Watershed

May 2021

Shell Rock River Watershed Total Maximum Daily Load Report

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

Authors

RESPEC
Cindie McCutcheon
Paul Marston
Chris Lupo
Seth Kenner
Julie Blackburn

Contributors/acknowledgements

MPCA
Ashley Ignatius
Bill Thompson
Charles Regan
Dennis Wasley
Emily Zanon
Joe Magee
Justin Watkins
Marco Graziani
Rachel Olmanson

Shell Rock River Watershed
Courtney Phillips

Editing and graphic design

RESPEC Administrative staff
Laura Fairhead
Andrea Wuorenmaa
Karla Lipp

Cover photo credit

Shell Rock River (MPCA EAO Staff)

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Acronyms

AFO	animal feeding operation
AUID	Assessment Unit ID
BC	Boundary Condition
BMP	Best management practice
BOD	Biological oxygen demand
BWSR	Board of Water and Soil Resources
CAFO	Concentrated animal feeding operations
CBOD	Carbonaceous biochemical oxygen demand
CBODU	Carbonaceous biochemical oxygen demand ultimate
chl-*a*	chlorophyll-a
CRP	Conservation Reserve Program
CV	Coefficient of variation
CWA	Clean Water Act
CWLA	Clean Water Legacy Act
DO	Dissolved Oxygen
DMR	Discharge monitoring reports
DNR	Minnesota Department of Natural Resources
EPA	U.S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
FIBI	Fish Index of Biological Integrity
FQI	Floristic quality index
GIS	Geographic Information System
GR	Geometry ratio
HSG	Hydrologic Soil Groups
HSPF	Hydrologic Simulation Program-Fortran
HUC	Hydrologic Unit Code
IBI	Index of Biological Integrity
ITPHS	Imminent threat to public health or safety
in/yr	inches per year
km2	square kilometer

LA	load allocation
lb	pound
lb/day	pounds per day
lb/yr	pounds per year
LDC	Load duration curve
LGU	Local Government Unit
LID	low impact development
m	meter
MAWQCP	Minnesota Agricultural Water Quality Certification Program
MCM	Minimum Control Measures
mg/L	milligrams per liter
MIBI	Macroinvertebrate Index of Biological Integrity
µg/L	microgram per liter
MIDS	Minimal Impact Design Standards
MINLEAP	Minnesota Lake Eutrophication Analysis Procedure
mL	milliliter
MnDOT	Minnesota Department of Transportation
MPCA	Minnesota Pollution Control Agency
MOS	Margin of safety
MS4	Municipal Separate Storm Sewer Systems
NBOD	Nitrogenous biochemical oxygen demand
NOAA	National Oceanic and Atmospheric Administration
NOD	Nitrogenous oxygen demands
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
RES	River Eutrophication Standard
SAM	Scenario Application Manager
SDT	Secchi disk transparency
SDS	State Disposal System
SIETF	SSTS Implementation and Enforcement Task Force
SOD	Sediment Oxygen Demand

SSTS	Subsurface sewage treatment systems
SWCD	Soil and Water Conservation District
SWPPP	Stormwater Pollution Prevention Plan
TDLC	total daily loading capacity
TMDL	total maximum daily load
TP	total phosphorus
TSI	Trophic State Index
TSS	total suspended solids
µg/L	microgram per liter
VSS	volatile suspended solids
WLA	wasteload allocation
WCBP	Western Corn Belt Plains
WRAPS	Watershed Restoration and Protection Strategy
WTP	Water Treatment Plant
WWTF	Wastewater Treatment Facility

Executive summary

This Total Maximum Daily Load (TMDL) study was completed for impaired waterbodies of the Shell Rock River Watershed (Hydrologic Unit Code [HUC] 07080202). The study addresses two stream reach bacteria impairments, two stream reach turbidity impairments, two stream reach nutrient impairments, one stream reach dissolved oxygen (DO) impairment, one stream reach pH impairment, one stream reach biology impairment of macroinvertebrates, one stream reach biology impairment of fish, and five lake nutrient impairments. The goal of this TMDL study is to quantify the pollutant reductions that are needed to meet the state water quality standards for *Escherichia coli* bacteria (*E. coli*), total suspended solids (TSS), DO, pH, macroinvertebrates, fish, and nutrients (phosphorus) for impaired streams and lakes located in the Shell Rock River Watershed. The time period for developing the TMDLs and data summaries for the TMDLs was the 10 year period from 2009 through 2018.

The TMDLs described herein were primarily derived from output of the Hydrologic Simulation Program-Fortran (HSPF) model that was developed for the entire Shell Rock River Watershed. HSPF is commonly used to support the development of DO TMDLs in rivers and is an EPA-supported model. The Shell Rock River Watershed HSPF model was run from 1995 through 2019 and was calibrated to available flows and monitored water quality data from 1996 through 2018 [Lupo 2019], with the initial year (1995) being simulated for the model to adjust to existing conditions. HSPF-simulated runoff and simulated pollutant loads were used to develop the Shell Rock River TMDLs. HSPF-generated flows were used to establish load duration curves (LDCs) for the two stream reach bacteria impairments with wasteload allocations (WLAs) and load allocations (LAs) established for five flow duration curve categories: very high, high, mid, low, and very low flow conditions. HSPF simulated flows and measured water quality data were used to develop TMDLS for bacteria, TSS and nutrients (TP), add DO throughout the watershed. In general the following reductions are required for impaired waters of the Shell Rock River Watershed:

- Bacteria (*E. coli*) reductions of 19% to 88%;
- TSS reductions of 0% to 59%;
- Nutrient (TP) reductions of 0% and 64%;
- Oxygen demand reduction of 70%.

Lake average annual phosphorus budgets were developed from HSPF-simulated flows and phosphorus loadings. Corresponding in-lake monitoring data were incorporated into the widely-used lake response model, BATHTUB. Internal phosphorus release was evaluated and incorporated through a weight-of-evidence approach. All five lakes are characterized as shallow lakes. The phosphorus reductions required to achieve lake standards ranged from 46% to 71%.

Lake rehabilitation should focus on reducing phosphorus that comes from non-point sources and internal loading, the two most primary sources. In addition, phosphorus reduction is needed from septic systems and urban stormwater. Water quality restoration will continue to be aided by the interdependent and cooperative efforts of the local community, county, state, and federal partners via leveraged management actions phased over budgetary cycles in relation to the largest pollutant sources. Improvements to up-gradient lakes will improve the quality of downstream lakes. In-lake treatment, rough fish kills, native fish restocking, and dredging could also potentially improve lake water quality. While there has been widespread adoption of stream and ditch buffers (98%) and selected stream bank restorations, improvement of soil health, and a suite of other nonpoint-source BMPs should be pursued that will address altered hydrology and upper watershed nutrient reductions in a comprehensive and sustainable fashion. The maintenance of existing practices and the adoption of new BMPs will reduce bacteria, TSS, phosphorus, and organic matter linked to DO and pH problems. Pollution sources have been identified for impaired streams as well as recommended best management practices (BMPs) to address pollution sources.

Storm rainfall amounts for typical 24-hour storm and multiday wet periods can be substantial with the potential for wide-ranging negative impacts to communities and agricultural producers, as well as receiving streams, lakes, wetlands, and associated aquatic habitats. Collectively, this report’s dry- and wet-cycle characterizations may aid in considering BMP design factors for wet periods and augmenting storage/retention practices for dry periods to increase stream-base flows and reuse (irrigation).

The findings from this TMDL study assisted in selecting implementation and monitoring strategies as a part of the Shell Rock River Watershed Restoration and Protection Strategy (WRAPS) process. The purpose of the WRAPS report is to support local working groups and jointly develop scientifically supported restoration and protection strategies to be used for subsequent implementation planning. The WRAPS report is publicly available on the Minnesota Pollution Control Agency (MPCA) concurrently with this report.

1. Project overview

1.1 Purpose

Section 303(d) of the Clean Water Act (CWA) and the U.S. Environmental Protection Agency (EPA) Water Quality Planning and Management Regulations (40 CFR § 130) require that states develop TMDLs for waterbodies that do not meet applicable water quality standards or guidelines to protect designated uses under technology-based controls. The Clean Water Legacy Act (CWLA) of Minnesota Statutes Section 114D also requires TMDLs to be developed for impaired waters. TMDLs specify the maximum pollutant load that a waterbody can receive and still meet water quality standards. Based on a calculation of the total allowable load, TMDLs allocate pollutant loads to sources and incorporate a margin of safety (MOS). TMDL pollutant load reduction goals for significant sources provide scientific bases for restoring surface-water quality, by linking developing and implementing control actions to attaining and maintaining water quality standards and designated uses.

This TMDL study addresses two stream *E. coli* impairments, one stream DO impairment, two stream nutrient (phosphorus) impairments, one stream pH impairment, two stream turbidity impairments, one stream biology impairment for macroinvertebrates, one stream biology impairment for fish, and five lake nutrient (phosphorus) impairments in the Shell Rock River Watershed. The TP and DO TMDLs for the Shell Rock River will address the pollutants contributing to the fish and macroinvertebrate impairments. The impaired waterbodies are located in Freeborn County, Minnesota. The impairments addressed in this TMDL were on the 2018 303(d) list and are listed in Table 1. The stream IDs from Table 1 are discussed in this document as the last three digits of the stream ID (i.e., Reach 501). According to the Minnesota 2018 inventory of impaired waters, a fecal coliform TMDL was previously developed for the Shell Rock River reach (07080202-501) in 2002.

Table 1. Water quality impairments addressed.

HUC8	Waterbody Name	AUID (HUC8-)	Use Class	Affected Use	Year Added to List	Proposed EPA Category	Impaired Waters Listing	Pollutant or Stressor	TMDL Developed in This Report
Shell Rock River (07080202)	Shell Rock River	-501	2Bg, 3C	Aquatic Life	2012	4A	DO	DO	**Yes:** Oxygen Demand
					2016	4A	Nutrients/Eutrophication	Phosphorus	**Yes:** Total phosphorus
					2012	5	Macroinvertebrate bioassessment (MIBI)	Nitrate Algal productivity (Chlorophyll-a) pH Phosphorus Habitat DO	**No:** Nitrate standard not applicable **No:** TP TMDL for RES will address. **No:** TP TMDL for RES will address. **No:** TP TMDL for RES will address. **No:** nonpollutant stressor **Yes**: Oxygen Demand TMDL will address.
					2012	5	Fish bioassessment (FIBI)		
					2002	4A	Turbidity	TSS	**Yes:** TSS
					2008	4A	pH	pH	**No:** TP TMDL for RES will address.
				Aquatic Recreation	1994	4A	*E. coli*	*E. coli*	**No:** 2002 TMDL approved
	Bancroft Creek (County Ditch 63)	-507	2Bg, 3C	Aquatic Recreation	2012	4A	*E. coli*	*E. coli*	**Yes:** *E. coli*
	Unnamed Creek (Shoff)	-516	2Bg, 3C	Aquatic Life	2016	4A	Nutrients/Eutrophication	Total phosphorus	**Yes:** Total phosphorus
					2010	4A	Turbidity	TSS	**Yes:** TSS
	Unnamed Creek (Wedge)	-531	2Bg, 3C	Aquatic Recreation	2012	4A	*E. coli*	*E. coli*	**Yes:** *E. coli*
	Albert Lea Lake	24-0014-00	2B, 3C	Aquatic Recreation	2008	4A	Nutrients/Eutrophication	Total phosphorus	**Yes:** Total phosphorus
	Fountain Lake (East Bay)	24-0018-01	2B, 3C	Aquatic Recreation	2008	4A	Nutrients/Eutrophication	Total phosphorus	**Yes:** Total phosphorus

HUC8	Waterbody Name	AUID (HUC8-)	Use Class	Affected Use	Year Added to List	Proposed EPA Category	Impaired Waters Listing	Pollutant or Stressor	TMDL Developed in This Report
	Fountain Lake (West Bay)	24-0018-02	2B, 3C	Aquatic Recreation	2008	4A	Nutrients/Eutrophication	Total phosphorus	**Yes:** Total phosphorus
	White Lake	24-0024-00	2B, 3C	Aquatic Recreation	2008	4A	Nutrients/Eutrophication	Total phosphorus	**Yes:** Total phosphorus
	Pickeral Lake	24-0025-00	2B, 3C	Aquatic Recreation	2008	4A	Nutrients/Eutrophication	Total phosphorus	**Yes:** Total phosphorus

The goal of this TMDL report is to quantify the pollutant reductions that are needed to meet state water quality standards for bacteria, TSS, nutrients, DO, pH, and biology for the addressed impaired stream reaches and nutrients for the lakes. This TMDL study is established in accordance with Section 303(d) of the CWA and defines the WLAs, LAs, and pollutant reductions needed to meet state water quality standards.

The TMDLs for the Shell Rock River Watershed, once developed, will provide a framework for the MPCA, other state and federal agencies, Freeborn County, and local government units (LGUs), upon which they can base management decisions. TMDLs will also provide reasonable assurance that impairments will be addressed via continued BMP implementation and that future impairments can be readily addressed with an in-place model.

Furthermore, the outcomes from the TMDLs, which will include increased implementation of BMPs, will protect designated uses and will not impair or threaten other designated uses that are assigned to these waterbodies.

1.2 Identification of waterbodies

The Shell Rock River Watershed is located along the southern border of Minnesota, as shown in Figure 1. Impaired stream reaches and lakes are also shown in Figure 1. No tribal lands are located within the Shell Rock River Watershed.

The state of Minnesota classifies streams that are protected for specific, designated uses into categories. All of the impairments addressed in this TMDL are Class 2B, 2Bg, and Class 3C waters.

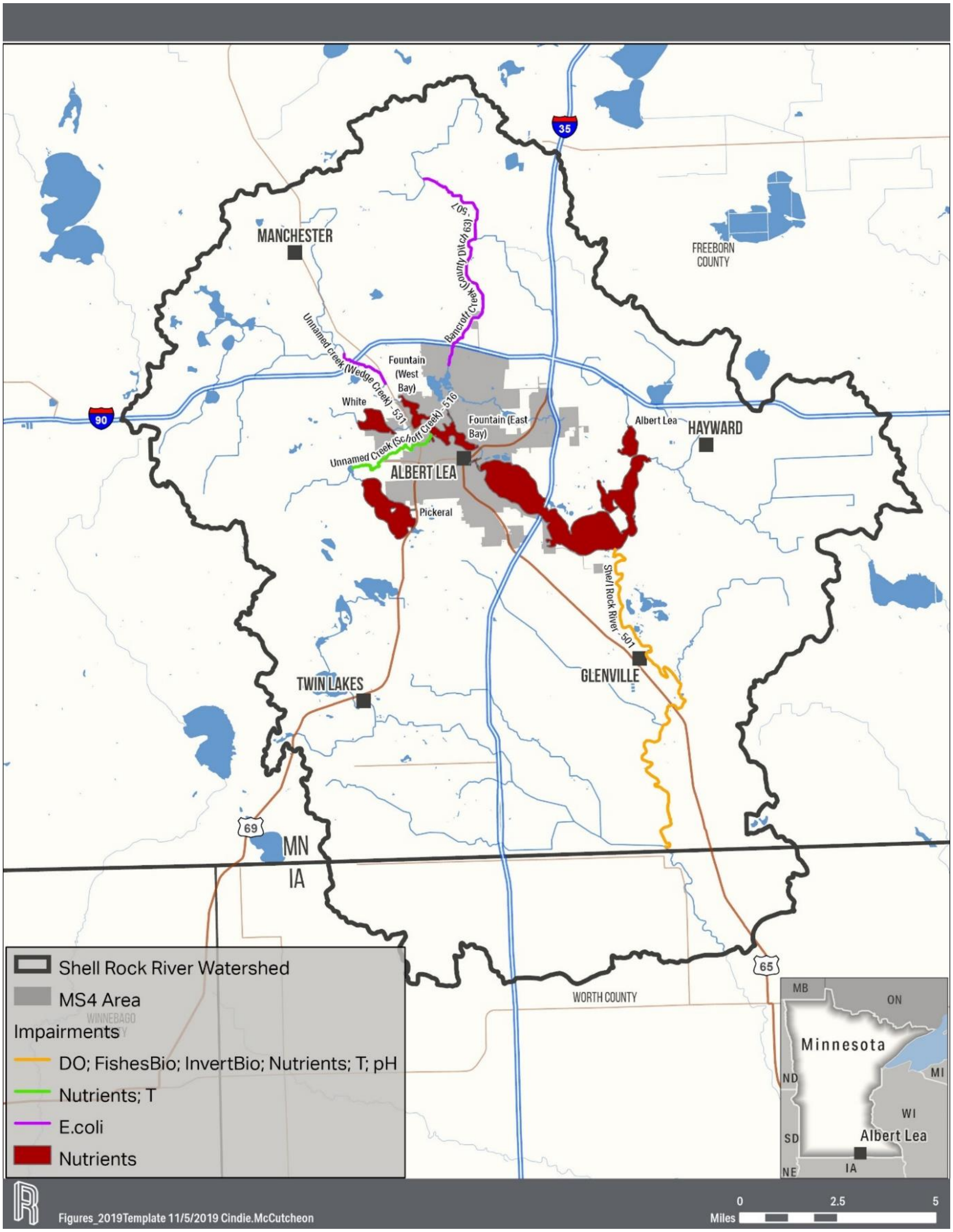
The quality of Class 2B surface waters shall permit the propagation and maintenance of a healthy community of cool- or warm-water sport or commercial fish and their associated aquatic life and habitats (Minn. R. ch. 7050.0222, subp. 4). These waters shall be suitable for all kinds of aquatic recreation, including bathing. This class of surface water is not protected as a source of drinking water.

Class 2Bg, or “general cool and warm water aquatic life and habitat” is a beneficial use that means waters capable of supporting and maintaining a balanced, integrated, adaptive community of warm or cool water aquatic organisms having a species composition, diversity, and functional organization comparable to the median of biological condition gradient level 4 (Minn. R. ch. 7050.0222, subp. 4C).

The quality of Class 3C waters in the state shall permit their use for industrial cooling and materials transport without a high degree of treatment being necessary to avoid severe fouling, corrosion, scaling, or other unsatisfactory conditions (Minn. R. ch. 7050.0223, subp. 4).

Applicable standards for Class 2B, 2Bg, and 3C waters from Minn. R. ch. 7050 are summarized in Section 2.

Figure 1. Project area and impaired waterbodies.



Note: Figure includes DNR baselayer which includes all lakes, ponds, and wetlands greater than 1 acre.

1.3 Priority ranking

The MPCA's schedule for TMDL completions, as indicated on the 303(d) impaired waters list, reflects Minnesota's priority ranking of this TMDL. The MPCA has aligned their TMDL priorities with the watershed approach and the WRAPS schedule. The MPCA developed a state plan, Minnesota's TMDL Priority Framework Report, to meet the needs of the EPA's national measure (WQ-27) under the EPA's Long-Term Vision for Assessment, Restoration, and Protection under the CWA Section 303(d) program. As part of these efforts, the MPCA identified water quality impaired segments, which will be addressed by TMDLs by 2022. The Shell Rock River Watershed waters that are addressed by this TMDL are a part of that MPCA prioritization plan to meet the EPA's national measure.

2. Applicable water quality standards and numeric water quality targets

The Shell Rock River Watershed is located in the Western Corn Belt Plains (WCBP) ecoregion. For the recently adopted river nutrient and TSS standards, the Shell Rock River Watershed is in the Southern River Nutrient Region.

2.1 *E. coli* bacteria

The Minnesota water quality rules (Minn. R. ch. 7050.0222) state that *E. coli* bacteria 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."

2.2 Turbidity and total suspended solids

Turbidity is the measurement of cloudiness or haziness of water, which is the result of dissolved and suspended materials, such as sediment or phytoplankton, in the water. Excess turbidity can harm aquatic life, increase the treatment costs for drinking water or food processing, and decrease the aesthetic qualities of a waterbody. Aquatic life is harmed by turbidity when it impacts their ability to find food, smothers spawning beds and habitat, and/or affects gill function.

Two reaches in the Shell Rock River Watershed are impaired by turbidity. The turbidity standard at the time of the impairment assessment for these reaches was 25 nephelometric turbidity units. This standard protected the designated use for propagation/maintenance of healthy cold-water sport or commercial fish and the aquatic life associated with them and their habitat. This turbidity standard was replaced by a TSS standard in January 2015. For the purposes of this TMDL, the newly adopted TSS standard of 65 milligrams per liter (mg/L) TSS for the Southern River Nutrient Region will be used in place of the turbidity standard. TSS standards for the class 2B North, Central, and South River Nutrient

Regions and the Red River Mainstem may be exceeded for no more than 10% of the time. The TSS standard applies April through September.

2.3 Nutrients (phosphorus) in streams

Regional stream-nutrient standards were adopted in 2015 in Minnesota and are listed in Table 2. River nutrient regions were defined by the MPCA. The Shell Rock River Watershed is in the Southern River Nutrient Region of Minnesota. Eutrophication standards for rivers and streams are compared to long-term summer average data. Exceedance of the TP levels and either chlorophyll-a (chl-*a* [seston]), five-day biochemical oxygen demand (BOD_5), diel DO flux (the difference between the maximum and the minimum daily DO concentration), or pH levels is required to indicate a polluted condition. Rivers and streams that exceed the phosphorus levels, but do not exceed the chl-*a* (seston), BOD_5, diel DO flux, or pH levels, meet the eutrophication standard. A polluted condition also exists when a chl-*a* (periphyton) concentration exceeds 150 milligrams per square meter (mg/m2) for more than 1 year in 10 as a summer average.

Table 2. River nutrient region standards; Southern 2B stream standards are applicable in the Shell Rock River TMDL.

River Nutrient Region Name	Total Phosphorus (ug/L)	Chlorophyll-a (ug/L)	Dissolved Oxygen Flux (mg/L)	5-Day Biochemical Oxygen Demand (mg/L)
North	≤ 50	≤ 7	≤ 3.0	≤ 1.5
Central	≤ 100	≤ 18	≤ 3.5	≤ 2.0
Southern 2A Streams	≤ 150	≤ 35	≤ 4.5	≤ 3.0
Southern 2B Streams	≤ 150	≤ 40*	≤ 5.0*	≤ 3.5*

ug/L = micrograms per liter

*Minn R. 7050.0222 incorrectly lists water quality standards for Chl-*a*, DO flux and BOD for 2B Southern Streams. Standards approved by EPA are: Chl-*a* ≤ 35 ug/L, DO flux ≤ 4.5 mg/L and BOD5 ≤ 3.0 mg/L. These errors will be addressed in future rule making efforts.

2.4 Dissolved oxygen

The Minnesota water quality rules (Minn. R. ch. 7050.0222) state that for 2B waters, the DO standard is "5 mg/L as a daily minimum. This DO standard may be modified on a site-specific basis according to Minn. R. 7050.0220, subp. 7, except that no site-specific standard shall be less than 5 mg/L as a daily average and 4 mg/L as a daily minimum. Compliance with this standard is required 50% of days at which the flow of the receiving water is equal to the $7Q_{10}$." The $7Q_{10}$ is the lowest 7-day average flow that occurs, on average, once every 10 years. The DO flux was incorporated into the river nutrient standards that are shown in Table 2.

2.5 pH

The pH of water is a measure of the degree of its acid or alkaline reaction. pH water quality standard values are provided in Minn. R. ch. 7050.0222 for Class 2B waters as a minimum of 6.5 and a maximum of 9.0. Any pH values that are too high or too low can be harmful to aquatic organisms; therefore, the designated use that this standard protects is aquatic life. The pH standard for Class 3C waters is less stringent at a minimum of 6.0 and a maximum of 9.0.

2.6 Aquatic macroinvertebrate and fish bioassessments

The guidance manual for Assessing the Quality of Minnesota Surface Waters [MPCA 2018a] states that,

> “*The presence of a healthy, diverse, and reproducing aquatic community is a good indication that the aquatic life beneficial use is being supported by a lake, stream, or wetland. The aquatic community integrates the cumulative impacts of pollutants, habitat alteration, and hydrologic modification on a waterbody over time. Monitoring the aquatic community, or biological monitoring, is therefore a relatively direct way to assess aquatic life use-support. Interpreting aquatic community data is accomplished using an Index of Biological Integrity or IBI. The IBI incorporates multiple attributes of the aquatic community, called “metrics,” to evaluate a complex biological system*.”

Once a waterbody is identified as having an impaired aquatic community, a stressor identification process is completed. For stressor identification, factors that include temperature, DO, eutrophication, TSS, connectivity, specific conductance, pH, and pesticides are evaluated to determine the most probable cause of the impairment.

Minnesota's biological criteria are based on preventing "material alteration of the species composition, material degradation of the stream beds, and the prevention or hindrance of the propagation and migration of fish and other biota normally present" (Minn. R. 7050.0150, subp. 6). The *Shell Rock River Watershed Biotic Stressor Identification Report* [MPCA 2014] provides detailed information on the fish and macroinvertebrate communities. For the Shell Rock River, the fish Index of Biological Integrity (FIBI) scores were evaluated by using the Southern Streams Class (Class 2), and the macroinvertebrate Index of Biological Integrity (MIBI) scores were evaluated with the Southern Forest Streams Glide Pool Class (Class 6). The thresholds and confidence intervals for the FIBI and MIBI are in Table 3. When IBI scores fall below the thresholds, the stream does not meet its IBI standards, and an assessment is completed to determine the stressor to the biotic communities.

Table 3. Thresholds and confidence intervals for the FIBI and MIBI.

Class	Class Name	IBI Threshold	Upper Confidence Limit	Lower Confidence Limit
2, FIBI	Southern Streams	45	54	36
6, MIBI	Southern Forest Streams Glide Pool	46.8	66	38.8

2.7 Nutrients (phosphorus) in lakes

Applicable lake eutrophication standards for the WCBP ecoregion are listed in Table 4. All lakes impaired by nutrients in the Shell Rock River Watershed are shallow.

Table 4. Lake nutrient and eutrophication standards for lakes and shallow lakes in the Western Corn Belt Plains Ecoregion as specified in Minn. R. ch. 7050.0222.

Ecoregion	Lake Type	Total Phosphorus (ppb)	Chlorophyll-a (ppb)	Secchi Transparency (meters)
Western Corn Belt Plains	Deep	≤ 65	≤ 22	≥ 0.9
	Shallow	≤ 90	≤ 30	≥ 0.7

ppb = parts per billion.

For a lake to be determined as impaired, the long-term summer average TP concentrations that are measured in the waterbody must show exceedances of the TP standard shown in Table 4 from Minn. R. ch. 7050.0222, along with one or both of the eutrophication response standards for chl-*a* and Secchi disk transparency (SDT). In developing the lake nutrient standards for Minnesota lakes, the MPCA evaluated data from a large cross section of lakes within each of the state's ecoregions [MPCA 2005]. Clear relationships were established between the causal factor TP and response variables chl-*a*, or SDT. Based on these relationships, the chl-*a* and SDT standards are expected to be met by meeting the TP target in each lake.

Definitions from Minn. R. ch. 7050.0150 that are pertinent to the Shell Rock River Watershed Lake TMDLs support these standards, as follows:

- "Lake" is defined as an enclosed basin filled or partially filled with standing fresh water with a maximum depth greater than 15 feet. Lakes may have no inlet or outlet, an inlet or outlet, or both an inlet and outlet."
- "Reservoir" is defined as a body of water in a natural or artificial basin or watercourse where the outlet or flow is artificially controlled by a structure such as a dam. Reservoirs are distinguished from river systems by having a hydraulic residence time of at least 14 days. For purposes of this calculation, residence time is determined using the lowest annual summer (June – Sept.) flows that occur in a 10 year cycle (122Q10).
- "Shallow lake" is defined as an enclosed basin filled or partially filled with standing fresh water with a maximum depth of 15 feet or less or with 80% or more of the lake area shallow enough to support emergent and submerged rooted aquatic plants (the littoral zone). It is uncommon for shallow lakes to thermally stratify during the summer. The quality of shallow lakes will permit the propagation and maintenance of a healthy indigenous aquatic community and they will be suitable for boating and other forms of aquatic recreation for which they may be usable. Shallow lakes are differentiated from wetlands and lakes on a case-by-case basis. Wetlands are defined in Minn. R. 7050.0186, subp. 1a."

3. Watershed and waterbody characterization

3.1 Historical/legacy perspectives

In 1855, European settlement began on the northwestern edge of Albert Lea Lake. A settler named George Ruble came to the area, found a mill site, and proposed a dam; when the dam was constructed, a new waterbody formed and was named Fountain Lake. Agriculture, farming support services, and manufacturing spurred early growth in the city of Albert Lea, which was a significant rail center. Albert Lea has a long history in the meat processing industry that dates back to 1877, and a main meat processing facility was established in 1898. In 2001, the facility burned down and has not reopened.

Fountain Lake was dredged in 1940 to deal with sediment filling the lake. During the 1940 dredging, one million cubic yards of sediment were removed. In 1963 and 1964, Dane Bay and Edgewater Bay of Fountain Lake were dredged with approximately 265 million cubic yards of sediment from the bays being used to fill areas at four different fill sites.

3.2 Demographic growth projections

Minnesota State Demographic Center demographic projections from 2015 and 2045 [Dayton 2014] indicate that the population of Freeborn County will increase by approximately 5.3%.

3.3 Climate

Basic climate data were reviewed to (1) define typical seasonal and annual cycles that affect runoff and water quality, (2) identify wet and dry patterns that affect pollutant loading dynamics, (3) assist in implementing design considerations, and (4) inform future performance monitoring efforts. The data assessment included monthly normal temperature and precipitation information, annual precipitation, frost-free season lengths, dry and wet periods, and average summer temperatures. The climate variability for the Shell Rock River Watershed was assessed by using long-term site data from the Midwest Regional Climate Center, Minnesota Department of Natural Resources (DNR) gridded precipitation, and National Oceanic and Atmospheric Administration (NOAA) databases that were summarized for south-central Minnesota (Climate Division 8). Few monitoring stations with long-term climate data exist across the Shell Rock River Watershed; hence, interpolated data from the DNR's gridded precipitation network and NOAA's Climate Division were evaluated. The monthly normals for Albert Lea, Minnesota (USC00210075) are presented as monthly average precipitation and maximum, average, and minimum temperatures for the 1981 through 2010 period in Figure 2. The monthly Normal plots use values that are calculated by the National Centers for Environmental Information every 10 years [Peake 2018]. An NOAA plot of average growing-season temperatures, as depicted in Figure 3, shows an increasing trend.

The annual precipitation across the Shell Rock River Watershed was examined via the DNR's gridded precipitation network from 1995 through 2018 by using the central portion of the watershed (Albert Lea), as shown in Figure 4. Annual precipitation has ranged from approximately 23 inches (in 2012) to approximately 46 inches (in 2016). Over the TMDL time period (2009 through 2018), the annual precipitation average was approximately 35.7 inches.

Figure 2. Observed monthly climate normals for Albert Lea, MN (USC00210075), from 1981 to 2010 [Midwestern Regional Climate Center 2019].

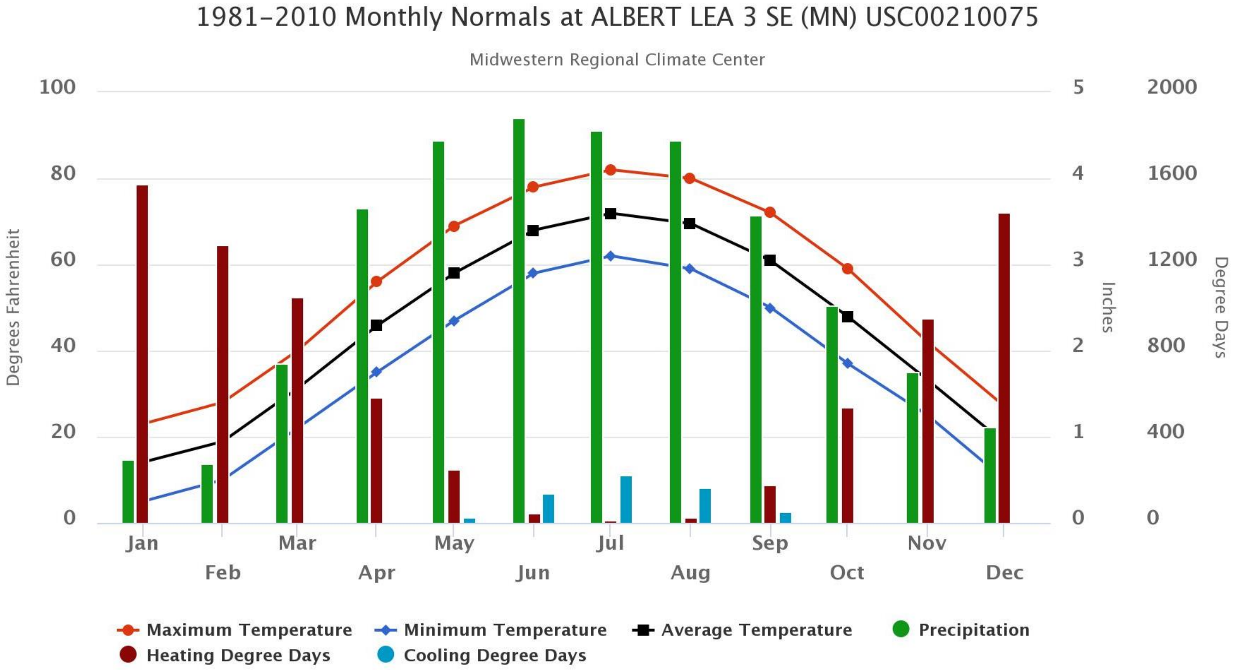


Figure 3. Growing-season (June through September) temperature for 1895–2018 from NOAA [2019a] for Minnesota Climate Division 8.

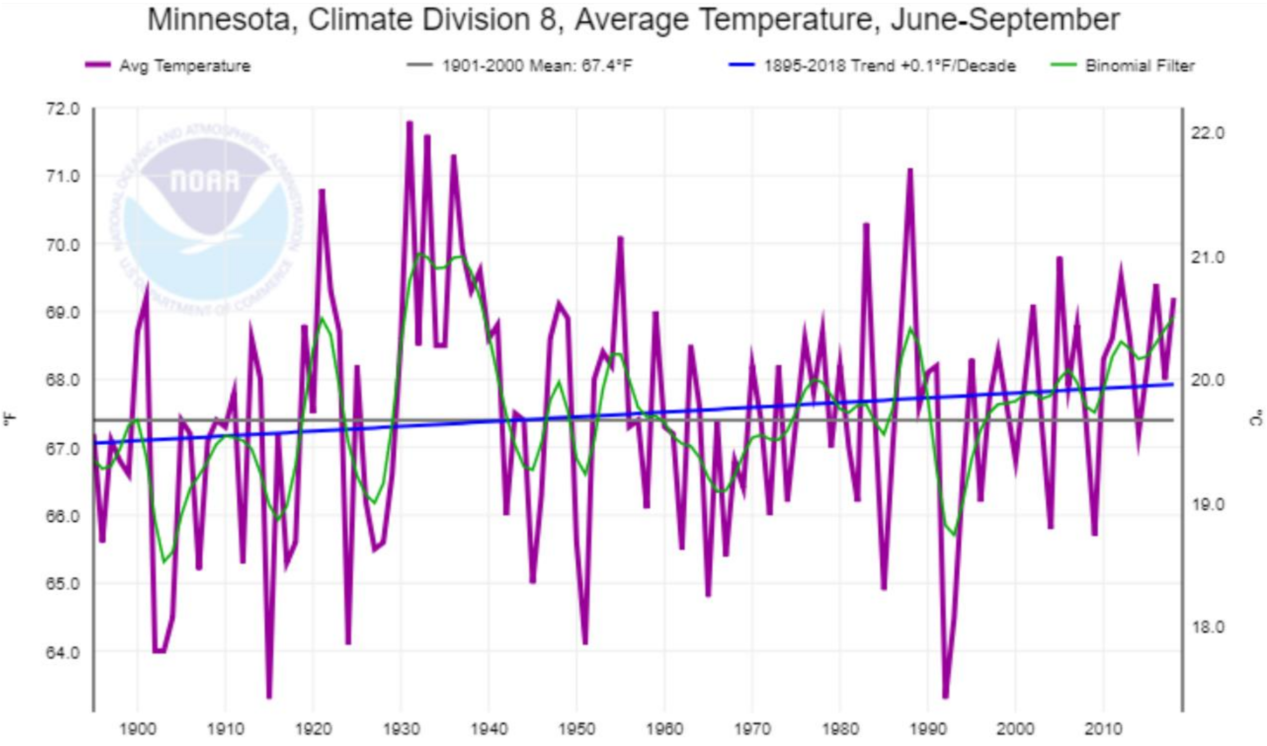


Figure 4. Long-term annual precipitation (inches) in the central portion of the Shell Rock River Watershed (Albert Lea) [DNR 2019a].

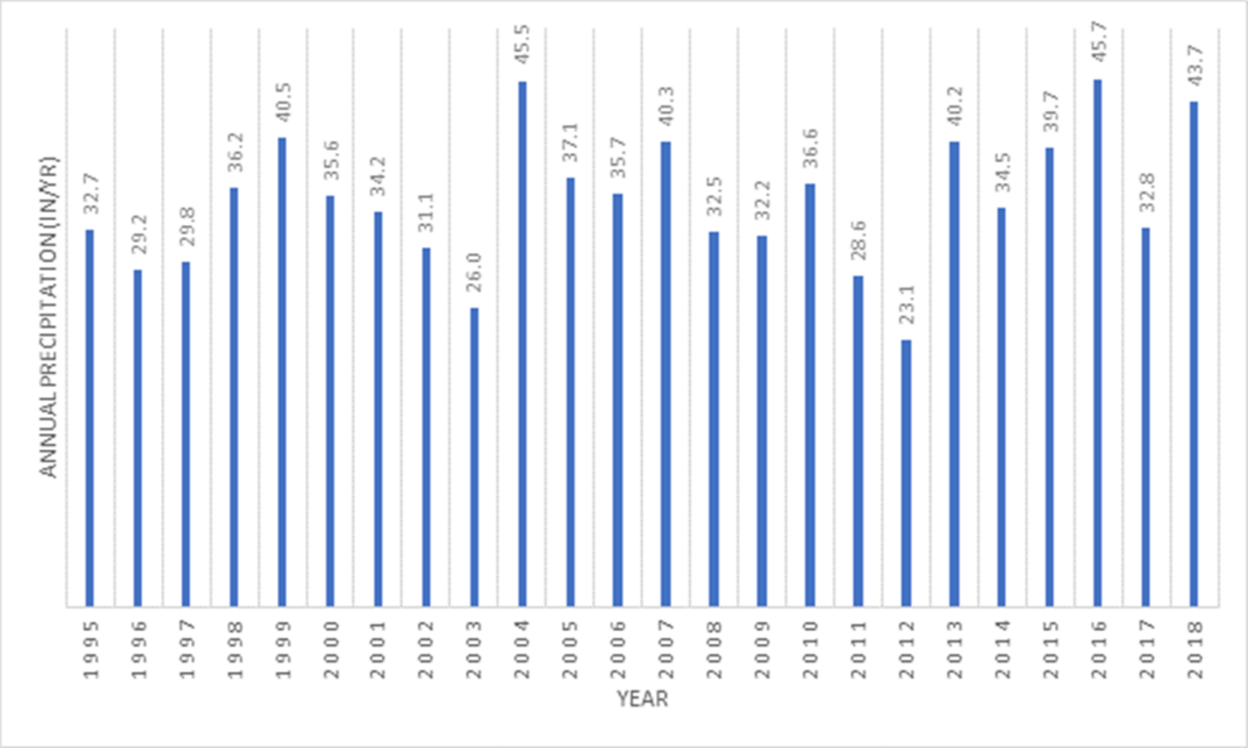
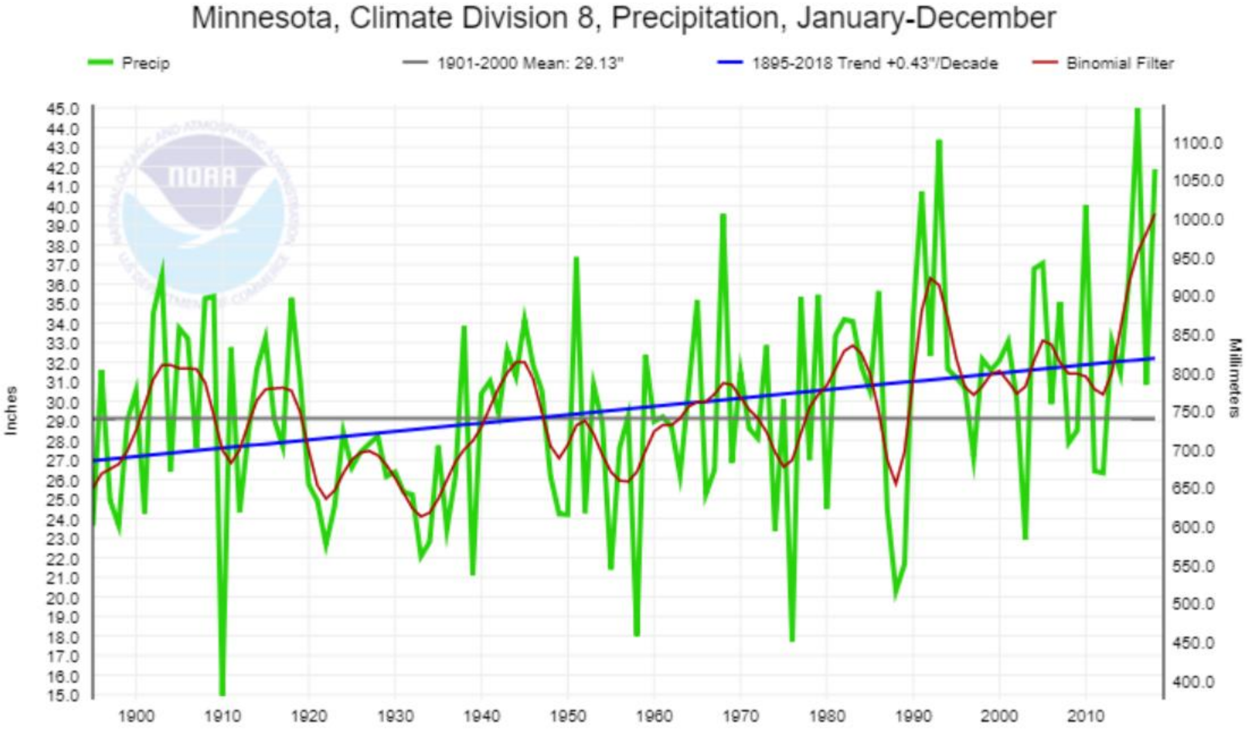


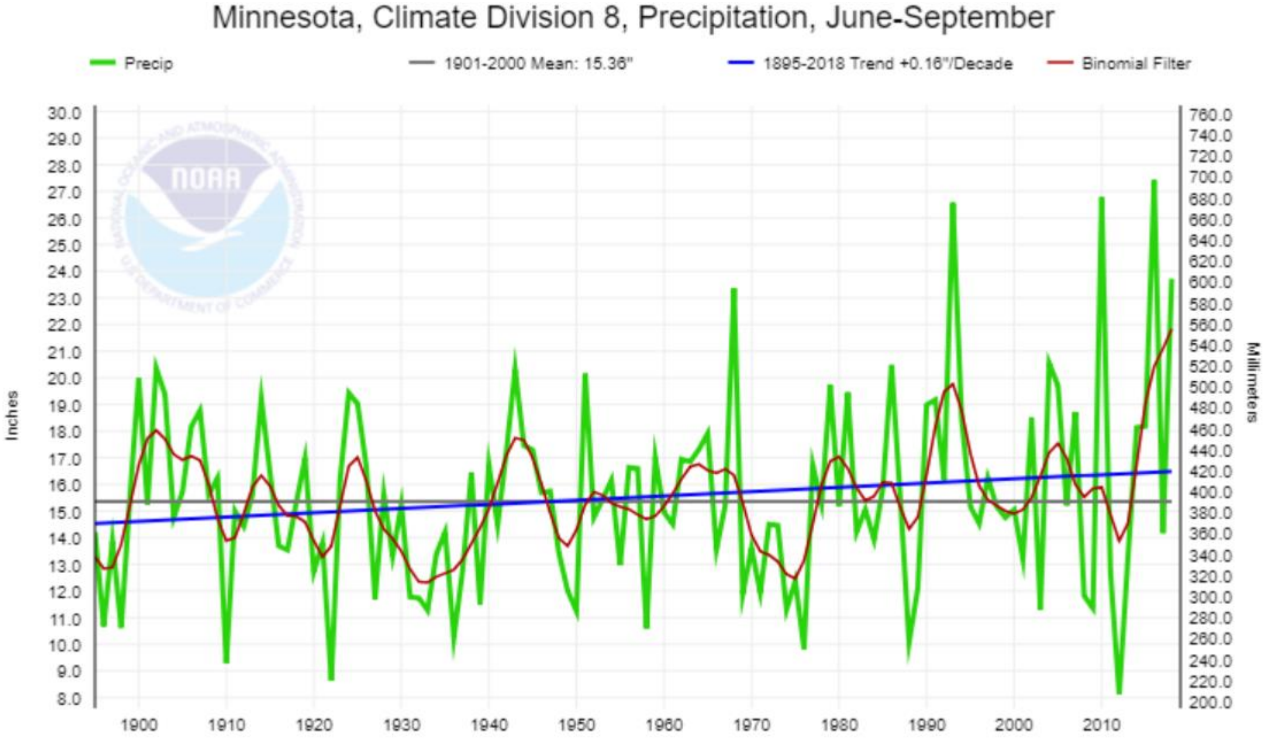
Figure 5. Annual precipitation for 1895–2018 from NOAA [2019a] for Minnesota Climate Division 8.



A long-term overview (1895 through 2018) of annual precipitation variation and trends for Climate Division 8 that covers south central Minnesota is depicted in Figure 5 from NOAA's National Centers for Environmental Information [NOAA 2019a]. The smoothed time-series and rolling-averaged plots facilitate observing longer periods of wet and dry precipitation patterns. Considerable year-to-year variability in annual precipitation is evident in this data; the smoothed binomial filter represented by the red line indicates a rolling pattern of multiyear averages. A variable but generally increasing pattern of annual precipitation since approximately 1895 can be noted, particularly for the recent years that encompass the TMDL report period (2009 through 2018).

A similar NOAA plot of summer precipitation patterns is shown for June through September for Climate Division 8 (south-central Minnesota) in Figure 6. In this figure, a long-term increase in growing-season precipitation is evident but is more muted than the increase in annual precipitation.

Figure 6. Growing-season (June–September) precipitation for 1895–2018 from NOAA [2019a] for Minnesota Climate Division 8.



3.3.1 Characterization of storm events

NOAA, in cooperation with the MPCA, the DNR State Climatology Office, and the Minnesota Department of Transportation (MnDOT), recently updated precipitation intensity and duration records for the entire state, which are referred to as Atlas 14. Storm event totals, such as those reported in various media weather reports, are typically for 24-hour periods that were summarized from data reported for stations representative of an area. Atlas 14 24-hour storm records in Albert Lea are shown in Table 5. An average recurrence interval of 1-year has a 100% chance of occurring every year, while an average recurrence interval of 1,000 years has a 0.1% chance of occurring every year. Back-to-back storms over several days often generate much larger totals than individual storms and are associated with peak runoff events; therefore, the frequencies of 10-day wet-period storms are summarized in Table 6. Ten-day wet-period precipitation amounts ranged from approximately 4.66 inches (1-year recurrence interval) to 15.3 inches (1,000 year recurrence interval). From a flooding perspective, wet periods can have large cumulative storm totals that affect watershed runoff, agricultural producers, public safety, and pollutant loading.

Table 5. Atlas 14 summaries of 24-hour precipitation amounts (inches) for Albert Lea [NOAA 2019b].

24-Hour Storms Depth (inches)	**Average Recurrence Interval (years)**	**1**	**2**	**5**	**10**	**25**	**50**	**100**	**200**	**500**	**1,000**
	Chance of Occurrence (%)	**100**	**50**	**20**	**10**	**4**	**2**	**1**	**0.5**	**0.2**	**0.1**
Location	Albert Lea	2.58	3.01	3.82	4.58	5.75	6.75	7.84	9.04	10.8	12.2

Table 6. Atlas 14 summaries of 10-day wet-period precipitation amounts (inches) for Albert Lea [NOAA 2019b].

10-Day Wet Period Depth (inches)	**Average Recurrence Interval (years)**	**1**	**2**	**5**	**10**	**25**	**50**	**100**	**200**	**500**	**1,000**
	Chance of Occurrence (%)	**100**	**50**	**20**	**10**	**4**	**2**	**1**	**0.5**	**0.2**	**0.1**
Location	Albert Lea	4.66	5.30	6.39	7.34	8.72	9.84	11.0	12.2	13.9	15.3

3.3.2 Precipitation variability: wet and dry periods

A closer examination of year-to-year and monthly precipitation variability was evaluated by using synthetic data from the DNR's *Monthly Precipitation Data From Gridded Database* [DNR 2019a]. Data were summarized by month and year and are presented in Table 7 for Albert Lea Township in Freeborn County. In this evaluation, the wet months (i.e., month's greater than 70th percentile) are color-coded blue and dry months (i.e., month's less than 30th percentile) are color-coded red. The in-between values (normal) are color-coded green. From 2007 to 2018, six years were wet (i.e., precipitation greater than 70th percentile), three were normal, and three were dry (i.e., precipitation less than 30th percentile). Note that peak spring (April and May) and June precipitation events carry the potential to generate stormwater runoff from fertilized fields, crop fields with undeveloped canopies, and urban conveyance systems just before the peak growing season. Data from 2007 to 2018 also show several substantial rotations between wet (blue) and dry (red) monthly precipitation amounts. Higher precipitation amounts that occur during July and August with established vegetative canopies and higher evaporative losses may not have peak runoff unless they are caused by extreme events and wet periods from back-to-back storm systems.

Table 7. Monthly precipitation by year (2007–2018) for Albert Lea Township, MN [DNR 2019a].

