Moving Total (kg/yr)	(kg/day)		25-0001-00	07010206-806/814	07010206-805	
Belgrade WWTP	MN0051381	807	2.211	1.10	461	461	0.71	
Brooten WWTP	MN0025909	184	0.504		103	103	0.32	Note 1, 2
Brownton WWTP	MN0022951	493	1.351	0.24	363	363	0.20	
Buffalo Lake Advanced Biofuels LLC	MN0063151	61	0.167	0.15	42	42	0.12	
Buffalo Lake WWTP	MN0050211	456	1.249	0.42	315	315	0.32	
Buffalo WWTP	MN0040649	4,774	13.079	2.29	4,062	4,062	2.12	
Cedar Mills WWTP	MN0066605	44	0.121	0.19	31	31	0.15	
Cokato WWTP	MN0049204	1,003	2.748	0.58	794	794	0.50	
Cosmos WWTP	MNG580056	249	0.682	0.44	168	168	0.33	
Darwin WWTP	MNG580150	69	0.189	0.16	49	49	0.13	
Dassel WWTP	MN0054127	260	0.712	0.61	188	188	0.48	
Delano WTP	MNG640123	21	0.058	0.03	18	18	0.03	
Delano WWTP	MN0051250	2,430	6.658	1.46	2,121	2,121	1.38	
Faribault Foods Inc	MN0030635	360	0.986		281	281	0.84	Note 1
Gascoyne Materials Handling & Recycling LLC	MN0069612	15	0.041	0.17	11	11	0.14	
Glacial Lakes SSWD	MN0052752	1,228	3.364	0.71	791	791	0.51	
Glencoe WWTP	MN0022233	2,874	7.874	1.72	2,236	2,236	1.47	
Great River Energy of Dickinson	MN0049077	41	0.112	0.17	36	36	0.16	
Greenfield WWTP	MN0063762	138	0.378	0.13	122	122	0.12	
Grove City WWTP	MN0023574	310	0.849		203	203	0.00	Note 1
Hector WWTP	MN0025445	912	2.499	0.52	619	619	0.39	
Hutchinson WWTP	MN0055832	6,001	16.441	2.16	4,454	4,454	1.76	
Lake Lillian WWTP	MNG580225	147	0.403	0.39	95	95	0.28	
Lester Prairie WWTP	MN0023957	503	1.378	0.29	403	403	0.25	
Litchfield WWTP	MN0023973	3,426	9.386	1.64	2,351	2,351	1.25	

Facility Name	Permit Number	Lake Pepin WLA		RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs			Notes
		12 Month Moving Total (kg/yr)	(kg/day)		kg/yr		kg/day	
					25-0001-00	07010206-806/814	07010206-805	
Loretto WWTP	MN0023990	11	0.030	0.40	9.0	9.0	0.027	
Mayer WWTP	MN0021202	601	1.647	0.35	499	499	0.31	
Meadows of Whisper Creek WWTP	MN0066753	97	0.266	0.09	86	86	0.08	
Montrose WWTP	MN0024228	1,079	2.956	0.62	923	923	0.58	
New Germany WWTP	MN0024295	144	0.395	0.13	119	119	0.12	
Otsego East WWTP	MN0064190	1,824	4.997	1.66	1,701	1,701	1.66	
Rockford WWTP	MN0024627	899	2.463	0.82	797	797	0.79	
Rogers WWTP	MN0029629	1,771	4.852	1.62	1,629	1,629	1.61	
Saint Michael WWTP	MN0020222	2,702	7.403	2.47	2,463	2,463	2.43	
Seneca Foods Corp - Glencoe	MN0001236	1,183	3.241	2.89	915	915	2.45	
Silver Lake WWTP	MNG580164	672	1.841	1.31	523	523	1.11	
Stewart WWTP	MNG580077	315	0.863	0.29	223	223	0.22	
Watertown WWTP	MN0020940	1,395	3.822	0.84	1,188	1,188	0.77	
Winsted WWTP	MN0021571	1,133	3.104	0.65	895	895	0.56	
Upper Mississippi River Basin								
Aitkin WWTP	MN0020095	953	2.611		493	493		Note 4
Albany WWTP	MN0020575	381	1.044		268	268		Note 4
Albertville WWTP	MN0050954	661	1.811		599	599		Note 4
Alexandria Lakes Area Sanitary District	MN0040738	665	1.822		269	269		Note 4
American Peat Technology LLC	MN0057533	45	0.123		22	22		Note 4
Anderson Custom Processing Inc	MNG255005	17	0.047		12	12		Note 4
Aspen Hills WWTP	MN0066028	27	0.074		24	24		Note 4
Avon WWTP	MN0047325	583	1.597		427	427		Note 4
Becker WWTP	MN0025666	903	2.474		785	785		Note 4
Benton Utilities WWTP	MN0065391	363	0.995		289	289		Note 4

Facility Name	Permit Number	Lake Pepin WLA		RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs			Notes
					kg/yr		kg/day	
		12 Month Moving Total (kg/yr)	(kg/day)		25-0001-00	07010206-806/814	07010206-805	
Bertha WWTP	MN0022799	884	2.422		467	467		Note 4
Big Lake WWTP	MN0041076	1,160	3.178		1,049	1,049		Note 4
Bowlus WWTP	MN0020923	83	0.227		62	62		Note 4
Brainerd WWTP	MN0049328	8,278	22.679		5,394	5,394		Note 4
Browerville WWTP	MN0022926	533	1.460		292	292		Note 4
Camp Ripley	MN0025721	1,592	4.362		1,137	1,137		Note 4
Camp Ripley - Area 22 Washrack	MN0063070	12	0.033		8.5	8.5		Note 4
Carlos WWTP	MN0023019	177	0.485		78	78		Note 4
Clarissa WWTP	MNG580008	282	0.773		152	152		Note 4
Clear Lake/Clearwater WWTP	MN0047490	669	1.833		575	575		Note 4
Cold Spring WWTP	MN0023094	1,978	5.419		1,522	1,522		Note 4
Crosslake WWTP	MN0064882	207	0.567		113	113		Note 4
Deer Creek WWTP	MNG580180	94	0.258		46	46		Note 4
DeZURIK Inc	MNG255084	0.95	0.003		0.77	0.77		Note 4
Eagle Bend WWTP	MN0023248	539	1.477		284	284		Note 4
East Gull Lake WWTP	MN0059871	664	1.819		430	430		Note 4
Elk River Municipal Utilities	MNG250016	2.0	0.005		1.8	1.8		Note 4
Elk River WWTP	MN0020788	2,431	6.660		2,259	2,259		Note 4
Flensburg WWTP	MNG580016	51	0.140		36	36		Note 4
Foley WWTP	MN0023451	1,026	2.811		812	812		Note 4
Freeport WWTP	MNG580019	359	0.984		236	236		Note 4
Garfield WWTP	MN0023515	83	0.227		32	32		Note 4
GEM Sanitary District	MNG580205	123	0.337		81	81		Note 4
Gilman WWTP	MNG580021	182	0.499		140	140		Note 4
Gold'n Plump Poultry LLC	MN0047261	2,901	7.948		2,239	2,239		Note 4

