Watershed

June 2020

Winnebago River Watershed Total Maximum Daily Load

MINNESOTA POLLUTION CONTROL AGENCY

wq-iw9-25e

CLEAN WATER LAND & LEGACY AMENDMENT

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Acronyms

ac-ft/yr	acre feet per year
AFO	Animal Feeding Operation
AUID	Assessment Unit ID
BMP	Best Management Practice
BOD_5	5-day Biochemical Oxygen Demand
CAFO	Concentrated Animal Feeding Operation
cfu	colony-forming unit
Chl-*a*	Chlorophyll-*a*
CRP	Conservation Reserve Program
CV	Coefficient of Variation
DO	Dissolved Oxygen
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
EQuIS	Environmental Quality Information System
F-IBI	Fish Index of Biotic Integrity
FQI	Floristic Quality Index
HSPF	Hydrologic Simulation Program – FORTRAN
HUC	Hydrologic Unit Code
IBI	Index of Biological Integrity
in/yr	inches per year
ISTS	Individual Sewage Treatment System
IPHT	Imminent Public Health Threat
km^2	square kilometer
LA	Load Allocation
Lb	pound
lb/day	pounds per day
lb/yr	pounds per year
LES	Lake Eutrophication Standard
LMP	Lake Management Plan
m	meter
mg/L	milligrams per liter
M-IBI	Macroinvertebrate Index of Biotic Integrity

mL	milliliter
DNR	Minnesota Department of Natural Resources
MOS	Margin of Safety
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer Systems
NLCD	National Land Cover Dataset
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
P	Phosphorus
RES	River Eutrophication Standard
RNR	River Nutrient Region
SDS	State Disposal System
SSTS	Subsurface Sewage Treatment Systems
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
TP	Total phosphorus
µg/L	microgram per liter
USDA	United States Department of Agriculture
WLA	Wasteload Allocation
WRAPS	Watershed Restoration and Protection Strategies
WRW	Winnebago River Watershed
WWTF	Wastewater Treatment Facility
WWTP	Wastewater Treatment Plant

Executive Summary

The Clean Water Act (1972) requires that each state develop a Total Maximum Daily Load (TMDL) Study to identify and restore any water body that is deemed impaired by state regulations. A TMDL identifies the pollutant that is causing the impairment and how much of that pollutant can enter the water body and still meet water quality standards.

This TMDL study addresses phosphorus (P) impairments in Bear Lake and State Line Lake and bacteria impairments in the form of *Escherichia coli* (*E. coli*) in Lime Creek located in the Winnebago River Watershed (WRW), Hydrologic Unit Code (HUC) 07080203, which are on Minnesota's 2018 303(d) list of impaired waters. The waterways of the WRW are headwaters to the Cedar River, in eastern Iowa.

Information from multiple sources was used to evaluate the ecological health of each water body:

- All available water quality data from the TMDL 10-year waterbody assessment time period (2008 through 2017)
- Cedar River/Little Cedar River and Shell Rock River/WRW Hydrologic Simulation Program – FORTRAN (HSPF) model
- Winnebago River and Upper Wapsipinicon River Watersheds Monitoring and Assessment Report (https://www.pca.state.mn.us/sites/default/files/wq-ws3-07080203b.pdf)
- WRW Stressor identification (SID) Report (https://www.pca.state.mn.us/sites/default/files/wq-ws5-07080203a.pdf)
- BATHTUB Model
- Published studies
- Stakeholder input

The following pollutant sources were evaluated for each impaired lake and stream: loading from upstream waterbodies, point sources, feedlots, septic systems, wildlife, and lake sediments. This TMDL study used an inventory of pollutant sources to develop a load duration curve model for the impaired stream and a lake water quality response model (BATHTUB) for each impaired lake. These models were then used to determine the pollutant reductions needed for the impaired waterbodies to meet water quality standards. In the case of the impaired lakes, the interaction between aquatic plants and fish on lake water quality was also investigated and in-lake management strategies were identified that are needed to maintain clear water in the impaired lakes, as well as watershed pollutant load reductions.

Lime Creek flows across the Minnesota state border into Iowa. TMDLs were calculated to meet Minnesota state water quality standards. The Minnesota Pollution Control Agency (MPCA) TMDL process calculates TMDL endpoints to attain water quality standards at the most downstream endpoint of the impaired reach. For a segment that crosses a state border, this is typically the state border. One should assume that compliance with TMDLs mean that Minnesota water quality standards are being met at the state border, and that water originating within its boundaries will not cause or contribute to impairments downstream.

The TMDL study's results aided in the selection of implementation activities during the Winnebago River Watershed Restoration and Protection Strategy (WRAPS) process. The purpose of the WRAPS process is to support local working groups in developing ecologically sound restoration and protection strategies for subsequent implementation planning. The Winnebago River WRAPS Report will be publically available concurrently with this draft TMDL on the MPCA WRW website: https://www.pca.state.mn.us/water/watersheds/Winnebago-river.

1 Project Overview

1.1 Purpose

The MPCA has determined that two lakes and four streams in the WRW are impaired because they exceed established state water quality standards and do not support their designated uses. In accordance with the Clean Water Act, TMDL studies must be conducted on impaired waters that are impaired by pollutants. The goals of this TMDL are to provide wasteload allocations (WLA) and load allocations (LA) for pollutant sources within the WRW and to quantify the pollutant reductions needed to meet Minnesota water quality standards. This TMDL study includes three total phosphorus (TP) TMDLs and one *E. coli* TMDL addressing the following impairments within the WRW (HUC 07080203) included in Minnesota's 2018, 303(d) list (Figure 1-1):

- aquatic recreation use impairments due to eutrophication (TP) in Bear Lake and State Line Lake,
- aquatic recreation use impairment due to *E. coli* and aquatic life use impairment due to eutrophication in Lime Creek.

The impairments in the WRW are found in a stream and lake chain system: Steward Creek flows into Bear Lake, and Bear Lake and State Line Lake flow to Lime Creek. As such, improvements in upstream impaired streams and lakes will improve downstream impaired stream and lake water quality. For example, the Bear Lake TP TMDL will improve the TSS impairment in Lime Creek. This approach is appropriate because Lime Creek is the outflow of Bear Lake and TSS is primarily total suspended volatile solids (TSVS); algae produced in Bear Lake.

Additionally, some stream impairments will be addressed through downstream TMDLs. This approach is used because LA reductions outlined in the downstream TMDL include stream tributaries or lake stream inflows. For example, because the DO impaired Judicial Ditch 25 is a tributary to Lime Creek, the impairment is addressed through the Lime Creek TP TMDL.

All impaired streams in the WRW have one or more parameters contributing to an impairment that are not addressed by this TMDL. This is because there was either not sufficient enough information to link an impairment to a pollutant, or the impairment was determined to be caused by a non-pollutant. Reference Table 1-1 for a list of impairments, related pollutants/stressors and corresponding TMDLs.

Lime Creek (referred to as the Winnebago River (IA 02-WIN-831) in Iowa) as it flows into Iowa is impaired for primary contact recreational use by the bacteria indicator *E. coli*, and addressed by the 2010 Iowa Cedar River Watershed *E. coli* TMDL. Lime Creek, in Iowa, is also impaired for aquatic life use due to a low fish and macroinvertebrate IBI score, but is not currently addressed by a TMDL. Lime Creek is also a headwater tributary river of the Cedar River, which is impaired by high nitrate concentrations in the drinking water supply for the city of Cedar Rapids, and addressed by the 2006 Iowa Cedar River Nitrate TMDL. Implementation activities identified by this TMDL that achieve *E. coli* and P load reductions to Lime Creek are expected to meet the TMDL assumptions for the Cedar River in Iowa.

Other WRW studies completed that are referenced in this TMDL include:

- WRW SID Report (MPCA 2017)

- Winnebago River and Upper Wapsipinicon River Watersheds Monitoring and Assessment Report (MPCA 2018)

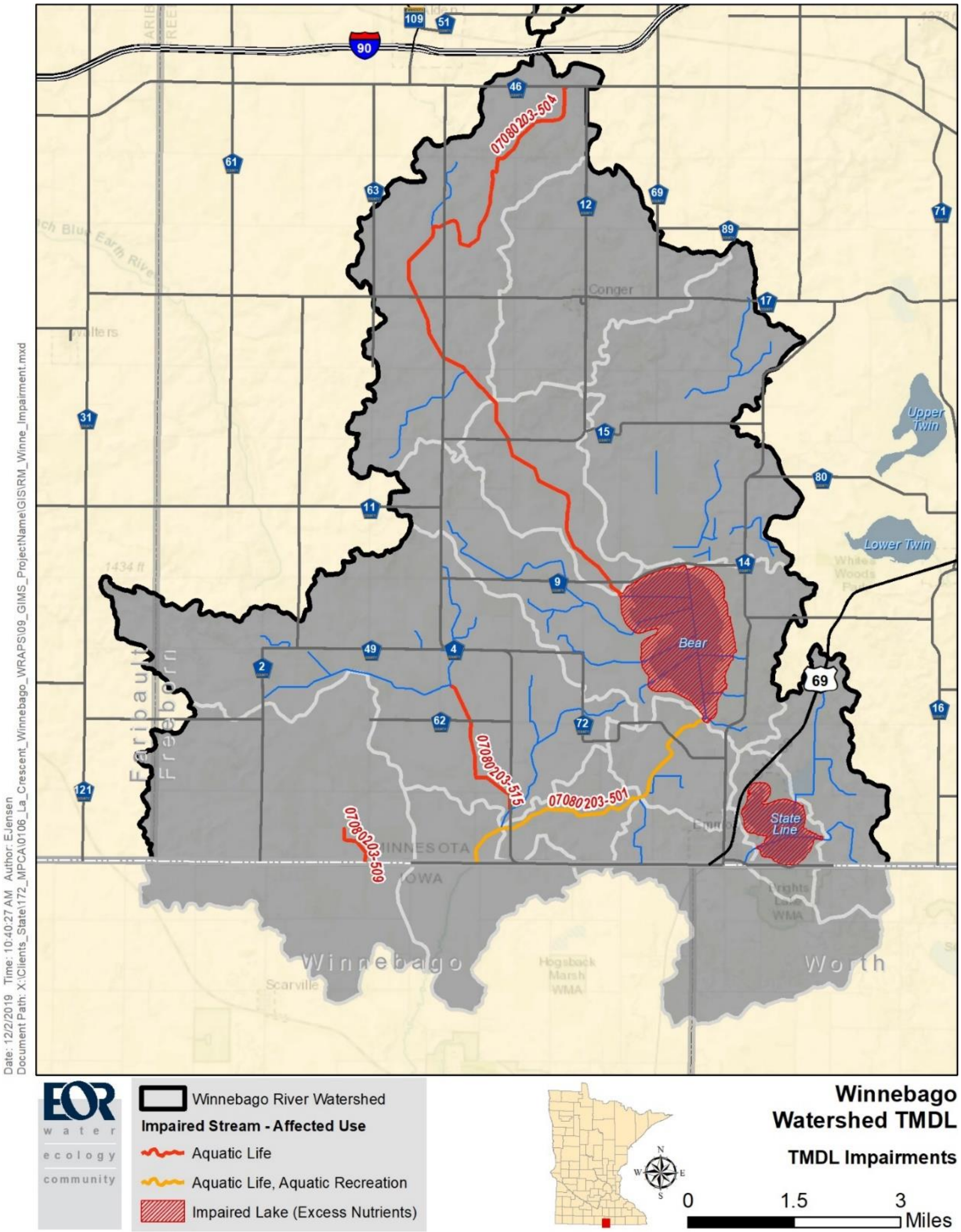


Figure 1-1. Impaired streams and lakes in the Winnebago River Watershed.

1.2 Identification of Waterbodies

Table 1-1 identifies and describes the causes of lake and stream impairments in the WRW and the pollutant-based stressors that will be addressed by TMDLs in this study. Some stressors not addressed in this TMDL, e.g. nitrate, DO, habitat and flow alteration, because these stressors either lack a standard, are connected to a stressor already being addressed, or are not pollutants. Stressors not included in this TMDL will be addressed in the WRAPS report. Lime Creek flows across the Minnesota state border into Iowa. TMDLs are being calculated to Minnesota state water quality standards. The MPCA's TMDL process calculates TMDL endpoints to attain water quality standards at the most downstream endpoint of the impaired reach. For a segment which crosses a state border, this is typically the state border. One should assume that compliance with TMDLs mean that Minnesota water quality standards are being met at the state border, and that water originating within its boundaries will not cause or contribute to impairments downstream.

Eutrophication and DO impairments and stressors are prevalent in the WRW. Bear Lake, State Line Lake and Lime Creek demonstrate eutrophication response to nutrient loading. Corresponding P TMDLs are included in this document. Steward Creek, JD-25 and Unknown Creek do not show a clear linkage between P loading/concentration and eutrophication and DO response (in fact SID work confirmed that P concentrations in these streams is regularly well below the respective river eutrophication standard (RES), which would be the end point for any P TMDLs); as such, P TMDLs for these reaches are not included in this document. In the case of Steward Creek, eutrophication and DO exceedances are expected to be addressed through the Bear Lake TP TMDL. The eutrophication impairment on JD-25 is expected to be addressed through the Lime Creek TP TMDL. While these downstream TMDLs will likely improve eutrophic and DO conditions, flow alteration is a probable key driver of eutrophication in these stream reaches, as concluded by SID work. For planning purposes, the three P TMDLs that are included apply to the vast majority of the WRW, including the two point source discharges at Emmons and Conger. Table 1-1 provides more detail and summarizes the rationale for completing P TMDLs in the Winnebago Watershed.

Table 1-1. Aquatic Life and Aquatic Recreation Use Impairments in the Winnebago River Watershed (07080203).

Water body Name	Reach Description	Stream AUID / Lake ID	Use Class	Year Added to List	Affected Use	Proposed Category	Impaired Waters Listing	Pollutant or Stressor	TMDL Developed in this Report
Bear Lake	3.5 Miles West of Twin Lakes	24-0028-00	2B, 3C	2018	Aquatic Recreation	4A	Nutrient/ Eutrophication Biological Indicators	Phosphorus	Yes: phosphorus
State Line Lake	At Emmons	24-0030-00	2B, 3C	2018	Aquatic Recreation	4A	Nutrient/ Eutrophication Biological Indicators	Phosphorus	Yes: phosphorus
Lime Creek	Bear Lake to MN/IA Border	501	2Bg, 3C	2018	Aquatic Life	4A	Aquatic macroinvertebrate bioassessments Fish bioassessment	TSS Eutrophication DO Habitat Flow alteration	Yes: addressed via Bear Lake TMDL[a] Yes: addressed via phosphorus TMDL Yes: addressed via phosphorus TMDL No: non-pollutant stressor No: non-pollutant stressor
							Dissolved oxygen	DO	Yes: addressed via phosphorus TMDL
							Nutrient/ Eutrophication Biological Indicators	Phosphorus	Yes: phosphorus
					Aquatic Recreation	4A	*E. coli*	*E. coli*	Yes: *E. coli*
Steward Creek (CD 23)	Headwaters to Bear Lake	504	2Bg, 3C	2018	Aquatic Life	5*	Aquatic macroinvertebrate bioassessments	Nitrate Eutrophication DO Habitat Flow alteration	No: No standard for 2Bg Yes: addressed via Bear Lake TMDL Yes: Not conclusively linked to phosphorus load but Bear Lake TP TMDL will address DO issue as it relates to eutrophication. No: non-pollutant stressor No: non-pollutant stressor
						4A	Dissolved oxygen	DO	Yes: Not conclusively linked to phosphorus load but Bear Lake TP

Water body Name	Reach Description	Stream AUID / Lake ID	Use Class	Year Added to List	Affected Use	Proposed Category	Impaired Waters Listing	Pollutant or Stressor	TMDL Developed in this Report
									TMDL will address DO issue as it relates to eutrophication.
Judicial Ditch 25	Unnamed Ditch to Unnamed Creek	515	2Bg, 3C	2018	Aquatic Life	4A	Fish bioassessment	Eutrophication DO Habitat Flow alteration	Yes: will be addressed via Lime Creek TMDL No: Not conclusively linked to phosphorus load. No: non-pollutant stressor No: non-pollutant stressor
						4A	Dissolved oxygen	DO	Yes: Insufficient information for eutrophication assessment but Lime Creek TP TMDL will address DO issue as it relates to eutrophication.
Unnamed Creek	Judicial Ditch 26 to MN/IA Border	509	2Bg, 3C	2018	Aquatic Life	5	Dissolved oxygen	DO	No: Not conclusively linked to phosphorus load. Insufficient information for eutrophication assessment.

[a.] Addressing Bear Lake eutrophication will improve Lime Creek TSS (via TSVS reductions).

* Unable to propose category 4A because pollutant exceedance (nitrate) is contributing to impairment.

1.3 Priority Ranking

The MPCA's schedule for TMDL completions, as indicated on Minnesota's Section 303(d) impaired waters list, reflects Minnesota's priority ranking of this TMDL. The MPCA has aligned our TMDL priorities with the watershed approach and our 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 Clean Water Act Section 303(d) Program. As part of these efforts, the MPCA identified water quality impaired segments that will be addressed by TMDLs by 2022. Impaired waters in the WRW addressed by this TMDL are part of that MPCA prioritization plan to meet EPA's national measure.

2 Applicable Water Quality Standards and Numeric Water Quality Targets

All waterbodies have a Designated Use Classification, defined by the MPCA, which defines the optimal purpose for that water body (see Table 1-1). The lakes and streams addressed by this TMDL study fall into one of the following three designated use classifications:

2B - a healthy warm water aquatic community;

2Bg - a warm water aquatic community that can be used for general use;

3C - industrial consumption with a high level of treatment

Class 2 waters are protected for aquatic life and aquatic recreation, and Class 3 waters are protected for industrial consumption as defined by Minn. R. ch. 7050.0140. The most protective of these classes is 2B, for which water quality standards are provided below.

The Minnesota narrative water quality standard for all Class 2 waters (Minn. R. 7050.0150, subp. 3) states, “For all Class 2 waters, the aquatic habitat, which includes the waters of the state and stream bed, shall not be degraded in any material manner, there shall be no material increase in undesirable slime growths or aquatic plants, including algae, nor shall there be any significant increase in harmful pesticide or other residues in the waters, sediments, and aquatic flora and fauna; the normal fishery and lower aquatic biota upon which it is dependent and the use thereof shall not be seriously impaired or endangered, the species composition shall not be altered materially, and the propagation or migration of the fish and other biota normally present shall not be prevented or hindered by the discharge of any sewage, industrial waste, or other wastes to the waters”.

The designated uses for the downstream impaired segment of the Cedar River in Iowa are significant resource warm water (Class B [WW]), primary contact recreational use (Class A1) and drinking water supply (Class C). Excess nitrate loading has impaired the drinking water supply water quality criteria (567 IAC 61.3(3)) and hindered the designated use.

The following section provides an overview of the water quality standards applicable to impairments in the WRW. See Section 3 for current conditions of WRW surface waters that led to impairment listings.

2.1 Lakes

2.1.1 Lake Eutrophication

TP is often the limiting factor controlling primary production in freshwater lakes: as in-lake P concentrations increase, algal growth increases resulting in higher chlorophyll-a (Chl-*a)* concentrations and lower water transparency. In addition to meeting P limits, lakes must also meet Chl-*a* concentration or Secchi transparency depth standards. In developing the lake nutrient standards for Minnesota lakes (Minn. R. 7050), the MPCA evaluated data from a large cross-section of lakes within each of the state’s ecoregions (Heiskary and Wilson 2005). Clear relationships were established between the causal factor

(TP) and the response variables (Chl-*a* and Secchi transparency). Based on these relationships, it is expected that by meeting the P target in each lake, the Chl-*a* and Secchi standards will, likewise, be met.

The two impaired lakes within the WRW were assessed against the Shallow Lakes Western Corn Belt Plains and Northern Glaciated Plains Ecoregion water quality standards (Table 2-1). A separate water quality standard was developed for shallow lakes, which tend to have poorer water quality than deeper lakes in this ecoregion. According to the MPCA definition of shallow lakes, a lake is considered shallow if its maximum depth is less than 15 feet, or if the littoral zone (area where depth is less than 15 feet) covers at least 80% of the lake's surface area. Bear and State Line Lakes are both shallow lakes by this definition.

To be listed as impaired (Minn. R. 7050.0150, subp. 5), the summer growing season (June through September) monitoring data must show that the standards for both TP (the causal factor) and either Chl-*a* or Secchi transparency (the response variables) were exceeded. If a lake is impaired with respect to only one of these criteria, it may be placed on a review list; a weight of evidence approach is then used to determine if it will be listed as impaired. For more details regarding the listing process, see the *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 303(b) Report and 303(d) List* (MPCA 2012).

Table 2-1. Lake Eutrophication Standards of Winnebago River Watershed Lakes.

Ecoregion	TP (µg/L)	Chl-a (µg/L)	Secchi (m)
Shallow Lakes in Western Corn Belt Plains and Northern Glaciated Plains Ecoregions	< 90	< 30	> 0.7

2.2 Streams

2.2.1 Stream Fish and Macroinvertebrate Bioassessments

The fish and/or macroinvertebrate bioassessment impairments in the WRW were characterized by low Index of Biological Integrity (IBI) scores for fish and/or macroinvertebrates. The presence of a diverse and reproducing aquatic community is a good indication that the aquatic life beneficial use is being supported by a stream. The aquatic community integrates the cumulative impacts of pollutants, habitat alteration, and hydrologic modification on a water body over time. Degradation of surface waters can lead to changes in biological communities as pollutant intolerant species are replaced by pollutant tolerant species. The Macroinvertebrate Index of Biotic Integrity (M-IBI) and other indices of biological integrity are biological monitoring frameworks used to quantify changes in the composition of biological communities. Characterization of an aquatic community is accomplished using IBI, which incorporates multiple attributes of the aquatic community, called "metrics", to evaluate complex biological systems. These metric scores are summed within each class and rescaled to a 0 to 100 range, with 100 being the highest score. For further information regarding the development of stream IBIs, refer to the Development of a Fish-Based (F-IBI) for Minnesota's Rivers and Streams (MPCA 2014a) and Development of a M-IBI for Minnesota's Rivers and Streams (MPCA 2014b).

Narrative language within Minn. R. 7050.0150, subp. 6 identifies an IBI calculation as the primary determinant for evaluating impairment of aquatic biota. The M-IBI and Fish Index of Biotic Integrity (F-IBI) thresholds for impaired streams in the WRW are listed in Table 2-2.

Lime Creek (referred to as the Winnebago River (IA 02-WIN-831) in Iowa) is also considered impaired due to low fish and macroinvertebrate IBI scores, but is not currently addressed by a TMDL in Iowa. No direct comparison can be made between the Minnesota and Iowa IBI criteria because they are based on different biological datasets. However, since both IBI thresholds are protective of warm water fish and macroinvertebrate communities, this TMDL assumes that the Minnesota criteria are protective of the Iowa criteria.

Table 2-2. State of Minnesota M-IBI and F-IBI Score Impairment Thresholds for Streams in the Winnebago River Watershed.

Impaired Reach Name (AUID)	M-IBI Class§ /(Use†)	M-IBI Score Threshold	F-IBI Class§ /(Use†)	F-IBI Score Threshold
Lime Creek (07080203-501)	Prairie Streams-Glide/Pool (Modified Use)	22	Southern Streams (Modified Use)	35
Steward Creek CD 23 Upstream of (-505) (07080203-504)	Prairie Streams-Glide/Pool (Modified Use)	22	Southern Headwaters (Modified Use)	33
Steward Creek CD 23 Downstream of (-505) (07080203-504)	Prairie Streams-Glide/Pool (Modified Use)	22	Low Gradient (Modified Use)	15
Judicial Ditch 25 (07080203-515)	Prairie Streams-Glide/Pool (Modified Use)	22	Low Gradient (Modified Use)	15

The FIBI impairment in the WRW will be addressed by the TP TMDL for Lime Creek (-501).

2.2.2 Eutrophication

Streams in the WRW were characterized by high P concentrations with high concentrations of Chl-*a* and BOD downstream of the two lakes (MPCA 2017). A stream is considered impaired by eutrophication if the summer-average (June through September) data exceeds water quality standard set in Minn. R. 7050.0222, for TP and at least one of the following response parameters:, Chl-*a*, pH, diel DO flux or 5-day Biochemical Oxygen Demand (BOD_5). A water does not meet eutrophication standards if the long-term mean of a single response parameter and the causal parameter exceed their respective criteria (MPCA 2015). Additionally, if the TP concentration of a water exceeds and all response parameter measurements meet their respective RES criteria, then it is considered a “no response” water (MPCA 2015). The eutrophication standards for 2B streams in the South River Nutrient Region (RNR) are in Table 2-3.

Table 2-3. South River Nutrient Region 2B Stream Eutrophication Standards (Minn. R. 7050.0220. subp. 4*)

Parameter	Standard
Total Phosphorus	Less than or equal to 150 µg/L
Chlorophyll-a (seston)	Less than or equal to 35 µg/L
Diel Dissolved Oxygen Flux	Less than or equal to 4.5 mg/L
Biochemical Oxygen Demand (BOD5)	Less than or equal to 3.0 mg/L
pH	Greater than or equal to 6.5; Less than or equal to 9.0

** For 2B rivers there is an error in Minn R. 7050.0222 which lists Chl-a ≤ 40 µg/L and BOD5 ≤ 3.5 mg/L. These errors will be addressed in future rule making efforts.*

2.2.3 Dissolved Oxygen

DO is essential to life for all aquatic organisms. When DO drops below acceptable levels, desirable aquatic organisms, such as fish, can be killed or harmed. One of the primary reasons for low DO conditions in streams is excessive algae growth caused by P. During the decomposition of the algae, DO is consumed by the decomposing bacteria and as a result there is insufficient DO for other aquatic life. While there are no DO TMDLs in this report, it is an important response parameter for eutrophication.

For class 2 streams, such as the Winnebago River, the daily minimum for DO is not to be less than 5 mg/L. A stream is considered impaired if there are at least three total violations and more than 10% of the "suitable" (taken before 9:00 a.m.) May through September measurements, more than 10% of the total May through September measurements, or more than 10% of the October through April measurements violate the standard (Minn. R. 7050.0220). The most informative measurements are taken before 9 a.m. because DO follows a general diurnal (24 hour, daylight/dark) cycle. A total of 20 independent observations are required for a complete DO assessment. Compliance for DO is required for 50% of the days at which flow of the receiving water is equal to the 7Q10. Based on stream stats, the 7Q10 for Lime Creek at the Minnesota Border is 0.335 cfs and 0.615 cfs downstream at the confluence of Unnamed Creek and Lime Creek (Eash and Barnes 2012).

2.2.4 Stream *E. coli*

The State of Minnesota has developed numeric water quality standards for bacteria (Minn. R. 7050.0222), in this case *E. coli*, which are protective concentrations for short- and long-term exposure to pathogens in water. The current *E. coli* numeric water quality standards for Class 2 waters are described below. Although most are harmless, fecal indicator bacteria, such as *E. coli*, are used as an easy-to-measure parameter to evaluate the suitability of recreational waters for the presence of pathogens and probability of illness. Pathogenic bacteria, viruses, and protozoa pose a health risk to humans, potentially causing illnesses with gastrointestinal symptoms (nausea, vomiting, fever, headache, and diarrhea), skin irritations, or other symptoms. Pathogen types and quantities vary among fecal sources; therefore, human health risk varies based on the source of fecal contamination.

E. coli concentrations are not to exceed 126 organisms per 100 milliliters (mL) as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than

10% of all samples taken during any calendar month individually exceed 1,260 organisms per 100 mL. The standard applies only between April 1 and October 31. Most analytical laboratories report *E. coli* concentrations in units of colony forming units (cfu) per 100 mL, which is equivalent to organisms per 100 mL.

Geometric average is used in place of an arithmetic average in order to measure the central tendency of the data, dampening the effect that very high or very low values have on arithmetic averages. *E. coli* can reproduce rapidly (hours to days) when waters become nutrient rich or very warm, and some individual readings can be orders of magnitude greater than the majority of all readings. The MPCA's *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List* provides details regarding how waters are assessed for conformance to the *E. coli* standard (MPCA 2012). See also the MPCA website on bacteria: https://www.pca.state.mn.us/water/bacteria.

The *E. coli* concentration standard of 126 organisms per 100 mL was considered reasonably equivalent to the previous fecal coliform standard of 200 organisms per 100 mL from a public health protection standpoint. The Statement of Need and Reasonableness (SONAR) section that supports this rationale uses a log plot that shows a good relationship between these two parameters. The following regression equation was deemed reasonable to convert any data reported in fecal coliform to *E. coli* equivalents:

E. coli concentration (equivalents) = 1.80 x (Fecal Coliform Concentration)

It should also be noted that most analytical laboratories report *E. coli* in terms of colony forming units per 100 mL (cfu/100 mL), not organisms per 100 mL. This TMDL report will present *E. coli* data in cfu/100 mL since all of the monitored data collected for this TMDL was reported in these units. Bacteria TMDLs were written to achieve the bacteria water quality standard of 126 org/100 mL.

The applicable *E. coli* bacteria Iowa water quality standard for primary contact recreation (Class A1 waters) is 126 org/100 mL as a geometric average and 235 org/100 mL as a sample maximum, applicable to all samples collected between March 15 and November 15. The geometric average *E. coli* criteria in Iowa is the same as Minnesota, but the sample maximum criteria in Iowa is more restrictive than Minnesota. However, because the implementation activities in this TMDL that address *E. coli* reductions are similar to the implementation activities identified in the 2010 Cedar River Watershed *E. coli* TMDL, it is assumed that this TMDL is protective of primary contact recreation for downstream reaches in Iowa.

3 Watershed and Waterbody Characterization

The impaired streams and lakes included in this study are located within the WRW (HUC 07080203) of Southern Minnesota (Figure 1-1). The WRW drains approximately 688 square miles in Iowa and Minnesota, with the Minnesota portion being roughly 10% or 71 square miles (45,649 acres). Freeborn County makes up the majority of the Minnesota portion, with a small percentage within Faribault County. Two municipal areas are located within the Minnesota portion of the watershed: Conger in the north and Emmons in the southeast. There are no tribal lands in the WRW. The two lakes, Bear Lake, and State Line Lake, in this study are located in the southeastern portion of the watershed. The WRW's predominant land use is cultivated crops (82%).

Lime Creek is a headwater tributary river of the Cedar River, which is impaired by high nitrate concentrations in the drinking water supply for the city of Cedar Rapids. The Cedar River Watershed extends from the headwaters in southern Minnesota to Conesville, Iowa, where it joins the Iowa River and subsequently flows into the Mississippi River. The Lime Creek drainage area comprises 9% of the total drainage area of the Cedar River (7,815 square miles).

3.1 Lakes

Both lakes in the WRW are classified as shallow lakes, with maximum depths less than 15 feet. The physical characteristics of the impaired lakes in the WRW are listed in Table 3-1. Lake surface areas, lake volumes, mean depths, littoral areas (less than 15 feet), and maximum depths were reported from Minnesota Department of Natural Resources (DNR) Lake Finder (https://www.dnr.state.mn.us/lakefind/index.html). Lake volumes were calculated by multiplying the mean depth and surface areas, while watershed areas and watershed to surface area ratios were calculated using Cedar River/Little Cedar and the Shell Rock/Winnebago River HSPF model subwatersheds.

Table 3-1. Impaired Lake Physical Characteristics.

Impaired Lake	Surface area (ac)	Littoral area (% total area)	Volume (acre-feet)	Mean depth (feet)	Maximum depth (feet)	Watershed area* (incl. lake area) (ac)	Watershed area : Surface area
Bear Lake (24-0028-00)	1,560	100%	4,680	3	6	24,901	16
State Line Lake (24-0030-00)	445	100%	1,291	2.9	5.5	3,422	8

*Note that the watershed area includes the surface area of the lake

3.2 Streams

Direct and total drainage area for the impaired stream reaches are listed in Table 3-2. Direct drainage areas were delineated using the National Resources Conservation Service (NRCS) Engineering Toolbox in conjunction with the Cedar River/Little Cedar and the Shell Rock/Winnebago River HSPF Model subwatersheds. The direct drainage areas include only the area downstream of any monitored upstream lake or stream. The flow through the watershed is characterized in Figure 3-1.

Table 3-2. Impaired Stream Reach Direct Drainage and Total Watershed Areas.

AUID 07080203	Name/Description	Direct Drainage Area (ac)	Upstream AUID/Lake ID	Total Drainage Area (ac)
-501	Lime Creek (Bear Lake to MN/IA Border)	8,960	24-0028-00	46,200

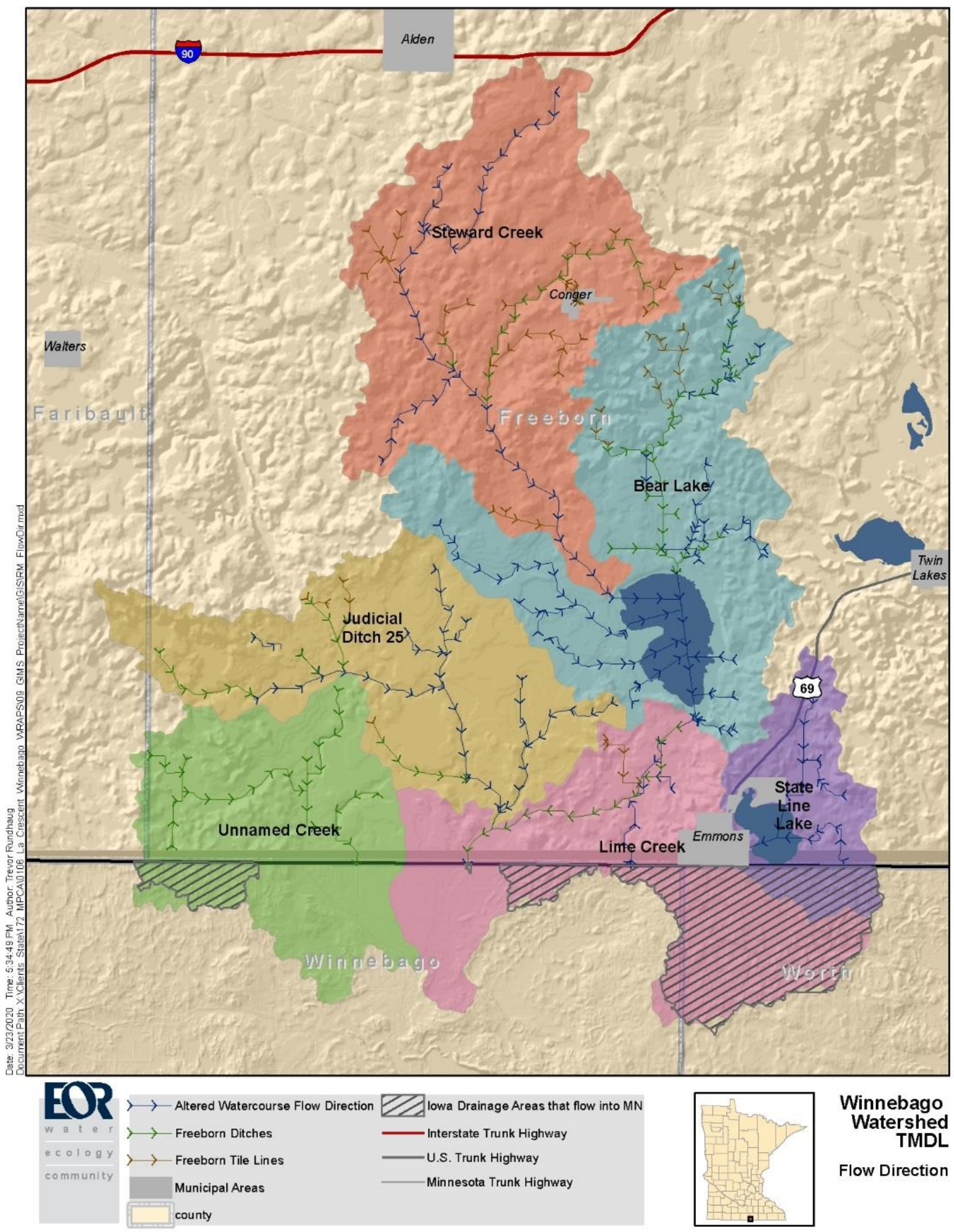


Figure 3-1. Flow direction through the Winnebago River Watershed.

3.3 Subwatersheds

The impaired stream subwatersheds and monitoring stations in the WRW are illustrated in Figure 3-2 below.