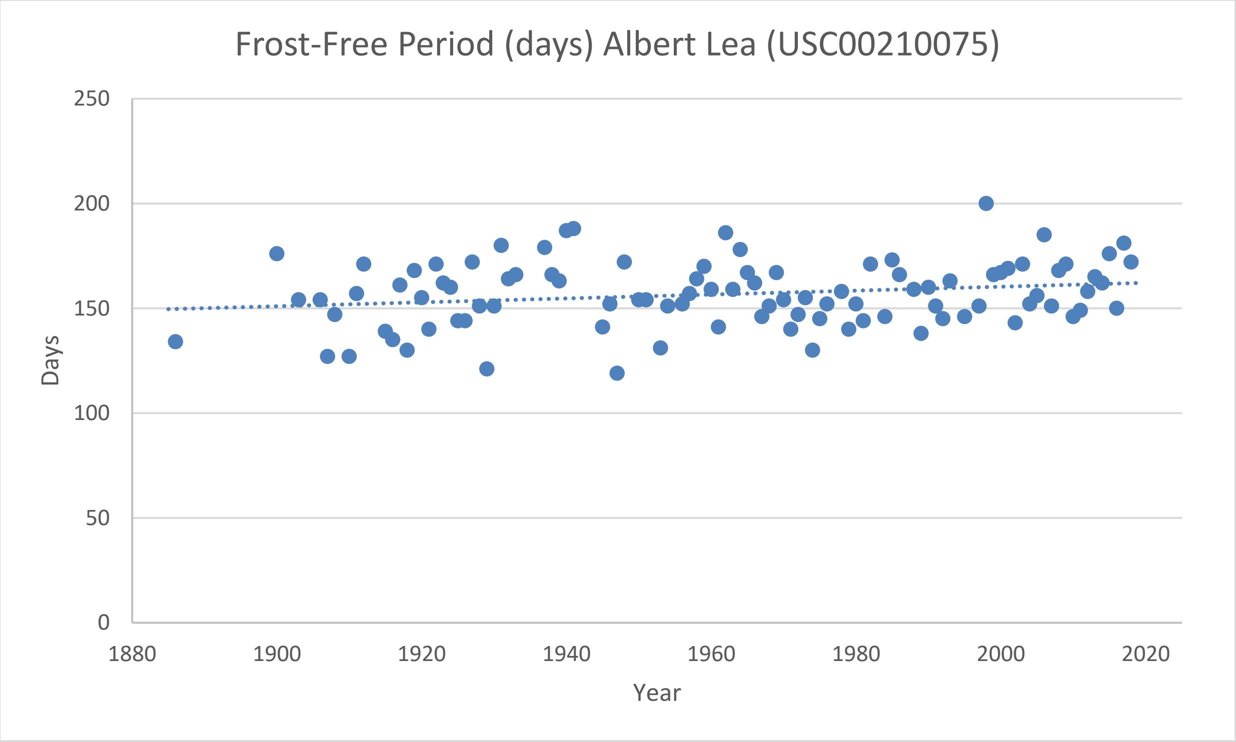
	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Period-of-Record Summary Statistics (inches)													
30%	0.48	0.43	1.06	1.90	2.73	3.38	2.50	2.47	1.96	1.38	0.66	0.64	17.84
70%	1.14	1.05	2.05	3.34	4.84	5.84	5.14	4.58	4.32	2.93	2.02	1.32	22.69
mean	0.87	0.88	1.66	2.84	4.07	4.73	4.02	3.82	3.53	2.24	1.49	1.06	20.17
1981 - 2010 Normals (inches)													
normal	0.84	0.79	1.82	3.48	4.19	4.76	4.73	4.52	3.54	2.45	1.76	1.15	21.73
Year-to-Year Data (inches)													
2018	1.36	1.11	1.20	3.02	5.77	7.77	4.79	3.53	8.05	3.63R	1.39R	1.99R	29.91
2017	1.25	1.08	2.07	2.79	4.25	4.61	4.76	3.15	3.07	5.22	0.35	0.58	19.84
2016	0.60	0.61	3.17	2.05	3.62	5.63	7.34	4.75	10.62	4.82	1.35	1.65	31.96
2015	0.53	0.62	0.48	4.85	4.35	7.59	5.24	5.07	3.56	1.00	2.82	3.37	25.81
2014	1.08	1.14	1.63	5.57	2.05	9.73	0.79	6.26	3.19	1.58	0.69	0.64	22.02
2013	0.38	0.79	2.56	6.02	7.60	8.85	3.66	3.44	1.14	3.39	0.95	0.95	24.69
2012	0.80	1.67	1.42	3.29	4.33	2.64	1.61	1.88	1.34	1.59	0.58	1.75	11.80
2011	1.10	0.94	1.90	4.14	4.75	4.30	5.36	1.23	2.18	1.17	0.24	1.11	17.82
2010	0.61	1.00	1.56	1.62	2.40	6.43	6.31	2.19	9.14	0.69	2.24	2.51	26.47
2009	0.76	0.75	1.51	2.71	2.85	6.15	2.26	3.56	1.19	6.93	0.59	2.10	16.01
2008	0.59	0.59	1.04	4.48	4.54	6.23	3.84	2.38	1.46	2.01	2.57	1.21	18.45
2007	0.82	2.03	2.15	2.18	4.28	3.96	4.45	9.94	5.15	3.46	0.22	1.23	27.78

Blue values = wet (or greater than 70th percentile)
Green values = mid-range (30th–70th percentile)
Red values = dry (or less than 30th percentile)

3.3.3 Frost-free season length

In addition to patterns of average summer ambient temperatures, variations in frost-free season length were examined. The frost-free season, as defined by the number of days between the last 32°F day of spring and the first 32°F day of autumn, was tabulated for Albert Lea, Minnesota (USC00210075), as shown in Figure 7. While the Albert Lea dataset was limited because of some missing data, the long-term pattern generally indicates increasing frost-free periods.

Figure 7. Frost-free period (days) in Albert Lea, MN, from 1886 to 2018.



3.3.4 Evaporation

Free water surface evaporation is approximately 38 inches per year (in/yr) in the project area [Farnsworth and Thompson 1982].

3.3.5 Climate summary

Growing-season runoff can be expected to be affected by wide variations in month-to-month rainfall amounts, increasing average temperatures, and storm intensities. Storm-precipitation intensities for typical 24-hour storms and multiday wet periods can be substantial with potential wide-ranging impacts that affect communities, agricultural producers, streams, wetlands, and associated aquatic habitats. These basic climate- and hydrologic-cycle components vary considerably between years and seasonally. These variations can cause wide ranges of watershed runoff and associated runoff-pollutant dynamics that should be factored into future restoration/protection and monitoring program design considerations.

3.4 Watershed characteristics

3.4.1 Subwatersheds

Assessment Unit Identifications (AUIDs), lengths, and drainage areas are presented in Table 8 for the impaired reaches addressed in this TMDL.

Table 8. Impaired reach lengths, locations, and watershed drainage areas.

Impaired Reach	AUID No.	Reach Description	Pollutants Addressed	Reach Length (miles)	Drainage Area (acres)
Shell Rock River	501	Albert Lea Lk to Goose Cr	DO, FIBI, MIBI, Nutrients, TSS, pH	12.12	122,739
Bancroft Creek (County Ditch 63)	507	CD 63 to Fountain Lk	*E. coli*	6.6	21,854
Unnamed Creek (Shoff Creek)	516	Mud Lk to Fountain Lk	Nutrients, TSS	3.12	9,764
Unnamed Creek (Wedge Creek)	531	T103 R22W S36, north line to unnamed ditch	*E. coli*	1.46	21,758

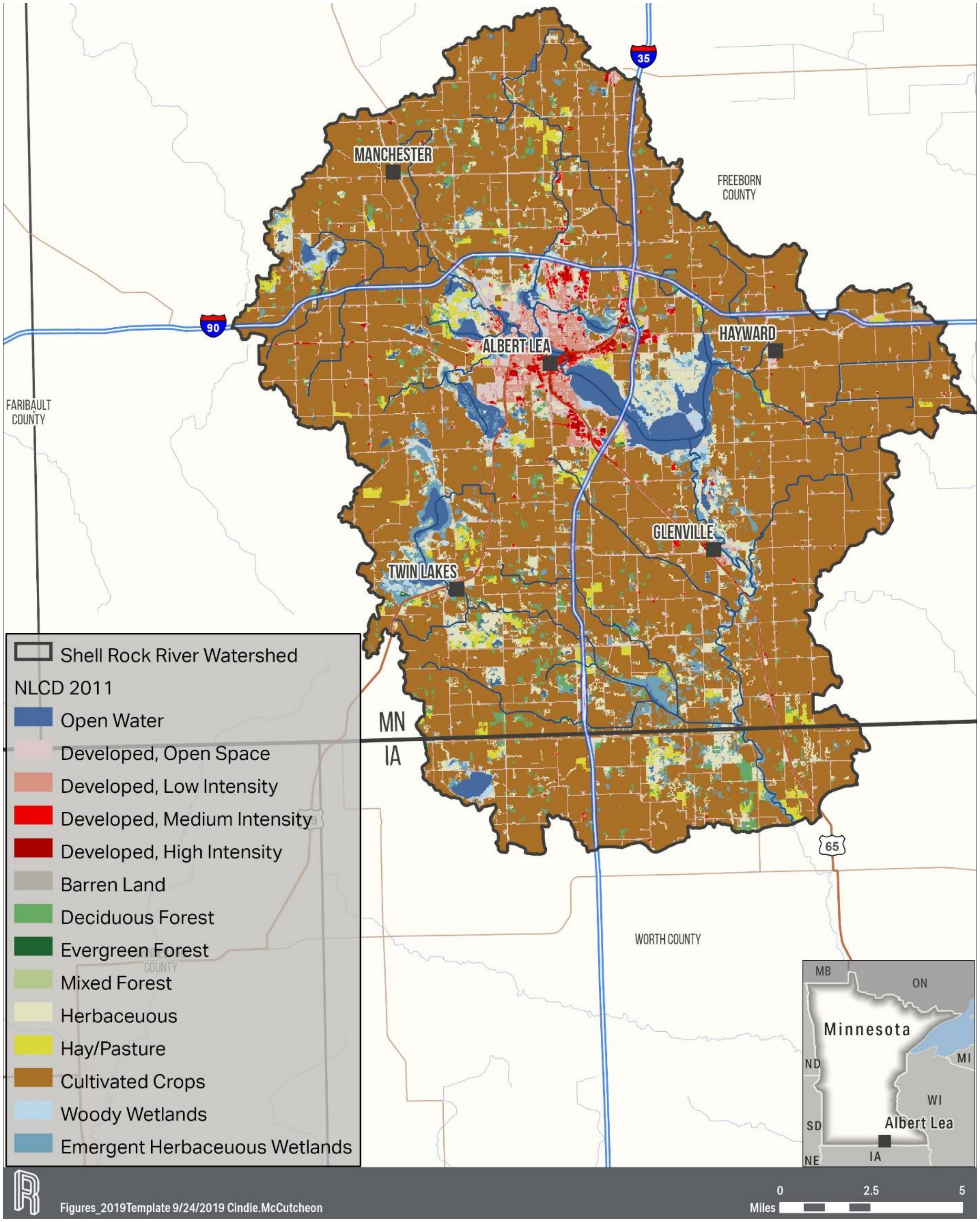
3.4.2 Land cover

The 2011 National Land Cover Dataset (NLCD) was used in developing the HSPF model for the Shell Rock River Watershed and each of the TMDLs described herein. Land cover data were summarized for areas draining to each impaired stream and lake, as shown in Table 9. Land cover types that were determined for the Shell Rock River Watershed are depicted in Figure 8. Most impaired streams and lakes have drainage areas that are over half row crops with the exceptions of Pickeral and White Lake, which have more diverse land cover in their drainage areas. However, row crops are still the dominant land cover for Pickeral and White lakes. Wetlands in the watershed have been extensively drained for agricultural use.

Table 9. Land cover distribution by impaired waterbody.

Name	ID	Drainage Area (Square Miles)	Open Water (%)	Developed (%)	Barren (%)	Forest (%)	Herbaceous (%)	Hay/ Pasture (%)	Row Crops (%)	Wetlands (%)
Shell Rock River	501	191.8	4.0	13.0	0.1	1.6	5.7	1.5	70.3	3.9
Bancroft Creek	507	34.1	0.3	10.1	0.0	2.5	4.7	1.5	79.2	1.7
Unnamed Creek (Shoff Creek)	516	15.3	6.7	12.3	0.0	1.9	6.2	2.6	62.5	7.8
Unnamed Creek (Wedge Creek)	531	34.0	1.2	8.0	0.0	1.7	3.7	1.4	81.3	2.7
Albert Lea Lake	24-0014-00	147.0	4.9	14.0	0.0	1.7	5.7	1.7	68.2	3.8
Fountain Lake (East Bay)	24-0018-01	97.5	2.9	13.9	0.0	2.0	5.3	2.0	69.9	4.0
Fountain Lake (West Bay)	24-0018-02	37.6	2.5	9.7	0.0	1.8	4.8	2.4	75.2	3.6
Pickeral Lake	24-0025-00	5.8	13.8	18.6	0.7	0.0	6.1	1.9	48.8	10.1
White Lake	24-0024-00	1.8	15.7	10.2	5.8	0.0	13.1	16.5	29.4	9.2

Figure 8. 2011 National Land Cover dataset



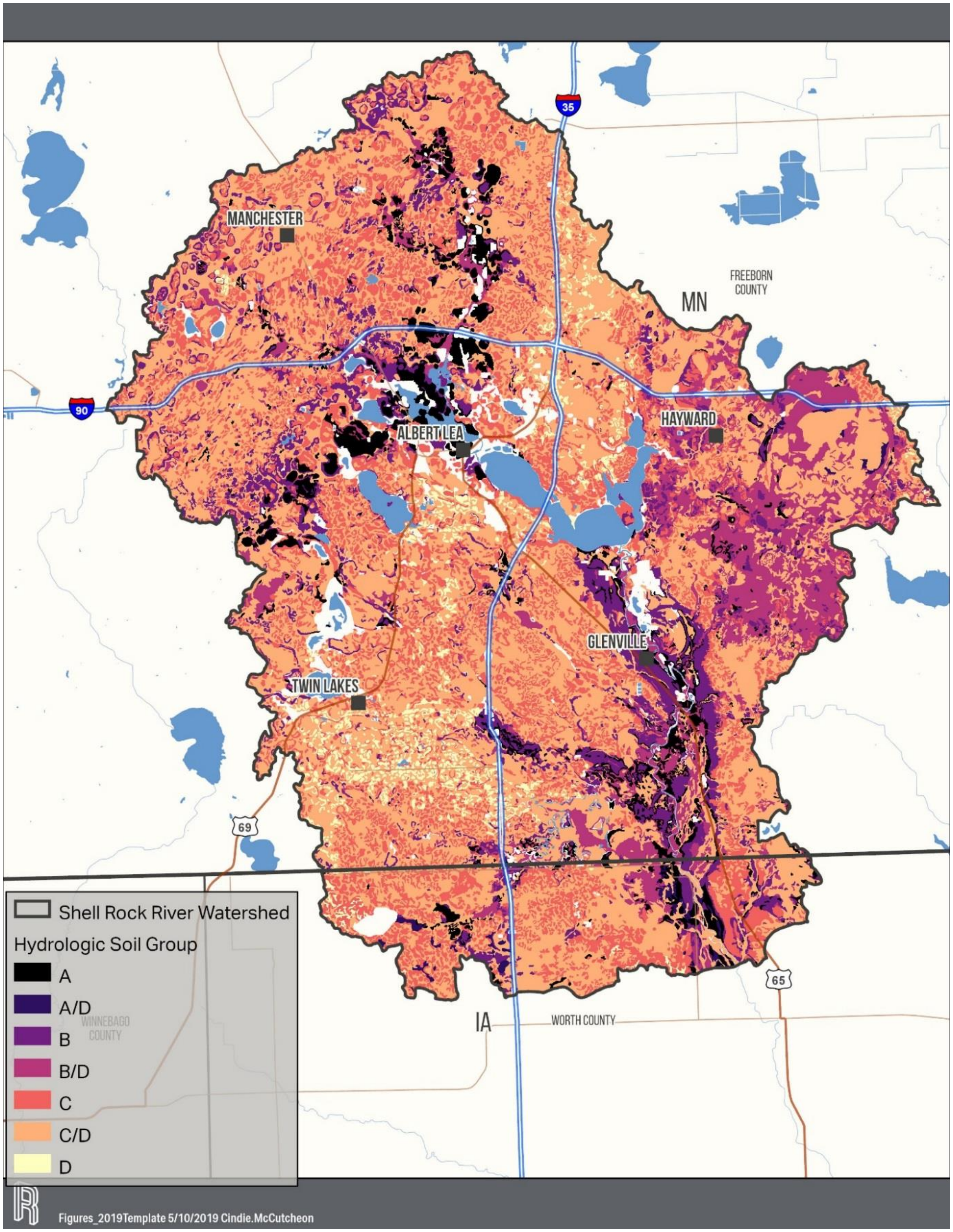
3.4.3 Soils

Watershed soils and their distributions are important factors to consider, because soils can significantly affect runoff and its quality from particle sizes, nutrients, interflow, and infiltration/groundwater recharge. Consequently, Hydrologic Soil Groups (HSGs), as defined by the Natural Resource Conservation Service [2016] are shown in Figure 9 for the four HSG soil groups (A, B, C, and D) and summarized in Table 10. The area that is draining to the Shell Rock River impairment (Reach 501) comprises of approximately 6% HSG A or A/D, 22% HSG B or B/D, and 72% HSG C , C/D, or D soils, as shown in Figure 9. Dual HSG classification soils (e.g., HSG A/D and B/D soils) behave like HSG D soils when undrained (when seasonal high water table is within 24” of the surface). The distributions of the different land covers, soil types, and aquatic ecoregions are foundational aspects that affect (1) runoff quantity and quality and (2) future implementation of stormwater treatment within the Shell Rock River Watershed.

Table 10. General descriptions of HSGs [NRCS 2009].

Hydrologic Soil Group	Abbreviated Description
A Soils	Sand, sandy loams with high infiltration rates. Well-drained soils with high transmission.
B Soils	Silt loam or loam soils. Moderate infiltration, moderately drained.
C Soils	Sandy clay loams. Low infiltration rates that impede water transmission.
D soils	Heavy soils, clay loams, silty, clay. Low infiltration rates that impedes water transmission.
Dual soils A/D and B/D	Dual HSG classification soils (notably, A/D and B/D) that behave as type D soils when undrained.

Figure 9. HSGs.



3.4.4 Lake characteristics

Minnesota's lake-nutrient standard development occurred in phases over three decades of monitoring and assessing a large cross section of lakes and lake types in Minnesota's aquatic ecoregions [Heiskary and Wilson 2005]. Distinct relationships were established between causal factors (TP) and the response variables chl-*a* and SDT. TP has often been found to be the limiting factor in freshwater lakes. As lake phosphorus concentrations increase, algal abundance increases, and causes in higher chl-*a* concentrations and reduced lake transparency. Based on these relationships, the chl-*a* and SDT standards are expected to be met by meeting the phosphorus target in each lake.

Minnesota's lake eutrophication standards for the WCBP ecoregion also factor in the effects of lake depth on water quality. Deep lakes that remain thermally stratified can be expected to have stable or declining surface-water phosphorus concentrations over the summer growing season. While deep-lake sediments may go anoxic, sediment-generated phosphorus (e.g., internal loading) can be less susceptible to mixing into surface waters because of thermal stratification. Conversely, shallow lakes are more prone to total water column mixing via wind-action, and may have widely fluctuating phosphorus concentrations as inflow phosphorus is mixed with resuspended organic matter and lake sediment-generated phosphorus quantities. Minnesota's eutrophication standards for shallow lakes are numerically higher than the standards for deeper lakes for TP and chl-*a* with reduced SDT, which indicates the cumulative impacts of the preceding factors. Internal phosphorus loading is often an important phosphorus source for lakes with temporary thermal stratification that forms an anoxic layer near sediments. The anoxic layer can allow a phosphorus release from the lake's sediments that periodically mixes into surface waters and provides phosphorus for algal growth. However, shallow, well-mixed, or well-flushed lakes that maintain oxic conditions near the sediment-water interface over most of the summer may have lower internal loading rates [Nürnberg 1995], depending on the populations of rough fish, such as carp and black bullhead, and presence of invasive species, such as *Potamogeton crispus* (curly-leaf pondweed).

Hondzo and Stefan [1996] evaluated lake thermal stratification by evaluating the use of a lake geometry ratio (GR) based on Equation 1. Lake GRs classify lakes as shallow (greater than 5.3), medium (1.6 to 5.3), or deep (0.9 to 1.6) [Hondzo and Stefan 1996].

$$\text{Lake Geometry Ratio} = \frac{A^{0.25}}{D_{\max}} \tag{1}$$

where A is lake-surface area (in square meters [m^2]) and $D_{\max}$ is maximum depth (in meters).

The Osgood Index [Osgood 1998] can also be used to characterize lakes by estimating the fraction of a lake's volume that is involved in mixing. The Osgood Index is defined as:

$$\text{Osgood Index} = \frac{D_{\text{mean}}}{A_{\text{surface}}} \tag{2}$$

where D_{mean} is the mean lake depth (in meters) and A_{surface} is the lake's surface area (in square kilometers [km^2]). Osgood Index values categorize lakes as polymictic (less than 4), intermediate (4 to 9), or dimictic (greater than nine).

All impaired lakes that are addressed in this TMDL document are classified as shallow lakes; all have a maximum depth of less than fifteen feet. Lake morphometric and watershed characteristics are noted in

Table 11. The estimated littoral area for all impaired Shell Rock River Watershed lakes is 100%, which is typical in very shallow lakes. Native aquatic plant and zooplankton communities in shallow lakes can help the lakes maintain a clear, aquatic plant dominated state as opposed to a turbid, algae dominated state. Residence times in Table 11 were calculated using volumes and 122Q10 values calculated from HSPF simulated flows. The estimated residence times for Fountain Lake and Albert Lea Lake are very low.

Table 11. Select TMDL lake morphometry and watershed characteristics.

Characteristic	Albert Lea	Fountain	White	Pickeral	Source
Lake Surface Area (acres)	2,669	522	168	588	DNR LakeFinder Fish Lake Surveys
Lake Littoral Area (acres)	2,669	521	168[a]	588	DNR LakeFinder Fish Lake Surveys
Mean Depth (ft)	3.5	5	2[b]	3.5	DNR LakeFinder Fish Lake Surveys
Maximum Depth (ft)	5.5	14	4[c]	7[c]	DNR LakeFinder Fish Lake Surveys
Percent Lake Littoral Surface Area	100	100	100	100	Calculated[d]
Drainage Area, Including Lake (acres)	94,090	62,398	1,179	3,702	Model Subwatersheds
Watershed Area to Lake Area Ratio (X:1)	35.3	119.6	7.0	6.3	Calculated[d]
Lake Volume (acre-feet)	4,637	1,946	405	2,027	Calculated[d]
Lake Geometry Ratio	34.2	8.9	31.4	21.5	Calculated[d]
Osgood Index Index	0.3	1.0	0.7	0.7	Calculated[d]
Estimated Water Residence Time (days)	46.5	23.0 West Bay, 17.1 East Bay	573.1	1,082.0	Calculated with HSPF Flow 122Q10 and Volume

a. Assumed based on maximum depth.
b. Estimated from lake map.
c. Shell Rock River Watershed District
d. Calculated by RESPEC using available characteristic data.

Estimates of Lake GRs and Osgood Index values produced corroborating evidence of shallow-lake classifications. The estimated lake GR was greater than 5.3 for all four lakes, which indicates shallow-lake conditions (i.e., a lake GR greater than 5.3). The calculated Osgood Index value was less than four in all four lakes, which indicates that the lakes are polymictic (well-mixed, i.e., Osgood Index values less than 4.0).

The total watershed to lake-surface area ratio (Ws:Ao ratio) was calculated as 35.3:1 for Albert Lea, 119.6:1 for Fountain, 7.0:1 for White, and 6.3:1 for Pickeral Lakes. For comparison, the average WCBP Ws:Ao ratio for lakes used in developing Minnesota Lake Eutrophication Analysis Procedure (MINLEAP) aquatic ecoregion eutrophication assessment was 7.1:1 [Wilson and Walker 1989].

The runoff volumes that were calculated from HSPF modeling for the 2009 through 2018 period were used to estimate lake-water residence times (times to completely fill lakes) that ranged from approximately 6 to 132 days. The WCBP lakes that were used to develop MINLEAP had an average water-residence time of 4.8 years [Wilson and Walker 1989]. Further information about lake characteristics is available in Appendix A through D.

3.5 Current and historic water quality conditions

3.5.1 Stream flows

Throughout Minnesota, county, regional, state, and federal entities have been actively involved in gathering and reporting stream and river discharge flow data. In the Shell Rock River Watershed, continuous discharge data are available for 14 stations from 2008 to 2018. This dataset was used to calibrate the hydrology model, which was the foundation for the TMDLs that are addressed in this report. Table 12 summarizes the available flow data by stream reach, years of data, and mean flows. Maps of flow-monitoring stations and point source discharge locations are included in Appendix E.

Table 12. Locations throughout the Shell Rock River Watershed with flow data available during the modeling period (1996–2018); no stations had flow data prior to 2008.

Site	Description	First Year Available	Final Year Available	Number of Days With Flow	Mean Flow (cfs)
SWC01	Wedge Creek	2009	2018	1,994	41
SMC01	Mud Lake	2009	2018	1,936	8
SSC01	Shoff Creek	2009	2018	1,786	12
SBC01	Bancroft Creek	2009	2018	1,996	33
SGC01	Wetland Stream	2009	2018	1,533	12
SFL01	Fountain Lake Dam	2009	2018	1,625	218
SNE01	Northeast Creek	2009	2018	1,631	5
SPL01B	Hayward Creek	2009	2018	1,818	23
SPL02	Hayward Creek	2009	2018	1,679	16
SLP01	Peter Lund Creek	2009	2009	45	6
SSR01	Albert Lea Lake Outlet	2013	2018	1,048	263
SSR02	Shell Rock River Glenville	2009	2018	2,082	207
SSR03	Shell Rock BR	2012	2018	1,779	235
H49009001	Shell Rock River near Gordonsville	2008	2018	3,569	199

3.5.2 Water quality

Water quality data from the MPCA Environmental Quality Information System (EQuIS) database and Shell Rock River Watershed District were used to development the TMDLs in this report. All TMDL analyses were based on the 10-year period from 2009 through 2018. The MPCA's assessment cycles are 10 years in length.

3.5.2.1 E. coli

E. coli data from 2009 through 2018 are summarized for the monitoring point that is nearest to the outlet of each *E. coli* impaired reach in Table 13, which includes geometric mean concentrations for each impaired reach by month. Geometric means were above the 126 organisms per 100 milliliter (org/100 mL) standard for every reach during all of the months with data between April and October. Monthly samples are shown for *E. coli*-impaired reaches in Figure 10 and Figure 11, respectively.

Table 13. Observed monthly geometric mean *E. coli* data summary from 2009 through 2018 between April and October; months with five or more samples are shown in bold.

Impaired Reach	Description	Month	Number of Samples	Geometric Mean (org/100 mL)
507, S004-120	Bancroft Creek (County Ditch 63), CD 63 to Fountain Lake	April	No Data	N/A
		May	No Data	N/A
		June	**5**	**306.8**
		July	**5**	**298.3**
		August	**5**	**423.9**
		September	No Data	N/A
		October	No Data	N/A
531, S004-121	Unnamed Creek (Wedge Creek), T103 R22W S36, North Line to Unnamed Ditch	April	No Data	N/A
		May	No Data	N/A
		June	**5**	**294.9**
		July	**5**	**208.2**
		August	**5**	**493.7**
		September	No Data	N/A
		October	No Data	N/A

Figure 10. Single-sample *E. coli* concentrations by month in Reach 507 at S004-120 from 2009 through 2018.

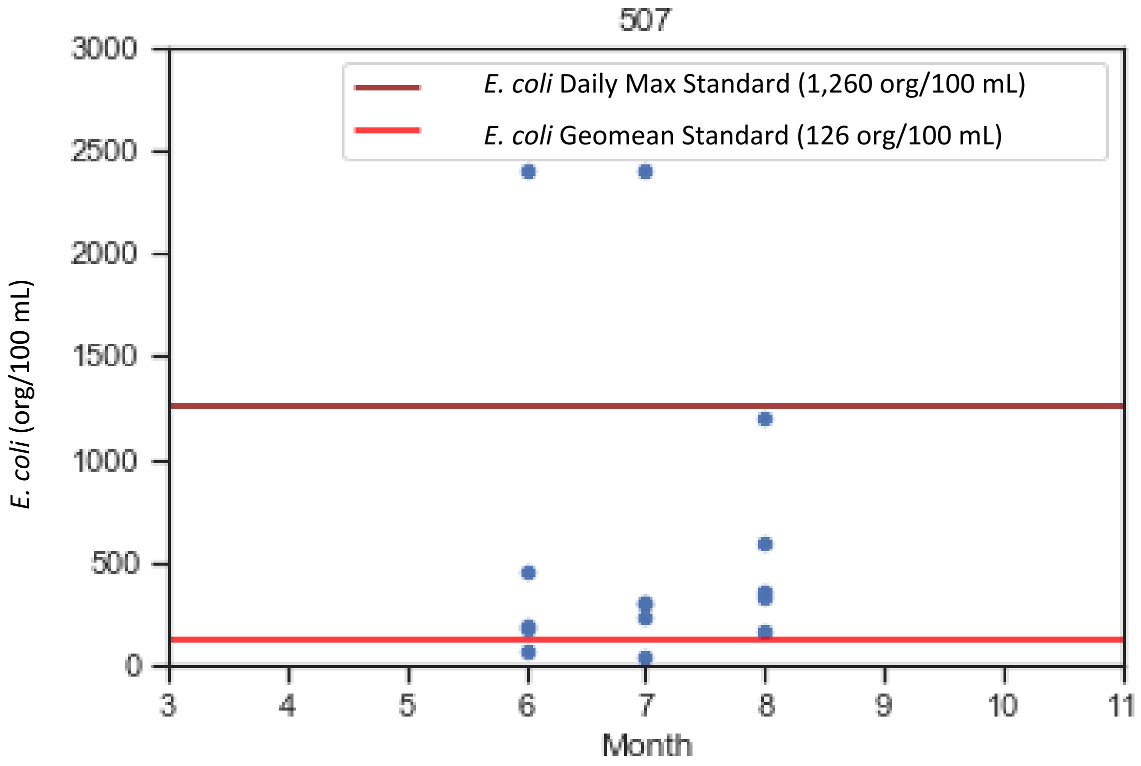
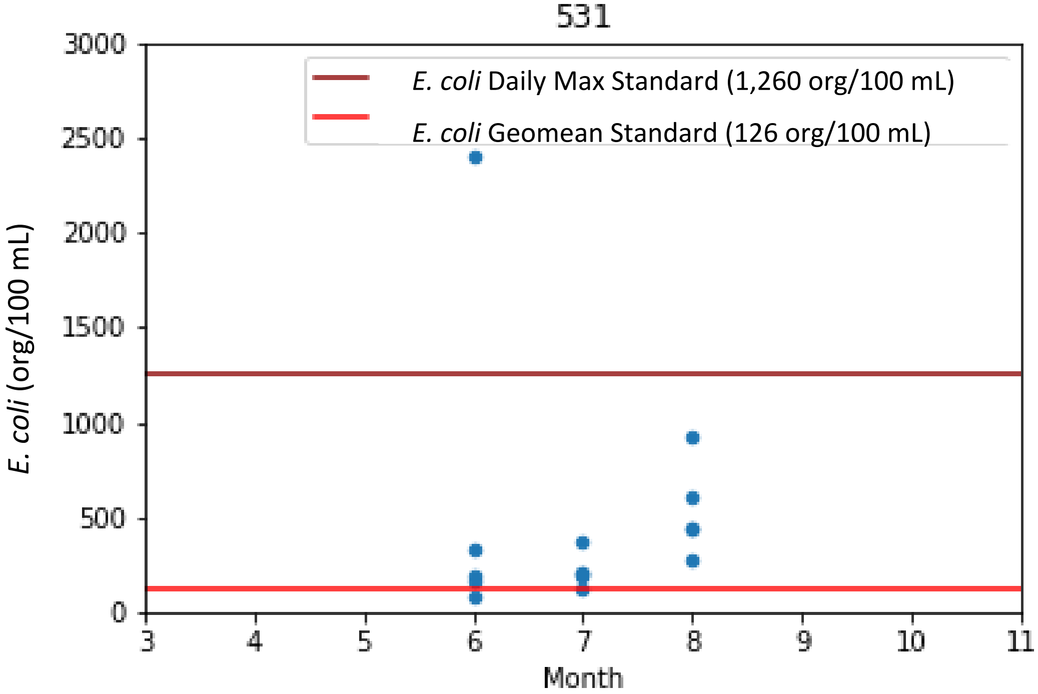


Figure 11. Single-sample *E. coli* concentrations by month in Reach 531 at S004-121 from 2009 to 2018.



Exceedances in the *E.coli* standard are not limited to the Shell Rock River Watershed. Bacteria impairments across the greater Cedar River and Lower Mississippi River Basins has identified *E. coli* as a Regional water quality issue. The widespread problem of *E.coli* impairment is caused by thousands of ubiquitous pollutant sources spread across the Basins – feedlots, manured fields, wildlife, and failing septic systems, to name the main ones -- rather than by a few large, discrete sources (MPCA 2007).

3.5.2.2 Total suspended solids

TSS data were summarized for the monitoring point that was nearest to the outlet of each turbidity impairment by using April through September data from 2009 to 2018, as shown in Table 14. Figure 12 and Figure 13 illustrate the seasonal variation of TSS data at each TMDL reach. Because it is expected that a large portion of the TSS are volatile in nature and related to a high phosphorus concentration from upstream impaired lakes, volatile suspended solids (VSS) data were also summarized by site along the turbidity impairments with April through September data from 2009 to 2018, as shown in Table 15. Figure 14 and Figure 15 show bar charts of monthly average TSS and VSS for all of the paired data collected between 2009 and 2018 for the turbidity-impaired reaches. On a monthly average basis, VSS make up between 29% and 80% of the TSS in the Shell Rock River between May and September. In the Unnamed Creek (Shoff Creek), VSS make up between 19% and 68% of the TSS in the Shell Rock River on a monthly average basis.

Table 14. Observed TSS data summary from 2009 to 2018 between April and September.

Reach	Description	Year	Count	Minimum	Mean	Maximum	Percent Exceedance of 65 mg/L
501, S000-084	Shell Rock River, Albert Lea Lake to Goose Creek	2009	45	1.2	22.8	250.0	2
		2010	29	1.2	7.8	36.0	0
		2011	32	12.0	25.5	53.0	0
		2012	20	6.8	38.9	130.0	25
		2013	36	7.0	25.3	47.0	0
		2014	35	4.0	23.2	140.0	3
		2015	36	3.0	25.6	270.0	3
		2016	39	7.0	29.5	110.0	5
		2017	24	18.0	48.8	90.0	21
		2018	36	16.0	47.1	79.0	14
516, S004-114	Unnamed Creek (Shoff Creek), Mud Lake to Fountain Lake	2009	10	17.0	98.3	220.0	70
		2010	9	3.6	17.8	81.0	11
		2011	10	2.0	47.8	388.0	10
		2012	6	6.0	10.3	14.0	0
		2013	12	2.0	18.7	97.0	8
		2014	14	2.0	18.8	96.0	7
		2015	14	3.0	22.4	127.0	7
		2016	13	2.0	7.6	24.0	0
		2017	11	2.0	14.6	58.0	0
		2018	10	2.0	10.9	31.6	0

Figure 12. TSS by month in Reach 501 at S000-084 from 2009 to 2018.

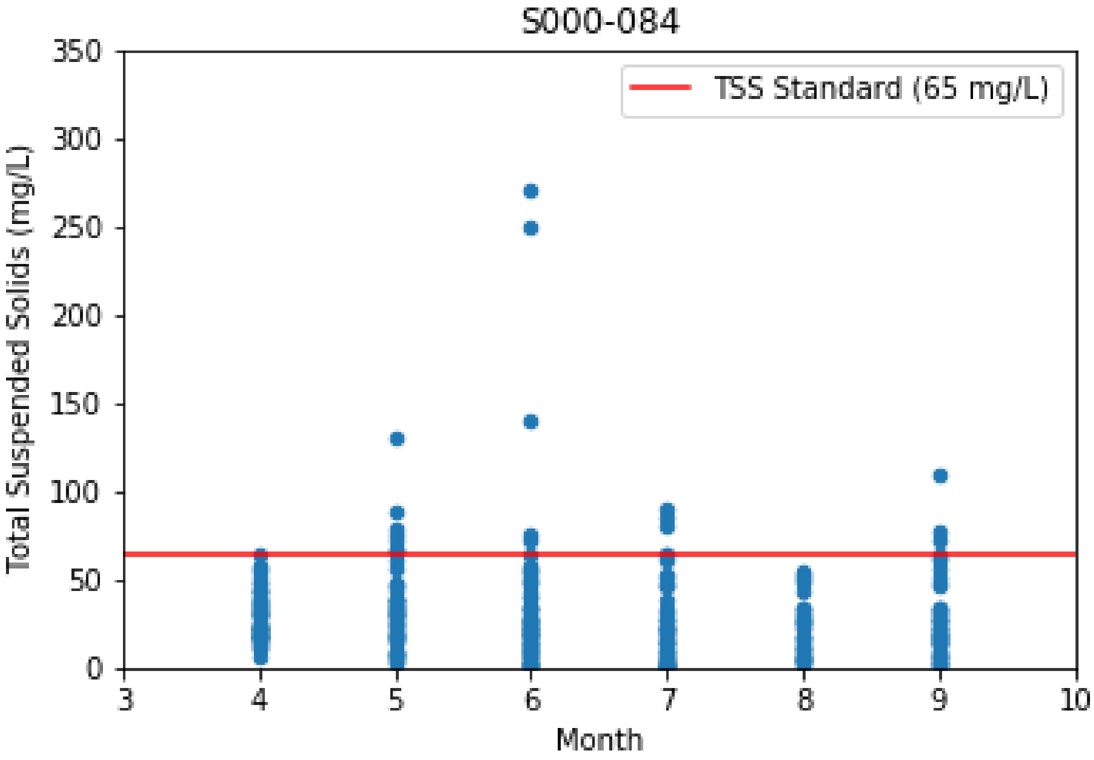


Figure 13. TSS by month in Reach 516 at S004-114 from 2009 to 2018.

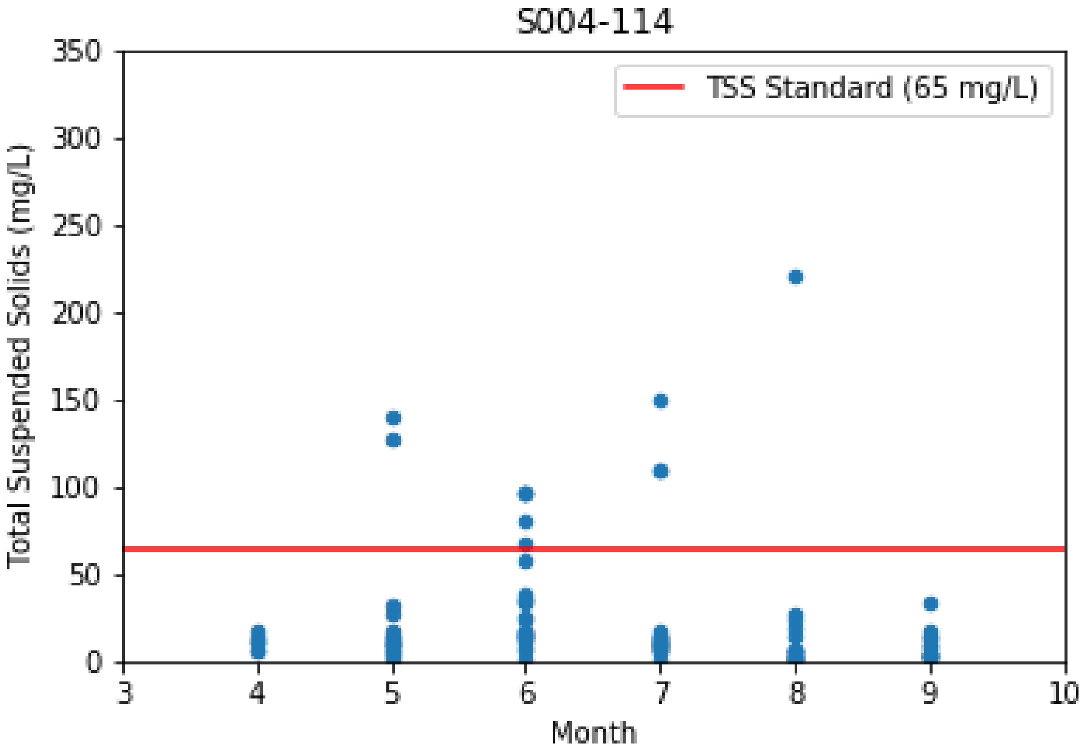


Table 15. Observed VSS data summary from 2009 to 2018 between April and September.

Reach	Description	Year	Count	Minimum	Mean	Maximum
501, S000-084	Shell Rock River, Albert Lea Lake to Goose Creek	2009	36	1.0	7.5	45.0
		2010	30	1.0	4.5	16.0
		2011	32	3.6	11.8	22.0
		2012	20	4.4	17.0	45.0
		2013	33	6.8	12.9	29.0
		2014	35	2.4	8.6	26.0
		2015	30	1.6	10.6	48.0
		2016	3	5.0	12.7	22.0
		2017	8	12.0	17.6	24.0
		2018	8	11.0	20.4	30.0
516, S004-114	Unnamed Creek (Shoff Creek), Mud Lake to Fountain Lake	2009	3	13.0	59.7	150.0
		2010	9	1.6	4.5	18.0
		2011	10	2.0	9.9	56.0
		2012	6	2.0	6.0	10.0

Figure 14. Monthly average TSS versus VSS (paired data) at S000-084 in Reach 501.

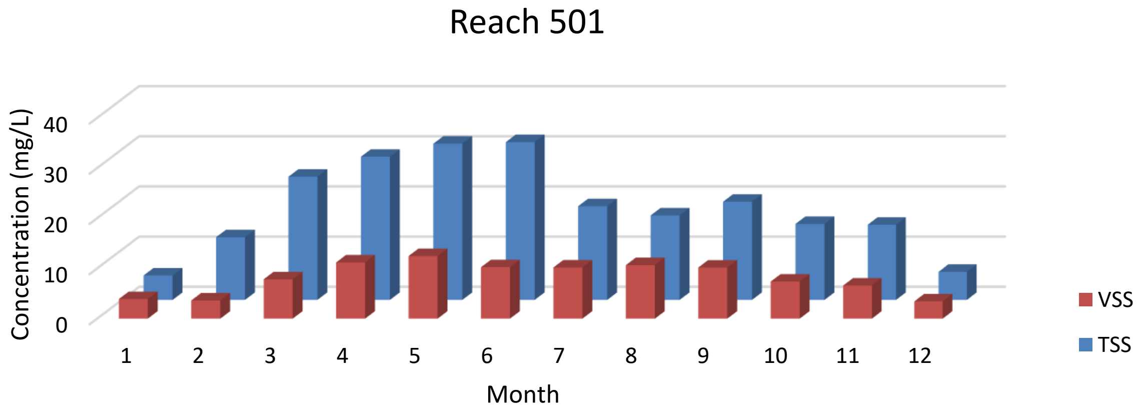
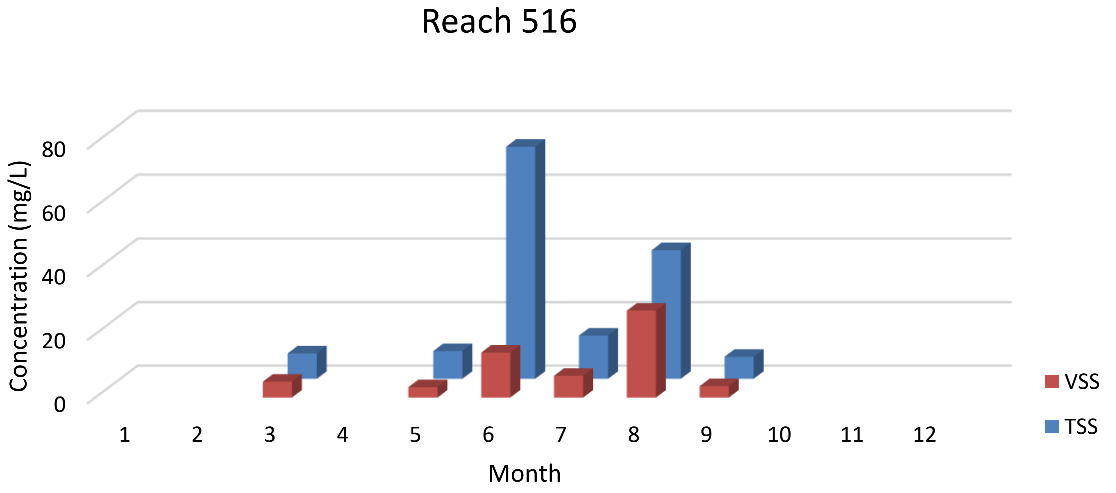


Figure 15. Monthly average TSS versus VSS (paired data) at S004-114 in Reach 516.



3.5.2.3 Nutrients (Total Phosphorus) in Streams

TP data were summarized at the monitoring point that was nearest to the outlet of each eutrophication impairment using June through September data from 2009 to 2020 for the Shell Rock River and 2009 to 2018 for Shoff Creek, as shown in Table 16.

Table 16. Observed total phosphorus data summary between June and September.

Reach	Description	Year	Count	Minimum (mg/L)	Mean (mg/L)	Maximum (mg/L)	Overall Average (mg/L)
501, S000-084	Shell Rock River, Albert Lea Lake to Goose Creek	2009	34	0.24	0.58	1.73	0.48
		2010	20	0.21	0.42	0.80	
		2011	20	0.24	0.41	0.96	
		2012[a]	14	0.14	0.80	1.97	
		2013	20	0.07	0.30	0.82	
		2014	22	0.19	0.38	0.84	
		2015	25	0.17	0.28	0.46	
		2016	26	0.15	0.26	0.43	
		2017	14	0.19	0.37	0.54	
		2018	25	0.15	0.32	0.55	
		2019[b]	8	0.28	0.74	1.16	
		2020[b]	8	0.35	0.85	1.67	
516, S004-114	Unnamed Creek (Shoff Creek), Mud Lake to Fountain Lake	2009	10	0.13	0.31	0.47	0.22
		2010	7	0.14	0.18	0.25	
		2011	8	0.12	0.27	0.99	
		2012	5	0.14	0.29	0.38	
		2013	9	0.12	0.26	0.50	
		2014	10	0.08	0.19	0.33	
		2015	10	0.07	0.16	0.30	
		2016	9	0.12	0.17	0.27	
		2017	8	0.12	0.18	0.24	
		2018	9	0.12	0.18	0.25	

a. 2012 noted as a very low flow year. During low flows, WWTP inputs to the Shell Rock River make up 10-12% of the total flow.

b. 2019 and 2020 values were collected as part of Cycle 2 IWM and were not available for use in calibrating 2019 HSPF model.

Figure 16 and Figure 17 show the seasonal variation of TP data at each TMDL reach. The chl-*a* data, diel DO flux, and BOD_5 were also summarized for the eutrophication-impaired reaches in the same time frame. The chl-*a* data are summarized in Table 17, Figure 18, and Figure 19, and BOD_5 data are shown in Table 18 and Figure 20 in Shell Rock River Reach 501. No BOD_5 data were available in Shoff Creek Reach 516 during the TMDL time period.

Figure 16. Total phosphorus by month in Reach 501 from 2009 to 2020.

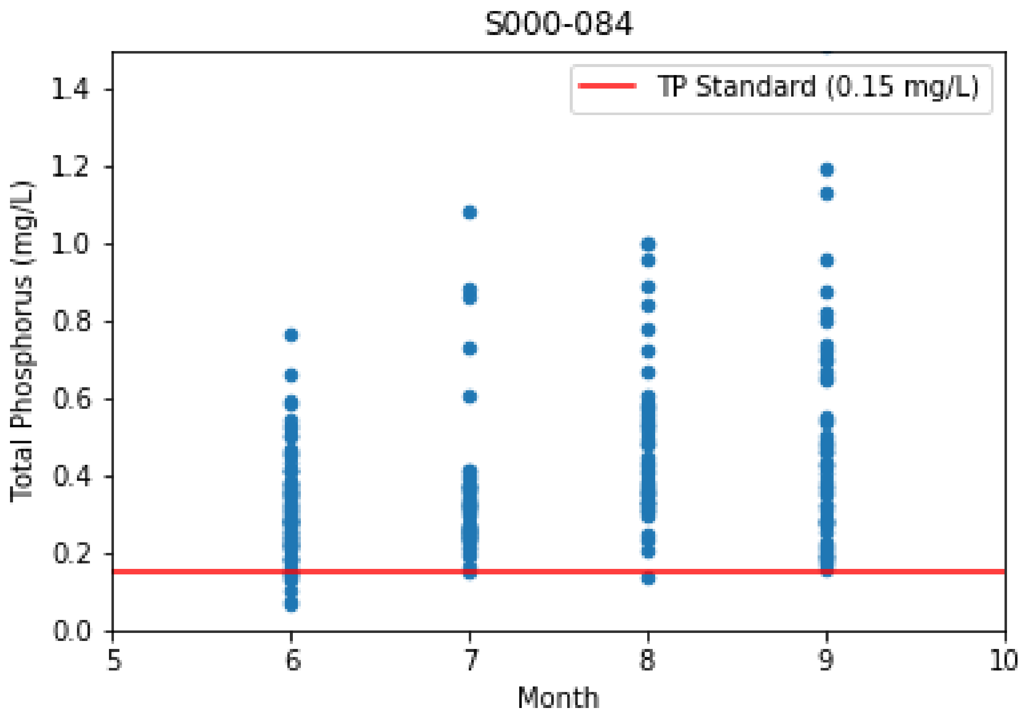
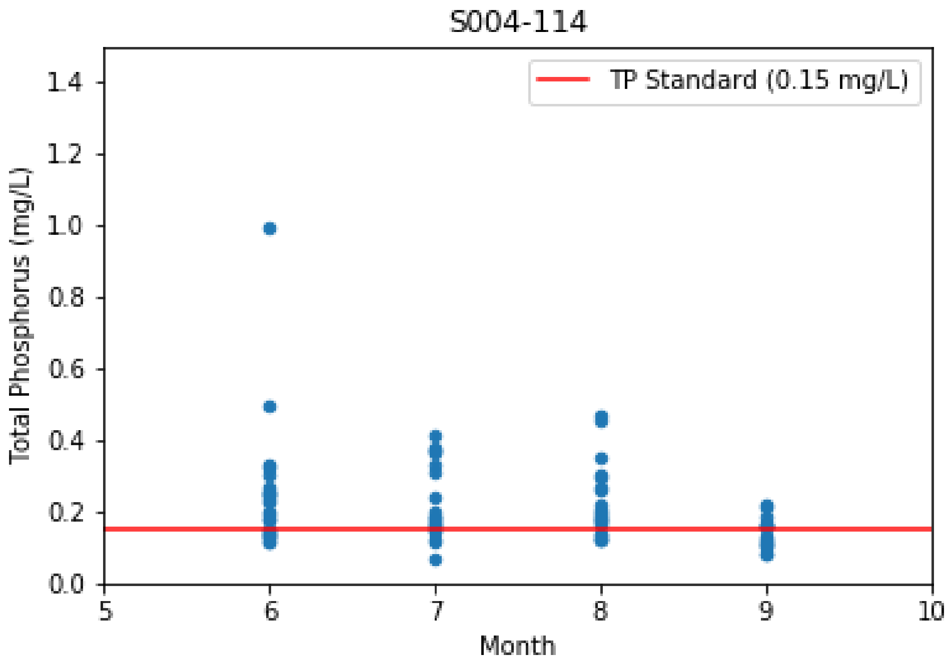


Figure 17. Total phosphorus by month in Reach 516 from 2009 to 2018.



The TP standard (0.15 mg/L) is greatly exceeded over the whole range of observed flow conditions (see Figure 33 in Pollutant Source Summary Section 3.7.4). Lowest flow ranges tend to have the highest TP concentrations.

Table 17. Observed chlorophyll-a data summary, June to September.

Reach	Description	Year	Count	Minimum (µg/L)	Mean (µg/L)	Maximum (µg/L)	Overall Average (µg/L)
501, S000-084	Shell Rock River, Albert Lea Lake to Goose Creek	2009	14	1.04	10.27	20.60	42.86
		2010	1	0.41	0.41	0.41	
		2011	11	22.30	53.26	123.00	
		2012	8	23.60	85.74	336.00	
		2013	11	8.60	36.55	92.90	
		2014	10	1.00	3.96	7.80	
		2015	10	1.00	28.89	90.40	
		2016	9	6.40	28.52	65.50	
		2017	8	34.20	55.63	89.70	
		2018	8	31.80	51.99	78.00	
		2019[a]	8	22.8	74.14	116	
		2020[a]	8	34.7	85	167	
516, S004-114	Unnamed Creek (Shoff Creek), Mud Lake to Fountain Lake	2009	10	7.96	87.37	152.00	14.04
		2010	7	3.11	6.71	13.10	
		2011	8	1.00	4.50	12.80	
		2012	5	1.50	2.68	4.60	
		2013	9	1.00	2.63	4.50	
		2014	10	1.00	2.23	5.00	
		2015	10	1.00	3.64	11.70	
		2016	9	1.00	5.84	10.70	
		2017	8	1.00	5.36	13.50	
		2018	9	1.00	5.01	13.70	

a. 2019 and 2020 values were collected as part of Cycle 2 IWM and were not available for use in calibrating 2019 HSPF model.

Figure 18. Chlorophyll-a by month in Reach 501 from 2009 to 2020.

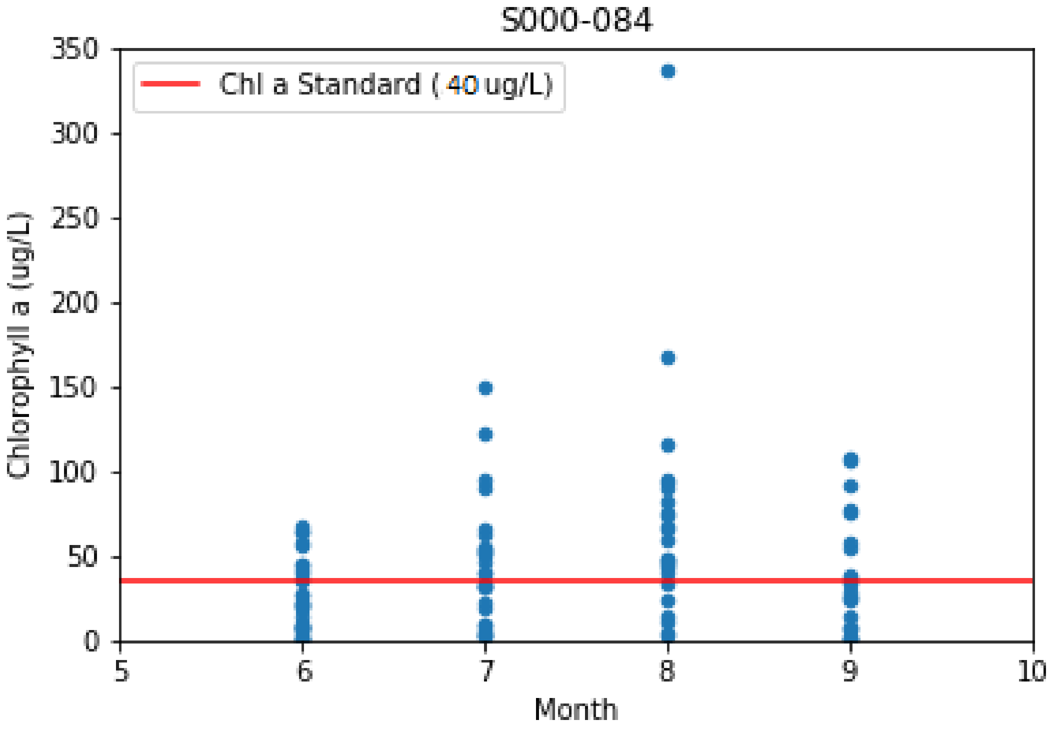


Figure 19. Chlorophyll-a by month in Reach 516 from 2009 to 2018.