Facility Name	Permit Number	Lake Pepin WLA		RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs			Notes
		12 Month Moving Total (kg/yr)	(kg/day)		kg/yr 25-0001-00	kg/yr 07010206-806/814	kg/day 07010206-805	
Great River Energy	MN0001988	98	0.268		91	91		Note 4
Grey Eagle WWTP	MN0023566	51	0.140		34	34		Note 4
Hewitt WWTP	MNG580024	94	0.258		48	48		Note 4
Holdingford WWTP	MN0023710	337	0.923		247	247		Note 4
Lake Andrew WWTP	MN0067733	73	0.200		58	58		Note 4
Lake Henry WWTP	MN0020885	193	0.529		132	132		Note 4
Little Falls WTP	MN0003182	2.3	0.006		1.67	1.67		Note 4
Little Falls WWTP	MN0020761	2,653	7.268		1,948	1,948		Note 4
Long Prairie Ground Water Remediation	MNG790134	25	0.068		13	13		Note 4
Long Prairie WWTP - Municipal	MN0066079	2,029	5.559		1,075	1,075		Note 4
Martin Marietta Materials - Saint Cloud Quarry	MN0004031	405	1.110		325	325		Note 4
Melrose WWTP	MN0020290	3,316	9.085		2,157	2,157		Note 4
Menahga WWTP	MNG580032	270	0.740		129	129		Note 4
Miltona WWTP	MN0024155	187	0.512		82	82		Note 4
Monticello WWTP	MN0020567	2,608	7.145		2,350	2,350		Note 4
Motley WWTP	MN0024244	594	1.627		371	371		Note 4
New Pirates Cove WWTP	MN0066109	69	0.189		55	55		Note 4
New York Mills WTP	MNG640121	6.5	0.018		3.2	3.2		Note 4
NuStar - Sauk Centre Terminal	MN0057771	63	0.173		38	38		Note 4
Order of St Benedict - Power Plant	MN0046035	93	0.255		73	73		Note 4
Order of St Benedict WWTP	MN0022411	334	0.915		261	261		Note 4
Osakis WWTP	MN0020028	121	0.332		64	64		Note 4
Otsego WWTP West	MN0066257	1,217	3.334		1,108	1,108		Note 4
Pillager WWTP	MNG580209	202	0.553		130	130		Note 4
Pine River Area Sanitary District	MN0046388	340	0.932		172	172		Note 4

Facility Name	Permit Number	Lake Pepin WLA 12 Month Moving Total (kg/yr)	Lake Pepin WLA (kg/day)	RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs kg/yr 25-0001-00	Delivered WLA to Applicable Impaired AUID TMDLs kg/yr 07010206-806/814	Delivered WLA to Applicable Impaired AUID TMDLs kg/day 07010206-805	Notes
Randall WWTP	MN0024562	880	2.411		612	612		Note 4
Rice WWTP	MN0056481	511	1.400		402	402		Note 4
Rich Prairie Sewer Treatment Facility	MNG580211	634	1.737		448	448		Note 4
Richmond WWTP	MN0024597	168	0.460		126	126		Note 4
Riverbend Mobile Home Park WWTP	MN0042251	290	0.795		271	271		Note 4
Royalton WWTP	MN0020460	207	0.567		158	158		Note 4
Saint Cloud WWTP	MN0040878	19,783	54.200		16,657	16,657		Note 4
Saint Martin WWTP	MN0024783	58	0.159		42	42		Note 4
Sauk Centre WWTP	MN0024821	983	2.693		608	608		Note 4
Sebeka WWTP	MN0024856	553	1.515		285	285		Note 4
Serpent Lake WWTP	MNG580215	928	2.542		561	561		Note 4
Sobieski WWTP	MNG580217	47	0.129		35	35		Note 4
Staples WWTP	MN0024988	939	2.573		554	554		Note 4
Swanville WWTP	MN0020109	882	2.416		616	616		Note 4
Sysco Western Minnesota	MN0052728	9.7	0.027		7.9	7.9		Note 4
Upsala WWTP	MNG580053	130	0.356		95	95		Note 4
Wadena WWTP	MN0020672	1,036	2.838		539	539		Note 4
Wolf Lake WWTP	MNG580226	24	0.066		8.8	8.8		Note 4
Xcel Energy - Monticello Generating Plt	MN0000868	1,500	4.110		1,336	1,336		Note 4
Xcel Energy - Sherburne Generating Plant	MN0002186	200	0.548		176	176		Note 4
X-cel Optical Co - Benton Dr	MNG255093	2.1	0.006		1.7	1.7		Note 4
Zimmerman WWTP	MN0042331	624	1.710		551	551		Note 4
Minnesota River Basin								
ADM Corn Processing - Marshall	MN0057037	3,647	9.992		1,357	1,357		
Alden WWTP	MNG580118	439	1.203		178	178		