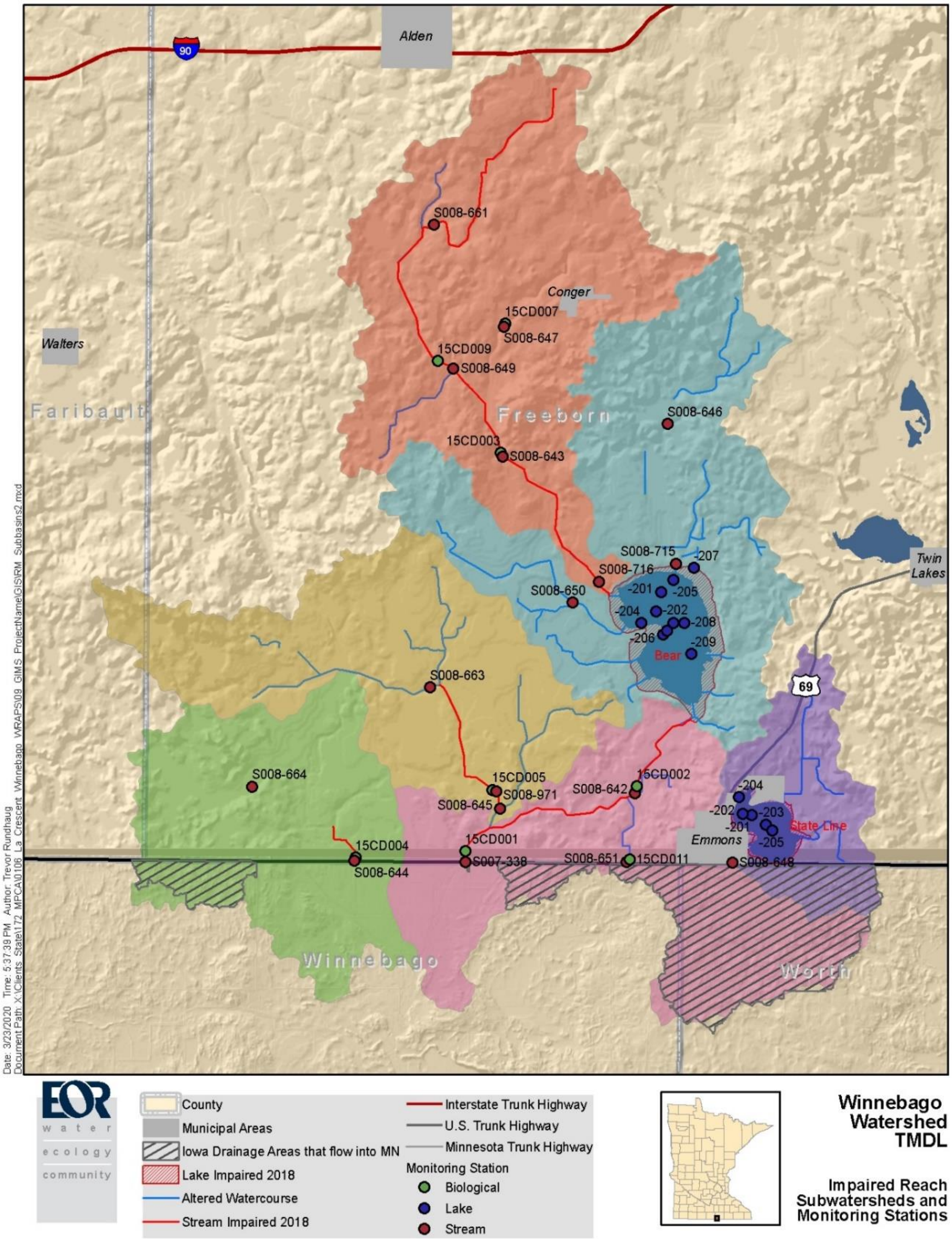


Figure 3-2. Impaired stream drainage areas and monitoring stations referenced in this TMDL.
*Lake monitoring stations are abbreviated to the last three digits of the identification code. The full identification code includes the water body identification (24-0028-00 for Bear Lake and 24-0030-00 for State Line Lake).

3.4 Land Use

Land cover in the WRW was assessed using the 2011 National Land Cover Dataset (https://www.mrlc.gov/). This information is necessary to draw conclusions about pollutant sources and best management practices (BMPs) that may be applicable within each subwatershed.

The land cover distribution within impaired stream watersheds is summarized in Table 3-3 and Figure 3-3. This data was simplified to reduce the overall number of categories. Wetlands include emergent herbaceous wetlands and woody wetlands. Forest includes deciduous forest, evergreen forest, and mixed forest. Developed includes developed open space, and low, medium and high density developed areas.

The primary land cover within the WRW is cultivated crops (82%). The impaired stream subwatersheds have land cover distributions very similar to the WRW as a whole.

Table 3-3. Winnebago River Watershed and Impaired Streams Total Drainage Area Land Cover (NLCD 2011).

Water body Name - AUID/Lake ID	Open Water	Developed	Forest	Grassland	Pasture/Hay	Cultivated Crops	Wetlands
Lime Creek (-501)	4%	6%	1%	3%	2%	81%	3%
Bear Lake (24-0028-00)	4%	6%	1%	2%	3%	80%	4%
State Line Lake (24-0030-00)	17%	9%	2%	5%	3%	56%	8%
Watershed	3%	6%	1%	3%	2%	82%	3%

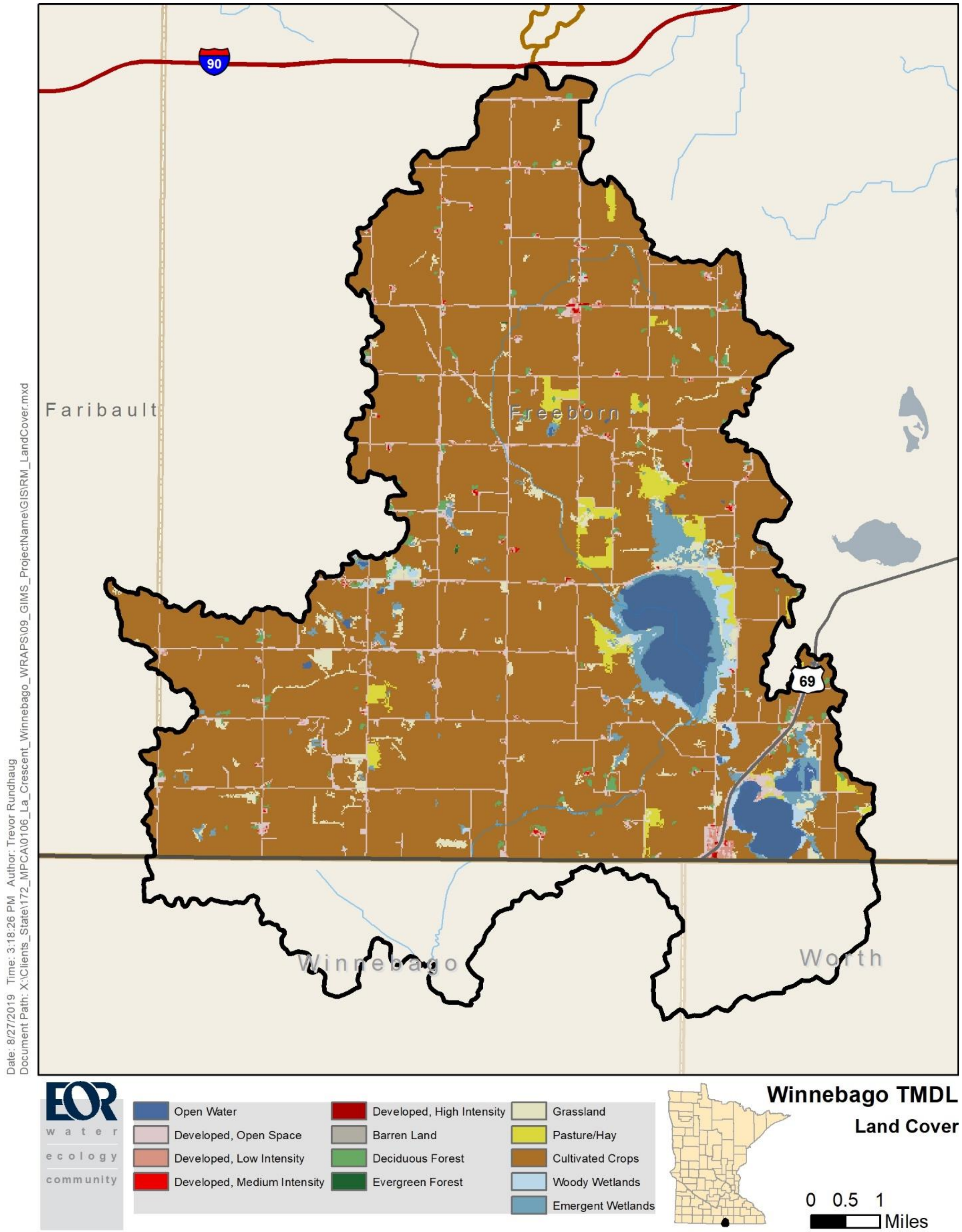


Figure 3-3. Land cover in the Winnebago River Watershed (NLCD 2011).

3.5 Current/Historical Water Quality

Water quality in the WRW is significantly impacted by an altered flow regime, excess nutrients, and lack of habitat. Flows throughout the watershed have been altered by tile drainage, stream channelization, and past drainage of wetlands. Excess nutrients throughout the watershed are contributing to eutrophic conditions in the lakes and stream reaches. The eutrophic lakes in turn enhance eutrophication, poor DO, and high TSS issues downstream in Lime Creek. Many of these water quality concerns continue downstream into Iowa. In Iowa's approved 2016 303(d) impaired waters list, there are six stream reaches, two wetlands, and a lake that are impaired (Table 3-4).

Table 3-4. Impairments in the Winnebago River Watershed in Iowa.

Name	Code	Water body Type	Cycle Listed	Impairment
Beaver Creek	02-WIN-1837	River	2010	Organic Enrichment: Low Dissolved Oxygen
Calamus Creek	02-WIN-845	River	2006	Biological: low fish and invert IBIs, cause unknown
Chelsea Creek	02-WIN-1922	River	2014	Fish Kill: Caused by Other
Winnebago River	02-WIN-826	River	2008	Bacteria: Indicator Bacteria, *E. coli*
Winnebago River	02-WIN-827	River	2008	Bacteria: Indicator Bacteria, *E. coli*
Winnebago River	02-WIN-831	River	2004	Biological: low fish & invert IBIs, cause unknown
Rice Lake	02-WIN-832	Wetland	2014	Algal Growth: Chlorophyll a
Rice Lake	02-WIN-832	Wetland	2014	Turbidity
Rice Lake	02-WIN-832	Wetland	2016	Algal Growth: Chlorophyll a
Ventura Marsh	02-WIN-844	Wetland	1998	Algal Growth: Chlorophyll a
Ventura Marsh	02-WIN-844	Wetland	1998	Aesthetics: aesthetically Objectionable Conditions
Clear Lake	02-WIN-841	Lake	2004	Bacteria: Indicator Bacteria, *E. coli*
Clear Lake	02-WIN-841	Lake	2002	Algal Growth: Chlorophyll a
Clear Lake	02-WIN-841	Lake	2004	Turbidity

The existing in-stream water quality conditions relating to impairment in the watershed were quantified using data downloaded from the MPCA EQuIS database available for the most recent 10-year time period (2008 through 2017), and overlapping with the MPCA's most recent intensive monitoring conducted in the watershed from 2015 to 2016.

3.5.1 Lake Plant Eutrophication

Minnesota DNR research on lake plants has found that one of the most common and serious stressors to lake plants is eutrophication. The DNR developed a lake plant IBI based on the Floristic Quality Index (FQI) to measure the entire lake plant community response to eutrophication (Radomski and Perleberg 2019). The FQI measures the tolerance of different plant species to disturbance, and is used to distinguish plant communities with similar species richness (or total number of species) but different species composition (Radomski and Perleberg 2012). The Lake Plant Eutrophication IBI is used to classify the biological potential of lakes as fully supporting and not supporting based on the stress received from anthropogenic eutrophication. This IBI recognizes the importance of light to all lake plants, but especially to submerged plant species. The Lake Plant

Eutrophication IBI support metric is based on plant richness and the threshold metric is based on the FQI. The Lake Plant Eutrophication IBI support and threshold metrics for aquatic life use vary by ecoregion, survey type, and lake type (deep lakes > 15 feet maximum depth; shallow lakes < 15 feet maximum depth or unknown maximum depth).

The Lake Plant Eutrophication IBI metrics for Bear and State Line Lake from the most recent 10-years (2008 through 2017) are listed in Table 3-5. All plant surveys of Bear and State Line Lakes during the most recent 10-years (2008 through 2017) were point-intercept. The most recent IBI for Bear Lake was below the threshold, and the most recent IBI for State Line Lake was at the threshold.

Table 3-5. Lake Plant Eutrophication IBI metrics (2008-2017).

Lake Name	Survey Date	Richness support metric	FQI threshold metric
Western Corn Belt Plains Ecoregion, Shallow Lakes	*Point-intercept survey*	*> 4*	*> 8.0*
Bear	8-12-2008	1	3
	6-16-2010	3	5.2
	8-31-2011	3	5.2
	8-02-2012	0	0
State Line	6-07-2010	1	3
	7-23-2012	1	6
	7-23-2013	4	11

3.5.2 Lake Eutrophication (Phosphorus)

3.5.2.1 Lake Water Quality Conditions

TP, Chl-*a*, and Secchi transparency depth means were calculated using monitoring data from the growing season (June through September), and are listed in Table 3-6 below.

Table 3-6. Ten-year growing season mean TP, Chl-a, and Secchi (2008-2017).

	Ten-year (2008-2017) Growing Season Mean (June – September)								
	TP			Chl-*a*			Secchi		
Lake Name	(µg/L)	CV	n	(µg/L)	CV	n	(m)	CV	n
Shallow Lakes in Western Corn Belt Plains and Northern Glaciated Plains Ecoregions	< 90	--	--	< 30	--	--	>0.7	--	--
Bear	262	11%	31	88	18%	27	0.24	8%	62
State Line	550	12%	12	276	19%	11	0.24	12%	39

CV = coefficient of variation, defined in BATHTUB as the standard error divided by the mean
n = Sample size

3.5.2.2 Shallow Lake Phosphorus and Algae Relationships

The relationship between P concentration and the response variables (algae/Chl-a and water clarity/Secchi depth) is often different in shallow lakes like Bear Lake and State Line Lake as compared to deeper lakes. In deeper lakes, algae abundance is often controlled by physical and chemical factors such as light availability, temperature, and nutrient concentrations. The biological components of lakes (such as microbes, algae, aquatic plants, zooplankton and other invertebrates, and fish) are distributed throughout the lake, along the shoreline, and on the bottom sediments. In shallow lakes, the biological components are more concentrated into less volume and consequently exert a stronger influence on the ecological interactions within the lake. There is a more dense biological community at the bottom of shallow lakes than in deeper lakes, because of the fact that oxygen is replenished in the bottom waters and light can often penetrate to the bottom. These biological components can control the relationship between P and the response variables algae and water clarity.

The result of biological components' impact on water clarity is that shallow lakes normally exhibit one of two ecologically alternative stable states (Figure 3-4): the turbid water, algae-dominated state, and the clear water, aquatic plant-dominated state (Scheffer et al. 1993). According to the Minnesota DNR Area Wildlife Manager, the turbid water state is currently the more stable state in both Bear Lake and State Line Lake. The clear state is the most ecologically preferred, since algae communities are held in check by diverse and healthy zooplankton and fish communities (Figure 3-5). Fewer nutrients are released from the sediments in this state. This is because roots of aquatic plants stabilize the sediments, lessening the amount of sediment stirred up by wind-driven mixing.

Nutrient reduction or addition in a shallow lake does not lead to linear improvement or degradation in water quality (Figure 3-6). As external nutrient loads are decreased in a lake in the turbid water, algae-dominated state, no improvements in water quality may occur at first. Drastic reductions in nutrient loads or a change in the biological community will cause the lake to abruptly shift from the turbid water, algae-dominated state to the clear water, aquatic plant-dominated state. Conversely, as external nutrient loads are increased in a shallow lake in the clear water, aquatic plant-dominated state, only slight degradations in water quality may occur at first. At some point, further increase in nutrient loads will cause the shallow lake to abruptly shift from the clear water, aquatic plant-dominated state to the turbid water, algae-dominated state. The general pattern in Figure 3-5 is often referred to as "hysteresis," meaning that when forces are applied to a system, it does not return completely to its original state nor does it follow the same trajectory on the way back.

The biological response of the lake to P inputs will depend on the stable state that the lake is in. For example, if the lake is in the clear state, the aquatic plants may be able to take up P instead of the algae. However, if enough stressors are present in the lake, increased P inputs may lead to a shift to the turbid state with an increase in algal density and decreased transparency. The two main categories of stressors that can shift the lake to the turbid state are:

- Disturbance to the aquatic plant community, for example from wind-driven mixing, bottom feeding fish (such as carp), boat motors, or light availability (influenced by algal density or water depth); and
- A decrease in the number of zooplankton can result in an increase in algae. A decrease in the number of zooplankton is usually caused by an increase in the number of fish that feed directly on zooplankton due to a decrease in or absence of piscivorous fish (Figure 3-6).

One implication of the alternative stable states in shallow lakes is that different management approaches are used for shallow lake restoration than those used for restoration of deeper lakes. Shallow lake restoration often focuses on restoring the macrophyte, zooplankton, and fish communities to the lake. This is commonly achieved through a whole lake drawdown in Minnesota (see Section 8.2.3.1).

CLEAR-AQUATIC PLANT DOMINATED STATE

Balanced fish community and abundant aquatic plants keep water clear.

TURBID-ALGAE DOMINATED STATE

Too many rough fish and/or too few aquatic plants keep water turbid.

Figure 3-4. Clear and turbid water states in shallow lakes

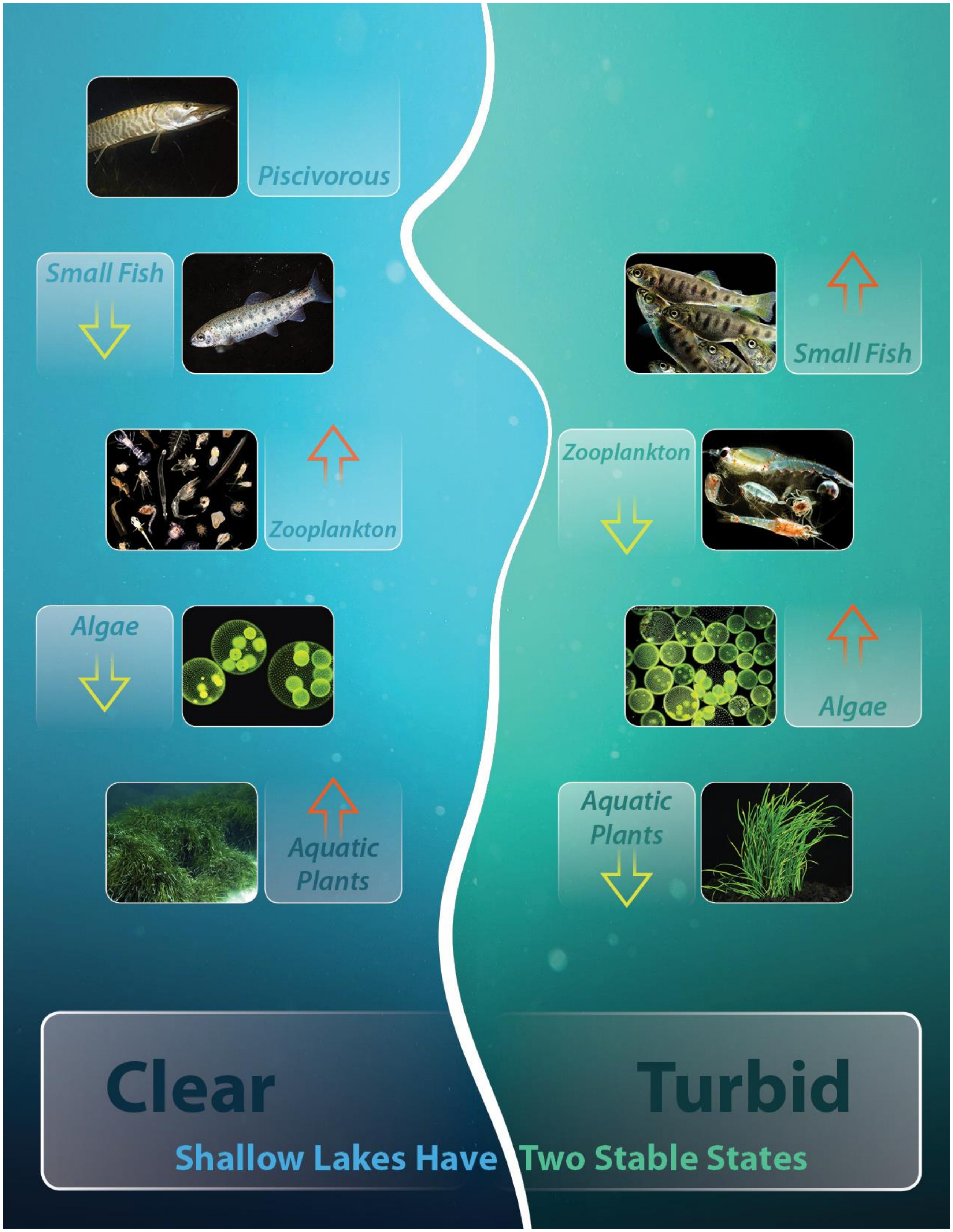


Figure 3-5. Cascading biological communities in shallow lakes under clear and turbid water states.

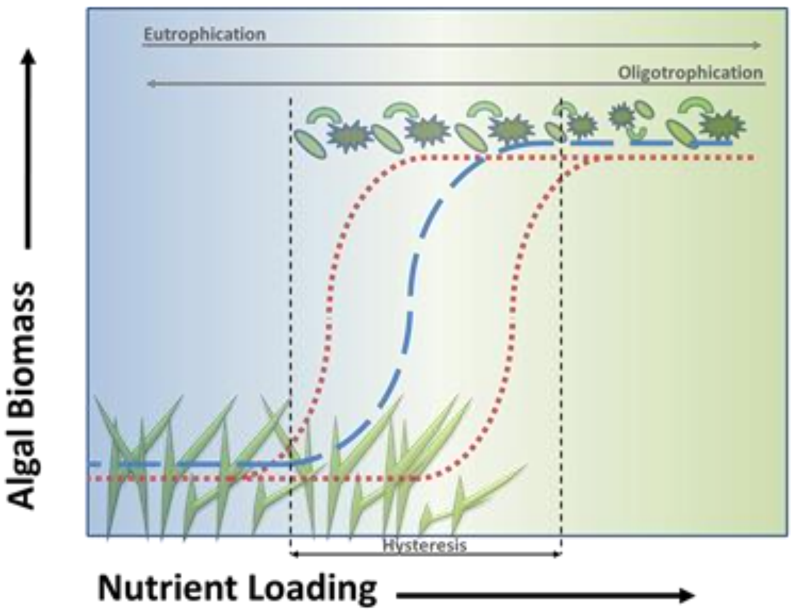


Figure 3-6. Nutrient loading and algae biomass hysteresis of alternative stable states in shallow lakes (Scheffer *et al.* 1993).
The red dotted lines represent the two relationships between nutrient loading and the amount of algae in shallow lakes (hysteresis) as they become more eutrophic (delayed growth of algae as nutrient loading increases, and delayed loss of algae as nutrient loading decreases). In other words, there is a delay in shallow lake water quality changes in response to increases or decreases in nutrient loading.

3.5.2.3 Bear and State Line Lake In-Lake Biological Conditions

Bear Lake

Bear Lake was designated as a Wildlife Management Lake in 1972 and is managed by the DNR shallow lakes program. DNR completed a Lake Management Plan (LMP) for Bear Lake in 2012, describing current and historical conditions and outlining in-lake management strategies to support the clear water, aquatic plant dominated state. According to this LMP, Bear Lake is characterized by turbid water, limited habitat and limited waterfowl and other wildlife use. The lake supports a fringe of emergent plants, predominantly hybrid and narrow-leafed cattail (Typha spp.) and is exhibiting symptoms of decline. The lake lacks a diversity of rooted vegetation. Occasionally, winterkill of rough fishes allows submersed vegetation to rebound, but the lake quickly reverts back to a turbid state. Due to all of the impacts on Bear Lake, it will remain in the turbid condition without active management. The 2012 LMP reported the following:

Aquatic Plants

Bear Lake has had periodic surveys since 1948 to assess the wildlife habitat (aquatic plants). Table 3-7 provides a summary of the findings of these assessments. When emergent and submersed vegetation degenerates, these habitats are replaced by turbid, open water. Wildlife and fish diversity declines and only a few species tolerant of poor water quality and habitat conditions such as common carp, black bullheads, double-crested cormorants, and white pelicans make extensive use of the lake.

Table 3-7. Bear Lake survey information, including depth, plant occurrence, Secchi depths and total phosphorus and waterfowl counts, 1948-2010 (Table 1 in the DNR Bear Lake 2012 Lake Management Plan)

Year	Average Depth (Maximum Depth) in feet	Avg. Secchi Depth (Max. Secchi Depth) in feet	Type of Report	% occurrence vegetation (number of species)	No. of Plots	Total Phosphorus (ppb)	Waterfowl Count
Sept. 1948	2 (3.5)	To bottom (3.5)	Wildlife Lake Survey	100 (13)	25	20	2475
July 1957	2.8 (4)	1.2 (2)	Wildlife Lake Survey	32 (12)	128	ND	4
July 1969	1.5 (2)	To bottom (2)	Narrative	Extensive* (6)	NA	ND	14
June and Aug. 1971	1.7 (2.3)	To bottom (2.3)	Narrative	100% coverage* (19)	NA	ND	600
July 1974	2 (2.5)	1.5	Narrative	99% coverage* (4)	NA	ND	NC
June 1977	0.7 (1)	To bottom (1)	Narrative	85% coverage * (7)	NA	ND	NC
June 1980		1.3	Narrative	No vegetation in open, windswept areas, submersed plants associated with protected areas in and near peripheral cattail fringe* (8)	NA	ND	NC
Sept. 1981	ND	ND	Narrative	Lush submersed plants in broad cattail fringe, submersed plnats rare in open water areas* (7)	NA	ND	1750
Nov. 1983	ND	1.4 (2)	Narrative	No vegetation in open, windswept areas, abundant submerge plants in NW and SW*	5	ND	3953
Aug. 1984	2.2 (3)	ND	Reconnaissance	87 (8)	16	ND	NC
June 1987	1.9 (2.3)	1.1 (2)	Reconnaissance	75 (6)	8	ND	NC
1988	1.1	0.3	Narrative	No submersed plants*	NA	ND	158
Oct. 1991	2.3 (3.1)	2.0 (3.1)	Narrative	18 (1)	11	ND	158
1992	2.4 (2.7)	1.4 (1.8)	Reconnaissance	33 (1)	6	ND	317
Sept. 1994	1.9 (3.0)	0.6 (0.7)	Index Survey	0	20	45-130	683
Sept. 1995	2 (2.5)	0.5	Index Survey	0	25	ND	108
1996	1.8 (2.0)	0.7 (1.5)	Reconnaissance	9 (1)	11	ND	3

Year	Average Depth (Maximum Depth) in feet	Avg. Secchi Depth (Max. Secchi Depth) in feet	Type of Report	% occurrence vegetation (number of species)	No. of Plots	Total Phosphorus (ppb)	Waterfowl Count
Oct. 1999	1.9 (3.0)	0.7 (0.9)	Reconnaissance	13 (4)	8	ND	64
July 2002	2.1 (4.5)	0.6 (1)	Wildlife Lake Survey	7 (2)	81	322	2
Sept. 2003	1.8	8 cm (10 cm)**	Narrative	Submersed plant coverage about 30% in open water areas*	4	ND	385
Aug. 2004	2.4 (3.0)	1.0 (2)	Wildlife Lake Survey	47 (8)	72	155	25
Aug. 2005	2.0 (3.0)	1.1 (2)	Wildlife Lake Survey	88 (18)	75	1650 (sample from inlet ditch)	12
Aug. 2008	2.4 (4.0)	0.5 (0.8)	Wildlife Lake Survey	46 (2)	76	142	70
June 2010	2.7 (3.5)	0.5 (0.5)	Wildlife Lake Survey	9 (4)	78	112	56
Aug. 2011	2.1(3.0)	0.5 (1.0)	Wildlife Lake Survey	37 (4)	78	300	1
Aug. 2012	1.3(2.0)	0.5 (0.8)	Wildlife Lake Survey	4.3 (1)	69	545	6
Aug. 2013	0.5(1.0)	0.5 (1.0)	Wildlife Lake Survey	81 (4)	32	301	4174
Sept. 2014	1.0(1.5)	1.0 (1.5)	Wildlife Lake Survey	100 (8)	22	378	2707
July 2015	1.4(2.5)	1.4 (2.0)	Wildlife Lake Survey	91 (8)	70	140	137

*Observational information on plant distribution and abundance and species richness
** Secchi tube measurements

NA = Not available

Fishery

Bear Lake supports a limited recreational fishery, which largely stems from catches of northern pike. Two inlets on the north end of the lake are channelized and are the deepest points on the lake. Both sites are the best locations for darkhouse spearing and winter and summer angling. The lake is shallow and subject to partial winterkills, and fishes intolerant of low DO are generally rare or absent. Current fisheries survey information is available on the DNR's website (https://www.dnr.state.mn.us/lakefind/lake.html?id=24002800). A 2009 fish survey sampled black bullhead, common carp, bigmouth buffalo, golden shiner, white sucker, northern pike, yellow perch, white and black crappie, orange-spotted sunfish and yellow bullhead. Fish grow quickly in this fertile lake and rough fishes dominate the fishery biomass. When water quality is poor, fishes that are less tolerant of water pollution and turbidity cannot compete or survive well in the lake. Bear Lake was locally well known for northern pike. Past management promoting aquatic vegetation has provided good spawning and nursery habitat for northern pike. The DNR has found that northern pike can reproduce naturally following winterkill events, potentially due to Bear Lake's wider connection to the Winnebago River and immediate connection to Lime Creek. Fish winterkills result from loss of oxygen during the winter under ice cover, when oxygen is consumed through respiration and decomposition much faster than it is produce through photosynthesis. In winter, there is no source of oxygen from diffusion from the atmosphere and wind cycling, and oxygen produced from photosynthesis decreases as ice thickness and snow depth increases, reducing the amount of sunlight that can penetrate through the ice (Figure 3-7). In the 2009 survey, the DNR recorded northern pike up to 29 inches in length which indicates that northern pike are not only surviving winters, but also reaching sexual maturity. Future fishery management efforts should focus on managing the lake for northern pike and yellow perch which are the most tolerant to low DO levels (refer to the oxygen requirements by fish species in the lower right corner of Figure 3-7).

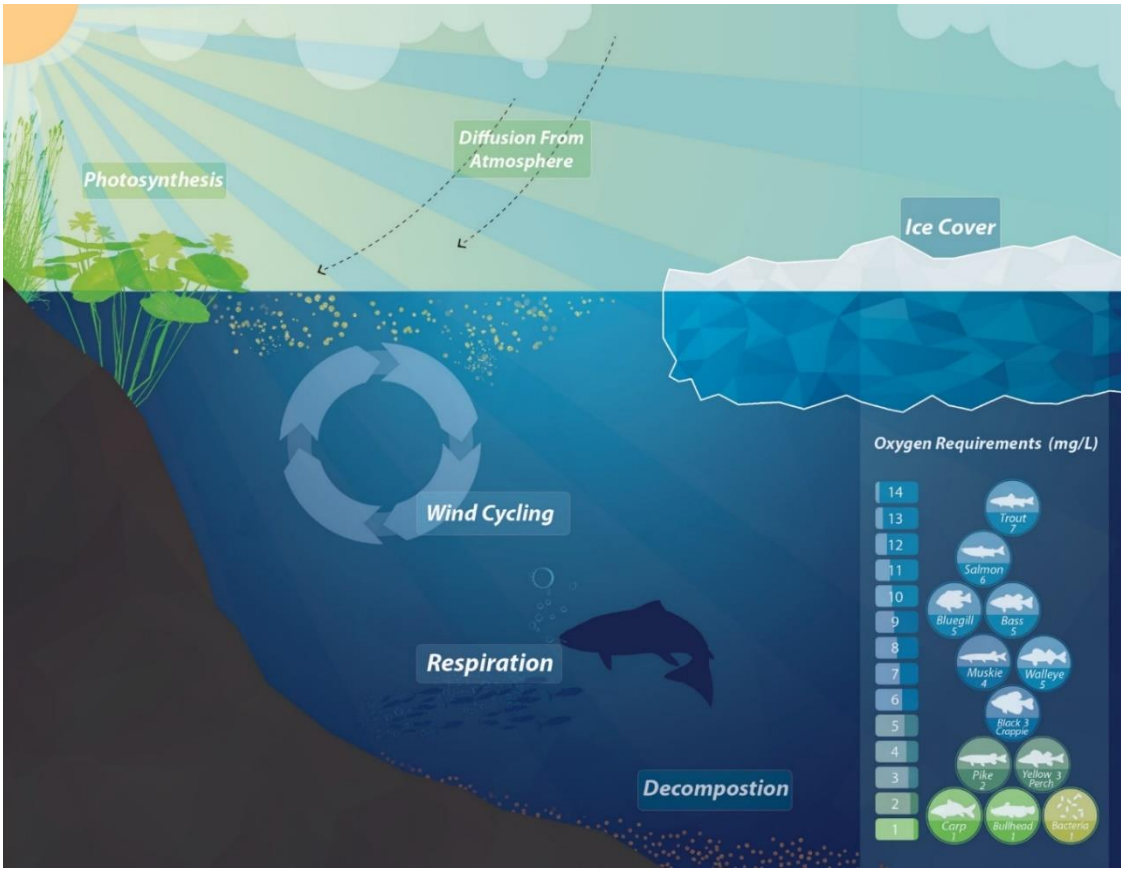


Figure 3-7. Sources and losses of dissolved oxygen in lakes, and dissolved oxygen requirements of fish by type. Derived from information from the Fondriest Environmental Learning Center webpage on lake dissolved oxygen (https://www.fondriest.com/environmental-measurements/parameters/water-quality/dissolved-oxygen/)

State Line Lake

State Line Lake is managed by the DNR shallow lakes program within the Section of Wildlife to improve water quality and habitat conditions. DNR completed a LMP for State Line Lake in 2012, describing current and historical conditions and outlining in-lake management strategies to support the clear water, aquatic plant dominated state. According to this Plan, State Line Lake typically has large populations of rough fishes (carp and bullhead), few aquatic plants, and is turbid due to algae and suspended sediments. However, State Line Lake is capable of supporting quality aquatic habitats benefitting a wide variety of fish and wildlife. The 2012 LMP strategies have been implemented since 2013.

Aquatic Plants

Aquatic habitat quality has been surveyed 6 times by the DNR Shallow Lake Program (1948, 1958, 1998, 2010, 2012, and 2013) prior to plan implementation. From this information, the DNR has calculated a Lake Plant Eutrophication Index of Biotic Integrity (LPEIBI). The LPEIBI is based on two metrics. The first is taxa richness or more simply the estimated total number of aquatic plant species in the lake. The second metric is the FQI. The FQI calculation is based on both the quantity of species observed (species richness) as well as the quality of each individual species. The DNR has determined thresholds for most ecoregions, survey types, and lake types across the state based on a wealth of accumulated aquatic plant data. A comparison of FQI scores and species richness scores indicates that Bear Lake is below the threshold (impaired) whereas State Line Lake was at or slightly above the threshold (not impaired).

Notable numbers of rough fish, poor water clarity and algae were cited in each survey except 2010. The number of aquatic plant species has declined. Eight and 16 aquatic plant species were recorded in 1948 and 1958, respectively. White water lily was the only species found at the 1998 sample points and it occurred at only one point. In 2010 sago pondweed was recorded at 51% of the 90 sample points, but was the only plant species documented at the sample locations. Emergent vegetation (primarily cattail) occupied about 1% of the basin. By 2012, habitat quality had deteriorated and results were similar to 1998.

Aquatic habitat quality has been surveyed four additional times to document the response to management efforts. Selected results from these surveys are shown in Table 3-8. Habitat conditions have responded positively to management efforts. However the turbid water state has proven resilient and improved conditions have not persisted.

The importance of rooted aquatic vegetation in shallow lakes is well documented. These plants can potentially grow throughout State Line Lake but are limited by turbidity and rough fish. Aquatic vegetation abundance is directly related to water clarity in fertile southern Minnesota lakes.

Table 3-8. Selected results from State Line Lake habitat surveys 2012 – 2018 before and after implementation of actions identified in the lake management plan.

Year	Management Action	Avg. (Max) Depth (ft)	Avg. (Max) Secchi Depth (ft)	% Occurrence of vegetation	Number of Plots	Total Phosphorus (ppb)	Chl. *a*
2012	Natural drought	1.7 (2.5)	0.3 (0.3)	1	83	784	ND
2013	-----	3.1 (5.0)	0.5 (0.5)	71	90	626	456
2014	Major Drawdown/Fall Rotenone	1.5 (3.5)	1.5 (3.3)	95	79	560	8
2015	-----	3.3 (5.5)	1.7 (2.8)	96	84	346	120
2017	Partial winter drawdown ('16-'17)	2.9 (4.8)	0.8 (1.0)	37	52	118	75
2018	Major winter drawdown ('17-18)		1.3	97	90		

Fishery

State Line is an inherently unstable fish habitat. The lake's nutrient load and shallow nature make it prone to algae blooms, with the potential to have low DO conditions in both winter and summer. Present conditions favor species of fish that tolerate turbidity and have limited habitat requirements. Prior to 2014, the downstream road culvert and fixed crest dam likely limited access to the lake by species such as northern pike because they cannot jump these partial barriers while common carp can. Channelization in Lime Creek and the State Line tributary has produced stretches of poor habitats for game and nongame fish.