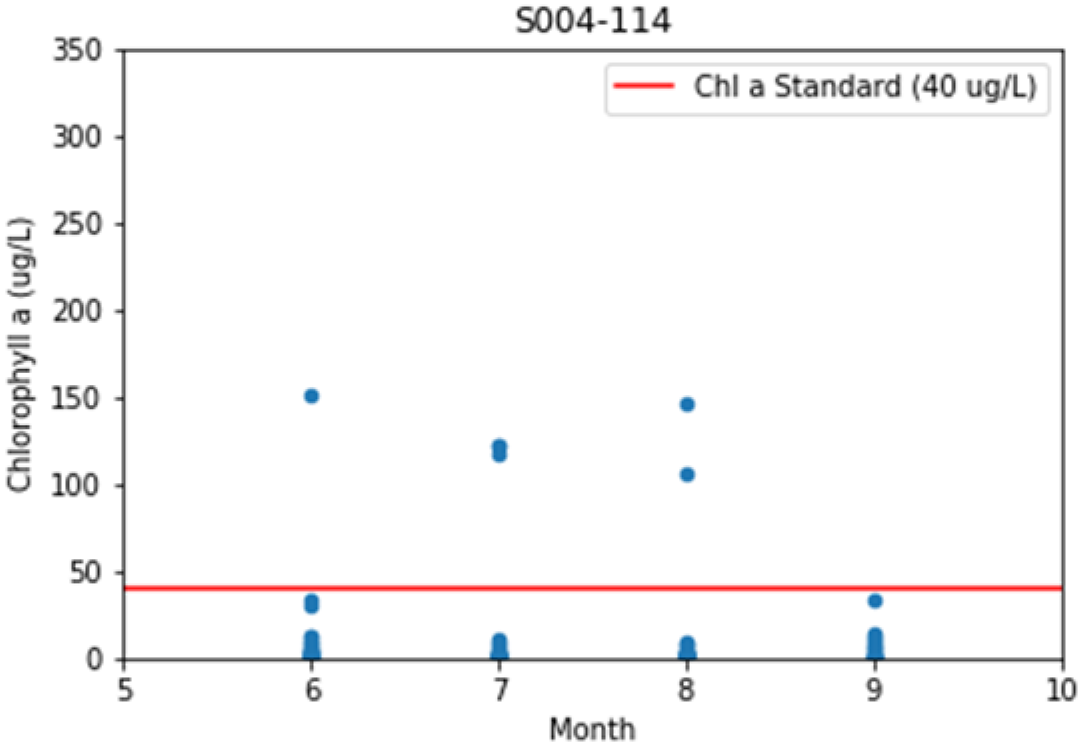
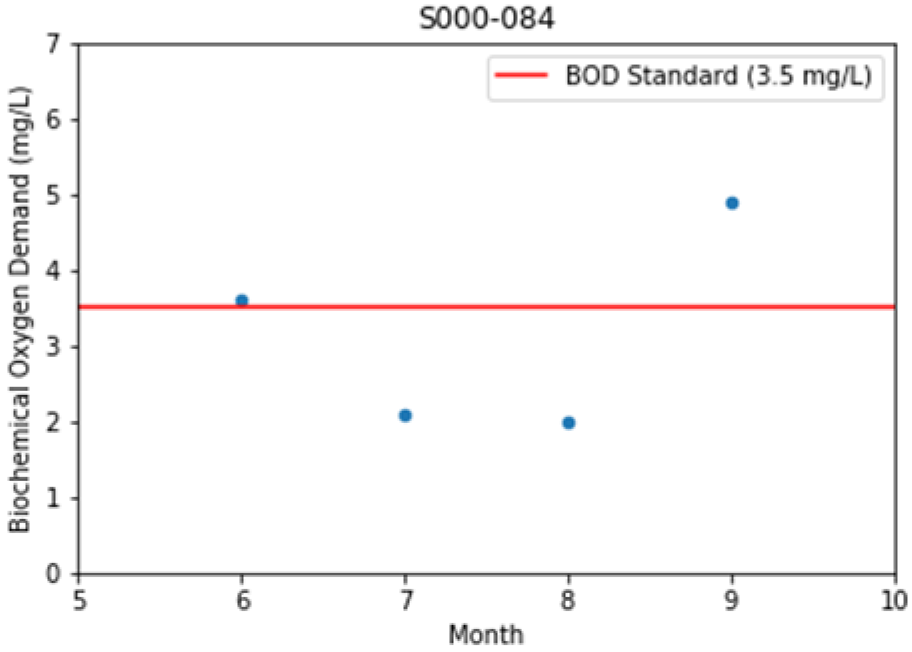


Table 18. Observed BOD_5 data summary from 2009 through 2018 from June to September.

Reach	Description	Year	Count	Minimum	Mean	Maximum
501	Shell Rock River, Albert Lea Lake to Goose Creek	2009	4	2	3.15	4.9

Figure 20. BOD by month in Reach 501 at S000-084 from 2009 to 2018.



In 2012 and 2013, the Shell Rock River Watershed district had sonde sensors (sondes) deployed for much of the growing season at three sites along the Shell Rock River below Albert Lea Lake. Additionally, in 2012; the MPCA deployed YSI sondes at the same sites. The YSI sondes continuously monitored DO concentrations in part, to establish DO flux. Continuous DO data are shown for the most downstream monitoring point on the Shell Rock River Reach 501 in Figure 21. As shown in Figure 21, some drift and constant zero concentrations occurred for extended periods of time for some of the sonde data. Figure 21 shows data that were impacted during these drift periods, which were not used for DO flux analysis. DO concentrations that were used for the DO flux analysis were often below the 5 mg/L target concentration in the early morning hours. The mean daily DO flux was 13 mg/L at the outlet of the impaired Shell Rock River Reach 501 while the Minn R. 7050.0222, river eutrophication standard for daily DO flux in the project area is 5.0 mg/L.

Figure 21. Continuous sonde data from SSR03 in Shell Rock River Reach 501 (which is the most downstream monitoring point on Shell Rock River) with a mean daily DO flux of 13 mg/L.

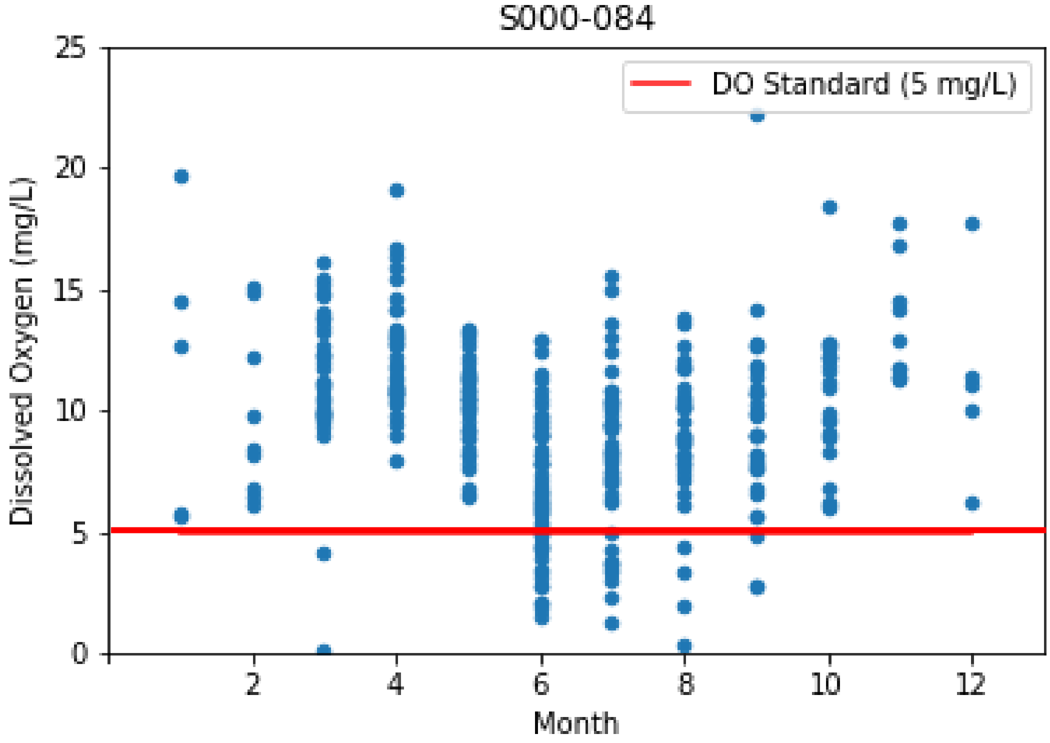
3.5.2.4 Dissolved oxygen

Available discreet, or grab, DO monitoring data at the monitoring point that was nearest to the outlet (S000-084) of the DO-impaired reach were summarized for the addressed impairment during the TMDL time period (2009 through 2018), and are tabulated in Table 19. It is important to note that, generally, discreet DO data is less informative that continuous DO collected data. This is because the lowest DO values of the diel cycles generally occur before 9 a.m., measurements taken after 9 a.m. may not always represent the lowest daily DO. Figure 22 depicts discreet DO data variability by month at the impaired reaches. Only 2 of the approximately 37 noncontinuous DO measurements that were measured along the DO impaired reach before 9 a.m. were below 5 mg/L. Continuous DO data are shown above in Figure 21.

Table 19. Observed discrete DO data summary (S000-084) for all of the months from 2009 to 2018.

Impaired Reach	Description	Year	Number of Samples	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)
501, S000-084	Shell Rock River, Albert Lea Lake to Goose Creek	2009	57	5.65	12.65	22.21
		2010	51	0.3	9.46	19.05
		2011	42	3.7	10.46	17.71
		2012	19	3.37	13.16	19.68
		2013	20	3.33	11.65	16.83
		2014	38	0.1	11.96	18.35
		2015	39	2.71	11.26	14.85
		2016	31	5.99	11.20	15.4
		2017	27	6.75	12.15	14.82
		2018	24	5.68	11.95	16.05

Figure 22. Observed discreet DO measurements by month in Reach 501 at S000-084 from 2009 to 2018.



Available noncontinuous data for the impaired DO reaches suggest that DO is lowest in the Shell Rock River during higher flows, and low concentrations (e.g., below 5 mg/L) primarily occur in the mid-, high-, and very-high flow zones, as shown in Figure 23. However, Figure 24 shows daily minimum DO measurements from continuous flow data measured in 2012 and 2013 (see also Figure 21) that suggests the opposite: that the lowest daily minima occur during in the lower flow zones. Low DO likely occurs in the Shell Rock River during all of the flow conditions, but many of the noncontinuous samples are likely higher than the minimum DO from the same sampling date because an extremely large DO flux occurs in the stream; also, more than 90% of noncontinuous sampling occurs after 9 a.m. while the minimum daily DO tends to occur before 9 a.m. Low DO likely occurs during higher flows because of high wash off from watershed sources (such as manure) or upland areas with high SOD being saturated. Low DO likely occurs during lower flows because of direct sources and high SOD in the stream bottom. When DO is not flow-dependent, it is likely caused by combined watershed direct sources of DO-demanding materials and high SOD.

Figure 23. Shell Rock River (Reach 501) DO data (noncontinuous, 2009-2018) monitored at S000-084 and plotted on a flow duration curve.

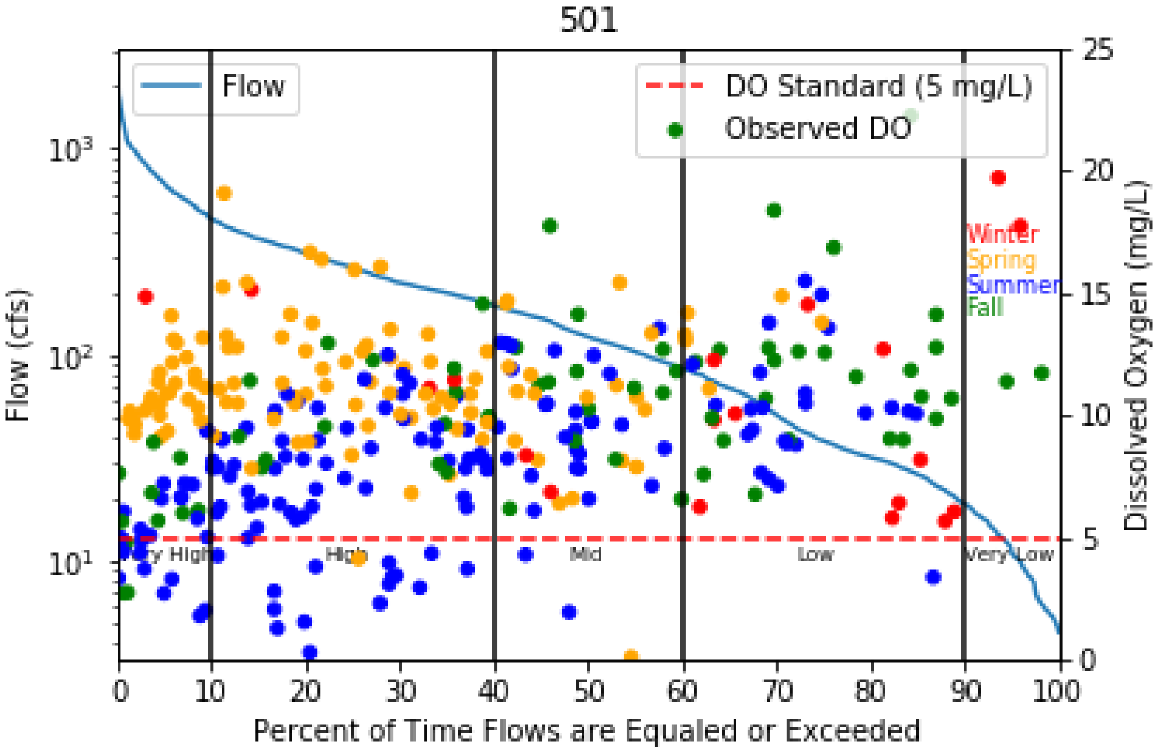
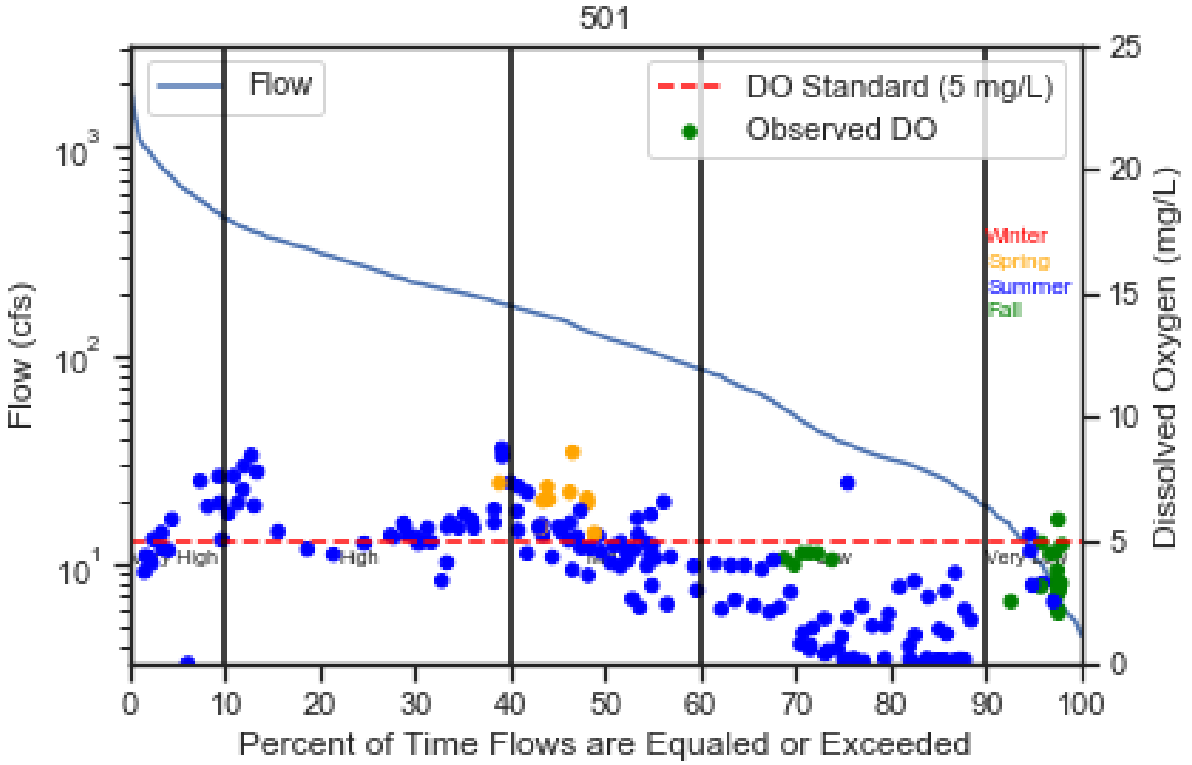


Figure 24. Shell Rock River (Reach 501) DO data (continuous daily minimums) monitored at S000-084 and plotted on a flow duration curve.



Monitored TP, chl-*a*, BOD_5, and ammonia concentrations can all have an impact on DO. Data for these parameters in Shell Rock River were paired with flow from USGS 05458910/DNR H49009001 and plotted with the flow duration curve at the gage nearest the outlet of the impaired reach (S000-084). The flow duration curve with TP data (Figure 25) indicated that TP concentrations are consistently above the 150 µg/L river standard, with the highest concentrations occurring during low and very low flows. The flow duration curve with chl-*a* data (Figure 26) indicated that chl-*a* is often above the river standard of 40 µg/L standard with higher concentrations occurring during high and very high flows. The flow duration curve with BOD_5 data (Figure 28) indicated that BOD_5 does climb above the river standard of 3.5 mg/L, but not enough data were available to glean information about the relationship between flow and BOD_5.

Figure 25. Shell Rock River (Reach 501) total phosphorus concentrations (2009-2018) monitored at S000-084 plotted on a flow duration curve.

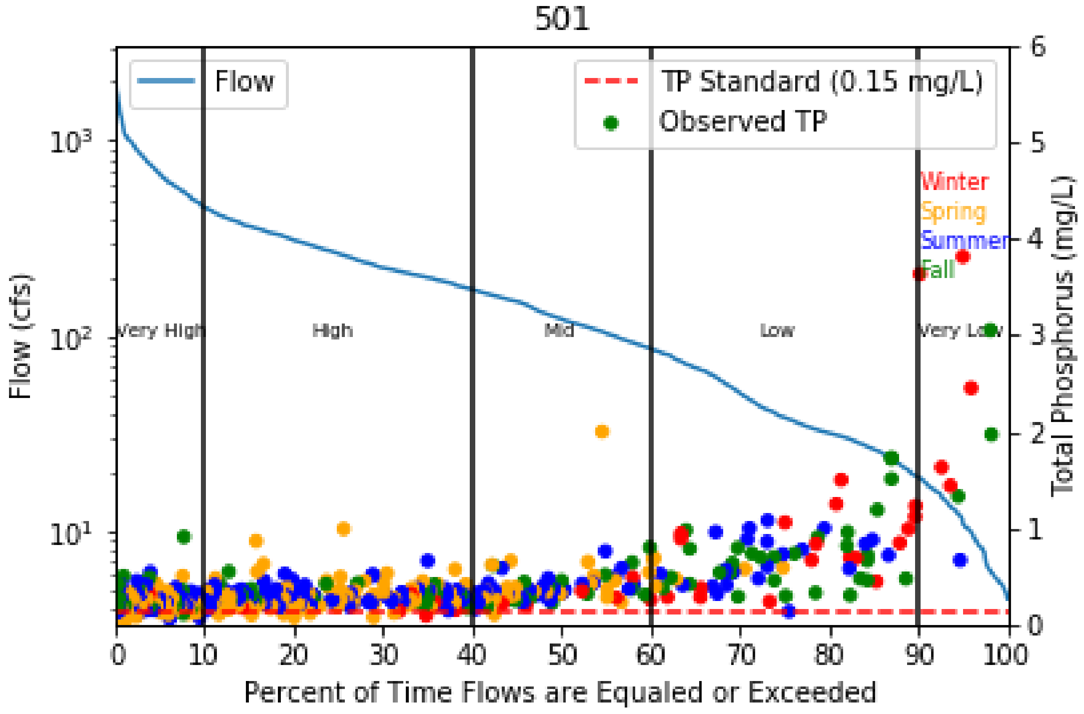
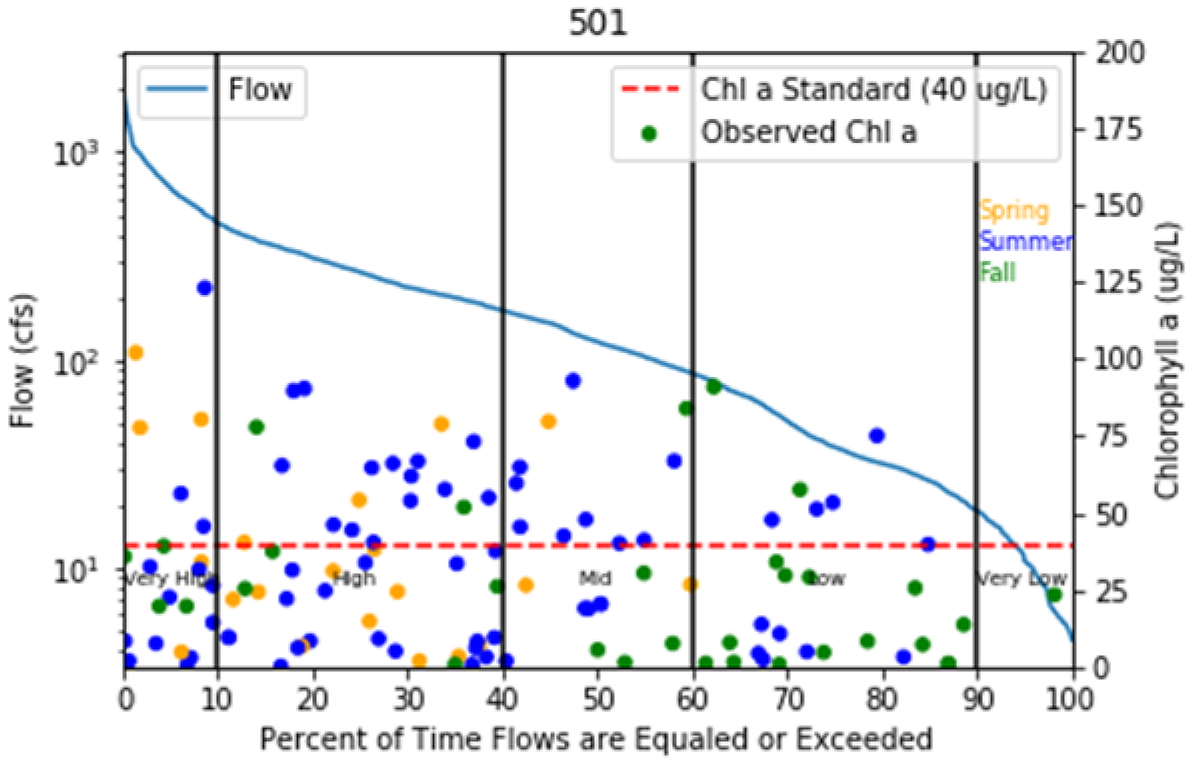


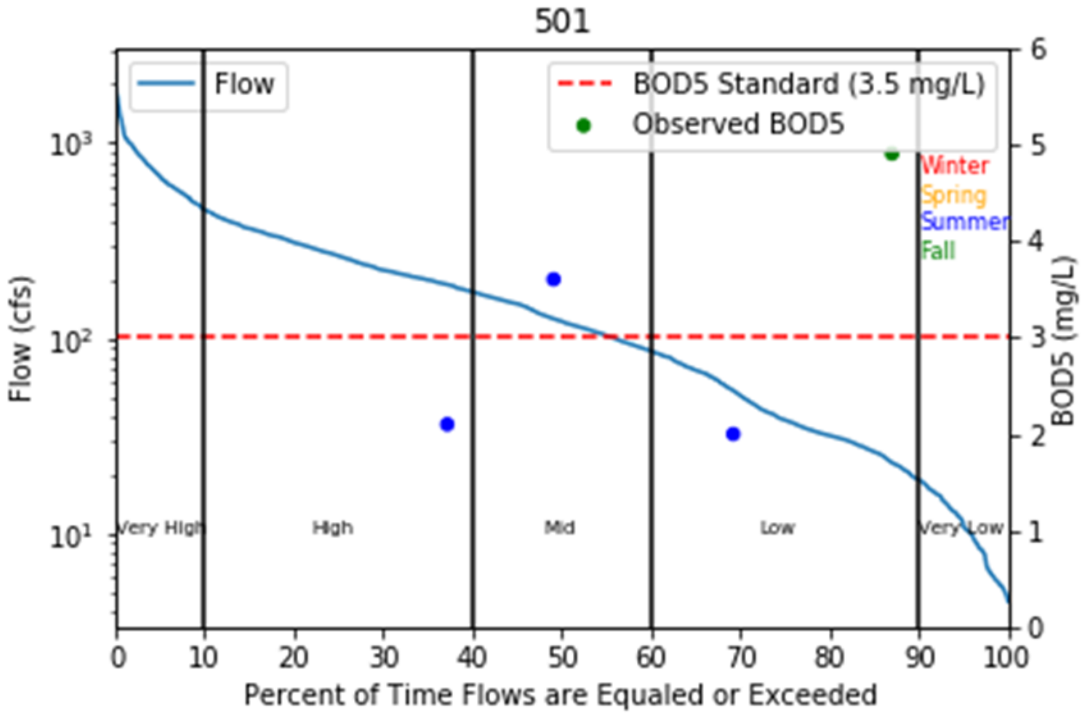
Figure 26. Shell Rock River Reach 501 chlorophyll-a concentrations (2009-2018) monitored at S000-084 and plotted on a flow duration curve.



The chl-*a* data shown in Figure 26 does not contain as many observed data points in the very low flow zone (unlike the TP data points in Figure 25). However, it is very likely that if chl-*a* data was available in the very low flow zone, in the spring and summer, it would likely exceed the standard. Photo documentation for the Shell Rock River during times of low flow (2012) supports for this hypothesis.

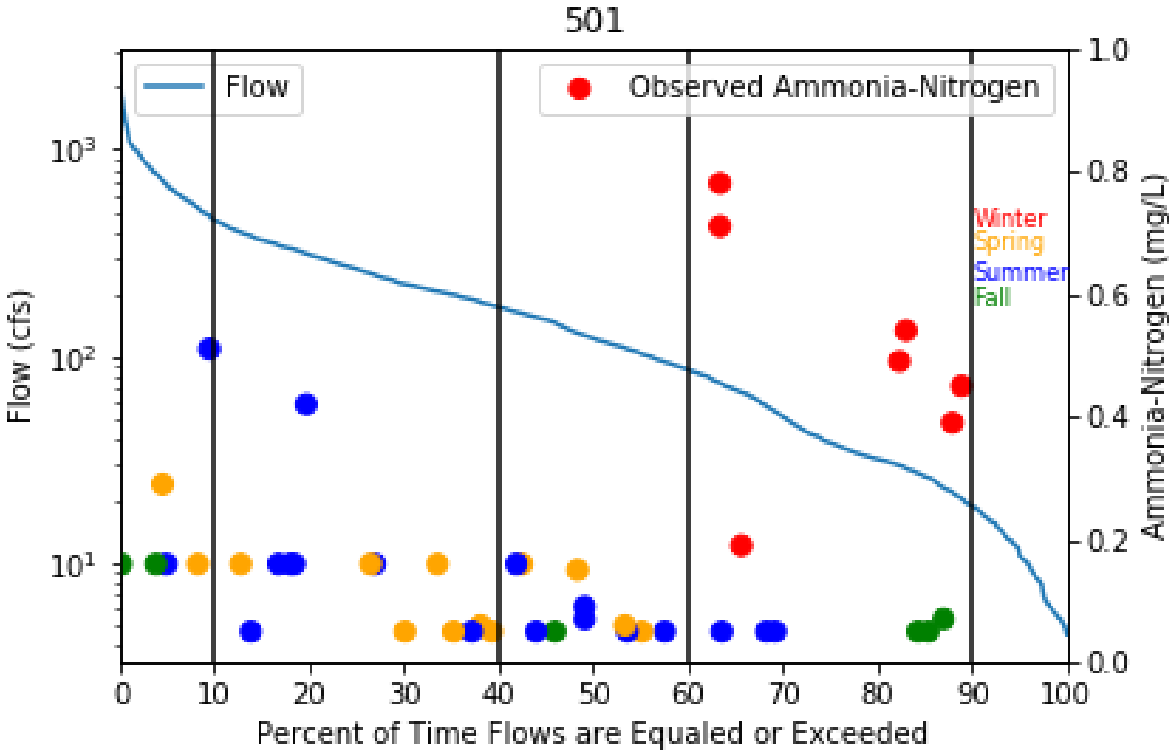
Figure 27. Monitoring station S000-084 taken by MPCA staff July 2012.

Figure 28. Shell Rock River (Reach 501) BOD5 concentrations monitored at S000-084 plotted on a flow duration curve.



The flow duration curve with ammonia data (Figure 29) indicated that ammonia concentrations are higher during low and very low flows.

Figure 29. Shell Rock River (Reach 501) ammonia concentrations monitored at S000-084 plotted on a flow duration curve.



Continued discussion of DO is found in the pollutant source summary section 3.7.4, including the impacts of point and nonpoint sources.

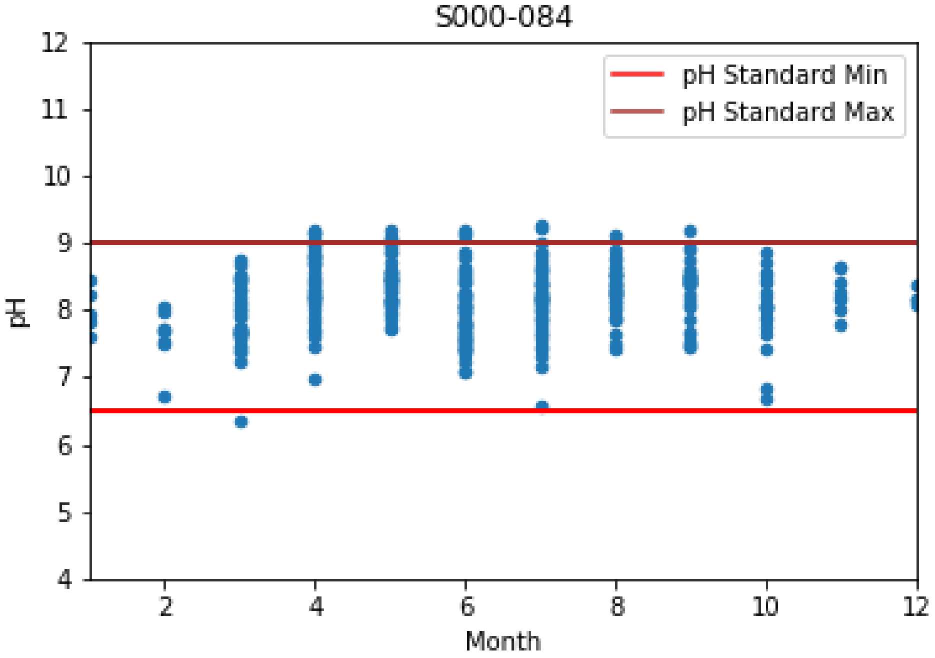
3.5.2.5 pH

Available pH monitoring data were summarized at the monitoring point that was nearest to the outlet (S000-084) of Shell Rock River Reach 501 during the TMDL time period (2009 through 2018), and are tabulated in Table 20. Figure 30 depicts pH variability by month at the impaired reaches.

Table 20. Observed pH data summary (S000-084) from 2009 to 2018.

Impaired Reach	Description	Year	Number of Samples	Minimum (mg/L)	Median (mg/L)	Maximum (mg/L)
501, S000-084	Shell Rock River, Albert Lea Lake to Goose Creek	2009	45	6.74	8.30	9.15
		2010	47	7.09	7.58	9.05
		2011	44	7.55	8.18	8.73
		2012	23	8.23	8.87	9.27
		2013	21	7.58	8.43	9.06
		2014	38	7.37	8.20	9.19
		2015	39	6.68	8.27	9.18
		2016	30	6.35	8.05	8.57
		2017	27	6.83	8.12	8.6
		2018	24	7.47	8.14	9.2

Figure 30. pH by month in Reach 501 (S000-084) from 2009 through 2018.



3.5.2.6 Aquatic Macroinvertebrate and Fish Bioassessments

The *Shell Rock River Watershed Biotic Stressor Identification Report* [MPCA 2014] states that the primary stressors in Shell Rock River Reach 501, include chl-*a*, DO, habitat, nitrate, pH, phosphorus, and TSS. Other possible stressors include chloride, ionic strength, low flow, temperature, and total VSS. Five of the seven primary stressors (excluding nitrate and habitat for Reach 501) have been addressed and are summarized in previous sections of this TMDL. No standard currently exists for nitrate, so it will be discussed with habitat in the WRAPS report.

3.5.2.7 Nutrients (total phosphorus) in lakes

Lake-by-lake summaries that include available data for water quality, bathymetry, lake-level fluctuations, DO and temperature profiles (changes by depth), select watershed characteristics, fisheries, and aquatic plant survey information are located in the Appendices. Table 21 summarizes the 10-year TMDL-period (2009 through 2018) growing-season mean TP, chl-*a*, and SDT by impaired lake, with the coefficient of variation (CV) for each parameter. The number and temporal coverage of lake samples that were used to develop the TMDLs are listed in the appendices. As part of a 2009 SRRWD lake internal phosphorus load investigation, phosphorus sediment cores were collected in a few lakes throughout the Shell Rock River Watershed. Because of the difficulty in quantifying the transfer of phosphorus from sediment to water column, these data were not used in this TMDL. Core data from the sediment into a waterbody during anoxic conditions (which are rare in the shallow lakes addressed in this TMDL) and from wind mixing and mixing by bottom-feeding fish, these data were not used or summarized in this TMDL. Since the Shallow lakes addressed in these TMDLs are typically always oxygenated (wind mixing and bottom-stirring fish) the TP in the bed sediments are rarely available to the water column. The TP content of the sediment cores were not directly incorporated in the TP budget for these lakes.

Table 21. Observed lake water quality (eutrophication parameters, total phosphorus, and chlorophyll-a from 0.5 m depth or less) growing season averages for the TMDL time period from 2009 to 2018.

Lake Name	Lake AUID	Classification	10-Year Growing Season Observed Averages and CV Means					
			Total Phosphorus (ug/L)	CV	Chlorophyll-a (ug/)	CV	Secchi Disk Transparency (m)	CV
Albert Lea (Central)	24-0014-00	WCBP Shallow	190.3	0.05	71.1	0.15	0.77	0.08
Albert Lea (East)	24-0014-00	WCBP Shallow	252.5	0.07	74.6	0.10	0.49	0.08
Albert Lea (West)	24-0014-00	WCBP Shallow	225.1	0.07	88.3	0.15	0.68	0.08
Fountain (East Bay)	24-0018-01	WCBP Shallow	257.4	0.08	65.9	0.08	0.71	0.04
Fountain (West Bay)	24-0018-02	WCBP Shallow	271.4	0.10	39.6	0.10	0.73	0.06
Pickeral	24-0025-00	WCBP Shallow	147.7	0.10	34.6	0.19	1.02	0.05
White	24-0024-00	WCBP Shallow	178.8	0.08	71.5	0.13	0.56	0.06

WCBP Shallow Lake WQS: TP ≤ 90 ug/L, chl-a: ≤ 30 ug/L, SDT: ≥ 0.7 m.

3.6 HSPF model methodology

HSPF is a comprehensive watershed hydrology and water quality model that includes modeling surface and subsurface hydrologic and water quality processes, which are linked to and closely integrated with corresponding stream and reservoir processes. This framework can be used to determine critical environmental conditions (e.g., certain flows or seasons) for the impaired segments by providing modeled continuous flows and pollutant loads at any point within the system. HSPF simulates the fate and transport of modeled pollutants as well as surface and subsurface concentrations. HSPF was used in this project to assess sources and determine the loading capacities for each pollutant TMDL. The following sections provide more details on the source-assessment approach and the quantitative results of the source load assessment.

An HSPF model application is developed via the following steps:

- Gathering and developing time-series data
- Characterizing and segmenting the watershed
- Calibrating and validating the HSPF model.

Each of the preceding components is described in the following sections.

3.6.1 Gathering and developing time-series data

The data requirements for developing and calibrating an HSPF model application are spatially and temporally extensive. For this HSPF model application, the modeling period was from 1995 to 2018. Time-series data that were used to develop the model application included meteorological, atmospheric deposition, and point-source data. Precipitation, potential evapotranspiration, air temperature, wind speed, solar radiation, dew-point temperature, and cloud cover data are needed for HSPF to simulate hydrology (which includes snow-related processes).

3.6.2 Characterizing and segmenting the watershed

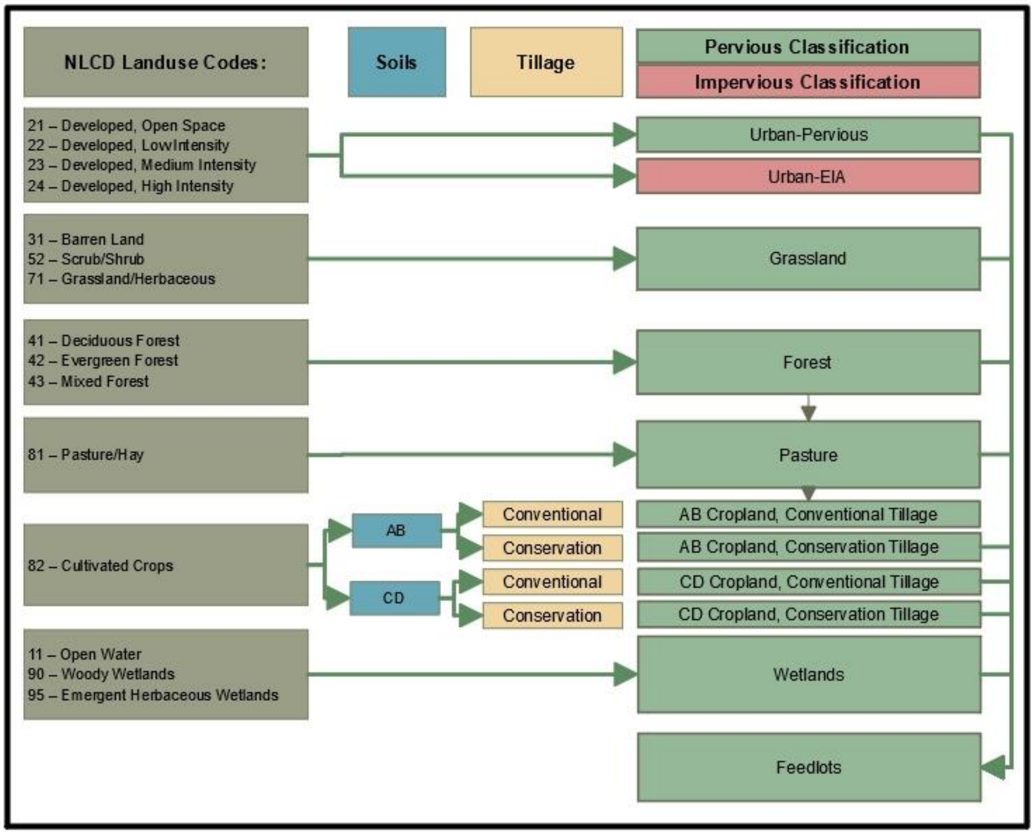
The Shell Rock River Watershed was divided into 59 subwatersheds to better capture hydrologic and water quality variability. The watershed was then subdivided into individual land and channel segments that are assumed to demonstrate relatively homogeneous hydrologic, hydraulic, and water quality characteristics. This segmentation provides the basis for assigning inputs, parameter values, or functions to the remaining portions of a land area or channel length that is contained in a model segment. The individual land and channel segments are linked together to represent the entire project area.

The land segmentation for the HSPF model application was defined by land cover. Land use and land cover affect the hydrologic and water quality response of a watershed through their impact on infiltration, surface runoff, and water loss from evapotranspiration. Water that moves through the system is affected by land cover. Land use (which is estimated by using land cover) affects the pollutant accumulation rate because certain land uses support different pollutant sources.

The NLCD 2011 land cover categories, which are summarized in Figure 31, were combined into six groups with similar characteristics. The urban categories were divided into pervious and impervious areas that were based on an estimated percentage of effective impervious area. The term “effective” implies that the impervious region is directly connected to a local hydraulic conveyance system (e.g., open channel and river) and the resultant overland flow will not run onto pervious areas but will directly enter the reach network.

The channel segmentation considers river travel time, riverbed slope continuity, temporal and spatial cross section, morphologic changes or obstructions, the confluence of tributaries, impaired reaches, and locations of flow and water quality calibration and verification gages. After the reach network was segmented, hydraulic characteristics of each reach were computed and areas of land cover categories that drained into each reach were calculated. Reach hydraulics are specified by a reach function table (F-table), which is an expanded rating curve that contains the reach surface area, volume, and discharge as functions of depth. Channel cross-sectional data were used to develop an F-table for each reach segment. Unsurveyed tributaries were assigned the geometry of hydraulically-similar channels.

Figure 31. Land cover category aggregation.



A notable feature in this TMDL is the use of boundary conditions. When a boundary condition is included in a TMDL, the load at the boundary condition location is subtracted from the total LA that at the impairment pourpoint (outlet of the TMDL reach) to obtain the local area load. In other words, to determine the local LA, the boundary condition should be subtracted from the total loading capacity. TMDL-specific boundary conditions are discussed in the TMDL development section 4. The boundary conditions utilized in this TMDL represent an upstream lake meeting the TP water quality standard of 90 µg/L. Using an upstream boundary condition allows for an estimated level of implementation to be specific to the downstream surface waters. For example, the boundary condition of Albert Lea Lake allows the Shell Rock River TMDL to focus reductions on point and nonpoint sources that contribute directly to the Shell Rock River.

3.6.3 Calibrating and validating the HSPF model

Model calibration involved hydrologic and water quality calibration that used observed flow and water quality data to compare to simulated results. Because water quality simulations are highly dependent on watershed hydrology, the hydrology calibration was completed first and was followed by the sediment, temperature, and finally the nutrient/oxygen/chl-*a* calibrations. The stream-discharge sites with time-series data were used for calibration and validation. Data from all but the first year of the simulation period were used to calibrate the model. The initial year (1995) was simulated so that the model would adjust to existing conditions. The 23-year calibration period included a range of dry and wet years. This range of precipitation improved the model calibration and validation and provides a model application that can simulate hydrology and water quality for a variety of climatic conditions.

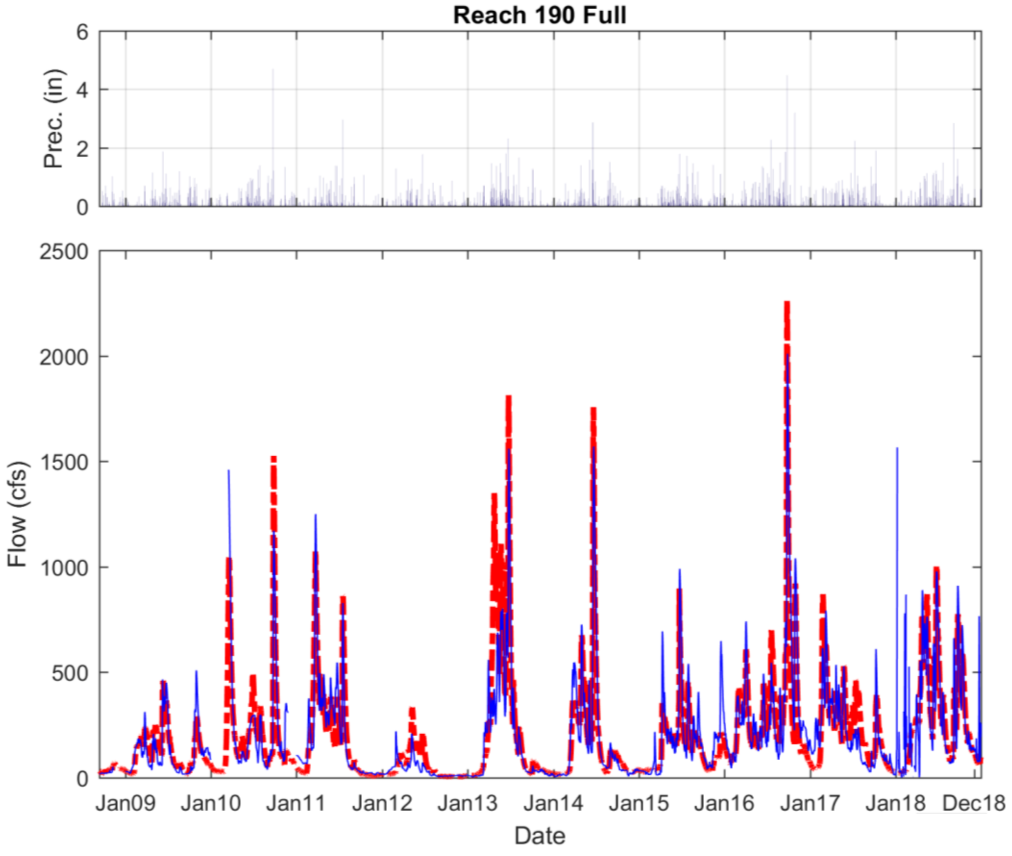
Hydrologic calibration is an iterative process that is intended to match simulated flow to observed flow by methodically adjusting model parameters. HSPF hydrologic calibration is divided into the following four sequential phases for adjusting parameters to improve model performance:

- Annual runoff
- Seasonal or monthly runoff
- Low- and high-flow distribution
- Individual storm hydrographs.

Iteratively adjusting the calibration parameters within accepted ranges improves simulation results to achieve an acceptable comparison of simulated results and measured data. The procedures and parameter adjustments that are involved in the preceding phases are more comprehensively described in Donigian et al. [1984] and Lumb et al. [1994].

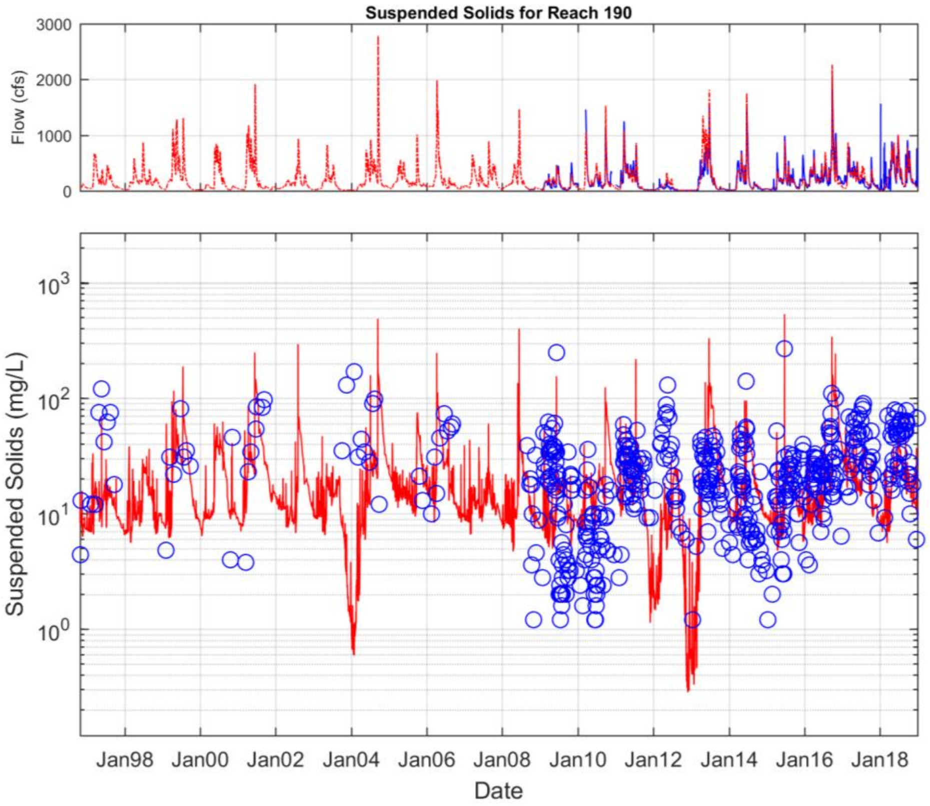
A weight-of-evidence approach was used to evaluate the hydrology calibration. Based on a variety of graphical comparisons and statistical tests. The performance criteria are described in more detail in Donigian [2002]. Graphical comparisons included monthly and average flow volume and daily time-series data comparisons, as well as flow duration plots. Statistical tests included annual and monthly runoff, low-flow and high-flow distribution, storm volume, and peak flow errors. The flow calibration time series from the Shell Rock River near Gordonsville (Site H49009001, Reach 190) is shown in Figure 32.

Figure 32. Flow calibration time series at the Shell Rock River near Gordonsville (H49009001/USGS 05458970). Blue lines indicate measured/observed data; red lines indicate HSPF simulated flows. Precipitation data from Lupo 2019.



The water quality calibration optimized the alignment between the loads that are predicted to be transported throughout the system and observed in-stream concentrations. Water quality data from monitoring sites were used to calibrate the model to observed conditions. Many parameters can be adjusted to calibrate water quality loads and concentrations. The TSS concentration calibration time series from the most downstream model reach of the Shell Rock River (Reach 190) is shown in Figure 33. More detailed information on the HSPF model application and model calibration results (hydrology and water quality) can be found in the Shell Rock model extension memoranda [Lupo 2019].

Figure 33. Total TSS concentration time series on Shell Rock River model Reach 190. Blue color indicates measured data; red indicates continuous simulated outputs from HSPF.



3.7 Pollutant source summary

Pollutant sources are summarized for *E. coli*, TSS, nutrient, DO, pH, aquatic macroinvertebrate, fish, and nutrient impairments in the following sections. *E. coli* production rates for each impaired stream drainage area were estimated by source with a GIS approach. Sources of TSS, nutrients, and DO were estimated with the HSPF model application.

3.7.1 *E. coli*

Sources of bacteria-to-stream impairments can include livestock, wildlife, human, and pet sources. Bacteria from human and animal waste are dispersed throughout the landscape, spread by humans, and/or treated in facilities. Once the bacteria are in the environment, their accumulation on the land and delivery to the stream are affected by die-off and decay, surface imperviousness, detention time, ultraviolet exposure, and other mechanisms.

3.7.1.1 Permitted

Detailed information on specific permitted *E. coli* sources is included in Section 4.2.2 of this TMDL. Clarks Grove Wastewater Treatment Facility (WWTF) drains into the *E. coli*-impaired Bancroft Creek (County Ditch 63) Reach 507, and no discharging point sources contribute to Unnamed Creek (Wedge Creek) Reach 531. Effluent from WWTFs is monitored and regulated but contributes an allowable amount of *E. coli* to the stream. Land application of biosolids from WWTFs was not included as an additional source of bacteria. Information about land application of biosolids is available in Minn. R. ch. 7041 (*Sewage Sludge Management*). A point-source map is included in Appendix E.

Of the approximately 61 animal feeding operations (AFOs) in the Shell Rock River Watershed, three are permitted concentrated animal feeding operations (CAFOs). All three CAFOS are in the subwatershed that drains to the *E. coli*-impaired Unnamed Creek (Wedge Creek) Reach 531. 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 animal unit (AU). In Minnesota, the following types of livestock facilities are required to operate under a National Pollutant Discharge Elimination System (NPDES) Permit or a state issued State Disposal System (SDS) Permit: a) all federally defined CAFOs that have had a discharge, some of which are under 1000 AUs in size; and b) all CAFOs and nonCAFOs that have 1000 or more AUs.