Facility Name	Permit Number	Lake Pepin WLA		RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs			Notes
		12 Month Moving Total (kg/yr)	(kg/day)		kg/yr		kg/day	
					25-0001-00	07010206-806/814	07010206-805	
Altona Hutterian Brethren WWTP	MN0067610	36	0.099		30	30		
Amboy WWTP	MN0022624	396	1.085		262	262		
Anchor Glass Container Corp	MN0003042	82	0.225		79	79		
Arlington WWTP	MN0020834	926	2.537		774	774		
August Schell Brewing Co	MN0022284	38	0.104		25	25		
Balaton WWTP	MN0020559	340	0.932		126	126		
Belle Plaine WWTP	MN0022772	1,160	3.178		1,036	1,036		
Belview WWTP	MNG580003	321	0.879		148	148		
Benson WWTP	MN0020036	1,361	3.729		339	339		
Bird Island WWTP	MN0022829	514	1.408		229	229		
Blomkest Svea Sewer Board WWTP	MN0069388	111	0.304		35	35		
Blue Earth WWTP	MN0020532	1,354	3.710		709	709		
Bongards' Creameries Inc	MN0002135	151	0.414		134	134		Note 1
Bricelyn WWTP	MNG580129	185	0.507		83	83		
Butterfield WWTP	MN0022977	372	1.019		216	216		
Chippewa Valley Ethanol Co LLLP	MN0062898	69	0.189		17	17		
CHS Mankato	MN0001228	663	1.816		499	499		
Clara City WWTP	MN0023035	636	1.742		236	236		
Clarkfield WWTP	MNG580093	452	1.238		168	168		
Clements WWTP	MNG580094	69	0.189		37	37		
Cleveland WWTP	MNG580009	379	1.038		300	300		
Clontarf WWTP	MNG580108	66	0.181		16	16		
Cologne WWTP	MN0023108	46	0.126		42	42		
Comfrey WWTP	MN0021687	245	0.671		144	144		
Community of Roseland WWTP	MN0070092	84	0.230		28	28		Note 1

Facility Name	Permit Number	Lake Pepin WLA		RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs			Notes
					kg/yr		kg/day	
		12 Month Moving Total (kg/yr)	(kg/day)		25-0001-00	07010206-806/814	07010206-805	
Cottonwood WWTP	MNG580010	442	1.211		177	177		
Courtland WTP	MNG640025	0.28	0.001		0.19	0.19		Note 1
Cypress Semiconductor Minnesota Inc	MN0056723	1,035	2.836		1,035	1,035		Note 1
Dairy Farmers of America Inc - Winthrop	MN0003671	400	1.096		303	303		
Danube WWTP	MNG580057	185	0.507		84	84		
Danvers WWTP	MNG580119	63	0.173		18	18		
Darling International Inc - Blue Earth	MN0002313	83	0.227		43	43		
De Graff WWTP	MN0071234	59	0.162		13	13		Note 1
Del Monte Foods Inc - Sleepy Eye Plant 114	MN0001171	352	0.964		216	216		
Delavan WWTP	MNG580109	149	0.408		93	93		
Delft Sanitary District WWTP	MN0066541	28	0.077		14	14		
Delhi WWTP	MN0067008	70	0.192		33	33		
Echo WWTP	MNG580059	239	0.655		104	104		
Eden Prairie Well House 6 & 7	MNG250084	3.4	0.009		3.3	3.3		Note 1
Elmore WWTP	MN0021920	176	0.482		86	86		Note 1
Evan WWTP	MNG580202	36	0.099		21	21		
Evansville WWTP	MN0023329	138	0.378		8	8		
Fabcon Inc	MN0068284	1.00	0.003		0.98	0.98		Note 1
Fairfax WWTP	MNG580060	439	1.203		249	249		
Fairmont Foods Inc	MN0001996	80	0.219		41	41		Note 1
Fairmont WTP	MN0045527	0.41	0.001		0.20	0.20		Note 1
Fairmont WWTP	MN0030112	4,310	11.808		2,232	2,232		
Farwell Kensington Sanitary District WWTP	MNG580220	211	0.578		27	27		
Franklin WWTP	MN0021083	556	1.523		305	305		
Freeborn WWTP	MN0040908	98	0.268		57	57		

Facility Name	Permit Number	Lake Pepin WLA		RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs			Notes
		12 Month Moving Total (kg/yr)	(kg/day)		kg/yr		kg/day	
					25-0001-00	07010206-806/814	07010206-805	
Frost WWTP	MNG580120	133	0.364		63	63		
Garvin WWTP	MNG580101	61	0.167		24	24		
Gaylord WWTP	MNG580204	760	2.082		595	595		
GE Osmonics Inc	MN0059013	164	0.449		157	157		Note 1
Ghent WWTP	MNG580121	102	0.279		36	36		
Gibbon WWTP	MNG580020	445	1.219		327	327		
Good Thunder WWTP	MNG580206	227	0.622		159	159		
Granada WWTP	MNG580023	109	0.299		59	59		
Granite Falls Energy LLC	MN0066800	413	1.132		172	172		
Granite Falls WWTP	MN0021211	1,105	3.027		449	449		
Great River Energy - Lakefield Junction Station	MN0067709	2.7	0.007		1.2	1.2		Note 1
Green Plains Fairmont LLC	MN0068063	0.00	0.000		0	0		Note 1
Hamburg WWTP	MN0025585	174	0.477		150	150		
Hancock WWTP	MN0023582	505	1.384		109	109		
Hanley Falls WWTP	MNG580122	94	0.258		37	37		
Hanska WWTP	MN0052663	138	0.378		90	90		
Hartland WWTP	MNG580102	124	0.340		68	68		
Hiniker Co	MN0064408	7.0	0.019		5.3	5.3		Note 1
Hoffman WWTP	MNG580134	439	1.203		53	53		
Hopkins Well 4 WTP	MNG640045	28	0.077		27	27		Note 1
Interstate Power Co - Fox Lake Station	MN0000957	300	0.822		142	142		Note 1
Ivanhoe WWTP	MNG580103	304	0.833		70	70		
Janesville WWTP	MNG580025	471	1.290		305	305		
Jeffers WWTP	MNG580111	193	0.529		104	104		
Jordan WWTP	MN0020869	1,425	3.904		1,311	1,311		