In addition to common carp and black bullheads, northern pike and sunfish were noted in the 1948 lake survey. Only common carp and black bullheads were cited in 1958. In 1998 the survey crew reported "Abundant large carp present, with over 50+ dead carp seen in the inlet channel." Few fish were observed in 2010, although approximately 15,300 pounds of carp and buffalo were commercially harvested that year. Common carp were abundant in 2012 and observations included many juvenile and young of year fish. Common carp were also noted in 2013 even though the lake had been naturally dry in late fall and winter of 2012-2013. Fish species such as common carp, black bullheads and fathead minnows may directly and indirectly contribute to continued poor water quality.

With habitat improvement and mitigation for barriers to migration (e.g., such as utilizing stocking programs in place of natural migration) State Line Lake should support a more diverse fishery. The primary management species are northern pike and yellow perch and the secondary species is bluegill sunfish. The management plan calls for stocking northern pike fry, pre-spawn adult yellow perch, and adult bluegill following reclamations or winterkill events. Pike and perch are more likely to survive stressful DO levels and should help suppress fat head minnow, black bullhead and common carp numbers.

Presently there is limited recreational fishing, although occasionally State Line has notable opportunities for northern pike, bullheads and pan fish. The lake supports some commercial fishing, especially for carp and bait.

3.5.3 Stream Eutrophication

Both monitoring stations on Lime Creek exhibited exceedances of all three of the river eutrophication parameters, which supported the link between stream eutrophication and poor fish and macroinvertebrate bioassessments in the SID Report. It should be noted that insufficient monitoring data was available to result in a direct exceedance of the RES (Table 3-9). All three of the eutrophication parameter concentrations decreased moving downstream (away) from Bear Lake and TP was no longer exceeded at the most downstream monitoring station (S007-338; Figure 3-2).

Table 3-9. Eutrophication Exceedances at Lime Creek (07080203-501)

Eutrophication Parameters	Monitoring Station (upstream to downstream)	Number of Samples	Standard*	Summer Average Concentration
Causal: Total Phosphorus (µg/L)	S008-642	5	150	274
	S007-338	13	150	142
Response: Chlorophyll a, corrected for pheophytin (µg/L)	S008-642	3	35	122
	S007-338	3	35	84
Response: Biochemical oxygen demand, standard conditions (mg/L)	S008-642	3	3.0	9.2
	S007-338	3	3.0	7.2

** For 2B rivers there is an error in Minn R. 7050.0222 which lists Chl-a ≤ 40 µg/L and BOD5 ≤ 3.5 mg/L. These errors will be addressed in future rule making efforts.*

3.5.4 Dissolved Oxygen

As previously mentioned, no separate DO TMDLs are included in this report because the DO impairments for Steward Creek, Lime Creek and JD-25 are addressed through a P TMDL. Because DO is an important eutrophication response parameter, the following information is presented.

3.5.4.1 Lime Creek, Bear Lake to MN/IA Border (AUID 07080203-501)

The 10-year (2008 through 2017) DO water quality standard exceedances for Lime Creek (07080203-501) are summarized in Table 3-10. The DO impairment for this reach was due to 10% of all samples measuring less than 5 mg/L collected between May and September at station S007-338 on Lime Creek, 3.7 mi west of Emmons, Minnesota. Instantaneous DO measurements are shown by month for each monitoring station in Figure 3-8. DO measurements below 5 mg/L occurred in July and August, and just barely exceed the aquatic life use standard.

Table 3-10. Ten-year DO Water Quality Standard Exceedances in Lime Creek (07080203-501).

Monitoring Station (upstream to downstream)	Criteria	No. of Samples (n)	No. of Samples < 5 mg/L	% Samples < 5 mg/L (If n>19)
S008-642	**Before 9AM May – Sept.**	4	0	Insufficient Data
	All May – Sept.	17	0	Insufficient Data
	Oct. – April	20	0	0%
S007-338	**Before 9AM May – Sept.**	6	2	Insufficient Data
	All May – Sept.	31	3	10%
	Oct. – April	34	3	9%
Combined Station Data	**Before 9AM May – Sept.**	10	2	Insufficient Data
	All May – Sept.	48	3	6%
	Oct. – April	54	3	6%

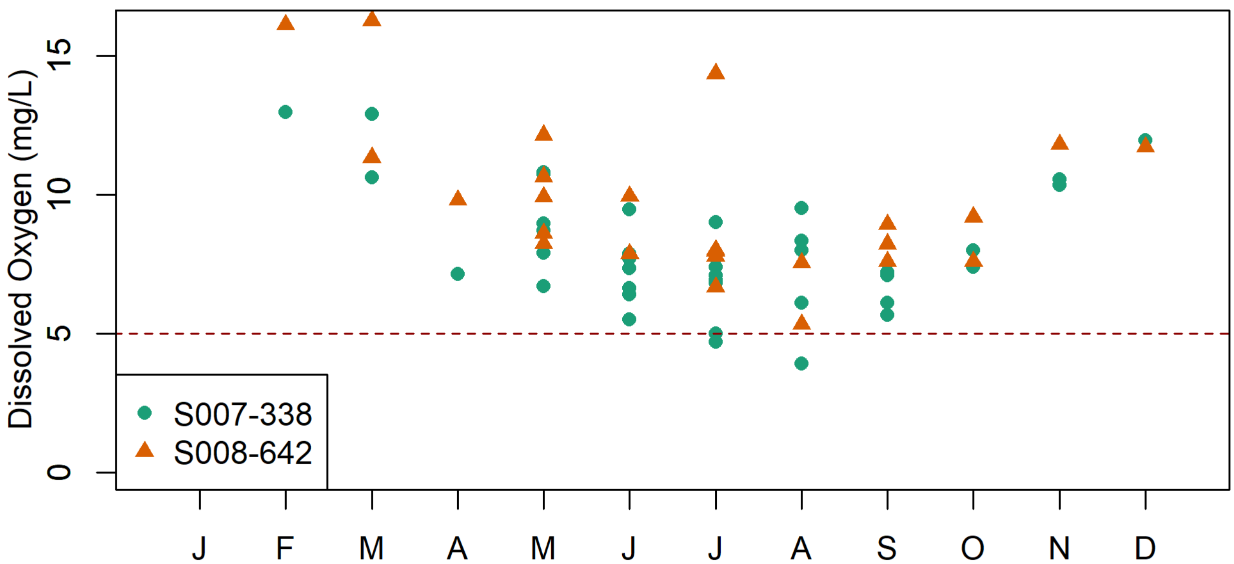


Figure 3-8. Number of samples with DO < 5 mg/L by month and station for Lime Creek, 2008-2017.

3.5.5 *Escherichia coli*

The 10-year (2008 through 2017) April through October monthly, geometric mean *E. coli* concentrations for Lime Creek (07080203-501) are reported in Table 3-11, and were based on data from 2015 and 2016. The *E. coli* impairment for this reach was due to a monthly geometric mean exceeding 126 cfu/100 mL in June and July at station S007-338. One instantaneous sample exceeded 1,260 cfu/100 mL on this reach. To illustrate the seasonal variability in *E. coli* concentration at each station, *E. coli* data are shown by month in Figure 3-9. To meet the standard concentration of 126 org/100 mL, a 52% reduction in *E. coli* concentration is needed during the month of June, and a 14% reduction in *E. coli* concentration is needed during the month of July.

Table 3-11. Ten-year Geometric Mean *E. coli* (cfu/100 mL) concentrations by month in Lime Creek (07080203-501), 2008-2017.

Monitoring Station	Month	Number of Samples	Geometric Mean (cfu/100 mL)	Min (cfu/100 mL)	Max (cfu/100 mL)	Total Samples >1,260 cfu/100 mL
S007-338	June	5	262	46	2,420	1
	July	5	147	32	1,000	0
	August	5	57	7	170	0

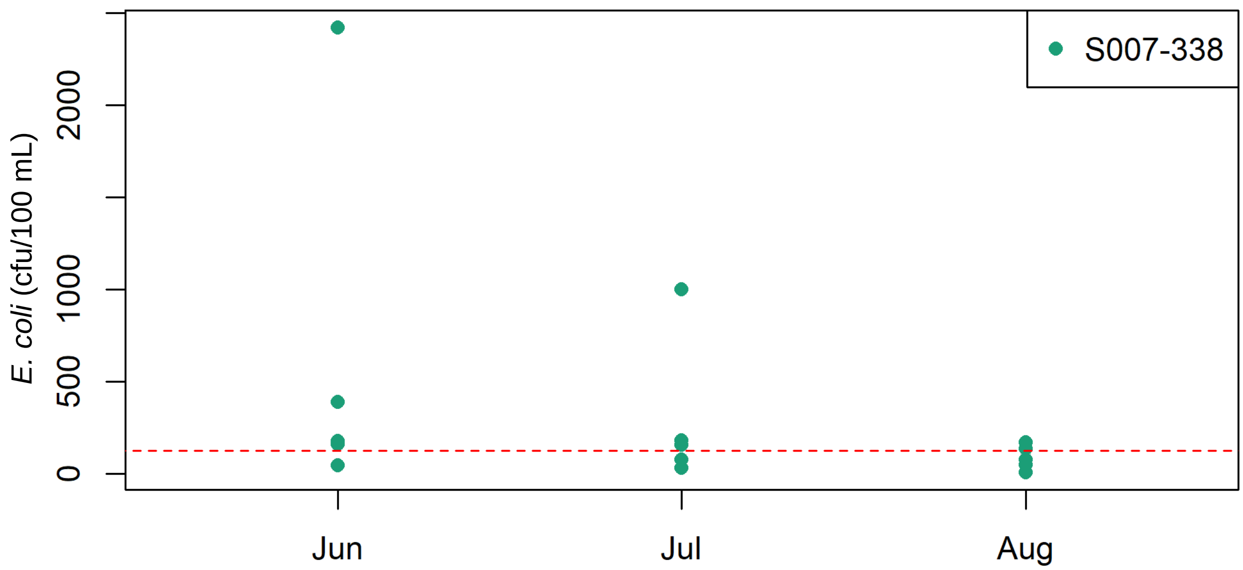


Figure 3-9. *E. coli* (cfu/100 mL) by month in Lime Creek (07080203-501) at monitoring station S007-338, 2008-2017. The dashed red line represents the stream water quality standard (126 org/100 mL).

3.6 Pollutant Sources and Stressors Summary

3.6.1 Permitted Source Types

Regulated sources of pollutants include WWTP effluent, NPDES permitted feedlots, construction stormwater, and industrial stormwater. P loads from National Pollutant Discharge Elimination System (NPDES) permitted wastewater and stormwater sources were accounted for using the methods described in subsequent Section 4.1.3.

3.6.1.1 Regulated Stormwater

Currently there are no regulated MS4s in the WRW. There are two types of regulated stormwater in the watershed:

1. **<u>Regulated Construction Stormwater</u>**

   Construction stormwater is regulated by NPDES permits (MNR100001) for any construction activity disturbing: (a) one acre or more of soil, (b) 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 (c) less than one acre of soil, but the MPCA determines that the activity poses a risk to water resources. The WLA for stormwater discharges, from sites where there are construction activities, reflects the number of construction sites greater than one acre in size that are expected to be active in the impaired lake or stream subwatershed at any one time.

2. **<u>Regulated Industrial Stormwater</u>**

   Currently, there are no regulated industrial stormwater sites in the WRW. Industrial stormwater is regulated by NPDES permits (MNR050000) if the industrial activity has the potential for significant materials and activities to be exposed to stormwater discharges. The WLA for stormwater discharges from sites where there is industrial activity reflects the number of sites in an impaired lake or stream subwatershed for which NPDES industrial stormwater permit coverage is required.

3.6.1.2 Municipal Wastewater

Municipal wastewater is the domestic sewage and wastewater collected and treated by municipalities before being discharged to waterbodies as municipal wastewater effluent. Conger and Emmons wastewater treatment plants (WWTPs) discharge to impaired waterbodies in the WRW.

3.6.1.3 Land Application of Biosolids

The application of biosolids from WWTP are highly regulated, monitored, and tracked (see Minn. R. ch. 7041 *Sewage Sludge Management* and Minn. R. ch. 7080 *Individual Subsurface Sewage Treatment Systems [SSTS]*). Pathogen reduction in biosolids is required prior to spreading on agricultural fields. Disposal methods that inject or incorporate biosolids within 24 hours of land application result in minimal possibility for mobilization of bacteria to downstream surface waters. While surface application could conceivably present a risk to surface waters, little to no runoff or bacteria transport are expected if permit restrictions are followed. Therefore, land application of biosolids was not included as a source of bacteria.

3.6.1.4 Animal Feeding Operations

Concentrated Animal Feeding Operation (CAFOs) are defined by the EPA based on the number and type of animals. 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 issues State Disposal System (SDS) Permit: a) all federally defined CAFOs that have had a discharge, some of which are under 1,000 AUs in size; and b) all CAFOs and non-CAFOs that have 1,000 or more AUs.

CAFOs and Animal Feeding Operation (AFOs) with 1,000 or more AUs must be designed to contain all manure contaminated runoff from precipitation events of less than a 25-year, 24-hour storm event. Having and complying with an NPDES permit allows some enforcement protection if a facility discharges due to a 25-year, 24-hour precipitation event and the discharge does not contribute to a water quality impairment. Large CAFOs permitted with an SDS permit or those not covered by a permit must contain all runoff, regardless of the precipitation event. Therefore, many large CAFOs in Minnesota have chosen to have a NPDES permit, even if discharges have not occurred in the past at the facility. A current manure management plan that 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.

There are six active NPDES permitted CAFOs in the WRW (Table 3-12). These CAFOs are mapped in Figure 3-14 in Section 3.6.2.3.

Table 3-12. Winnebago River Watershed CAFOs.

Permit ID	Name	Animal Type	Animal Units
MNG440526	Gary and Mary Chicos Farm	Swine	1179
MNG441029	Kjell Mattson Farm 2	Swine	750
MNG440443	Kjell Mattson Farm	Swine	1890
MNG441056	Perschbacher Hog Farm – Sec 10	Swine	1200
MNG441961	John Perschbacher Hog Farm - Conger	Swine	1500
MNG442059	Precision Pork Producers Inc	Swine	1420.6

3.6.2 Non-permitted Sources

3.6.2.1 Lake Phosphorus Source Summary

This section provides a brief description of the potential sources in the WRW that contribute to excess nutrients in the impaired lakes. P in lakes often originates from surrounding landscapes. P from sources such as P-containing fertilizer, manure, and the decay of organic matter can adsorb to soil particles. Wind and water action erode the soil, detach particles and convey them via stormwater runoff to nearby waterbodies where the P becomes available for algal and aquatic plant growth. Organic material, such as leaves and grass clippings, can leach dissolved P into standing water and runoff, or be conveyed directly to waterbodies where biological action breaks down the organic matter and releases P. In addition, P in lake sediments can be released and transported to surface waters through chemical release under no oxygen (anoxic) bottom water conditions, fish excretion, and physical disturbance of the sediments from wind or wave action or bottom fish feeding behaviors.

The following sources of P that do not require an NPDES permit were evaluated:

- Watershed runoff and loading from upstream waters
- Atmospheric deposition
- Internal loading

Watershed runoff

A HSPF model was used to estimate watershed runoff volumes and TP loads from the direct drainage area of impaired lakes and upstream tributaries (Table 3-13). These P loads include sources from overland runoff, feedlots not requiring NPDES permit coverage, and SSTSs. The HSPF model generates overland runoff flows on a daily time step for 13 individual subwatersheds in the WRW based on land cover and soil type. Model calibration was completed using meteorological data from 1999 through 2012. A 17 year (1996 through 2012) average annual flow was calculated for lake BATHTUB models.

Table 3-13. Average Annual Flow Volumes and TP Loads (1996-2012) for Lake Direct and Upstream Tributary Drainage Areas.

Impaired Lake Watershed	Impaired Lake or Upstream Tributary	Drainage area (ac)	TP Conc. (µg/L)	Flow (ac-ft/yr)	TP Load (lb/yr)
Bear Lake	Bear Direct Drainage*	4,530	210.4	5,158	2,950
	Unnamed Creek (-509)	6,033	215.5	6,223	3,646
	Steward Creek (-504)	12,778	211.5	13,262	7,624
State Line Lake	State Line Direct Drainage*	700	176.8	784	377
	Unnamed Creek (-508)	2,277	198.7	2,330	1,259

* Excludes lake surface area

Atmospheric Deposition

Atmospheric deposition represents the P that is bound to particulates in the air and is deposited directly onto surface waters. Average P atmospheric deposition loading rates were approximately 0.42 pounds per acre per year (lb/ac/yr) of TP per year for an average rainfall year for the Cedar River Basin (Barr 2007 addendum to MPCA 2004). This rate was applied to the lake surface areas in the WRW to determine the total atmospheric deposition load per year to the impaired lakes and streams.

Internal Loading

Internal loading in lakes refers to the P within a lake's bottom sediments or aquatic plants that is released back into the water column. Internal loading can occur via:

1. *Chemical release from bottom sediments:* Caused by anoxic (lack of oxygen) conditions in the overlying water column layers or high pH (greater than 9). If a lake's hypolimnion (bottom area) remains anoxic for a portion of the growing season, the P released due to anoxia will be distributed throughout the water column during fall mixing. In shallow lakes, the periods of anoxia can last for short periods of time and occur frequently.

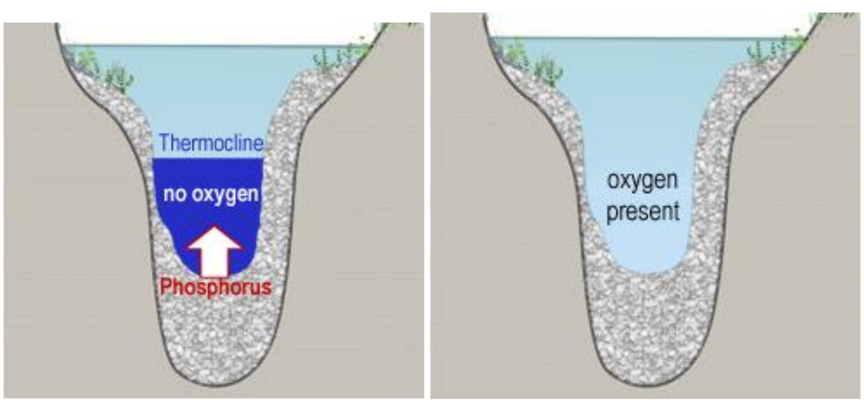


Figure 3-10. Sediment phosphorus release under anoxic (no oxygen) conditions in lakes (From: RMBEL https://www.rmbel.info/primer/total-phosphorus/)

2. *Physical disturbance of bottom sediments*: Caused by bottom-feeding fish bioturbation (such as carp and bullhead), motorized boat activity, and wind-driven mixing/wave action. This is more common in shallow lakes than in deeper lakes.
3. *Fish feeding and excretion*: Benthivorous (bottom feeding fish) move P from the sediment to the water by feeding on lake bottom food items, providing new P for algae growth. Some studies have shown that release of P from fish feeding can release more P than all other lake organisms combined, and can be on the same order of magnitude of external, watershed loading (Persson 1997; Brabrand et al. 1990).

3.6.2.2 Stream Phosphorus Source Summary

The HSPF model was used to simulate non-point sources of TP in the WRW. HSPF has been used extensively in Minnesota and nationwide in support of TMDLs to simulate the complex nutrient cycling associated with P, nitrogen, DO, algal growth, and biological oxygen demand. The model splits a watershed into small segments based on unique combinations of homogenous soils, land slope, land cover, and climate. From these segments, daily landscape hydrology and water quality are simulated and routed through the stream channel network to the watershed outlet.

The Cedar River/Little Cedar River and Shell Rock River/Winnebago River HSPF model was set up to account for the heavily agricultural landscape of the four watersheds. The model accounts for the variability of soils with different hydrologic groups and the varying tillage throughout the watershed, summarized from tillage transect surveys of the area. Furthermore, animal feedlot operations were included to estimate their contribution of nutrients to streams. These inclusions in the model improved the model performance and accounted for the variability throughout the agricultural watersheds.

The model was calibrated and run using data from 1999 through 2012. The water quality constituents that were modeled and calibrated were flow, sediment, total ammonia, nitrite and nitrate, total nitrogen, orthophosphate, and TP. More intense consideration was given to TP because of their impact to impairments in the WRW.

Average annual precipitation, runoff flow, TSS, and TP yields were calculated from HSPF modeled daily outputs and are summarized graphically in Figure 3-11 through Figure 3-13.

Watershed Runoff

HSPF modeled results indicate TP yields were consistent throughout the Winnebago River Subwatersheds, with slope of the land providing the majority of the variability due to steeper soils eroding more than flatter soils. P concentrations in overland runoff generally increase with increasing slope of the land due to greater erosion of P bound to soil particles. The two lake subwatersheds had the lowest TP yields because there was less agricultural land in the subwatersheds. However, the lake subwatersheds had an average TSS yield 2.5 times greater than the average TSS yield from stream subwatersheds because of the high total suspended solids as algae and other organic matter suspended in the lake water. Thus, reductions are needed from both Bear Lake and from the immediate drainage (including an effluent P limit for Emmons WWTP) to improve Lime Creek water quality.

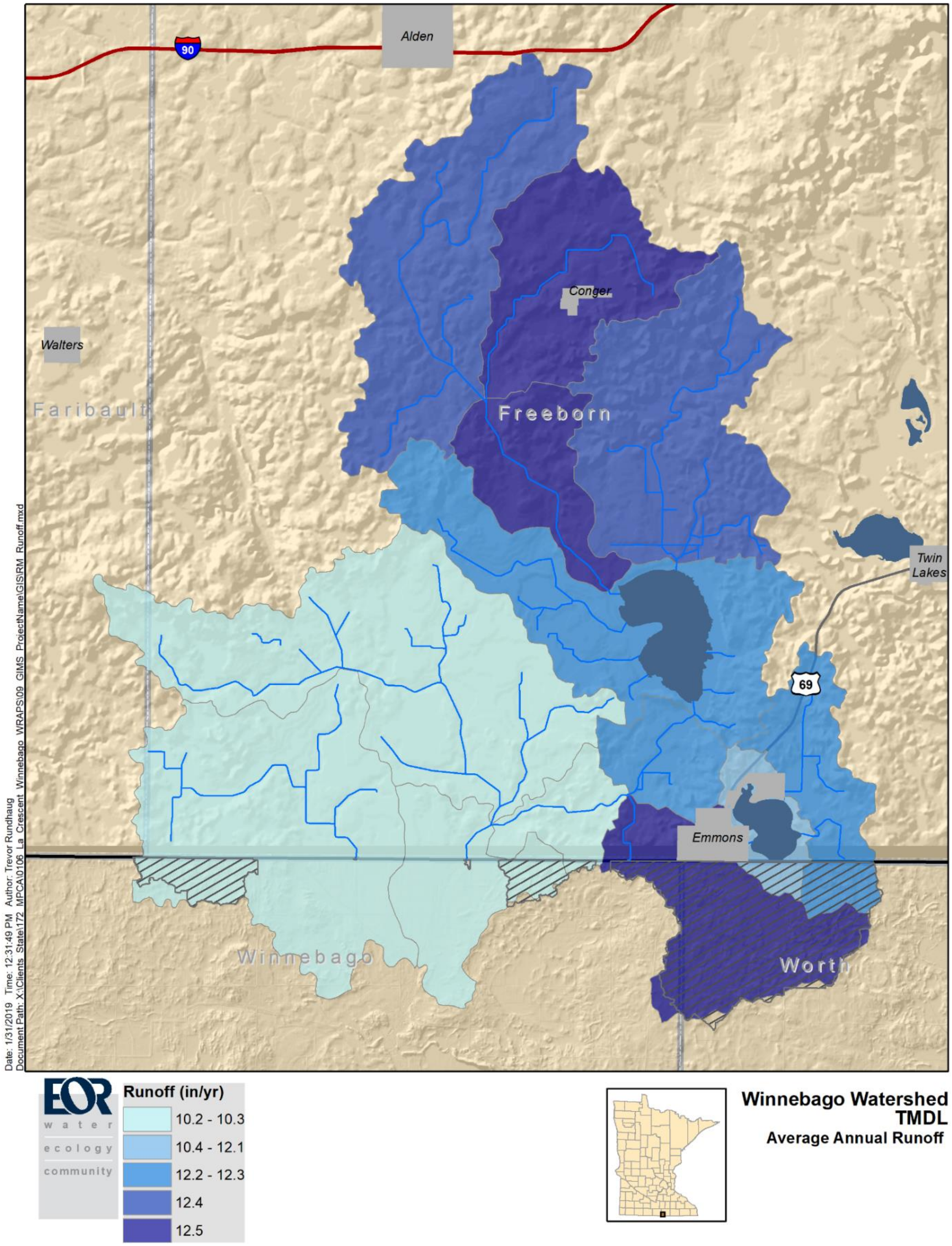


Figure 3-11. HSPF 1996-2012 average annual runoff (in/yr) by subwatershed.

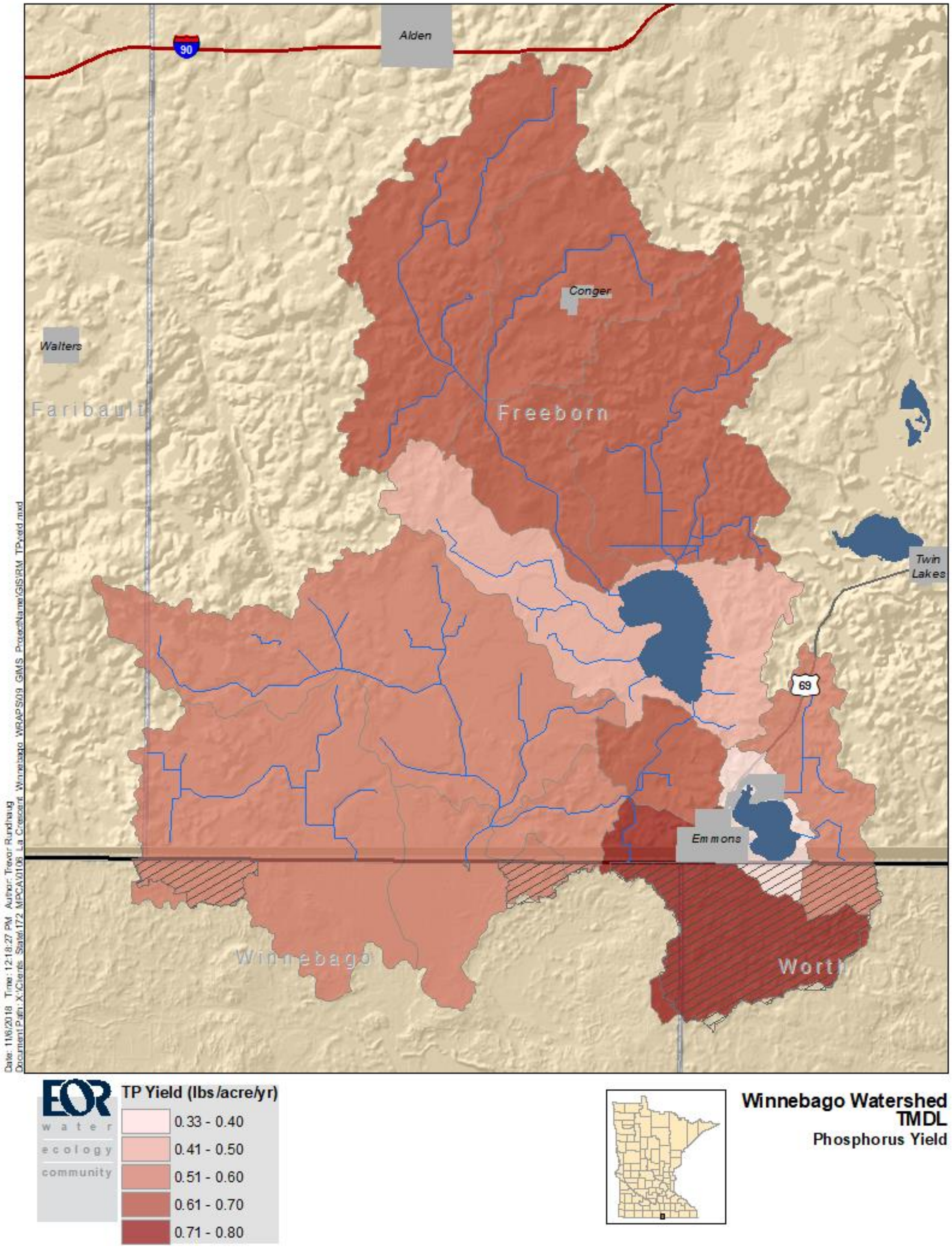


Figure 3-12. HSPF 1996-2012 average annual TP yields (lbs/acre/yr) by subwatershed.

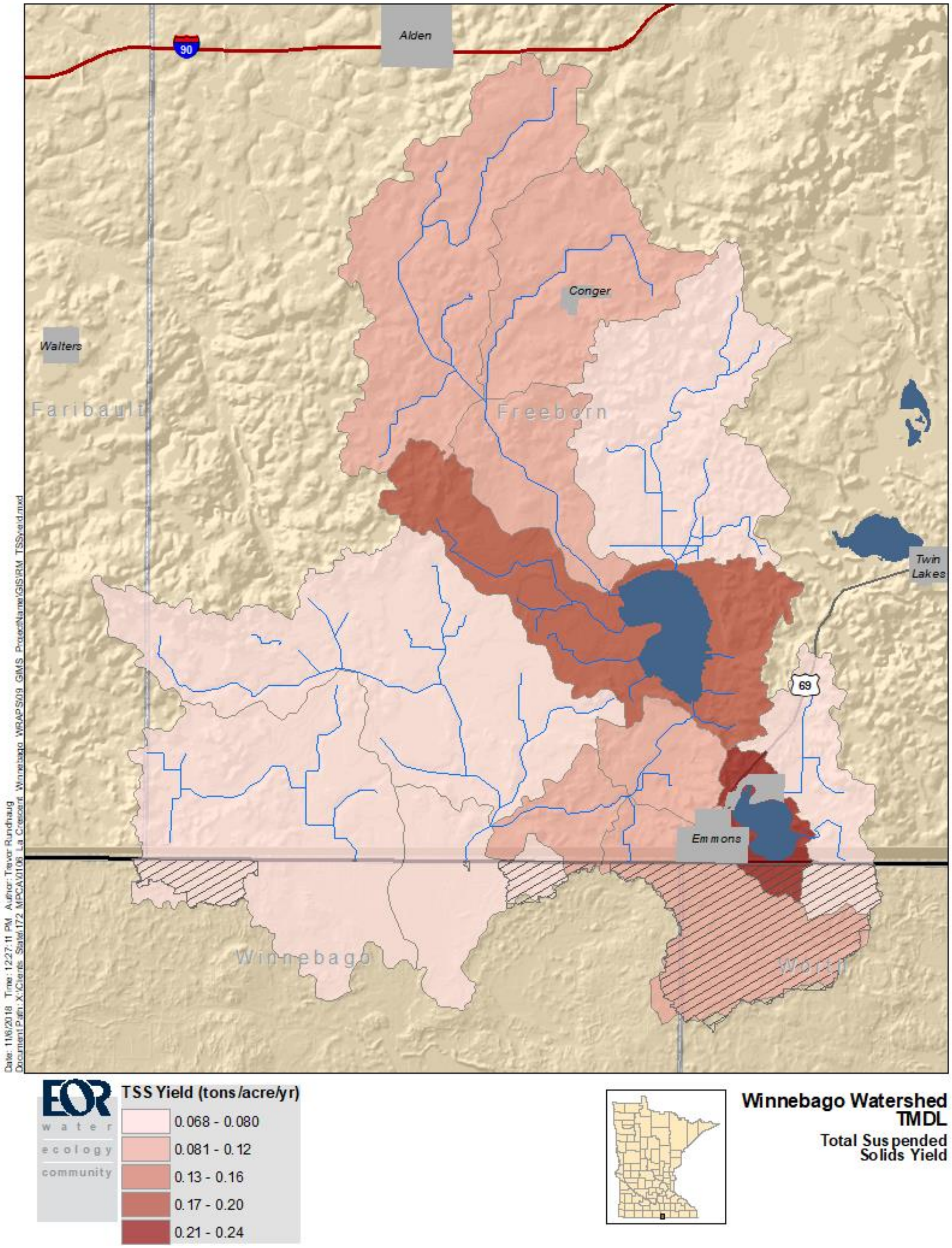


Figure 3-13. HSPF 1996-2012 average annual TSS yield (tons/acre/yr) by subwatershed.

Agricultural Runoff

In the Cedar River Basin, which the Winnebago lies within, cropland and pasture runoff represents more than 20% of the total basin loading for average flows and high flows, and 10% to 20% of the loading under low flow conditions (Barr Engineering 2004). In the WRW TP was distributed based on land cover. The model predicted that 90% of the TP at the outlet of the watershed comes from cropland. This is equivalent to a total annual load of 12,390 lb/yr.

Tile Drainage

Another source of TP in the WRW is tile drainage with surface inlets. Tile drains are designed to remove excess water off the landscape efficiently. In the process, nutrients that would have otherwise been trapped in the soil and vegetation is transported to nearby waterbodies. TP loads from tile drainage are not explicitly quantified in the HSPF model but are implicitly included in the overall load estimates

3.6.2.3 Stream *E. coli* Source Summary

Humans, pets, livestock, and wildlife all contribute bacteria to the environment. These bacteria, after appearing in animal waste, are dispersed throughout the environment by an array of natural and human-made mechanisms. Bacteria fate and transport is affected by disposal and treatment mechanisms, methods of manure reuse, imperviousness of land surfaces, and natural decay and die-off due to environmental factors such as ultraviolet (UV) exposure and detention time in the landscape. These mechanisms add a degree of complexity and variability. Bacterial sources are considered with a general risk perspective that involves both prevalence of the source and the runoff/delivery pathways. Two examples of this approach can be illustrated on the “two ends” of the bacteria LDCs, which follow in Section 4.2. On the low-flow end (dry and low flow zones), municipal wastewater and SSTS sources are more critical. During higher flows (high and very high flow zones), the sources that correlate positively with runoff are the most critical – such as urban stormwater, pastures close to streams, feedlots with runoff pollution hazards, and manure applied to agricultural fields. During intermediate flows, a mix of sources may be present. Across the flow spectrum, the natural growth and reproduction of bacteria in sediments and soils can occur, and this can augment the bacterial community associated with runoff. Overall, with limited indicator group bacterial data sets at some stream sites in the WRW, this more simplified general risk approach process is appropriate. The following discussion highlights sources of bacteria in the environment and mechanisms that drive the delivery of bacteria to surface waters.

The following text is excerpted and adapted from *the Revised Regional TMDL Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Minnesota* (MPCA 2006) and provides a description of nonpoint sources of fecal coliforms, *E. coli*, and associated pathogens. At the time of the study Minnesota’s water quality standard was based on fecal coliform bacteria. Since that time, the standard was changed to *E. coli*.

The relationship between land use and fecal coliform concentrations found in streams is complex, involving both pollutant transport and rate of survival in different types of aquatic environments. Intensive sampling at several of the sites listed above in southeastern Minnesota shows a strongly positive correlation between stream flow, precipitation, and fecal coliform bacteria concentrations. In the Vermillion River Watershed, storm-event samples often showed concentrations in the thousands of organisms per 100 mL, far above non-storm-event samples. A study of the Straight River Watershed divided sources into continuous (failing individual sewage treatment systems [ISTS], unsewered communities, industrial and institutional sources, wastewater treatment facilities [WWTFs]) and weather-driven (feedlot runoff, manured fields, urban stormwater categories). The study hypothesized that when precipitation and stream flows are high, the influence of continuous sources is overshadowed by weather-driven sources, which generate extremely high fecal coliform concentrations. However, during drought, low-flow conditions continuous sources can generate high concentrations of fecal coliform, the study indicated. Besides precipitation and flow, factors such as temperature, livestock management practices, wildlife activity, fecal deposit age, and channel and bank storage also affect bacterial concentrations in runoff (Baxter-Potter and Gilliland 1988).

Several studies have found a strong correlation between livestock grazing and fecal coliform levels in streams running through pastures. Several samples taken in the Grindstone River in the St. Croix River Basin, downstream of cattle observed to be in the stream, were found to contain a geometric mean of 11,000 organisms/100 mL, with individual samples ranging as high as 110,000 organisms/100 mL. However, carefully managed grazing can be beneficial to stream water quality. A study of southeastern Minnesota streams by Sovell, et. al., found that fecal coliform, as well as turbidity, were consistently higher at continuously grazed sites than at rotationally grazed sites where cattle exposure to the stream corridor was greatly reduced. This study and several others indicate that sediment-embeddedness, turbidity, and fecal coliform concentrations are positively related. Fine sediment particles in the streambed can serve as a substrate harboring fecal coliform bacteria. “Extended survival of fecal bacteria in sediment can obscure the source and extent of fecal contamination in agricultural settings,” (Howell et. al. 1996).

Despite the complexity of the relationship between sources and in-stream concentrations of fecal coliform, the following can be considered major source categories.