CAFOs and AFOs with 1,000 or more AUs must be designed to contain all manure and manure contaminated runoff from precipitation events of less than a 25-year – 24-hour storm event. Having and complying with an NPDES permit allows some enforcement protection if a facility discharges due to a 25-year 24-hour precipitation event (approximately 5.75” in 24 hours) 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, which complies with Minn. R. 7020.2225 and the respective permit is required for all CAFOs and AFOs with 1,000 or more AUs. A map of animal feedlots and CAFO is included in Appendix E. CAFOs are inspected by the MPCA in accordance with the MPCA NPDES Compliance Monitoring Strategy approved by the EPA. All CAFOs (NPDES permitted, SDS permitted and not required to be permitted) are inspected by the MPCA on a routine basis with an appropriate mix of field inspections, offsite monitoring and compliance assistance. For the Shell Rock River Watershed TMDL, all NPDES and SDS permitted feedlots are designed to have zero discharge.

The Albert Lea City Multiple Municipal Separate Storm Sewer System (MS4) is located within the Shell Rock River Watershed. It overlaps the watershed of the *E. coli* impaired Bancroft Creek (County Ditch 63) Reach 507. Municipal stormwater permits are required for specified Phase II cities that are defined as MS4s by permit (General Permit Authorization to Discharge Stormwater Associated with small MS4s under the NPDES/SDS Permit [MNR040000]). The MPCA defines MS4s as conveyance systems (roads with drainage systems, municipal streets, catch basin, curb gutters, ditches, man-made channels, and storm drains) that are owned or operated by a public entity, such as a city, town, county, district, state, or other public body that has jurisdiction. Sources of human bacteria in MS4s can include cross connections between sanitary sewers and storm drain systems, leaks or overflows from sanitary sewer systems, and wet-weather discharges from centralized wastewater collection and treatment facilities in MS4 areas. Wildlife and pet waste are other potential MS4 bacterial sources. Pet waste that is not properly disposed of along a stream or near/within a stormwater conveyance system can be washed off during precipitation events [EPA 2001]. Bacteria can also survive and grow within storm sewer systems and receiving waters and catch basins can be a source of bacteria because of internal growth [MPCA 2019a].

E. coli is not a likely pollutant stemming from construction stormwater. Also, benchmark monitoring of bacteria or *E. coli* is not required with industrial permits and *E. coli* is not typically contributed from industrial stormwater.

3.7.1.2 Nonpermitted

Livestock manure is a potential nonpermitted source of bacteria to streams. Livestock contribute bacteria loads directly by defecating in streams and indirectly by defecating on cropland or pastures where bacteria can wash off during precipitation events, snowmelt, or irrigation. Spreading livestock manure on cropland or pasture also contributes *E. coli* to waterbodies. The livestock in the project area mainly include cattle, poultry, hogs, horses, sheep, and goats. Livestock are grazed and/or confined in the areas that drain into *E. coli*-impaired waterbodies. Approximately 11 active animal feedlots are within the watershed of the *E. coli*-impaired Bancroft Creek (County Ditch 63) Reach 507. Of these feedlots, 45% have open lots, 55% use pastures, and 55% have some type of manure storage. Approximately 16 active animal feedlots (which do not include CAFOs) are located within the watershed of the *E. coli*-impaired Unnamed Creek (Wedge Creek) Reach 531. Of these feedlots, 81% have open lots, 56% use pastures, and 63% have some type of manure storage. No feedlot facilities in these *E. coli*-impaired subwatersheds are located in shoreland. In Reach 531, 77% is from hogs, 22% from cattle, and 1% from sheep. Hogs and poultry are typically kept in a sheltered facility with their manure collected liquid manure storage area and spread and/or incorporated on or into agricultural land later. Grazed animals can also be kept in sheltered areas but are more likely to be pastured or have access to waterbodies than hogs and poultry. Bacteria that has been incorporated or spread into or on agricultural fields can contribute *E. coli* to waterways, but incorporation decreases the likelihood of transport.

Wildlife (e.g., waterfowl and large-game species) also contribute bacteria loads directly by defecating while wading or swimming in the stream and indirectly by defecating on lands that produce stormwater runoff during precipitation events. According to the CWLA, the term natural background refers to characteristics of the waterbody caused by the multiplicity of factors in nature (e.g., climate and ecosystem dynamics), that affect the physical, chemical, or biological conditions in a waterbody, and does not include measurable pollution that is attributable to human activity or influence. Bacteria loads that are contributed by wildlife are generally considered to be natural background. Some BMPs that reduce loads from livestock and other sources can also reduce loads from wildlife.

Human bacteria sources in nonMS4 permitted urban settings include cross connections between sanitary sewers and storm drain systems, leaks or overflows from sanitary sewer systems, and wet-weather discharges from centralized wastewater collection and treatment facilities. Outside of city domestic wastewater-coverage areas, septic systems can be a potential human source of bacteria loads. Septic systems that discharge untreated sewage to the land surface are considered an imminent threat to public health or safety (ITPHS) in Minn. R. ch. 7080. The 2018 SSTS Annual Report from Freeborn County estimated that 26% of septic systems were failing to protect groundwater (FTPGW) and 14% were an ITPHS in Freeborn County [MPCA 2018b]. Pet waste is another potential source of bacteria from nonregulated communities in a watershed.

Research in the last 15 years has found the persistence of *E. coli* in soil, beach sand, sediments, and algal mats 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. An MPCA study of cold-water streams in southeastern Minnesota discovered the resuspension of *E. coli* in the stream-water column due to stream sediment disturbance [MPCA 2019a]. 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. Fecal coliform survival and growth have been documented in storm sewer sediment in Michigan [Marino and Gannon 1991].

Sources of *E. coli* evaluated in this study include livestock, human, wildlife, and pet populations. *E. coli* is unlike other pollutants in that it is a living organism and can multiply and persist in soil and water environments (Ishii et al. 2006, Chandrasekaran et al. 2015, Sadowsky et al. n.d., and Burns & McDonnell 2017). Use of watershed models for estimating relative contributions of *E. coli* sources delivered to streams is difficult and generally has high uncertainty. Thus, a weight of evidence approach was used to determine the likely primary sources of *E. coli*, with a focus on the sources that can be effectively reduced with management practices. Additional information on bacteria can be found on the MPCA Bacteria webpage: https://www.pca.state.mn.us/water/bacteria.

3.7.1.3 Source Assessment

A Geographic Information System (GIS)-based assessment was completed within each impaired drainage area to estimate livestock, wildlife, human, and pet populations. Animal populations were multiplied by average excretion rates that were obtained from scientific literature. The reported literature values for fecal coliform excretion were converted to *E. coli* excretion by using a fecal coliform to *E. coli* ratio of 200:126 org/100 mL. Annual excretion estimates for livestock (excluding hogs) and wildlife were obtained from the *Bacteria Source Load Calculator: A Tool for Bacteria Source Characterization for Watershed Management* [Zeckoski et al. 2005], and bacterial estimates for humans and hogs were obtained from *Wastewater Engineering: Treatment, Disposal, Reuse* [Metcalf and Eddy 1991]. Annual excretion rates for dogs and cats were from *Identification and Evaluation of Nutrient and Bacterial Loadings to Maquoit Bay, New Brunswick and Freeport, Maine* [Horsley and Witten, Inc. 1996]. Literature values for bacteria excretion rates are estimates and do not represent all sources and dynamics of bacteria in a natural system. The state of Minnesota is working to expand upon knowledge of both readily evident sources of bacteria (such as unsewered communities and problem feedlots) as well as complex unknown sources (such as growth in soils and sewer systems).

The domestic wastewater sewers within each *E. coli*-impaired drainage area were estimated by summing the 2010 population for all of the 2010 Census Block Centroid Population points that fall within urban areas that have a WWTF. Points that were located within the urban areas were assumed to be connected to the WWTFs in applicable impairment drainage areas.

The number of people that use septic systems was estimated by summing the 2010 population for all of the 2010 Census Block Centroid Population points that fall outside of urban areas that have a WWTF.

Pet populations were estimated by calculating the number of households from the 2010 Census Block Centroid Population points within each applicable impairment drainage area and assuming 0.58 dogs (36.5% of households × 1.6 dogs per household) and 0.64 cats (30.4% of households × 2.1 cats per household) per household [American Veterinary Medical Association 2016].

The most recent MPCA feedlot data layer (which was downloaded on March 20, 2019) at the time of the analysis with animal counts and AUs was obtained from the Minnesota Geospatial Commons. The layer was spatially joined to the impaired-reach drainage area of the impaired reaches, and the total number of birds, bovines, goats, sheep, horses, and pigs from active feedlots was calculated.

The deer population was estimated by using deer densities in deer-permit area boundaries, which were downloaded from the Minnesota Geospatial Commons (https://gisdata.mn.gov/group/boundaries), and densities were provided by the DNR [Norton 2018]. Duck and geese numbers were obtained from the DNR and U.S. Fish and Wildlife Service *2018 Waterfowl Breeding Population Survey* (which was downloaded from the DNR [2018]) with estimated subwatershed waterbody densities. Coot and swan numbers were also estimated; coots were included in the duck population while swans were included in the geese population. Small mammals, such as beaver, muskrat, and mink, as well as other birds, such as swallows, are difficult to estimate but also contribute to wildlife bacteria.

Table 22 shows the literature amounts of bacteria produced by each animal per day with sources. Table 23 shows the number of animals, the estimated bacteria produced, and the percent of the total bacteria from each animal within each impaired-reach drainage area. These estimates provide watershed managers with the relative magnitudes of total production by source and do not account for wash-off, availability, delivery, instream growth, or die-off dynamics that occur with bacteria. Many factors affect whether bacteria reach a stream.

Table 22. Bacteria production rates per head per day from literature sources.

Category	Subcategory	Bacteria Production Rate (colony-forming units per day per head [cfu/day/head])	Source of Bacteria Production Rate
Humans	Wastewater Treatment Plant	1.3E+09	[Metcalf and Eddy 1991]
	Subsurface Sewage Treatment Systems	1.3E+09	
Pets	Cats	3.2E+09	[Horsley and Witten, Inc. 1996]
	Dogs	3.2E+09	
Livestock	Cattle	2.1E+10	[Zeckoski et al. 2005]
	Horses	2.6E+10	
	Poultry	5.9E+07	
	Sheep	7.6E+09	
	Goats	1.8E+10	
	Hogs	5.6E+09	[Metcalf and Eddy 1991]
Wildlife	Deer	2.2E+08	[Zeckoski et al. 2005]
	Ducks	1.5E+09	
	Geese	5.0E+08	

Table 23. Estimated number of animals, bacteria produced, and percent of total bacteria produced by source impaired reach.

Category	Subcategory	Bancroft Creek Reach 507			Wedge Creek Reach 531		
		Count	Total Bacteria Produced (cfu/day)	Total Bacteria Produced (%)	Count	Total Bacteria Produced (cfu/day)	Total Bacteria Produced (%)
Total Humans	Wastewater Treatment Plant	454	5.70E+11	2	53	6.70E+10	<1
	Subsurface Sewage Treatment Systems	581	7.30E+11	3	388	4.90E+11	<1
Total Pets	Cats	259	8.20E+11	3	116	3.70E+11	<1
	Dogs	237	7.50E+11	3	106	3.30E+11	<1
Total Livestock	Cattle	62	1.30E+12	5	1,962	4.10E+13	22
	Horses	5	1.30E+11	<1	11	2.90E+11	<1
	Poultry	51,950	3.00E+12	11	0	0.00E+00	<1
	Sheep	1,125	8.50E+12	31	140	1.10E+12	<1
	Goats	0	0.00E+00	<1	16	2.80E+11	<1
	Hogs	1,950	1.10E+13	40	25,545	1.40E+14	76
Total Wildlife	Deer	171	3.80E+10	<1	170	3.70E+10	<1
	Ducks	251	3.80E+11	1	257	3.90E+11	0
	Geese	74	3.70E+10	0	111	5.60E+10	0

3.7.2 Total suspended solids

Contributors of TSS to stream impairments include overland flow from large storm events, instream bed/bank scour, and point sources. Upstream nutrient-impaired lakes with high algae/phytoplankton growth can also contribute TSS to streams.

3.7.2.1 Permitted

Section 4.3.2 of this TMDL includes detailed information about specific permitted TSS sources. Two permitted wastewater and one industrial stormwater (POET Biorefining) point sources discharge into turbidity-impaired Shell Rock River Reach 501 below Albert Lea Lake. No point sources discharge into turbidity-impaired Unnamed Creek (Shoff Creek) Reach 516. HSPF analysis was completed to evaluate TSS contributions from point sources upstream of Albert Lea Lake to the Shell Rock River, and all of the contributions were found to have a negligible impact on Reach 501. Effluent from WWTFs is monitored and regulated but contributes an allowable amount of TSS to streams. A map of point sources in the Shell Rock River Watershed is included in Appendix E.

All three of the active CAFOs in the Shell Rock River Watershed are located in the drainage area above the Albert Lea Lake boundary condition for the Shell Rock River Reach 501. Because the boundary condition creates a maximum concentration, any potential influence of the CAFOs on Albert Lea Lake's TSS would be muted. No active CAFOs are in the Unnamed Creek (Shoff Creek) Reach 516 drainage area. CAFOs are generally not permitted to discharge to surface water except in the event of chronic or catastrophic precipitation. Appendix E includes a map of the AFOs and CAFOs.

The Albert Lea City MS4 (MS400263) is located within the Shell Rock River Watershed and overlaps the watersheds of turbidity-impaired Unnamed Creek (Shoff Creek) Reach 516 and Shell Rock River Reach 501. MS4s contribute to TSS through erosion and washoff, while increased runoff from impervious areas can increase flow and therefore bed and bank erosion TSS sources. Industrial and construction stormwater contribute to TSS in watersheds through erosion and washoff during rainfall events. In Shoff Creek drainage area below the Pickeral Lake boundary condition, there are approximately 251 acres of MS4 area of 1,234 total acres. In the Shell Rock River drainage area below the Albert Lea Lake boundary condition, there are approximately 209 acres of MS4 area of 28,644 total acres.

Industrial stormwater is regulated through an NPDES permit when stormwater discharges have the potential to come into contact with materials and activities associated with industrial activities. A search of the MPCA's Industrial Stormwater Database on July 11, 2019, revealed that 35 industrial facilities exist in Albert Lea with 14 facilities having no-exposure exclusions; 1 industrial facility exists in Hayward that has a no-exposure exclusion; and 2 industrial facilities exist in Glenville without no-exposure exclusions. "No-Exposure" means all the materials and activities at a facility are indoors or protected from exposure to rain, snow, snowmelt and runoff and would have a far smaller impact to nearby waterbodies.

Construction stormwater is an additional source of sediment and is regulated through an NPDES permit. Untreated stormwater that runs off a construction site often carries sediment and other pollutants to surface water bodies. An NPDES permit is needed for construction activity that disturbs one acre or more of soil, or if the activity is part of a larger development. A permit may also be ordered if the MPCA determines that the activity poses a risk to water resources. Coverage under the construction stormwater general permit requires sediment and erosion control measures that reduce stormwater pollution during and after construction activities. Local regulations may require additional permits for land disturbance activities for sites smaller than one acre.

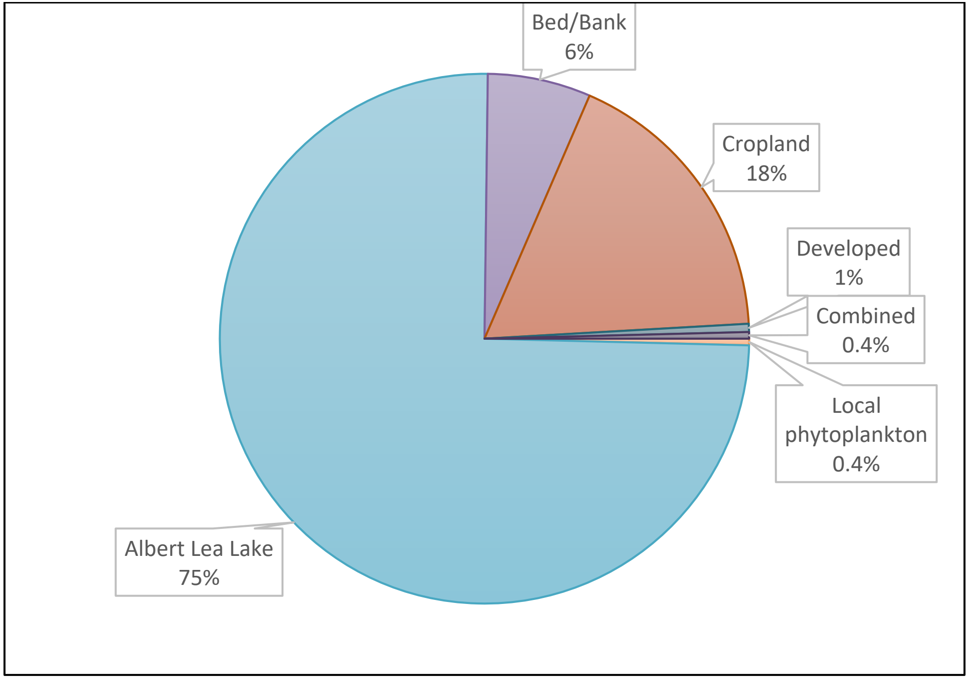
3.7.2.2 Nonpermitted

Nonpoint TSS sources generally include surface runoff washoff from impervious surfaces, bed and bank scour, erosion from cropland and other land categories, and erosion from small construction projects. Additionally, feedlots often have bare ground that is prone to contributing sediment to impaired streams during rainfall events. Upstream nutrient-impaired lakes with high algae/phytoplankton concentrations also contribute TSS. Natural background sediment occurs from natural background runoff, especially when local soils are comprised of very fine clays.

3.7.2.3 Potential sources

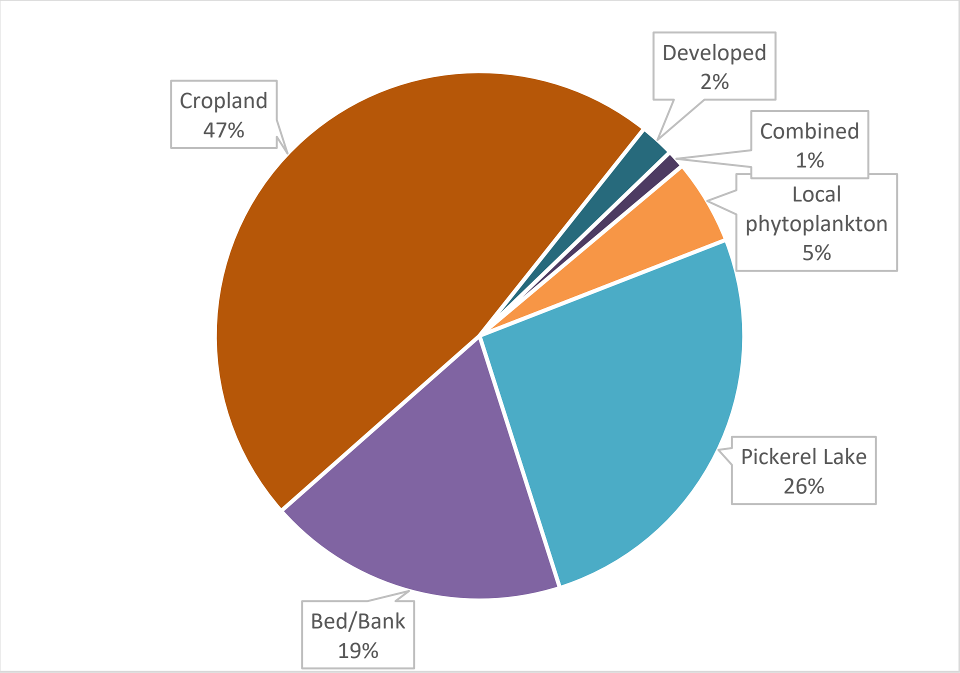
The HSPF model was used to determine the TSS contributions from identified sources to each sediment-impaired reach. Regression analyses were completed for TSS and VSS and show that at S000-084 in Shell Rock River Reach 501, 70% of TSS variance is explained by VSS, while at S004-114 in Shoff Creek Reach 516, 53% of TSS variance is explained by VSS. This is because both of the TSS-impaired streams have a nutrient-impaired lake contributing large loads of algae/phytoplankton. Consequently, HPSF source-assessment pie charts include the sum of inorganic TSS (i.e., sand/silt/clay) and phytoplankton from the upstream impaired lake (Albert Lea Lake for Reach 501 and Pickeral Lake for Reach 516), and phytoplankton from sources other than the upstream impaired lake. The source-assessment from the watersheds that are below the impaired lakes included the following categories: bed/bank, cropland, developed land (both MS4 and nonMS4), pasture, grassland, forest, wetlands, permitted point sources, and phytoplankton. Figure 34 and Figure 35 show pie charts that were produced for each TMDL endpoint to show the relative contribution of each source from the HSPF model. In Reach 501, the primary TSS source is Albert Lea Lake and the secondary TSS source is local cropland. In Reach 516, the primary TSS source is local cropland and the secondary TSS source is Pickeral Lake. Local bed/bank sediment contributed approximately 6% of TSS in Reach 501 and 18% in Reach 516. Bed/bank sediment can increase from practices that increase the "flashiness" of the system, such as straightening of channels (ditches), tile drainage, and runoff from impervious urban land.

Figure 34. TSS source-assessment modeling results in impaired Shell Rock River Reach 501.



Note: Combined % is sum of point sources, pasture, grasslands and feedlots.

Figure 35. TSS source-assessment modeling results in impaired Shoff Creek Reach 516.



3.7.3 Nutrients (total phosphorus) in streams

Natural background phosphorus sources include surface runoff and atmospheric deposition of windblown particulate matter from the natural landscape, stream-channel erosion, and groundwater discharge. The internal loading of phosphorus in upstream lakes is an additional nonpoint source that can be both anthropogenic and natural in origin, and is primarily caused by phosphorus releasing from lake sediments or aquatic plants. Human-made influences typically include state- and federal- permitted discharges from wastewater, industrial and commercial entities, urban development, impervious surfaces (roads, roofs, and driveways), stormwater from artificial drainages on urban and agricultural lands, row cropping, pastured lands, individual sanitary-treatment systems, feedlots, and channelized streams/ditches. The following section provides brief descriptions of the potential permitted and nonpermitted sources that can contribute to TP.

3.7.3.1 Permitted

Permitted sources are point sources or those that originate from a discrete, identifiable source within the watershed and are regulated by the NPDES or SDS permits. These include the following:

- Regulated municipal and industrial wastewater treatment systems.
- Feedlots that require NPDES coverage.
- Regulated stormwater.

Detailed information about specific permitted phosphorus sources is included in WLA methodology Section 4.4.4. Any industrial, municipal, or private-entity point source that discharges treated wastewater into Minnesota surface waters must have an NPDES/SDS permit that specifies the discharge location(s), volumes, and treated effluent quality. No WWTFs drain to Reach 516. Albert Lea Water Treatment Plant (WTP), Clarks Grove WWTF, Hayward WWTF, DNR Myre Big Island State Park, and Cargill Value Added Meats discharge above the Albert Lea Lake boundary condition. Albert Lea WWTF and Glenville WWTF drain directly to the nutrient impaired Shell Rock River Reach 501. Land application of biosolids from WWTFs was not included as an additional source of nutrients because of the rigorous monitoring and regulation associated with them. Information about land application of biosolids is available in Minn. R. ch. 7041 (*Sewage Sludge Management*).

All three of the permitted CAFOs are located in the drainage area above the Albert Lea Lake boundary condition for the Shell Rock River Reach 501. No CAFOs drain to Reach 516. CAFOs are not allowed to discharge to surface water from the production area, except in the event of chronic or catastrophic precipitation (greater than the 25-year 24-hour precipitation event). Manure from liquid manure storage areas or dry manure stockpiles is used as fertilizer. A current manure management plan which complies with Minn. R. 7020.2225 and the respective permit is required for all CAFOs and AFOs with 1,000 or more AUs. Appendix E includes a map of animal feedlots and CAFOs.

The Albert Lea City MS4 (MS400263) is located within the Shell Rock River Watershed. It overlaps the watershed of both the phosphorus impaired Unnamed Creek (Shoff Creek) Reach 516 and the phosphorus impaired Shell Rock River Reach 501. In Shoff Creek drainage area below the Pickeral Lake boundary condition, there are approximately 251 acres of MS4 area of 1,234 total acres. In the Shell Rock River drainage area below the Albert Lea Lake boundary condition, there are approximately 209 acres of MS4 area of 28,644 total acres. Winter thaws and rainfall events generate runoff within city areas that reaches storm sewer conveyances, and is largely influenced by the amounts and distribution of impervious areas associated with rooftops, sidewalks, driveways/parking lots, streets, and other compacted surfaces. Lawns, soils, grass clippings, road-surface particles, vehicular and organic debris, eroded soil particles, pet and wildlife waste, and atmospheric deposition are potential phosphorus-containing substances.

Construction stormwater and industrial stormwater contribute sediment, nutrients, and organics to impaired streams. A search of the MPCA's Industrial Stormwater Database on July 11, 2019, revealed that 35 industrial facilities exist in Albert Lea, with 14 facilities having no-exposure exclusions; 1 industrial facility exists in Hayward that has a no-exposure exclusion; and 2 industrial facilities exist in Glenville, without no-exposure exclusions. "No-Exposure" means all the materials and activities at a facility are indoors or protected from exposure to rain, snow, snowmelt and runoff and would have a far smaller impact to nearby waterbodies.

3.7.3.2 Nonpermitted

Phosphorus sources that are not required to have NPDES/SDS permits include direct watershed runoff, loading from upland watershed tributaries and lakes, subsurface sewage treatment systems (SSTS), and atmospheric deposition.

Direct watershed runoff occurs from precipitation and snowmelt events. Runoff from agricultural lands, urban lands, forests, and other sources contributes to phosphorus. Some phosphorus is attached to sediment and enters a stream system during runoff events. Upstream direct watershed runoff, SSTS, atmospheric deposition, scour/bank erosion, and other sources also contribute to phosphorus in streams.

SSTS loadings were estimated for HSPF by using 2013 permit data that were provided by Freeborn County. The number of residences that were served by SSTS was summed from the provided permit data per township; the total number of SSTS was determined based on the percent of each subwatershed. Loading rates that incorporated septic failure rates were developed for ammonia, nitrate, orthophosphate, carbonaceous biochemical oxygen demand ultimate (CBODU), and water on a per capita basis and applied to each modeled reach.

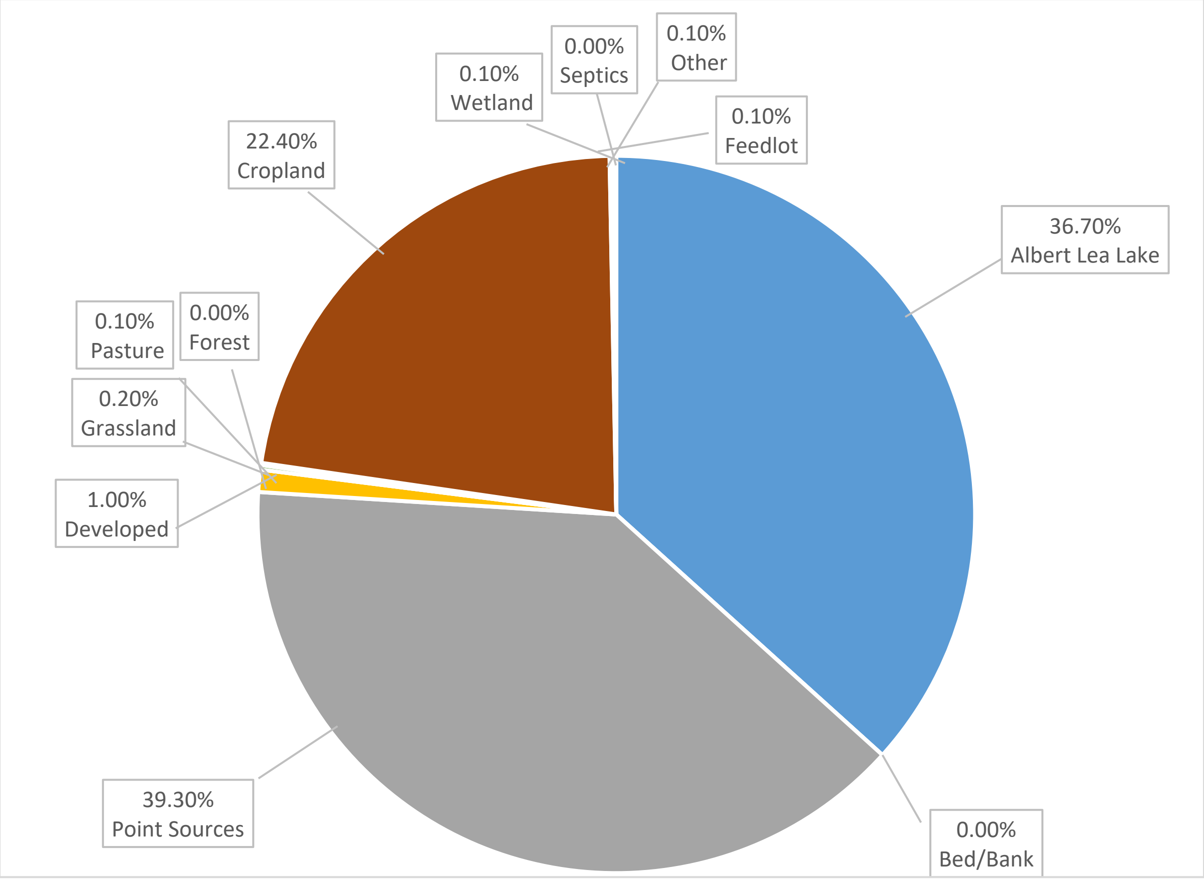
Atmospheric phosphorus deposition can be an important part of the phosphorus budget. Atmospheric deposition occurs as wet (i.e., carried by precipitation) and dry (i.e., dry particles carried as dust) deposition to waterbodies and their surrounding lands. In the HSPF model, atmospheric deposition of phosphorus to waterbodies is explicitly represented, while atmospheric deposition of phosphorus to land is captured implicitly through sediment washoff. Unlike other nonpoint sources, such as watershed runoff or septic loading, atmospheric phosphorus deposition originates at least partly outside of the watershed and cannot be controlled.

3.7.3.3 Potential sources

The HSPF model was used to determine the TP contribution from identified sources to each nutrient-impaired reach. Because nutrient TMDLs are being developed for Albert Lea Lake, which drains to Reach 501, and Pickeral Lake, which drains to Reach 516, all sources above these lakes were grouped together and assigned the lake name, and remaining local sources are separated into the following categories: developed land (both MS4 and nonMS4), cropland, pasture, grassland, forest, wetlands, feedlots (non-

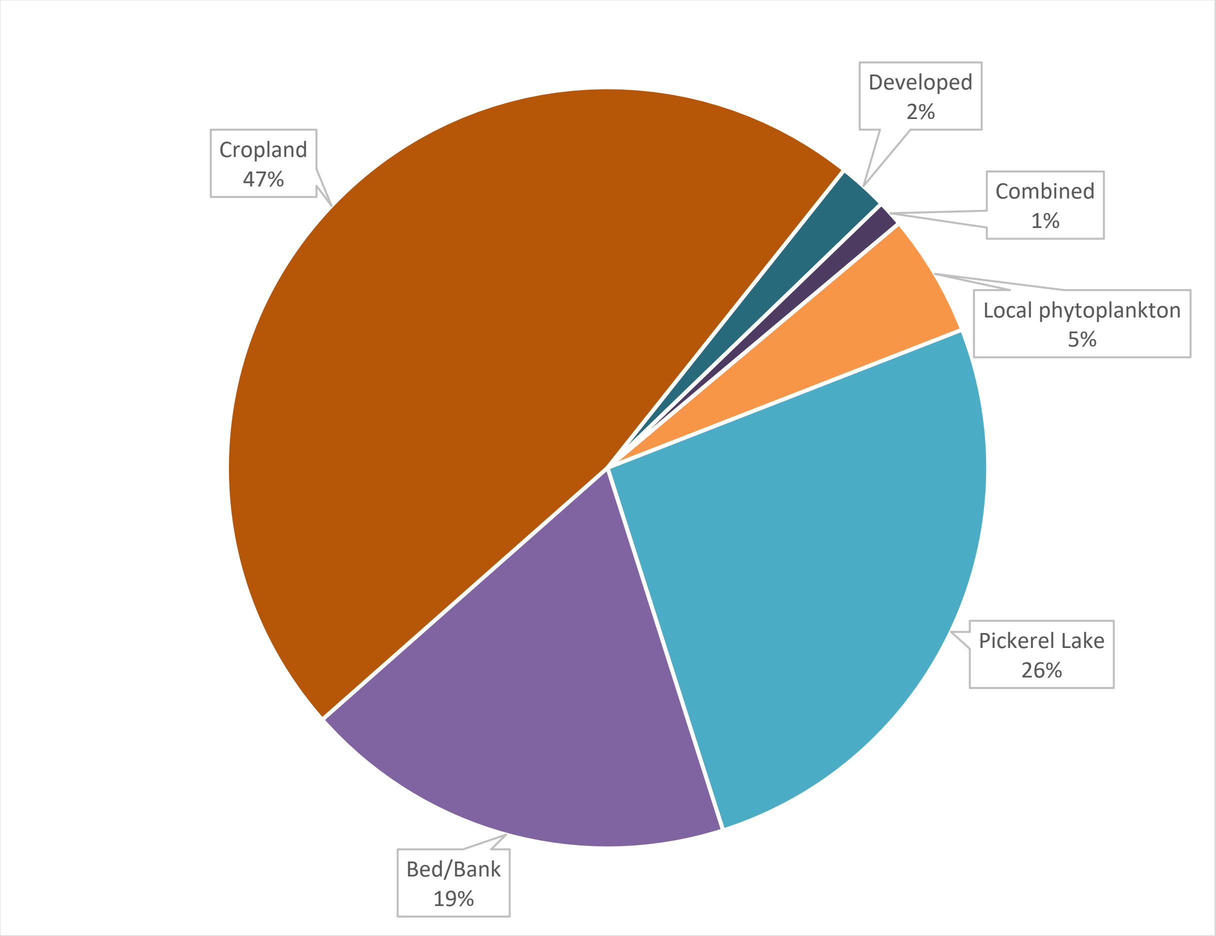
NPDES/SDS Feedlots in this instance), permitted point sources, and bed/bank. Phosphorus from animal manure that is spread on cropland is accounted for in the cropland category in the source pie charts. Figure 36 and Figure 37 illustrate pie charts that cover the growing season at each of the TMDL endpoints to show the relative contribution of each source from the HSPF model. In Reach 501, local point sources and Albert Lea Lake (which includes all upstream sources contributing to Albert Lea Lake, see section 3.7.7 for discussion on sources to Albert Lea Lake) are the primary and secondary sources of phosphorus, and local cropland is the tertiary source. In Reach 516, local cropland is the primary source of phosphorus and Pickeral Lake (which includes all upstream sources contributing to Pickeral Lake, see section 3.7.7) is the secondary source. An agricultural phosphorus balance calculator was developed and gave a detailed phosphorus balance for sources above Albert Lea Lake [Peterson et al. 2017]. The balance used was generated using discharge and phosphorus data from 2009 through 2011. Loads calculated from subwatershed sources were comparable to loads generated using the HSPF model application.

Figure 36. Total phosphorus source-assessment modeling results in impaired Shell Rock River Reach 501 for June



- September.*Estimated phosphorus contributions from the growing season time frame were used because RES standards are in effect June – Sept. See Figure 38 for estimated annual TP contributions.

Figure 37. Total phosphorus source-assessment modeling results in impaired Shoff Creek Reach 516.



3.7.4 Dissolved oxygen

The water quality target for the DO-impaired reaches is maintaining a daily minimum concentration at or above 5 mg/L. The pollutants of concern are constituents that reduce or lead to DO reduction in the listed reach. Oxygen is consumed by decomposing organic matter (e.g., proteins, human and animal waste, and dead plant matter) and oxidizing inorganic ammonia. One required element of a TMDL is the identification of the pollutants of concern. Phosphorus (or in some cases nitrogen) can be a limiting nutrient to the production of algae and aquatic macrophytes, which die, decompose, and use oxygen in the water [EPA 1995]. Phosphorus is delivered to streams via washoff from cropland, urban areas, and other land sources and directly from point sources. Phosphorus is also released during phytoplankton respiration and death. When algal death occurs, the phosphorus, nitrogen, and carbon contained in the algal biomass are returned to the stream as CBOD, organic nitrogen, and organic phosphorus [EPA 1995]. Living material such as algae can exude an oxygen demand on the water column. Algae, both suspended in the water (phytoplankton) and attached to rocks and wood debris on the stream bed (periphyton), use oxygen during respiration. Hence, Minnesota's river nutrient standards include measures of chl-*a*, biological oxygen demand (BOD), and daily (diel) oxygen fluctuation.

Settling and ultimately deposition of dead plant matter and debris, including algae and macrophytes, eroded organic soils, wastewater bypasses, and historical sludge deposits from old rudimentary WWTFs can result in organic benthic deposits in the streams sediments. The aerobic decomposition of the surface layer of these benthic deposits generates an oxygen demand during decomposition known as Sediment Oxygen Demand (SOD) [EPA 1995]. High spring-flow rates in the stream can scour these sediments and reduce the demand in a reach but may redeposit the sediment in a reduced velocity zone downstream. SOD is best determined by using in situ testing but can also be approximated with laboratory analyses of sediment samples. In TMDL analyses, SOD is commonly determined through water quality models to avoid expensive and labor-intensive in situ monitoring.

Natural background sources of oxygen-demanding substances are abundant and include decaying material from forests and grasslands. In addition to oxygen-demanding substances, sources of low oxygen content (anoxic) water, such as groundwater and wetland drainage, can also reduce the DO concentration of a stream reach.

Legacy sources of sediments and nutrients to waterbodies may also influence present-day system oxygen demand by influencing algal/macrophyte growth, decay, and release of nutrients. Sources leading to low DO may include the following:

- Phosphorus
- Nitrogen
- Anoxic water
- Algal respiration
- CBOD
- NBOD
- SOD.

Conventionally, BOD (which is determined by laboratory analysis) is used to define the oxygen demand of wastes and plant matter from water samples. Biochemical oxidation of organic material can be a slow process, but it is usually 95% complete within 20 days of initiation. During the initial portion of this period (from 6 to 10 days), most of the oxygen is consumed as a part of the oxidation of carbonaceous matter. The hydrolysis of proteins in wastewater produces ammonia. After 6 to 10 days, the autotrophic bacteria that use oxygen to oxidize ammonia are present in sufficient numbers to exert a measurable oxygen demand. These two sources of oxygen demand are referred to as carbonaceous biochemical oxygen demand (CBOD) and nitrogenous biochemical oxygen demand (NBOD). The oxygen demand, which is determined by continuing the BOD test until DO consumption is reduced to a negligible level while inhibiting nitrifying bacteria, is defined as the ultimate BOD of the wastewater. Most laboratories limit the ultimate biochemical oxygen demand (BODu) test to 20 days or 40 days. Because of the time requirements of the BODu test, the oxygen demand from the 5-day CBOD test to attain $CBOD_5$ is commonly used to evaluate the organic waste load of wastewater.

3.7.4.1 Permitted

Effluent from WWTFs contributes an allowable, permitted amount of oxygen-demanding materials to the stream. Detailed information about specific permitted sources of oxygen-demanding material is included in Section 4.5.4 of this TMDL. Albert Lea WTP, Clarks Grove WWTF, Hayward WWTF, DNR Myre Big Island State Park, and Cargill Value Added Meats discharge above the Albert Lea Lake boundary condition to the DO-impaired Shell Rock River Reach 501. The Albert Lea and Glenville WWTFs drain directly to the DO-impaired Shell Rock River Reach 501. Land application of biosolids from WWTFs was not included as an additional source of oxygen-demanding materials. Information about land application of biosolids is available in Minn. R. ch. 7041 (*Sewage Sludge Management*). Appendix E includes a map of point sources.

Three CAFOs are located in the drainage area above the Albert Lea Lake boundary condition to the DO-impaired Shell Rock River Reach 501. CAFOs are not allowed to discharge to surface water except in the event of chronic or catastrophic precipitation. Manure from liquid manure storage areas or dry manure stockpiles is used as fertilizer. A current manure management plan which complies with Minn. R. 7020.2225 and the respective permit is required for all CAFOs and AFOs with 1,000 or more AUs. Appendix E includes a map of animal feedlots and CAFOs.

The Albert Lea City Multiple MS4 (MS400263) drains to the DO impaired Shell Rock River Watershed Reach 501. Winter thaws and rainfall events generate runoff within city areas that reaches storm sewer conveyances and is largely influenced by the amounts and distribution of impervious areas associated with rooftops, sidewalks, driveways/parking lots, streets, and other compacted surfaces. Lawns, soils, grass clippings, road-surface particles, organic and vehicular debris, eroded soil particles, pet and wildlife waste, and atmospheric deposition are potential phosphorus- containing substances.

Construction and industrial stormwater contribute sediment, nutrients, and organics and therefore are sources of oxygen demand. A search of the MPCA's Industrial Stormwater Database on July 11, 2019, revealed that 35 industrial facilities exist in Albert Lea, with 14 facilities having no-exposure exclusions; 1 industrial facility exists in Hayward and has a no-exposure exclusion; and 2 industrial facilities exist in Glenville without no-exposure exclusions.

3.7.4.2 Nonpermitted

The project area contains a mix of pasture/hay, row crops, forest, wetlands, and other land covers, which is likely to contribute to oxygen demand via nutrient, manure, and other organic material washoff from the land during precipitation events. Non-NPDES/SDS permitted AFOs are required to comply with Minn. R. 7020. Inadequately managed manure runoff from open lots feedlot facilities and improper application of manure can contribute to oxygen demanding materials to the stream. Sources of oxygen-demanding materials that are not required to have NPDES/SDS permits include direct watershed runoff, loading from upland watershed tributaries and lakes, SSTS, and atmospheric deposition.

SSTS loadings were estimated for HSPF by using 2013 permit data that were provided by Freeborn County. The number of residences that were served by SSTS was summed from the provided permit data per township; the total number of SSTS was determined based on the percent of each subwatershed. Loading rates that incorporated septic-failure rates were developed for ammonia, nitrate, orthophosphate, CBODU, and water on a per capita basis and applied to each modeled reach.

3.7.4.3 Potential sources

CBOD, NBOD, and SOD are the sources that contribute to low DO concentrations in streams. The following general guidelines are based on chemical stoichiometry (amounts of substances involved in reactions):

- 2.7 mg of oxygen are required to completely stabilize every mg of carbon
- 3.43 mg of oxygen are required to completely stabilize every mg of ammonia-nitrogen

    - ($NH_4^+ + 3/2O_2 \rightarrow 2H^+ + H_2O + NO_2^-$)
- 1.14 mg of oxygen is required to completely stabilize every mg of nitrate-nitrogen
    - ($NO_2^- + 1/2O_2 \rightarrow NO_3^-$).

SOD can be a key contributor to low DO concentrations in streams and causes oxygen to be removed from overlying waters because of settled organic matter decomposition. SOD rates are defined in units of oxygen used per surface area per day (g-O_2/m^2/day).

Organic material degradation also causes phosphorus to release into overlying waters [Price et al. 1994] and further generate algal/organic matter. High oxygen consumption (without replacement by reaeration or primary production) creates low oxygen conditions and, in severe cases, hypoxic or anoxic conditions that cause fish kills, invertebrate mortality, and species displacement. Increased oxygen depletion can affect fish and macroinvertebrate survival and propagation by increasing stress and disease potential, which can lead to a loss of diversity as more pollution-tolerant species replace sensitive species. Seasonality is therefore an important factor that affects SOD rates with warmer temperatures accelerating the ambient chemical reaction rates that can influence aquatic DO concentrations.

Several factors affect SOD; the primary focus is often given to biological components, such as the organic content of benthic sediment and microbial concentrations. Three of the most important parameters that affect SOD are temperature near the sediment-water interface, stream depth [Ziadat and Berdanier 2004], and the overlying water velocity [Truax et al. 1995]. Specifically, SOD increases linearly with velocity at low velocities (less than 10 centimeters per second [cm/s]), but becomes independent at high velocities [Makenthun and Stefan 1998]. Ziadat and Berdanier [2004] found that depth was the most important hydrologic variable that affects the SOD in Rapid Creek, South Dakota. The base SOD rate changes throughout the year because of multiple factors, including DO concentration in the water column, seasonal benthic population changes, the mixing rate of the overlying water, presence of toxic chemicals, and changes in temperature. Ambient temperatures increase in the summer growing season, which is when lower flows and stream velocities are typical; these factors can increase the biologic activity and oxygen consumption at the sediment-water interface with minimal reaeration from water movement. Previously described watershed climate patterns that affect SOD included varying dry/wet periods, increasing ambient growing-season temperatures, and increasing frost-free periods. Sediment organic content is also a key factor that affects SOD rates.

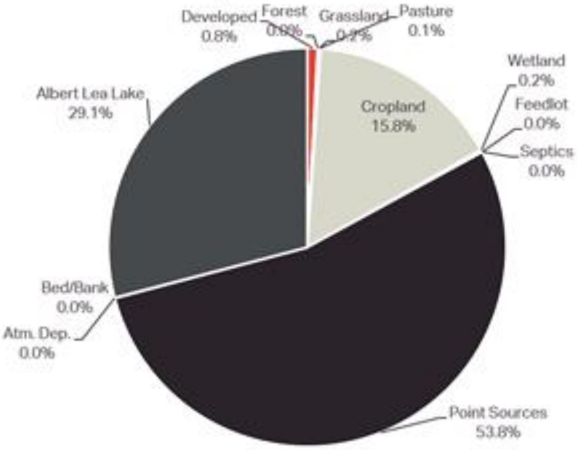
Oxygen-demand terms and methodologies that are borrowed from wastewater treatment for BOD_5 (which is represented as the sum of carbonaceous and nitrogenous oxygen demands [NODs]) are closely associated with SOD. CBOD represents the oxygen equivalent amount of oxygen that microorganisms require to break down and convert organic carbon to CO_2 from carbonaceous organic matter.

Microorganisms rapidly transform organic nitrogen to ammonia-nitrogen (NH_3-N). Bacteria then transform NH_3-N to nitrate through an oxygen-consuming process called nitrification. While these laboratory measures from sampled waters are appropriate, they do not adequately describe cumulative oxygen depletions from upland ditches, drained wetlands, and eutrophic lakes; therefore, several SOD measurement methodologies employ a variety of in situ and laboratory core measurements. Alternative evaluations are employed to approximate SOD when such assessments are unavailable.

Stream eutrophication standards (targets) were recently adopted for TP, chl-*a*, diel DO flux, and BOD.

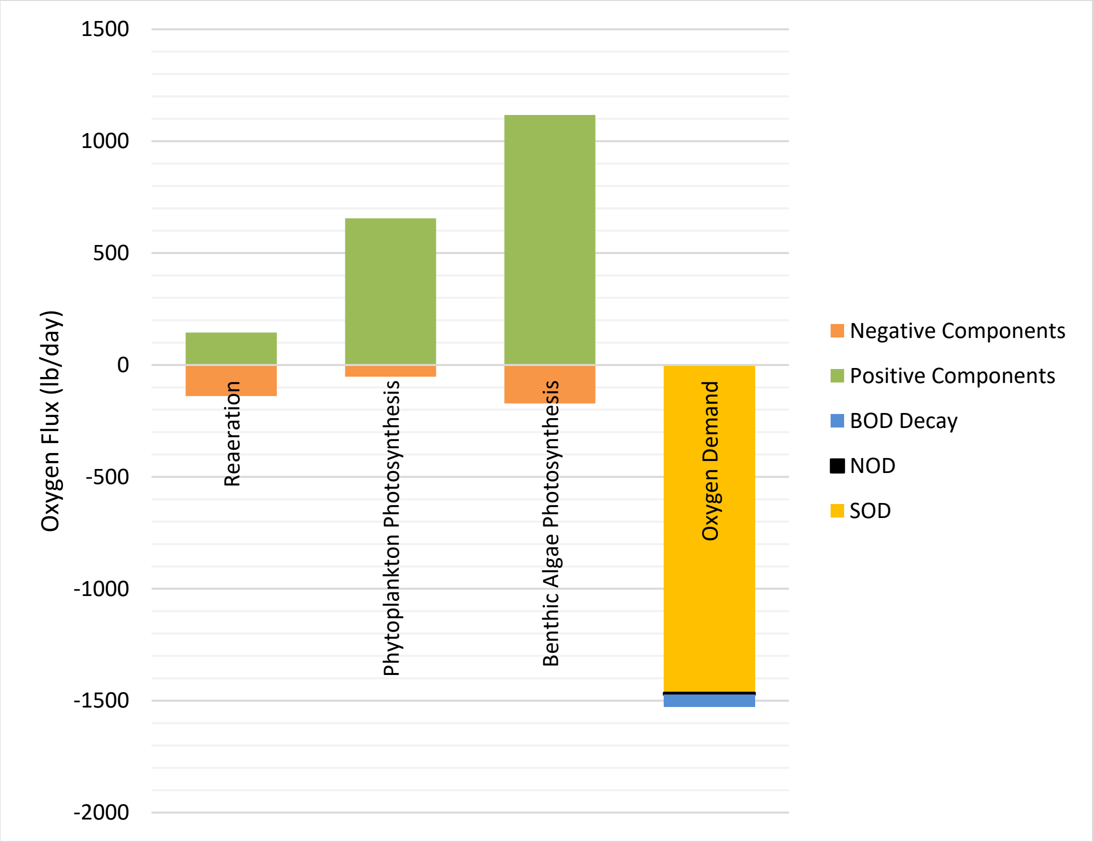
The HSPF model estimated the contribution of phosphorus from identified sources, which include Albert Lea Lake and local developed land, cropland, forest, grassland, pasture, feedlots, SSTS, point sources, atmospheric deposition, and beds/banks. Approximately 54% of the annual phosphorus load in the stream was from permitted point sources: Albert Lea and Glenville WWTFs. Approximately 95% of treated wastewater comes from Albert Lea WWTF and 5% from Glenville WWTF (see Table 31). Remaining annual phosphorus load is estimated to come from; Albert Lea Lake (29%); local cropland (16%); and the remaining approximately 1% from other local sources (such as forest, pasture, grassland, MS4 and non-MS4 developed land), as depicted in pie charts of Figure 38 (the left-hand pie chart shows the land cover of the drainage area for each reach). These simulated estimates are consistent with the amounts indicated on the WWTP DMRs as well as the TP masses measured at the Shell Rock River Gordonsville flow gage. For additional discussion on the contribution of phosphorus from various sources, see the Shell Rock River WRAPS Report Section 2.3.2.

Figure 38. Shell Rock River Watershed Reach 501 annual total phosphorus source summary estimated by HSPF modeling.



Animal manure that is spread on cropland is accounted for in the cropland category in the source pie charts. The HSPF model was used to evaluate the oxygen flux from reaeration (both positive and negative), phytoplankton respiration (negative) and photosynthesis (positive), benthic algae respiration and photosynthesis, and total oxygen demand (i.e., BOD decay, NOD, and reach SOD combined) at the outlet of the Shell Rock River Reach 501 during the TMDL time period, as shown in Figure 39. The modeled SOD makes up approximately 96% of the total oxygen demand, BOD makes up just under 4%, and NOD makes up under 1%. Because phosphorus significantly contributes to algae growth in the Shell Rock River, it is expected that that decreases in TP concentrations from Albert Lea Lake, the local area draining to the Shell Rock River, and the local point sources will lead to decreases in algae and organic matter that will cause eventual decreases in SOD [and compliance with the DO standard. The amount of time for the SOD to respond can depend on the climate and stream characteristics that could affect the removal of oxygen demanding materials from the system through nutrient cycling processes and transport of sediment [EPA 1995].

Figure 39. HSPF-modeled oxygen flux at the outlet of Shell Rock River Reach 501 during the TMDL time period.



3.7.5 pH

The pH level is a measure of the hydrogen ion activity in water expressed as a logarithm [EPA 1986]. Lind [1979] describes pH as the logarithm of the reciprocal of the hydrogen ion concentration, and notes that one pH unit represents a tenfold change in hydrogen ion concentration (a pH of 6 has 10 times the hydrogen ions of pH 7). Because of this logarithmic nature of pH units, this report uses individual data points and median values (i.e., not mean or average values). The pH of natural waters most frequently lies in the range of 6.0 to 8.0, with a pH of 7.0 being considered neutral. The pH is an important factor in natural-water chemical and biological systems [EPA 1986]. Photosynthesis and respiration are two major factors that influence the amount of free carbon dioxide (CO_2) in water. Photosynthesis takes up CO_2 and raises the pH while respiration releases CO_2 and lowers the pH. At pH values less than approximately 6.2, free CO_2 is the most dominant form of inorganic carbon present. Between pH values of 7.0 and 9.5, most of the present inorganic carbon is bicarbonate [Wetzel 1975].