Facility Name	Permit Number	Lake Pepin WLA		RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs			Notes
		12 Month Moving Total (kg/yr)	(kg/day)		kg/yr		kg/day	
					25-0001-00	07010206-806/814	07010206-805	
Kerkhoven WWTP	MN0020583	725	1.986		155	155		
Kiester WWTP	MNG580097	249	0.682		108	108		
Kraemer Mining & Materials - Burnsville	MN0002224	1,312	3.595		1,299	1,299		Note 1
La Salle WWTP	MN0067458	73	0.200		45	45		
Lafayette WWTP	MN0023876	459	1.258		347	347		
Lake Crystal WWTP	MN0055981	815	2.233		589	589		
Laketown Community WWTP	MN0054399	23	0.063		21	21		Note 1
Lamberton WWTP	MNG580100	553	1.515		273	273		
Le Center WWTP	MN0023931	1,138	3.118		900	900		
Le Sueur Cheese Co	MN0060216	66	0.181		55	55		
Lewisville WWTP	MN0065722	166	0.455		104	104		
LifeCore Biomedical LLC	MN0060747	21	0.058		20	20		Note 1
Lowry WWTP	MN0024007	61	0.167		7.6	7.6		
Lucan WWTP	MNG580112	122	0.334		60	60		
Lynd WWTP	MNG580030	126	0.345		43	43		
MA Gedney Co	MN0022446	292	0.800		278	278		
Madelia WWTP	MN0024040	1,448	3.967		939	939		
Magellan Pipeline Co LP - Marshall	MN0059838	23	0.063		8.2	8.2		Note 1
Mankato Water Resource Recovery Facility	MN0030171	12,434	34.066		9,456	9,456		
Mapleton WWTP	MN0021172	561	1.537		375	375		
Marshall WWTP	MN0022179	4,973	13.625		1,857	1,857		
Maynard WWTP	MN0056588	740	2.027		288	288		
McLaughlin Gormley King Co	MN0058033	6.3	0.017		5.9	5.9		Note 1
Met Council - Blue Lake WWTP	MN0029882	17,407	47.690		16,866	16,866		Note 1
Met Council - Seneca WWTP	MN0030007	15,749	43.148		15,749	15,749		Note 1, 3.

Facility Name	Permit Number	Lake Pepin WLA		RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs			Notes
					kg/yr		kg/day	
		12 Month Moving Total (kg/yr)	(kg/day)		25-0001-00	07010206-806/814	07010206-805	
Metropolitan Airports Commission	MN0002101	1,153	3.159		1,153	1,153		
MG Waldbaum Co	MN0060798	571	1.564		447	447		
Millerville WWTP	MN0054305	54	0.148		2.3	2.3		
Milroy WWTP	MNG580124	96	0.263		40	40		
Minneota WWTP	MNG580033	660	1.808		191	191		
Montevideo WWTP	MN0020133	3,316	9.085		1,196	1,196		
Montgomery WWTP	MN0024210	1,337	3.663		1,144	1,144		
Morgan WWTP	MN0020443	496	1.359		280	280		Note 1
Morton WWTP	MN0051292	638	1.748		336	336		
Mountain Lake WWTP	MNG580035	655	1.795		354	354		Note 1
MRVPUC WWTP	MN0068195	2,036	5.578		1,709	1,709		
MTS Systems Corp	MNG255101	60	0.164		57	57		Note 1
Murdock WWTP	MNG580086	119	0.326		24	24		
Neuhof Hutterian Brethren	MNG580113	12	0.033		6.3	6.3		
New Prague Utilities Commission	MNG640117	19	0.052		17	17		Note 1
New Prague WWTP	MN0020150	1,523	4.173		1,348	1,348		
New Richland WWTP	MN0021032	829	2.271		465	465		
New Ulm WWTP	MN0030066	7,482	20.499		5,048	5,048		
Nicollet WWTP	MNG580037	575	1.575		408	408		
Northern Con-Agg LLP - Frohrip Kaolin Mine	MN0062154	28	0.077		16	16		Note 1
Northern Con-Agg LLP - Redwood Falls	MN0059331	78	0.214		40	40		Note 1
Northrop WWTP	MN0024384	138	0.378		73	73		
Northstar Ethanol LLC dba Poet Biorefining - Lake Crystal	MN0067172	179	0.490		130	130		
Norwood Young America WWTP	MN0024392	1,254	3.436		1,086	1,086		
Odin-Ormsby WWTP	MN0069442	83	0.227		47	47		

Facility Name	Permit Number	Lake Pepin WLA		RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs			Notes
					kg/yr		kg/day	
		12 Month Moving Total (kg/yr)	(kg/day)		25-0001-00	07010206-806/814	07010206-805	
Old Castle Materials/New Ulm Quartzite Quarry	MN0061638	207	0.567		140	140		Note 1
Olivia WWTP	MN0020907	1,354	3.710		622	622		
Pemberton WWTP	MNG580075	146	0.400		95	95		
Pennock WWTP	MNG580104	238	0.652		73	73		
Pepsi Beverages Co	MN0060101	173	0.474		171	171		
Polar Semiconductor LLC	MN0064661	41	0.112		41	41		Note 1
Porter WWTP	MNG580128	52	0.142		13	13		
Prinsburg WWTP	MN0063932	264	0.723		94	94		
Rahr Malting Co	MN0031917	4,054	11.107		3,881	3,881		
Raymond WWTP	MN0045446	228	0.625		76	76		Note 1
Redwood Falls WWTP	MN0020401	1,460	4.000		736	736		
Renville WWTP	MN0020737	1,178	3.227		529	529		
Revere WWTP	MNG580114	49	0.134		23	23		
Russell WWTP	MNG580062	232	0.636		74	74		
Ruthton WWTP	MNG580105	157	0.430		40	40		
Sacred Heart WWTP	MN0024708	327	0.896		142	142		
Saint Clair WWTP	MN0024716	293	0.803		198	198		
Saint George District Sewer System	MN0064785	45	0.123		28	28		
Saint James WWTP	MN0024759	3,271	8.962		1,970	1,970		
Saint Leo WWTP	MN0024775	47	0.129		15	15		
Saint Peter city of	MN0022535	4,421	12.112		3,547	3,547		
Sanborn WWTP	MNG580115	152	0.416		80	80		
Seagate Technology LLC - Bloomington	MN0030864	10	0.027		10	10		Note 1
Searles WWTP	MNG580080	141	0.386		95	95		
Seneca Foods Corp - Arlington	MN0000264	38	0.104		32	32		Note 1