Individual Sewage Treatment Systems

“Failing” SSTSs are specifically defined as systems that are failing to protect groundwater from contamination. Failing SSTS were not considered a significant source of fecal pollution to surface water. However, systems which discharge partially treated sewage to the ground surface, road ditches, tile lines, and directly into streams, rivers, and lakes are considered an imminent public health threat (IPHT). IPHT systems also include illicit discharges from unsewered communities (sometimes called “straight-pipes”). Straight pipes are illegal and pose an imminent threat to public health as they convey raw sewage from homes and businesses directly to surface water. Community straight pipes are more commonly found in small rural communities. There are no identified unsewered communities in the WRW.

IPHT data are derived from surveys by County staff and County level Subsurface Sewage Treatment System (SSTS) status inventories. In Freeborn County, 14% of all SSTS were IPHT in 2018. There are only two SSTS located in Faribault County within the WRW.

Pets

Human pets (dogs and cats) can contribute bacteria to a watershed when their waste is not properly managed. When this occurs, bacteria can be introduced to waterways from:

- Dog parks
- Residential yard runoff (spring runoff after winter accumulation)
- Areas where there are no pet cleanup ordinances (rural and city)
- Animal elimination of excrement directly into waterbodies

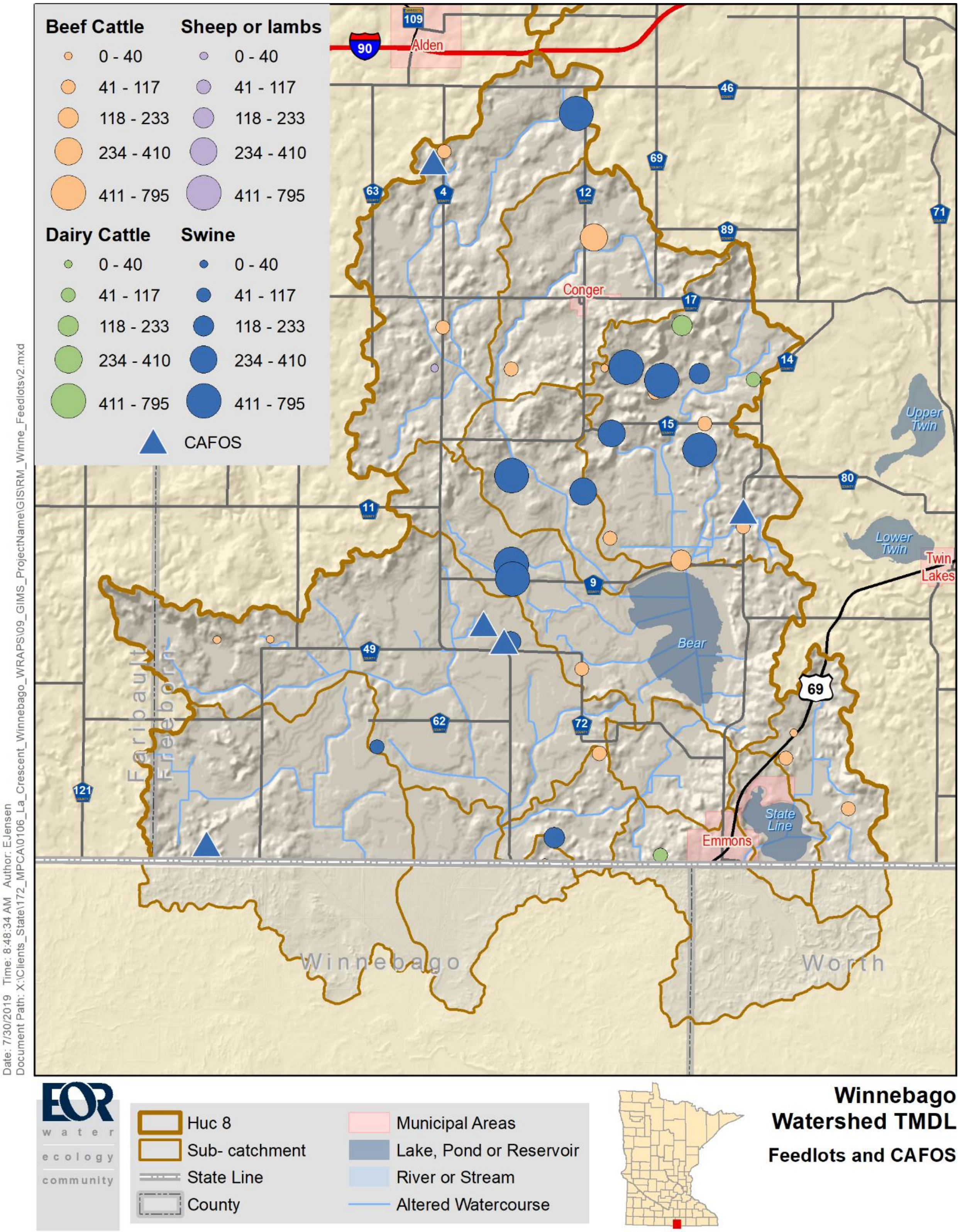
Dog waste can be a significant source of pathogen contamination of water resources (Geldreich 1996). Dog waste in the immediate vicinity of a waterway could be a significant local source with local water quality impacts. However, it is generally thought that these sources may be only minor contributors of fecal contamination on a watershed scale because the estimated magnitude of this source is very small compared to other sources in the WRW due to the small human population.

Livestock

Livestock are potential sources of fecal bacteria to streams in the WRW, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas. There are a total number of 56 registered feedlots in the WRW.

Animal waste from non-permitted AFOs can be delivered to surface waters from failure of manure containment, runoff from the AFO itself, or runoff from nearby fields where the manure is applied. While a full accounting of the fate and transport of manure was not accounted for in this project, a large portion of it is ultimately applied to the land surface and, therefore, this source is of concern. Minn. R. 7020.2225 contains several requirements for land application of manure; however, there are no explicit requirements for *E. coli* or bacteria treatment prior to land application. Manure practices that inject or incorporate manure pose lower risk to surface waters than surface application with little or no incorporation. In addition, manure application on frozen/snow covered ground in late winter months presents a high risk for runoff (Frame et al. 2012). Registered feedlots are mapped in Figure 3-14.

Figure 3-14. Number of animal units per feedlot classified by primary livestock type.



Wildlife

In the rural portions of the project area, deer, waterfowl, and other animals can be *E. coli* sources, with greater numbers in remnant natural areas, wetlands and lakes, and river and stream corridors. Deer densities in the WRW range from five to seven animals per square mile (Norton and Giudice 2017). Large geese populations near and within developed areas can also be of concern. Due to the relatively low density of deer compared to livestock in the watershed, wildlife is likely not a major contributor to *E. coli* in surface waters in the WRW.

Natural growth/reproduction of bacteria

Research in the last 15 years has found the persistence of *E. coli* in soil, beach sand, and sediments throughout the year in the north central United States without the continuous presence of sewage or mammalian sources. An Alaskan study (Adhikari et al. 2007) found that total coliform bacteria in soil were able to survive for six months in subfreezing conditions. A study of cold water streams in southeastern Minnesota completed by the MPCA staff found the resuspension of *E. coli* in the stream water column due to stream sediment disturbance. A recent study near Duluth, Minnesota (Ishii et al. 2010) found that *E. coli* were able to grow in agricultural field soil. A study by Chandrasekaran et al. (2015) of ditch sediment in the Seven Mile Creek watershed in southern Minnesota found that strains of *E. coli* had become naturalized to the water−sediment ecosystem. Survival and growth of fecal coliform has also been documented in stormsewer sediment in Michigan (Marino and Gannon 1991).

4 TMDL Development

This section presents the overall approach to estimating the components of the TMDLs. The pollutant sources were first identified and estimated in the pollutant source assessment. The loading capacity (TMDL) of each lake or stream was then estimated using an in-lake water quality response model or stream load duration curve, and was divided among WLAs and LAs. A TMDL for a water body that is impaired, as the result of excessive loading of a particular pollutant, can be described by the following equation:

$$\text{TMDL} = \text{LC} = \sum \text{WLA} + \sum \text{LA} + \text{MOS} + \text{RC}$$

Where:

Loading capacity (LC): the greatest pollutant load a water body can receive without violating water quality standards;

Wasteload allocation (WLA): the pollutant load that is allocated to point sources, including WWTFs, regulated construction stormwater, and regulated industrial stormwater, all covered under NPDES permits for a current or future permitted pollutant source;

Load allocation (LA): the pollutant load that is allocated to sources not requiring NPDES permit coverage, including non-regulated stormwater runoff, atmospheric deposition, and internal loading;

Margin of Safety (MOS): an accounting of uncertainty about the relationship between pollutant loads and receiving water quality;

Reserve Capacity (RC): the portion of the loading capacity attributed to the growth of existing and future load sources.

4.1 Natural background consideration

"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) defines natural background as "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."

Natural background was given consideration in the development of LA in this TMDL. Natural background is the landscape condition that occurs outside of human influence. Natural background conditions refer to 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, and loading from forested land, wildlife, etc. For each impairment, natural background levels are implicitly incorporated in the water quality standards used by the MPCA to determine/assess impairment and therefore natural background is accounted for and addressed through the MPCA's water body assessment process. Natural background conditions were also evaluated, where possible, within the modeling and source assessment portion of this study. The source assessment exercises indicate that natural background inputs are generally low compared to livestock, cropland, failing SSTSs, and other anthropogenic sources.

Based on the MPCA's waterbody assessment process and the TMDL source assessment exercises, there is no evidence at this time to suggest that natural background sources are a major driver of any of the impairments and/or affect the waterbodies' ability to meet state water quality standards. For all impairments addressed in this TMDL study, natural background sources are implicitly included in the LA portion of the TMDL allocation tables and TMDL reductions should focus on the major anthropogenic sources identified in the source assessment. Federal law instructs an agency to distinguish between natural and nonpoint source loads "[w]herever possible." 40 CFR § 130.2(g). However, Minnesota law does not compel the MPCA to develop a separate LA for natural background sources, distinct from nonpoint sources.

4.2 Phosphorus

4.2.1 Loading Capacity

4.2.1.1 Lake Response Model

The modeling software BATHTUB (Version 6.1) was selected to link P loads with in-lake water quality. A publicly available model, BATHTUB was developed by William W. Walker for the U.S. Army Corps of Engineers (Walker 1999). It has been used successfully in many lake studies in Minnesota and throughout the United States. BATHTUB is a steady-state annual or seasonal model that predicts a lake's summer (June through September) mean surface water quality. BATHTUB's time-scales are appropriate because watershed P loads are determined on an annual or seasonal basis, and the summer season is critical for lake use and ecological health. BATHTUB has built-in statistical calculations that account for data variability and provide a means for estimating confidence in model predictions. The heart of BATHTUB is a mass-balance P model that accounts for water and P inputs from tributaries, watershed runoff, the atmosphere, sources internal to the lake, and groundwater; and outputs through the lake outlet, water loss via evaporation, and P sedimentation and retention in the lake sediments.

System Representation in Model

In typical applications of BATHTUB, lake and reservoir systems are represented by a set of segments and tributaries. Segments are the basins (lakes, reservoirs, etc.) or portions of basins for which water quality parameters are being estimated, and tributaries are the defined inputs of flow and pollutant loading to a particular segment. For this study, the direct drainage runoff and outflow from an upstream tributary (e.g., Steward Creek) were defined as separate tributaries to each lake (i.e., segment).

Model Inputs

The input required to run the BATHTUB model includes lake geometry, climate data, and water quality and flow data for runoff contributing to the lake. Observed lake water quality data are also entered into the BATHTUB program in order to facilitate model verification and calibration. Lake segment inputs are listed in Table 4-1; tributary inputs are listed in Table 4-2. Average annual precipitation rates are based on the Minnesota Climatology Working Group Gridded Precipitation Database of annual average precipitation for 2008 through 2017 (http://climateapps.dnr.state.mn.us/index.htm) at the centroid of each impaired lake. Average annual evaporation rates are based on the University of Minnesota St. Paul Campus Pan Evaporation measurements for 2008 through 2017 (https://www.dnr.state.mn.us/climate/wxsta/pan-evaporation.html), multiplied by a pan evaporation coefficient of 0.795. Precipitation and evaporation rates apply only to the lake surface areas. Average P atmospheric deposition loading rates were estimated to be 0.469 kilograms per hectare per year (kg/ha-yr) for the greater Cedar River Basin (Barr 2007), applied over each lake's surface area.

Table 4-1. BATHTUB segment input data for impaired lakes.

Impaired Lake	Average Annual Precipitation (m/yr)	Average Annual Evaporation (m/yr)	Surface area (km^2)	Lake fetch (km)	Mean depth (m)	Total Phosphorus	
						(µg/L)	CV (%)
Bear	**0.870**	**0.722**	**6.3131**	**3.5662**	**0.91**	**262**	**11%**
State Line Lake	**0.865**	**0.722**	**1.8009**	**2.0574**	**0.88**	**550**	**12%**

CV = coefficient of variation, defined in BATHTUB as the standard error divided by the mean

Table 4-2. BATHTUB tributary input data for impaired lakes.

Impaired Lake	Tributary	Drainage area (km^2)	TP Conc. (µg/L)	Flow (hm3/yr)
Bear Lake	Bear Direct Drainage*	18.3322	210.4	6.3597
	Unnamed Creek (-509)	24.4160	215.5	7.6727
	Steward Creek (-504)	51.7096	211.5	16.3520
State Line Lake	State Line Direct Drainage*	2.8322	176.8	0.9964
	Unnamed Creek (-508)	9.2141	198.7	2.8734

* TP concentration includes phosphorus load from HSPF runoff, septic systems, and livestock

Model Equations

BATHTUB allows a choice among several different P sedimentation models. The Canfield-Bachmann Lake P sedimentation model (Canfield and Bachmann 1981) best represents the lake water quality response of Minnesota lakes, and is the model used by the majority of lake TMDLs in Minnesota. In order to perform a uniform analysis, Canfield-Bachmann Lakes was selected as the standard equation for the study. However, the Canfield-Bachmann Lakes P sedimentation model tends to under-predict the amount of internal loading in shallow, frequently mixing lakes.

Model Calibration

The lake models were calibrated to existing water quality data, found in Table 3-6, and then were used to determine the P loading capacity (TMDL) of each lake.

Because some amount of internal loading is explicit in the BATHTUB lake water quality model, the calibrated internal loading rates from the BATHTUB model represents the excess sediment release rate beyond the average background release rate accounted for by the model development lake dataset. The BATHTUB model development lake dataset is less representative of the shallow lake type and therefore accounts for less implicit internal loading in shallow lakes.

When the predicted in-lake TP concentration was *lower* than the average observed (monitored) concentration, an explicit additional load was added to calibrate the model. It is widely recognized that Minnesota lakes in agricultural regions have histories of high P loading and/or very poor water quality. For this reason, it is reasonable that internal loading may be higher than that of the lakes in the data set used to derive the Canfield-Bachmann lakes formulation.

Due to the extremely shallow nature and the turbid water, algae-dominated state conditions in Bear and State Line Lakes, the very large amount of excess internal loading needed to calibrate the lake BATHTUB models to existing conditions represents the imbalance between P loading and in-lake P concentrations under turbid water, algae-dominated conditions (refer to the hysteresis) relationship between P loading and algae biomass in shallow lakes, as discussed in Section 3.5.2.2.

Determination of Lake Loading Capacity

Using the existing conditions model as a starting point, excess internal loading was first reduced to 0 to represent the shift from a turbid water, algae-dominated state to a clear water, plant-dominated state. Then the P concentrations associated with tributaries were reduced to 175 ppb for State Line Lake and 141 ppb for Bear Lake, such that the model indicated that the TP state standard was met, to the nearest whole number. Minnesota lake water quality standards are based on a large lake database that establishes a clear relationship between TP, Chl-*a*, and Secchi transparency (Heiskary and Wilson 2005). When the TP standard is met, the Chl-*a* and Secchi transparency standards will likewise be met (see *Section 2.1.1 Applicable Water Quality Standards*). With this process, a series of models were developed that included a level of P loading consistent with lake water quality state standards, or the TMDL goal. Actual load values are calculated within the BATHTUB software, so loads from the TMDL goal models could be compared to the loads from the existing conditions models to determine the amount of load reduction required.

4.2.1.2 Stream Load Capacity and Load Reductions

In order to align with the RES, the loading capacity is based on the seasonal (June through September) average of the midpoint flows of five equally spaced flow zones: 0% to 20%, 20% to 40%, 40% to 60%, 60% to 80%, and 80% to 100% of flow exceedance. In other words, the average seasonal flow is the average of the 10%, 30%, 50%, 70%, and 90% of flow exceedances. (Figure 4-1). This type of averaging was used over a simple average of all flows in order to limit the bias of very high flows on P loading, recognizing that the effects of P (i.e., algal growth) are most problematic at lower flows.

Note that these five flow zones are divided up differently than those used for the *E. coli* TMDL. The P approach is based on using an average of the five flow zones, and having five “equally-sized” zones avoids weighting some zones more than others when calculating the average. The loading capacity was calculated as the average seasonal flow multiplied by the South RNR TP standard of 150 µg/L.

The existing concentration of each impaired reach was calculated as the average of the seasonal (June through September) average P concentrations of the years of available data. The overall estimated concentration-based percent reduction needed to meet each TMDL was calculated as the existing concentration minus the TP standard (150 µg/L), divided by the existing concentration.

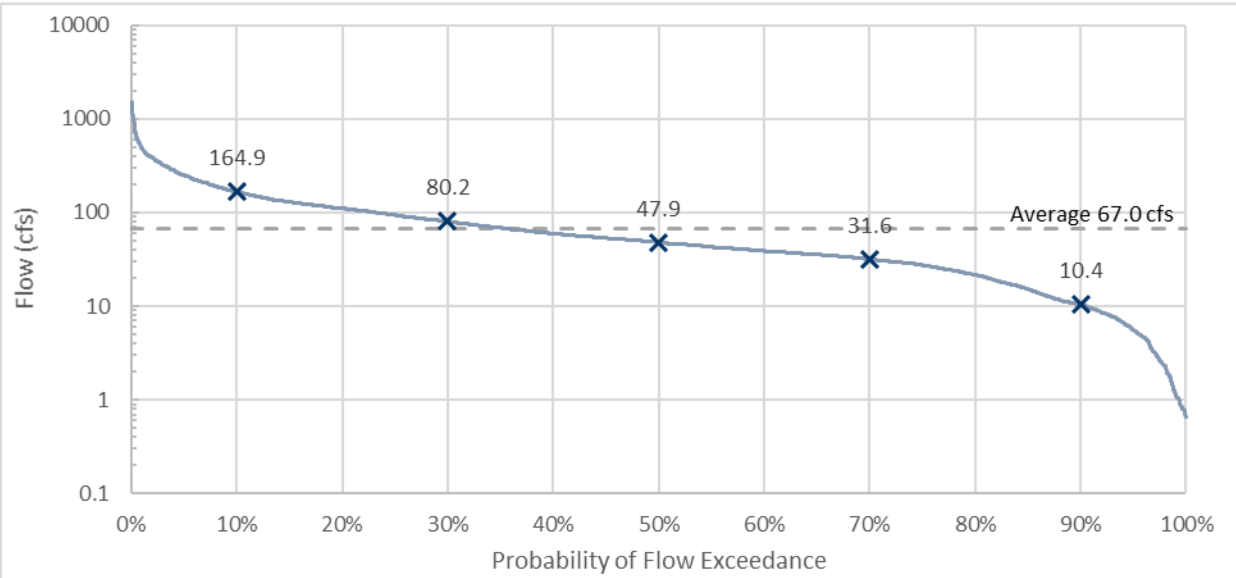


Figure 4-1. Flow duration curve from Lime Creek (AUID-501) to illustrate calculation of average seasonal flow.

4.2.2 Load Allocation

The LA represents the portion of the loading capacity designated for nonpoint sources of P. The LA includes all sources of P that do not require NPDES permit coverage, including unregulated watershed runoff, internal loading, groundwater, and atmospheric deposition, a consideration for natural background conditions, and any other identified loads are described in Section 3.6.2.2 The LA is calculated as the remaining portion of the LC once the WLA and MOS are subtracted for each impaired lake or stream. The remainder of the LA, after subtraction of atmospheric deposition LA and internal loading LA, was used to determine the watershed runoff LA for each impaired lake or stream on an areal basis.

4.2.3 Wasteload Allocation

All regulated stormwater and wastewater were assigned a WLA based on the methods described in the following section.

4.2.3.1 MS4 Regulated Stormwater

There is no Municipal Separate Storm Sewer Systems (MS4) regulated stormwater in the WRW.

4.2.3.2 Regulated Construction Stormwater

A categorical WLA was assigned to all construction activity in each impaired stream or lake subwatershed. First, the average annual fraction of the watershed area under construction activity over the past five years, was calculated based on MPCA Construction Stormwater Permit data from January 1, 2014, to January 1, 2019. This fraction, calculated to be 0.25% of the watershed, was multiplied by the watershed runoff load component to determine the construction stormwater WLA. The watershed runoff load component is equal to the total TMDL (loading capacity) minus the sum of the non-watershed runoff load components (upstream loads, internal loads, and MOS) and any WLAs.

4.2.3.3 Regulated Industrial Stormwater

There are currently no industrial stormwater permits in the watershed. A categorical industrial stormwater WLA was set equal to the construction stormwater WLA in the event of future industrial stormwater activity.

4.2.3.4 Animal Feeding Operations

There are two NPDES permitted AFOs in the direct drainage area of one P impaired lake (Bear Lake). Due to the requirement of permitted AFOs to completely contain runoff, facilities that are permit compliant are not a source of P to surface waters and these facilities were assigned a zero WLA consistent with the conditions of the permit.

4.2.3.5 Municipal and Industrial Wastewater Treatment Systems

Individual WLAs were provided for two NPDES-permitted WWTF that discharge within a P impaired lake or stream subwatershed including: Conger WWTF within the Bear Lake (24-0028-00) Subwatershed and the Emmons WWTF within the Lime Creek (07080203-501) Subwatershed. The MPCA recently completed a watershed-based review of TP effluent limits for these two WWTFs. The Conger WWTF is a pond system with intermittent discharge. Based on six inches of discharge per day from the secondary pond, the design flow for this facility is 0.28 mgd. Currently, the Conger WWTF has an annual TP limit of 72 kg/yr (Table 4-3) and the MPCA determined that a more restrictive TP limit is not presently needed. The Emmons WWTF is a continuous mechanical system with a design flow of 0.124 mgd. The TP limit for the Emmons WWTF has been established by the MPCA at a limit of 1.1 kg/day. This limit will be added to their permit when it is renewed in May 2023 (Table 4-3). This new TP effluent limit for Emmons WWTF should be attainable as this facility currently discharges only about 0.38 kg/d, on average, during the summer, about a third of their new 1.1 kg/d limit.

Table 4-3. Summary of TP effluent limits for facilities in the Winnebago River Watershed.
The Conger WWTF limit addresses the Bear Lake eutrophication (phosphorus) TMDL, and the Emmons WWTF limit addresses the Lime Creek Eutrophication (phosphorus) TMDL. The Conger WWTF is applicable from January through December whereas the Emmons WWTF daily limit is applicable from June through September. SDR and WLA abbreviate state discharge restriction and wasteload allocation, correspondingly.

Domestic Facilities (Impaired Reach)	Permit ID	Type	Action	SDR Limit (mg/L)[a]	Annual Average Limit (kg/yr)[b]	River WLA (kg/d)[c]	June-Sept. Daily Limit (kg/d)[d]
Conger WWTF (24-0028-00)	MN0068519	Pond	Limit	–	72	–	–
Emmons WWTF (-501)	MN0023311	Continuous	Limit	–		1.1	1.1

[a]SDR limits derive from Minn. R. 7053.0255 and are calendar month average limits.
[b]These limits are calendar year to date, total.
[c]WLAs must be met as long-term averages.
[d]These limits are calendar month averages.

The MPCA determined a WLA for Emmons WWTF with an HSPF model of the WRW. The MPCA created a limit scenario in which the P concentrations of both impaired lakes in the WRW – State Line Lake (WID: 24-0030-00) and Bear Lake (WID: 24-0028-00) are capped at the LES criterion (90 µg/L). Recall, State Line Lake is upstream of Emmons WWTF; Bear Lake drains to Lime Creek (WID: 07080203-501), which is downstream of Emmons WWTF. For all model runs of the limit scenario, Conger and Emmons WWTF discharged constantly at their average wet weather design flow (AWWDF), for their full allowable discharge period, and, in the case of Conger WWTF, at their maximum permitted P load given their water quality based effluent limit (WQBEL). Additionally, the model runs entailed slight modifications to the P discharge of Emmons WWTF so that MPCA was able to determine a WLA for Emmons WWTF that would ensure Lime Creek meets the RES TP criterion (150 µg/L). The limit scenario results were compared to the baseline scenario in which point sources, non-point sources, and environmental variables occurred at their historical levels.

Emmons WWTF discharging at a TP concentration of 3.5 mg/L will result in the long-term summer average TP concentration of Lime Creek (WID: 07080203-501) being less than the RES TP criterion (150 µg/L), see Figure 4-2. As a long-term summer average, the TP concentration will decrease from 180 µg/L to 127 µg/L as a result of Emmons discharging at a 3.5 mg/L TP concentration on average, as well as Bear (WID: 24-0028-00) and State Line (WID 24-0030-00) Lakes meeting LES criteria.

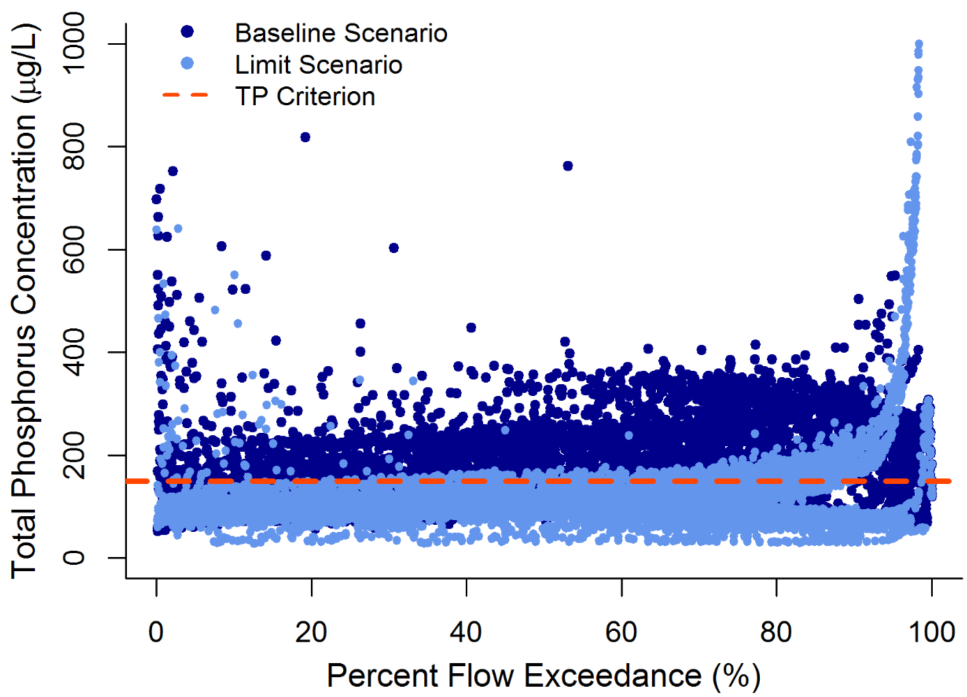


Figure 4-2. HSPF model results for Lime Creek (WID: 07080203-501).

The Baseline scenario entails the point sources operating at their historical discharges and without caps on the P concentrations of Bear (WID: 24-0028-00) and State Line (WID: 24-0030-00) Lakes. The limit scenario sets caps on the P concentrations of Bear and State Line Lakes, has Conger WWTF operating at its maximum permitted levels, and has Emmons WWTF operating at its AWWDF and discharging effluent at a 3.5 mg/L concentration. All data are for the applicable RES time period (June-September).

Given that HSPF model results show that Emmons WWTF must discharge effluent with a TP concentration of 3.5 mg/L, on average, in order for Lime Creek (WID: 07080203-501) to eventually meet RES, we calculate a WLA for this facility using a TP concentration of 3.5 mg/L. Additionally, we use a flow value for this facility of 70% of their AWWD since, typically, operation does not exceed this value. We calculate a WLA for Emmons WWTF of 1.1 kg/d, see Equation 1.

Equation 1. Calculation of Emmons WWTF's WLA.

$$0.7 \times 0.124\ \frac{Mgal}{d} \times 3.5\ \frac{mg}{L} \times 3.785\ \frac{L}{gal} \times \frac{10^6 gal}{Mgal} \times \frac{1\ kg}{10^6 mg} = 1.1\ \frac{kg}{d}$$

4.2.4 Margin of Safety

An explicit 10% MOS was accounted for in the TMDL for each impaired lake. This MOS is sufficient to account for uncertainties in predicting P loads to lakes and predicting how lakes respond to changes in P loading. This explicit MOS is considered to be appropriate based on:

- BATHTUB model calibration using added internal load with values typical of very shallow, eutrophic lakes (see Section 3.6.1.2: Internal Loading);

- the generally good agreement between BATHTUB model predicted and observed values indicating that the models reasonably reflect the conditions in the lakes and their subwatersheds; and
- three or more years of in-lake water quality data used to calibrate the BATHTUB model.

An explicit MOS equal to 10% of the loading capacity was used for the stream TMDLs based on the following considerations:

- Most of the uncertainty in flow is the result of extrapolating flows in upstream areas of the watershed based on HSPF model calibration at stream gages near the outlet of the Shell Rock Watershed and Cedar Watershed, the other two watersheds modeled jointly with the WRW. The explicit MOS, in part, accounts for this; and
- Allocations are a function of flow, which varies from high to low flows. This variability is accounted for through the development of a TMDL for each of five flow regimes.

4.2.5 Seasonal Variation

In-lake and in-stream water quality varies seasonally. In Minnesota lakes and streams, the majority of the watershed P load often enters the lake during spring runoff. During the growing season months (June through September), P concentrations may not change drastically if major runoff events do not occur. However, Chl-*a* concentrations generally peak during growing season due to warmer temperatures that foster higher algal growth rates. The growing season also corresponds to the peak recreational period for Minnesota lakes and streams. This seasonal variation in water quality and growing season critical condition is taken into account in the TMDL by using the eutrophication standards (which are based on growing season averages) as the TMDL goals. The load reductions are designed so that the lakes and streams will meet the water quality standards over the course of the growing season when algae levels are typically highest (June through September).

4.2.6 TMDL Summary

4.2.6.1 Lime Creek (07080203-501)

- **303(d) listing year: 2018**
- **Baseline year: 2012**

Table 4-4. Lime Creek (07080203-501) Seasonal (June – September) Phosphorus TMDL and Allocations

Lime Creek 07080203-501 Load Component		Existing TP load	Allowable TP load	Estimated load reduction[b]	
		(lb/d)	(lb/d)	(lb/d)	(%)
Wasteload Allocations	*Emmons WWTP (MN0023311)*	*2.43*	*2.43*	*0.00*	0%
	Construction Stormwater	*0.07*	*0.06*	*0.00*	0%
	Industrial Stormwater	*0.07*	*0.06*	*0.00*	0%
	Total WLA	**2.57**	**2.57**	**0.00**	0%
Load Allocations	*Bear Lake (24-0028-00)*	*26.98*	*18.52*	*8.46*	31%
	Stateline Lake (24-0030-00)	*3.54*	*2.38*	*1.16*	33%
	Watershed Runoff	*31.41*	*25.34*	*6.07*	19%
	Total LA	**61.93**	**46.24**	**15.69**	
10% MOS			**5.42**		
Total		**64.50** [a]	**54.23**	**15.69**	27%

Applicable TP criterion: 150 µg/L
Allowable TP loads applied as calendar month averages, June-September
[a] Existing load is based on the model predicted summer average flow and observed TP concentrations
[b] The total reduction from existing loads to the goal were distributed to the LAs based on drainage area

4.2.6.2 Bear Lake (24-0028-00)

- **303(d) listing year: 2018**
- **Baseline year: 2012**

Table 4-5. Bear Lake (24-0028-00) Total Phosphorus TMDL and Allocations.

TMDL parameter		Existing TP load	Allowable TP load		Estimated load reduction	
Sources		(lb/yr)	(lb/yr)	(lb/day)	(lb/yr)	(%)
Wasteload Allocations	Construction stormwater (MNR100001)	4.41	4.41	0.012	0.0	0%
	Industrial stormwater (MNR500000)	4.41	4.41	0.012	0.0	0%
	Conger WWTF (MN0068519)	158.7	158.7	0.43	0.0	0%
	Total WLA	**167.52**	**167.52**	**0.454**	**0.0**	
Load Allocations	Direct Drainage Runoff	3,114.7	1,598.0	4.376	1,516.7	49%
	Unnamed Creek (-506)	3,645.2	2,130.1	5.831	1,515.2	42%
	Steward Creek (-504)	7,624.5	4,539.6	12.430	3,084.9	40%
	Excess Internal Load	24,299.1	0.0	0.000	24,299.1	100%
	Atmospheric	652.7	652.7	1.788	0.0	0%
	Total LA	**39,266.2**	**8,920.4**	**24.425**	**30,345.8**	
MOS			**1,009.8**	**2.765**		
TOTAL		**39,503.8**	**10,097.72**	**27.644**	**30,415.9**	**77%**

*LA components are broken down for guidance in implementation planning; loading goals for these components may change through the adaptive implementation process, but the total LA for each lake will not be modified from the total listed in the table above.

Phosphorus Reductions Needed to Meet Water Quality Goal

- 1,517 lb/yr from watershed sources
- 1,505 lb/yr from Unnamed Creek
- 3,085 lb/yr from Steward Creek
- 24,299 lb/yr from excess internal load. Whole-lake drawdowns and aquatic plant and fish management are needed to maintain a clear water, aquatic plant-dominated state and address excess internal loading from the existing turbid water, algae-dominated state (see Section 8.2.3.1). Note that some internal loading is explicit in the BATHTUB lake water quality model based on the average background internal loading rate accounted for by the model development lake dataset. The estimated internal load reduction from the existing and allowable calibrated BATHUB model represents a reduction in all of the excess internal load

beyond background loading rates, but not all of the internal loading present in the lake. Small levels of internal loading are a natural component of lake water quality and will continue even following in-lake management.

Phosphorus Source Summary

- Bear Lake is 1,560 acres with an average depth of 3 feet. The lake is currently in a turbid water, algae-dominated state with sparse aquatic vegetation and a fishery dominated by common carp and black bullheads. The shoreline is mostly undeveloped.
- The lake watershed is 24,901 acres, or 16 times the lake surface area. Approximately 80% of the watershed is row crop agriculture.

4.2.6.3 State Line Lake (24-0030-00)

- **303(d) listing year: 2018**
- **Baseline year: 2012**

Table 4-6. State Line Lake (24-0030-00) Total Phosphorus TMDL and Allocations.

State Line Lake Load Component		Existing	Goal		Reduction	
		(lb/yr)	(lb/yr)	(lb/day)	(lb/yr)	(%)
Wasteload Allocations	Construction stormwater (MNR100001)	0.827	0.827	0.0023	0.0	0%
	Industrial stormwater (MNR500000)	0.827	0.827	0.0023	0.0	0%
	Total WLA	**1.654**	**1.654**	**0.0046**	**0.0**	
	Direct Drainage Runoff	392.9	329.2	0.902	63.7	16%
	Unnamed Creek (-508)	1,258.7	983.8	2.694	274.9	22%
	Excess Internal Load	20,301.9	0.0	0.000	20,301.9	100%
	Atmospheric	186.2	186.2	0.509	0.0	0%
	Total LA	**22,139.7**	**1,499.2**	**4.105**	**20,640.5**	
MOS			**166.8**	**0.456**		
TOTAL		**22,141.4**	**1,667.654**	**4.5656**	**20,640.6**	**93%**

*LA components are broken down for guidance in implementation planning; loading goals for these components may change through the adaptive implementation process, but the total LA for each lake will not be modified from the total listed in the table above.

Phosphorus Reductions Needed to Meet Water Quality Goal

- 64 lb/yr from watershed sources
- 275 lb/yr from Unnamed Creek
- 20,302 lb/yr from excess internal load. Whole-lake drawdowns and aquatic plant and fish management are needed to maintain a clear water, aquatic plant-dominated state and address

excess internal loading from the existing turbid water, algae-dominated state (see Section 8.2.3.1). Note that some internal loading is explicit in the BATHTUB lake water quality model based on the average background internal loading rate accounted for by the model development lake dataset. The estimated internal load reduction from the existing and allowable calibrated BATHUB model represents a reduction in all of the excess internal load beyond background loading rates, but not all of the internal loading present in the lake. Small levels of internal loading are a natural component of lake water quality and will continue even following in-lake management.

Phosphorus Source Summary

- State Line Lake is 445 acres with an average depth of 2.9 feet. The lake is currently in a turbid water, algae-dominated state with sparse aquatic vegetation and a fishery dominated by common carp and black bullheads. The shoreland is mostly undeveloped.
- The lake watershed is 3,422 acres, or eight times the lake surface area. Approximately 56% of the watershed is row crop agriculture, and 17% is open water (the lake surface).