3.7.5.1 Permitted

WWTFs contribute an allowable, permitted amount of effluent to the stream with an associated pH. The pH permit limits for all of the facilities that contribute to the pH-impaired Shell Rock River Reach 501 are a minimum of six and maximum of nine. Above the pH-impaired Shell Rock River Reach 501, the Clarks Grove WWTF drains to Fountain Lake (East Bay), Albert Lea WTP drains to Albert Lea Lake and Fountain Lake (East Bay), and Hayward WWTF, DNR Myre Big Island State Park, and Cargill Value Added Meats drain to Albert Lea Lake. The Albert Lea and Glenville WWTFs drain directly to the pH-impaired Shell Rock River Reach 501.

Three CAFOs are located within the Shell Rock River Watershed above Albert Lea Lake and within the area that drains to the pH-impaired Shell Rock River Reach 501. CAFOs are not allowed to discharge to surface water except in the event of chronic or catastrophic precipitation. A map of animal feedlots and CAFOs is included in Appendix E.

Albert Lea City Multiple MS4 (MS400263) drains to the pH impairment on the Shell Rock River Watershed Reach 501. Winter thaws and rainfall events generate runoff within city areas that reach storm sewer conveyances largely influenced by the amounts and distribution of impervious areas associated with roof tops, sidewalks, driveways/parking lots, streets, and other compacted surfaces. The stormwater runoff from MS4s typically have neutral pH values. However, lawns, soils, grass clippings, organic debris, road-surface particles, vehicular debris, eroded soil particles, pet and wildlife wastes, and atmospheric deposition all contribute phosphorus to waterbodies. Because the pH is influenced by the photosynthesis and respiration of algae, which grows in excess when excessive nutrients are present, MS4 areas potentially can impact pH. Similarly, construction and industrial stormwater likely have neutral pH values but do contribute sediment and nutrients which can impact pH because of photosynthesis and respiration.

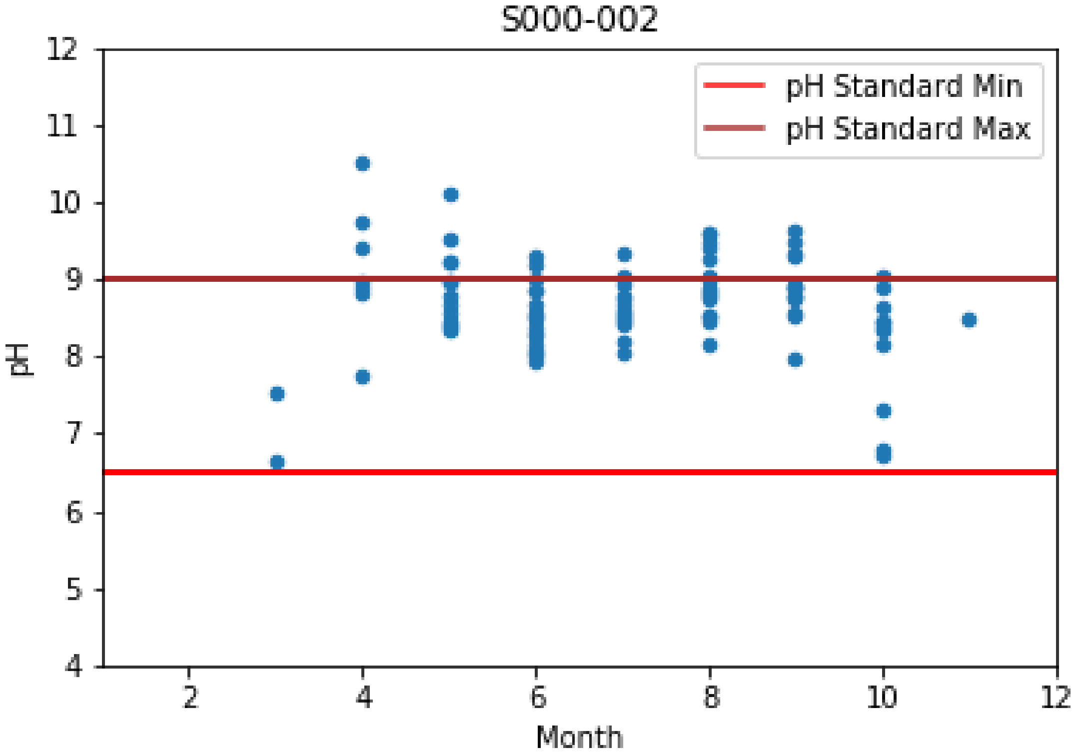
3.7.5.2 Nonpermitted

The project area contains a mixture of pasture/hay, row crops, forest, wetlands, and other land cover. Lands in the area contribute nutrients to Albert Lea Lake and the Shell Rock River via washoff from the land during precipitation events. NonNPDES/SDS permitted AFOs are required to comply with Minn. R. 7020. Inadequately managed manure runoff from open lots feedlot facilities and improper application of manure can contribute to nutrients to upstream lakes and impaired rivers. Excess nutrients in lakes lead to abundant algae, and the photosynthesis and respiration processes increase the pH, as discussed previously.

3.7.5.3 Potential Sources

The pH impairment cannot be addressed if the pH in Albert Lea Lake remains substantially above the standard, because discharge from Albert Lea Lake makes up a high proportion of the stream flow in the Shell Rock River. By addressing eutrophication in Albert Lea Lake and in Shell Rock River via the nutrient TMDLs, it is reasonable to assume that the high pH in the Shell Rock River will also be addressed. The pH measurements on a monthly basis at the monitoring site directly below Albert Lea Lake (S000-002) before any local point source (Albert Lea WWTF or Glenville WWTF) influences are shown in Figure 40, and indicate that pH from the lake is very likely the primary cause of the high pH throughout Shell Rock River Reach 501. An evaluation of the pH from local point sources shows that it is unlikely that the effluent from point sources is the primary cause of the high pH in the Shell Rock River. Discharge monitoring data from the Albert Lea WWTF and POET Biorefining (which no longer discharges directly to the Shell Rock River) consistently remained below 9, and although the Glenville WWTF did occasionally exceed a pH of nine, the flow is such that it does not significantly impact the pH in the Shell Rock River. These facilities do; however, contribute phosphorus to the stream, and therefore potentially impact the pH in the Shell Rock River. The pH-impaired the Shell Rock River Reach 501 is expected to meet the pH water quality standard when Albert Lea Lake meets its eutrophication targets.

Figure 40. The pH by month at the outlet of Albert Lea Lake in Reach 501 (S000-002) from 2009 to 2018.



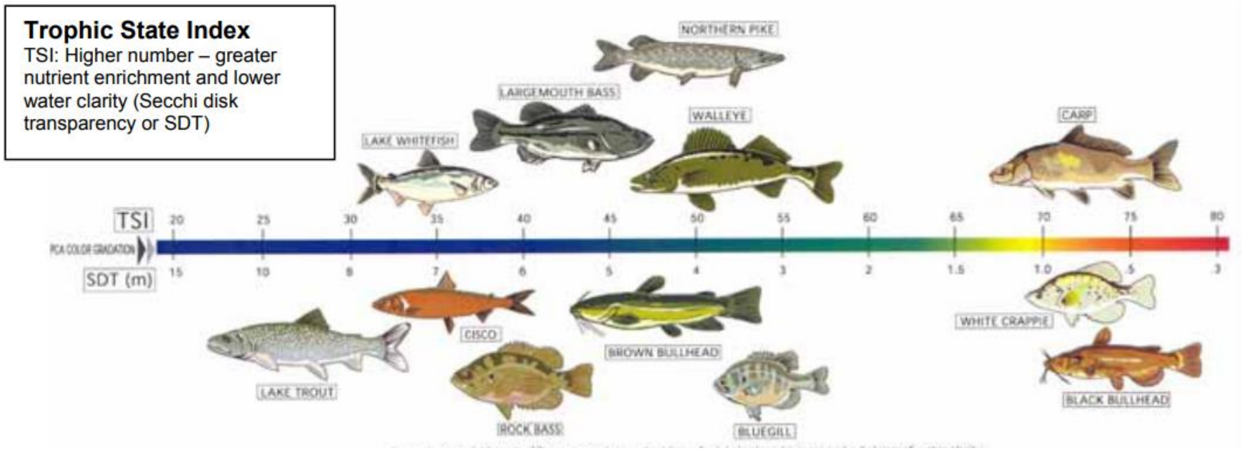
3.7.6 Aquatic macroinvertebrate and fish bioassessments

Aquatic macroinvertebrate and fish health in the Shell Rock River Reach 501 was linked to elevated nitrate, phosphorus, pH, chl-*a*, and resultant DO fluctuations in the *Shell Rock River Watershed Biotic Stressor Identification Report* [MPCA 2014]. The study also mentioned that bedded sediment is affecting habitat availability, and the undercutting of stream-banks is contributing to the influx of fine sediment. Therefore, TSS and bedded sediment are closely tied. TSS in the Shell Rock River Reach 501 is also related to nutrient concentrations in the upstream Albert Lea Lake. Research shows that nitrate-nitrogen can be toxic. Because there is not a nitrate aquatic life standard in Minnesota for Class 2 or 3 waters, nitrate-nitrogen will be addressed in the Shell Rock River WRAPS Report, while the remainder of the parameters affecting aquatic macroinvertebrates and fish are addressed in this TMDL. Therefore, permitted, nonpermitted, and potential sources from the TSS, phosphorus, DO, and pH sections of this TMDL (3.7.2, 3.7.3, 3.7.4, 3.7.5, and 3.7.7) impact the aquatic macroinvertebrates and fish in the Shell Rock River Reach 501.

3.7.7 Nutrients (total phosphorus) in lakes

This TMDL study addresses several nutrient-impaired lakes in the Shell Rock River Watershed. Phosphorus is the primary nutrient of concern in this TMDL because excess quantities typically drive a wide array of aquatic biological responses that can negatively affect established beneficial uses. High phosphorus concentrations are associated with elevated algal production, increased organic content and decay, and increased oxygen depletions that affect fish survival and propagation. Schupp and Wilson [1993] compared the relative abundance and presence of various fish across the spectrum of lake water quality by use of the Carlson Trophic State Index (TSI) [Carlson 1977], as depicted in Figure 41, which illustrates that the highest phosphorus concentrations (and TSI values) are associated with carp and black bullheads. As phosphorus concentrations increase and give rise to more algae and reduced water clarity, recreational uses are also affected. Increased algal abundance and reduced water clarity are negatively related to user preferences for swimmable conditions [Heiskary and Wilson 2005]. Heiskary and Walker [1988] further refined lake quality evaluations based on the frequency of extreme chl-*a* concentrations or blooms as opposed to average summer chl-*a* concentrations.

Figure 41. Lake fish species relative to Carlson TSI (top of the bar) with average summer Secchi disk depth (across the bottom of the bar, in meters). MPCA graphic adapted from Schupp and Wilson [1993].



The chl-*a* and SDT exhibit nonlinear responses to increased phosphorus concentrations. The observed frequency of chl-*a* concentrations that exceed 30 ug/L (or severe nuisance conditions in Heiskary and Wilson [2005]) is quite low at phosphorus concentrations of approximately 30 ug/L, and increase steadily with phosphorus concentrations of about 100--120 ug/L. Algal blooms in severe form are frequently dominated by cyanobacteria that can be periodically toxic. Hence, these interrelationships were the building blocks used to define lake phosphorus thresholds that became Minnesota's lake eutrophication standards and the targets for the lake-nutrient TMDL allocations that are described in this document.

One of the main components of a TMDL is identifying watershed phosphorus sources and the magnitude of their contributions to each lake. Natural background phosphorus sources to lakes include surface runoff from the natural landscape, background stream-channel erosion, groundwater discharge, and atmospheric deposition of windblown particulate matter from the natural landscape. Internal loading of phosphorus is an additional nonpoint source, which can be of anthropogenic and natural origin. This loading is primarily from release of phosphorus from lake sediments or aquatic plants. Additional loading, although minimal, comes from rough fish. Current carp and goldfish populations and distributions are being studied by the SRRWD for the development of management plans. Typical man-made influences to lakes typically include state- and federal-permitted discharges from wastewater, industrial and commercial entities, shoreland development, impervious surfaces (roads, roofs, and driveways), stormwater via artificial drainages from urban and agricultural lands, row cropping, pastured lands, individual sanitary treatment systems, feedlots, and channelized streams/ditches. The following section provides brief descriptions of permitted and nonpermitted sources that potentially contribute to impaired lakes in the Shell Rock River Watershed.

3.7.7.1 Permitted

Permitted sources are point sources or those that originate from a discrete, identifiable source within the watershed and are regulated by the NPDES or SDS permits. These include the following:

- Regulated municipal and industrial wastewater treatment systems
- Feedlots that require NPDES/SDS coverage
- Regulated stormwater.

Detailed information about specific permitted phosphorus sources is included in Section 4. Any industrial, municipal, or private-entity point source discharging treated wastewater to Minnesota surface waters must have an NPDES/SDS permit that specifies discharge location(s), volumes, and treated effluent quality. The Albert Lea WTPs have two filter backwash discharges to Albert Lea Lake and to Fountain Lake (East Bay). Clarks Grove WWTF contributes to Fountain Lake (East Bay), and the Hayward WWTF, DNR Myre Big Island State Park, and Cargill Value Added Meats contribute to Albert Lea Lake. Land application of biosolids from WWTFs was not included as an additional source of nutrients. Information about land application of biosolids is available in Minn. R. ch. 7041 (*Sewage Sludge Management*).

Three active permitted CAFOs located in the Shell Rock River Watershed are in the drainage area of Fountain Lake (West Bay and East Bay) above Albert Lea Lake. CAFOs are not allowed to discharge to surface water from the production area (with exceptions specified in the Permit), but manure from CAFO liquid manure storage areas is land applied on cropland and used as fertilizer. A current manure management plan which complies with Minn. R. 7020.2225 and the respective permit is required for all CAFOs and AFOs with 1,000 or more AUs. The Albert Lea MS4 (MS400263) is located within the watersheds of all nutrient-impaired lakes addressed in this TMDL. Winter thaws and rainfall events generate runoff within city areas that reach storm sewer conveyances largely influenced by the amounts and distribution of impervious areas associated with roof tops, sidewalks, driveways/parking lots, streets, and other compacted surfaces. Lawns, soils, grass clippings, organic debris, road-surface particles, vehicular debris, eroded soil particles, pet and wildlife wastes, and atmospheric deposition are all potential phosphorus-containing substances. Construction stormwater and industrial stormwater contribute sediment, nutrients, and organics and therefore, are sources of phosphorus. A search of the MPCA’s Industrial Stormwater Database on July 11, 2019, in communities above impaired lakes revealed that 35 industrial facilities exist in Albert Lea, with 14 facilities having no-exposure exclusions, and 1 industrial facility exists in Hayward that has a no-exposure exclusion.

3.7.7.2 Nonpermitted

Phosphorus sources that are not required to have NPDES/SDS permits include direct watershed runoff, loading from upland watershed tributaries, SSTS, atmospheric deposition, and internal loading.

Direct watershed runoff occurs from precipitation and snowmelt events. Runoff from agricultural lands, urban lands, forests, and so on has decomposing organic material and these contribute to phosphorus. Additionally, phosphorus is attached to sediment and is transferred with sediment into the stream during runoff events.

Upland tributary loading occurs from contributing areas outside of the direct lakeshed. These upstream loads are the result of upstream direct watershed runoff, SSTS, atmospheric deposition, scour/bank erosion, and other influences.

Atmospheric phosphorus deposition on the lake surface is an important part of the phosphorus budget. Atmospheric deposition occurs as wet (carried by precipitation) and dry (dry particles carried as dust) deposition. Unlike other nonpoint sources such as watershed runoff or septic loading, atmospheric phosphorus deposition originates at least partly outside at the watershed and cannot be controlled. An atmospheric phosphorus deposition of 0.469 kilogram/hectare/year (kg/ha/yr) [Twarowski et al. 2007] was used to quantify average annual total (wet plus dry) deposition on the lake surface.

Lake-nutrient cycling (or internal loading) refers to several processes that can cause phosphorus release into the water column, where it can be available to algal growth, as dissolved phosphorus forms. In general, lake phosphorus cycling can occur from the following types of processes:

1. Phosphorus that is released from lake sediments in aerobic and anerobic conditions, which is typically moderated by amounts of available iron and other factors, such as legacy loading.
2. The resuspension of sediments from physical disturbance by bottom-feeding fish (e.g., rough fish such as carp and black bullheads) and/or wave and wind action, particularly in shallow-lake areas, can cause resuspension of nutrients, including phosphorus. Small particles (e.g., clay and silt) are most vulnerable to resuspension; these particles also have the largest specific area (surface area per mass) and, therefore, are capable of holding much more phosphorus per unit mass than larger particles (e.g., sand). Wave mixing of deeper waters can cause sediment phosphorus transport into the surface waters.
3. Phosphorus that is released from macrophyte decay—particularly the decay of dense stands of invasive species, such as curly-leaf pondweed (*Potamogeton crispus*) and Eurasian watermilfoil (*Myriophyllum spicatum*) that can dominate littoral areas. Curly-leaf pondweed typically dies off in early to midsummer and is subject to rapid decay in warm water, thereby potentially contributing to summer phosphorus concentrations. In other instances, macrophytes can be effective at stabilizing sediment and limiting resuspension. However, peak macrophyte growth can increase pH and contribute to low daily minimum DO concentrations at the sediment-water interface, which causes phosphorus release from sediments.
4. High concentrations of TP and dissolved phosphorus from tributary and lakeshed runoff pulses can contribute to elevated in-lake concentrations and increased algal growth. The resultant increased biological growth, decay, and deposition may increase the soluble/dissolved phosphorus in shallow-lake sediments, which may be temporally mistaken for phosphorus from traditional internal loading sources.

Distinguishing internal versus external phosphorus loading is more difficult in shallow lakes that are more wind mixed vertically and subject to tributary-induced horizontal exchange.

3.7.7.3 Potential sources

For the nutrient portion of this TMDL, sources are broken down by what occurs within each impaired lake and how each potential source needs to be reduced in the TMDL development section (Section 4). The calibrated HSPF model was used to develop runoff volumes and phosphorus load estimates by source within each impaired lake’s watershed from 2009 to 2018. This included upland tributaries identified by reach number and direct drainage or lakeshed loading to each lake. Section 3.6 of this report details the HSPF model development that explicitly included regulated and nonregulated sources of phosphorus, which were incorporated into the phosphorus loads for each lake. The HSPF- generated, lake-specific loadings along with permitted and nonpermitted sources discussed in Sections 3.7.7.1 and 3.7.7.2 were entered into BATHTUB to quantify each lake’s loading capacity by source and distribute the TMDL allocations and reductions. A study by Zimmer et al. [2006] concluded that phosphorus can also be contributed to waterbodies via fish excretion. Phosphorus from fish excretion is included in the internal loading component of the TMDL tables.

4. TMDL development

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 CWLA (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 LAs 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 waterbody 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 40 CFR § 130.2(g), instructs an agency to distinguish between natural and nonpoint source loads “wherever possible.” However, Minnesota law does not compel the MPCA to develop a separate LA for natural background sources, distinct from nonpoint sources.

4.2 *E. coli*

LDCs, which represent the allowable daily *E. coli* load under a wide range of flow conditions, were used to represent the *E. coli*-loading capacity and allocations for each impaired reach. The LDC approach results in a flow-variable target that considers the entire flow regime within the time period of interest. Five flow intervals were developed for each reach, and loading capacities and allocations were developed for each flow interval. The five flow intervals were very high (0% to 10%), high (10% to 40%), mid (40% to 60%), low (60% to 90%), and very low (90% to 100%), which is in adherence to guidance provided by the EPA [2007].

The TMDL is the loading capacity of a reach and the sum of the LA, WLA, and a MOS, as shown in Equation 3.

$$\mathrm{TMDL} = \sum(\mathrm{WLA}) + \sum(\mathrm{LA}) + \mathrm{MOS}. \qquad (3)$$

4.2.1 Loading capacity

LDCs were used to represent the loading capacity. The flow component of the loading capacity curve is the HSPF-simulated daily average flow (from 2009 to 2018) at the outlet of each impaired reach, and the concentration component is geometric mean *E. coli* concentration criterion (126 org per 100 mL [mpn/100 mL]). The loading capacities that are presented in the TMDL tables are the products of the median simulated flow, geometric mean concentration criterion, and unit conversion factor in each flow interval. The current load is based on the median simulated flow and the observed geometric mean in each flow zone. The reduction needed in each flow zone is the percent difference between the current load and loading capacity.

The LDC method is based on an analysis that encompasses cumulative historical flow data frequency 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 curve. In the *E. coli* TMDL tables in this report, only five points are depicted on the loading capacity curve (i.e., the midpoints of the designated flow zones). However, the entire curve represents the TMDL and is what will ultimately be approved by the EPA.

4.2.2 Wasteload allocation methodology

TMDL WLAs are typically divided into three categories: NPDES point-source dischargers, permitted MS4s, and construction and industrial stormwater. The following sections describe how each of these WLAs was estimated.

The permitted NPDES wastewater discharger that contributes to an *E. coli*-impaired reach is shown in Table 24 with the impairment to which it contributes. The WLAs were calculated as the product of the maximum permitted daily flow volume (6 inches per day drawdown of the secondary pond[s]) that may be discharged in a 24-hour period, allowed effluent concentration, and unit conversion factor. The maximum permitted daily flow rate was used because the Clarks Grove WWTF is a controlled facility. The loads from controlled municipal discharging WWTFs are calculated based on the maximum daily volume that may be discharged in a 24-hour period. The WWTF has fecal coliform regulations instead of *E. coli*. The *E. coli* standard of 126 org/100 mL was used to calculate the WLAs instead of the fecal coliform permit limit of 200 org/100 mL. The flow, *E. coli* concentration limits, and resultant WLA for the contributing facility is included in Table 25. The WLAs do not vary based on flow.

Table 24. Wastewater treatment facilities design flows and *E. coli* WLAs.

Impaired Reach	Facility	Permit	Maximum Daily Volume (mgd)	Permitted Concentration (org/100 mL)	*E. coli* WLA (billion org/day)	Impaired Reach Point-Source WLA (billion org/day)
507, Bancroft Creek (County Ditch 63)	Clarks Grove WWTF	MNG580067	1.059	126	5.05E+09	5.05E+09

mgd = million gallons per day.
org/day – organisms per day.

The Albert Lea City MS4 (MS400263) overlaps the watershed of Bancroft Creek (County Ditch 63) *E. coli* impairment. Allocations were therefore developed for the MS4 by multiplying the loading capacity in each flow zone by a factor representing the percent of the volume of water from areas located within the MS4 from the HSPF model. The MS4 factor for Bancroft Creek is 0.0267.

The Minnesota Construction Stormwater Permit is MNR100001, and the Minnesota Industrial Stormwater Permit is MNR050000. *E. coli* is not a likely pollutant stemming from construction stormwater; therefore, a construction stormwater WLA was not necessary. No benchmark monitoring of bacteria or *E. coli* are required with industrial permits, and *E. coli* is not typically contributed from industrial stormwater; therefore, an industrial stormwater WLA was not necessary.

Three CAFOs drain to the Unnamed Creek (Wedge Creek) *E. coli* impairment. For the Shell Rock River Watershed TMDL, all NPDES and SDS permitted feedlots are designed to have zero discharge and as such, they do not receive a WLA. All other nonpermitted feedlots and the land application of all manure are accounted for in the LA for nonpoint sources.

4.2.3 Margin of safety

MOS is a portion of the TMDL that is set aside to account for the uncertainties associated with achieving water quality standards. MOS is usually expressed in terms of the percentage of the loading capacity. The MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit and expressed in the TMDL as a set-aside load. For *E. coli* TMDLs, an explicit MOS was calculated for each impairment as 10% of the loading capacity. This percent was considered an appropriate and sufficient MOS because the LDC approach minimizes the uncertainty associated with developing TMDLs. Additionally, 10% is appropriate because no rate of decay or die-off rate of pathogen species was used in calculating the TMDL or creating LDCs. As stated in the EPA's Protocol for Developing Pathogen TMDLs (EPA 841-R-00-002), many different factors affect the survival of pathogens, including the physical condition of the water. These factors include, but are not limited to sunlight, temperature, salinity, and nutrient deficiencies. These factors vary depending on the environmental condition/circumstances of the water, and therefore asserting that the rate of decay caused by any given combination of these environmental variables was enough to meet the water quality standard of 126 org/100 mL would be difficult.

4.2.4 Load allocation methodology

The LA represents the load that is allowed from nonpoint or nonregulated sources of *E. coli* and was calculated as the loading capacity minus the MOS and WLA.

4.2.5 Total Maximum Daily Load summaries

The LDCs and *E. coli* TMDL tables are shown for each impaired reach in Figure 42, Figure 43, Table 25 and Table 26. The required loading capacities, current loads, and load reductions are shown in the TMDL tables and represent the loads for each reach minus any boundary conditions, whereas LDCs show the entire loading capacity at the outlet of the impaired reach. Based on the geometric mean of available data, Bancroft Creek (County Ditch 63) and Unnamed Creek (Wedge Creek) are exceeding their total daily loading capacity (TDLC) in all flow zones having data. Neither *E. coli* impaired reach has *E. coli* data in the very low flow zone. The percent exceedance of the loading capacity in each flow interval were calculated to provide the overall magnitude of the exceedances. Exceedance magnitudes also help focus future management actions; if higher exceedances occur in a certain flow interval, management practices should focus on the sources that most likely influence concentrations in those flow conditions. Exceedances of the *E. coli* target during high flows are typically caused by larger, area-induced, indirect pollutant sources that reach surface waters through watershed runoff. Low-flow exceedances are typically caused by direct pollutant loads or sources near the stream, such as direct defecation by wildlife or livestock in the stream channel or failing septic systems [EPA 2007]. The exceedance of the loading capacity in each flow zone is shown in the bottom row of Table 25 and Table 26. Reductions of bacteria that occur to meet the exceedances could come from different combinations of sources as long as the specified allocations are met.

Figure 42. Bancroft Creek (County Ditch 63) Reach 507 *E. coli* LDC generated with simulated flow data from HSPF and observed *E. coli* data from S004-120.

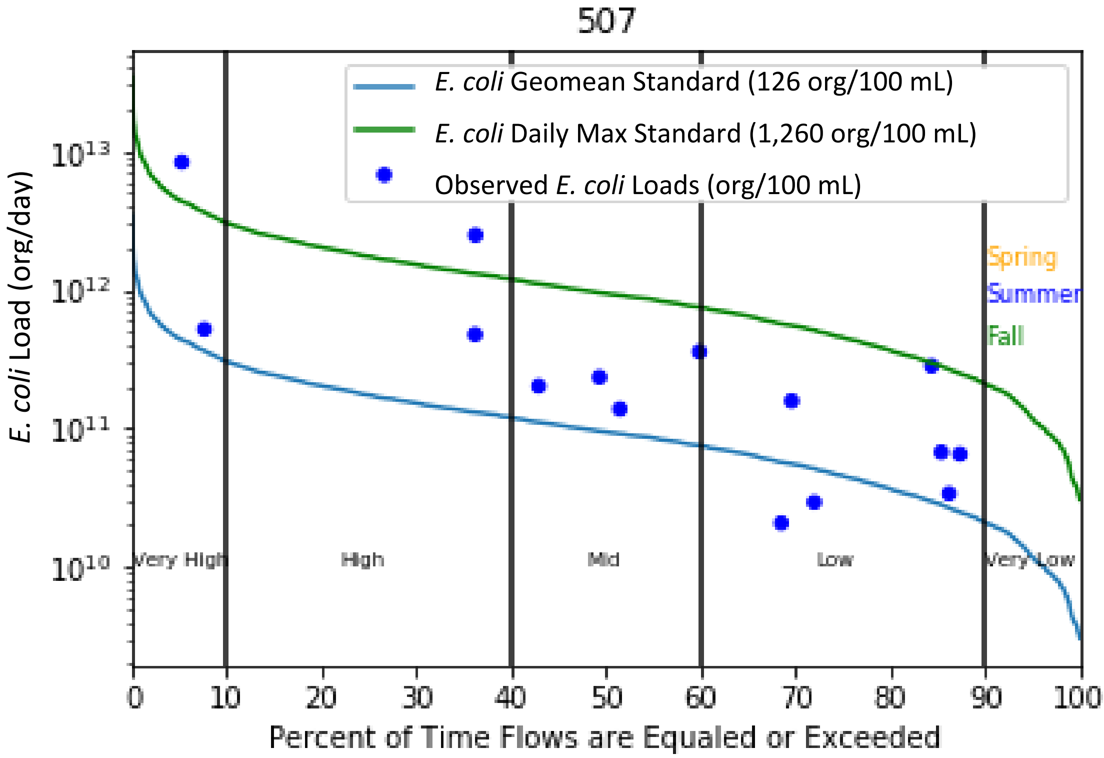


Table 25. Bancroft Creek (County Ditch 63) Reach 507 *E. coli* TMDL summary.

07080202-507		Flow Zone									
***E. coli* TMDL Component (billion org/day)**		**Very High**		**High**		**Mid**		**Low**		**Very Low**	
Wasteload Allocations	Permitted Wastewater Dischargers	5.05	15.10	5.05	9.10	5.05	7.18	5.05	6.00	5.05	5.20
	MS4	10.05		4.05		2.13		0.950		0.147	
	Industrial and Construction Stormwater	–		–		–		–		–	
Load Allocation		382		148		77.8		34.7		5.33	
Margin of Safety		44.20		17.40		9.44		4.52		1.17	
Loading Capacity (TMDL)		441.3		174.5		94.42		45.22		11.697	
Current Load		2,310		1,450		225		77.8		(a)	
Current Load Exceedance of Loading Capacity (%)		80.89		87.96		58.03		41.87		(a)	

(a) No data available to calculate current load.

(a) No data available to calculate current load.

Figure 43. Unnamed Creek (Wedge Creek) Reach 531 *E. coli* LDC generated with simulated flow data from HSPF and observed *E. coli* data from S004-121.

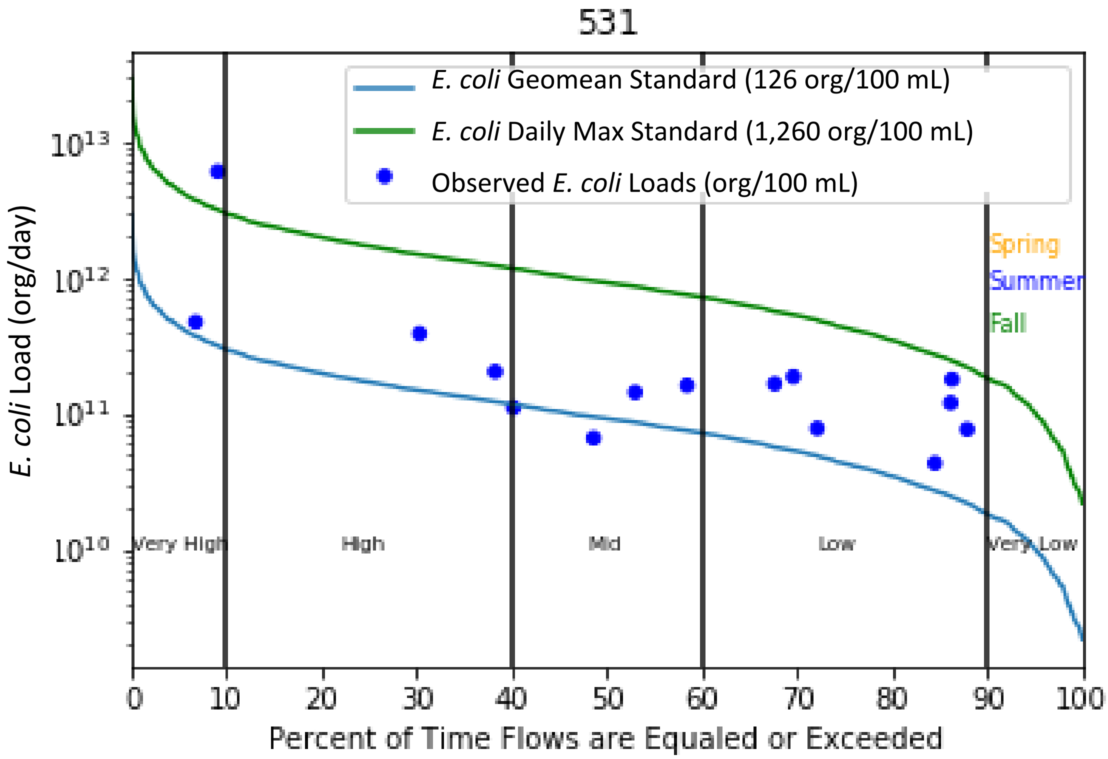


Table 26. Unnamed Creek (Wedge Creek) Reach 531 *E. coli* TMDL summary.

07080202-531		Flow Zone									
***E. coli* TMDL Component (billion org/day)**		**Very High**		**High**		**Mid**		**Low**		**Very Low**	
Wasteload Allocations	Permitted Wastewater Dischargers	–	–	–	–	–	–	–	–	–	–
	MS4	–		–		–		–		–	
	Industrial and Construction Stormwater	–		–		–		–		–	
Load Allocation		391		153		82.3		38.7		9.05	
Margin of Safety		43.50		17.00		9.14		4.29		1.01	
Loading Capacity (TMDL)		434.5		170		91.44		42.99		10.06	
Current Load		2140		356		113		136		(a)	
Current Load Exceedance of Loading Capacity (%)		80		52		19		68		(a)	
(a) No data available to calculate current load.											

(a) No data available to calculate current load.

4.3 Total suspended solids

LDCs, which represent the allowable daily TSS load under a wide range of flow conditions, were used to represent the TSS loading capacity and allocations of each impaired reach. This approach results in a flow-variable target that considers the entire flow regime within the time period of interest. Five flow intervals were developed for each reach, and the loading capacity and allocations were developed for each flow interval. The five flow intervals were very high (0% to 10%), high (10% to 40%), mid (40% to 60%), (40% to 60%), low (60% to 90%), and very low (90% to 100%), which is in adherence to guidance provided by the EPA [2007]. As discussed in Section 3.7.2, an important source of TSS in the turbidity impaired reaches in the Shell Rock River Watershed are upstream nutrient impaired lakes. Therefore, TSS boundary conditions were developed to account for the reduced lake TSS loading (decreased phytoplankton) that would be expected to occur if the lakes were in compliance with their eutrophication standards.

4.3.1 Loading capacity

The LDC 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 average flow, the resultant curve represents the full spectrum of allowable loading capacities. This report's TMDL tables only depict five points of the loading capacity curve (i.e., one for each flow zone). However, the entire curve represents the TMDL, which is the loading capacity of a reach and the sum of the LA, WLA, and an MOS, as shown in Equation 4.

$$\mathrm{TMDL} = \sum(\mathrm{WLA}) + \sum(\mathrm{LA}) + \mathrm{MOS}. \qquad (4)$$

The LDCs represent the loading capacity. The flow component of the loading capacity curve is based on the HSPF-simulated daily average flows (2009 through 2018), and the concentration component is the TSS concentration criteria of 65 mg/L. The TMDL tables present loading capacities as the product of the median simulated flow in each flow zone, TSS concentration criterion, and a unit conversion factor.

4.3.2 Wasteload allocation methodology

TMDL WLAs are typically divided into three categories: NPDES point-source dischargers, permitted MS4s, and construction and industrial stormwater. The following sections describe how each of these WLAs was estimated.

Two active regulated NPDES wastewater dischargers drain to the TSS-impaired Shell Rock River Reach 501 below Albert Lea Lake, and no active regulated NPDES wastewater dischargers drain to Unnamed Creek (Shoff Creek) Reach 516. The WLAs for the permitted wastewater dischargers that contribute to the turbidity-impaired reaches are based on facility design flow. The MPCA provided facility TSS WLAs as the product of the facility design flow, TSS effluent limit, and a unit conversion factor, as shown in Table 27. Facilities that discharge upstream of Albert Lea Lake (Cargill Value Added Meats [MNG255077], the Clarks Grove WWTF [MNG580067], Hayward WWTF [MN0041122], and Minnesota DNR Myre Big Island State Park [MN0033740]) were not included in the WLA because TSS contribution from these facilities is expected to settle out before reaching the Shell Rock River Reach 501. Also, POET Biorefining in Glenville was recently converted to an industrial stormwater-only discharge and does not require a permitted wastewater discharger WLA. The continuously discharging municipal WWTF WLA (Albert Lea WWTF) was calculated based on the average wet-weather design flow, which is equivalent to the 30 wettest days of influent flow that are expected over the course of a year.

Table 27. Permitted TSS allocations for point sources in the Shell Rock River Watershed.

Impaired Reach	Facility	Permit	Design Flow (mgd)	Permitted TSS Concentration (mg/L)	TSS WLA (tons/day)	Impaired Reach Point-Source WLA (tons/day)
501	Albert Lea WWTF	MN0041092	18.38	30	2.30	2.42
	Glenville WWTF	MN0021245	0.647	45	0.12	

Controlled municipal pond discharge WWTF WLA (Glenville WWTF) was calculated based on the maximum permitted daily volume (which is based on a 6-inch drawdown of the secondary pond[s]) that may be discharged in a 24-hour period. In the Shell Rock River, the portion of the WLA from permitted wastewater dischargers exceeded the low-flow regime TDLC (minus the MOS). In this flow regime, as shown in the TMDL tables, the WLA is denoted by an asterisk (*) and should be calculated as the product of the current flow, TSS concentration limit, and a conversion factor.

The Albert Lea City MS4 (MS400263) overlaps the watersheds of the Shell Rock River Reach 501 and Shoff Creek Reach 516 impairments. The MS4 allocation for the local area in the Albert Lea MS4 below the Albert Lea Lake boundary condition was set based on the HSPF-modeled fraction of flow contribution from the HSPF-modeled MPCA designated MS4 areas draining to Shell Rock River Reach 501 (which is 0.010). The HSPF-modeled fraction of flow contribution from the MS4 areas that drains to Shoff Creek below the Pickeral Lake boundary condition (which is 0.048) was similarly used to set the Shoff Creek Reach 516 MS4 allocation. The loading capacity (not including the boundary condition, MOS, or permitted point source WLAs) was multiplied by the fraction of MS4 flow to calculate the MS4 LA.

Construction stormwater is regulated by NPDES permits for any construction activity that disturbs (1) one acre or more of soil; (2) 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 (3) 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 with construction activities reflects the number of construction sites that have less than one acre and are expected to be active in the impaired reach subwatershed at any one time.

A categorical WLA was assigned to all of the construction activity in the watershed. The average annual acres under construction in Freeborn County were available from 2009 to 2018 from MPCA Construction Stormwater Permit data. The percent of acres that were under construction in the county was calculated by dividing the total construction acres by the total county acres; this percentage was multiplied by the portion of the TMDL LA associated with direct drainage to determine the construction stormwater WLA. The average annual construction acres from 2009 to 2018 made up 0.26% of the total county acres. If 0.26% is applied to total acres draining to the Shell Rock River, it would translate to approximately 315 acres under construction at any given time. The 0.26 was rounded up to 0.3% of the area in all impairment drainage areas assumed to be under construction.

Industrial stormwater is regulated by NPDES permits if the industrial activity has the potential for significant materials and activities to be exposed to stormwater discharges. The number of active acres that were regulated under industrial permits in Freeborn County was available from MPCA Industrial Stormwater Permit data. The percent of area with an industrial stormwater permit was determined by dividing the total industrial stormwater acres by the total county acre; the total active permitted industrial stormwater acres made up 0.097% of the total area. To add in a small MOS, 0.1% of the area in all impairments was assumed to be under an active industrial stormwater permit.

To determine the load that was allowed from construction and industrial stormwater, the loading capacity in each flow zone (not including the boundary condition, the MOS, or the permitted point source WLAs) was multiplied by 0.004 to represent 0.3% from construction stormwater and 0.1% from industrial permits.

4.3.3 Margin of safety

For TSS TMDLs in the Shell Rock River Watershed, an explicit MOS was calculated for each impairment as 10% of the loading capacity. Ten percent was considered an appropriate and sufficient MOS because the LDC approach minimizes the uncertainty that is associated with TMDL development because the calculation of the loading capacity is the product of the simulated flow and TSS target concentration.

4.3.4 Load allocation methodology

The LA represents the load that is allowed from nonpoint or nonregulated sources of TSS. The LA was calculated as the loading capacity minus the MOS and WLA.

4.3.5 Total Maximum Daily Load summaries

The LDC and TSS TMDL tables for each impaired reach are shown in Figure 44, Figure 45, Table 28, and Table 29. When a boundary condition is included in a TMDL, the load at the boundary condition location is subtracted from the total LA that at the impairment pourpoint, or the outlet of the TMDL reach, to obtain the local LA. In other words, the total LA is the sum of the boundary condition load and the local load. A map of boundary condition and pourpoint locations is included in Appendix E. The percent exceedance of the loading capacity in each flow interval was calculated to provide the magnitude of the exceedance at different flows. Exceedance magnitudes needed by flow help focus future management actions; if higher exceedances occur in a certain flow interval, the management practices should focus on the sources that are most likely to influence the concentrations in those flow conditions. Exceedances of the TSS target during higher flows are typically caused by storm-related sediment washoff or instream/near-stream erosion and scour (i.e., bed and bank loads). Low-flow exceedances are more likely to be caused by direct pollutant loads or sources near the stream [EPA 2007]. The TSS TMDLs in this section have a nutrient-impaired lake draining to them with high concentrations of associated algae. Therefore, boundary conditions were set for each flow zone by assuming that upstream lake-nutrient TMDLs were met (with TP at 90 ug/L and chl-*a* at 30 ug/L), and by reducing the average simulated TSS concentration from the lake by the TSS amount associated with the capped nutrient/phytoplankton concentrations.

The required loading capacities, current loads, and exceedance of loading capacities are shown in the TMDL tables and represent the loads for each reach minus any boundary conditions, while the LDCs show the entire loading capacity at the outlet of the impaired reach. Based on the HSPF-simulated TSS loads, all of the turbidity-impaired reaches exceed the loading capacity in the higher flow zones and none exceed the loading capacity in the lower flow zones. Exceedance of the TSS loading capacity is not specified by source and reductions to meet TMDLs could come from any combination of sources from the LA and WLA.

Figure 44. Shell Rock River Reach 501 TSS LDC with simulated flow and observed TSS from S000-084.

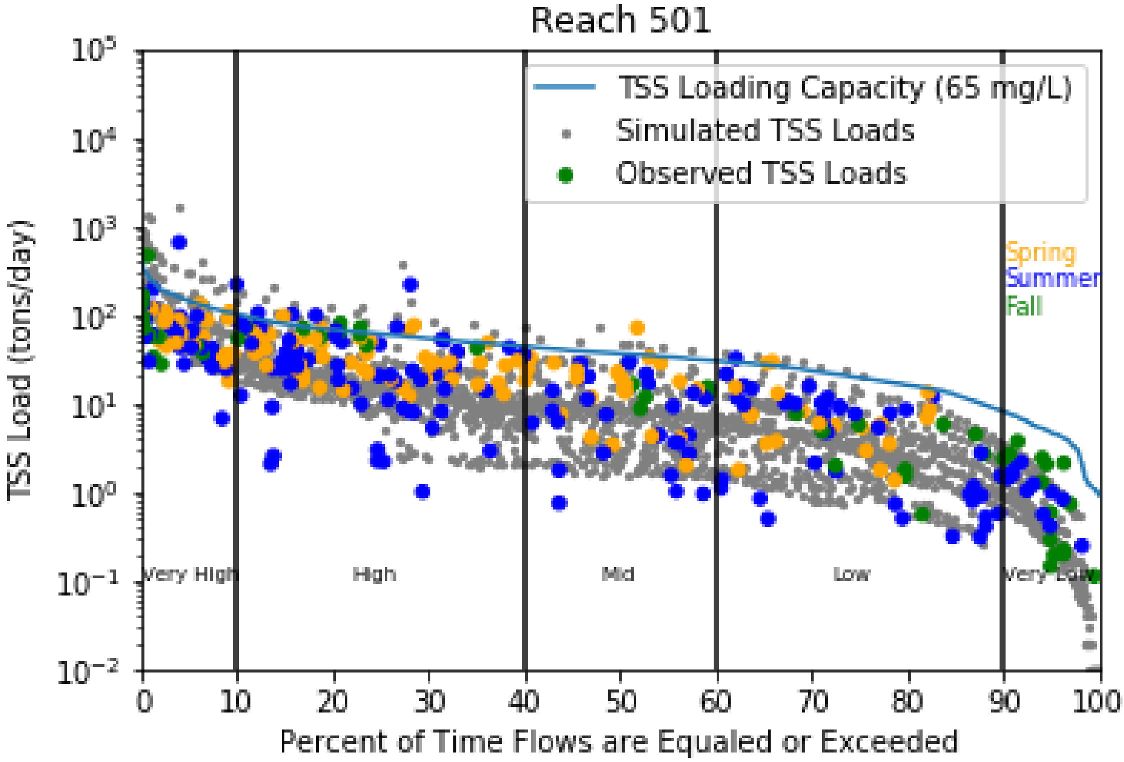


Table 28. Shell Rock River Reach 501 TSS TMDL Summary.

07080202-501		Flow Zone									
TSS TMDL Component (tons/day)		**Very High**		**High**		**Mid**		**Low**		**Very Low**	
Wasteload Allocations	Permitted Wastewater Dischargers	2.42	2.85	2.42	2.56	2.42	2.50	2.42	2.45	*	
	Industrial/Construction Stormwater	0.12		0.04		0.02		0.01		0.01	0.03
	MS4 (MS400263)	0.31		0.1		0.06		0.02		0.02	
Load Allocation	Local	30.65	136.22	9.78	56.55	5.82	32.89	2.19	16.52	1.72	4.45
	Albert Lea Lake Boundary Condition (BC) Load	105.57		46.77		27.07		14.33		2.73	
Margin of Safety (10% of the Overall Allowable Load from the Impaired Reach Local Watershed)		3.72		1.37		0.92		0.52		0.19	
Loading Capacity	At Impairment Pourpoint (TMDL)	142.79		60.48		36.31		19.49		4.67	
	Adjusted for Albert Lea Lake BC	37.22		13.71		9.24		5.16		1.94	
Current Load	At Impairment Pourpoint	327.26		48.26		27.36		11.31		1.42	
	From Albert Lea Lake BC	235.90		27.86		21.46		9.83		1.45	
	Adjusted for Albert Lea Lake BC	91.36		20.40		5.90		1.48		0.00	
Current Load Exceedance of Loading Capacity (%)	At Impairment Pourpoint	56		0		0		0		0	
	Below Albert Lea Lake BC	59		33		0		0		0	

Note: The WLAs for the permitted wastewater dischargers are based on facility design flows. The WLA that exceeded the low-flow regime total daily loading capacity is denoted in the table by an asterisk (*). For this flow regime, the WLA and nonpoint-source LA is determined by the following formula:

Allocation = (flow contribution from a given source) × (TSS concentration limit or standard) × conversion factor.

Allocation = (flow contribution from a given source) × (TSS concentration limit or standard) × conversion factor.

Figure 45. Shoff Creek Reach 516 TSS LDC with simulated flow and observed TSS from S004-114.

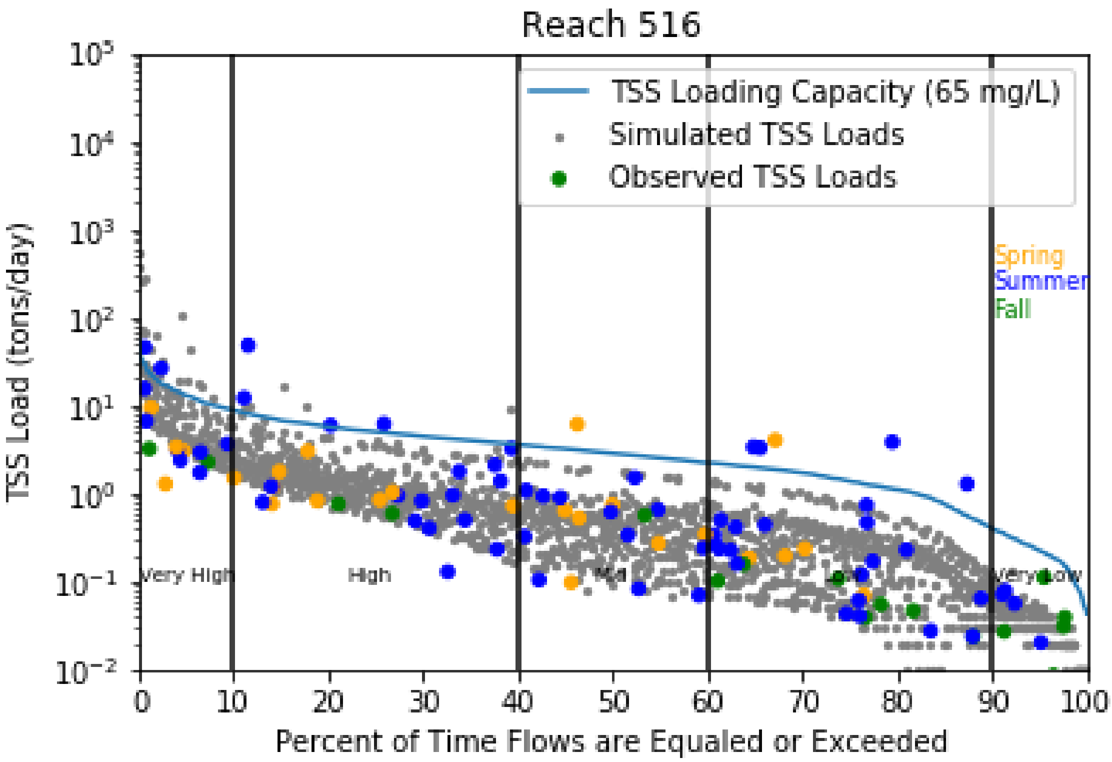


Table 29. Shoff Creek Reach 516 TSS TMDL summary.

07080202-516		Flow Zone									
TSS TMDL Component (tons/day)		**Very High**		**High**		**Mid**		**Low**		**Very Low**	
Wasteload Allocations	Permitted Wastewater Dischargers	N/A	0.34	N/A	0.13	N/A	0.076	N/A	0.043	N/A	0.011
	Industrial/Construction Stormwater	0.03		0.01		0.006		0.003		0.001	
	MS4 (MS400263)	0.31		0.12		0.07		0.04		0.01	
Load Allocation	Local	6.17	11.91	2.38	4.63	1.39	2.62	0.72	1.25	0.20	0.20
	Pickeral Lake Boundary Condition (BC) Load	5.74		2.25		1.23		0.53		0.00	
Margin of Safety (10% of the Overall Allowable Load from the Impaired Reach Local Watershed)		0.72		0.28		0.16		0.09		0.02	
Loading Capacity	At Impairment Pourpoint (TMDL)	12.97		5.04		2.86		1.38		0.23	
	Adjusted for Pickeral Lake BC	7.23		2.79		1.63		0.85		0.23	
Current Load	At Impairment Pourpoint	23.45		3.36		0.98		0.62		0.05	
	From Pickeral Lake BC	7.07		2.11		0.55		0.45		0.00	
	Adjusted for Pickeral Lake BC	16.38		1.25		0.43		0.17		0.05	
Current Load Exceedance of Loading Capacity (%)	At Impairment Pourpoint	44.69		0		0		0		0	
	Below Pickeral Lake BC	56		0		0		0		0	

4.4 Nutrients (phosphorus) in streams

Because river eutrophication standards are in place for the annual growing season (June to September) averages, the TP TMDLs were based on annual growing-season averages. The Shell Rock River TMDL allocations that are discussed below were verified by using an HSPF scenario (See Section 3.6).

4.4.1 Loading capacity

The loading capacity for the TP TMDL was set by multiplying the median of daily average simulated flow over the growing season from 2009 to 2018 with the target concentration of 0.150 mg/L and a unit conversion factor. The TMDL is the reach loading capacity and the sum of the LA, WLA, and an MOS, as shown in Equation 5. Because the average Albert Lea WWTF flows over the TMDL time period (4.040 mgd) were less than half of what is permitted (dry weather design flow 9.125 mgd), the additional permitted point-source flow (5.085 mgd) was added to the median daily average simulated flow at the pourpoint for the TMDL calculations. For consistency, the additional flows from the Glenville WWTF (0.124 mgd) were also added to the median daily average flow at the pourpoint for the TMDL calculations.

$$\mathrm{TMDL} = \sum\left(\mathrm{WLA}\right) + \sum\left(\mathrm{LA}\right) + \mathrm{MOS}. \tag{5}$$

4.4.2 Margin of safety

For TP TMDLs in the Shell Rock River Watershed, an explicit MOS was calculated for each impairment as 10% of the loading capacity. Ten percent was considered an appropriate and sufficient MOS because the loading capacity calculation is the product of the median growing-season simulated flow, growing-season TP target concentration, and a conversion factor. Additionally, the percent difference between the median of observed flow available during the TMDL time period and paired simulated flow from the HSPF model is under 10%.