Facility Name	Permit Number	Lake Pepin WLA		RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs			Notes
					kg/yr		kg/day	
		12 Month Moving Total (kg/yr)	(kg/day)		25-0001-00	07010206-806/814	07010206-805	
Seneca Foods Corp - Blue Earth	MN0001287	65	0.178		34	34		Note 1
Seneca Foods Corp - Montgomery	MN0001279	99	0.271		84	84		Note 1
Sleepy Eye WWTP	MNG580041	967	2.649		597	597		
Southern Minnesota Beet Sugar - Renville	MN0040665	1,247	3.416		558	558		
Springfield WWTP	MN0024953	1,078	2.953		595	595		
Starbuck WWTP	MN0021415	414	1.134		68	68		
Starland Hutterian Brethren Inc	MN0067334	30	0.082		22	22		
Storden WWTP	MNG580106	97	0.266		43	43		
Sunburg WWTP	MNG580125	43	0.118		7.4	7.4		
Taunton WWTP	MNG580090	58	0.159		16	16		
Tracy WWTP	MN0021725	414	1.134		180	180		
Trimont WWTP	MN0022071	899	2.463		418	418		
Truman WTP	MNG640129	2.1	0.006		1.3	1.3		Note 1
Truman WWTP	MN0021652	1,078	2.953		661	661		
Tyler WWTP	MNG580116	484	1.326		131	131		
Unimin Corp - Kasota Mining Project	MN0053082	4,145	11.356		3,262	3,262		Note 1
Unimin Corp - Ottawa Plant	MN0001716	6,217	17.033		5,049	5,049		Note 1
Urbank WWTP	MN0068446	30	0.082		0.6	0.6		
US Air Force Reserve/934th Airlift Wing	MN0052141	300	0.822		300	300		Note 1
Vernon Center WWTP	MN0030490	284	0.778		188	188		
Vesta WWTP	MNG580043	99	0.271		44	44		
Wabasso WWTP	MN0025151	544	1.490		280	280		
Waldorf WWTP	MN0021849	99	0.271		61	61		Note 1
Walnut Grove WWTP	MN0021776	280	0.767		131	131		
Walters WWTP	MNG580223	43	0.118		18	18		

Facility Name	Permit Number	Lake Pepin WLA		RES WLA Seasonal (Jun-Sep) Calendar Month Average (kg/day)	Delivered WLA to Applicable Impaired AUID TMDLs			Notes
		12 Month Moving Total (kg/yr)	(kg/day)		kg/yr 25-0001-00	kg/yr 07010206-806/814	kg/day 07010206-805	
Wanda WWTP	MNG580126	46	0.126		24	24		
Waseca WWTP	MN0020796	3,868	10.597		2,386	2,386		
Welcome WWTP	MN0021296	359	0.984		175	175		
Wells Public Utilities	MN0025224	1,202	3.293		696	696		
Westbrook WWTP	MNG580127	414	1.134		176	176		
Willmar WWTF	MN0025259	8,300	22.740		2,538	2,538		
Winnebago WWTP	MN0025267	1,879	5.148		1,090	1,090		
Winthrop WWTP	MN0051098	481	1.318		364	364		
Wood Lake WWTP	MNG580107	188	0.515		78	78		
Xcel Energy - Black Dog Generating Plant	MN0000876	500	1.370		500	500		Note 1
Xcel Energy - Key City/Wilmarth	MN0000914	11	0.030		8.4	8.4		Note 1
Xcel Energy - Minnesota Valley	MN0000906	100	0.274		41	41		Note 1

Notes

1) RES WLA = Pepin WLA ÷ 365 for TMDL analysis. 12 month moving total mass limit will be sufficient to address RES.

2) Brooten WWTP is upstream of Rice Lake - does not contribute to RES impairment.

3) Met Council Seneca WWTP: Met Council Basin Permit is consistent with WLAs assigned in TMDLs.

4) The Rum River is meeting RES standards and is therefore a boundary condition for the 07010206-805 TMDL. Therefore, no RES WLAs are needed for these facilities.

Appendix C – MS4 Entities Included in TMDLs

MS4 Name The WLA for each MS4 included in the TMDLs in this report is 0.35 lb/acre/year for the area served by the stormwater collection and conveyance system	Permit Number	Type	Applicable Impaired AUID TMDLs			Notes
			25-0001-00	07010206-806/814	07010206-805	
Albertville City MS4	MS400281	City	X	X	X	
Alexandria City MS4	MS400264	City	X	X	X	
Andover City MS4	MS400045	City	X	X	X	Note 1
Anoka City MS4	MS400001	City	X	X	X	Note 1
Anoka County MS4	MS400066	County	X	X	X	Note 1
Anoka Technical College MS4	MS400222	Non-traditional	X	X	X	Note 1
Anoka-Ramsey Community College MS4	MS400223	Non-traditional	X	X	X	
Apple Valley City MS4	MS400074	City	X	X		
Arden Hills City MS4	MS400002	City	X	X	X	
Baxter City MS4	MS400231	City	X	X	X	
Benton County MS4	MS400067	County	X	X	X	
Big Lake City MS4	MS400249	City	X	X	X	
Big Lake Township MS4	MS400234	Township	X	X	X	
Birchwood Village City MS4	MS400004	City	X	X	X	
Blaine City MS4	MS400075	City	X	X	X	
Bloomington City MS4	MS400005	City	X	X		
Blue Earth County MS4	Ms400276	County	X	X		
Brainerd City MS4	MS400266	City	X	X	X	
Brockway Township MS4	MS400068	Township	X	X	X	
Brooklyn Center City MS4	MS400006	City	X	X	X	
Brooklyn Park City MS4	MS400007	City	X	X	X	
Buffalo City MS4	MS400238	City	X	X	X	
Burnsville City MS4	MS400076	City	X	X		
Cambridge City MS4	MS400250	City	X	X		Note 2
Capitol Region WD MS4	MS400206	Watershed District	X	X	X	
Carver City MS4	MS400077	City	X	X		
Carver County MS4	MS400070	County	X	X		
Centerville City MS4	MS400078	City	X	X	X	
Century College MS4	MS400171	Non-traditional	X	X	X	
Champlin City MS4	MS400008	City	X	X	X	
Chanhassen City MS4	MS400079	City	X	X		
Chaska City MS4	MS400080	City	X	X		
Circle Pines City MS4	MS400009	City	X	X	X	
Columbia Heights City MS4	MS400010	City	X	X	X	
Coon Creek WD MS4	MS400172	Watershed District	X	X	X	Note 1
Coon Rapids City MS4	MS400011	City	X	X	X	Note 1
Corcoran City MS4	MS400081	City	X	X	X	