4.2.7 TMDL Baseline

The lake and stream P TMDLs are based on modeling results for the period 1996 through 2012 (see *HSPF modeling*). Any activities implemented during or after 2012 that lead to a reduction in loads or an improvement in an impaired lake or stream water quality may be considered as progress towards meeting a WLA or LA.

4.3 Bacteria (*E. coli*)

4.3.1 Loading Capacity Methodology

The loading capacities for impaired stream reaches receiving a TMDL, as a part of this study, were determined using load duration curves (LDCs). Flow and LDCs are used to determine the flow conditions (flow regimes) under which exceedances occur. Flow duration curves provide a visual display of the variation in flow rate for the stream. The x-axis of the plot indicates the percentage of time that a flow exceeds the corresponding flow rate as expressed by the y-axis. LDCs take the flow distribution information constructed for the stream and factor in pollutant loading to the analysis. A standard curve is developed by applying a particular pollutant standard or criteria to the stream flow duration curve and is expressed as a load of pollutant per day. The standard curve represents the upper limit of the allowable in-stream pollutant load (loading capacity) at a particular flow. Monitored loads of a pollutant are plotted against this curve to display how they compare to the standard. Monitored values that fall above the curve represent an exceedance of the standard.

For the stream TMDL derivation, HSPF modeled flows for the period 1996 through 2012 were used to develop flow duration curves. The loading capacities were determined by applying the *E. coli* water quality standard (126 org/100 mL) to the flow duration curve to produce a bacteria standard curve. Loading capacities presented in the allocation tables represent the median *E. coli* load (in billion org/day) along the bacteria standard curve within each flow regime. A bacteria load duration curve and a TMDL allocation table are provided for each stream in Section 4.3.6 There were no observations that paired with the model results. Therefore, the TMDL for *E. coli* was based on concentration reductions.

The load duration curve method is based on an analysis that encompasses the cumulative frequency of historical flow data over a specified period. Because this method uses a long-term record of daily flow volumes, virtually the full spectrum of allowable loading capacities is represented by the resulting curve.

4.3.2 Load Allocation Methodology

LAs represent the portion of the loading capacity that is designated for non-regulated sources of *E. coli*, as described in Section 3.6.2.3, that are located downstream of any other impaired waters with TMDLs located in the WRW. The remainder of the loading capacity (TMDL) after subtraction of the MOS and calculation of the WLA was used to determine the LA for each impaired stream, on an aerial basis.

4.3.3 Wasteload Allocation Methodology

All regulated stormwater and wastewater were assigned a WLA based on the methods described in the following section.

4.3.3.1 MS4 Regulated Stormwater

There is no MS4 regulated stormwater in the WRW.

4.3.3.2 Regulated Construction Stormwater

E. coli WLAs for regulated construction stormwater (permit #MNR100001) were not developed since *E. coli* is not a typical pollutant from construction sites.

4.3.3.3 Regulated Industrial Stormwater

There are no *E. coli* benchmarks associated with the industrial stormwater permit because no industrial sectors regulated under the permit are known to be *E. coli* sources. Therefore, *E. coli* TMDLs will not include an industrial stormwater WLA.

4.3.3.4 Animal Feeding Operations

There are no active NPDES permitted feedlot operations (CAFO) within an *E. coli* impaired stream reach drainage area in the WRW. See Section 3.6.1.4 for registered feedlots. Non-CAFO *E. coli* sources are addressed in the LA for the watershed.

4.3.3.5 Municipal and Industrial Waste Water Treatment Systems

An individual WLA was provided for all NPDES-permitted WWTP that have fecal coliform discharge limits (200 org/100 mL, March 1 through October 31) and whose surface discharge stations fall within an impaired stream subwatershed.

The WLAs are based on *E. coli* loads even though the facilities' discharge limits are based on fecal coliform. Like *E. coli*, fecal coliform are an indicator of fecal contamination. The primary function of a bacterial effluent limit is to assure that the effluent is being adequately treated with a disinfectant to assure a complete, or near-complete, kill of fecal bacteria prior to discharge (MPCA 2007 SONAR Book

III). WWTP are required to test fecal coliform bacteria levels in effluent twice per week during discharge. Dischargers to Class 2 waters are required to disinfect their wastewater from April through October, while wastewater disinfection is required during all months for dischargers within 25 miles of a potable water supply system intake (Minn. R. 7053.0215, subp. 1). The geometric mean for all samples collected in a month must not exceed 200 cfu/100 mL fecal coliform bacteria.

The *E. coli* concentration standard of 126 organisms per 100 mL was considered reasonably equivalent to the previous fecal coliform standard of 200 organisms per 100 mL from a public health protection standpoint. The SONAR section that supports this rationale uses a log plot that shows a good relationship between these two parameters. The following regression equation was deemed reasonable to convert any data reported in fecal coliform to *E. coli* equivalents:

E. coli concentration (equivalents) = 1.80 x (Fecal Coliform Concentration)

It should also be noted that most analytical laboratories report *E. coli* in terms of colony forming units per 100 mL (cfu/100 mL), not organisms per 100 mL. This TMDL report will present *E. coli* data in cfu/100 mL since all of the monitored data collected for this TMDL was reported in these units. Bacteria TMDLs were written to achieve the bacteria water quality standard of 126 org/100 mL.

The total daily loading capacity in the low or very low flow zones for some reaches is less than the calculated wastewater treatment allowable load. This is an artifact of using design flows for allocation setting and results in these point sources appearing to use all (or more than) the available loading capacity. In reality, actual treatment facility flow can never exceed stream flow as it is a component of stream flow. To account for these unique situations, the WLAs and LAs in these flow zones where needed are expressed as an equation rather than an absolute number:

Allocation = flow contribution from a given source x 126 org *E. coli*/100 mL

This amounts to assigning a concentration-based limit to these sources for the lower flow zones. By definition rainfall, and thus runoff, is very limited if not absent during low flow. Thus, runoff sources would need little to no allocation for these flow zones.

There is one NPDES-permitted WWTP whose surface discharge stations fall within an *E. coli* impaired stream subwatershed (city of Emmons in the AUID 07080203-501 subwatershed). This WWTP is a mechanical system with continuous discharge and must disinfect from May to October. Bacteria loads from NPDES-permitted WWTP are estimated based on the design flow and permitted bacteria effluent limit of 200 cfu/100 mL (Table 4-7).

Table 4-7. WWTP design flows and permitted bacteria loads.

Stream Reach	Facility Name, Permit #	Design Discharge (mgd)	Permitted Bacteria Load as Fecal Coliform: 200 cfu/ 100 mL [billion cfu/day]	Equivalent Bacteria Load as *E. coli*: 126 cfu / 100 mL[1] [billion cfu/day]
-501	Emmons WWTP, MN0023311	0.124	0.9	0.6

[1] WWTP permits are regulated for fecal coliform, not *E. coli*. The MPCA surface water quality standard for *E. coli* (126 org/100 mL) was used in place of the fecal coliform permitted limit of 200 cfu/100 mL, which was also the MPCA surface water quality standard prior to the March 2008 revisions to Minn. R. ch. 7050.

4.3.4 Margin of Safety

An explicit MOS equal to 10% of the loading capacity was used for the stream TMDLs based on the following considerations:

- Most of the uncertainty in flow is the result of extrapolating flows in upstream areas of the watershed based on HSPF model calibration at stream gauges near the outlet of the Shell Rock Watershed and Cedar Watershed, the other two watersheds modeled jointly with the WRW. The explicit MOS, in part, accounts for this.
- Allocations are a function of flow, which varies from high to low flows. This variability is accounted for through the development of a TMDL for each of five flow regimes.
- The load duration analysis does not address bacteria re-growth in sediments, die-off, and natural background levels. The MOS helps to account for the variability associated with these conditions.

4.3.5 Seasonal Variation

Use of these water bodies for aquatic recreation occurs from April through October, which includes all or portions of the spring, summer, and fall seasons. *E. coli* loading varies with the flow regime and season. Spring is associated with large flows from snowmelt, the summer is associated with the growing season as well as periodic storm events and receding streamflows, and the fall brings increasing precipitation and rapidly changing agricultural landscapes.

Critical conditions and seasonal variation are addressed in this TMDL through several mechanisms. The *E. coli* standard applies during the recreational period, and data was collected throughout this period. The water quality analysis conducted on these data evaluated variability in flow through the use of five flow regimes: from high flows such as flood events, to low flows such as baseflow. Through the use of LDCs and monthly summary figures, *E. coli* loading was evaluated at actual flow conditions at the time of sampling (and by month), and monthly *E. coli* concentrations were evaluated against precipitation and streamflow.

4.3.6 TMDL Baseline

The stream *E. coli* TMDLs are based modeled flows results for the period 1996 through 2012 and water quality data collected from 2015 through 2016. Any activities implemented after the mid-point of the TMDL time period (2013) that lead to a reduction in loads or an improvement in an impaired stream water quality may be considered as progress towards meeting a WLA or LA.

4.3.7 TMDL Summary

4.3.7.1 Lime Creek (07080203-501)

- **303(d) listing year: 2018**
- **Baseline year: 2013**

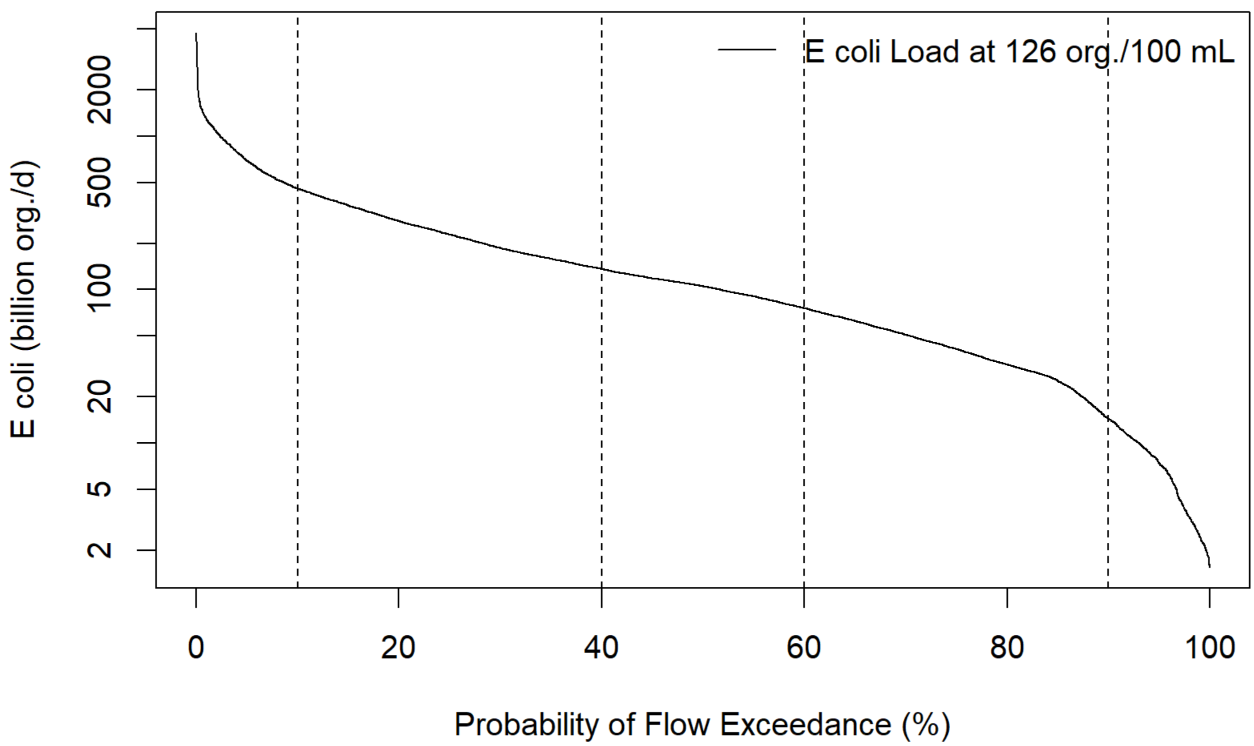


Figure 4-3. Lime Creek (07080203-501) *E. coli* load duration curve

Table 4-8. Lime Creek (07080203-501) *E. coli* TMDL and Allocations

Lime Creek 07080203-501 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		E. coli (billion organisms per day)				
Existing Load		Refer to Section 3.5.5				
Wasteload Allocations	*Emmons WWTP (MN0023311)*	*1*	*1*	*1*	*1*	*1*
	Total WLA	**1**	**1**	**1**	**1**	**1**
Load Allocations	*Watershed Runoff*	*616*	*203*	*93*	*35*	*5*
	Total LA	**616**	**203**	**93**	**35**	**5**
10% MOS		**69**	**23**	**11**	**4**	**1**
Total Loading Capacity		**686**	**227**	**105**	**40**	**7**
Estimated Load Reduction (See Section 3.5.5)		*NA*	*NA*	*NA*	*NA*	*NA*
		NA	*NA*	*NA*	*NA*	*NA*

5 Future Growth/Reserve Capacity

The top economic activity in the WRW is agriculture, with 82% of the land in cultivated cropland. Land use is not expected to change much in the future. In addition, the population in the WRW has declined slightly (Freeborn County: -2.3% and Faribault County: -5%) between 2010 and 2017. Large increases in urban or rural population are not expected in this watershed.

How changing sources of pollutants may or may not impact TMDL allocations are discussed below, in the event that population and land use in the Winnebago Watershed do change over time.

5.1 New or Expanding Permitted MS4 WLA Transfer Process

Note that there are currently no MS4s located in the WRW. Future transfer of watershed runoff loads in this TMDL may be necessary if any of the following scenarios occur within the project watershed boundaries:

1. New development occurs within a regulated MS4. Newly developed areas that are not already included in the WLA must be transferred from the LA to the WLA to account for the growth.
2. One regulated MS4 acquires land from another regulated MS4. Examples include annexation or highway expansions. In these cases, the transfer is WLA to WLA.
3. One or more non-regulated MS4s become regulated. If this has not been accounted for in the WLA, then a transfer must occur from the LA.
4. Expansion of a U.S. Census Bureau Urban Area encompasses new regulated areas for existing permittees. An example is existing state highways that were outside an Urban Area at the time the TMDL was completed, but are now inside a newly expanded Urban Area. This will require either a WLA to WLA transfer or a LA to WLA transfer.
5. A new MS4 or other stormwater-related point source is identified and is covered under a NPDES permit. In this situation, a transfer must occur from the LA.

Load transfers will be based on methods consistent with those used in setting the allocations in this TMDL (see Sections 4.2.3 and 4.3.3). One transfer rate was defined for each impaired stream as the total WLA (in billion org/day) divided by the watershed area downstream of any upstream impaired water body (acres). In the case of a load transfer, the amount transferred from LA to WLA will be based on the area (acres) of land coming under permit coverage multiplied by the transfer rate. The MPCA will make these allocation shifts. In cases where WLA is transferred from or to a regulated MS4, the permittees will be notified of the transfer and have an opportunity to comment.

5.2 New or Expanding Wastewater

There are currently two permitted WWTFs that discharge in the WRW. The MPCA, in coordination with the EPA Region 5, has developed a streamlined process for setting or revising WLAs for new or expanding wastewater discharges to waterbodies with an EPA approved TMDL (MPCA 2012). This procedure will be used to update WLAs in approved TMDLs for new or expanding wastewater dischargers whose permitted effluent limits are at or below the in-stream target and will ensure that the effluent concentrations will not exceed applicable water quality standards or surrogate measures. The process for modifying any and all WLAs will be handled by the MPCA, with input and involvement by the EPA, once a permit request or reissuance is submitted. The overall process will use the permitting public notice process to allow for the public and EPA to comment on the permit changes based on the proposed WLA modification(s). Once any comments or concerns are addressed, and the MPCA determines that the new or expanded wastewater discharge is consistent with the applicable water quality standards, the permit will be issued and any updates to the TMDL WLA(s) will be made.

For more information on the overall process visit the MPCA's [TMDL Policy and Guidance] webpage.

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 LAs and WLAs, respectively. 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."

In order to address pollutant loading in the WRW, already required point source controls will be effective in improving water quality if accompanied by considerable reductions in nonpoint source loading. Reasonable assurance for permitted sources, such as stormwater, CAFOs, and wastewater, is provided via compliance with their respective NPDES permit programs, as described in Section 3.6.

The following sections provide reasonable assurance that implementation will occur and result in pollutant load reductions in the WRW. These reasonable assurances are outlined in the following areas:

1. Availability of reliable means of addressing pollutant loads (see Sections 6.1 Non-permitted source reduction programs and Section 6.3 Example non-permitted source reduction projects and partners);
2. A means of prioritizing and focusing management (see Winnebago River WRAPS – EOR 2020);
3. Development of a strategy for implementation (see Section 8 Implementation strategy summary);
4. Availability of funding to execute projects (see Section 6.4 Funding availability);
5. A system of tracking progress and monitoring water quality response (see Sections 7 Monitoring plan and 8.7 Adaptive management);
6. Nonpoint source pollution reduction examples at multiple scales (see Section 6.3 Example non-permitted source reduction projects and partners)

6.1 Examples of non-permitted source reduction programs

There are many opportunities available through local, county, state, and federal programs to address the pollutant loads in the WRW. These programs identify BMPs, provide means of focusing BMPs, and support their implementation via state initiatives, ordinances, and/or provide dedicated funding. The following examples describe large-scale programs that have proven to be effective and/or will reduce P and *E. coli l*oads going forward.

6.1.1 Non-regulatory

Watershed load reductions will be achieved through management of septic systems, shoreline erosion, and agricultural BMPs. At the local level, the Freeborn Soil and Water Conservation District (SWCD), NRCS, Freeborn County, Faribault SWCD and Faribault County currently implement programs that target improving water quality and have been actively involved in projects to improve water quality in the past. The following examples describe large-scale programs that have proven to be effective and/or will reduce pollutant loads going forward.

6.1.1.1 Agricultural Water Quality Certification Program

The Minnesota Agricultural Water Quality Certification Program (MAWQCP) 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 are 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 assistance**: Producers seeking certification can obtain specially designated technical and financial assistance to implement practices that promote water quality

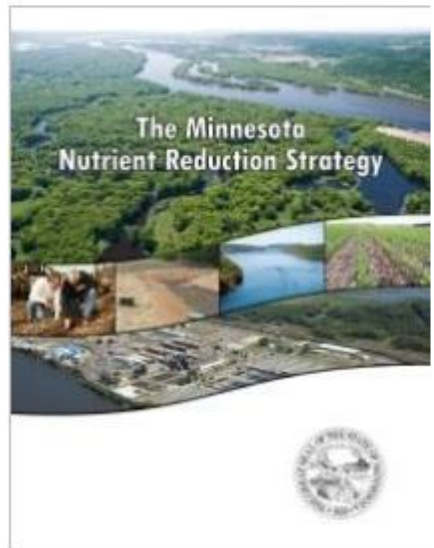
Through this program, the public receives assurance that certified producers are using conservation practices to protect Minnesota's lakes, rivers, and streams. As of March 9, 2020, the Ag Water Quality Certification Program has (Redlin, personal communication):

- Enrolled over 578,531 acres;
  - Included over 850 producers;
- Added more than 1,791 new conservation practices;
  - Kept over 37,511 tons of sediment out of Minnesota rivers per year;
  - Saved 104,595 tons of soil and 46,401 lbs of P on farms per year;
  - 37,172 C02-equivalent tons of Greenhouse Gas emission reductions per year;
  - Reduced nitrogen losses by up to 49%.

6.1.1.2 Minnesota Nutrient Reduction Strategy

The *Minnesota Nutrient Reduction Strategy* (MPCA 2014) guides activities that support nitrogen and P reductions in Minnesota waterbodies and those downstream of the state (e.g., Lake Winnipeg, Lake Superior, and the Gulf of Mexico). The Nutrient Reduction Strategy was developed by an interagency coordination team with help from public input. Fundamental elements of the Nutrient Reduction Strategy include:

- Defining progress with clear goals
- Building on current strategies and success
- Prioritizing problems and solutions
- Supporting local planning and implementation
- Improving tracking and accountability



Included within the strategy discussion are alternatives and tools for consideration by drainage authorities, information on available tools and approaches for identifying areas of P and nitrogen loading and tracking efforts within a watershed, and additional research priorities. The Nutrient Reduction Strategy is focused on incremental progress and provides meaningful and achievable nutrient load reduction milestones that allow for better understanding of incremental and adaptive progress toward final goals. It has set a reduction of 45% for both P and nitrogen in the Mississippi River, downstream of the Winnebago Watershed.

Successful implementation of the Nutrient Reduction Strategy will require broad support, coordination, and collaboration among agencies, academia, local government, and private industry. The MPCA is implementing a framework to integrate its water quality management programs on a major watershed scale, a process that includes:

- Intensive watershed monitoring
- Assessment of watershed health
- Development of WRAPS reports to inform local water planning
- Management of NPDES and other regulatory and assistance programs

This framework will result in nutrient reduction for the basin as a whole and the major watersheds within the basin.

6.1.1.3 Conservation Easements

Conservation easements are a critical component of the state's efforts to improve water quality by reducing soil erosion, P and nitrogen loading, and improving wildlife habitat and flood attenuation on private lands. Easements protect the state's water and soil resources by permanently restoring wetlands, adjacent native grassland wildlife habitat complexes and permanent riparian buffers. In cooperation with county SWCDs and the USDA NRCS, BWSR's programs compensate landowners for granting conservation easements and establishing native vegetation habitat on economically marginal, flood-prone, environmentally sensitive or highly erodible lands. These easements vary in length of time from 10 years to permanent/perpetual easements. Types of conservation easements in Minnesota include: Conservation Reserve Program (CRP); Conservation Reserve Enhancement Program (CREP); Reinvest in Minnesota (RIM); and the Wetland Reserve Program (WRP) or Permanent Wetland Preserve (PWP). As of August 2019, in Freeborn County, there was 10,962 acres of short-term conservation easements such as CRP and 9,991 acres of long term or permanent easements (CREP, RIM, WRP).

6.1.2 Regulatory

6.1.2.1 Regulated Construction Stormwater

State implementation of the TMDL will be through action on NPDES permits for regulated construction stormwater. To meet the WLA for construction stormwater, construction stormwater activities are required to meet the conditions of the Construction General Permit under the NPDES program and properly select, install, and maintain all BMPs required under the permit, including any applicable additional BMPs required in Appendix A of the Construction General Permit for discharges to impaired waters, or meet local construction stormwater requirements if they are more restrictive than requirements of the State General Permit.

6.1.2.2 Regulated Industrial Stormwater

To meet the WLA for industrial stormwater, industrial stormwater activities are required to meet the conditions of the industrial stormwater general permit or Nonmetallic Mining and Associated Activities general permit (MNG49) under the NPDES program and properly select, install and maintain all BMPs required under the permit.

6.1.2.3 Wastewater National Pollutant Discharge Elimination System and State Disposal System Permits

The MPCA issues permits for WWTFs that discharge into waters of the state. The permits have site specific limits on bacteria that are based on water quality standards. Permits regulate discharges with the goals of: (1) protecting public health and aquatic life, and (2) assuring that every facility treats wastewater. In addition, SDS permits set limits and establish controls for land application of sewage.

6.1.2.4 Subsurface Sewage Treatment Systems Program

SSTSs are regulated through Minn. Stat. §§ 115.55 and 115.56. Regulations include:

- Minimum technical standards for individual and mid-size SSTS
- A framework for local units of government to administer SSTS programs
- Statewide licensing and certification of SSTS professionals, SSTS product review and registration, and establishment of the SSTS Advisory Committee
- Various ordinances for septic installation, maintenance, and inspection

In 2008, the MPCA amended and adopted rules concerning the governing of SSTS. In 2010, the MPCA was mandated to appoint a SSTSs Implementation and Enforcement Task Force (SIETF). Members of the SIETF include representatives from the Association of Minnesota Counties, Minnesota Association of

Realtors, Minnesota Association of County Planning and Zoning Administrators, and the Minnesota Onsite Wastewater Association. The group was tasked with:

- Developing effective and timely implementation and enforcement methods to reduce the number of SSTS that are an IPHT and enforce all violation of the SSTS rules (See report to the legislature; MPCA 2011)
- Assisting MPCA in providing counties with enforcement protocols and inspection checklists

Both counties within the WRW have ordinances establishing minimum requirements for regulation of SSTS, for the treatment and dispersal of sewage within the applicable jurisdiction of the County, to protect public health and safety, groundwater quality, and prevent or eliminate the development of public nuisances. Ordinances serve the best interests of the County's citizens by protecting its health, safety, general welfare, and natural resources. In addition, each county zoning ordinance prescribes the technical standards that on-site septic systems are required to meet for compliance and outlines the requirements for the upgrade of systems found not to be in compliance. This includes systems subject to inspection at transfer of property, upon the addition of living space that includes a bedroom and/or a bathroom, and at discovery of the failure of an existing system. From 2002 through 2016, Freeborn County has, on average, upgraded/replaced 93 systems per year (Figure 6-1).

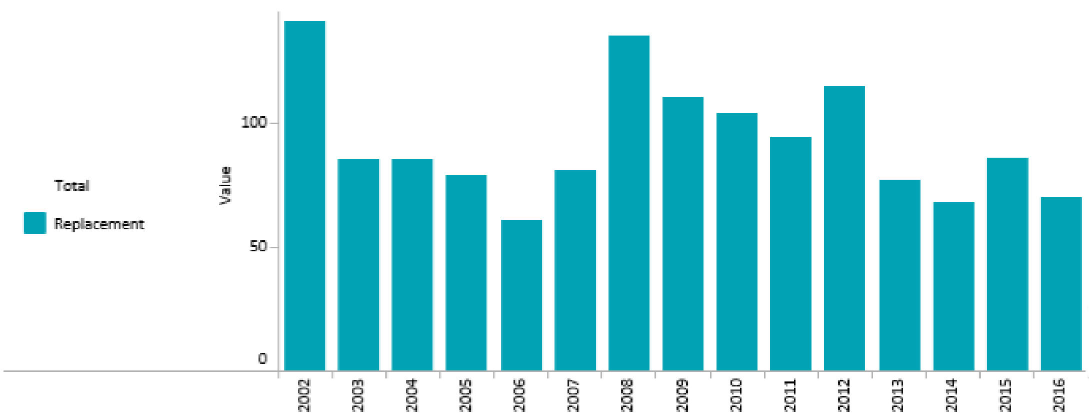


Figure 6-1. Number of upgraded or replaced SSTS in Freeborn County by year.

All known IPHTs are recorded in a statewide database by the MPCA. From 2006 to 2017, 742 straight pipes were tracked by the MPCA statewide. Seven hundred-one of those were abandoned, fixed, or were found not to be a straight pipe system. There have been 17 Administrative Penalty Orders issued and docketed in court. The remaining straight pipe systems received a notification of non-compliance and are currently within the 10-month deadline.

6.1.2.5 Feedlot Rules

The MPCA Feedlot Program implements rules governing the collection, transportation, storage, processing, and disposal of animal manure and other livestock operation wastes. Minn. R. 7020 regulates feedlots in the state of Minnesota. All feedlots capable of holding 50 or more AUs, or 10 in shoreland areas, are subject to this rule. A feedlot holding 1,000 or more AUs is permitted in the state of Minnesota. The focus of the rule is on animal feedlots and manure storage areas that have the greatest potential for environmental impact. Smaller feedlot operations are registered by counties and do not have permits.

The Feedlot Program is implemented through a cooperation between MPCA and county governments in 50 counties in the state. The MPCA works with county representatives to provide training, program oversight, policy and technical support, and formal enforcement support when needed. A county participating in the program, or a delegated county, has been given authority by the MPCA to delegate administration of the feedlot program. These delegated counties receive state grants to help fund their feedlot programs based on the number of feedlots in the county and the level of inspections they complete. In recent years, since 2012, annual grants given to these counties totaled about two million dollars (MPCA 2017). Both Faribault and Freeborn counties are delegated counties. Since 2012, there has been 20 feedlot facility inspections in the WRW, with 18 of those inspection occurring at non-CAFO facilities and 2 at CAFO facilities. There has been an additional nine manure application reviews within the watershed. Three of those inspections were conducted at CAFO facilities and six at non-CAFO facilities.

6.1.2.6. Buffer Program

The Buffer Law signed by Governor Dayton in June 2015 was 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. 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
- allowed landowners to be granted a compliance waiver until July 1, 2018, when they filed a compliance plan with the SWCD.

The Board of Water and Soil Resources (BWSR) provides oversight of the buffer program, which is primarily administered at the local level; compliance with the Buffer Law in the state is displayed at the Buffer Program Update webpage. As of January 2020, 94% to 100% of all parcels are in compliance in Faribault County and Freeborn County with the buffer law.

6.2 Prioritization and Focusing Management

As part of the complementary Winnebago River WRAPS Report, EOR worked with representatives from Freeborn County SWCD staff to identify all existing and proposed BMPs in the WRW. Estimated TP and total nitrogen load reductions were estimated for each given BMP and for each HSPF subwatershed using a combination of literature values, University of Minnesota's nitrogen and P BMP spreadsheets, and the HSPF-SAM tool. Then modeled nutrient reductions achieved through implementation of the BMPs were compared to the required nutrient reductions from watershed sources as identified in the TMDL for Bear Lake, State Line Lake, and Lime Creek; statewide nitrogen and P goals in the Minnesota Nutrient Reduction Strategy; and downstream nitrate reductions in the Cedar River TMDL. In addition, the nutrient reduction associated with the implementation of cover crops on 50% of the existing agricultural land was compared to the nutrient reduction goals in this TMDL. With these results BMPs were identified and prioritized in the watershed. More information is provided in the WRAPS.

6.3 Implementation Strategy

The WRAPS, TMDLs and all supporting information provide a starting point for progressing the watershed to cleaner water. Future local watershed plans such as the Shell Rock/Winnebago Comprehensive Watershed Management Plan will further develop tools and identify ways to improve water quality in the watershed, as well as provide a detailed implementation plan. Development of the CWMP is currently underway and is expected to be completed by 2021. Upon completion of the plan, the watershed will receive noncompetitive watershed-based implementation funding.

6.4 Funding Availability

There are many funding opportunities in the WRW that are used to reduce pollutant loads. Through federal programs including CRP and EQIP, Freeborn County has received $29,502,685, since 1995. Since 1997 the contributions from these programs has increased (Figure 6-2). More information on federal conservation funding in the two counties can be found on the Environmental Working Group's (EWG) website: [https:/ /conservation.ewg.org/index.php](https://conservation.ewg.org/index.php).

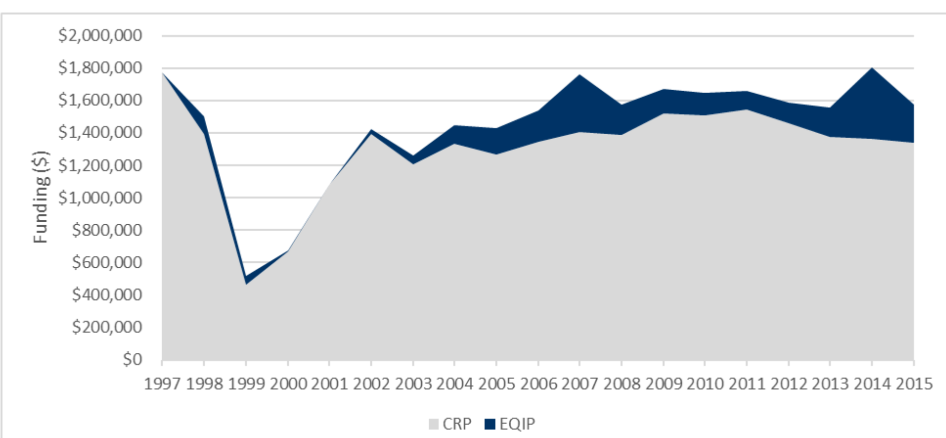


Figure 6-2. Federal Funding for conservation (CRP and EQIP) in Freeborn County (1997-2005) (Environmental Working Group)

Additional funds to improve water quality are available through Minnesota's Legacy Fund. The Legacy Fund was an amendment passed by Minnesota's voters in 2008 that provides funding to protect drinking water sources; protect, enhance, and restore wetlands, prairies, forests, and fish, game, and wildlife habitat; preserve arts and cultural heritage; support parks and trails; and protect, enhance and restore lakes, rivers, streams, and groundwater. Since 2010, the Clean Water Fund, one of the funds funded through the Legacy amendment, has received $943.8 million (MPCA et. al 2018).

Since 2004, over $6.2 million dollars have been spent addressing water quality issues in the WRW (Figure 6-3).

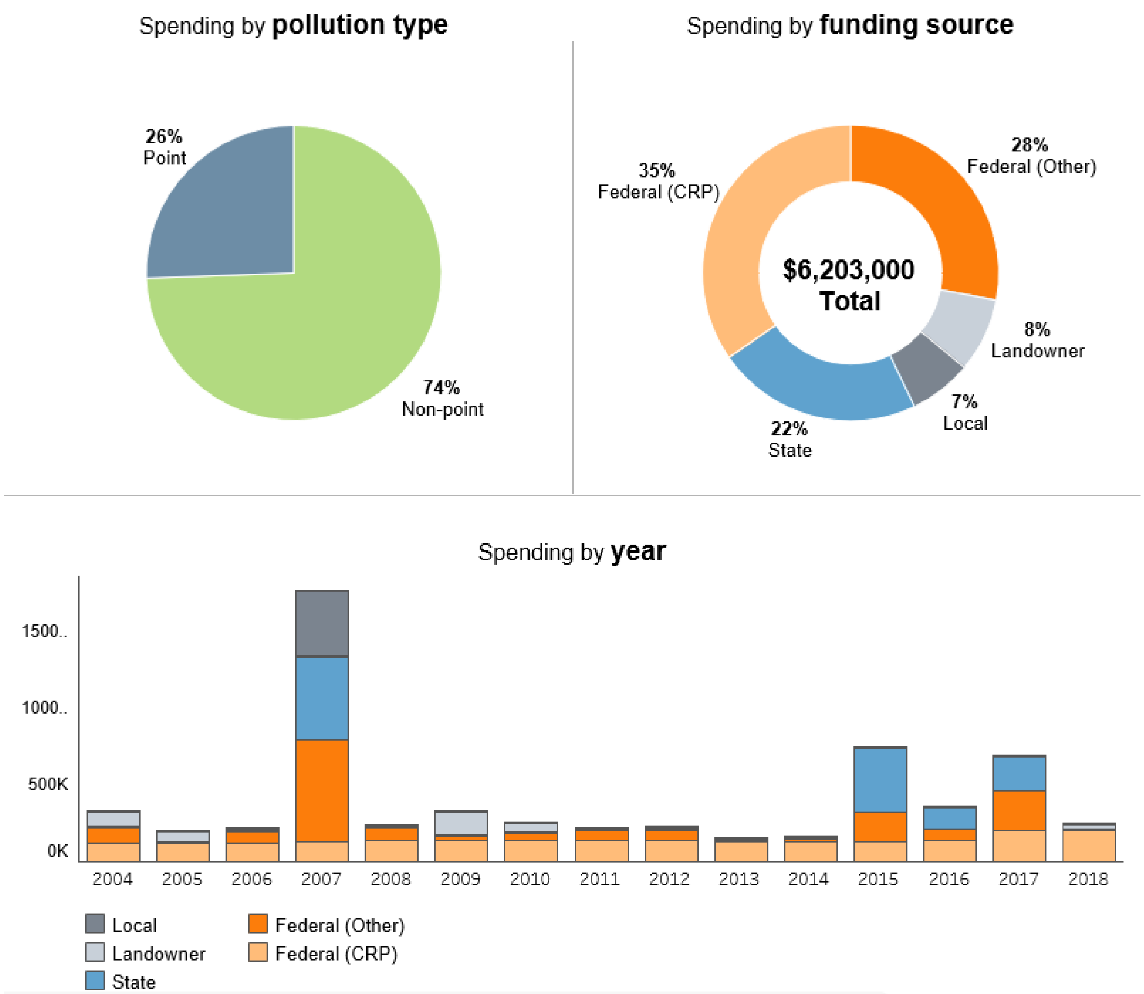


Figure 6-3. Winnebago River Watershed water quality funding by pollution type, funding source, and year

6.5 Tracking Progress and Monitoring Water Quality Response

The MPCA uses IWM to monitor and assess the water quality of Minnesota. More information about monitoring in the watershed is provided in Section 7.

In addition, the MPCA maintains the Healthier Watersheds webpage, which is an online database viewer of BMPs implemented by major watershed since 2004: https://www.pca.state.mn.us/water/best-management-practices-implemented-watershed. A summary of BMPs implemented in the WRW since 2004 is shown in Figure 6-4. From 2004 through 2018, 78 BMPs have been implemented in the WRW. The three most common strategies used were tillage and residue management (16), designed erosion control structures (14), and irrigation water management (10).