4.4.3 Load allocation methodology

The LA represents the load that is allowed from nonpoint or nonregulated sources of TP. For the Shell Rock River Reach 501, the “total local allocation” was estimated for model reaches that were downstream of Albert Lea Lake and contributed to Shell Rock River, with the assumption that flow from local land that contributed to the Shell Rock River (obtained from the HSPF model application) could be reduced to an average concentration of 0.150 mg/L (the growing-season instream target concentration). This reduction equated to an approximate 34% reduction from local loads. The feasibility of this assumption was verified by using scenarios in which local cropland was converted to grassland loads and to wetland loads. The historical modeled average instream concentrations from local watersheds varied from 0.12 mg/L to 0.18 mg/L; when local cropland was converted to grassland and/or wetlands for the verification scenarios, the average instream concentrations from all of the local watersheds were reduced to approximately 0.03 mg/L. The local allocation of 31.5 lb/day was decreased by 10% to 28.3 lb/day to account for the MOS and was then separated into the LA (98.6% or 27.9 lb/day), the MS4 load (1% or 0.3 lb/day), and the industrial/construction load (0.4% or 0.1 lb/day). For the Shoff Creek TMDL, the LA was calculated as the loading capacity minus the MOS and WLA.

4.4.4 Wasteload allocation methodology

TMDL WLAs are typically divided into three categories: NPDES point-source dischargers, permitted MS4s, and construction and industrial stormwater. Long term average compliance with wasteload allocations represents TMDL goal attainment for wastewater treatment facilities. The following sections describe how each of these WLAs was estimated.

4.4.4.1 Municipal Wastewater WLAs

Two active NPDES wastewater dischargers drain to the TP-impaired Shell Rock River Reach 501 below Albert Lea Lake. Wastewater dischargers that are upstream of Albert Lea Lake will be given WLAs in their associated upstream-lake TMDLs, and are therefore not given WLAs for the Shell Rock River Reach 501 TMDL. The Glenville WWTF is a controlled discharge stabilization pond facility that is authorized to discharge at a maximum rate of 6 inches per day from its 3.97-acre secondary pond, which is equivalent to 0.647 mgd. The facility is not authorized to discharge in the summer from June 15 to September 15, which leaves 30 days during the 122-day growing season in which the facility can discharge (24.6% of growing-season days). Therefore, to set the Glenville WWTF WLA of 2.7 lbs/day, it was assumed that the facility discharges 0.647 mgd at 2 mg/L for 24.6% of the growing season. The other facility that drains directly to the Shell Rock River, the Albert Lea WWTF, is a mechanical plant that discharges daily. The Albert Lea WWTF is permitted with a dry-weather design flow of 9.125 mgd and a 30-day wet-weather design flow of 18.38 mgd. However, the Albert Lea WWTF discharge over the TMDL time period generally remained well under its dry-weather design flow, at an average of approximately 4.04 mgd. The allowable load for the Albert Lea WWTF was set as the remainder of the available TMDL load after the load from Albert Lea Lake and local allowable load were subtracted (48.4 lb/day). No active NPDES wastewater dischargers drain to Shoff Creek Reach 516. The TP WLAs are shown in Table 30. The LAs and WLAs used in the RES compliance scenario are described in section 4.4.5.

Table 30. Total phosphorus WLAs for permitted point sources.

Impaired Reach	Facility	Permit	Design Flow (mgd)	TMDL Concentration (mg/L)	Total Phosphorus WLA (lbs/day)	Impaired Reach Point-Source WLA
501	Glenville WWTF	MN0021245	0.647	2.000	2.7	51.1
	Albert Lea WWTF	MN0041092	9.125	0.636	48.4	

4.4.4.2 Municipal Separate Storm Sewer System (MS4) WLAs

The Albert Lea City MS4 (MS400263) overlaps the watersheds of the Shell Rock River Reach 501 and Shoff Creek Reach 516 impairments. The MS4 allocation for the local area in the Albert Lea MS4 only includes the area that is below the Albert Lea Lake boundary condition. This allocation was set based on the HSPF-modeled fraction of flow contribution from the HSPF-modeled MPCA designated MS4 areas that drained to each impaired reach. For Shell Rock River Reach 501, the fraction of flow (0.010) from the MS4 that is below Albert Lea Lake was applied to the local allocation (as discussed in Section 4.4.3) minus the 10% MOS. For Shoff Creek Reach 516, the MS4 allocation fraction (0.048) was applied to the TDLC below the Pickeral Lake boundary condition minus the 10% MOS and permitted wastewater dischargers.

For the Shell Rock River Watershed TMDL, all NPDES and SDS permitted feedlots are permitted to have zero discharge and as such, they do not receive a WLA. All other nonpermitted feedlots and the land application of all manure are accounted for in the LA for nonpoint sources.

4.4.4.3 Construction/Industrial Stormwater WLAs

Construction stormwater is regulated by NPDES permits for any construction activity that disturbs (1) one acre or more of soil; (2) 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 (3) 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 with construction activities reflects the number of construction sites that have less than one acre and are expected to be active in the impaired reach subwatershed at any one time. A categorical WLA was assigned to all of the construction activity in the watershed. The average annual acres that are under construction in Freeborn County were available from 2009 to 2018 from MPCA Construction Stormwater Permit data. The percent of acres that were under construction in the county was calculated by dividing the total construction acres by the total county acres; this percentage was multiplied by the portion of the TMDL LA that was associated with direct drainage to determine the construction stormwater WLA. The average annual construction acres from 2009 to 2018 made up 0.26% of the total county acres. Also, 0.3% of the area in all of the impairment drainage areas was assumed to be under construction to add a small MOS. Industrial stormwater is regulated by NPDES permits if the industrial activity has the potential for significant materials and activities to be exposed to stormwater discharges. The number of active acres that were regulated under industrial permits in Freeborn County was available from MPCA Industrial Stormwater Permit data. The percent of area with an industrial stormwater permit was determined by dividing the total industrial stormwater acres by the total county acres. The total active permitted industrial stormwater acres made up 0.097% of the area. Also, 0.1% of the area in all of the impairments was assumed to be under an active industrial stormwater permit to add a small MOS.

To determine the local load that was allowed from construction and industrial stormwater in Shell Rock River Reach 501, the local allocation (which was based on all local watersheds that achieved a concentration of 0.150 mg/L [the growing season in-stream target concentration]) minus the MOS was multiplied by 0.004 to represent 0.3% from construction stormwater and 0.1% from industrial permits. To determine the load that was allowed from construction and industrial stormwater in Shoff Creek Reach 516, the loading capacity below the Pickeral Lake boundary condition (not including the MOS or the permitted point-source WLAs) was multiplied by 0.004 to represent 0.3% from construction stormwater and 0.1% from industrial permits.

4.4.5 Total Maximum Daily Load summaries

Table 31 shows the TP TMDL for the Shell Rock River Reach 501. When a boundary condition is included in a TMDL, the load at the boundary condition location is subtracted from that at the pourpoint, or the outlet of the TMDL reach, to obtain the locally available load. A map of boundary condition and pourpoint locations is included in Appendix E. In the Shell Rock River Reach 501, it was determined that a 64.3% reduction is needed at the pourpoint. If Albert Lea Lake is in compliance with its TMDL, a 74.4% reduction is required from sources that are below Albert Lea Lake. For the Shell Rock River Reach 501, the TMDL allocations were verified using an HSPF model scenario in which assumptions discussed in previous sections for the loading capacity, the Albert Lea Lake boundary condition (capped at 0.09 mg/L (90 µg/L)), the local load (reduced by approximately 34%), and the WLAs (reduced facility loads to meet the loading capacity) were adjusted from the base condition. The scenario was run assuming that during the majority of the growing season, the Albert Lea WWTF was discharging at the dry weather design flow (9.125 mgd). When the facility is discharging at the 30-day wet weather design flow (the flow that would be expected during the wettest 30-days of a year–18.38 mgd), it was assumed that the streamflow would be dominated by flows from Albert Lea Lake and local areas below Albert Lea Lake and would have a minimal impact on the phosphorus concentrations and loads in the Shell Rock River. Because the facility has not historically been discharging at their dry weather design flow, additional scenarios were run to determine what the maximum concentration could be if the Albert Lea WWTF continues to discharge at their lower historical flows (an average of 4.04 mgd). The scenario results showed that if the Albert Lea WWTF were to discharge their TP TMDL WLA at the lower historic flows, the Shell Rock River would be in exceedance of the 0.150 mg/L (150 µg/L) water quality standard. This is because the WLA load at lower flows (4.04 mgd) would increase the concentration to a value much higher than the 0.636 mg/L shown in Table 30. The scenario showed that the maximum concentration that could be discharged from the facility should remain at or below 1 mg/L for the Shell Rock River to remain in compliance with their seasonal average standard of 0.150 mg/L. Therefore, in addition to the WLA of 48.4 lb/day for the Albert Lea WWTP that is based off the dry-weather design flow of 9.125 mgd, a concentration limit of 1 mg/L should be implemented.

Table 31. Shell Rock River Reach 501 total phosphorus TMDL.

09020309-501 Total Phosphorus TMDL Component		Load Allocation (lbs/day)	
Wasteload Allocation	Permitted Wastewater Dischargers	51.1	51.5
	MS4 (MS400263)	0.3	
	Industrial/Construction	0.1	
Load Allocation	Local	27.9	94.5
	Albert Lea Lake Boundary Condition (BC) Load	66.6	
Margin of Safety (10% of the Overall Allowable Load from the Impaired Reach Local Watershed)		8.8	
Loading Capacity	At Impairment Pourpoint (TMDL)	154.8	
	Adjusted for Albert Lea Lake BC	88.2	
Current Load	At Impairment Pourpoint	433.6	
	From Albert Lea Lake BC	88.4	
	Adjusted for Albert Lea Lake BC	345.2	
Current Load Exceedance of Loading Capacity (%)	At Impairment Pourpoint	64.3%	
	Below Albert Lea Lake BC	74.4%	

Table 32 shows the TP TMDL table for Shoff Creek Reach 516, where it was determined that a 3.8% reduction is needed at the pourpoint. If Pickeral Lake is in compliance with its TMDL, a 0% reduction is required from sources that are below Pickeral Lake.

Table 32. Shoff Creek Reach 516 total phosphorus TMDL summary.

09020309-516 Total Phosphorus TMDL Component		Load Allocation (lbs/day)	
Wasteload Allocations	Permitted Wastewater Dischargers	NA	0.43
	MS4 (MS400263)	0.4	
	Industrial/Construction	0.03	
Load Allocation	Local	6.8	9.6
	Pickeral Lake Boundary Condition (BC) Load	2.8	
Margin of Safety (10% of the Overall Allowable Load from the Impaired Reach Local Watershed)		0.8	
Loading Capacity	At Impairment Pourpoint (TMDL)	10.83	
	Adjusted for Pickeral Lake BC	8.0	
Current Load	At Impairment Pourpoint	11.2	
	From Pickeral Lake BC	4.0	
	Adjusted for Pickeral Lake BC	7.2	
Current Load Exceedance of Loading Capacity (%)	At Impairment Pourpoint	3.8%	
	Below Pickeral Lake BC	0.0%	

4.5 Dissolved oxygen

The Shell Rock River DO TMDL is required because the reach exceeded Minnesota's DO standard of 5 mg/L (daily minimum) more than 10% of the time. The numerical TMDL is the sum of the WLA, LA, and MOS. Implementation of the phosphorus TMDL described in Section 4.4 will significantly improve the DO concentrations in the Shell Rock River because the reduction of phosphorus will lead to a reduction in algae and ultimately, a reduction in BOD, NOD, and SOD. Therefore, if the TP TMDL is met, HSPF model scenarios indicate the DO TMDL will also be met.

4.5.1 Loading capacity

The loading capacity in a DO TMDL is the maximum allowable oxygen demand that the stream can withstand and still meet water quality standards. To determine the loading capacity for the Shell Rock River Reach 501 DO TMDL, the TP and its associated oxygen demand rates were decreased in an HSPF-modeled DO TMDL scenario until the model-predicted minimum daily DO in the impaired reach stayed at or above the 5.0 mg/L standard.

The TMDL is the reach loading capacity and the sum of the LA, WLA, and an MOS, as shown in Equation 6.

$$\mathrm{TMDL} = \sum(\mathrm{WLA}) + \sum(\mathrm{LA}) + \mathrm{MOS}. \tag{6}$$

4.5.2 Margin of safety

For DO TMDLs, an explicit 10% MOS was included to provide a reasonable and sufficient safety factor. The oxygen demand for this TMDL was not measured directly because it was calculated by using model-predicted rates and variables. A 10% MOS accounts for the uncertainty in model-predicted loads and how the stream may respond to changes in oxygen demand loading.

4.5.3 Load allocation methodology

The LA represents the oxygen demand load that is allowed from nonpoint or nonregulated sources of oxygen demand. For Shell Rock River Reach 501, the total local allocation was estimated for model reaches that were downstream of Albert Lea Lake and contributed to Shell Rock River, with the assumption that the TP from local land that contributed to the Shell Rock River could be reduced to an average concentration of 0.150 mg/L (the instream target concentration). The modeled oxygen demand that was associated with the reduced local TP represented the total local allocation. The LA represented 98.6% of the total local allocation less the 10% MOS to account for the nonMS4 flow (1.0%) and nonindustrial/construction stormwater areas (0.4% of the local area).

4.5.4 Wasteload allocation methodology

TMDL WLAs are typically divided into three categories: NPDES point-source dischargers, permitted MS4s, and construction and industrial stormwater. Long term average compliance with wasteload allocations represents TMDL goal attainment for wastewater treatment facilities. The following sections describe how each of these WLAs was estimated.

Two active NPDES wastewater dischargers drain to the DO-impaired Shell Rock River Reach 501 below Albert Lea Lake. Wastewater dischargers that are upstream of Albert Lea Lake will be given TP WLAs in the associated upstream TP lake TMDLs, and an associated oxygen demand boundary condition will be set for the lake with the assumption that it is meeting the TP TMDL during the growing season. Therefore, wastewater dischargers upstream of Albert Lea Lake will not be given TP WLAs in relation to the DO TMDL. The Glenville WWTF WLA from the TP TMDL (2.7 lb/day) was used in the HSPF-modeled DO TMDL scenario for consistency with the TP TMDL and is applicable for the full year. The other facility that drains directly to the Shell Rock River, the Albert Lea WWTF, is a mechanical plant that discharges daily. The Albert Lea WWTF is permitted with a dry-weather design flow of 9.125 mgd and a 30-day wet-weather design flow of 18.38 mgd. However, the Albert Lea WWTF discharge over the TMDL time period generally remained well under its dry-weather design flow, at an average of approximately 4.04 mgd. For the HSPF-modeled DO TMDL scenario, the Albert Lea WWTF was run at the dry-weather design flow (9.125 mgd), with the concentration reduced until the DO in the stream was met 100% of the time at flows above the 7Q10. The TP WLAs that are associated with the required oxygen demand reductions for the DO TMDL are shown in Table 33. The HSPF-modeled DO TMDL scenario was run with the assumption that during the majority of the year, the facility discharges at the dry-weather design flow, and when the facility discharges at the 30-day wet-weather design flow (the flow that would be expected during the 30 wettest days of a year), the stream flow will be dominated by lake and local discharge and the facility will have a minimal impact on the TP that is delivered to the Shell Rock River (and, in turn, on the DO in the river).

Table 33. Total phosphorus WLAs for permitted point sources.

Impaired Reach	Facility	Permit	Design Flow (mgd)	Permitted Concentration (mg/L)	Total Phosphorus WLA (lbs/day)	Associated Oxygen Demand (lb/day)	Impaired Reach Point-Source WLA
501	Glenville WWTF	MN0021245	0.647	2.00	2.7	8.7	175.8
	Albert Lea WWTF	MN0041092	9.125	0.68	51.8	167.1	

The Albert Lea City MS4 (MS400263) overlaps the Shell Rock River Reach 501 watershed. The MS4 allocation for the local area in the MPCA designated Albert Lea MS4 that was below the Albert Lea Lake boundary condition was set based on the HSPF-modeled fraction of flow contribution from the MS4 areas that drained to the impaired reach. For Shell Rock River Reach 501, the fraction of flow (0.010) from the MS4 that was below Albert Lea Lake was applied to the local allocation that was discussed in Section 4.5.3 less the 10% MOS.

For the Shell Rock River Watershed TMDL, all NPDES and SDS permitted feedlots are designed to have zero discharge and as such, they do not receive a WLA. All other nonpermitted feedlots and the land application of all manure are accounted for in the LA for nonpoint sources.

Construction stormwater is regulated by NPDES permits for any construction activity that disturbs (1) one acre or more of soil; (2) 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 (3) 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 with construction activities reflects the number of construction sites that have less than one acre and are expected to be active in the impaired reach subwatershed at any one time. A categorical WLA was assigned to all of the construction activity in the watershed. The average annual acres that were under construction in Freeborn County were available from 2009 to 2018 from MPCA Construction Stormwater Permit data. The percent of acres in the county that were under construction was calculated by dividing the total construction acres by the total county acres; this percentage was multiplied by the portion of the TMDL LA that was associated with direct drainage to determine the construction stormwater WLA. The average annual construction acres from 2009 to 2018 made up 0.26% of the total county acres. Also, 0.3% of the area in all of the impairment drainage areas was assumed to be under construction to add a small MOS.

Industrial stormwater is regulated by NPDES permits if the industrial activity has the potential for significant materials and activities to be exposed to stormwater discharges. The number of active acres that were regulated under industrial permits in Freeborn County was available from MPCA Industrial Stormwater Permit data. The percent of area with an industrial stormwater permit was determined by dividing the total industrial stormwater acres by the total county acres. The total active permitted industrial stormwater acres made up 0.097% of the area. Also, 0.1% of the area in all of the impairments was assumed to be under an active industrial stormwater permit to add a small MOS.

To determine the local load that was allowed from construction and industrial stormwater in Shell Rock River Reach 501, the local allocation (which was based on all local watersheds achieving a concentration of 0.150 mg/L) less the 10% MOS was multiplied by 0.004 to represent 0.3% from construction stormwater and 0.1% from industrial permits.

4.5.5 Total Maximum Daily Load summaries

The final TMDL allocations for the Shell Rock River Reach 501 are included in Table 34. When a boundary condition is included in a TMDL, the load at the boundary condition location is subtracted from that at the impairment pourpoint, or the outlet of the TMDL reach. A map of boundary condition and pourpoint locations is included in Appendix E. The TP was systematically reduced throughout the areas that drain directly to impaired reaches until the 5.0 mg/L DO standard was achieved 100% of the time because the lowest DO concentration occurred at a flow that was greater than the 7Q10. The loads represent the total potential oxygen demand, which is counteracted in the stream by reaeration and other oxygen-supplying processes that are simulated in the model application. The total oxygen demand is the combination of BOD, NOD, and SOD. The modeled SOD makes up approximately 96% of the total oxygen demand, BOD makes up just under 4%, and NOD makes up under 1%. The SOD dominates the system oxygen demand but is driven by nutrient loads and BOD and NOD components. The oxygen demand presented in the DO TMDL table from the HSPF model scenarios takes into account that decreases in TP concentrations from Albert Lea Lake, the local area draining to the Shell Rock River, and the local point sources will lead to decreases in algae and organic matter that will cause eventual decreases in SOD [EPA 1995]. The amount of time for the SOD to respond can depend on the climate and stream characteristics that could affect the removal of oxygen demanding materials from the system through nutrient cycling processes and transport of sediment [EPA 1997]. From the HSPF model DO scenario, after the 69.7% reduction in oxygen demand, SOD makes up 86% of the total oxygen demand, while BOD and NOD both make up 7% of the total oxygen demand.

Table 34. Shell Rock River Reach 501 DO TMDL.

TMDL Component		Oxygen Demand(a) (lb/day)	
Wasteload Allocation	Permitted Wastewater Dischargers	175.8	176.4
	MS4 (MS400263)	0.4355	
	Construction and Industrial Stormwater	0.1742	
Load Allocation	Local	42.94	263.2
	Albert Lea Lake Boundary Condition (BC) Load	220.3	
Margin of Safety (10% of the Overall Allowable Load from the Impaired Reach Local Watershed)		24.37	
Loading Capacity	At Impairment Pourpoint (TMDL)	464.0197	
	Adjusted for Albert Lea Lake BC	243.7	
Current Load at Impairment Pourpoint		1529	
Current Load Exceedance of Loading Capacity (%) at Impairment Pourpoint		69.7%	

(a) Oxygen demand accounts for the combination of SOD, NOD, and BOD.
(b) If RES TP TMDL is met, HSPF model indicates that DO TMDL will also be met.

4.6 pH

The Shell Rock River is impaired by pH below Albert Lea Lake; the high pH level can be attributed to excess phosphorus in Albert Lea Lake, as indicated in Section 3.7.5. For the Shell Rock River Reach 501, TP in Albert Lea Lake is considered to be the surrogate for pH. The TP allocations that were provided in Section 4.8 to address eutrophication in Albert Lea Lake via the excess nutrient TMDL will also address the pH impairment in the Shell Rock River Reach 501. A separate TMDL is not needed for pH.

4.7 Aquatic macroinvertebrate and fish bioassessments

The Stressor ID Study [MPCA 2014] found that in the Shell Rock River Reach 501, the prominent stressors are the elevated nitrate, phosphorus, pH, and chl-*a* levels and resultant DO fluctuations. The study mentioned that bedded sediment affects habitat availability, and the undercutting of stream banks contributes to the influx of fine sediment. The suspended and bedded sediment are closely tied. TMDLs written for the Shell Rock River Reach 501 include phosphorus, DO, and TSS. An additional TMDL is written for TP in Albert Lea Lake directly upstream of the Shell Rock River Reach 501. The TP, TSS, and DO surrogate parameters will address the aquatic macroinvertebrate and fish bioassessments. pH is expected to be addressed with the surrogate Albert Lea Lake TP TMDL, and will also help address the aquatic macroinvertebrate and fish bioassessments. Therefore, TMDLs in Sections 4.3, 4.4, 4.5, and 4.8 will be used as surrogates for aquatic macroinvertebrate and fish bioassessments and an additional TMDL is not needed. Because there is not currently an in-stream standard for nitrate in Class 2 or 3 streams, the nitrate in the Shell Rock River is addressed in the WRAPS report.

4.8 Nutrients (phosphorus) in lakes

The loading capacity for impaired lakes was determined by using calibrated BATHTUB models that were based on annual HSPF-model output and calibrated to the growing-season (June to September) monitored mean values for TP, chl-*a*, and SDT from 2009 to 2018. The allowable loading capacity (i.e., the TMDL) is defined as the maximum allowable pollutant load that will allow for water quality standards to be met. The loading capacities were defined by using the calibrated BATHTUB models and reducing source loads until the appropriate standards were achieved for each lake.

The TMDL equation is as follows:

$$\mathrm{TMDL} = \sum\left(\mathrm{WLA}\right) + \sum\left(\mathrm{LA}\right) + \mathrm{MOS}. \tag{7}$$

The LA represents the load that is allowed from nonpoint sources; the WLA represents the load that is allowed from permitted discharging point sources, MS4s, and stormwater sources; and the MOS is an explicit amount (which is usually expressed as a percent of the TMDL) that is used to increase the likelihood of compliance by accounting for potentially unknown or unquantifiable nutrient sources.

Watershed loading to the lakes is derived by using the calibrated Shell Rock River HSPF model [Lupo 2019]. The mean annual runoff and flow-weighted mean TP concentrations with mean coefficients of variation (CVMeans) for each tributary and lakeshed provide the input to each lake’s BATHTUB model, as defined in Section 4.4.1.

4.8.1 Lake model

The lake-modeling software BATHTUB (Version 6.1), which was developed by Dr. William W. Walker for the U.S. Army Corps of Engineers, integrates watershed runoff with lake-water quality. This publicly available, peer-reviewed model has been successfully implemented in lake studies throughout the U.S. for more than 30 years and uses steady-state annual water and nutrient mass balances to model advective and diffusive transport and nutrient sedimentation [Walker 2006]; lake responses (e.g., chl-*a* concentration or SDT) are predicted via empirical relationships [Walker 1985]. BATHTUB allows its users to specify single lake segments (lake bays) or multiple segments with complicated flow routing, and calculates the lake response for each segment from morphometry and user-supplied lake fetch data. The cumulative annual phosphorus load of all of the external watershed and internal lake sources can be empirically related to the lake recreation period (e.g., growing-season) conditions [Walker 1996] and expressed as the average summer TP, chl-*a*, and SDT. This predictive model includes statistical analyses to account for variability and uncertainty.

4.8.1.1 Representations of lake systems in BATHTUB models

Two of the TMDL lakes, Pickeral and White, were represented by a single lake segment, as defined by lake surface area, mean depth, and fetch length. Fountain Lake has three distinct bays, with two bays

(East and West) that require TMDLs. The East and West Bay had separate impairment listings and have two distinct BATHTUB models, each with one segment. Albert Lea Lake had four bays that required four separate segments in the BATHTUB model. One TMDL was required at the outlet of Albert Lea Lake. The lake surface area, mean depth, and length and fetch of each bay were determined by using GIS and lake bathymetry data. A GIS layer was provided to RESPEC by the Shell Rock River SRRWD with lake bathymetry data. The GIS data had 1 foot contours which were used to calculate the volume at each contour (i.e. 0 to 1ft). The volumes of each contour were summed to get the lake volume. The BATHTUB model requires surface area and average depth. The surface area was determined based on the GIS data while average depth was calculated by dividing the lake volume by the surface area.

Lakes that were in series, joined, or in close proximity to each other were assessed separately, as needed. The HSPF-derived average annual water and phosphorus inputs to each lake from the TMDL time period were entered for all of the upgradient tributaries and each lake's immediate drainage areas (lakesheds). A number of homes/businesses in each impaired lake watershed are served by SSTS. SSTS within 1,000 feet of impaired lakes were supplied by Freeborn County for this TMDL [Wehner 2019], and literature values were used to estimate the total annual loading from SSTS for BATHTUB input. Applicable WWTF contributions also provided BATHTUB input. The annual precipitation and evaporation that were used in these models were from 0.92 meters per year (m/yr) to 0.95 m/yr and 0.7 m/yr, respectively, for all of the BATHTUB model lakes. The precipitation values were based on HSPF climate station average values; the evaporation value came from the *Minnesota Lake Water Quality Assessment Report: Developing Nutrient Criteria* [MPCA 2005]. Observed lake water quality data (i.e., TP, chl-*a*, SDT, and conservative substances) were entered as growing-season (June to September) mean and CVMean values for the TMDL period. The tributary inflows to each lake segment included the mean annual flow volume (in cubic hectometers [hm^3]); pollutant concentrations are entered as flow-weighted mean concentrations and CVMeans.

Lakes in the series include East/West Fountain and Albert Lea Lake. The TMDL allocations for upgradient lakes were determined separately, with corresponding reductions incorporated into the downstream lake TMDL allocation; the inclusion of an explicit MOS in the upstream lake offers an implicit MOS for the downstream lake. A tributary to East Fountain Lake, Shoff Creek, had a TMDL allocation with corresponding phosphorus reduction incorporated into East Fountain Lake's reductions.

BATHTUB includes several model choices to predict TP, chl-*a*, SDT, and other lake responses (with selected models listed by lake); a complete list of input and modeling coefficients is included in Appendix F.

4.8.1.2 Modeling Sequence

Lake modeling can determine the present-day phosphorus loads that could exceed lake standards, as well as the allowable phosphorus loads and reductions required to achieve water quality standards and MOS. The modeling of present-day conditions was completed for each lake and calibrated to the TMDL time period's (2009 to 2018) growing-season average water quality data. Each lake's BATHTUB model was calibrated by adjusting the calibration coefficients and/or internal loading rates.

4.8.2 Loading capacity

The loading capacity for each lake TMDL was determined by down-scaling the HSPF-simulated tributary, lakeshed, and SSTS loads as well as internal loads (BATHTUB), to achieve a targeted average P concentration of 90 ug/L for each lake. In many cases, the reductions that are required to achieve the water quality standards in each lake require that the tributaries and lakeshed be reduced to below the river standards for the ecoregion that the lake resides in. To determine how much of a reduction should be applied to tributaries and lakesheds, a load- reduction analysis approach (where loads are decreased from available sources until each lake meets standards) ensures that the load reductions are achievable. Land-based load reductions are assumed to come from the following land cover types: cropland, pastureland, and developed land. Therefore, reductions were applied based on the percentage of these land cover types that existed in the area that drained to each impaired lake. The load from these land uses is considered to be the reducible load. Land use load reductions are weighted based on each land use's contribution to the total reducible load; a loading rate can be calculated from the final reduced loads and areas to determine whether or not the reductions are realistic. The SSTS allocation was set to zero phosphorus loading and assumes 100% future compliance to county SSTS regulations. The relative reductions for each lake are a function of the overall reductions necessary to achieve that lake's water quality standards.

4.8.2.1 Subsurface sewage treatment system loading

Freeborn County provided the total number of residences on each lake, septic compliance rates, and year-round versus seasonal residences. The number of occupied homes (year-round and seasonal), average house size, and noncompliance and phosphorus-loss rates of compliant and noncompliant septic systems are included in Table 35. Noncompliant TP-loss rates were based on soil data with sandy soils having a loss rate of 75% and mixed soils having a loss rate of 50%. An estimate of the annual TP loss per capita of 1 kg [Heiskary and Wilson 2005] was used to estimate the mean annual TP loading on septic systems.

The HSPF septic loading estimates are based on large-scale county data and are not appropriately detailed for a TMDL in small lakesheds. Refined estimates of septic system loading were developed independently for each directly impaired lakeshed, and HSPF-modeled lakeshed septic system phosphorus loads replaced these refined estimates.

Table 35. Subsurface sewage treatment system information.

Lake	Year-Round Septics	Noncompliant Septics	Average Household Size	Total Phosphorus-Loss Rate Complying (%)	Total Phosphorus-Loss Rate Noncomplying (%)
Pickeral	42	5	2.28	5	50
White	10	4	2.28	5	50
Fountain (West Bay)	11	4	2.28	5	75
Fountain (East Bay)	0	0	2.28	5	75
Albert Lea	37	6	2.28	5	50

4.8.2.2 Atmospheric loading

An atmospheric phosphorus deposition of 46.9 milligrams per meter squared per year (mg m^{-2}/yr) [Twarowski et al. 2007] was used to quantify average annual total (wet plus dry) deposition on the lake surface. The values reported for dry and wet years were 0.433 and 0.520 kilograms per hectare per year (kg/ha/yr), respectively.

4.8.2.3 Internal loading—cumulative weight-of-evidence approach

Growing-season lake water quality is largely determined by annual phosphorus-loading rates from all sources. However, excessive phosphorus loading can accumulate in lake sediments and influence present-day lake phosphorus concentrations; this process is called internal loading (i.e., phosphorus that is recycled from enriched sediments back into lake waters) and increases lake phosphorus and algal concentrations. The process typically occurs when low- or no-oxygen conditions occur along the sediment-water interface and can be enhanced by other factors, such as low sediment iron, calcium or aluminum content, invasive macrophyte species, and rough fish.

Internal loading can also occur with oxygenated sediments in relation to wind/wave action and rough fish mixing and/or invasive plant phosphorus contributions. Assessments of lake TP dynamics, lake mixing, DO concentrations, and mass-balance unexplained residuals were conducted to evaluate each lake's potential for significant internal loading:

- **Growing-season lake phosphorus dynamics.** Net increases were tabulated for the growing-season mean surface water TP concentrations. Progressive increases in monthly mean phosphorus concentrations reflect internal and external (watershed) loading sources that affect lakes with limited dilution and are subject to resuspension potential. The HSPF modeling also provides estimates of dissolved P loading from lakeshed and tributary sources, which can directly influence shallow lake concentrations and be misidentified as internal loading.
- **Lake mixing.** Lake mixing was evaluated by calculating the lake GR and Osgood Index values for each lake. All of the lakes were assessed as polymictic (well-mixed) lakes.
- **DO.** All shallow lakes experience depleting deeper water DO concentrations to values of 2 mg/L or less.
- **Mass balances.** BATHTUB modeling was conducted for each lake based on HSPF inputs from watershed sources, along with reported Minnesota atmospheric phosphorus deposition and estimated phosphorus loading from septic tanks. The unexplained residual or phosphorus loads needed to balance the income; outgo budgets were assigned as internal load.

Internal loads are not calculated but, rather, appropriated based on a mass balance and weight of evidence approach. This mass balance analysis starts with entering known TP loads (HSPF modeled lakeshed and tributary, and atmospheric deposition) into BATHUB and running the model to compare the simulated lake TP concentrations versus the observed lake TP concentrations. If there is a large discrepancy (modeled TP concentration is much lower than observed) this is an indication that internal loading is likely occurring. The weight of evidence is based on:

1. reviewing observed data, such as DO and water column temperature profiles, to determine if the lake goes anoxic,
2. Osgood index values to determine if the lake mixes, and
3. seasonal TP and chl-*a* trends to see if levels rise consistently through the growing season (a signature of internal loading).

This is the basic approach used for all lakes. It is known that these lakes have internal loading but the approaches above were used to confirm this. Determining the exact amount of internal loading requires more professional judgement than objective calculations. Since detailed soil boring data was not available to estimate an internal loading rate, the mass balance approach was used. Internal loading was added to lakes to get the simulated TP to match the observed TP. This is reflected in lakes with explicit allocations for internal loading including: White, Fountain (East Bay), Fountain (West Bay), and Albert Lea.

Regarding Pickeral Lake, the mass balance and weight of evidence approach indicated there was no internal loading above and beyond what the lake model simulated. This does not mean that there is no internal loading in Pickeral Lake. Rather, it means that there is no internal loading beyond what is represented in the BATHTUB model. This conclusion aligns with what is known of the lake and past management activities (rough fish kill).

Because of the shallow nature of the lakes, it is expected that internal loading is more related to wind/wave action and rough fish mixing and contributions from invasive plants such as curly-leaf pondweed, than to anoxic conditions at the sediment-water interface. Plots showing the DO and temperature profiles for impaired lakes are included in Appendix A through D.

4.8.3 Wasteload allocation methodology

40 C.F.R. § 130.2(h) states that a WLA is “the portion of a receiving water’s loading capacity that is allocated to one of its existing or future point sources of pollution.” WLA components include permitted point sources, MS4s, and industrial and construction stormwater facilities.

Permitted point sources that contribute to impaired lakes in the Shell Rock River Watershed are listed with their individual WLAs in Table 36. There are a total of six permitted point sources, with two discharging to Fountain Lake (East Bay) (the Clarks Grove WWTF and Albert Lea WTP SD002), and four to Albert Lea Lake (Albert Lea WTP SD001, Cargill Value Added Meats, DNR Myre Big Island State Park, and Hayward WWTF). The city of Clarks Grove has a WWTF (MNG580067) that consists of a stabilization pond and outlets to Bancroft Creek. Albert Lea WTPs SD002 and SD001 (MNG640002) discharge to Fountain Lake (East Bay) and Albert Lea Lake, respectively, with a permitted effluent limit of 28 kg/yr each. Cargill Value Added Meats (MNG255077) outlets to Albert Lea Lake. DNR Myre Big Island State Park (MN0033740) consists of a stabilization pond and outlets to Albert Lea Lake. The Hayward WWTF (MN0041122) consists of a stabilization pond and outlets to CD 22 with a permitted effluent limit of 62 kg/yr. Observed effluent TP loads are below the permitted effluent limits for each point source, which is represented as a negative percent reduction in the TMDL tables.

Table 36. Total phosphorus wasteload allocations for permitted point sources.

Impaired Reach	Facility	Permit	Design Flow (mgd)	Concentration Assumption (mg/L)	Total Phosphorus WLA (lbs/yr)	Total Phosphorus WLA (lbs/day)
Fountain (East Bay)	Albert Lea WTP SD002	MNG640002	0.040	0.5	60.9	0.1669
	Clarks Grove WWTF	MNG580067	1.059	2.0	706.9	1.9366
Albert Lea	Albert Lea WTP SD001	MNG640002	0.040	0.5	60.9	0.1669
	Cargill Value Added Meats	MNG255077	0.061	0.5	92.9	0.2546
	DNR Myre Big Island State Park	MN0033740	0.202	1.0	30.5	0.0835
	Hayward WWTF	MN0041122	0.261	1.0	136.7	0.3745

The Albert Lea MS4 (MS400263) drains to all five nutrient-impaired lakes that are addressed in this report. The model estimated cumulative MS4 load contribution to the TMDL lakes is 2510.5 lbs/yr. This load excludes the MS4 load contribution accounted for in the Shoff Creek nutrient TMDL. Table 37 summarizes the MS4 loads attributed to each tributary and TMDL lakeshed from the HSPF model application.

For the Shell Rock River Watershed TMDL, all NPDES and SDS permitted feedlots are designed to have zero discharge and as such, they do not receive a WLA. All other nonpermitted feedlots and the land application of all manure are accounted for in the LA for nonpoint sources.

Table 37. Model estimated MS4 source total phosphorus loading.

Lake	MS4 Source Location	MS4 Area (acres)	Model Estimated MS4 Phosphorus Load (lbs/yr)	TMDL MS4 Phosphorus Load (lbs/yr)
White	Lakeshed	167	53.5	44.8
Pickeral	Lakeshed	403	131.3	113.6
Fountain (West bay)	Lakeshed	308	100.3	87.8
	Wedge Creek	30	9.3	8.6
	Outlet of White Lake to Fountain West	287	22.5	16.2
Fountain (East Bay)	Lakeshed	705	141.5	66.6
	Shoff Creek	248	85.6	85.6
	Bancroft Creek	3,507	1234	623.6
Albert Lea	Lakeshed	2,472	818.1	769.1

Construction stormwater is regulated by NPDES permits for any construction activity that disturbs (1) one acre or more of soil; (2) 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 (3) 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 with construction activities reflects the number of construction sites that have less than one acre that are expected to be active in the impaired subwatershed at any one time.

A categorical WLA was assigned to all of the construction activity in the watershed. The average annual acres under construction in Freeborn County were available from 2009 to 2018 from MPCA Construction Stormwater Permit data. The percent of acres in the county that were under construction was calculated by dividing the total construction acres by the total county acres; this percentage was multiplied by the portion of the TMDL LA that was associated with direct drainage to determine the construction stormwater WLA. The average annual construction acres from 2009 to 2018 made up 0.26% of the total county acres. Also, 0.3% of the area in all of the impairment drainage areas was assumed to be under construction to add a small MOS.

Industrial stormwater is regulated by NPDES permits if the industrial activity has the potential for significant materials and activities to be exposed to stormwater discharges. The number of active acres that were regulated under industrial permits in Freeborn County was available from MPCA Industrial Stormwater Permit data. The percent of area with an industrial stormwater permit was determined by dividing the total industrial stormwater acres by the total county acres. The total active permitted industrial stormwater acres made up 0.097% of the area. Also, 0.1% of the area in all of the impairments was assumed to be under an active industrial stormwater permit to add a small MOS.

To determine the load that was allowed from construction and industrial stormwater, the loading capacity in each flow zone (minus the MOS) was multiplied by 0.004 to represent 0.3% from construction stormwater and 0.1% from industrial permits.

4.8.4 Margin of safety

The MOS is a portion of the TMDL that is set aside to account for the uncertainties that are associated with achieving water quality standards. It is usually expressed as an explicit percentage of the loading capacity that also serves as an uncertainty insurance measure. An explicit 10% MOS was included for every lake to ensure that water quality goals were met. Lakes that are joined or in close proximity to each other include Fountain (West Bay), Fountain (East Bay), and Albert Lea lakes. TMDL allocations for upgradient lakes were determined separately and assume future compliance with lake water quality standards; they were also incorporated into downstream lake TMDL allocations. Hence, the inclusion of an explicit MOS in the upstream lake offers an implicit MOS for the downstream lake. Note that the endpoint targets for each lake are 1 µg/L below lake eutrophication P standards and offer a slightly higher implicit MOS for each lake.

4.8.5 Load allocation methodology

The LA for each lake is apportioned from the loading capacity (TMDL) minus the MOS and WLAs. It includes all nonregulated sources and those that do not require NPDES permit coverage, as well as unregulated watershed runoff, internal loading, and atmospheric deposition.

4.8.6 Total Maximum Daily Load summaries

The TMDL allocation tables for the impaired lakes are summarized below. BATHTUB modeling determines the allowable load from which the MOS can be subtracted to determine the new total load and apportion the WLAs and LAs. BATHTUB is run on an annual basis and therefor the load in lb/year is divided by 365 to attain lb/day. TMDL tables summarize the existing and allowable loads, TMDL allocations, and required reductions by allocation category. Allocation table values reflect the following conventions in reporting significant digits:

- Pounds per year values are rounded to the nearest 0.1.

- WLA pounds per day values are reported to four significant digits so that values greater than zero are listed in the tables.
- LA category loading of pounds per day is reported to two significant digits.

The reductions that are required to achieve lake standards are listed in Table 38 and range from 46% in Pickeral Lake to 71% in Fountain Lake (West Bay). Individual TMDL allocations for phosphorus-impaired lakes in the Shell Rock River Watershed are included in Table 39, Table 40, Table 41, Table 42, and Table 43. Sequential improvement of water quality will be realized for lakes in series (i.e., joined or in close proximity to each other), as noted for Fountain (East Bay) and Albert Lea lakes. A rough fish kill in Pickeral Lake occurred in 2009. Following the fish kill water quality in the lake improved dramatically. However, water clarity has begun to diminish again in recent years. The Pickeral Lake TMDL represents the average water quality condition from 2009 to 2018. If in-lake management is not readdressed, water quality may continue to decline in future years. Because the TMDL goal for the Pickeral Lake is to further reduce both the internal and external loads, as long as actions are taken (such as recurrent rough fish kills) to achieve the TMDL goals, internal loading should remain at or below the current condition.

Table 38. Required phosphorus reductions for lake TMDLs.

Lake/Type	Required TMDL Reductions
Pickeral	46%
White	55%
Fountain (West Bay)	71%
Fountain (East Bay)	69%
Albert Lea	63%

Table 39. Pickeral Lake nutrient TMDL.

Pickeral Lake Load Allocation		Existing Total Phosphorus Load			Allowable Total Phosphorus Load			Estimated Load Reduction	
		lbs/yr	lbs/day	Daily Load (%)	lbs/yr	lbs/day	Daily Load (%)	lbs/yr	%
Loading Capacity					**2,134.4**	**5.83459**			
Margin of Safety 10%					**213.4**	**0.58**			
Wasteload	**Total WLA**	**139.8**	**0.38309**	**3.9**	**122.1**	**0.33459**	**6.4**	**17.7**	**13**
	MS4 (Albert Lea City MS400263)	131.3	0.3597	3.7	113.6	0.3112	5.9	17.7	13
	Construction/Industrial Stormwater	8.5	0.02339	0.2	8.5	0.02339	0.4	0.0	–
Load	**Total LA**	**3,401.5**	**9.31**	**96.1**	**1798.9**	**4.92**	**93.6**	**1,602.6**	**47**
	Lakeshed	1602.6	4.39	45.3	742.0	2.03	38.6	860.6	54
	Reach 191 (Unnamed)	1095.8	3.00	30.9	734.1	2.01	38.2	361.7	33
	Internal Loading	435.0	1.19	12.3	76.7	0.21	4.0	358.3	82
	SSTS	22.0	0.06	0.6	0.0	0.00	0.0	22.0	100
	Atmospheric Deposition	246.1	0.67	6.9	246.1	0.67	12.8	0.0	–
Total Load		**3,541.4**	**9.70**	**100.0**	**1,921.0**	**5.26**	**100.0**	**1,620.4**	**46**

Table 40. White Lake nutrient TMDL.

White Lake Load Allocation		Existing Total Phosphorus Load			Allowable Total Phosphorus Load			Estimated Load Reduction	
		lbs/yr	lbs/day	Daily Load (%)	lbs/yr	lbs/day	Daily Load (%)	lbs/yr	%
Loading Capacity					**455.4**	**1.247792**			
Margin of Safety 10%					**45.6**	**0.12**			
Wasteload	**Total WLA**	**55.3**	**0.151692**	**6.0**	**46.6**	**0.127792**	**11.4**	**8.7**	**16**
	MS4 (Albert Lea City MS400263)	53.5	0.1467	5.8	44.8	0.1228	10.9	8.7	16
	Construction/Industrial Stormwater	1.8	0.004992	0.2	1.8	0.004992	0.4	0.0	–
Load	**Total LA**	**860.0**	**2.36**	**94.0**	**363.2**	**1.00**	**88.6**	**496.8**	**58**
	Lakeshed	395.5	1.08	43.2	241.9	0.66	59.0	153.6	39
	Internal Loading	385.3	1.06	42.1	53.1	0.15	13.0	332.2	86
	SSTS	11.0	0.03	1.2	0.0	0.00	0.0	11.0	100
	Atmospheric Deposition	68.2	0.19	7.5	68.2	0.19	16.6	0.0	–
Total Load		**915.5**	**2.51**	**100**	**410.0**	**1.12**	**100.0**	**505.5**	**55**

Table 41. Fountain Lake (West Bay) nutrient TMDL.

PRELIMINARY DRAFT: Fountain Lake (West Bay) Load Allocation		**Existing Total Phosphorus Load**			**Allowable Total Phosphorus Load**			**Estimated Load Reduction**	
		lbs/yr	**lbs/day**	**Daily Load (%)**	**lbs/yr**	**lbs/day**	**Daily Load (%)**	**lbs/yr**	**%**
Loading Capacity					**6,902.9**	**18.90415**			
Margin of Safety 10%					**690.3**	**1.89**			
Wasteload	**Total WLA**	**159.6**	**0.43745**	**0.8**	**140.2**	**0.38415**	**2.3**	**19.4**	**12**
	MS4 (Albert Lea City MS400263)	132.0	0.3618	0.6	112.6	0.3085	1.8	19.4	15
	Construction/Industrial Stormwater	27.6	0.07565	0.1	27.6	0.07565	0.4	0.0	–
Load	**Total LA**	**20,936.0**	**57.36**	**99.2**	**6072.4**	**16.63**	**97.7**	**14,863.6**	**71**
	Tributary 70 (Wedge Creek -517)	16844.9	46.15	79.9	5658.8	15.50	91.1	11186.1	66
	White Lake BC	654.2	1.79	3.1	329.4	0.90	5.3	324.9	50
	Tributary 73 (Outlet of White Lake to Fountain Lake)	7.4	0.02	0.0	6.8	0.02	0.1	0.6	8
	Lakeshed	20.5	0.06	0.1	17.4	0.05	0.3	3.1	15
	Internal Loading	3331.4	9.13	15.8	0.0	0.00	0.0	3331.4	100
	SSTS	17.6	0.05	0.1	0.0	0.00	0.0	17.6	100
	Atmospheric Deposition	60.0	0.16	0.3	60.0	0.16	1.0	0.0	–
Total Load		**21,095.7**	**57.80**	**100.0**	**6,212.6**	**17.02**	**100.0**	**14,883.1**	**71**

Table 42. Fountain Lake (East Bay) nutrient TMDL.

PRELIMINARY DRAFT: **Fountain Lake (East Bay)** **Load Allocation**		**Existing Total Phosphorus Load**			**Allowable Total Phosphorus Load**			**Estimated Load Reduction**	
		lbs/yr	**lbs/day**	**Daily Load (%)**	**lbs/yr**	**lbs/day**	**Daily Load (%)**	**lbs/yr**	**%**
Loading Capacity					**18,435.1**	**50.5119**			
Margin of Safety 10%					**1,843.5**	**5.05**			
Wasteload	**Total WLA**	**1,826.0**	**5.00229**	**3.4**	**1617.4**	**4.4319**	**9.7**	**208.6**	**11**
	Albert Lea WTP SD 002	7.0	0.01909	0.0	60.9	0.1669	0.4	-	-
	Clarks Grove WWTP	284.1	0.7782	0.5	706.9	1.937	4.3	-	-
	MS4 (Albert Lea City MS400263)	1,461.2	4.003	2.7	775.9	2.126	4.7	685.3	47
	Construction/Industrial Stormwater	73.7	0.2020	0.1	73.7	0.2020	0.4	0.0	–
Load	**Total LA**	**51,940.8**	**142.31**	**96.6**	**14,974.2**	**41.03**	**90.3**	**36,966.6**	**71**
	Tributary 80 (Fountain Lake West Bay) BC	20,748.0	56.84	38.6	6,043.6	16.56	36.4	14,704.4	71
	Tributary 87 (Shoff Creek -516)	4,809.9	13.18	8.9	2,585.2	7.08	15.6	2,224.7	46
	Tributary 102 (Bancroft Creek)	17,748.7	48.63	33.0	6,241.0	17.10	37.6	11,507.7	65
	Internal Loading	8,529.8	23.37	15.9	0.0	0.00	0.0	8,529.8	100
	Atmospheric Deposition	104.4	0.29	0.2	104.4	0.29	0.6	0.0	–
Total Load		**53,766.7**	**147.31**	**100**	**16,591.7**	**45.46**	**100**	**37,175.1**	**69**

“-“ indicates that no reduction is required.

Table 43. Albert Lea Lake nutrient TMDL.

PRELIMINARY DRAFT: Albert Lea Lake Load Allocation		Existing Total Phosphorus Load			Allowable Total Phosphorus Load			Estimated Load Reduction	
		lbs/yr	lbs/day	Daily Load (%)	lbs/yr	lbs/day	Daily Load (%)	lbs/yr	%
Loading Capacity					**33,625.0**	**92.12497**			
Margin of Safety 10%					**3,362.5**	**9.21**			
Wasteload	**Total WLA**	**1055.9**	**2.8924**	**1.3**	**1224.6**	**3.35497**	**4.0**	**–168.9**	**–16**
	Albert Lea WTP SD001	5.1	0.01384	0.0	60.9	0.1669	0.2	-	-
	Cargill Value Added Meats SD 001	36.7	0.1006	0.0	92.9	0.2546	0.3	-	-
	DNR Myre Big Island State Park SD 001	5.6	0.01526	0.0	30.5	0.08347	0.1	-	-
	Hayward WWTP	55.9	0.1532	0.1	136.7	0.3745	0.5	-	-
	MS4 (Albert Lea City MS400263)	818.1	2.241	1.0	769.1	2.107	2.5	49.0	6
	Construction/Industrial Stormwater	134.5	0.3685	0.2	134.5	0.3685	0.4	0.0	–
Load	**Total LA**	**81,820.8**	**224.16**	**98.7**	**29037.9**	**79.56**	**96.0**	**52,782.9**	**65**
	Tributary 120 (Fountain Lake) BC	53190.4	145.73	64.2	18430.8	50.50	60.9	34759.5	65
	Tributary 147 (Peter Lund Creek -512)	13003.0	35.62	15.7	6866.5	18.81	22.7	6136.5	47
	Tributary 131 (CD 16 -513)	1704.0	4.67	2.1	1298.3	3.56	4.3	405.7	24
	Lakeshed	2175.6	5.96	2.6	1321.5	3.62	4.4	854.1	39
	Internal Loading	10605.0	29.05	12.8	0.0	0.00	0.0	10605.0	100
	SSTS	22.0	0.06	0.0	0.0	0.00	0.0	22.0	100
	Atmospheric Deposition	1120.8	3.07	1.4	1120.8	3.07	3.7	0.0	–
Total Load		**82,876.6**	**227.06**	**100.0**	**30,262.6**	**82.91**	**100.0**	**52,614.0**	**63**

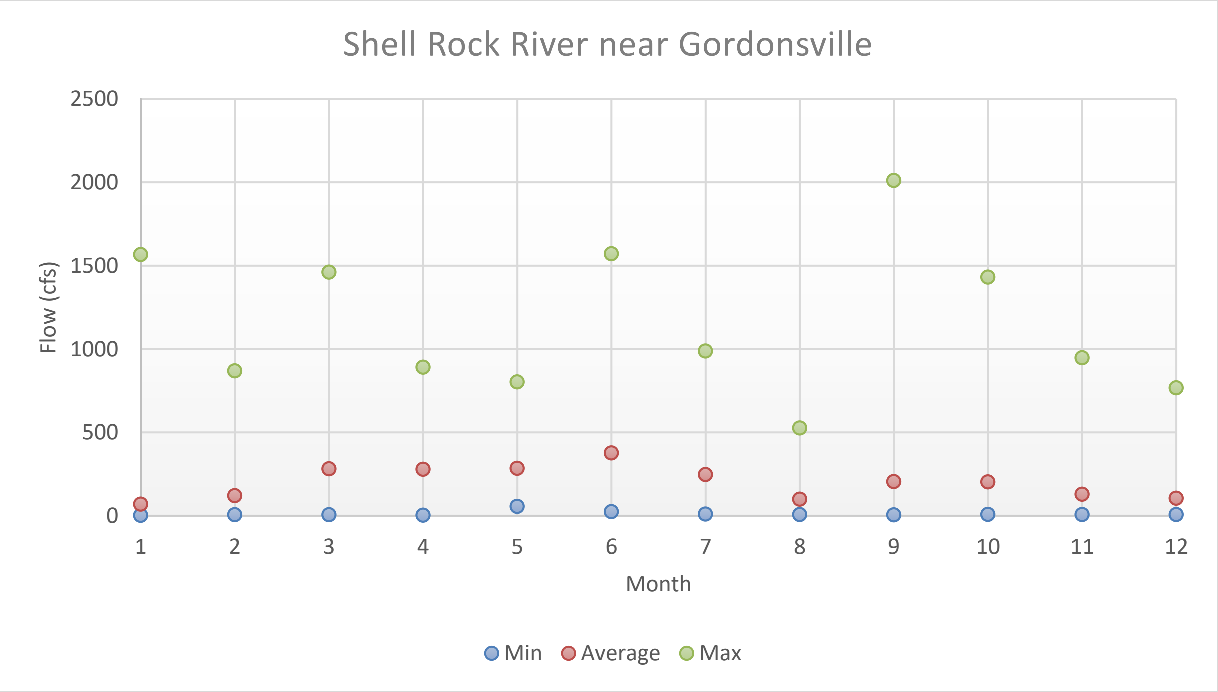
“-“ indicates that no reduction is required.