MS4 Name The WLA for each MS4 included in the TMDLs in this report is 0.35 lb/acre/year for the area served by the stormwater collection and conveyance system	Permit Number	Type	Applicable Impaired AUID TMDLs			Notes
			25-0001-00	07010206-806/814	07010206-805	
Cottage Grove City MS4	MS400082	City	X	X		
Credit River Township MS4	MS400131	Township	X	X		
Crystal City MS4	MS400012	City	X	X	X	
Dakota County MS4	MS400132	County	X			
Dakota County Technical College MS4	MS400254	Non-traditional				
Dayton City MS4	MS400083	City	X	X	X	
Deephaven City MS4	MS400013	City	X	X		
Dellwood City MS4	MS400084	City	X	X	X	
Eagan City MS4	MS400014	City	X	X		
Eagle Lake City MS4	MS400284	City	X	X		
East Bethel City MS4	MS400087	City	X	X	X	Note 1
Eden Prairie City MS4	MS400015	City	X	X		
Edina City MS4	MS400016	City	X	X		
Elk River City MS4	MS400089	City	X	X	X	Note 1
Elko New Market City MS4	MS400237	City	X	X		
Empire Township MS4	MS400135	Township	X			
Excelsior City MS4	MS400017	City	X	X		
Fairmont City MS4	MS400239	City	X	X		
Falcon Heights City MS4	MS400018	City	X	X	X	
Farmington City MS4	MS400090	City	X			
Forest Lake City MS4	MS400262	City	X	X	X	
Fridley City MS4	MS400019	City	X	X	X	
Gem Lake City MS4	MS400020	City	X	X		
Glencoe City MS4	MS400252	City	X	X	X	
Golden Valley City MS4	MS400021	City	X	X	X	
Grant City MS4	MS400091	City	X	X	X	
Greenwood City MS4	MS400022	City	X	X		
Ham Lake City MS4	MS400092	City	X	X	X	Note 1
Hanover City MS4	MS400286	City	X	X	X	
Hastings City MS4	MS400240	City	X	X		
Haven Township MS4	MS400136	Township	X	X	X	
Hennepin County MS4	MS400138	County	X	X		
Hennepin Technical College Brooklyn Pk - MS4	MS400198	Non-traditional	X	X	X	
Hennepin Technical College Eden Prairie MS4	MS400199	Non-traditional	X	X		
Hilltop City MS4	MS400023	City	X	X	X	
Hopkins City MS4	MS400024	City	X	X		
Hugo City MS4	MS400094	City	X	X	X	
Hutchinson City MS4	MS400248	City	X	X	X	
Independence City MS4	MS400095	City	X	X	X	

MS4 Name The WLA for each MS4 included in the TMDLs in this report is 0.35 lb/acre/year for the area served by the stormwater collection and conveyance system	Permit Number	Type	Applicable Impaired AUID TMDLs			Notes
			25-0001-00	07010206-806/814	07010206-805	
Inver Grove Heights City MS4	MS400096	City	X	X		
Inver Hills Community College MS4	MS400224	Non-traditional	X	X		
Isanti City MS4	MS400287	City	X	X		Note 2
Jackson Township MS4	MS400140	Township	X	X		
Lake City MS4	MS400288	City	X			
Lake Elmo City MS4	MS400098	City	X	X		
Laketown Township MS4	MS400142	Township	X	X		
Lakeville City MS4	MS400099	City	X	X		
Landfall City MS4	MS400025	City	X	X		
Lauderdale City MS4	MS400026	City	X	X		
Le Sauk Township MS4	MS400143	Township	X	X	X	
Lexington City MS4	MS400027	City	X	X	X	
Lilydale City MS4	MS400028	City	X	X		
Lino Lakes City MS4	MS400100	City	X	X	X	
Litchfield City MS4	MS400253	City	X	X	X	
Little Canada City MS4	MS400029	City	X	X		
Little Falls City MS4	MS400227	City	X	X	X	
Long Lake City MS4	MS400101	City	X	X		
Loretto City MS4	MS400030	City	X	X	X	
Louisville Township MS4	MS400144	Township	X	X		
Mahtomedi City MS4	MS400031	City	X	X	X	
Mankato City MS4	MS400226	City	X	X		
Mankato Township MS4	MS400297	Township	X	X		
Maple Grove City MS4	MS400102	City	X	X	X	
Maple Plain City MS4	MS400103	City	X	X	X	
Maplewood City MS4	MS400032	City	X	X		
Marshall City MS4	MS400241	City	X	X		
Medicine Lake City MS4	MS400104	City	X	X	X	
Medina City MS4	MS400105	City	X	X	X	
Mendota City MS4	MS400033	City	X	X		
Mendota Heights City MS4	MS400034	City	X	X		
Metropolitan State University - MS4	MS400201	Non-traditional	X	X		
Minden Township MS4	MS400147	Township	X	X	X	
Minneapolis Municipal Storm Water	MN0061018	City	X	X	X	
Minnehaha Creek WD MS4	MS400182	Watershed District	X	X	X	
Minnesota Correctional-Lino Lakes MS4	MS400177	Non-traditional	X	X	X	
Minnesota Correctional-St Cloud MS4	MS400179	Non-traditional	X	X	X	
Minnesota State University-Mankato MS4	MS400279	Non-traditional	X	X		
Minnetonka Beach City MS4	MS400036	City	X	X		