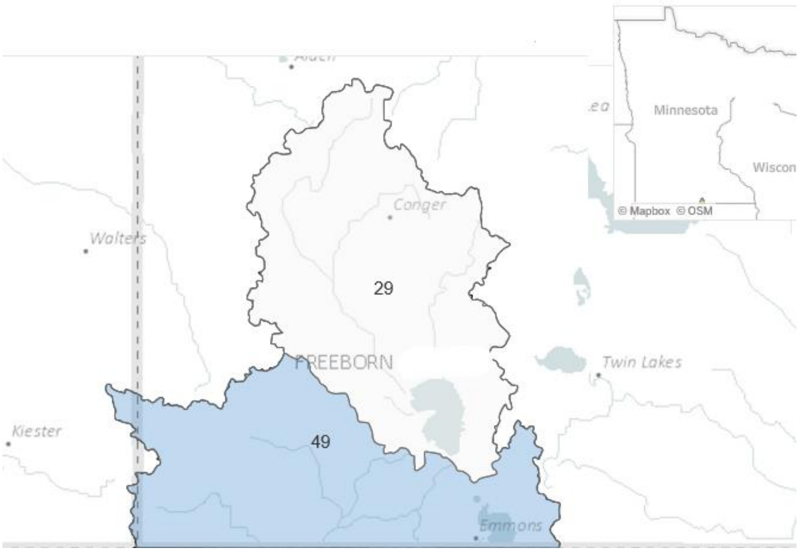


Figure 6-4. BMPs implemented in the Winnebago River Watershed since 2004

6.6 Nonpoint Source Pollution Reduction

Analysis of water quality data from 80 monitoring locations across Minnesota has shown that five pollutants, TSS, TP, ammonia, biological oxygen demand (BOD), and bacteria have significantly decreased, while nitrate and chloride concentrations have increased over a 30 year period. These trends continue in the Shell Rock River, a river adjacent to the WRW (Christopherson 2014). These trends are a result of the state's efforts to control municipal and industrial discharges and a continuing effort by state, county and local groups to reduce nonpoint source pollution. A few, but by no means a full summary of, projects that are contributing to these decreasing trends, are discussed below.

Started in 1995, the AgBMP Loan Program is a statewide program, administered by MDA, which has provided funding for local implementation of proven clean water practices. Practices that are applicable for this program include: Feedlot Improvements, Conservation Tillage Equipment, Septic System Replacements/Upgrades, Erosion Control Structures, Shoreline Stabilization, and Wetland Restoration. The total cost for all completed projects throughout the state that include AgBMP Loan Program financing is estimated to be $380.3 million. In biennium 2019–2020, 1,893 projects were completed across the state totaling $43.4 million in loans. These most recent projects include 256 loans for agricultural waste management projects, 197 for conservation tillage equipment, 740 structural erosion control practices and 545 septic systems upgrades or relocations (Wilcox 2019).

In 2014, as part of a $1.79 million Accelerated Wetland and Shallow Lake Enhancement program, Ducks Unlimited completed the construction of shallow lake outlet to prevent the passage of carp that contribute to eutrophication in State Line Lake. In addition, the DNR applied rotenone treatment to remove existing unwanted carp followed by a lake drawdown to improve the aquatic communities and health of the State Line Lake. All of these management practices improve water quality in State Line Lake.

At a local level the Freeborn County SWCD promotes soil and water conservation through technical, educational and financial assistance. Starting in 2017, Freeborn SWCD has established five cover crop contracts. These contracts, three of which are in the WRW, resulted in the planting of 162 total acres of cover crops. A new cover crop contract located in the WRW that will plant cover crops in 2019 through 2021 on 60 acres. In 2018, Freeborn SWCD assisted in developing the 11 buffer planting contracts as part of the state cost share program. With EQIP funding five conservation plans were developed including three contracts for Comprehensive Nutrient Management Plans. Under easement programs the SWCD conducted 58 CRP plans for 2018 re-enrollment and new-enrollment. Also, 35 acres of wetland restoration were created. In total there are 9,585.7 acres of perpetual easements in the county. More information about local projects can be found on the Freeborn SWCD website (https://www.freebornswcd.org/). All of these efforts contribute to improved water quality in the WRW.

In summary, significant time and resources have been devoted to identifying the best BMPs, providing means of focusing them in the WRW, and supporting their implementation via state initiatives and dedicated funding. The WRW WRAPS and TMDLs process engaged partners to arrive at reasonable examples of BMP combinations that attain pollutant reduction goals. Minnesota is a leader in watershed planning as well as monitoring and tracking progress toward water quality goals and pollutant load reductions. Finally, examples cited herein confirm that BMPs and restoration projects have proven to be effective over time. As stated by the State of Minnesota Court of Appeals in A15-1622 Minnesota Center for Environmental Advocacy (MCEA) vs MPCA and Metropolitan Council Environmental Services (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 Nutrient Reduction Strategy (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.

7 Monitoring Plan

7.1 Stream Monitoring

As part of the MPCA Intensive Watershed Monitoring strategy, four stream sites and two lakes were monitored for biology (fish and macroinvertebrates) in 2015-2016. Details about the MPCA IWM strategy can be found in the Winnebago River and Upper Wapsipinicon River Watersheds Monitoring and Assessment Report: https://www.pca.state.mn.us/sites/default/files/wq-ws3-07080203b.pdf

The second round of intensive water quality monitoring in the Winnebago began in 2019. Lime Creek (15CD001) and Steward Creek (15CD003) will be monitored for fish and invertebrates; Lime Creek (S007-338) will be monitored for chemistry.

As mentioned previously, the WRW will be included in the comprehensive watershed plan (CWMP) developing as of 2019, and scheduled for completion in 2021. Implementing and monitoring BMPs is recommended to be included as a priority within this plan.

7.2 Future Monitoring

Due to the small geographic size of the Winnebago watershed, certain monitoring components typical of most watersheds of greater size are not in place. An example would be the lack of a flow gage measuring long-term stream flow record. The installation of a flow gage would allow for better calibration of future modelling efforts and provide better trend analysis. Additional possible future monitoring projects include aquatic plant and fish surveys on Bear Lake and State Line Lake to continue evaluating current shallow lake state status, and growing season biweekly surface water monitoring of TP, Chl-*a*, and Secchi depth in Bear Lake and State Line Lake to track progress towards achieving the TMDL clear water goals.

8 Implementation Strategy Summary

The TMDL results and the WRAPS report will support local working groups in developing scientifically-supported restoration and protection strategies for subsequent implementation planning. The Winnebago River WRAPS Report will be publically available on the MPCA WRW website: https://www.pca.state.mn.us/water/watersheds/Winnebago River-river.

8.1 Permitted Sources

8.1.1 Construction Stormwater

The WLA for stormwater discharges from sites where there is construction activity reflects the number of construction sites greater than one acre in size, that are expected to be active in the watershed at any one time, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at construction sites are defined in the State'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 WLA in this TMDL. All local construction stormwater requirements must also be met.

8.1.2 Industrial Stormwater

The WLA for stormwater discharges from sites where there is industrial activity reflects the number of sites in the watershed for which NPDES industrial stormwater permit coverage is required, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at the industrial sites are defined in the State's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000), or NPDES/SDS General Permit for Construction Sand and Gravel, Rock Quarrying and Hot Mix Asphalt Production facilities (MNG490000). If a facility owner/operator obtains stormwater coverage under the appropriate NPDES/SDS Permit and properly selects, installs and maintains all BMPs required under the permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. All local stormwater management requirements must also be met.

8.1.3 Wastewater

The MPCA issues permits for WWTFs that discharge into waters of the state. The permits have site specific limits that are based on water quality standards. Permits regulate discharges with the goals of: (1) protecting public health and aquatic life, and (2) assuring that every facility treats wastewater. In addition, SDS permits set limits and establish controls for land application of sewage.

8.2 Non-Permitted Sources

This section provides an overview of example BMPs that may be used for implementation, organized by pollutant source. The BMPs included in this section are not exhaustive; a variety of BMPs to restore and protect the lakes and streams within the WRW have been outlined and prioritized in the WRAPS report.

8.2.1 Septic Systems

A watershed-wide inventory of current systems and continuation of inspection programs in the area are necessary to help locate IPHTs. Once found, all known IPHTs must be brought into compliance within a 10-month period (see Section 6.1.2.4). The reductions in loading resulting from upgrading or replacing failing systems in the watershed depend on the level of failure present in the watershed. Upgrading or replacing IPHTs systems will result in 100% reduction in fecal bacteria loading from that system. As one option for funding, the MPCA offers the Clean Water Partnership 0% interest loan program for SSTS upgrades and compliance (as well as for other non-regulated sources). See Section 6.1.2.4 for more information on the program.

The most cost-effective BMP for managing loads from septic systems is regular maintenance. EPA recommends that septic tanks be pumped every three to five years, depending on the tank size and number of residents in the household (EPA 2002b). When not maintained properly, septic systems can cause the release of pathogens and excess nutrients into surface water. Annual inspections, in addition to regular maintenance, ensure that systems function properly. Compliance with state and county code is essential to reducing *E. coli* and P loading from septic systems. Septic systems are regulated under Minn. Stat. §§ 115.55 and 115.56. Counties must enforce ordinances in Minn. R. 7080 to 7083.

8.2.2 Agricultural Sources

Several different agricultural BMPs can be used to target priority sources and their associated pollutants. Table 8-1 provides a summary of agricultural BMPs, their NRCS code, and their targeted pollutants. Descriptions of each BMP are provided below. More information on agricultural BMPs in the state of Minnesota can be found in the *Agricultural BMP Handbook for Minnesota* (Lenhart et al. 2017).

Table 8-1. Summary of agricultural BMPS for agricultural sources and their primary targeted pollutants.

BMP (NRCS standard)	Targeted Pollutant	
	E. coli	Phosphorus
Filter strips (636)	X	X
Riparian buffers (390)	X	X
Clean water diversion (362)	X	X
Access control/fencing (472 and 382)	X	X
Waste storage facilities (313) and nutrient management (590)	X	X
Prescribed grazing system (528)	X	X
Grassed waterways (412)		X

BMP (NRCS standard)	Targeted Pollutant	
	E. coli	Phosphorus
Water and sediment control basins (638)		X
Conservation cover (327)		X
Conservation/reduced tillage (329 and 345)		X
Cover crops (340)		X

8.2.2.1 Filter strips (636) and riparian buffers (390)

Feedlot/wastewater filter strips are defined as "a strip or area of vegetation that receive and reduce sediment, nutrients, and pathogens in discharge from a setting basin or the feedlot itself. In Minnesota, there are five levels of runoff control, with Level 1 being the strictest and for the largest operations" (Lenhart et al. 2017). Riparian buffers are composed of a mix of grasses, forbs, sedges, and other vegetation that serves as an intermediate zone between upland and aquatic environments (Lenhart et al. 2017). The vegetation is tolerant of intermittent flooding and/or saturated soils that are prone to occur in intermediate zones.

Riparian buffers and filter strips that include perennial vegetation and trees can filter runoff from adjacent cropland, provide shade and habitat for wildlife, and reinforce streambanks to minimize erosion. The root structure of the vegetation uses enhanced infiltration of runoff and subsequent trapping of pollutants. Both, however, are only effective in this manner when the runoff enters the BMP as a slow moving, shallow "sheet"; concentrated flow in a ditch or gully will quickly pass through the vegetation offering minimal opportunity for retention and uptake of pollutants. Similarly, tile lines can often allow water to bypass a buffer or filter strip, thus reducing its effectiveness.

8.2.2.2 Clean water diversions (362)

Clean runoff water diversion "involves a channel constructed across the slope to prevent rainwater from entering the feedlot area or the farmstead to reduce water pollution" (Lenhart et al. 2017). Clean water diversions can take many forms including roof runoff management, grading, earthen berms, and other barriers that direct uncontaminated runoff from areas that may contain high levels of *E. coli* and nutrients.

8.2.2.3 Access control/fencing (472 and 382)

Fencing can be used with controlled stream crossings to allow livestock to cross a stream while minimizing disturbance to the stream channel and streambanks. Providing alternative water supplies for livestock allows animals to access drinking water away from the stream, thereby minimizing the impacts to the stream and riparian corridor. Some researchers have studied the impacts of providing alternative watering sites without structural exclusions and found that cattle spend 90% less time in the stream when alternative drinking water is furnished (EPA 2003).

8.2.2.4 Waste storage facilities (313) and nutrient management (590)

Manure management strategies depend on a variety of factors. A pasture or open lot system with a relatively low density of animals (one to two head of cattle per acre [EPA 2003]) may not produce manure in quantities that require management for the protection of water quality. For mid-size and large facilities, additional waste storage is needed. A waste storage facility is "an impoundment created by excavating earth or a structure constructed to hold and provide treatment to agricultural waste" (Lenhart et al. 2017). Waste storage facilities hold and treat waste directly from animal operations, process wastewater, or contaminated runoff.

Confined swine operations typically use liquid manure storage areas that are located under the confinement barn. Wash water used to clean the floors and remove manure buildup combines with the solid manure to form a liquid or slurry in the pit. The mixture is usually land applied in the spring and fall by injection/incorporation into the soil or transported offsite.

Dairies in the WRW store and handle manure in both liquid and solid form to be land applied at a later date. Other potential sources of wastewater include process wastewater such as parlor wash down water, milk-house wastewater, silage leachate, and runoff from outdoor silage feed storage areas. There are potential runoff problems associated with these wastewater sources if not properly managed. In addition, many small dairy operations have limited to no manure storage. Most poultry manure is handled as a dry solid in the state; liquid poultry manure handling and storage is rare. Improperly stockpiled poultry manure or improper land application can pose runoff issues.

Final disposal of waste usually involves land application on the farm or transportation to another site. Minn. R. 7020.2225 contains several requirements for land application of manure. These requirements vary depending on feedlot size and include provisions on manure nutrient testing, nutrient application rates (based on determination of crop needs and P soil testing), manure management plans, recordkeeping, and various limitations in certain areas or near environmentally-sensitive areas. Manure is typically applied to the land once or twice per year. To maximize the amount of nutrients and organic material retained in the soil, application should not occur on frozen ground or when precipitation is forecast during the next several days.

The MDA has recently developed an interactive model to assist livestock producers to evaluate the potential runoff risk for manure applications, based on weather forecasts for temperature and precipitation along with soil moisture content. The model can be customized to specific locations. It is advised that all producers applying manure utilize the model to determine the runoff risk, and use caution when the risk is "medium" and avoid manure application during "high" risk times. For more information and to sign up for runoff risk alerts from the MDA Runoff Risk Advisory Forecast, please see the MDA website.

8.2.2.5 Grassed waterways (412) and water and sediment control basins (WASCOB) (638)

Grassed waterways and WASCOBs are both agricultural BMPs that aim to slow water flow off agricultural fields. Grassed waterways are areas of vegetative cover that are placed in line with high flow areas on a field. WASCOBs are vegetative embankments that are placed perpendicular to water's flow path to pool and slowly release water. Both practices reduce erosion and sediment and P loss from agricultural fields.

8.2.2.6 Conservation Cover (327), conversation/reduced tillage (329 and 345), and cover crops (340)

Conservation cover, conversation/reduced tillage, and cover crops are all on-field agricultural BMPs that aim to reduce erosion and nutrient loss by increasing and/or maintaining vegetative cover and root structure. Conservation cover is the process of converting previously row crop agricultural fields to permanent perennial vegetation. Conservation or reduced tillage can mean any tillage practice that leaves additional residue on the soil surface; 30% or more cover is typically considered conservation tillage. In addition to reducing erosion, conservation tillage preserves soil moisture. Cover crops refer to "the use of grasses, legumes, and forbs planted with annual cash crops to provide seasonal soil cover on cropland when the soil would otherwise be bare" (Lenhart et al. 2017).

8.2.3 Internal Loading Lake Phosphorus Sources

Implementation strategies for internal loading reduction include water level drawdown, sediment P immobilization or chemical treatment (e.g., alum), and biomanipulation (e.g., carp).

Sequencing of in-lake management strategies both relative to each other as well as relative to external load reduction is important to evaluate and consider. In general, external loading, if a moderate to high proportion of all loading, should be the initial priority for reduction efforts. Biomanipulation may also be an early priority, which can follow water level drawdowns. However, it is generally believed that further in-lake management efforts involving chemical treatment (e.g., alum) can be considered after substantial external load reduction has occurred. The success of alum treatments depends on several factors including lake morphometry, water residence time, alum dose used, and presence of benthic-feeding fish (Huser et al. 2016).

The MPCA recommends feasibility studies for any lakes in which water level drawdown or chemical treatment is considered.

8.2.3.1 Whole Lake Drawdowns

Whole-lake drawdowns and aquatic plant and fish management are needed to maintain a clear water, aquatic plant-dominated state, and address excess internal loading from the existing, turbid water, algae-dominated state. A whole lake draw down is the process of drawing lake water levels down through an outlet structure to the lowest elevation possible. This management tool is a common strategy used for shallow lakes (less than 15 ft) in Minnesota. Drawdowns mimic natural droughts and aim to expose bottom sediments causing:

- Consolidation of lake sediments when subjected to drying, which reduces resuspension of lake sediment from wave action (once water level is restored) resulting in a clearer water column;
- Oxidation of organic matter in lake sediments which reduces P release in the water column;
- Fish kill which allows zooplankton populations to rebound and reduce algae levels in the water column, resulting in a clearer water column and more aquatic plant growth;

- Exposure of lake sediments to air which results in germination of some aquatic plant seeds (like bulrush) that need to be dried or exposed on mud flats in order to germinate.

More detailed information from DNR regarding LMPs and whole lake drawdowns for Bear Lake and State Line Lake is included in the WRAPS.

8.3 Education and Outreach

A crucial part in the success of the WRAPS will be participation from local citizens. In order to gain support from these citizens, education and public participation opportunities will be necessary. A variety of educational avenues can and will be used throughout the WRW. These include (but are not limited to):

- Events, meetings, workshops, focus groups, trainings
    - Public meetings for TMDL, WRAPS, and CWMP Reports
- Publications
    - Monthly water quality reports
    - Annual reports
    - County newsletter
- Websites
    - http://www.freebornswcd.org/

8.3.1.1 Winnebago River Watershed Restoration and Protection Project Accomplishments

The following education and outreach activities were accomplished between 2015 and 2019 as part of the WRW Restoration and Protection Project by Freeborn County and Freeborn SWCD:

- Collected crop residue data from 116 points in 2015 and 2016, and collected cropping and crop residue data during the 2017 through 2019 growing seasons.
- Completed a Drainage Water Management Plan for County Ditch 23 and County Ditch 5.
- Identified 20 suitable sites for potential BMPs (wetland restoration, two stage ditch, controlled drainage, in ditch sediment basins, and nitrogen bioreactors).
- Conducted 28 landowner/producer interviews that resulted in identification of 24 BMPs landowners were interested in implementing.
- Identified 170 proposed new or existing BMPs.
- Replaced one open surface tile intake with a rock inlet and buffer.
- Identified four controlled drainage sites.
- Hosted an educational watershed booth at the Freeborn County fair (2017 through 2019).
- Hosted one technical committee meeting and three public outreach meetings.

- Planned a field-scaled conservation drainage management demonstration site in 2019.

Local staff (conservation district, watershed, county, etc.) and board members will continue to work to educate the residents of the watersheds about ways to clean up their streams on a regular basis throughout the WRW.

8.4 Technical Assistance

The SWCDs, NRCS, and county staff within the watershed provide assistance to landowners for a variety of projects that benefit water quality. Assistance provided to landowners varies from agriculture to lakeshore BMPs. This technical assistance includes education and one-on-one training. Many opportunities for technical assistance are as a result of educational workshops of trainings. It is important that these outreach opportunities for watershed residents continue. Marketing is necessary to motivate landowners to participate in voluntary cost-share assistance programs.

Programs such as state cost share, CREP, and RIM are administered through the county. In addition, financial assistance is available from Clean Water Legacy funding, Environmental Quality Incentives Program (EQIP), CRP, State Buffer Law Implementation, MAWQCP and Conservation Stewardship Program (CSP). All of these programs are available to help implement the best conservation practices that each parcel of land is eligible for to target the best conservation practices per site. Conservation practices may include, but are not limited to: septic system upgrades, feedlot improvements, invasive species control, wastewater treatment practices, agricultural BMPs, and shoreline restorations. More information about types of practices and implementation of BMPs are discussed in the WRW WRAPS Report.

8.5 Partnerships

Partnerships with counties, cities, townships, citizens, and co-ops are one mechanism through which the Freeborn and Faribault County SWCDs will protect and improve water quality. Strong partnerships with state and local government to protect and improve water resources and to bring waters within the WRW into compliance with State standards will continue. A partnership with local government units and regulatory agencies such as cities, townships and counties may be formed to develop and update ordinances to protect the areas water resources.

8.6 Cost

The Clean Water Legacy Act requires that a TMDL study include an overall approximation of the cost to implement the TMDL study (Minn. Stat. 2007, section 114D.25).

8.6.1 Phosphorus

An analysis of the cost to implement the P TMDLs was completed as part of the WRAPS process. The total cost for agricultural BMPs needed to achieve the watershed pollutant reductions required to improve the P impaired lakes and streams was $370,000 per year. In addition, annual in-lake management for Bear Lake and State Line Lake is expected to cost approximately $5,000 per year to execute and maintain minor drawdowns and survey the fish and aquatic plant communities.

8.6.2 *E. coli*

The initial estimate for implementing the Lower Mississippi River Fecal Coliform TMDL was $240M; the WRW is approximately 1% (71 sq. mi. out of 7266 sq. mi.) of the basin and given the regional and ubiquitous nature of pathogen impairments in southeast Minnesota, a 1% apportionment of the overall cost (or $2.4M) is a reasonable estimate for addressing the issue at the HUC-8 WRW scale.

8.7 Adaptive Management

This list of implementation elements and the more detailed WRAPS report prepared concurrently with this TMDL assessment focuses on adaptive management Figure 8-1. Continued monitoring and "course corrections" responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in this TMDL. Management activities will be changed or refined to efficiently meet the TMDL and lay the groundwork for de-listing the impaired water bodies. The upcoming Shell Rock/Winnebago River CWMP will follow the adaptive management approach. Evaluation of practices will occur every five years after the commencement of implementation actions, for the next 25 years.

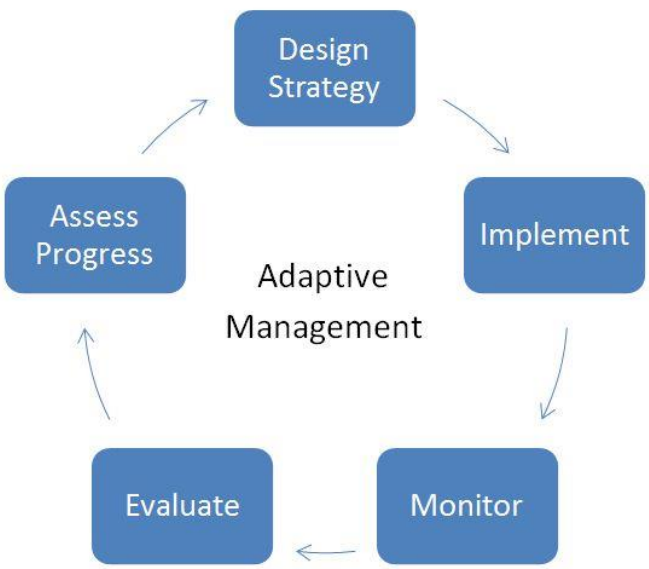


Figure 8-1. Adaptive Management.

9 Public Participation

Public notice

An opportunity for public comment on the draft TMDL report was provided via a public notice in the State Register from April 20, 2020 through May 20, 2020. There were two comment letters received and responded to as a result of the public comment period.

9.1 Technical Committee Meetings

The Technical Advisory Committee (TAC) was comprised of representatives from the SWCDs and state agencies. Table 9-1 outlines the date, location and meeting focus of TAC meetings held during the TMDL development process.

Table 9-1. Winnebago River Watershed TMDL Technical Advisory Committee Meetings.

Date	Location	Meeting Focus
12/12/2014	Freeborn SWCD Office	Winnebago Watershed Planning and Coordination Meeting
3/28/2017	Rochester MPCA	Winnebago Watershed Assessment Team meeting
5/25/2017	Freeborn County Courthouse	Winnebago Professional Judgement Group Meeting
4/15/2018	Freeborn Co. Courthouse (Albert Lea)	Tillage transects, Public drainage projects, TMDLs for Bear and Stateline, SWCD efforts and successes.
9/18/2018	Freeborn SWCD Office	Winnebago WRAPS update and project status update
10/15/2018	Freeborn SWCD Office	Review monitoring sites in Winnebago Watershed for Cycle 2 IWM
2/22/2019	Freeborn SWCD Office	Update on Winnebago TMDL and WRAPS. Identify priority areas
4/23/2019	Shell Rock Watershed District	Identify BMPs to include in WRAPS, review SAM model.
5/23/2019	Freeborn SWCD Office	Review TMDL, and WRAPS drafts as group

9.2 Civic Engagement

The MPCA along with the local partners and agencies in the WRW recognize the importance of public involvement in the watershed process. Table 9-2 outlines the opportunities used to engage the public and targeted stakeholders in the watershed.

Table 9-2. Winnebago River Watershed TMDL Civic Engagement Opportunities.

Date	Location	Meeting Focus
6/28/18	Conger Community Center	Winnebago Watershed update to local residents.
3/10/15 – 6/30/16	Freeborn County	Phase I landowner interviews (20)
4/22/2013	Freeborn County Courthouse	Bear Lake Watershed: Winnebago Watershed update
2017-2019	Freeborn County	Phase II Landowner interviews (8)
3/19/2019	Conger Community Center	Winnebago Watershed update to local residents
12/5/2019	Agricultural field west of Bear Lake	Controlled Drainage Field Public Demonstration

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APPENDIX A. 2018 POINT-INTERCEPT AQUATIC PLANT SURVEYS

A.1 Bear Lake

SURVEY_ID	DOWLKNUM	PROGRAM	SURV_TYPE	PROG_TYPE	SURVEYDATE	NUM_TAXA	FQI	PD_Richness	PD_FQI
2400280034130	24002800	Fisheries	Transect	Fish_Transect	06/10/1993	1	10.0	-75	30
2723	24002800	ShallowLks	PI	SLP_PI	07/01/2002	2	9.2	-50	19
2913	24002800	ShallowLks	PI	SLP_PI	08/11/2004	8	13.4	100	74
3154	24002800	ShallowLks	PI	SLP_PI	08/16/2005	12	17.3	200	125
4164	24002800	ShallowLks	PI	SLP_PI	08/12/2008	1	3.0	-75	-61
4388	24002800	ShallowLks	PI	SLP_PI	06/16/2010	3	5.2	-25	-33
4600	24002800	ShallowLks	PI	SLP_PI	08/31/2011	3	5.2	-25	-33
4736	24002800	ShallowLks	PI	SLP_PI	08/02/2012	0	0.0	-100	-100

A.2 State Line Lake

A point-intercept aquatic plant survey was completed by Emmons & Olivier Resources on September 7, 2018, on State Line Lake to assess the impacts of the winter 2017/2018 drawdown on the aquatic plant community in State Line Lake. The 2018 aquatic plant survey was compared with an aquatic plant point-intercept survey completed by DNR on September 11, 2017, as part of a 2017 Wildlife Lake Habitat Survey.

The points selected for sampling were based on a 140 by 140 meter grid initially created by the DNR in 2017. The point-intercept method is considered the standard protocol by the DNR for sampling aquatic plants because it offers a methodology that is quantitative (e.g., frequency of occurrence), repeatable (can be used to track trends in aquatic plant communities over time), and georeferenced (can be used to compare plant communities within different areas of a lake).

Using the point-intercept survey data, a FQI was calculated that measures the diversity and health of the aquatic plant community. The FQI calculation is based on both the quantity of species observed (species richness) as well as the quality of each individual species. Every aquatic plant in Minnesota has been assigned a coefficient of conservatism value (c-value) ranging from 0 to 10. The c-value of all aquatic plants sampled from a lake is used to determine the FQI for a given lake. Species with a c-value of 0 include non-native species such as curly-leaf pondweed (*Potamogeton crispus*) that are indicative of a highly disturbed environment. In comparison, the native species Oakes pondweed (*Potamogeton oakesainus*) has a c-value of 10 because this species is extremely rare and only found in undisturbed, pristine environments. In 2016, the DNR developed a robust geodatabase of aquatic plant surveys and associated FQI scores from more than 3,600 lakes across the state. FQI scores ranged from 0 to 49 with a median of 25.1±9.

The FQI score for State Line Lake was 25.0, which is nearly equivalent to the median FQI score for assessed lakes in the DNR geodatabase. The results of the State Line Lake survey and associated FQI score are summarized in Table A-1. Included in Table A-1 is a list of all **native** aquatic plants sampled and their associated c-values and frequency of occurrence values. Table A-2 includes **introduced** species, which have been assigned a c-value of 0. FQI scores from the DNR geodatabase exclude introduced species from their FQI calculation; therefore, Table A-1 provides the best means of comparison with the DNR geodatabase. Table A-2 is useful in that introduced species are both an indication of anthropogenic stress and a stressor themselves in terms of their direct impacts to the surrounding plant community. Shoreline species associated with the wetland habitat that bordered the lake (*e.g.*, jewelweed) were also excluded from the FQI calculation.

The distribution and density ranking for each individual species with a frequency of occurrence ≥ 5% is mapped in Figure A-2 through Figure A-10 at the end of the memo. For each data point mapped, a density ranking of 1 indicates only a few individual plants were observed while a ranking of four4 indicates an abundance of plants. It should be noted that nearshore species like hybrid/narrow-leaf cattail are likely under-represented in terms of abundance as the primary focus of this survey was on plants growing within the lake basin itself. In both the 2017 and 2018 surveys, a ring of hybrid/narrow-leaf cattails was observed along the entire perimeter of the lake basin.

2017 State Line Lake Survey Results

On September 11, 2017, the DNR completed a Wildlife Lake Habitat Survey, which included an aquatic plant point-intercept survey of State Line Lake. Water clarity was extremely poor during the survey with secchi disk readings averaging 0.75 feet. Poor water clarity restricted aquatic plants to near shore areas and mid-lake areas were devoid of aquatic vegetation. The 2017 survey included a sample of 52 of the 90 points present within the 140 by 140 meter sampling grid; 33 of the 52 (63.5%) points sampled contained no aquatic vegetation. Individual species observed, coefficient of conservatism values, and associated FQI scores from the 2010 survey conducted by the DNR are provided in Table A-3.

Pre/Post Drawdown Comparison

The plant communities observed during the 2017 and 2018 surveys were significantly different in terms of:

1. The number of aquatic plant species sampled
    a. In 2018, 21 aquatic plant species were observed, a large increase in comparison with the 2017 survey in which only 4 aquatic plant species were observed.
2. The distribution and abundance of aquatic plants
    a. In 2018, aquatic plants were observed at 88 of the 90 (97%) points sampled, a significant increase in comparison with the 2017 survey in which only 29 of the 90 (21%) points sampled contained any aquatic plants.
3. The floristic quality of plants sampled
    a. The average coefficient of conservatism score increased from 1.7 in 2017 to 5.6 in 2018. The FQI increased from 6.7 in 2017 to 25.0 in 2018.

Drawdown Overview

The 2017 drawdown allowed for a ***moderately*** healthy aquatic plant community to become established in 2018. Healthy aquatic plant communities contain a large number *and* variety of aquatic plant species, which are largely evenly distributed across the entire lake. Lakes containing a cosmopolitan distribution of aquatic plant species provide a more complex habitat that is suitable for a wider range of aquatic organisms including a variety of fish and macroinvertebrate species. In comparison, ***moderately*** healthy aquatic plant communities may contain a comparatively large number of species but are often dominated by one or two species, this metric is referred to as ***species evenness***. An example species richness diagram is provided in Figure A-1. In waterbodies receiving excessive nutrient loads, it is not uncommon to see **one or two**

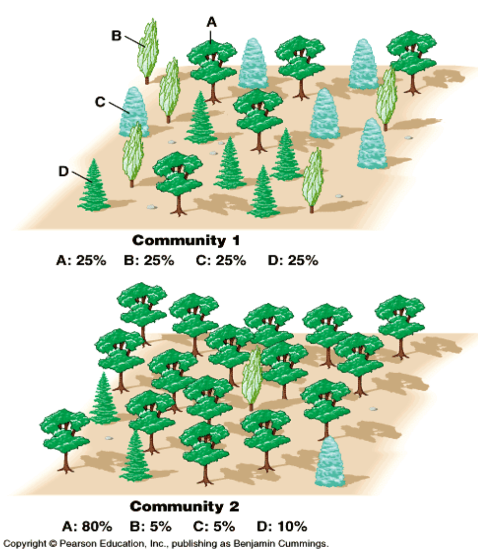


Figure A-1. Species richness.

species become overly prolific, thereby reducing the average number of species found at any one point within the lake which ultimately reduces the overall complexity and variety of habitats a lake system offers. Macrophyte species that are most likely to become overly abundant in shallow, nutrient rich lakes include coontail, Canada waterweed, sago pondweed, Eurasian watermilfoil, and curly-leaf pondweed. In State Line Lake, sago pondweed has occupied this role.

Sago pondweed was found at more than 94% of sampling locations in 2018, compared to 1.9% of sampling locations in 2017. According to several leading waterfowl food habitat authorities, sago pondweed is one of the most important waterfowl food plants in the United States (Mabbot 2010; Martin and Uhler 1939; McAtee 1918). It should be noted that a significant number of waterfowl species were observed during the 2018 survey including 220 American coots, 30 blue-winged teal, 5 ruddy ducks, 2 trumpeter swans, 1 northern shoveler, 1 Canada goose, and 1 pied-billed grebe. While it is encouraging that sago pondweed will provide a valuable food refuge for waterfowl, the prolific nature and largely monotypic distribution of this species is indicative of a disturbed ecosystem.

Furthermore, it should be noted that water clarity was poor during the survey, with observed secchi disk readings averaging approximately 1.3 feet. The continued degradation of water quality and clarity will most likely result in a return to an algae dominated, turbid water state. A healthy aquatic plant community can help to maintain a clear-water, aquatic plant-dominated state, which is the ecologically preferred state. Maintaining a greater variety of aquatic plant species also helps to perpetuate a clear-water phase throughout the growing season given that different aquatic plant species become more or less prolific throughout the growing season.

Results from the 2017 and 2018 surveys should be compared with future surveys to determine if an increase in the number and quality of species observed is occurring along with a concomitant increase in water clarity and quality.

Table A-1. State Line Lake Point-intercept Survey Results - Native species only.

Common Name	Scientific Name	C-Value	Frequency of Occurrence
Bushy pondweed	*Najas flexilis*	6	15.6%
Canada waterweed	*Elodea canadensis*	4	2.2%
Columbian watermeal	*Wolffia columbiana*	5	7.8%
Common bladderwort	*Utricularia vulgaris*	7	1.1%
Coontail	*Ceratophyllum demersum*	2	44.4%
Flatstem pondweed	*Potamogeton zosteriformis*	6	2.2%
Floating leaf pondweed	*Potamogeton natans*	5	1.1%
Giant bur-reed	*Sparganium eurycarpum*	5	1.1%
Greater duckweed	*Spirodela polyrhiza*	5	16.7%
Lesser bladderwort	*Utricularia minor*	8	1.1%
Lesser duckweed	*Lemna minor*	5	24.4%
Long leaf pondweed	*Potamogeton nodosus*	6	1.1%
Northern watermilfoil	*Myriophyllum exalbescens*	7	1.1%
Sago pondweed	*Stuckenia pectinata*	3	94.4%
Slender riccia	*Riccia fluitans*	7	1.1%
Slender waterweed	*Elodea nuttallii*	7	21.1%
Small pondweed	*Potamogeton pusillus*	7	15.6%
Star duckweed	*Lemna trisulca*	5	3.3%
Stiff pondweed	*Potamogeton strictifolius*	8	13.3%
Water smartweed	*Persicaria amphibia*	4	2.2%
White water lily	*Nymphaea odorata*	6	1.1%

Summary Table FQI = C*√S	**Average C-Value**	5.6
C= Mean coefficient of conservatism value	**Number of species**	20
S= Number of species in sample	**FQI**	**25.0**

* FQI calculation does not include narrow leaf/hybrid cattail which has a C-value of 0.

Table A-2. State Line Lake Point-intercept Survey Results with Introduced Species.

Common Name	Scientific Name	C-Value	Frequency of Occurrence
Bushy pondweed	*Najas flexilis*	6	15.6%
Canada waterweed	*Elodea canadensis*	4	2.2%
Columbian watermeal	*Wolffia columbiana*	5	7.8%
Common bladderwort	*Utricularia vulgaris*	7	1.1%
Coontail	*Ceratophyllum demersum*	2	44.4%
Flatstem pondweed	*Potamogeton zosteriformis*	6	2.2%
Floating leaf pondweed	*Potamogeton natans*	5	1.1%
Giant bur-reed	*Sparganium eurycarpum*	5	1.1%
Greater duckweed	*Spirodela polyrhiza*	5	16.7%
Lesser bladderwort	*Utricularia minor*	8	1.1%
Lesser duckweed	*Lemna minor*	5	24.4%
Long leaf pondweed	*Potamogeton nodosus*	6	1.1%
Narrow-Leaf/hybrid cattail*	*Typha angustifolia/ 'Typha X glauca*	0	14.4%
Northern watermilfoil	*Myriophyllum exalbescens*	7	1.1%
Sago pondweed	*Stuckenia pectinata*	3	94.4%
Slender riccia	*Riccia fluitans*	7	1.1%
Slender waterweed	*Elodea nuttallii*	7	21.1%
Small pondweed	*Potamogeton pusillus*	7	15.6%
Star duckweed	*Lemna trisulca*	5	3.3%
Stiff pondweed	*Potamogeton strictifolius*	8	13.3%
Water smartweed	*Persicaria amphibia*	4	2.2%
White water lily	*Nymphaea odorata*	6	1.1%
Summary Table FQI = C*√S	**Average C-Value**	5.3	
C= Mean coefficient of conservatism value	**Number of species**	21	
S= Number of species in sample	**FQI**	**24.4**	

*Introduced species

State Line Lake Historical Survey Results and Comparison

Table A-3. Floristic Quality Index from 2010 DNR survey.