5. Seasonal variation

Monthly precipitation, flows, and pollutant concentrations vary seasonally. The average monthly precipitation in the project area is generally highest in spring and summer (May through August), as shown in Figure 46. Short-duration, high-intensity rainstorms are common during the spring and summer months. These localized storms can cause significant runoff with the potential of increasing pollutant concentrations for a relatively short time period, particularly from spring and early-summer events. Occasionally, large events can occur during the drier summer months that have significant wash-off of pollutants while not significantly increasing stream flow.

The monthly average flows in the Shell Rock River Watershed were typically highest during the late-spring and early-summer months (April through July) and lowest during the winter months (December through February), as shown in Figure 46.

Figure 46. Monthly average annual flow (2009–2018) from the Shell Rock River near Gordonsville



5.1 *E. coli*

The highest average and median *E. coli* concentrations and highest bacteria loads in Minnesota streams typically occur in spring and summer months. Figure 10 and Figure 11 show the bacteria concentrations in impaired reaches by month in Section 3.5.2.1. The bacteria concentration geometric means were highest in August in the impaired reaches. The LDC approach (Figure 42 and Figure 43) that was used to develop the TMDL allocations for the five flow zones accounts for variability in flow and *E. coli* loads. The *E. coli* TMDLs are also seasonal because the *E. coli* standard only applies from April to October.

5.2 Total suspended solids

The highest average and median TSS concentrations and highest TSS loads in Minnesota streams typically occur in spring and summer months. Figure 12 and Figure 13 show TSS in impaired reaches by month in Section 3.5.2.2. The mean TSS concentration was highest in the TSS-impaired reaches in May. The LDC approach that was used to develop the TMDL allocations for the five flow zones accounts for the seasonal variability in flow and TSS loads (e.g., the high-flow zone contains loads that primarily occur in the spring and summer). The TSS TMDLs are seasonal in nature because the TSS criterion is active from April to September.

5.3 Nutrients (phosphorus) in streams

Nutrient seasonality is discussed in Section 3.5.2.3. Monthly TP plots (Figure 16 and Figure 17) for the phosphorus impaired streams show that the mean TP in Shell Rock River Reach 501 was highest in September, while the mean TP in Shoff Creek Reach 516 was highest in June. Nutrient wash-off tends to peak in the spring months. In the summer months, nonpoint runoff of water is reduced and therefore provides less dilution from TP loads from point sources. The rate of plant growth and eutrophication is largely affected by water temperature and therefore the most eutrophic conditions are often observed in late summer.

5.4 Dissolved oxygen

DO seasonality is discussed in Section 3.5.2.4. The DO-impaired Shell Rock River Reach 501 often dropped below 5 mg/L between June and August. Some low DO measurements also occurred in March. The combination of higher precipitation that washed off organic materials and algae growth that can occur with warmer temperatures during these months likely contributes to the lower DO concentrations.

5.5 pH

The pH seasonality is discussed in Section 3.5.2.5. The pH-impaired Shell Rock River Reach 501 had pH measurements above nine between April and September. The high pH is directly related to the nutrients and resultant chl-*a* growth in Albert Lea Lake. Photosynthesis and respiration are two major factors that influence the amount of free CO_2 in the water. Photosynthesis takes up CO_2 and raises the pH while respiration releases CO_2 and lowers the pH. The processes of photosynthesis and respiration from present algae are more likely to occur during warmer months.

5.6 Aquatic macroinvertebrate and fish bioassessments

By nature, aquatic macroinvertebrate and fish bioassessment impairments indicate that the long-term water quality condition is impaired. If the impaired parameters (most of which are seasonal in nature) are addressed, the aquatic macroinvertebrate and fish bioassessments will also improve.

5.7 Nutrients (phosphorus) in lakes

Lake water quality varies seasonally and critical conditions occur in the summer recreational season. Minnesota’s lake-nutrient standards were developed in phases over three decades of monitoring and assessing a large subset of lakes and lake types in the state’s aquatic ecoregions [Heiskary and Wilson 2005]. Seasonal variation factored into the development of Minnesota’s lake standards for swimmable and fishable uses in the summer recreational period of June to September [Heiskary and Wilson 2005]. Distinct relationships were established between the causal factor (TP) and the response variables chl-*a* and SDT. TP has often been found to be the limiting factor in freshwater lakes; as lake phosphorus concentrations increase, algal abundance increases, which results in higher chl-*a* concentrations and reduced lake transparency. Based on these relationships, the chl-*a* and SDT standards are expected to be met by meeting the phosphorus target for each lake. An annual reduction in the phosphorus loads that are defined by these TMDLs will ensure meeting the seasonal water quality standards during critical conditions.

6. Future growth considerations

6.1 New or expanding permitted MS4 WLA transfer process

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 nonregulated 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 a modeled MS4 flow-percent basis, which is consistent with methods used in setting the allocations in this TMDL. 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.

6.2 New or expanding wastewater (TSS and *E. coli* TMDLs only)

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 instream 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 (https://www.pca.state.mn.us/water/tmdl-policy-and-guidance).

7. Reasonable assurance

An important part of the TMDL implementation strategy is to provide reasonable confidence or reasonable assurance that the TMDL allocations (1) were properly developed, documented, and calibrated and (2) will be implemented by local Soil and Water Conservation Districts (SWCDs) and LGUs, landowners, state entities, and federal entities. The TMDL allocations described herein have been based on the best and latest available information. The TMDL goals defined by this report are consistent with objectives defined in the draft comprehensive watershed management plan (Shell Rock – Winnebago 1W1P) that are further refined by the MPCA's Shell Rock River WRAPS Report. The Shell Rock River Watershed local governmental units have been active participants in the TMDL planning and development process, and most have decades of water quality management experience. Stakeholder meetings have been conducted to provide comments/feedback and support (including from LGUs that receive TMDL allocations). Future water quality restoration efforts will be led by the Shell Rock River Watershed local and county entities.

7.1 Nonregulatory

At the local level, the SWCDs have a long history of completing water quality improvement projects with well-developed infrastructure (i.e., technical assistance, administrative support, and fiscal oversight) in place. The implementation strategies described in Section 9 have been demonstrated to be effective in reducing pollutant loads to Minnesota waters. Performance monitoring will continue to guide adaptive management, which includes evaluating progress-to-goals in achieving water quality standards and established beneficial uses.

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.

7.1.1 Pollutant load reduction

Reliable means of reducing nonpoint source pollutant loads are addressed in the Shell Rock River WRAPS Report, which was written to be a companion to this TMDL report. In order for the impaired waters to meet water quality standards, a portion of the pollutant reductions in the Shell Rock River Watershed will need to come from nonpoint sources. The strategies and BMPs described in the WRAPS report have been demonstrated to be effective in reducing transport of pollutants to surface water. The combinations of BMPs are derived from Minnesota's Nutrient Reduction Strategy [MPCA 2019d] and related tools. As such, they have been vetted by a statewide engagement process.

BMP site selections will be led by LGUs (including SWCDs, watershed districts, and county planning and zoning offices) with support from state and federal agencies. The selected BMPs will be those supported by programs administered primarily by the SWCDs, Board of Water and Soil Resources (BWSR), and the NRCS. Selected BMPs will be those which local resource managers are well-trained in promoting, placing, and installing. State and local agencies will need to work with landowners to identify priority areas for BMPs and practices that will help reduce runoff, as well as stream bank and overland erosion. Selected BMPs will reduce pollutant loads from runoff (i.e., phosphorus, sediment, and pathogens) and loads delivered through drainage tiles.

To help achieve nonpoint source reductions, the watershed's citizens and communities will need to voluntarily adopt the practices at the necessary scale and rates to achieve the 10-year targets presented in the Shell Rock River WRAPS Report. The WRAPS report also presents the allocations of the pollutants/stressors, goals and targets for the primary sources, and the estimated years to meet the goals. The strategies identified and relative adoption rates that are included in the Shell Rock River Watershed WRAPS Report can be used to calculate the adoption rates needed to meet the pollutant/stressor 10-year targets. In addition to public participation, several government programs are in place to support increase in the adoption of strategies that will improve watershed conditions and reduce loading from nonpoint sources.

Minnesota Nutrient Reduction Strategy

The *Minnesota Nutrient Reduction Strategy* (MPCA 2014) guides activities that support nitrogen and phosphorus 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

Included within the strategy discussion are alternatives and tools for consideration by drainage authorities, information on available tools and approaches for identifying areas of phosphorus 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 phosphorus and nitrogen in the Mississippi River, downstream of the Shell Rock River 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
- 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.

Agricultural Water Quality Certification Program

The Minnesota Agricultural Water Quality Certification Program is a voluntary opportunity for farmers and agricultural landowners to take the lead in implementing conservation practices that protect waters. Those who implement and maintain approved farm management practices 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. Since the start of the program in 2014, the Ag Water Quality Certification Program has:

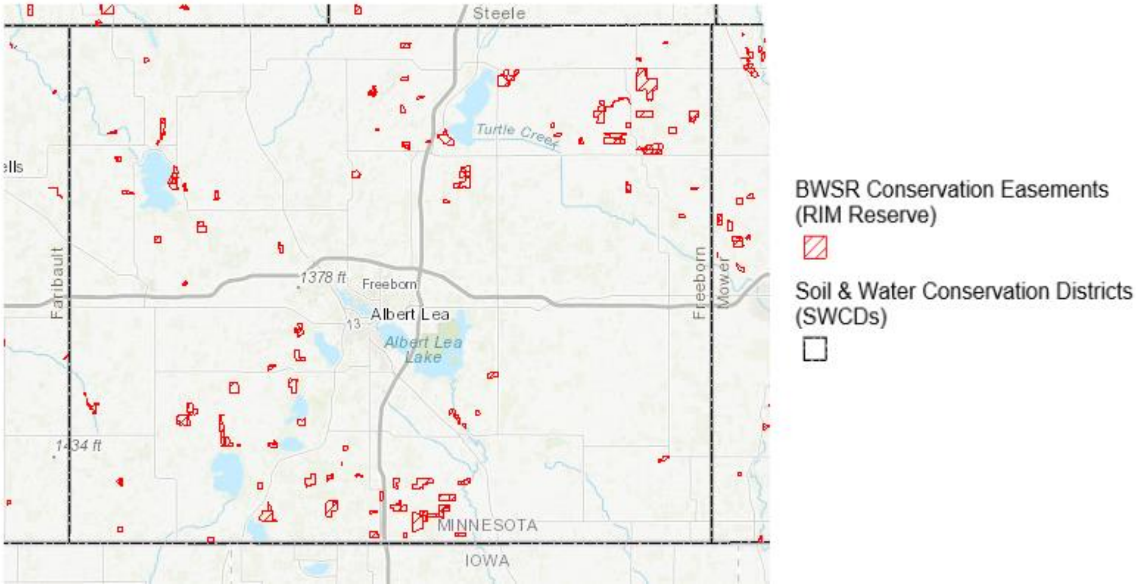
- Enrolled over 619,343 acres;
- Included 896 producers;
- Added more than 1,800 new conservation practices;
- Kept over 66 million pounds of sediment out of Minnesota rivers;
- Saved 163 million pounds of soil and 39,766 pounds of phosphorus on farms; and
- Reduced nitrogen losses by up to 49%.

As of June 2020, there are 8,256 acres certified in the Shell Rock River Watershed.

Conservation Easements.

Conservation easements are a critical component of the state’s efforts to improve water quality by reducing soil erosion, phosphorus 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 Natural Resources Conservation Service (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).

Figure 47. Conservation lands in Freeborn County.



7.1.2 Prioritization

The WRAPS report details a number of tools, such as Scenario Application Manager (SAM), for local water planners that provide means to identify priority pollutant sources and implementation work in the watershed. Further, LGUs in the Shell Rock River Watershed often employ their own local analyses to determine work priorities. Currently, a comprehensive watershed management plan is being developed for the Shell Rock River watershed, referred to as Shell Rock – Winnebago One Watershed, One Plan. This Plan is the main forum for prioritizing water quality work in the Shell Rock River watershed. Three committees (steering, advisory, and policy committees) help steer and develop the priorities and goals contained in this Plan. These committees included representatives from SWCDs, municipalities, state, local governments, agricultural groups, conservation groups, and county commissioners. For additional information on the Shell Rock-Winnebago One Watershed, One plan, see the SRRWD website.

7.1.3 Funding

On November 4, 2008, Minnesota voters approved the Clean Water, Land and Legacy Amendment to the constitution 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
- Protect, enhance, and restore lakes, rivers, streams, and groundwater.

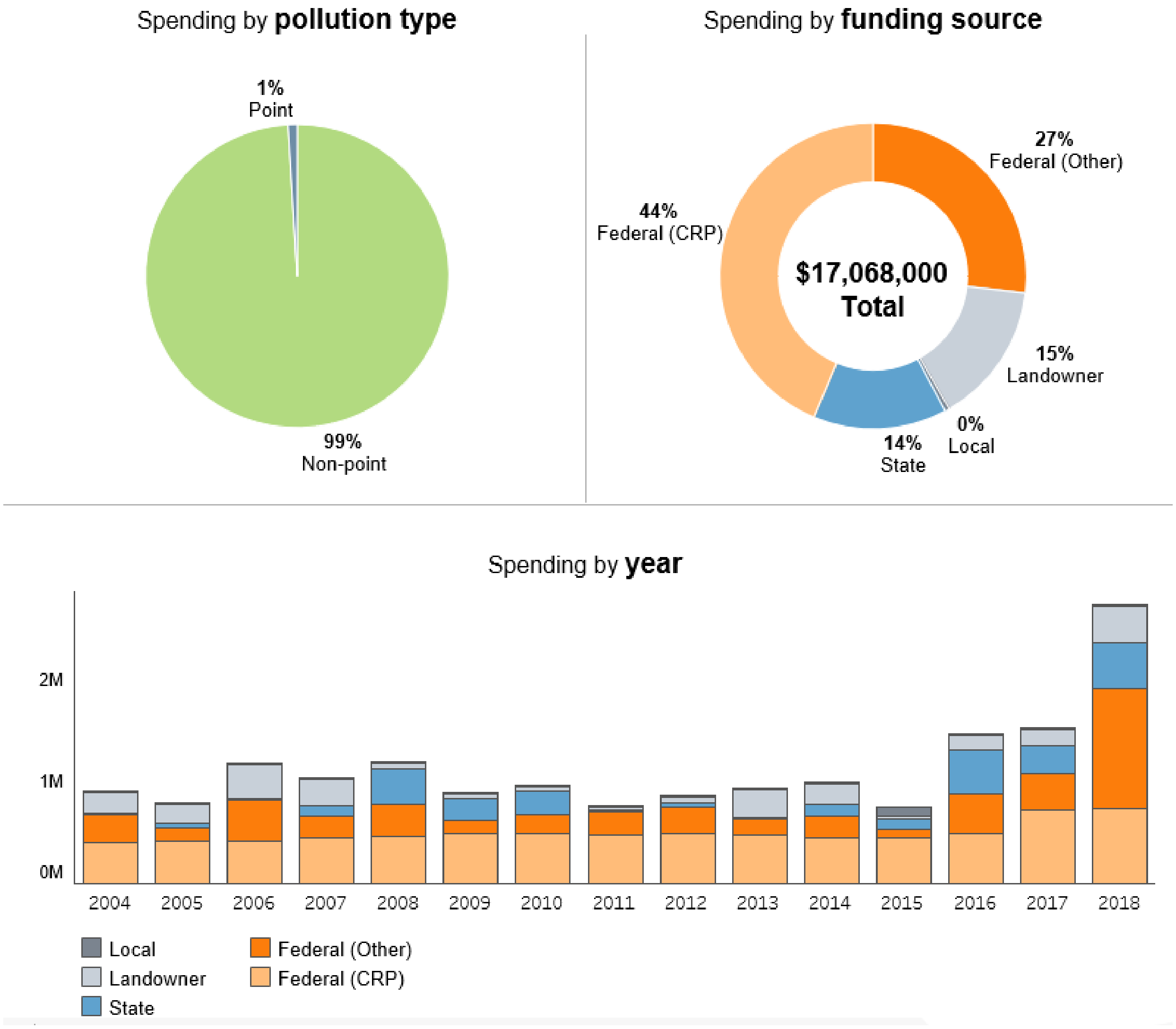
The amendment is a secure funding mechanism, which allocates 33% of sales tax revenue to the Clean Water Fund supporting water quality improvement projects.

Funding resources can be obtained from the following state and/or federal programs:

- Minnesota Clean Water, Land, and Legacy Funds
- EPA funding, such as Section 319 grants
- NRCS cost-share funds
- Local governmental funds and utility fees
- Local and lake association-related resources.

Since 2004, more than $17 million have been spent on implementation in the Shell Rock River Watershed, mostly on nonpoint source implementation. Approximately 44% of dollars were federal on CRP payments; 24% were federal dollars spent on other projects; 15% were landowner dollars; and 14% were state funds [MPCA 2019c]. Additionally, the SRRWD has spent over $41.7 million on implementation in the watershed.

Figure 48. Spending reported for Shell Rock River Watershed by MPCA's Healthier Watersheds.



Note: Local spending is not assigned because it is not reported to MPCA.

7.1.4 Planning and implementation

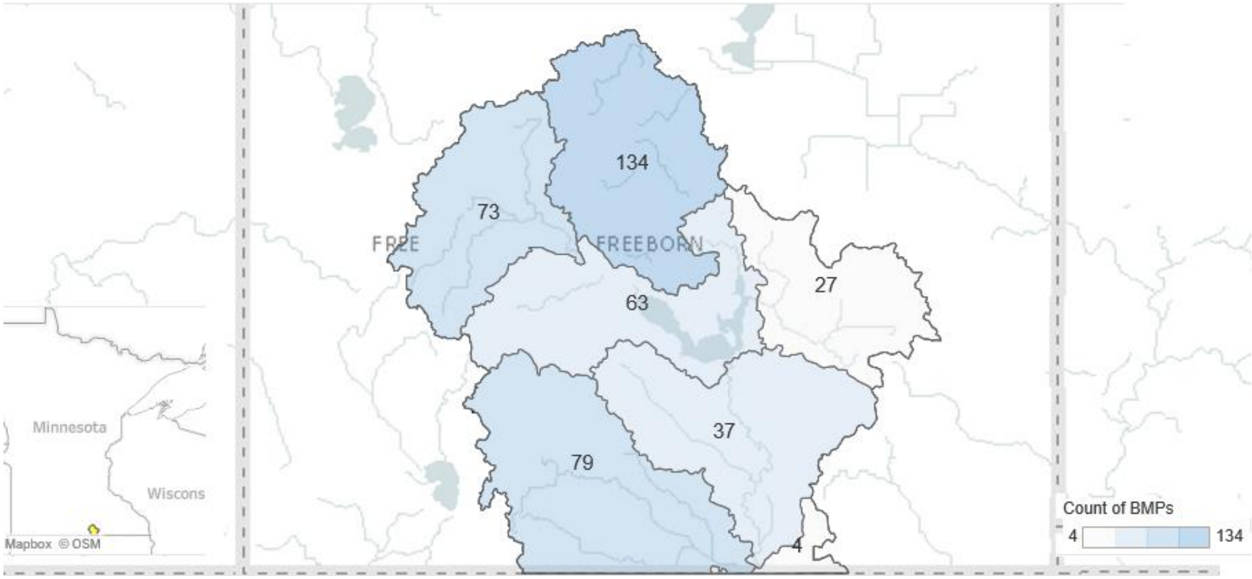
The WRAPS, TMDLs, and all the supporting documents provide a foundation for planning and implementation. A One Watershed One Plan process is also underway for this watershed. Subsequent planning will draw on the goals, technical information, and tools to describe strategies and actions for implementation. For the purposes of reasonable assurance, the WRAPS document will be sufficient in that it provides strategies for achieving pollutant reduction goals. In addition, the commitment and support from the LGUs will ensure that this TMDL project is carried successfully through implementation.

7.1.5 Tracking progress

Water monitoring efforts within the Shell Rock River Watershed are diverse and constitute a sufficient means for tracking progress and supporting adaptive management (see Section 8).

According to the BMPs implemented by watershed link on the MPCA Healthier Watersheds webpage (https://www.pca.state.mn.us/water/healthier-watersheds), since 2004 there have been over 413 BMPs implemented in the Shell Rock River Watershed. Cover crops have been implemented on over 6,500 acres, erosion control has been implemented on nearly 4,500 acres, conversion to perennials has been implemented on over 500 acres, wetland restoration has been implemented on approximately 400 acres, tillage/residue management has been implemented on over 12,000 acres, and buffers/filters have been implemented on over 500 acres. For reference, the Shell Rock River Watershed is 254 acres in size.

Figure 49. BMPs implemented in the Shell Rock River Watershed, reported by MPCA's Healthier Watersheds.



7.2 Regulatory

The following section describes reasonable assurances from permitted point sources in the Shell Rock River Watershed.

7.2.1 Construction stormwater

State implementation of the TMDL will be through action on NPDES Permits for regulated construction stormwater. To meet the categorical WLA that includes 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 the Construction General Permit for discharges to impaired waters. Construction stormwater activities must meet local construction stormwater requirements if they are more restrictive than the requirements of the State General Permit.

7.2.2 Industrial stormwater

To meet the categorical WLA that includes industrial stormwater, industrial stormwater activities are required to meet the conditions of the Industrial Stormwater General Permit or Nonmetallic Mining & Associated Activities General Permit (MNG49) under the NPDES program and properly select, install and maintain all BMPs required under the permit.

7.2.3 MS4 permits

Phase II MS4 NPDES-permitted stormwater communities are required by permit (the General Permit Authorization to Discharge Stormwater Associated with Small MS4s Under the NPDES/SDS Permit [MNR040000]) to develop and implement a Stormwater Pollution Prevention Plan (SWPPP). This permit requires MS4s to develop regulatory mechanisms, including enforcement of construction sites under the MPCA's General Permit, Discharges of Stormwater Associated with Construction Activity (MNR100001), and post-construction stormwater management. MS4s are also required to inventory and map the storm sewer system and implement a minimum of six control measures (public education and outreach, public participation and involvement, illicit discharge detection and elimination, construction site runoff controls, post-construction stormwater runoff controls and pollution prevention, and good housekeeping measures). Measurable goals must be specified for each of the six minimum control measures (MCMs), including public participation and involvement in the review of the SWPPPs. Routine inspection and maintenance of the MS4 conveyance system is required. Additionally, the MS4 Permit requires permittees with an applicable WLA for DO or oxygen demand, nitrate, TSS, or TP to provide reasonable assurance that progress is being made toward achieving all TMDL WLAs approved by the EPA before the effective date of the General MS4 permit issued at five-year intervals. MS4s must determine that the WLA(s) are being met, and if not, a compliance schedule is required. The compliance schedule includes interim milestones (expressed as BMPs), which will be implemented over the current five-year permit term. As MS4 management activities occur across 10-year capital budgetary cycles, a target date for full compliance to the WLAs must be included. More information about the MS4s in Minnesota can be found online (https://www.pca.state.mn.us/water/municipal-stormwater-ms4). The MS4 General Permit is currently going through reissuance. Currently, the MPCA is in the process of reviewing comments from the MS4 General Permit public notice and plans to provide written responses in summer 2020. Information about the draft MS4 permit update is available online (https://www.pca.state.mn.us/water/municipal-stormwater-ms4#overview-6718de6a).The following DRAFT permit language is subject to change:

> *For permittees with applicable WLAs for bacteria, chloride, and temperature, the draft permit contains specific requirements to address these pollutants. These pollutant-specific requirements can*

> *be found within the Minimum Control Measures (MCMs) sections of the permit. Each permittee with a WLA for bacteria must comply with the MCM requirements for these WLAs. Because the permit includes pollutant-specific requirements, a compliance schedule will not be required for applicable WLAs for bacteria.*

All MS4 permittees are required to distribute educational materials focused on pet waste to residents. The educational materials must include information on the impacts of pet waste on water quality; proper management of pet waste; and any existing permittee regulatory mechanism regarding pet waste. If the permittee has a bacteria WLA, the permittee must maintain a written or mapped inventory of potential areas and sources of bacteria (e.g., dense populations of waterfowl or other birds, dog parks). The permittee must also maintain a written plan to prioritize reduction activities to address the areas and sources identified in the inventory. The written plan must include BMPs the permittee will implement over the permit term to reduce bacteria. For cities, townships, and counties, the permittee's regulatory mechanism must require owners or custodians of pets to remove and properly dispose of feces.

If a permittee has an applicable WLA for DO or oxygen demand, nitrate, TSS, or TP, a compliance schedule is required. The compliance schedule is based on information provided by the permittee in the SWPPP document (i.e., the Part 2 permit application). The SWPPP document becomes part of the permit and is subject to public notice (see item 5.4 in the draft permit).

Information on each permittee's applicable WLAs and reporting requirements can be provided in a customized compliance schedule. In the compliance schedule, the permittee must provide the proposed BMPs or progress toward implementation of BMPs to be achieved during the permit term, the year each BMP will be implemented, and a target year the applicable WLA(s) will be achieved.

7.2.4 Wastewater NPDES and SDS permits

The MPCA issues permits for WWTFs and industrial facilities that discharge into state waters. The permits have site-specific limits on many of the TMDL pollutants 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 its wastewater. NPDES and SDS Permits set limits and establish controls for land application of waste and byproducts. See Section 9.1.6 for a summary of discharge monitoring reports (DMRs) from the WWTFs in the Shell Rock River Watershed. Table 44 below summarizes permitted wastewater facilities in the Shell Rock River watershed and their associated WLAs. In some cases, reductions outlined in the TMDLs will be translated into future permit limits.

Table 44. Permitted wastewater dischargers in the Shell Rock River Watershed.

Facility	Permit	Receiving waterbody	Parameter	*WLA*	*Pollutant reduction needed beyond current permit conditions/limits?*
Clarks Grove WWTF	MNG580067	Bancroft Ck	*E. coli*	5.05E+09 billion org/day	No
		Fountain Lake (East Bay)	Total phosphorus	706.9 lbs/year	No**
Glenville WWTF	MN0021245	Shell Rock River	TSS	0.12 tons/day	No
			Total phosphorus	2.7 lbs/day	Yes**
			Oxygen demand	8.7 lbs/day*	Yes[a]
Albert Lea WWTF	MN0041092	Shell Rock River	TSS	2.30 tons/day	No
			Total phosphorus	48.4 lbs/day	Yes**
			Oxygen demand	167.1 lbs/day*	Yes[b]
Albert Lea WTP SD002	MNG640002	Fountain Lake (East Bay)	Total phosphorus	60.9 lbs/year	No[d]
Albert Lea WTP SD001	MNG640002	Albert Lea Lake	Total phosphorus	60.9 lbs/year	No[d]
Cargill Value Added Meats	MNG255077	Albert Lea Lake	Total phosphorus	92.9 lbs/year	No**
DNR Myre Big Island State Park	MN0033740	Albert Lea Lake	Total phosphorus	30.5 lbs/year	No[c]
Hayward WWTF	MN0041122	Albert Lea Lake	Total phosphorus	136.7 lbs/year	No[d]

*Will be addressed through total phosphorus TMDL.

**No current discharge limit on parameter. TMDL will likely result in a permit limit for listed parameter.

a. In-stream oxygen demand is closely tied to available phosphorus provided by effluent. DO WLA is equal to RES (phosphorus) WLA.

b. In-stream oxygen demand is closely tied to available phosphorus provided by effluent. DO WLA is less restrictive than the RES (phosphorus) WLA.

c. Permit limit type will change from calendar month average to annual limit but will not be more restrictive.

d. Permit already includes a limit and are consistent with WLA.

Four wastewater facilities will likely receive phosphorus limits in their future discharge permits as a result of this TMDL (Albert Lea WWTF, Glenville WWTF, Clarks Grove WWTF, and Cargill Value Added Meats). Clarks Grove WWTF and Cargill Value Added Meats are already meeting their respective WLAs so a future phosphorus limit would not require additional TP reductions. Glenville WWTF has been able to meet the TP WLA but may need to evaluate its existing capacity to meet the limit in the future. It is expected that Albert Lea WWTF will need to make changes to their effluent treatment in order to meet a future phosphorus limit in their discharge permit.

7.2.5 SSTS program

SSTS, which are commonly known as septic systems, are regulated by Minn. Stat. §§ 115.55 and 115.56. Counties and other LGUs that regulate SSTS must meet the requirements for local SSTS programs in Minn. R. ch. 7082, and adopt and implement SSTS ordinances in compliance with Minn. R. chs. 7080 to 7083.

The preceding regulations detail the following:

- Minimum technical standards for individual and mid-size SSTS
- A framework for LGUs to administer SSTS programs
- Statewide licensing and certification of SSTS professionals, SSTS product review and registration, and establishment of the SSTS Advisory Committee.

Counties and other LGUs enforce Minn. R. chs. 7080 to 7083 through their local SSTS ordinance and issue permits for systems designed with flows up to 10,000 gallons per day. There are approximately 200 LGUs across Minnesota, and depending on the location, an LGU may be a county, city, township, or sewer district. LGU SSTS ordinances vary across the state. Some require SSTS compliance inspections prior to property transfer, require permits for SSTS repair and septic tank maintenance, and may have other requirements, which are stricter than the state regulations.

Compliance inspections by counties and other LGU are required by Minn. R. for all new construction and for existing systems if the LGU issues a permit for the addition of a bedroom. In order to increase the number of compliance inspections, the MPCA has developed and administers several grants to LGUs for various ordinances and specific actions. Additional grant dollars are awarded to counties that have additional provisions in their ordinance above the minimum program requirements. The MPCA has worked with counties through the SSTS Implementation and Enforcement Task Force (SIETF) to identify the most beneficial way to use these funds to accelerate SSTS compliance statewide.

The MPCA staff keep a statewide database of known ITPHS systems that include straight pipe systems, which are reported to the counties or the MPCA by the public. Upon confirmation of a straight pipe system, the county sends out a notification of noncompliance, which starts a 10-month deadline to fix the system and bring it into compliance. From 2006 through 2017, 742 straight pipe systems have been tracked by the MPCA. Seven hundred and one of those were abandoned, fixed, or were found not to be a straight pipe system as defined in Minn. Stat. 115.55, subd. 1. Seventeen Administrative Penalty Orders have been issued and docketed in court while the remaining straight pipe systems received a notification of noncompliance.

In 2004, a methodical effort began to inspect and upgrade Individual SSTS in the Shell Rock River Watershed. This Shell Rock River Watershed District-led effort was called the Pollution Prevention Program and was focused on residences within the 1,000-foot shoreland corridor. The objective was to target failing and noncompliant SSTS for upgrade. This was accomplished on a township-by-township basis from 2007 through 2014, in coordination with Freeborn County Environmental Services staff, homeowners, and the SSTS installation contractors. The program worked by providing a $100 payment to homeowners who cooperated to have an SSTS inspection completed. If the system was found to be in compliance, a compliance report was provided. If the system was found to be an ITPHS or was noncompliant because of drainfield location in the soil profile, the system was upgraded to gain compliance. Results of the inspection are shown in Table 45. Over 8 years and covering 13 townships, approximately 742 systems were placed in a “to be upgraded” category. The systems in the ITPHS were upgraded. For those systems classified as IPHTs, many often discharged to tile lines, and/or drainage ditches. For the 430 systems classified as “failing to protect groundwater (FTPGW),” not all of them have been upgraded at this time.

Table 45. SRRW Pollution Prevention Program SSTS results, 2007–2014.

Compliant SSTS	Failing to Protect Groundwater	Imminent Threat to Public Health and Safety	Not in Inventory	Total to Be Upgraded
374	430	312	587	742

Using these data as the best available for the Shell Rock River Watershed, approximately 18% of the total SSTS are ITPHT, and 25% fail because of soil separation factors in the drainfield.

An assessment of county-scaled data is another method to assess the SSTS source of bacteria and pollutants to water resources. County-wide data are available from the Freeborn County Environmental Services office.

Because watershed-specific data are not available, Freeborn County percentages of total systems that are either in compliance, failing, or classified as ITPHS are noted in Table 46 as of 2016 (as reported by the county to the MPCA).

Table 46. Percentages for SSTS compliance categories for Freeborn County, 2016.

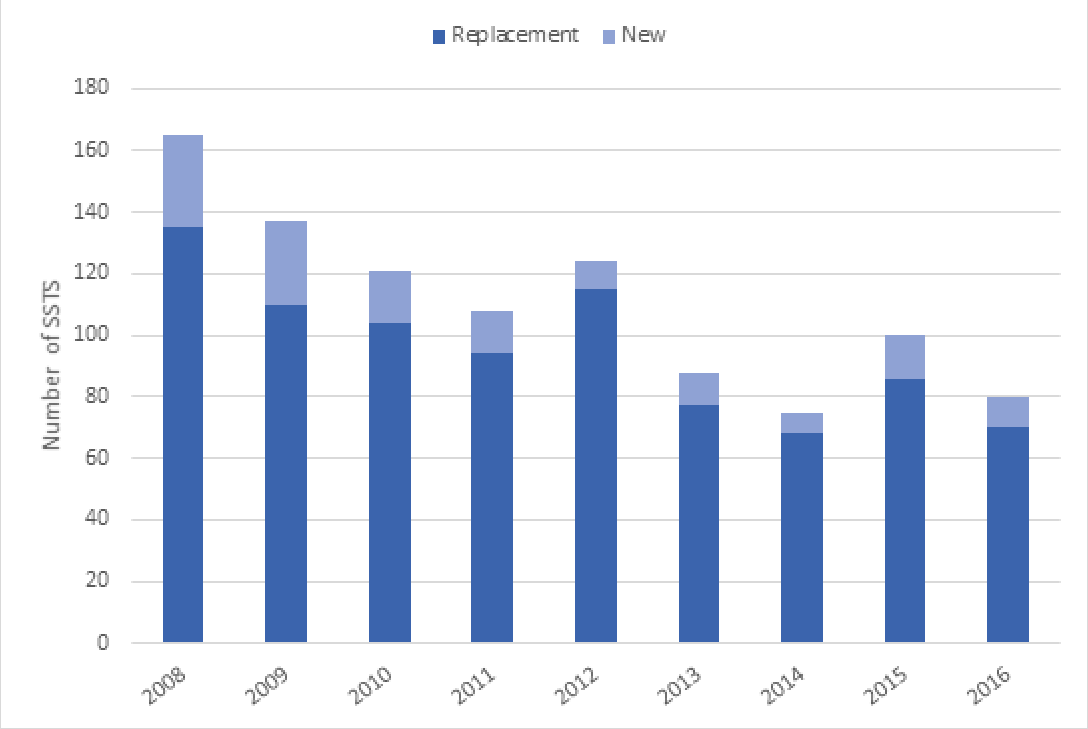
County	% Failing	% ITPHS	% In Compliance	Total SSTS
Freeborn	32	15	53	3,935

It should be emphasized that these are county-wide statistics, which do not pertain specifically to the Shell Rock River Watershed scale, as explained in the above text. The ITPHS percent between the watershed scale and the county scale match. The “% failing” or noncompliant (separation) are similar between the two scales.

Ongoing programs for Freeborn County involve inspection and upgrading of SSTS, through local ordinance compliance and implementation, and this is covered in more detail in Section 7.

Figure 50 shows a graph of replaced and repaired SSTS. In 2016, 70 systems were reported as replaced and 10 new systems were installed. Based on reported numbers, an average of 95 systems get replaced and 15 new systems get installed annually.

Figure 50. Graph of replaced and repaired SSTS.



7.2.6 Feedlot program

The MPCA regulates the collection, transportation, storage, processing, and disposal of animal manure and other livestock operation waste. The MPCA Feedlot Program implements rules governing these activities and provides assistance to counties and the livestock industry. The feedlot rules apply to most aspects of livestock waste management including the location, design, construction, operation and management of feedlots, and manure-handling facilities. All of the feedlots in Minnesota are regulated by Minn. R. ch. 7020. The MPCA has regulatory authority of feedlots, but counties may choose to participate in a delegation of the feedlot regulatory authority to the LGU. Delegated counties are then able to enforce Minn. R. ch. 7020 (along with any other local rules and regulations) within their respective counties for facilities that are under the CAFO threshold. In the Shell Rock River Watershed, Freeborn County is delegated the feedlot regulatory authority. The county will continue to implement the feedlot program and work with producers on manure management plans. Since 2006, feedlot compliance staff conducted 37 inspections. During that time, compliance staff deemed two feedlot facilities with minor noncompliance for failing to keep adequate manure application records, and one with major noncompliance for not meeting water quality discharge standards. Four manure application inspections were documented within this timeframe. All were found to be compliant.

7.2.7 Nonpoint source

A portion of the pollutant loads in these TMDLs is attributed to nonpoint sources; therefore, for TMDLs that require reductions in pollutant loads, nonpoint sources will be important targets for reductions. The existing state statutes/rules that pertain to nonpoint sources are as follows:

- A 50-ft (on average) buffer (with a minimum of 30 ft) is required for the shore impact zone of streams that are classified as protected waters (Minn. Stat. § 103F.201) for agricultural land uses. November 1, 2017, was the deadline for compliance. A 16.5-ft minimum width buffer is required on public drainage ditches (Minn. Stat. § 103E.021). November 1, 2018, was the deadline for compliance. Compliance estimates as of January 2019 [BWSR 2019a] indicate that compliance with the buffer law in Freeborn County is more than 95%.

- Protection of highly erodible land within the 300-foot shoreland district (Minn. Stat. § 103F.201).
- Excessive soil loss statute (Minn. Stat. § 103F.415).
- Nuisance nonpoint source pollution (Minn. R. 7050.0210, subp. 2).

As a summary, significant time and resources have been devoted to identifying the best BMPs, providing means of focusing them in the Shell Rock River Watershed, and supporting their implementation via state initiatives and dedicated funding. The Shell Rock River WRAPS 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.

8. Monitoring plan

The plan to track progress toward achieving the TMDL load reductions will primarily rely on monitoring each impaired watershed for (1) BMP implementation and (2) tracking attainment to water quality standards. The Shell Rock River Watershed SWCD and other LGUs will track and report implementation projects annually within their jurisdictions. Therefore, existing tools, such as the pollutant reduction calculators, input into Minnesota BWSR web-based eLINK tracking system [BWSR 2019b], the MPCA Healthier Watersheds webpage, and other methods of tracking will be used to report on progress. BMP effectiveness may be estimated by BWSR and MPCA calculators based on BMP designs, construction, and operation and maintenance considerations.

A combination of volunteer monitors, the Shell Rock River Watershed District, and county/SWCD technicians will conduct water monitoring as part of the WRAPS process. The monitoring level of effort will vary among the Shell Rock River entities as staffing and budgets vary. Annual reporting by the Shell Rock River Watershed partners will provide benchmarks for measuring progress of the implemented TMDLs and for adaptive management. Details of the monitoring plan are specified in the Shell Rock River Watershed WRAPS Report. Some monitoring also occurs in the Shell Rock River Watershed at the local and state level independently of the WRAPS schedule; for example, MPCA's watershed pollutant load monitoring network [MPCA 2019e] and DNR's cooperative stream gaging [DNR 2019b] both provide useful long-term, on-going water monitoring data. Additionally, the Shell Rock River Watershed District has been performing intensive monitoring in the watershed for many years. Cycle 2 IWM in the Shell Rock River began in 2019. This second round of monitoring included eight sites for biology and three sites for water chemistry. Shell Rock River Watershed District is the lead for the chemistry sampling and MPCA is the lead for the biological sampling. Chemistry samples were collected on Goose Creek, Wedge Creek, and Bancroft Creek, while biology measurements were taken on Goose Creek, Wedge Creek, Bancroft Creek, Shoff Creek, County Ditch 16, Peter Lund Creek, and the Shell Rock River. There is a remaining fish site on Goose Creek that will be sampled in 2021; delayed because of restrictions due to the Corona Virus.

9. Implementation strategy summary

Minnesota's watershed approach to restoring and protecting water quality is based on a major watershed, or HUC-8, scale. This watershed-level approach begins with intensive watershed monitoring (which occurs on a 10-year cycle) and culminates in local implementation. A WRAPS report is produced as part of this approach and addresses restoration of impaired watersheds and protection of unimpaired waters in each HUC-8 watershed. The Shell Rock WRAPS includes elements such as implementation strategies and recommended timelines for achieving the needed pollutant reductions. Another available implementation resource, referenced in the Shell Rock WRAPS, is the SRRWD's TMDL Implementation Plan (IP) Report; drafted in 2013. The IP includes restorative measures, BMP descriptions for watershed lakes, and a map of potential BMP locations.

These high-level reports are used to inform watershed management plans (Shell Rock-Winnebago One Watershed, One Plan) that focus on local priorities and knowledge to identify prioritized, targeted, and measurable actions and locally based strategies. The Shell Rock-Winnebago One Watershed, One Plan, once finalized and approved, will further define specific actions, measures, roles, and financing for accomplishing water resource goals. Implementation activities in the Shell Rock River WRAPS Report will heavily influence and support implementation of this TMDL. The following sections provide an overview of potential implementation strategies to address the likely pollutant sources.

Rehabilitation actions within the impaired river reach watersheds will require cooperative planning and implementation by nonregulated and regulated entities with Freeborn County, Freeborn SWCD, Shell Rock River Watershed District, regional, state, and federal agencies, and funding sources. Pollutant reductions can be achieved via a combination of point source permitting, land use changes and BMPs, benchmark assessments, and monitoring to identify critical areas.

9.1 Permitted sources

9.1.1 Phase II MS4

Phase II MS4 NPDES-permitted stormwater communities are required by permit (the General Permit Authorization to Discharge Stormwater Associated with small MS4s under the NPDES/SDS Permit [MNR040000]) to develop and implement an SWPPP. This Permit requires MS4s to develop regulatory mechanisms, including enforcement of construction sites under the MPCA's General Permit to Discharge Stormwater Associated with Construction Activity (MNR100001) and post-construction stormwater management. MS4s are also required to inventory and map the storm sewer system and implement a minimum of six control measures (public education and outreach, public participation and involvement, illicit discharge detection and elimination, construction site runoff controls, post-construction stormwater runoff controls and pollution prevention, and good housekeeping measures). Measurable goals must be specified for each of the six MCMs, including public participation and involvement in reviewing the SWPPPs. Routine inspection and maintenance of the MS4 conveyance system is required. Additionally, the MS4 permit requires regulated communities to provide reasonable assurance that progress is being made toward achieving all TMDL WLAs approved by the EPA before the effective date of the General MS4 permit issued at five-year intervals. MS4s must determine that the WLA(s) are being met, and if not, a compliance schedule is required. The compliance schedule includes interim milestones (expressed as BMPs such as pet waste programs and urban BMPs in MS4 areas) that are not one of the six MCMs and that will be implemented over the current five-year permit term. As MS4 management activities occur across 10-year capital budgetary cycles, a long-term implementation strategy and target date for full compliance to the WLAs must be included. The stormwater manual can be found online (https://stormwater.pca.state.mn.us) and includes specific BMPs to improve water quality for pollutants addressed in this TMDL. More information on MS4 regulations is included in Section 7.2.3 of this TMDL. A pilot project is currently underway to evaluate the potential opportunity for and benefit of implementing a stormwater quality credit trading program for the City of Albert Lea MS4 area that drains to Fountain Lake. This voluntary program may provide a lower cost mechanism for Albert Lea to meet its MS4 LA for this TMDL by working with willing landowners who can implement projects and practices that reduce upstream loads. The Shell Rock River Watershed District was awarded a Legislative Citizens Commission on Minnesota Resources (LCCMR) grant to evaluate this opportunity. Results from the pilot project will be available before the end of calendar year 2020.

MS4 Baseline year:

The City of Albert Lea has MS4 loads allocated in these TMDLs. For this MS4, the baseline year will be the beginning of the TMDL time period (2009). A baseline year is used because the effects of BMPs are not always immediate. BMPs implemented since 2009 will qualify toward MS4 load reductions for these TMDLs. Appropriate implementation strategies and MS4 BMPs will be further defined in the WRAPS report.

9.1.2 CAFOs

Three CAFOs are located in the Shell Rock River Watershed. CAFOs are not allowed to discharge to surface water (with permit-specified exceptions). The CAFO permits state "in the event of a discharge due to a storm event, as specified in Part IX.A.1.a, from chronic or catastrophic precipitation (greater than the 25-year 24-hour precipitation event), from a discharge from a land application site, or any discharge due to noncompliance with the conditions of this Permit, the permittee shall report the discharge in a manner required under Part VIII.B.4.b." A chronic or catastrophic precipitation event is a 25-year 24-hour precipitation event. CAFOs were not given a WLA in this TMDL.

9.1.3 Construction stormwater

The WLA for stormwater discharges from sites where there is construction activity reflects the number of construction sites greater than one acre 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 Minnesota'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. Construction activity must also meet all local government construction stormwater requirements.

9.1.4 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 Minnesota’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. Industrial activity must also meet all local government construction stormwater requirements.

9.1.5 Wastewater

DMR data for each facility in the impaired watersheds were downloaded from the MPCA database to assess effluent levels.

A bacteria effluent evaluation was completed for the facilities in the watersheds of bacteria-impaired reaches with monthly average DMR monitoring data during the TMDL time period. The current fecal coliform bacteria permit limit for these facilities is 200 colony-forming units per 100 milliliters (cfu/100 mL). The monitoring data shows that the one facility (Clarks Grove WWTF) contributing to a bacteria-impaired reach typically discharges at fecal coliform concentrations below 200 cfu/100 mL. The Clarks Grove WWTF exceeded the 200 mg/L cfu/100 mL one time in 2015. The monthly geometric mean load from the facility did not exceed the WLA (5.05×10^9) during the TMDL time period.

A TSS effluent evaluation was completed for the facilities in the watersheds of turbidity-impaired reaches that have a WLA with monthly average DMR monitoring data during the TMDL time period. The monitoring data show that the Glenville WWTF exceeded the limit of 45 mg/L once in 2017. The monitoring data show that the Albert Lea WWTF did not exceed the limit of 30 mg/L during the TMDL time period. The reported TSS load from the Glenville exceeded the WLA of 0.12 tons per day once during the TMDL time period, and the reported TSS load from the Albert Lea WWTF did not exceed the WLA of 2.30 tons per day during the TMDL time period.

An effluent evaluation was also completed for TP for the facilities with available monthly average DMR monitoring data in the watersheds of the TP impaired reaches and the DO impaired reach addressed. No TP permit limits currently exist, but the recommended TMDL WLAs are loading values calculated from concentration flow assumptions. The monitoring data shows that the Glenville WWTF typically discharges at TP concentrations below 2 mg/L, while the Albert Lea WWTF typically discharges at TP concentrations well above 0.636 mg/L generally above 3 mg/L). The average reported phosphorus load from the Albert Lea WWTF during the TMDL time period was approximately 190 lb/day, which is well above their TMDL WLA of 48.4 lb/day. Reported phosphorus loads from Glenville did not exceed their TMDL WLA of 2.7 lb/day during the TMDL time period. In summary, no TP reductions are expected for Glenville WWTP but Albert Lea WWTP TP reductions of approximately 75% are needed.

The pH of facilities contributing to the Shell Rock River was evaluated with available monthly minimum and maximum DMR data. Daily minimum pH remained above the minimum instream standard of 6.5 and at or below the maximum instream standard of 9 for all facilities considered in this TMDL during the TMDL time period.

For the lake TMDLs, the phosphorus WLAs for the Albert Lea WTP and Cargill Value Added Meats were based on concentrations of 0.5 mg/L, while the WLAs for the Hayward WWTF and DNR Myre Big Island State Park were based on concentrations of 1 mg/L, and the WLA for Clarks Grove WWTF was based on a concentration of 2 mg/L. The monthly average concentrations at the Albert Lea WTP exceeded 0.5 mg/L once in 2010 at their SD001 station and once in 2014 at their SD002 station for the time period between 2009 and 2018 (i.e., less than 3% of the time). The monthly average concentrations at Cargill Value Added Meats exceeded 0.5 mg/L for 50% of their 18 samples which began in 2014. Cargill Value Added Meats did not report load over the TMDL time period. The Clarks Grove WWTF exceeded 2 mg/L in 4% of their 45 monthly average measurements from 2009 to 2018. Reported loads from Clarks Grove WWTP also showed exceedance of the WLA being assigned for this TMDL (1.937 lb/day) approximately 64% of the time. None of the Hayward WWTF or DNR Myre Big Island State Parke samples exceeded 1 mg/L since 2009. Reported loads over the TMDL time period from Hayward WWTF and DNR Myre Big Island State Park also did not exceed their WLA assigned for this TMDL.

Many of point sources are performing very well a majority of the time. In order to meet the TMDL, it is expected that all NPDES permitted facilities will meet their phosphorus permit limits under all conditions. Because some permit-limit exceedances occur for all TMDL parameters at some facilities (Albert Lea WWTF, Cargill Value Added Meats, DNR Myre Big Island State Park), the point-source contributions in the Shell Rock River Watershed can be improved.

9.2 Nonregulated sources

Nonregulated rehabilitation actions within the impaired river reach watersheds will require cooperative planning and implementation by the Freeborn County SWCD, Shell Rock River Watershed District, and regional, state, and federal agencies. The One Watershed One Plan process is already underway in the watershed. The BMPs that are expected to reduce loads of pollutants addressed in this TMDL to impaired streams are identified below with details provided by *The Agricultural BMP Handbook for Minnesota* [Miller et al. 2012] and *Minnesota Stormwater Manual* [MPCA 2019a]. Cost, targets, and other BMP information are further discussed in the WRAPS Report. Options listed below will improve the water quality regarding most or all of the water quality parameters addressed in this TMDL.

- **Buffers and Stream Bank Stabilization**: Freeborn County has 98% compliance with the Minnesota Buffer Law. Additional work could be considered to protect and stabilize private ditches. This work would be above what is required by the Buffer Law and implementation would be voluntary.
- **Agricultural (Cropland) BMPs:** Cropland BMPs such as conversion to pasture with rotational grazing, conversion to grassland/perennials, the use of no-till cropping systems, the use of cover crops, and many others help to filter out or reduce the sediment that moves into the stream system. Cropland BMPs also help to redirect overland flow into interflow and groundwater flow to reduce the flashiness of the system.