MS4 Name The WLA for each MS4 included in the TMDLs in this report is 0.35 lb/acre/year for the area served by the stormwater collection and conveyance system	Permit Number	Type	Applicable Impaired AUID TMDLs			Notes
			25-0001-00	07010206-806/814	07010206-805	
Minnetonka City MS4	MS400035	City	X	X	X	
Minnetrista City MS4	MS400106	City	X	X	X	
MNDOT Metro District MS4	MS400170	Non-traditional	X	X	X	Note 1
MNDOT Outstate District MS4	MS400180	Non-traditional	X	X	X	
Montevideo City MS4	MS400261	City	X	X		
Monticello City MS4	MS400242	City	X	X	X	
Mound City MS4	MS400108	City	X	X		
Mounds View City MS4	MS400037	City	X	X	X	
Mpls Community/Technical College MS4	MS400207	Non-traditional	X	X	X	
New Brighton City MS4	MS400038	City	X	X	X	
New Hope City MS4	MS400039	City	X	X	X	
New Ulm City MS4	MS400228	City	X	X		
Newport City MS4	MS400040	City	X	X		
Normandale Community College MS4	MS400255	Non-traditional	X	X		
North Hennepin Community College - MS4	MS400205	Non-traditional	X	X	X	
North Mankato City MS4	MS400229	City	X	X		
North Oaks City MS4	MS400109	City	X	X	X	
North St Paul City MS4	MS400041	City	X	X		
Nowthen City MS4	MS400069	City	X	X		Note 2
Oak Grove City MS4	MS400110	City	X	X		Note 2
Oakdale City MS4	MS400042	City	X	X		
Orono City MS4	MS400111	City	X	X		
Osseo City MS4	MS400043	City	X	X	X	
Otsego City MS4	MS400243	City	X	X	X	
Pine Springs City MS4	MS400044	City	X	X	X	
Plymouth City MS4	MS400112	City	X	X	X	
Prior Lake City MS4	MS400113	City	X	X		
Prior Lake-Spring Lake WSD MS4	MS400189	Watershed District	X	X		
Ramsey City MS4	MS400115	City	X	X	X	Note 1
Ramsey County Public Works MS4	MS400191	County	X	X	X	
Ramsey-Washington Metro WD MS4	MS400190	Watershed District	X	X	X	
Red Wing City MS4	MS400235	City	X			
Redwood Falls City MS4	MS400236	City	X	X		
Rice Creek WD MS4	MS400193	Watershed District	X	X	X	
Richfield City MS4	MS400045	City	X	X	X	
Robbinsdale City MS4	MS400046	City	X	X	X	
Rogers City MS4	MS400282	City	X	X	X	
Rosemount City MS4	MS400117	City	X	X		
Roseville City MS4	MS400047	City	X	X	X	

MS4 Name The WLA for each MS4 included in the TMDLs in this report is 0.35 lb/acre/year for the area served by the stormwater collection and conveyance system	Permit Number	Type	Applicable Impaired AUID TMDLs			Notes
			25-0001-00	07010206-806/814	07010206-805	
Saint Augusta City MS4	MS400293	City	X	X	X	
Saint Francis City MS4	MS400296	City	X	X		Note 2
Sartell City MS4	MS400048	City	X	X	X	
Sauk Rapids City MS4	MS400118	City	X	X	X	
Sauk Rapids Township MS4	MS400153	Township	X	X	X	
Savage City MS4	MS400119	City	X	X		
Scott County MS4	MS400154	County	X	X		
Shakopee City MS4	MS400120	City	X	X		
Sherburne County MS4	MS400155	County	X	X	X	Note 1
Shoreview City MS4	MS400121	City	X	X	X	
Shorewood City MS4	MS400122	City	X	X		
Skyline City MS4	MS400292	City	X	X		
South Bend Township MS4	MS400299	Township	X	X		
South St Paul City MS4	MS400049	City	X	X		
South Washington WD MS4	MS400196	Watershed District	X	X		
Spring Lake Park City MS4	MS400050	City	X	X	X	
Spring Lake Township MS4	MS400156	Township	X	X		
Spring Park City MS4	MS400123	City	X	X		
St Anthony Village City MS4	MS400051	City	X	X	X	
St Bonifacius City MS4	MS400124	City	X	X		
St Cloud City MS4	MS400052	City	X	X	X	
St Cloud State University MS4	MS400197	Non-traditional	X	X	X	
St Cloud Technical College - MS4	MS400204	Non-traditional	X	X	X	
St Joseph City MS4	MS400125	City	X	X	X	
St Joseph Township MS4	MS400157	Township	X	X	X	
St Louis Park City MS4	MS400053	City	X	X	X	
St Michael City MS4	MS400246	City	X	X	X	
St Paul Community & Technical College - MS4	MS400202	Non-traditional	X	X		
St Paul Municipal Storm Water	MN0061263	City	X	X		
St Paul Park City MS4	MS400054	City	X	X		
St Peter City MS4	MS400245	City	X	X		
Stearns County MS4	MS400159	County	X	X	X	
Sunfish Lake City MS4	MS400055	City	X	X		
Tonka Bay City MS4	MS400056	City	X	X		
U of M-Twin Cities Campus MS4	MS400212	Non-traditional	X	X	X	
VA Medical Center- St. Cloud	MS400298	Non-traditional	X	X	X	
Vadnais Heights City MS4	MS400057	City	X	X		
Victoria City MS4	MS400126	City	X	X		
Waconia City MS4	MS400232	City	X	X		
Waite Park City MS4	MS400127	City	X	X	X	
Waseca City MS4	MS400258	City	X	X		

MS4 Name The WLA for each MS4 included in the TMDLs in this report is 0.35 lb/acre/year for the area served by the stormwater collection and conveyance system	Permit Number	Type	Applicable Impaired AUID TMDLs			Notes
			25-0001-00	07010206-806/814	07010206-805	
Washington County MS4	MS400160	County	X	X	X	
Watab Township MS4	MS400161	Township	X	X	X	
Wayzata City MS4	MS400058	City	X	X		
West St Paul City MS4	MS400059	City	X	X		
White Bear Lake City MS4	MS400060	City	X	X	X	
White Bear Township MS4	MS400163	Township	X	X	X	
Willernie City MS4	MS400061	City	X	X	X	
Willmar City MS4	MS400272	City	X	X	X	
Woodbury City MS4	MS400128	City	X	X		
Woodland City MS4	MS400129	City	X	X		
Cities not currently in the MS4 program but now exceed or are approaching a population of 5,000 and will eventually be brought into the MS4 program						
Becker	Not Applicable	City	X	X	X	
Belle Plaine		City	X	X		
Delano		City	X	X	X	
Jordan		City	X	X		
Le Sueur		City	X	X		
New Prague		City	X	X		
Princeton		City	X	X		Note 2
Rockford		City	X	X	X	
Saint James		City	X	X		
Sauk Centre		City	X	X	X	
Zimmerman		City	X	X	X	