Common Name	Scientific Name	C-Value	Frequency of Occurrence	Found in 2018
Coontail	*Ceratophyllum demersum*	2	1.9%	Yes
Narrow-Leaf/hybrid cattail	*Typha angustifolia/ 'Typha X glauca*	0	7.7%	Yes
Sago pondweed	*Stuckenia pectinata*	3	1.9%	Yes
Watermoss	*Drepanocladus or Fontinalis species*	NA	26.9%	No
Summary Table FQI = C*√S	**Average C-Value**	1.7		
C= Mean coefficient of conservatism value	**Number of species**	4		
S= Number of species in sample	**FQI**	**6.7**		

References

Beck, M.W., L.K. Hatch, B. Vondracek, and R.D. Valley. 2010. Development of a macrophyte based index of biotic integrity for Minnesota lakes. Ecological Indicators 10:968-979.

Mabbott, D. C. 1920. Food habits of seven species of American shoalwater ducks. U. S. Department of Agriculture. Bull. 862. 67 p.

Martin, A. C., and F. M. Uhler. 1939. Food of game ducks in the United States and Canada. U. S. Department of Agriculture Technical Bull. 6.34.

McAtee, W. 1. 1918. Food habits of the mallard duck in the United States. U. S. Department of Agriculture Bull. 720.

Stateline Lake 2018 Aquatic Plant Species Distribution

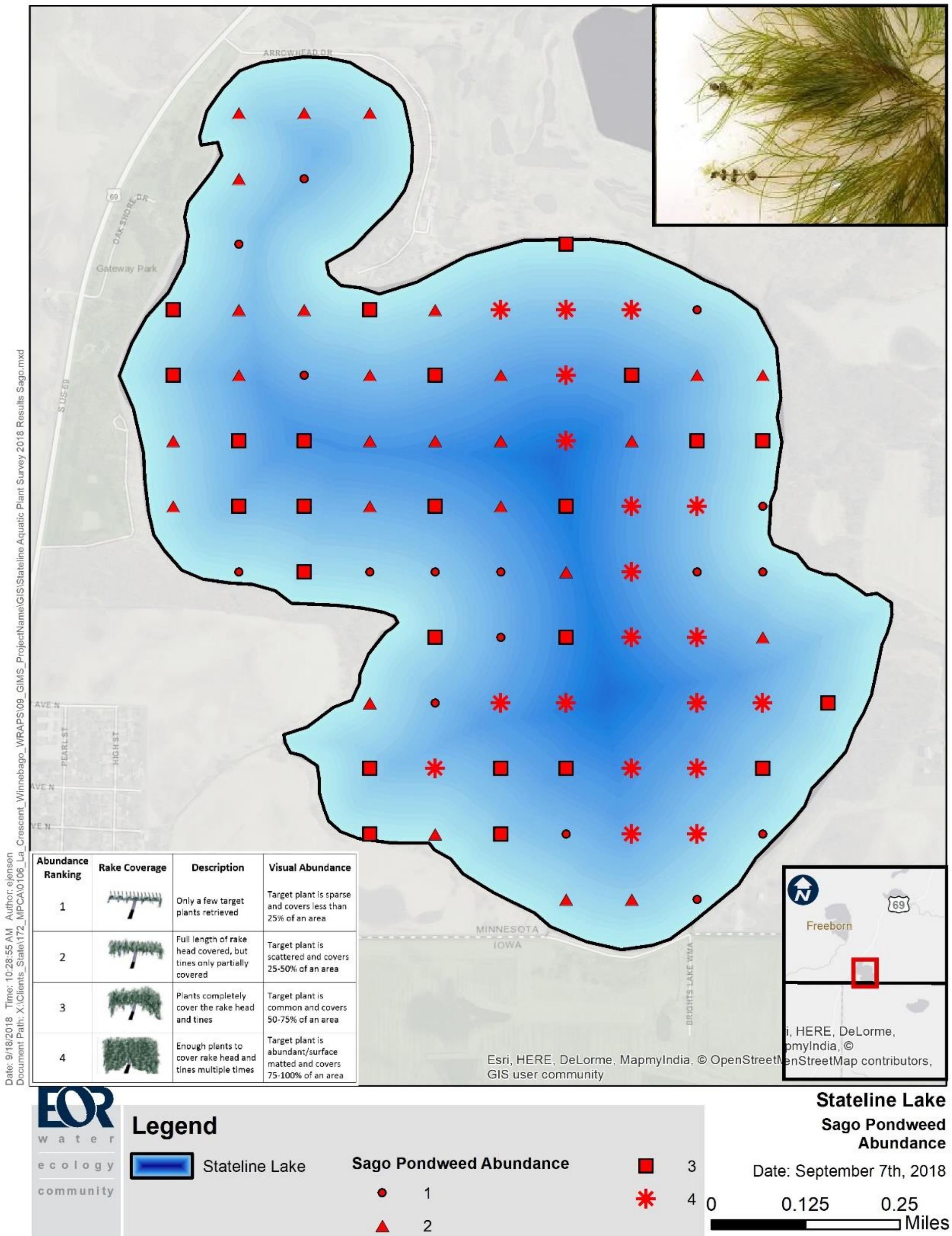


Figure A-2. Sago pondweed distribution and abundance - September, 2018.

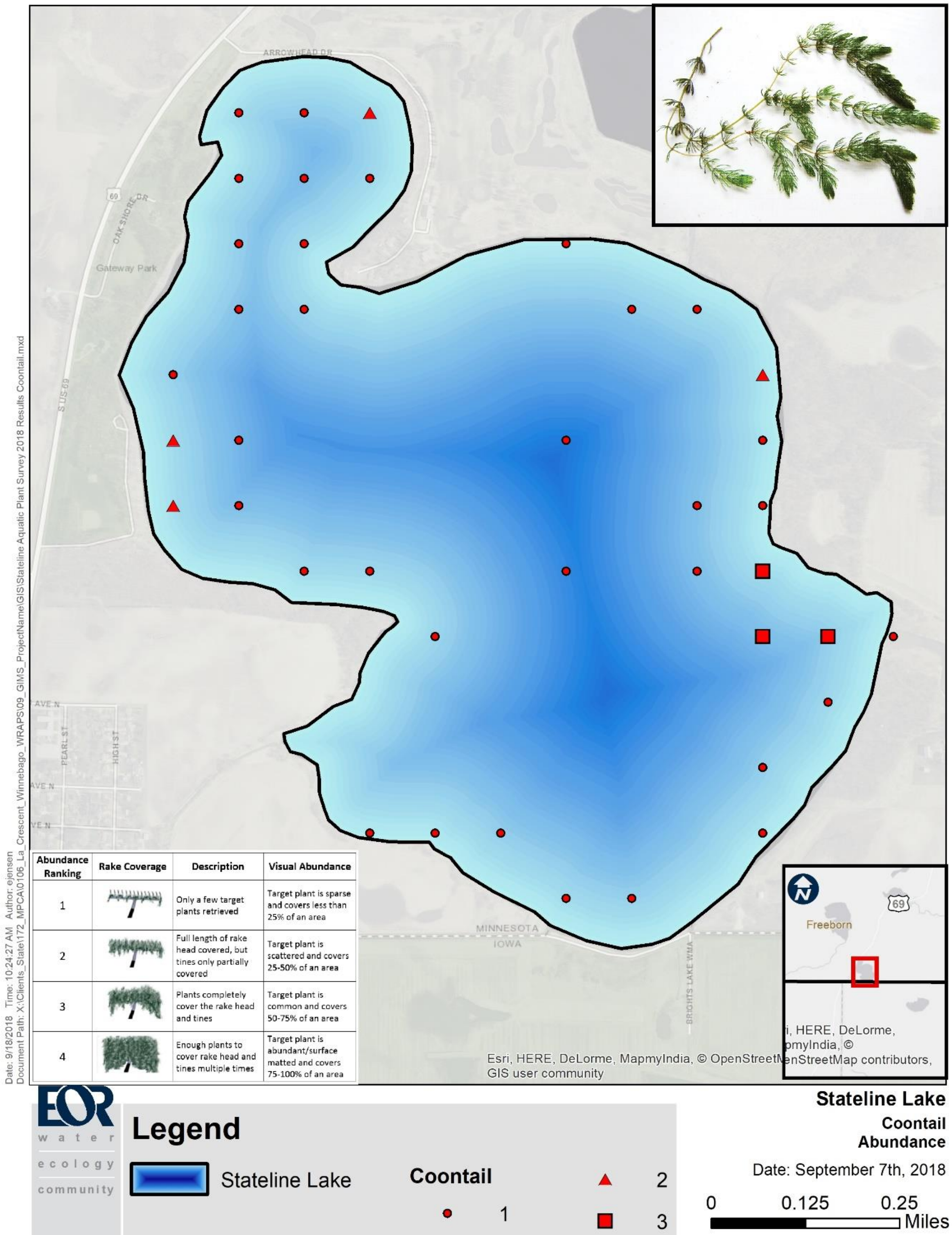


Figure A-3. Coontail distribution and abundance - September, 2018.

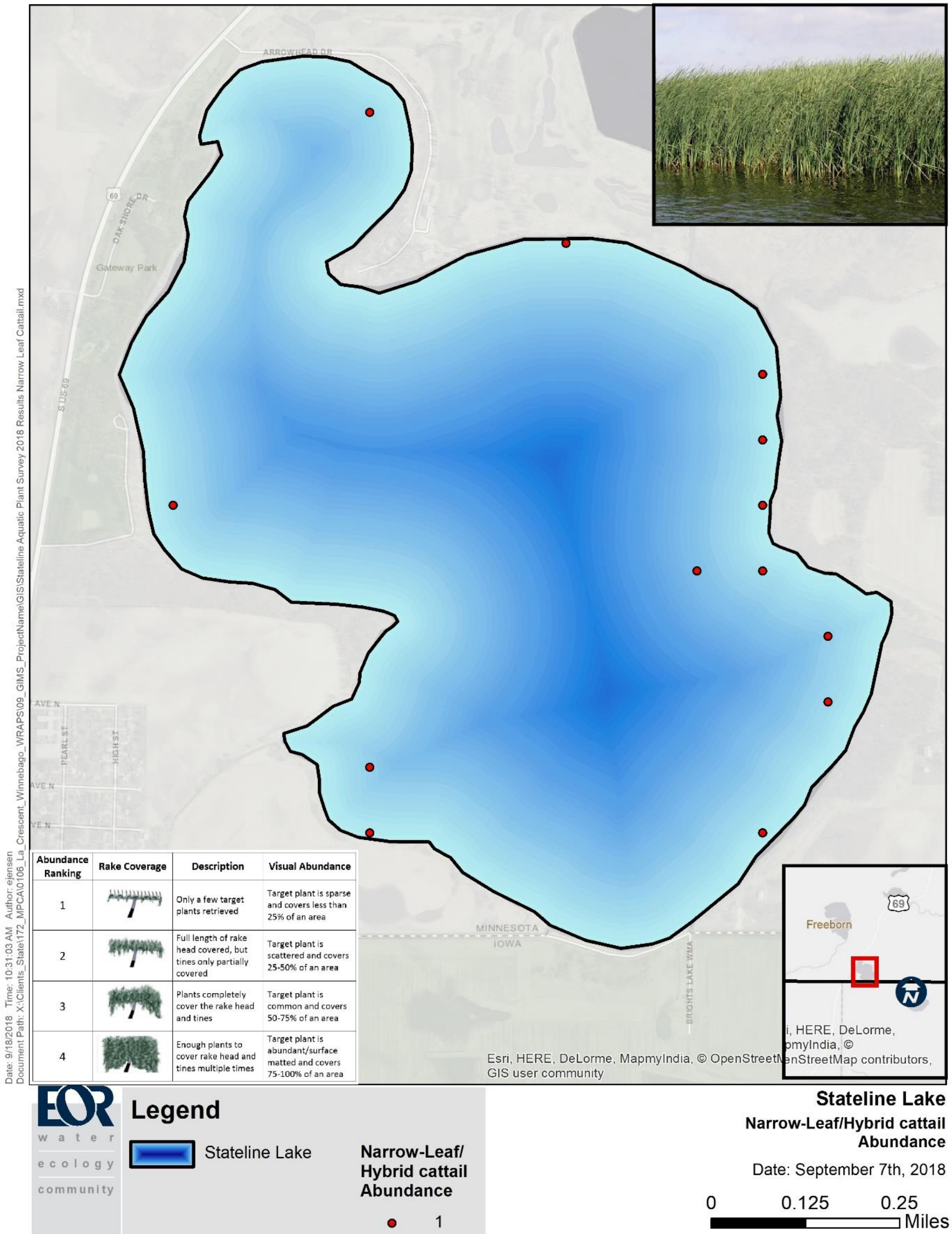


Figure A-4. Narrow-leaf/Hybrid cattail distribution and abundance - September, 2018.

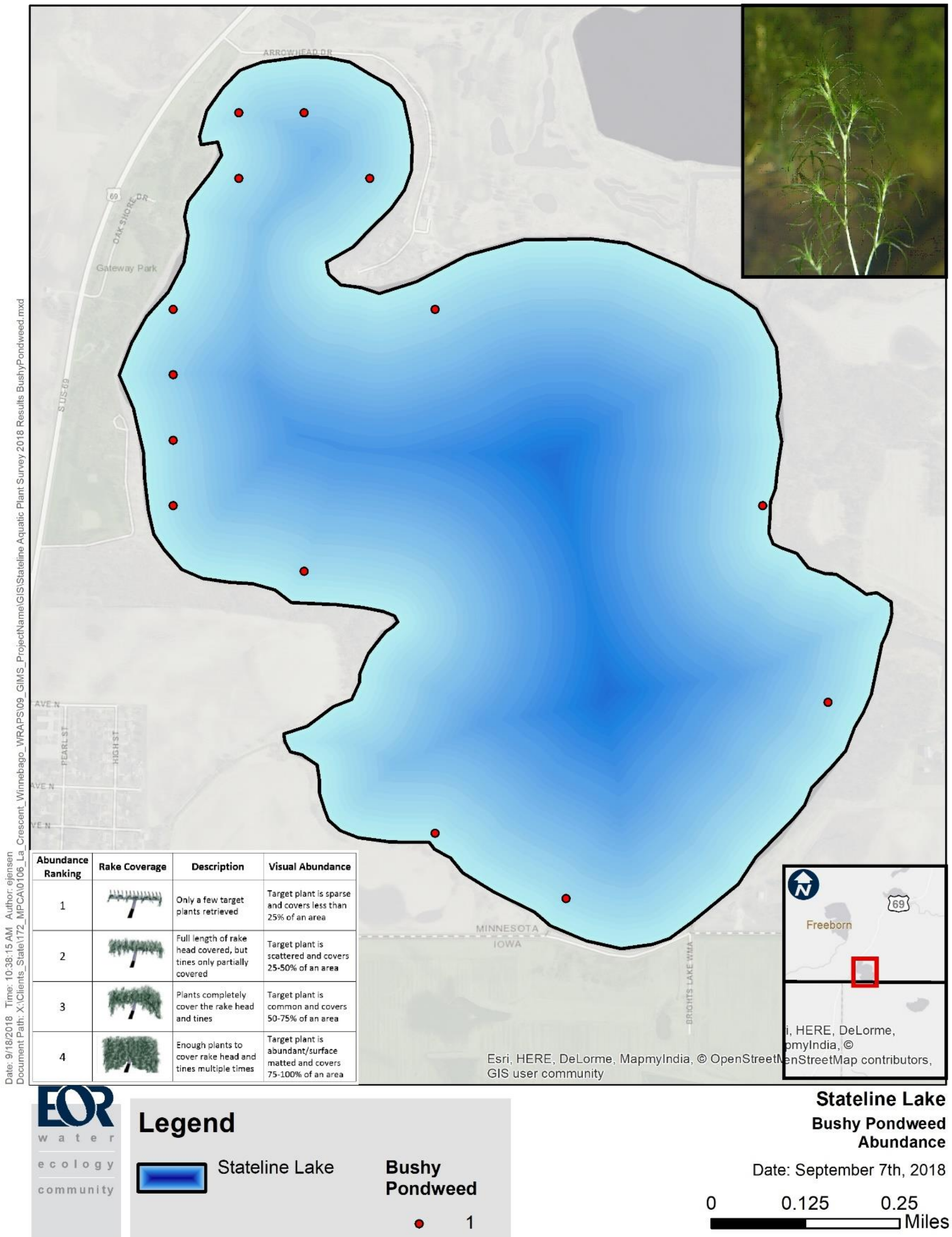


Figure A-5. Bushy pondweed distribution and abundance - September, 2018.

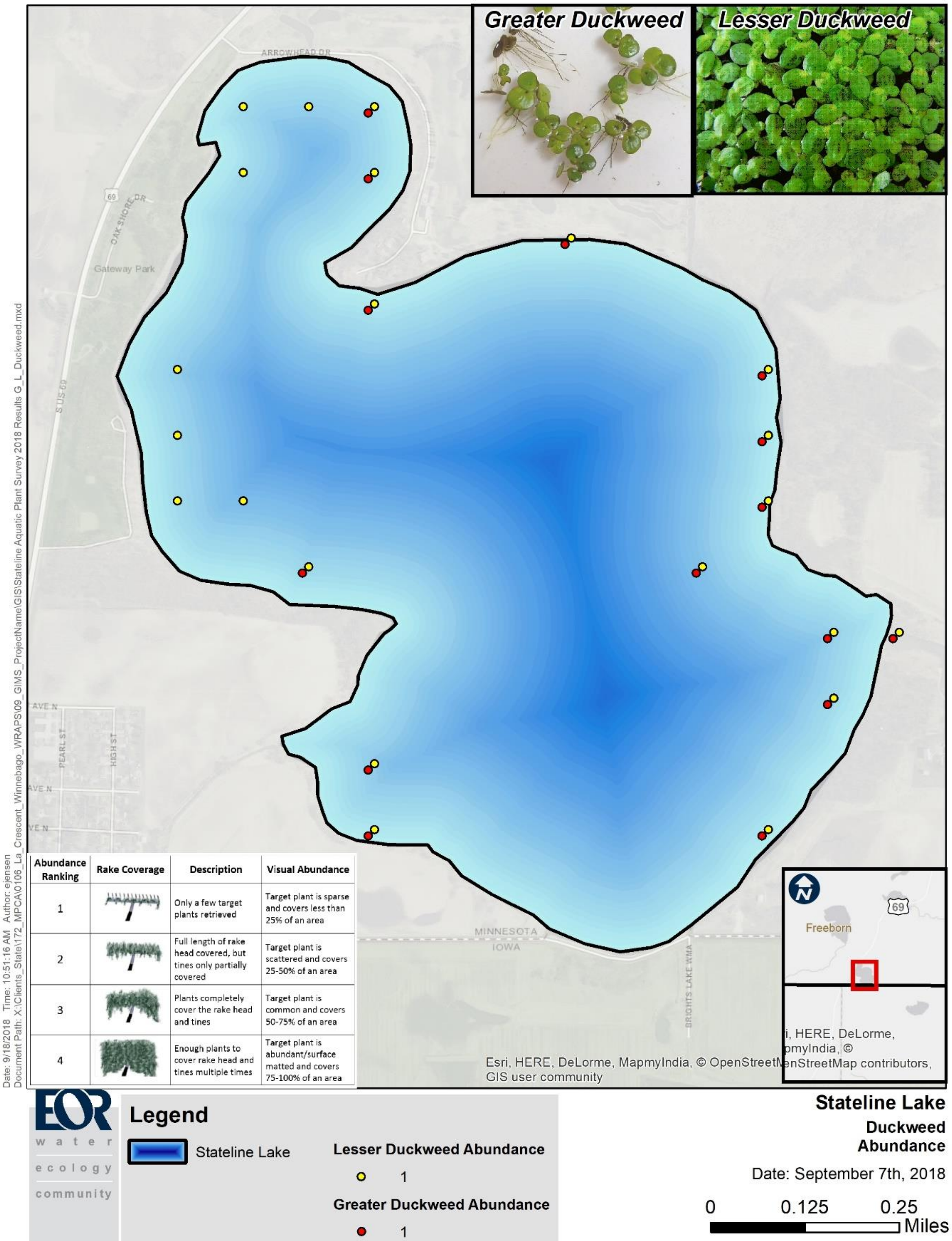


Figure A-6. Duckweed spp. distribution and abundance - September, 2018.

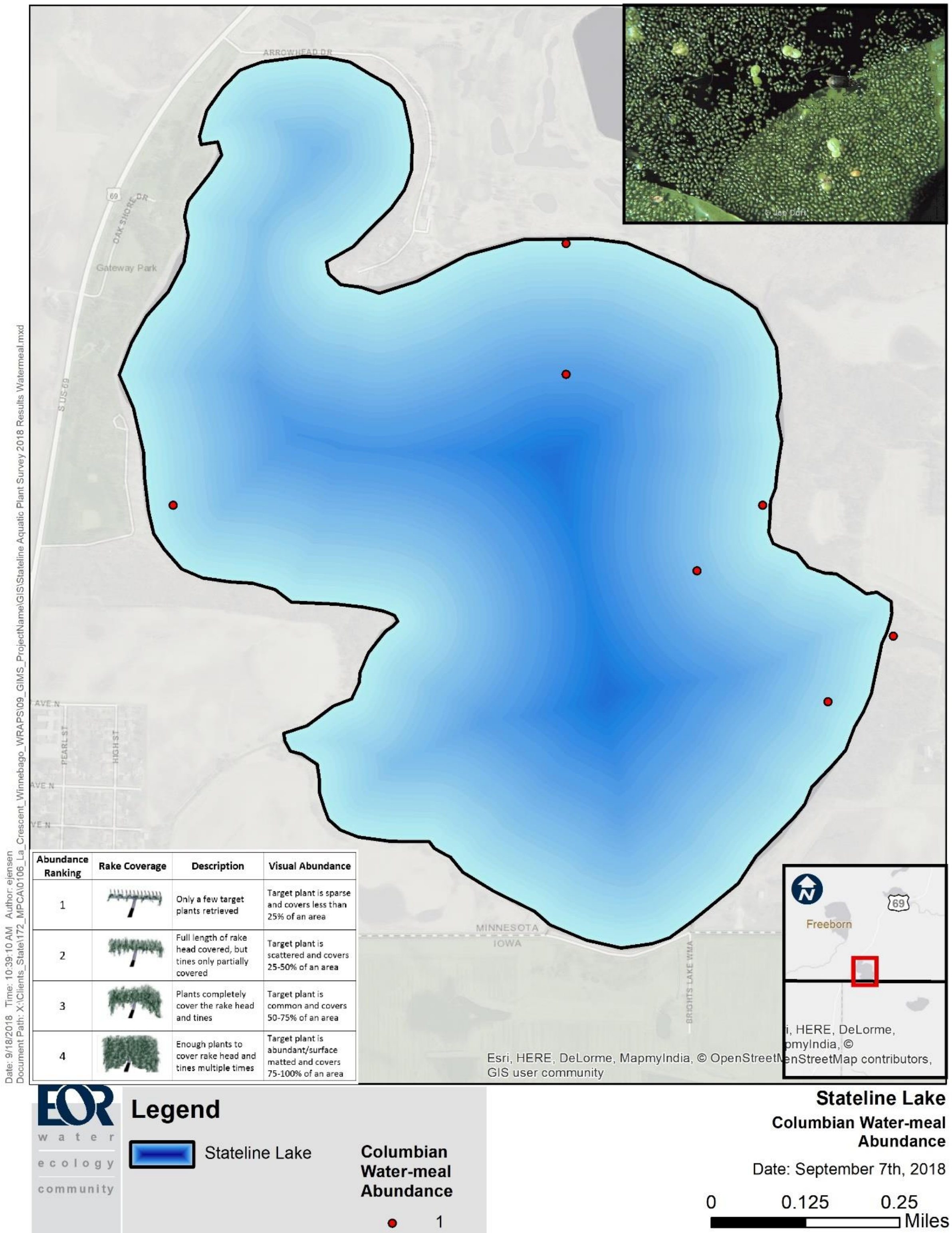


Figure A-7. Columbian watermeal distribution and abundance - September, 2018.

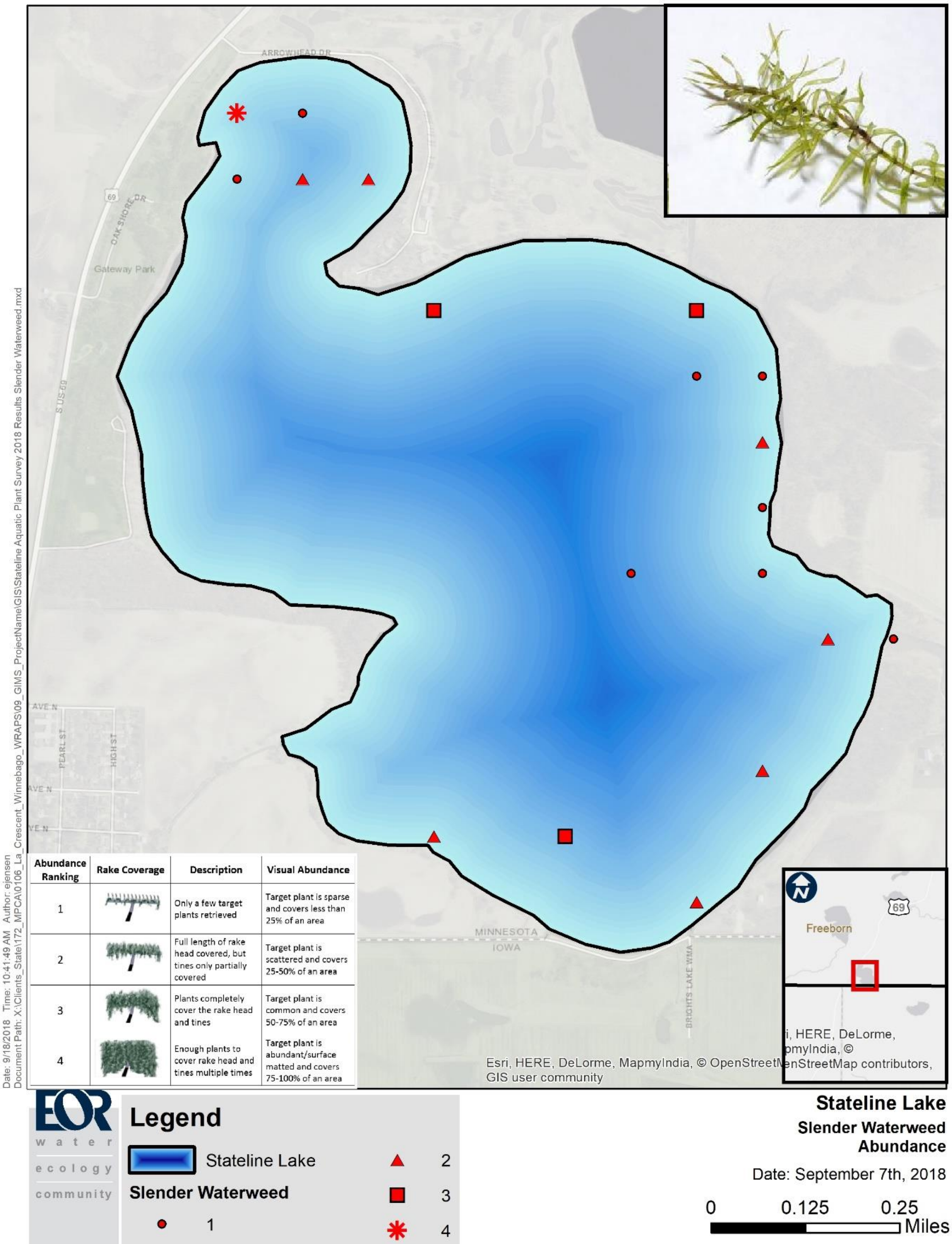


Figure A-8. Slender waterweed distribution and abundance - September, 2018.

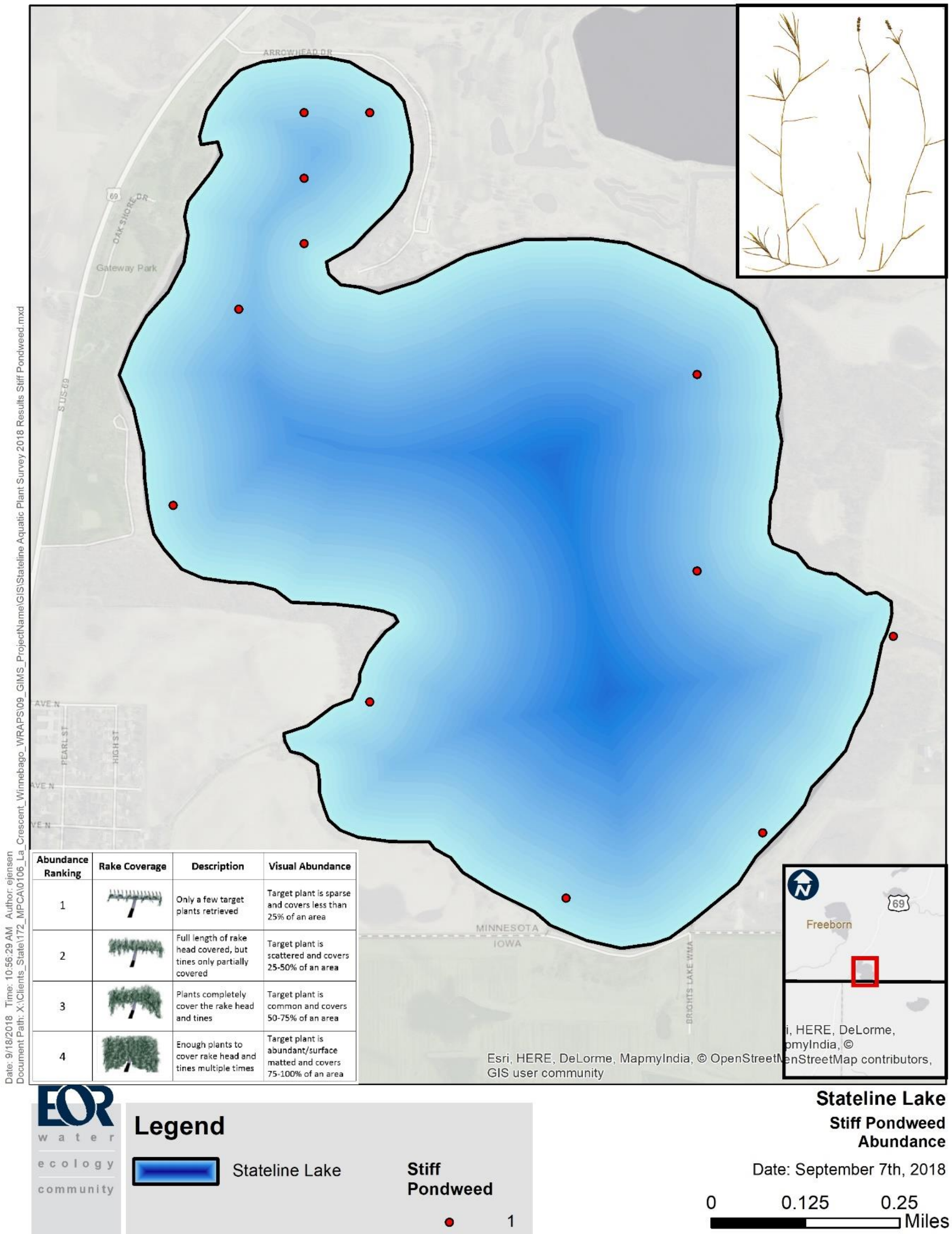


Figure A-9. Stiff pondweed distribution and abundance – September, 2018.

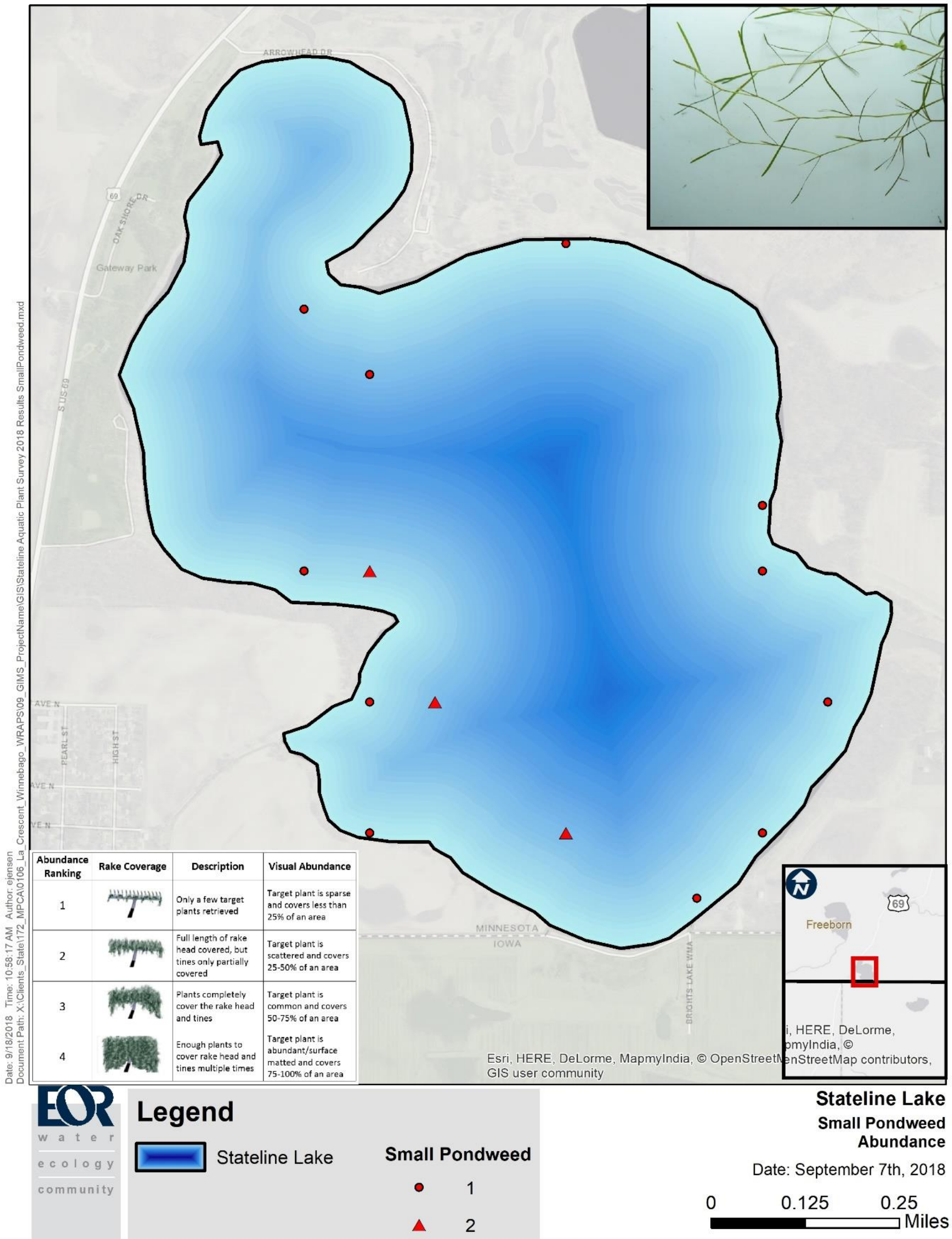


Figure A-10. Small pondweed distribution and abundance – September, 2018.

Appendix B. BATHTUB Supporting Information

B.1 Bear Lake

Table B-1. Bear Lake existing conditions model predicted and observed values.

Predicted & Observed Values Ranked Against CE Model Development Dataset						
Segment:	1	Bear Lake				
	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P	262.0	0.24	97.0%	262.0	0.11	97.0%

Table B-2. Bear Lake existing conditions model water and phosphorus balances.