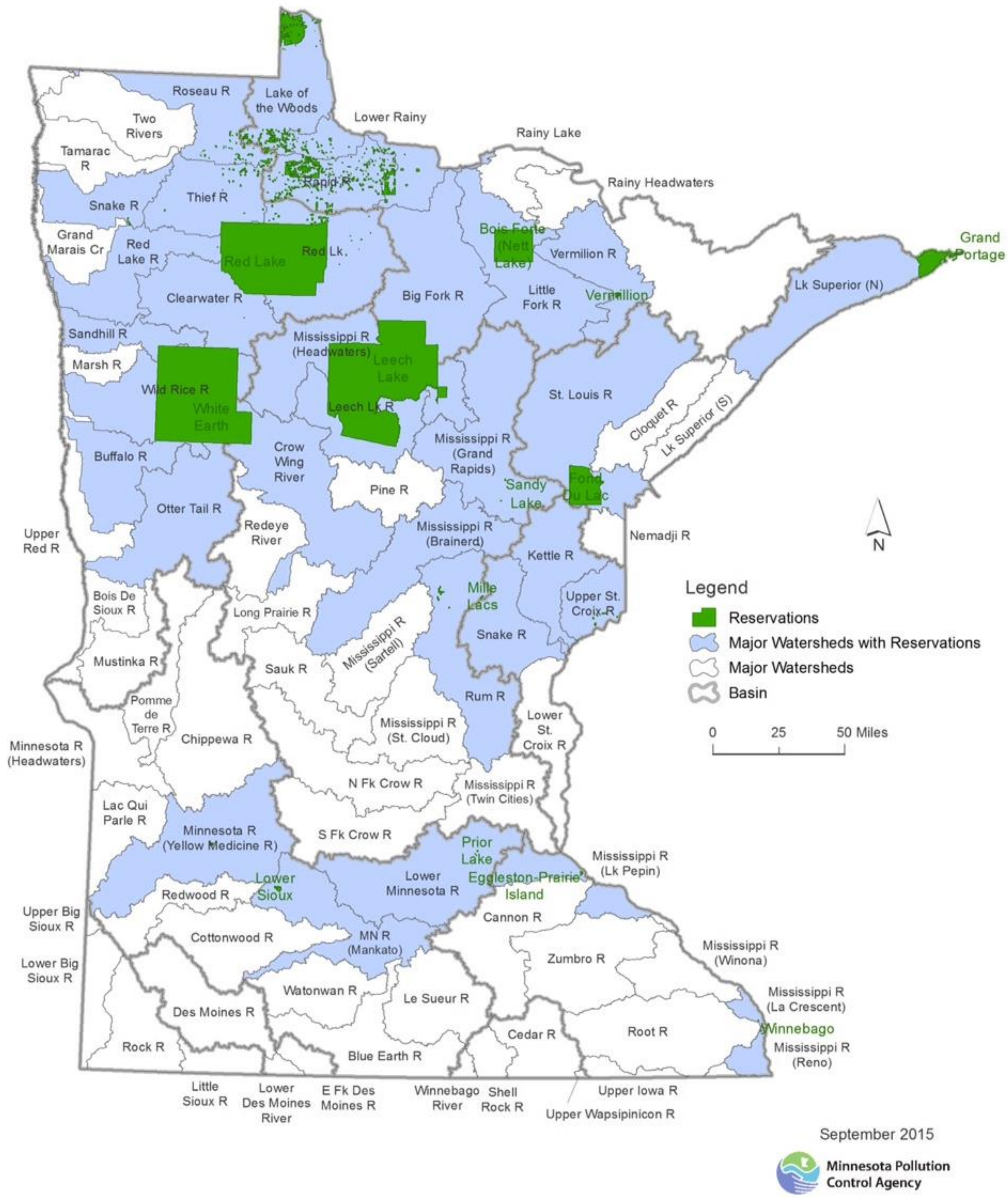
Note 1: A portion of these MS4s are in the Rum River Watershed and, therefore, those portions are not subject to the TMDL for 07010206-805.

Note 2: The entire MS4 area is in the Rum River Watershed, which is a boundary condition for AUID 07010206-805, and therefore not subject to the TMDL.

Appendix D – Tribal Lands in Lake Pepin Watershed

Location of Tribal Lands within the Lake Pepin Watershed. Tribes such as Mille Lacs and Fond du Lac have lands in multiple locations, which have been identified on this map.

Tribal Reservations and Major Watersheds in Minnesota



Appendix E – Wisconsin Loads accounted for in Lake Pepin TMDL

The table below represents the Wisconsin phosphorus loads below the St Croix River confluence with the Mississippi River that are accounted for in the Lake Pepin (AUID 25-0001-00) TMDL but are not included in the TMDL table.

TMDL Component		Allowable TP Load	
		kg/year	kg/day
Load Capacity (LC)		**14,833**	**40.6**
Wasteload Allocation (WLA)	**Total WLA**	**4,295**	**11.8**
	Wisconsin WWTP WLAs	*3,925*	*10.8*
	Construction and Industrial Stormwater	*15*	*0.04*
	Wisconsin General Permit WLA	*355*	*0.97*
Load Allocation (LA)	**Total LA**	**9,600**	**26.3**
	Natural Background	*8,160*	*22*
Margin of Safety (MOS): Explicit 5% of LC		**742**	**2.0**
Reserve Capacity (RC)		**196**	**0.5**

Wisconsin WWTP WLAs accounted for in Lake Pepin TMDL

Facility Name	Permit Number	Lake Pepin WLA 12 Month Moving Total (kg/yr)
Mississippi River/Lake Pepin Direct Tributaries		
City of Prescott	WI0022403	703
Ellsworth Co-op Creamery (Process)	WI0022942	419
Village of Baldwin	WI0026891	1,167
Village of Bay City	WI0061255	202
Village of Ellsworth	WI0021253	794
Village of Maiden Rock	WI0032361	64
Village of Pepin	WI0022811	576
	Total	**3,925**