Overall Water Balance					Averaging Period =		1.00	years
				Area	Flow	Variance	CV	Runoff
Trb	**Type**	**Seg**	**Name**	**km^2**	**hm^3/yr**	**(hm3/yr)^2**	**-**	**m/yr**
1	1	1	Unnamed	24.4	7.7	5.89E-01	0.10	0.31
2	1	1	Steward C	51.7	16.4	2.67E+00	0.10	0.32
3	1	1	Direct Dra	18.3	6.4	4.04E-01	0.10	0.35
PRECIPITATION				6.3	5.5	3.02E-01	0.10	0.87
TRIBUTARY INFLOW				94.5	30.4	3.67E+00	0.06	0.32
***TOTAL INFLOW				100.8	35.9	3.97E+00	0.06	0.36
ADVECTIVE OUTFLOW				100.8	31.3	4.80E+00	0.07	0.31
***TOTAL OUTFLOW				100.8	31.3	4.80E+00	0.07	0.31
***EVAPORATION					4.6	8.31E-01	0.20	

Overall Mass Balance Based Upon				Predicted		Outflow & Reservoir Concentrations				
Component:				TOTAL P						
				Load		Load Variance			Conc	Export
Trb	**Type**	**Seg**	**Name**	**kg/yr**	**%Total**	**(kg/yr)^2**	**%Total**	**CV**	**mg/m^3**	**kg/km^2/yr**
1	1	1	Unnamed	1653.5	9.2%	5.47E+04	15.2%	0.14	215.5	67.7
2	1	1	Steward C	3458.4	19.3%	2.39E+05	66.4%	0.14	211.5	66.9
3	1	1	Direct Dra	1488.8	8.3%	4.43E+04	12.3%	0.14	234.1	81.2
PRECIPITATION				296.1	1.7%	2.19E+04	6.1%	0.50	53.9	46.9
INTERNAL LOAD				11022.0	61.5%	0.00E+00		0.00		
TRIBUTARY INFLOW				6600.7	36.8%	3.38E+05	93.9%	0.09	217.2	69.9
***TOTAL INFLOW				17918.8	100.0%	3.60E+05	100.0%	0.03	499.5	177.8
ADVECTIVE OUTFLOW				8205.5	45.8%	4.10E+06		0.25	262.0	81.4
***TOTAL OUTFLOW				8205.5	45.8%	4.10E+06		0.25	262.0	81.4
***RETENTION				9713.3	54.2%	3.98E+06		0.21		
	Overflow Rate (m/yr)			5.0		Nutrient Resid. Time (yrs)			0.0840	
	Hydraulic Resid. Time (yrs)			0.1834		Turnover Ratio			11.9	
	Reservoir Conc (mg/m3)			262		Retention Coef.			0.542	

Table B-3. Bear Lake TMDL goal scenario model predicted and observed values.

Predicted & Observed Values Ranked Against CE Model Development Dataset						
Segment:	**1**	**Bear Lake**				
	Predicted Values--->			**Observed Values--->**		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P	90	0.18	75.6%	262	0.11	97.0%

Table B-4. Bear Lake TMDL goal scenario model water and phosphorus balances.

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	**Type**	**Seg**	**Name**	**Area** km^2	**Flow** hm^3/yr	**Variance** $(hm3/yr)^2$	**CV** -	**Runoff** m/yr
1	1	1	Unnamed	24.4	7.7	5.89E-01	0.10	0.31
2	1	1	Steward C	51.7	16.4	2.67E+00	0.10	0.32
3	1	1	Direct Dra	18.3	6.4	4.04E-01	0.10	0.35
PRECIPITATION				6.3	5.5	3.02E-01	0.10	0.87
TRIBUTARY INFLOW				94.5	30.4	3.67E+00	0.06	0.32
***TOTAL INFLOW				100.8	35.9	3.97E+00	0.06	0.36
ADVECTIVE OUTFLOW				100.8	31.3	4.80E+00	0.07	0.31
***TOTAL OUTFLOW				100.8	31.3	4.80E+00	0.07	0.31
***EVAPORATION					4.6	8.31E-01	0.20	

Overall Mass Balance Based Upon Predicted Component: TOTAL P — **Outflow & Reservoir Concentrations**

Trb	**Type**	**Seg**	**Name**	**Load** kg/yr	**%Total**	**Load Variance** $(kg/yr)^2$	**%Total**	**CV**	**Conc** mg/m^3	**Export** $kg/km^2/yr$
1	1	1	Unnamed	1081.9	23.6%	2.34E+04	14.0%	0.14	141.0	44.3
2	1	1	Steward C	2305.6	50.3%	1.06E+05	63.4%	0.14	141.0	44.6
3	1	1	Direct Dra	896.7	19.6%	1.61E+04	9.6%	0.14	141.0	48.9
PRECIPITATION				296.1	6.5%	2.19E+04	13.1%	0.50	53.9	46.9
TRIBUTARY INFLOW				4284.2	93.5%	1.46E+05	86.9%	0.09	141.0	45.4
***TOTAL INFLOW				4580.3	100.0%	1.68E+05	100.0%	0.09	127.7	45.5
ADVECTIVE OUTFLOW				2803.5	61.2%	3.00E+05		0.20	89.5	27.8
***TOTAL OUTFLOW				2803.5	61.2%	3.00E+05		0.20	89.5	27.8
***RETENTION				1776.8	38.8%	2.63E+05		0.29		

Overflow Rate (m/yr)	5.0	Nutrient Resid. Time (yrs)	0.1123
Hydraulic Resid. Time (yrs)	0.1834	Turnover Ratio	8.9
Reservoir Conc (mg/m3)	90	Retention Coef.	0.388

B.2 State Line Lake

Table B-5. State Line Lake existing conditions model predicted and observed values.

Predicted & Observed Values Ranked Against CE Model Development Dataset						
Segment: 1 State Line Lake						
	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P	550	0.34	99.7%	550	0.12	99.7%

Table B-6. State Line Lake existing conditions model water and phosphorus balances.

Overall Water Balance					Averaging Period =	1.00 years		
				Area	Flow	Variance	CV	Runoff
Trb	**Type**	**Seg**	**Name**	**km²**	**hm³/yr**	**(hm3/yr)²**	**-**	**m/yr**
1	1	1	Unnamed	9.2	2.9	8.26E-02	0.10	0.31
2	1	1	Direct Dra	2.8	1.0	9.34E-03	0.10	0.34
PRECIPITATION				1.8	1.6	2.43E-02	0.10	0.87
TRIBUTARY INFLOW				12.0	3.8	9.19E-02	0.08	0.32
***TOTAL INFLOW				13.8	5.4	1.16E-01	0.06	0.39
ADVECTIVE OUTFLOW				13.8	4.1	1.84E-01	0.10	0.30
***TOTAL OUTFLOW				13.8	4.1	1.84E-01	0.10	0.30
***EVAPORATION					1.3	6.76E-02	0.20	

Overall Mass Balance Based Upon				Predicted		Outflow & Reservoir Concentrations				
Component:				TOTAL P						
				Load		Load Variance			Conc	Export
Trb	**Type**	**Seg**	**Name**	**kg/yr**	**%Total**	**(kg/yr)²**	**%Total**	**CV**	**mg/m³**	**kg/km²/yr**
1	1	1	Unnamed	570.9	5.7%	6.52E+03	72.9%	0.14	198.7	62.0
2	1	1	Direct Dra	179.0	1.8%	6.41E+02	7.2%	0.14	185.2	63.2
PRECIPITATION				84.5	0.8%	1.78E+03	19.9%	0.50	54.2	46.9
INTERNAL LOAD				9208.9	91.7%	0.00E+00		0.00		
TRIBUTARY INFLOW				749.9	7.5%	7.16E+03	80.1%	0.11	195.3	62.3
***TOTAL INFLOW				10043.3	100.0%	8.94E+03	100.0%	0.01	1860.7	725.3
ADVECTIVE OUTFLOW				2255.1	22.5%	6.27E+05		0.35	550.4	162.9
***TOTAL OUTFLOW				2255.1	22.5%	6.27E+05		0.35	550.4	162.9
***RETENTION				7788.1	77.5%	6.18E+05		0.10		
	Overflow Rate (m/yr)			2.3		Nutrient Resid. Time (yrs)			0.0869	
	Hydraulic Resid. Time (yrs)			0.3868		Turnover Ratio			11.5	
	Reservoir Conc (mg/m3)			550		Retention Coef.			0.775	

Table B-7. State Line Lake TMDL goal scenario model predicted and observed values.

Predicted & Observed Values Ranked Against CE Model Development Dataset						
Segment:	**1**	**State Line Lake**				
	Predicted Values--->			**Observed Values--->**		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P	90	0.24	75.7%	550	0.12	99.7%

Table B-8. State Line Lake TMDL goal scenario model water and phosphorus balances.

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	Unnamed	9.2	2.9	8.26E-02	0.10	0.31
2	1	1	Direct Dra	2.8	1.0	9.34E-03	0.10	0.34
PRECIPITATION				1.8	1.6	2.43E-02	0.10	0.87
TRIBUTARY INFLOW				12.0	3.8	9.19E-02	0.08	0.32
***TOTAL INFLOW				13.8	5.4	1.16E-01	0.06	0.39
ADVECTIVE OUTFLOW				13.8	4.1	1.84E-01	0.10	0.30
***TOTAL OUTFLOW				13.8	4.1	1.84E-01	0.10	0.30
***EVAPORATION					1.3	6.76E-02	0.20	

Overall Mass Balance Based Upon Predicted Component: TOTAL P — **Outflow & Reservoir Concentrations**

Trb	Type	Seg	Name	Load kg/yr	Load %Total	Load Variance $(kg/yr)^2$	Load Variance %Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	Unnamed	502.8	66.5%	5.06E+03	68.2%	0.14	175.0	54.6
2	1	1	Direct Dra	169.1	22.4%	5.72E+02	7.7%	0.14	175.0	59.7
PRECIPITATION				84.5	11.2%	1.78E+03	24.1%	0.50	54.2	46.9
TRIBUTARY INFLOW				672.0	88.8%	5.63E+03	75.9%	0.11	175.0	55.8
***TOTAL INFLOW				756.4	100.0%	7.41E+03	100.0%	0.11	140.1	54.6
ADVECTIVE OUTFLOW				367.8	48.6%	8.98E+03		0.26	89.8	26.6
***TOTAL OUTFLOW				367.8	48.6%	8.98E+03		0.26	89.8	26.6
***RETENTION				388.6	51.4%	9.40E+03		0.25		

Overflow Rate (m/yr)	2.3	Nutrient Resid. Time (yrs)	0.1881
Hydraulic Resid. Time (yrs)	0.3868	Turnover Ratio	5.3
Reservoir Conc (mg/m3)	90	Retention Coef.	0.514

APPENDIX C. EMMONS WWTP TP LIMIT MEMO

DATE : 05/15/2019

TO : File

FROM :

Emily Brault

Effluent Limits Unit

Environmental Analysis and Outcomes Division

PHONE : 651-757-2377

SUBJECT : Phosphorus Effluent Limit Review for the Winnebago River Watershed.

VERSION: 1.0 Original Memorandum

Overview

- One of the two facilities in the WRW, Conger WWTF, does not presently require a more stringent TP effluent limit than their existing one.
- However, the other discharger in the WRW, Emmons WWTF, has the reasonable potential (RP) to cause or contribute to the eutrophication impairment in the downstream water, Lime Creek.
- Thus, a TP WQBEL will now be required of Emmons WWTF to protect Lime Creek.
- **If future monitoring shows that both TP and response variables exceed eutrophication standards in additional WRW waters, then more restrictive limits may be needed for WRW facilities at that time.**

Executive Summary

Algae are an important part of aquatic food webs, but high algal density has adverse effects on humans and wildlife. When algae become dense in lakes or rivers they turn these waters green and may cause the suffocation of fish and other biota. Furthermore, lakes and rivers with high algal densities become smelly and murky, making them unpleasant for canoeing, swimming, and other recreation.

In Minnesota's lakes and rivers, the availability of the nutrient, P, typically drives the growth of algae. Thus, controlling P concentrations in these waters is essential for preventing eutrophication, a state of a water where excess nutrients has resulted in excess algae.

In 2008, Minnesota approved lake eutrophication standards (LES), targets to reduce TP and algae in these waters. In 2015, Minnesota adopted rules that include such standards for rivers and streams, RES. At that time, the MPCA also began setting TP limits on a watershed basis, ensuring that all TP contributors do their "fair share" to reduce P in a watershed. The MPCA worked with the EPA for multiple years to develop its procedures for implementing effluent limits to meet the TP and algae standards. When TP and algae concentrations are too high in a water, the MPCA is required by law to develop a plan to reduce them.

This memorandum discusses the MPCA's watershed-based review of TP effluent limits for NPDES facilities (i.e., WWTFs) that discharge to the WRW (HUC: 07080203). Two WWTFs operate in the WRW. A more restrictive TP limit than the existing one for Conger WWTF is not presently needed. However, Emmons WWTF will now receive a P effluent limit in order to ensure that an impaired downstream water meets RES criteria. We summarize our recommendations on TP effluent limits for the WRW in Executive Table 1:

Executive Summary Table 1. Summary of TP effluent limits for facilities in the WRW.
LES limits are applicable from January through December whereas RES limits are applied from June through September. *SDR* and *WLA* abbreviate *state discharge restriction* and *wasteload allocation*, correspondingly.

Domestic Facilities	Permit ID	Type	Action	SDR Limit (mg/L)[a]	Lake Limit (kg/yr)[b]	River WLA (kg/d)[c]	River Limit (kg/d)[d]
Conger WWTF	MN0068519	Pond	Limit	–	72	–	–
Emmons WWTF	MN0023311	Continuous	Limit	–		1.1	1.1

[a]SDR limits derive from Minn. R. 7053.0255 and are calendar month average limits.

[b]These limits are 12-month rolling totals.

[c]WLAs must be met as long-term averages.

[d]These limits are calendar month averages.

Background

Eutrophication standards

Minnesota has numeric LES and recently adopted numeric RES. The river reaches downstream of WWTFs in the WRW are located in the South RNR, and its lakes reside in the Western Corn Belt Plains Ecoregion. Each RNR and ecoregion have different LES and RES criteria (Minn. R. 7050.0222, subp. 4, Heiskary 2013) and those relevant to the WRW are shown in Table C-1.

Table C-1. River and lake eutrophication criteria for waters of in the WRW.

Class	River Nutrient Region	Causal	Response			Class	Lake Ecoregion	Lake Type	Causal	Response	
		TP (µg/L)	Chl–a (µg/L)	DO flux (mg/L)	BOD_5 (mg/L)				TP (µg/L)	Chl–a (µg/L)	Secchi (m)
2Bd	South	≤ 150	≤ 35	≤ 4.5	≤ 3.0	2Bd/B	Western Corn Belt Plains	Lakes and reservoirs[a]	≤ 65	≤ 22	≤ -0.9[c]
2B		≤ 150	≤ 40	≤ 5.0	≤ 3.5			Shallow lakes[b]	≤ 90	≤ 30	≤ -0.7[c]

[a]Lakes and reservoirs have regions that are greater than or equal to 15 feet deep.
[b]Shallow lakes have regions that are less than 15 feet and greater than 7 feet deep.
[c]The negative sign denotes depth below the surface.

A water meets its eutrophication standards if it has long-term means of causal (TP concentration) and response variables that do not exceed their standards, see Procedures for implementing RES in NPDES wastewater permits in Minnesota (MPCA 2015). A water does not meet eutrophication standards if the long-term mean of a single response parameter and the causal parameter exceed their respective criteria (MPCA 2015). Additionally, if the TP concentration of a water exceeds and all response parameter measurements meet their respective RES criteria, then it is considered a “no response” water (MPCA 2015).

For rivers, response variables are: Chl-*a* concentration, $bBOD_5$, or DO Flux. Response variables for lakes are: Chl-*a* concentration or Secchi disk depth. Datasets must consist of at least 12 and 8 samples in order to influence the impairment status of a river and lake, respectively. The summer season is the period of interest for lake and river eutrophication assessments.

Winnebago River Watershed

Only about 10.4% of the WRW is within Minnesota, equivalent to approximately 45,927 acres (Figure C-1). Iowa contains the remainder of this watershed. Minnesota’s portion of this watershed is largely within Freeborn County (99%) with 1% of it being within Faribault County. This watershed does not have any large metropolitan areas. The largest cities in the WRW are: Emmons (391 people) and Conger (146 people). Cropland composes the majority of the WRW (84% of total land cover). Developments (6%), waters (4%), prairies/shrubs (3%), wetlands (3%), and forests (1%) compose the remaining surface area.

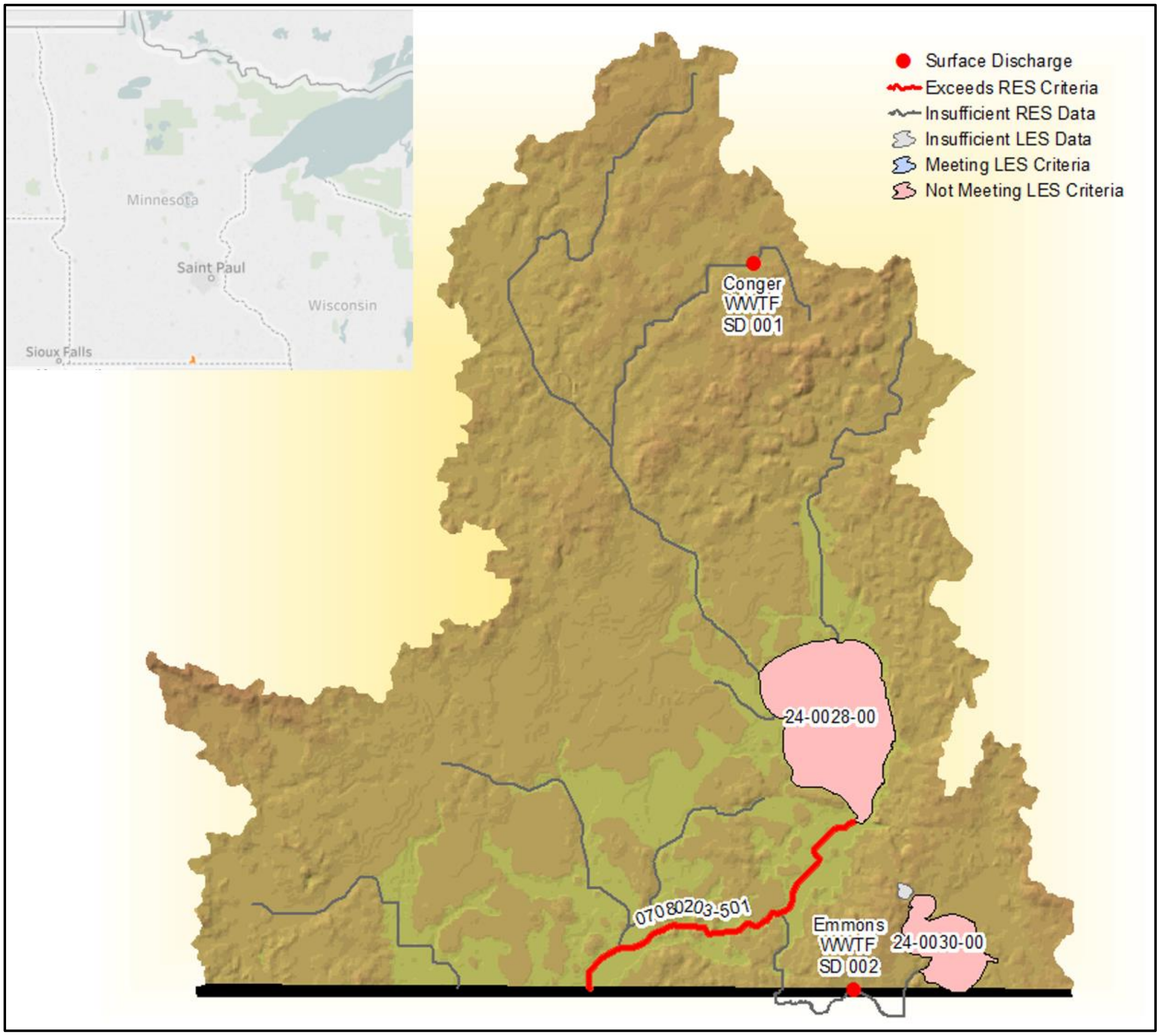


Figure C-1. Location of WRW, facilities in the WRW and eutrophication status of WRW's assessed waters. Via orange shading, the insert indicates the location of the WRW in Minnesota.

Important lakes in the WRW are Bear (Water Identification [WID]: 24-0028-00) and State Line (WID: 24-0030-00). Both are shallow lakes, and Bear Lake (1,560 acres) is notably larger than State Line Lake (445 acres). Additionally, the DNR designated Bear Lake as a Wildlife Management Lake in 1972. Bear and State Line Lake have poor water quality and invasive species. A primary river and the only one with sufficient data for an RES assessment is Lime Creek (WID: 7080203-501), which drains from Bear Lake and receives drainage from State Line Lake – via an unnamed creek (WID: 07080203-508, 516, and 503). This river subsequently flows into Iowa.

Figure C- 2. Image of Lime Creek (07080203-501) from August 9, 2016.

The DNR has developed an ecological health score for Minnesota's watersheds using their Watershed Health Assessment Framework (WHAF). The WHAF considers five components of watershed health: Hydrology, Geomorphology, Biology, Connectivity, and Water Quality, providing a score for each of them. Health scores are ranked on a scale from 0 (worst) to 100 (best). Among all watersheds, the mean score for the five components ranges from 40 (Marsh River Watershed) to 84 (Rapid River Watershed). The WRW's mean score for all components is 49. Scores for Geomorphology (66), Water Quality (62), and Hydrology (58) are the greatest. Biology and Connectivity have scores of 44 and 14, respectively. The Nonpoint Pollution Sources score is 53 with a P Risk subscore of only 2. Further details may be found at:
http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/ReportCard_Major_50.pdf.

As part of MPCA's watershed approach, intensive biological, chemical, and flow monitoring occurred in the WRW in 2009. These data are the primary sources for the water quality analyses of the WRW and presented below. An array of restoration and protection efforts help guide water quality improvement strategies. The intensive watershed monitoring program will begin the next monitoring cycle in the WRW in 2019.

Wastewater facilities

The WRW contains two active NPDES facilities that discharge via a surface discharge (SD) station, shown in Figure C-1 and described in Table C-2. Both of these facilities have been included in this memorandum, which will review applicable state discharge requirements (SDRs) and necessary P effluent limits for WRW facilities in order for downstream waters to meet eutrophication standards.

Table C-2. Background information on facilities in the WRW.

Domestic Facilities	Permit ID	Type	Station	Description	AWWDF (mgd)
Conger WWTF	MN0068519	Pond	SD 001	Main facility discharge Tile Line	0.021
Emmons WWTF	MN0023311	Continuous	SD 002	Bypass Main facility discharge	0.124

AWWDF abbreviates *average wet weather design flow*.

Phosphorus limit determination

The following text presents a review of TP effluent limits for facilities in the WRW. Effluent limit analysis follows an iterative review process (Figure C-3). Each analysis evaluates the potential impact of upstream WWTFs to cause or contribute to an exceedance of the eutrophication standards under current and permitted conditions on downstream waters. Our analysis follows established guidelines (MPCA 2015).

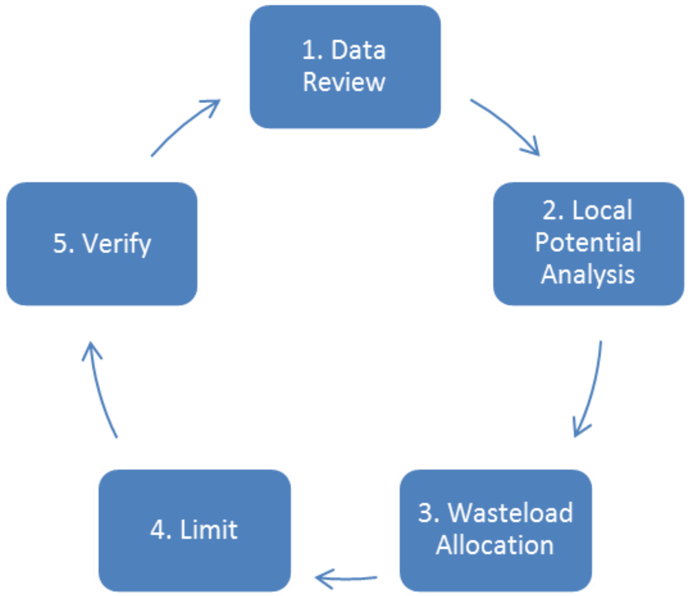


Figure C-3. Overview of RES analysis and NPDES limit determination.

Overview of analysis

As is described further below, all assessed WRW waters show nutrient impairments. Both of the two NPDES dischargers are upstream of at least one of these impaired waters. These facilities, Conger and Emmons WWTFs, have the RP to cause or contribute to their respective downstream impairments since they: (1) discharge upstream of nutrient impaired waters, (2) discharge at TP concentrations greater than the ambient target of these reaches, and (3) have no geographical barriers capable of trapping a significant mass of nutrients between their outfalls and impairments during most streamflow conditions. Federal law [40 CFR § 122.44(d)] restricts mass increases upstream of impaired waters and states that all NPDES dischargers with the RP to cause or contribute to downstream impaired waters must have WQBELs.

Earlier work (Weiss 2011) determined the necessary TP WQBEL for Conger WWTF to protect the downstream impaired water, Bear Lake (WID: 24-0028-00). The goal of the analysis in this memorandum is to establish a TP WQBEL for Emmons WWTF that will ensure that the impaired downstream water, Lime Creek (WID: 07080203-501), will eventually meet RES criteria.

We used a Hydrological Simulation-Fortran (HSPF) model of the WRW to conduct our analysis. This model simulates the hydrology and water quality of all reaches within the WRW. With this model, we analyzed two scenarios: (1) a *baseline* scenario which modeled water quality given existing environmental, non-point source, and point source conditions, and (2) a *limit* scenario that capped TP concentrations in both impaired lakes – Bear (WID: 24-0028-00) and State Line (WID: 24-0030-00), set Conger WWTF operating at its maximum permitted levels, and manipulated the maximum permitted levels of Emmons WWTF. With the latter action, we explored a potential WLA for Emmons WWTF that would be protective of the downstream impaired river.

Water quality of downstream waters

Multiple waters are downstream of the two facilities in the WRW (Table C-3). However, only two have eutrophication assessments. Assessed downstream waters are: Bear Lake (WID: 24-0028-00) and Lime Creek (WID: 07080203-501).

Table C-3. Waters downstream of WRW facilities.

Facilities	Permit ID	Type	Station	Downstream Water Name	Downstream Water WID
Conger WWTF	MN0068519	Pond	SD 001	County Ditch 48 Steward Creek Bear Lake Lime Creek	07080203-505 07080203-504 24-0028-00 070080203-501
Emmons WWTF	MN0023311	Continuous	SD 002	Unnamed Creek Unnamed Creek Lime Creek	07080203-516 07080203-503 07080203-501

For assessed waters, data from the most recent nutrient assessment and from the last 10 years are presented in Table C-4. Data from the last 10 years (2009 through 2018) and the conclusions of nutrient assessments show that both assessed waters with upstream dischargers in the WRW, Lime Creek (WID: 07080203-501) and Bear Lake (24-0028-00), do not meet eutrophication criteria. Lime Creek has TP (158.3 ± 22 µg/L, n = 17), Chl-*a* (103.3 ± 25 µg/L, n = 3), DO Flux (6.47 ± 1.2 µg/L, n = 2), and BOD_5 (8.2 ± 1.9 µg/L, n = 3) concentrations that all exceed their RES criteria: 150 µg/L, 40 µg/L 5.0 mg/L, and 3.5 mg/L, respectively. Bear Lake, likewise, has all of its causal and response parameters exceeding their applicable criteria. This lake has TP concentrations (250.2 ± 23 µg/L, n = 41), Chl-a concentrations (92.2 ± 13 µg/L, n = 36), and Secchi depths (-0.3 ± 0.0 m, n = 55) exceeding their respective LES criteria: 90 µg/L, 30 µg/L, and -0.7 m, correspondingly.

Table C-4. Applicable eutrophication criteria compared to the water quality data for WRW lakes and rivers with upstream NPDES dischargers and nutrient assessments.

Water	TP Concentration (µg/L)	Chl-a Concentration (µg/L)	DO flux (mg/L)	BOD_5 (mg/L)	Secchi Depth (m)	Data Source
South RNR 2B	≤ 150	≤ 40	≤ 5.0	≤ 3.5	NA	
Lime Creek 07080203-501	158.3 ± 22 (17) 158.3 ± 22 (17)	103.3 ± 25 (3)[a] 103.3 ± 25 (3)[a]	6.47 ± 1.2 (2)[b] ND	8.2 ± 1.9 (3)[a] 8.2 ± 1.9 (3)[a]	NA	2017 Assessment 2015-2016 Data
Western Corn Belt Plains 2B	≤ 90	≤ 30	NA	NA	≤ -0.7	
Bear Lake 24-0028-00	250.2 ± 23 (41) 253.9 ± 26 (35)	92.2 ± 13 (36) 92.4 ± 15 (31)	NA	NA	-0.3 ± 0.0 (55) -0.3 ± 0.0 (41)	2017 Assessment 2009-2016 Data

Water quality values are the mean ± standard error (n) with n being the sample size. Data are reported only for the summer season (June-September). *NA* and *ND* abbreviate *not applicable* and *not determined*, respectively. Data are reported from the last 10 years and the most recent nutrient assessment.
[a]Insufficient data for assessment
[b]In this case, the sample size refers to two deployments, one each in 2015 and 2016. Additionally, the standard error is for the means of the two datasets.

Reasonable potential analysis

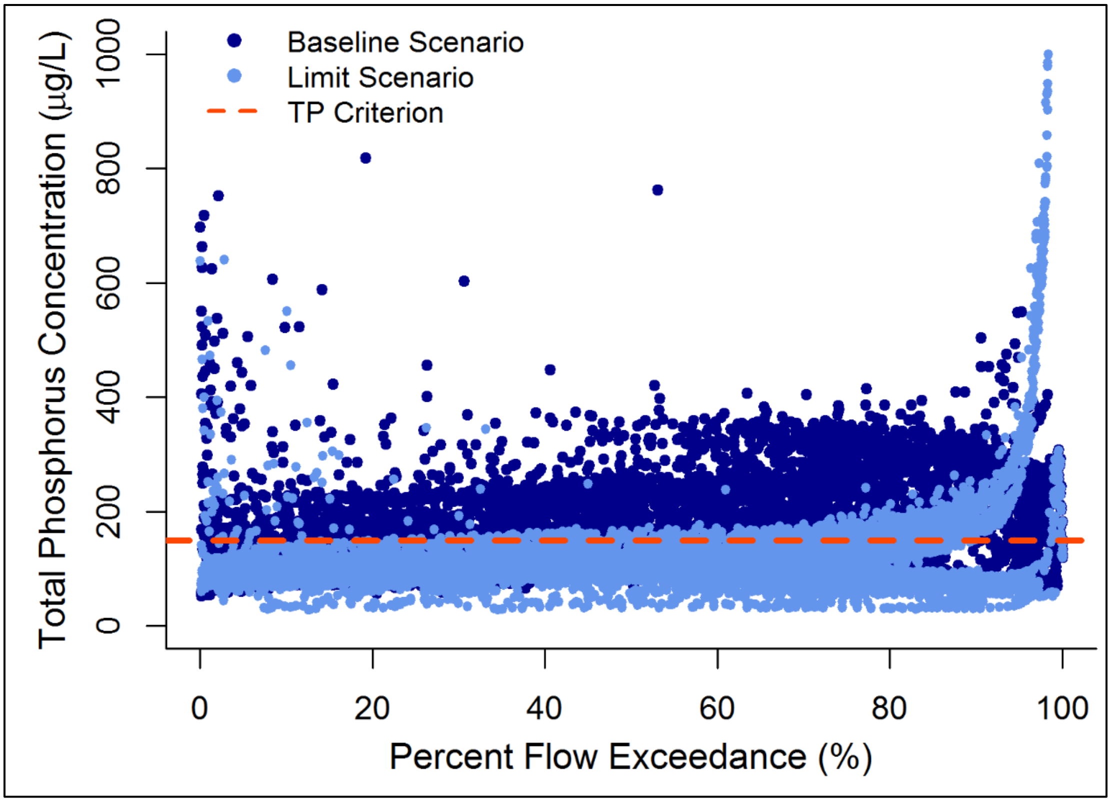
As stated above, Conger and Emmons WWTF discharge upstream of nutrient impaired waters, Bear Lake (WID: 24-0028-00) and Lime Creek (WID: 07080203-501), respectively. Thus, they both have the RP to cause or contribute to their given downstream impairments. According to federal law [40 CFR § 122.44(d), these facilities require WLAs and WQBELs.

WLA calculation via a modeling approach

Conger WWTF discharges upstream of Bear Lake (WID: 24-0028-00), which is impaired by nutrients. Prior work has determined that a P WLA and annual mass limit of 72 kg/yr for Conger WWTF, along with considerable non-point reductions, will result in Bear Lake meeting LES criteria in time (Weiss 2011). The determination of this previous analysis will be continued in the Bear Lake TMDL, which is underway. For our analysis, we will maintain the recommended 72 kg/yr limit for Conger WWTF and assume that Bear Lake will meet LES criteria, following completion of the actions that will be recommended by the TMDL.

We determined a WLA for Emmons WWTF with an HSPF model of the WRW. We created a limit scenario in which the P concentrations of both impaired lakes in the WRW – State Line Lake (WID: 24-0030-00) and Bear Lake (WID: 24-0028-00) are capped at the LES criterion (90 µg/L). Recall, State Line Lake is upstream of Emmons WWTF; Bear Lake drains to Lime Creek (WID: 07080203-501), which is downstream of Emmons WWTF (Table C-1). For all model runs of the limit scenario, Conger and Emmons WWTF discharged constantly at their AWWDF, for their full allowable discharge period, and, in the case of Conger WWTF, at their maximum permitted P load given their WQBEL. Additionally, the model runs entailed slight modifications to the P discharge of Emmons WWTF so that we were able to determine a WLA for Emmons WWTF that would ensure Lime Creek meets the RES TP criterion (150 µg/L). The limit scenario results were compared to the baseline scenario in which point sources, non-point sources, and environmental variables occurred at their historical levels.

Emmons WWTF discharging at a TP concentration of 3.5 mg/L will result in the long-term summer average TP concentration of Lime Creek (WID: 07080203-501) being less than the RES TP criterion (150 µg/L), see Table C-4. As a long-term summer average, the TP concentration will decrease from 180 µg/L to 127 µg/L as a result of Emmons discharging at a 3.5 mg/L TP concentration on average, as well as Bear (WID: 24-0028-00) and State Line (WID 24-0030-00) Lakes meeting LES criteria.



The Baseline scenario entails the point sources operating at their historical discharges and without caps on the P concentrations of Bear (WID: 24-0028-00) and State Line (WID: 24-0030-00) Lakes. The limit scenario sets caps on the P concentrations of Bear and State Line Lakes, has Conger WWTF operating at its maximum permitted levels, and has Emmons WWTF operating at its AWWDF and discharging effluent at a 3.5 mg/L concentration. All data are for the applicable RES time period (June-September).

Figure C- 4. HSPF model results for Lime Creek (AUID: 07080203-501).

Given that our model results show that Emmons WWTF must discharge effluent with a TP concentration of 3.5 mg/L, on average, in order for Lime Creek (WID: 07080203-501) to eventually meet RES, we calculate a WLA for this facility using a TP concentration of 3.5 mg/L. Additionally, we use a flow value for this facility of 70% of their AWWD since, typically, operation does not exceed this value. We calculate a WLA for Emmons WWTF of 1.1 kg/d, see Equation 1.

Equation 2. Calculation of Emmons WWTF's WLA.

$$0.7 \times 0.124\ \frac{Mgal}{d} \times 3.5\ \frac{mg}{L} \times 3.785\ \frac{L}{gal} \times \frac{10^6 gal}{Mgal} \times \frac{1\ kg}{10^6 mg} = 1.1\ \frac{kg}{d}$$

Converting WLAs to permit effluent limits

As mentioned above, prior work determined the TP effluent limit needed for Conger WWTF in order for the downstream waters to meet eutrophication criteria (Weiss 2011). We will continue this TP effluent limit recommendation. For Emmons WWTF, we recommend a daily mass limit (applicable June through September) for Emmons WWTF equivalent to their WLA (i.e., 1.1 kg/d). This new TP effluent limit for Emmons WWTF should be attainable as this facility currently discharges only about 0.38 kg/d, on average, during the summer, about a third of their new 1.1 kg/d limit.

Verify TP effluent limits

We have recommended a new WQBEL protective of Lime Creek (WID: 07080203-501), which flows into Iowa. Iowa does not have RES and, thus, the permitting actions recommended in this memorandum will meet downstream requirements.

Summary of TP effluent limits

This memorandum recommends continuing the previously determined WQBEL for Conger WWTF, which is protective of Bear Lake (WID: 24-0028-00). Since Emmons WWTF has the RP to cause or contribute to the downstream nutrient impairment in Lime Creek (WID: 07080203-501), we have determined a WLA and WQBEL for this facility. Using a modeling approach, we have found that Emmons WWTF must comply with WQBEL of 1.1. kg/d, equivalent to their WLA, in order for Lime Creek to eventually meet RES. Our TP effluent limit recommendations for all WRW facilities are summarized in Executive Table 1.

References

Heiskary, S., W. Bouchard Jr., and H. Markus. 2013. Minnesota Nutrient Criteria Development for Rivers. MPCA St. Paul, MN, 176 pp.

Minnesota Pollution Control Agency (MPCA). 2015. Implementing River and Lake Eutrophication Standards for NPDES Wastewater Permits. MPCA St. Paul, MN.

Weiss, S. 2011. Total Phosphorus Water Quality Based Effluent Limit Analysis: City of Conger WWTP to Bear Lake. MPCA St. Paul, MN.