- **Animal Access Control**: Off stream watering and fencing will aid in restricting animal access to stream and sensitive stream bank areas and allow growth of riparian vegetation.
- **Manure Management**: Proper manure management will assist in reducing the amount of manure-derived organic matter that is carried in runoff volumes. Manure management techniques include applying manure at recommended rates, controlling manure stockpile runoff, avoiding manure application near open inlets, and avoiding winter manure spreading.
- **Pasture Management**: Rotational grazing, off-stream watering, and maintenance of riparian vegetation will aid in keeping bacteria from entering stream systems.
- **Urban BMPs in NonMS4 Areas:** Urban BMPs and pollutant removal calculators are detailed by the MPCA website and the *Minnesota Stormwater Manual* [MPCA 2019a] and include source, rate, and volume controls and minimizing impervious sources. Reducing nutrients that are discharged to public waters is the primary concern. Source controls act to reduce residential/commercial erosion areas, fertilizer use, and organic debris from lawns (e.g., grass clippings and leaves) and pet wastes. Community use of lawn-waste recycling and street sweeping are examples. Primary urban BMPs reduce stormwater pollutants via filtration, infiltration, sedimentation, and chemical treatments. The voluntary Minimal Impact Design Standards (MIDS) practices are particularly amendable for use in areas that have soil types with high infiltration rates. MIDS is based on LID, which is an approach to stormwater management that mimics a site’s natural hydrology as the landscape is developed. Using the LID approach, stormwater is managed on site and the rate and volume of predevelopment storm water that reaches receiving waters is unchanged. The calculation of predevelopment hydrology is based on present-day native soil and vegetation. This program will help with reviewing and updating existing stormwater-related ordinances to better protect and restore water resources. The program could also streamline compliance under the state’s NPDES Construction Permit (which applies to all grading activities that disturb more than one acre), because this permit has more strict requirements for impaired waters and has greater antidegradation restrictions.
- **Pet Waste Management in NonMS4 Areas**: Ensure that local ordinances are being followed by using public education and enforcement of pet waste regulations.
- **County SSTS (Septic System) Compliance and Inspection Programs**: County ordinances have been developed to protect human health and the environment and need public support. Upgrades of noncompliant systems may be required to obtain building permits and upon property sale. County support via the WRAPS process may result in designating grants or loans to help in upgrading old and failing septic systems. Failing and noncompliant SSTSs adjacent to lakes, streams, and associated drainages should receive the highest priority.
- **Targeted Monitoring.** Monitoring of potential critical areas that discharge low DO and/or high DO-demanding substances should be considered. For example, sequential monitoring (grab sampling of upstream and downstream discharge locations from a post summer storm event) of wetland complexes could be considered.
- **Restoration of Hydrology to Altered Watercourses and Wetland Complexes:** Wetland restoration, reduction of tile-drains, and restoration of the altered waterways would help to

reduce the flashiness of the system and, therefore, the in-stream sediment issues related to high flows such as bed and bank scour.

- **Drainage System Management (Public and Multi-Purpose).** Management of drainage systems will improve flow flashiness and delivery of pollutants to waterways.
- **Source, Rate, and Volume Control Practices**. This BMP will be effective in reducing DO-demanding substances as well as improving base flow conditions for biota considerations.
- **Lakeshore Buffers and SSTS Compliance:** Encouraging and tracking the adoption of lakeshore buffers and SSTS compliance rates are efforts that lake associations can provide local leadership, via information campaigns, acquiring local/state funding to aid homeowners, and tracking lakeshore buffers and septic compliance rates with support provided by the local counties.
- **General Nutrient Reduction in Lakes:** Internal loading can comprise an important portion of the phosphorus income to impaired lakes and legacy source-impacted wetlands. Internal phosphorus loading is typically the result of excessive historical watershed loading and a recommended first step is to reduce watershed phosphorus loading as much as possible. This includes reducing runoff from shore lands, developed land, noncompliant SSTSs, and other upland sources.
- **Alum Treatment in Lakes:** Whole lake treatment by alum can be very effective in reducing lake internal loading of phosphorus for 10 to 30 years. In alum treatment, a white alum band is deposited along the top of the lake's sediments serving to trap released P. However, effectiveness in shallow lakes may be reduced because of wind mixing and disruption of the sediment's alum layer [Cooke et al. 1986]. After reducing watershed phosphorus loading sources, the appropriateness of a whole lake alum treatment can be assessed by a detailed feasibility study. Mobilization and treatment costs could amount to about $1,000 per acre depending on dosage requirements and alum costs.
- **Other Lake Treatments:** Hypolimnetic treatments such as ferric chloride, aeration, and oxygenation.
    - A recommended total iron to TP concentration ratio of 3:1 for lake bottom water has been used to control lake sediment released phosphorus. If the total iron to TP ratio is less than 3:1, then iron is likely not effectively reducing sediment- liberated phosphorus concentrations. In the latter case, iron augmentation of lake sediments may be required by using ferric chloride or similar iron compounds. The details, including oxygen supply rates, would have to be determined by an engineering design study.
    - High oxygen depletion rates can be expected to accompany elevated lake productivity (e.g., algal concentrations). Replenishing oxygen supplies via oxygenation of bottom waters may be a viable option in some cases. This would require installing a series of pipes and diffusers on the lake bottom along with required pump house and oxygenation system on land. The details, including oxygen supply rates, would have to be determined by an engineering design study. Lake aeration (without oxygenation) will require careful examination if intended for something other than reduced winter fish kill potential. Whole

lake aeration during the growing season can result in increased phosphorus concentrations that feed increased algal growth and potentially degrade lake quality.

- **Rough Fish Kills in Lakes:** Rough fish such as carp and other bottom feeders stir up sediment in lakes contributing to increased phosphorus concentrations. Rough fish kills help to reset the fish population so that rough fish are less prevalent. However, they do make their way back into the lake after a period of time.
- **Dredging Lakes:** Dredging lakes can be a temporary option to remove phosphorus and sediments from lake bottoms.
- **Herbicides or Mechanical Removal of Invasive Plants in Lakes:** Curly-leaf pondweed produces dense mats at the water's surface. In mid-summer, the plants usually die and dying plants accumulate on the shorelines, and their death is often followed by low water clarity and increased algal blooms. Curly-leaf pondweed can be managed by treatment with herbicides or the mechanical removal of plants.
- **Water Quality Trading:** Water quality credits can be traded between urban areas and upstream agricultural areas to attain reductions using the most cost-effective methods
- **Public Education, Public Outreach, and Civic Engagement**: Public education, public outreach, and civic engagement on the benefits of the above practices should continue within the Watershed. The Freeborn SWCD, Freeborn County, and other LGUs should provide core materials for reinforcing messages aimed at target audiences.

9.3 Cost

The CWLA Minn. Stat. § 114D.25 requires that a TMDL include an overall approximation of the cost to implement it. The cost estimate included below is, by nature, a very general approximation that has considerable uncertainties associated with design complexity, local regulatory requirements, unknown site constraints, and BMP choices with widely variable costs per water quality volume treated. This is a large- scale estimate, and many other implementation strategies will likely be used in addition to (or in replacement of) the general practices used in this estimate.

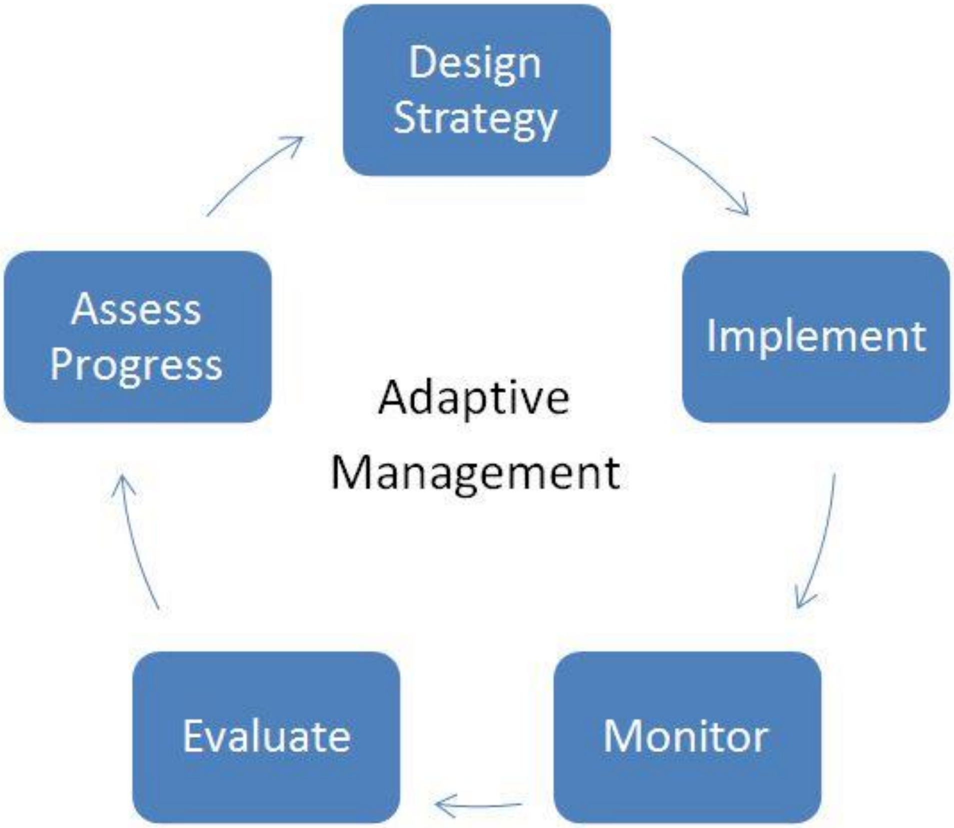
The cost estimate for this TMDL includes implementing buffers along public ditches and waterways in impaired drainage areas (50-foot buffers on both sides of streams and around lakes and 16.5-foot buffers on both sides of ditches). Approximately 98% of buffers on public ditches and waterways have already been implemented in the Shell Rock River Watershed, and an additional 15 miles along streams/lakes/and ditches need to be buffered at approximately $200 per acre after cost share [Shaw 2016]). Freeborn County had installed many ditch buffers before the new buffer law was effective. Total costs for additional buffers are expected to be approximately $6,000. Alum treatments could be employed in impaired lake acres (approximately 3,947 acres at $1,000 per acre [Kretsch 2016]); however, these shallow lakes are less likely to show a significant response to alum because internal loading likely occurs more from rough fish and invasive plants. If alum were used in all impaired lakes, it would cost nearly $4 million dollars. A rough fish kill/fish restocking costs approximately $10,000 per lake but is not a permanent fix as rough fish populations will eventually reestablish themselves. A rough fish kill/restock of all impaired lakes would cost approximately $50,000. Herbicide/mechanical removal of invasive plants would also help improve the impaired lakes in the Shell Rock River Watershed. Septic updates around impaired lakes (19 failing septic systems at $15,000 to $20,000 a system) is another option for improving lake water quality. Cropland BMPs would also make substantial water quality improvements through the watershed. There are approximately 86,000 acres of cropland draining to the impaired reaches in the Shell Rock River Watershed. Using costs from the SAM, if cover-crops ($46.50/acre/year) were implemented on one-third, nutrient management ($8.45/acre/year) on one-third, and no-till ($10.01/acre/year) or reduced-till ($19.52/acre/year) on one-third, it would cost an average of approximately $23/acre/year or about $6.5 million over 10 years. Overall, nonpoint source implementation of the TMDL could cost approximately $11 million.

MIDS on half of all high- and medium-intensity developed lands (approximately 8,000 acres at $5,000 per acre or $40 million dollars) [Barr 2011] would also improve both stream and lake water quality in the watershed. Urban BMP costs estimated in this overview are primarily based on construction and maintenance costs. Land areas required for constructed BMPs generally require 2% to 5% of the watershed drainage area, but land costs are not generally included because they can vary. Finally, the city estimates that upgrades needed to the Albert Lea WWTF will be approximately $20 to $30 million dollars for electrical, digester, biogas, and grit improvements [Jahnke 2019]. Overall, implementation for the MS4 and point sources could cost approximately $60 million.

9.4 Adaptive management

The list of implementation elements and the more detailed WRAPS report prepared concurrently with this TMDL assessment will focus on adaptive management, as illustrated in Figure 51. Continued monitoring and “course corrections” that respond 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 provide the groundwork for delisting the impaired waterbodies. Currently, the cycle depicted in Figure 51 is repeated every 10 years for monitoring, and subsequent activities follow on that as appropriate. Ongoing monitoring and analysis of trend data and BMP implementation information will assist managers to make informed decisions on adapting management approaches.

Figure 51. Adaptive management cycle.



10. Public participation

Efforts to facilitate public education, review, and comment with developing the Shell Rock River Watershed TMDLs included meetings with local groups in the watershed on the assessment findings and a 30-day public notice period for public review and comment of the draft TMDL document. All input, comments, responses, and suggestions from public meetings and the public notice period were addressed or were taken into consideration in developing the TMDL. The draft TMDL report was first made available to SRRW stakeholders for preliminary review on October 14, 2019. Regular updates regarding the TMDL process with the Watershed WRAPS team included meetings to discuss TMDL processes and results. Public and team meetings are listed below:

Table 47. Meetings conducted between MPCA and SRRW stakeholders for WRAPS/TMDL report development.

Date	Meeting/Event	Topics
Jan. 10, 2012	SRRWD	TMDL
Feb. 9, 2012	City of Albert Lea, City Council Work Session	TMDL, Stormwater
Feb. 9, 2012	Freeborn SWCD	TMDL
Dec. 6, 2012	Freeborn County Board work session	TMDL
July 22, 2015	TMDL/WRAPS committee	WRAPS development meeting #1
Apr. 13, 2016	TMDL/WRAPS committee	WRAPS development meeting #2 & SRRW wetlands
Jan. 15, 2019	TMDL Discussion	Discussion of modeling results and took input for future modeling scenarios.
Aug. 6, 2019	WRAPS working meeting	Assign N & P reduction scenarios
Oct. 22, 2019	WRAPS working group meeting	Review and determine watershed priorities
Nov. 12, 2019	TMDL discussion	Discuss the draft Shell Rock TMDL and the updated modeling/associated documentation.
Dec. 12, 2019	WRAPS working group meeting	Review preliminary WRAPS report

Throughout these meetings, several accommodations by MPCA have resulted in changes to the TMDL and or the Shell Rock River Watershed HSPF model. At the City of Albert Lea's request the following was done:

- The simulated time period of the SRRW HSPF model was appended to 2013 through 2018.
- Extended simulated time period allowed MPCA to incorporate more water quality data in the model calibration, including continuous DO data provided by the SRRWD.

The MPCA presented information on the TMDL and facilitated public comments/questions at the following public meetings during the public notice:

- MPCA Webex public meeting; August 4th
- City of Albert Lea Council Meeting; August 25th

In addition, an informational presentation on the TMDL was recorded and published on MPCA's Shell Rock River Watershed webpage.

Public notice

An opportunity for public comment on the draft TMDL report was provided via a public notice in the State Register from July 27, 2020 through September 25, 2020. There were eight comment letters received and responded to as a result of the public comment period.

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Appendices

Appendix A: Albert Lea Lake (24-0014-00)

Land cover

Land cover defined by the 2011 NLCD is summarized for the Albert Lea Lake Watersheds in Table A-1 with the majority of the land cover draining to the western portion of the lake consisting of row crops (64.4%) and developed (15.7%) and draining to the eastern portion of the lake consisting of row crops (78.9%) and developed land (9.2%).

Table A-1. Albert Lea Lake Watershed land cover.

Impairment	Developed (%)	Wetlands (%)	Open Water (%)	Forest (%)	Grassland (%)	Hay/ Pastures (%)	Row Crops (%)
Albert Lea (Western Portion)	15.7	4.4	5.5	1.9	6.2	1.9	64.4
Albert Lea (Eastern Portion)	9.2	2.2	3.3	1.1	4.5	0.9	78.9

Physical characteristics

Albert Lea Lake is located on the southeast side of Albert Lea, Minnesota, in Freeborn County in the center of the Shell Rock River HUC 8. From a regulatory standpoint, Albert Lea Lake is categorized as a shallow WCBP ecoregion lake. Select lake morphometric and watershed physical characteristics are listed in Table A-2. Albert Lea Lake has three public access sites. One access site is maintained by the city of Albert Lea and has 2 ramps, parking for 24 boat trailers, and 1 dock. The other two access sites are maintained by the DNR. One of the DNR access sites has one concrete ramp, parking for eight boat trailers, and one dock, and the other DNR access site has one concrete ramp, parking for seven boat trailers, and one dock. Figure A-1 shows aerial imagery of Albert Lea Lake. Figure A-2 shows lake level data from Albert Lea Lake.

Table A-2. Select lake morphometric and watershed characteristics for Albert Lea Lake.

Characteristic	Albert Lea Lake	Source
Lake Surface Area (acres)	2,669.2	DNR LakeFinder Fish Lake Surveys
Lake Littoral Area (acres)	2,669.2	DNR LakeFinder Fish Lake Surveys
Shore Length (miles)	23.79	DNR LakeFinder Fish Lake Surveys
Mean Depth (ft)	3.5	DNR LakeFinder Fish Lake Surveys, Calculated (*), or Estimated from Lake Map (**)
Maximum Depth (ft)	5.5	DNR LakeFinder Fish Lake Surveys
Average Water Clarity (ft)	2**	DNR LakeFinder Fish Lake Surveys, Average Growing Season Secchi Disk Depth (*), or Shell Rock River Watershed District (**)
Recorded Water Level Range (ft)	5.52	DNR LakeFinder Water Level
Percent Lake Littoral Surface Area	100	Calculated
Number of Islands	1	DNR Lakefinder Map
Public Access Sites	4	DNR LakeFinder Water Access Sites
Drainage Area, Including Lake (acres)	94,090	Model Subwatersheds
Watershed Area to Lake Area Ratio (X:1)	35.3	Calculated
Wetland Area (acres)	3,582.6	NLCD 2011
Number of Upland Lakes	40	DNR Hydro Layer
Number of Perennial Inlet Streams	2	NHD Flowlines Fcode 46006
Lake Volume (acre-feet)	4,637	Calculated
Maximum Fetch Length (ft)	15,000	Measured Using ArcGIS Imagery
Lake Geometry Ratio (A^0.25/Dmax), A is surface area in square miles (m^2) and Dmax is maximum depth in meters (m)	34.2	Calculated
Lake Geometry Classification	Shallow	Shallow>5.3, Medium1.6-5.3, Deep<0.9
Osgood Index (Dmean/sqrt(A)), A is surface area in km^2 and Dmean is mean depth in m	0.3	Calculated
Osgood Index Category	Polymictic	Polymictic<4, Intermediate4-9,Dimictic>9
Estimated Water Residence Time (days)	46.5	Calculated With Volume and 122Q10 From HSPF Simulated Flow

Figure A-1. Albert Lea Lake bathymetry and aerial imagery.

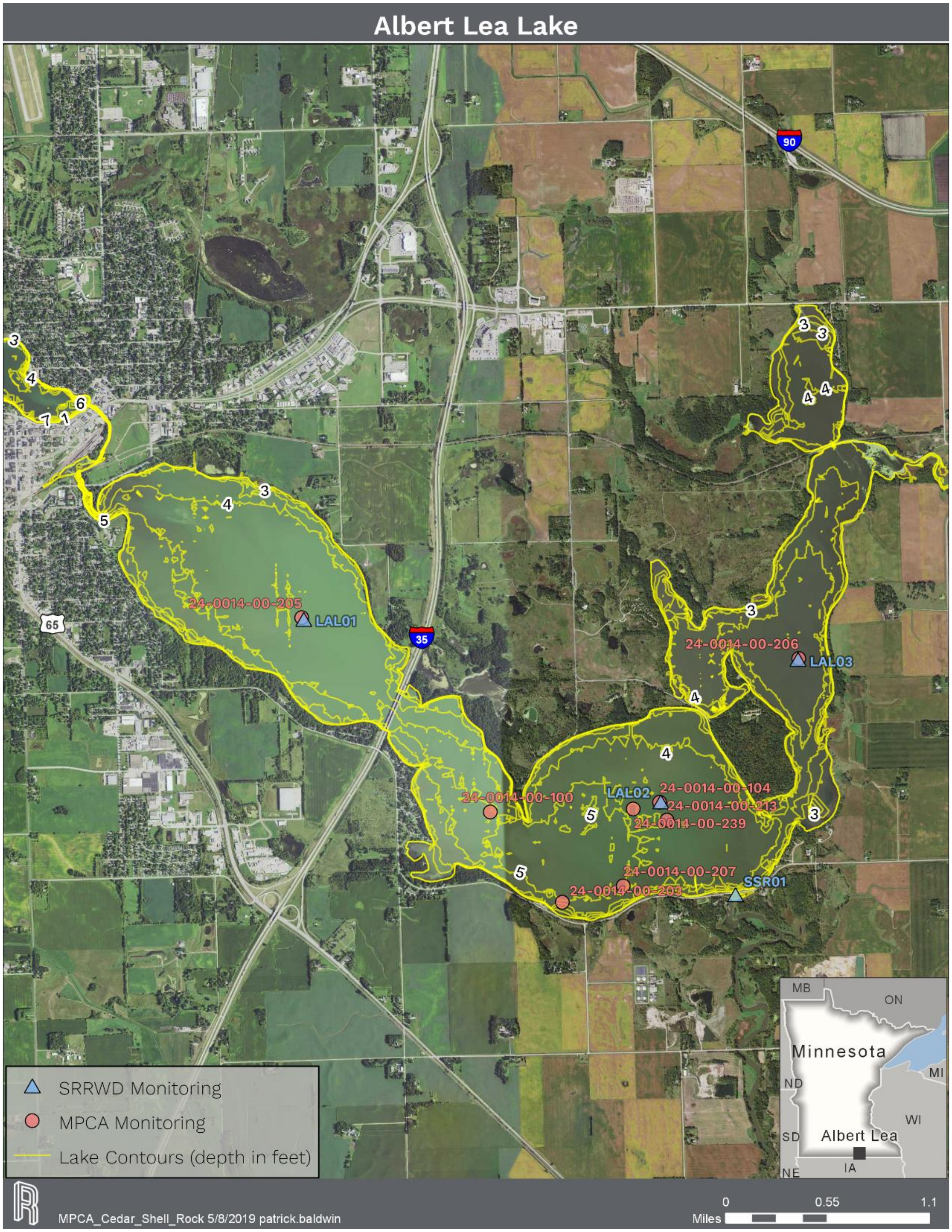
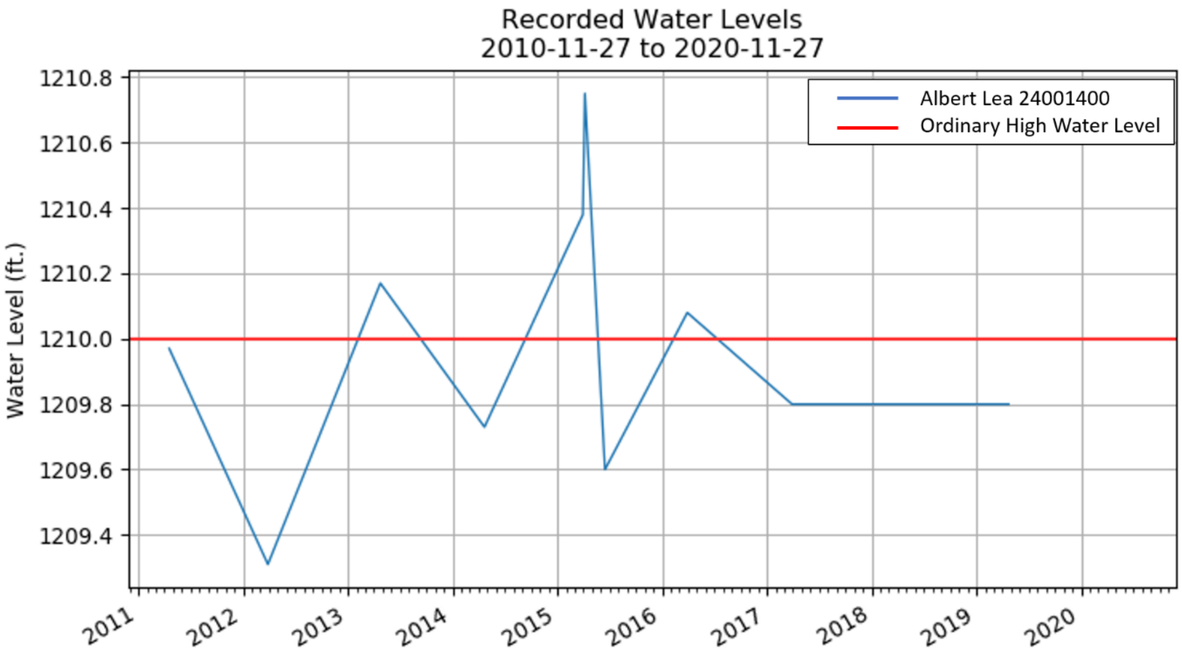


Figure A-2. Albert Lea Lake levels (DNR 2020).



Water quality

Monitoring data annual sample counts are shown in Table A-3 and are summarized over the TMDL period (2009 through 2018) in Table A-4 as mean growing season values for TP, chl-*a*, and SDT. Corresponding lake water quality standards are also included. Mean values for TP and chl-*a* are above the water quality standard for all three sections of Albert Lea Lake, while the mean SDT is in compliance water quality standard in the central portion of Albert Lake but is not in compliance in the eastern or western portions of the lake. These data indicate that Albert Lea Lake exceeds the phosphorus standard and will require reductions to achieve lake standards. Extremely high values of TP were over 400 micrograms per liter (µg/L) in all portions of the lake and of chl-*a* were over 250 µg/L in all portions of the lake, while the lowest SDT reading was 0.49 meter (m) in the eastern portion of the lake. Individual growing season means from data available between 2000 through 2018 were plotted in Figures A-2 to A-10 in the three portions of the lake (western, central, and eastern) and show that water quality standards are exceeded most years with available data.

Multiyear growing season mean monthly water quality observations are summarized in Figures A-11 through A-19 for data available from 2009 through 2018 in the three portions of the lake (western, central, and eastern). Plots of this mean monthly data indicate a general decline in water quality from June through September. Error bars in annual and monthly phosphorus and SDT plots indicate standard error.

Table A-3. Growing season total phosphorus, chlorophyll-a, and Secchi disc depth number of samples annually.

Lake	Constituent	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Albert Lea (Western Portion)	TP	7	7	8	7	6	8	8	7	8	5	71
	Chlorophyll-a (µg/L)	7	5	8	7	6	9	8	7	8	5	70
	Secchi disc depth	7	7	8	7	6	9	8	7	8	5	72
Albert Lea (Central Portion)	TP	8	8	8	7	6	11	8	7	8	5	76
	Chlorophyll-a	8	7	8	7	6	11	8	7	8	5	75
	Secchi disc depth	8	8	8	7	6	10	8	7	8	5	75
Albert Lea (Eastern Portion)	TP	7	7	8	7	6	9	8	7	8	5	72
	Chlorophyll-a	7	7	8	7	6	9	8	7	8	5	72
	Secchi disc depth	7	7	8	7	6	9	8	7	8	5	72

Table A-4. Total phosphorus, chlorophyll-a, and Secchi disc depth growing season means.

Lake	Parameter	Minimum	Mean	Maximum	Standard Deviation	Lake Standards
Albert Lea (Western Portion)	TP (µg/L)	26.0	225.1	707.0	125.1	≤90
	Chlorophyll-a (µg/L)	1.1	88.3	626.0	109.2	≤30
	Secchi disk depth (m)	0.15	0.68	1.77	0.47	≥0.7
Albert Lea (Central Portion)	TP (µg/L)	33.0	190.3	424.0	86.3	≤90
	Chlorophyll-a (µg/L)	1.0	71.1	433.0	94.7	≤30
	Secchi disk depth (m)	0.15	0.77	1.83	0.55	≥0.7
Albert Lea (Eastern Portion)	TP (µg/L)	18.0	252.5	733.0	151.2	≤90
	Chlorophyll-a (µg/L)	1.1	74.6	277.0	63.5	≤30
	Secchi disk depth (m)	0.12	0.49	1.37	0.35	≥0.7

Figure A-3. Albert Lea Lake (west) annual growing season mean total phosphorus concentrations.

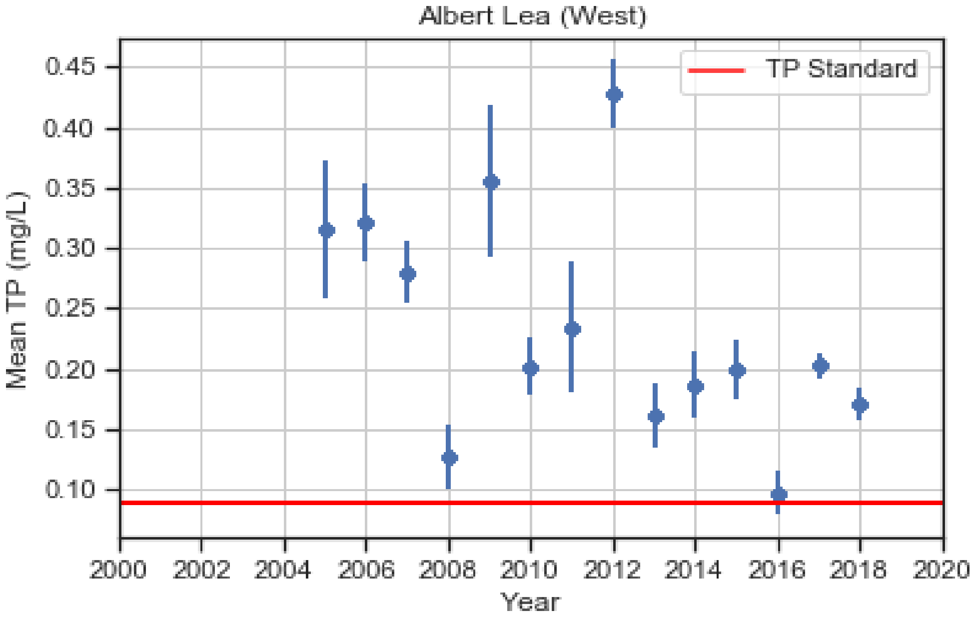


Figure A-4. Albert Lea Lake (west) annual growing season mean chlorophyll-a concentrations.

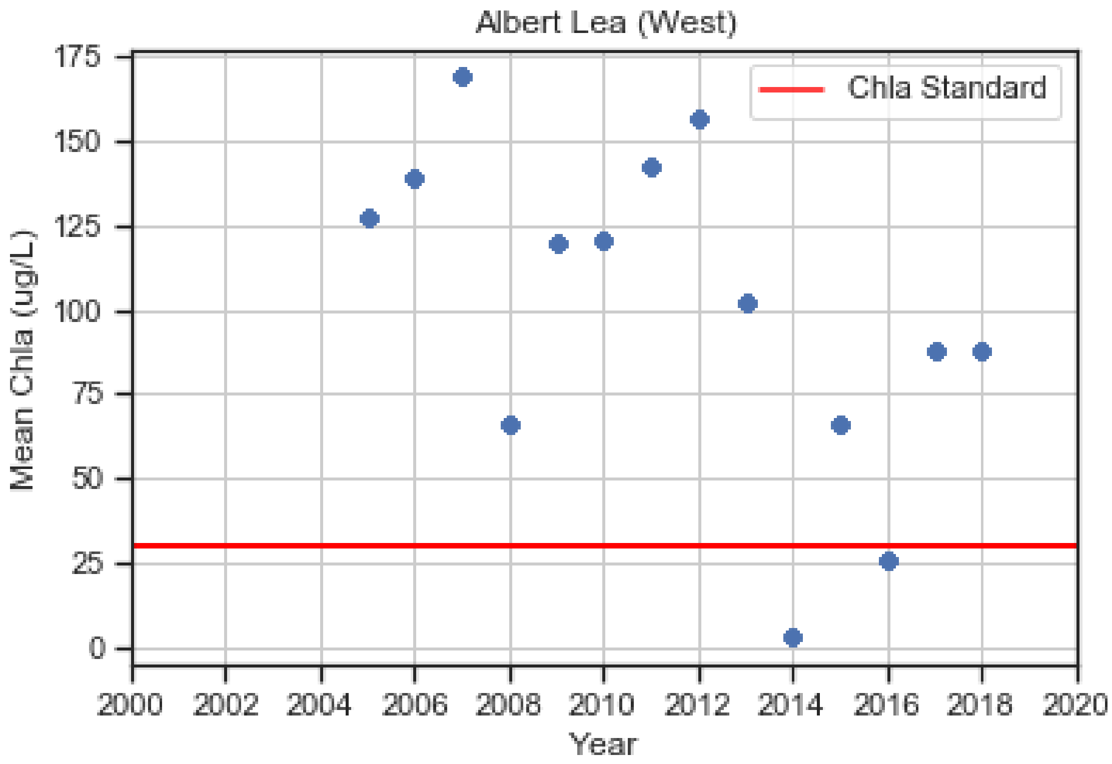


Figure A-5. Albert Lea Lake (west) annual growing season mean Secchi disc depth.

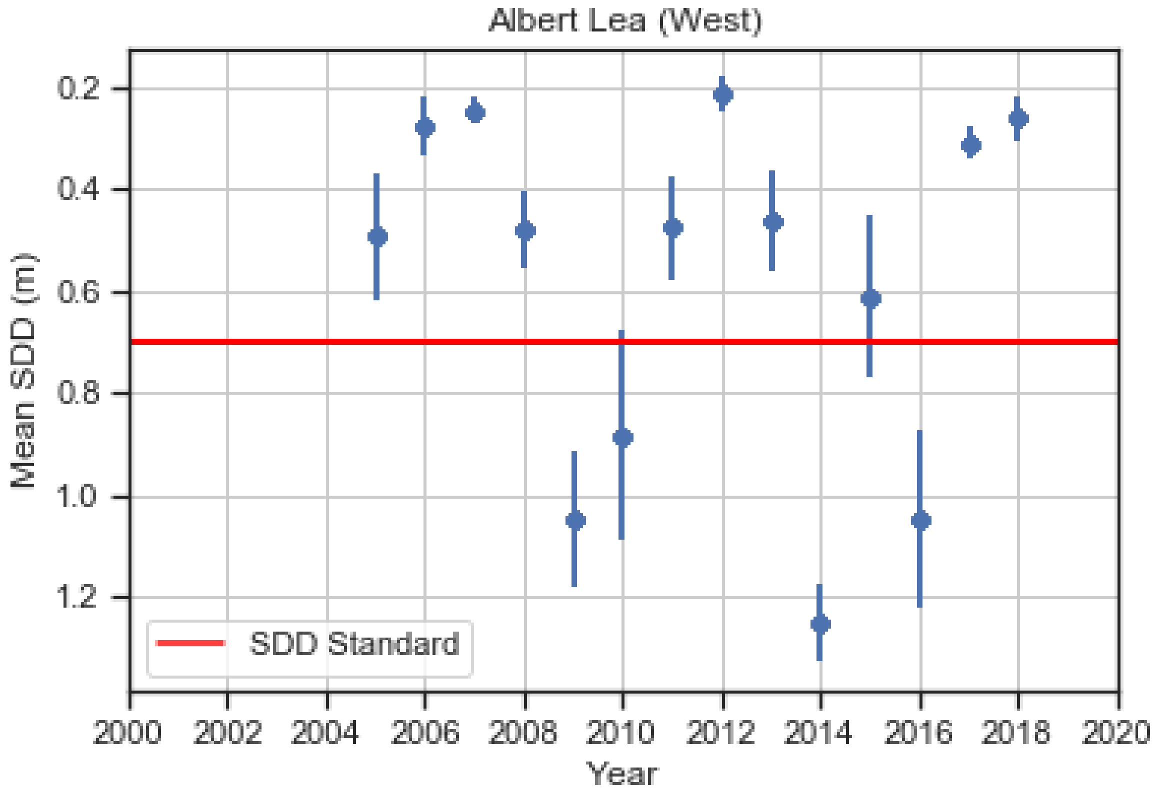


Figure A-6. Albert Lea Lake (central) annual growing season mean total phosphorus concentrations.

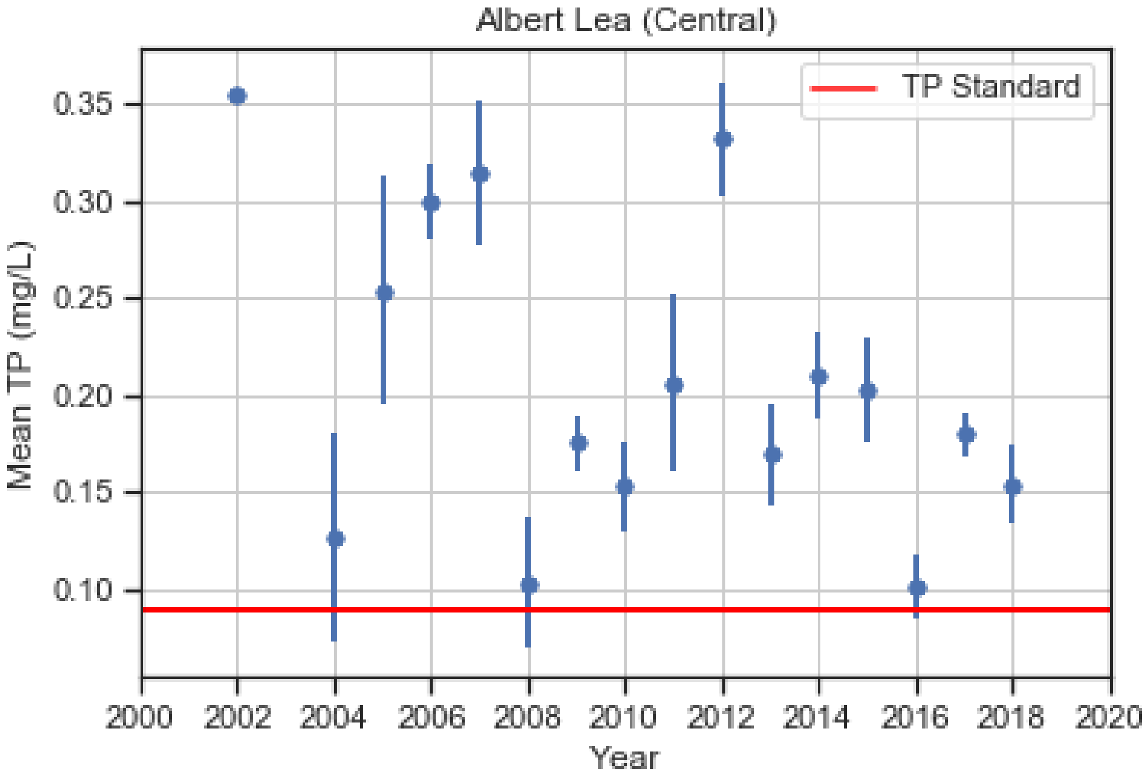


Figure A-7. Albert Lea Lake (central) annual growing season mean chlorophyll-a concentrations.

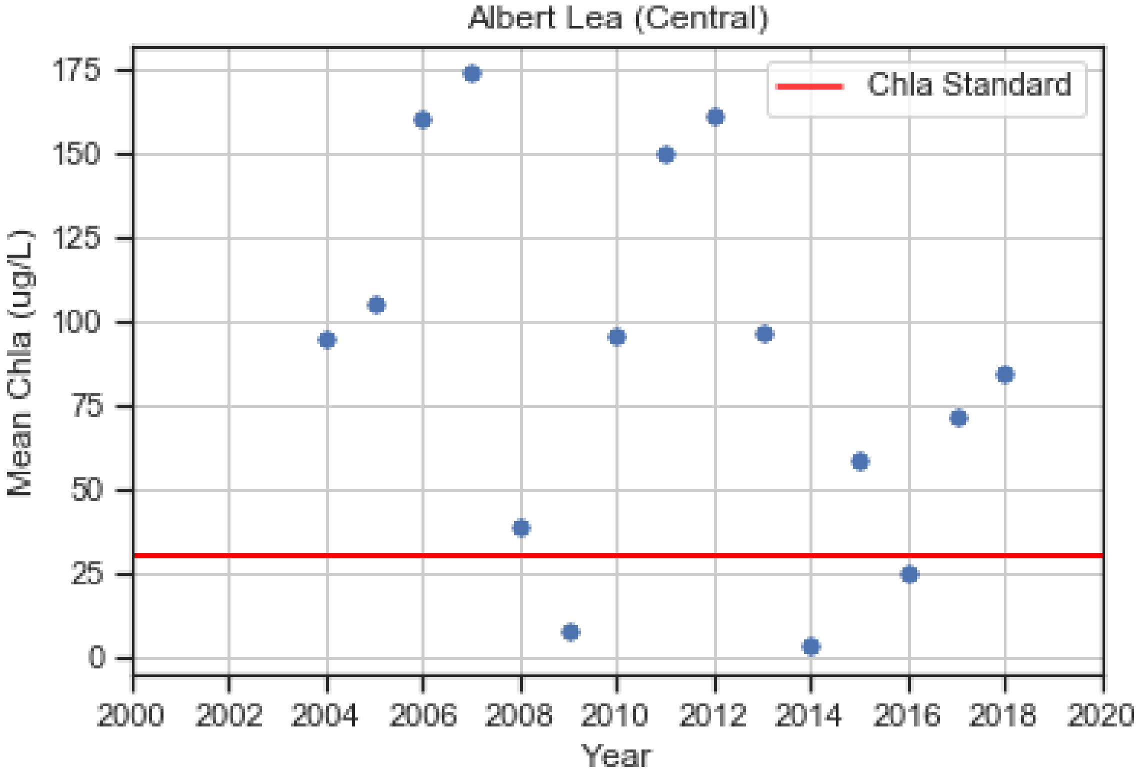


Figure A-8. Albert Lea Lake (central) annual growing season mean Secchi disc depth.

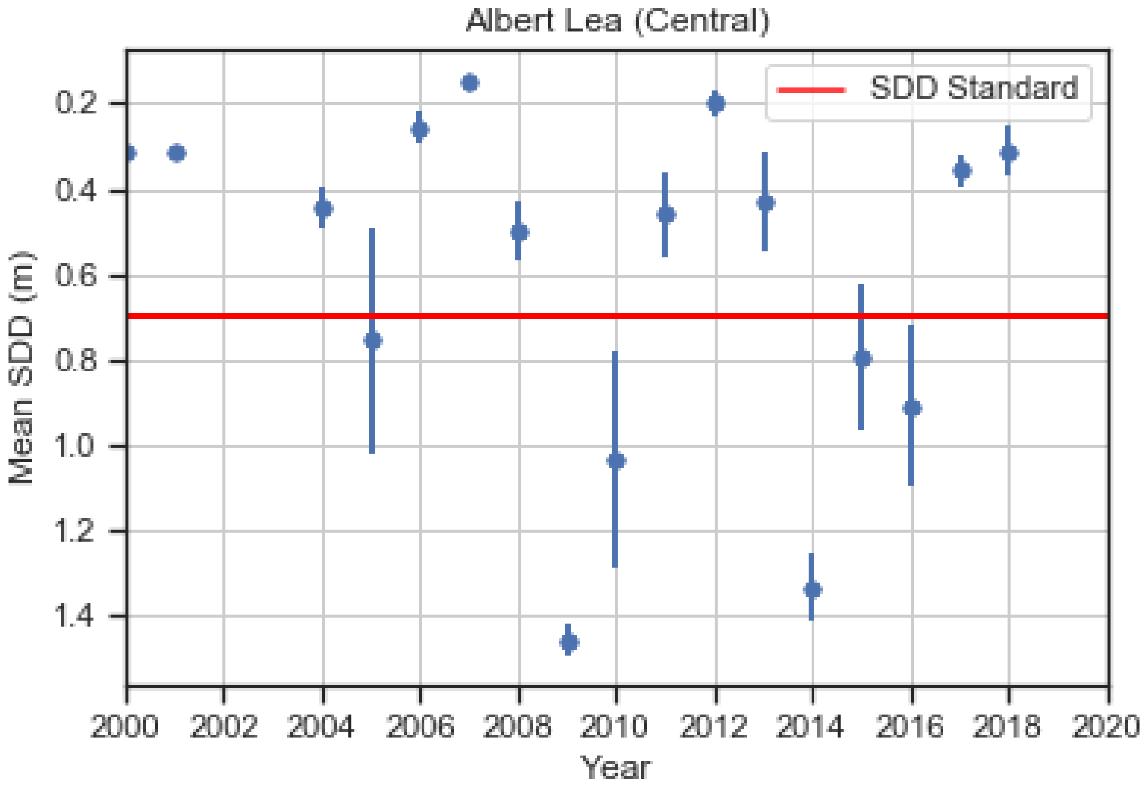


Figure A-9. Albert Lea Lake (east) annual growing season mean total phosphorus concentrations.

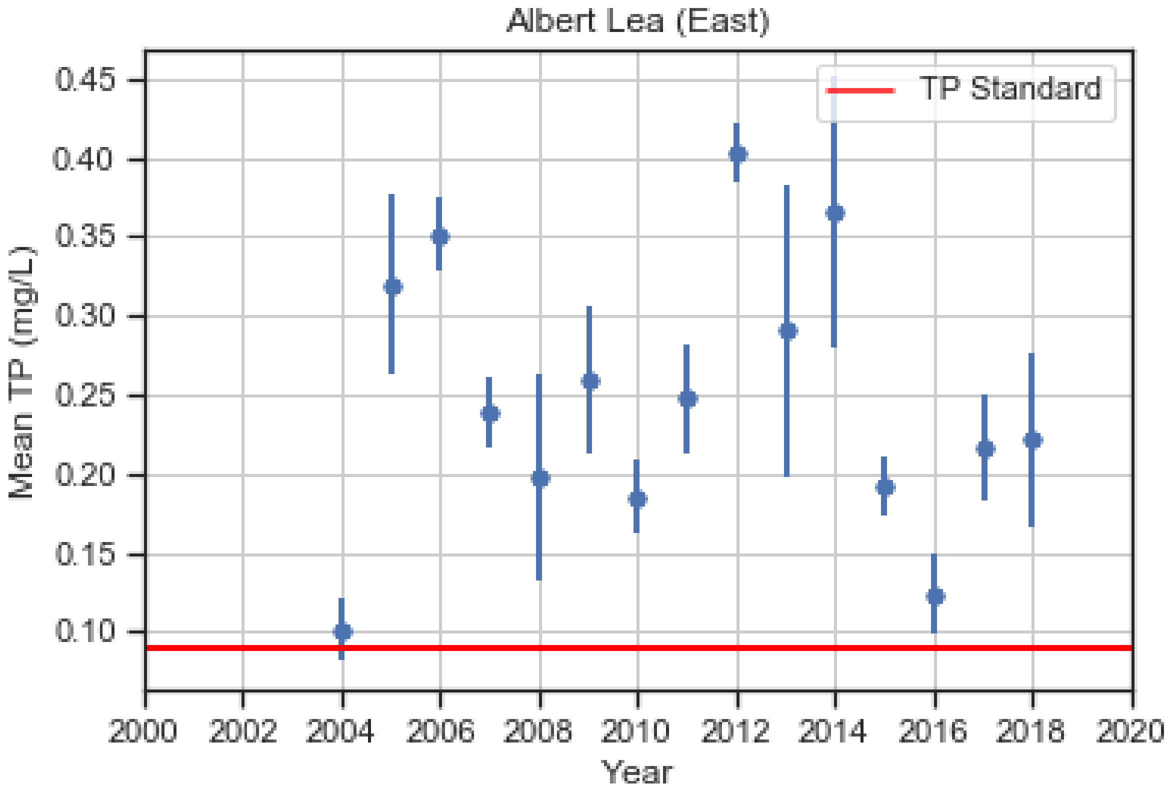


Figure A-10. Albert Lea Lake (east) annual growing season mean chlorophyll-a concentrations.

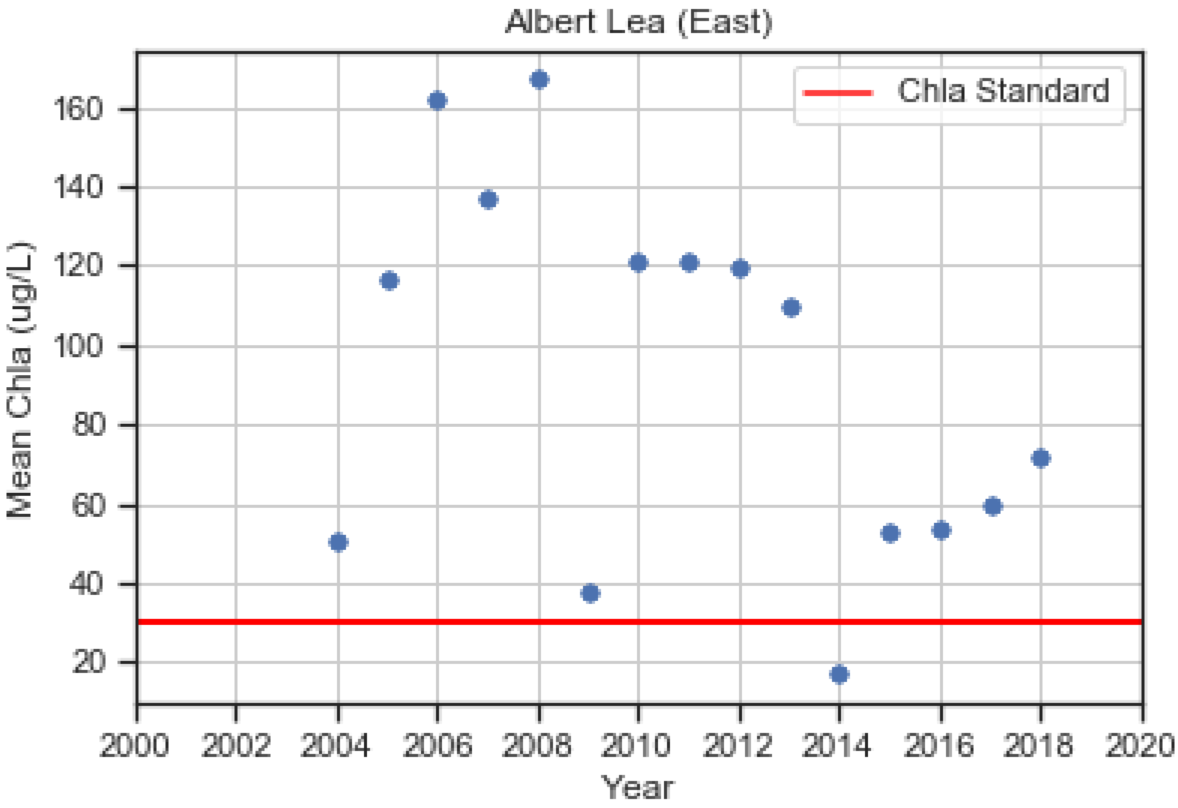


Figure A-11. Albert Lea Lake (east) annual growing season mean Secchi disc depth.

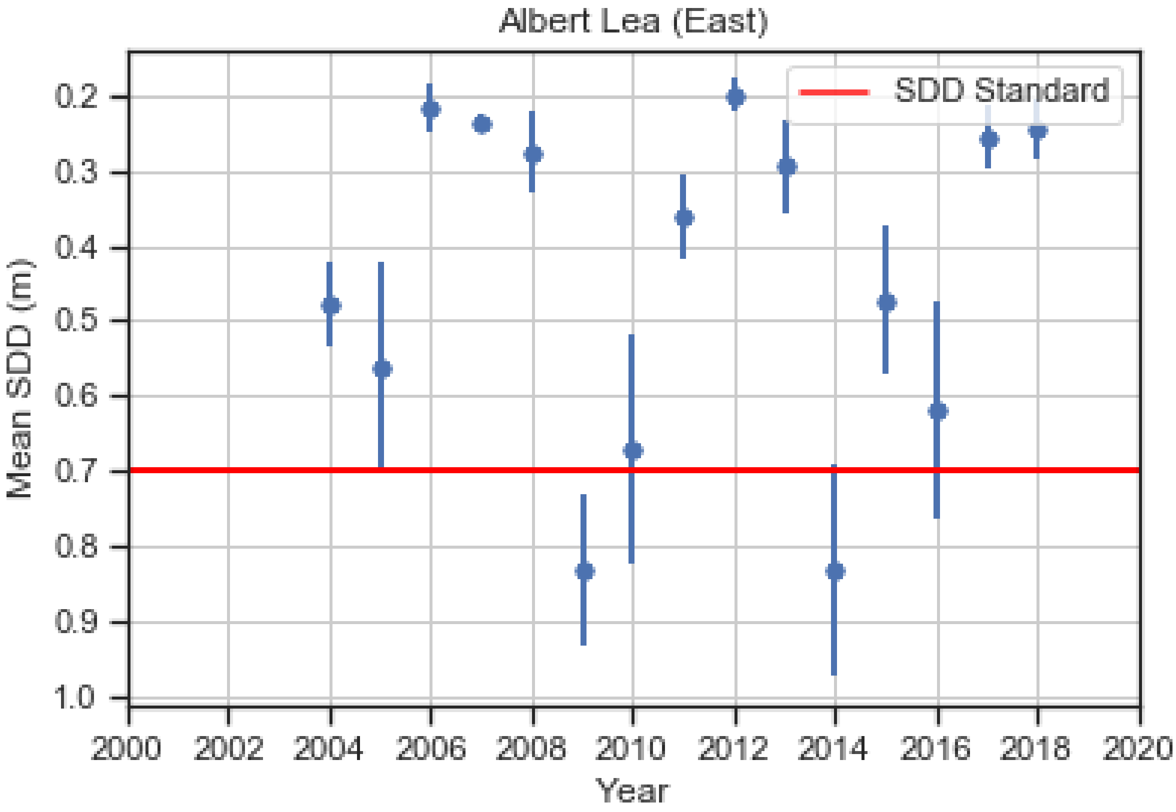


Figure A-12. Albert Lea Lake (west) growing season monthly mean total phosphorus.

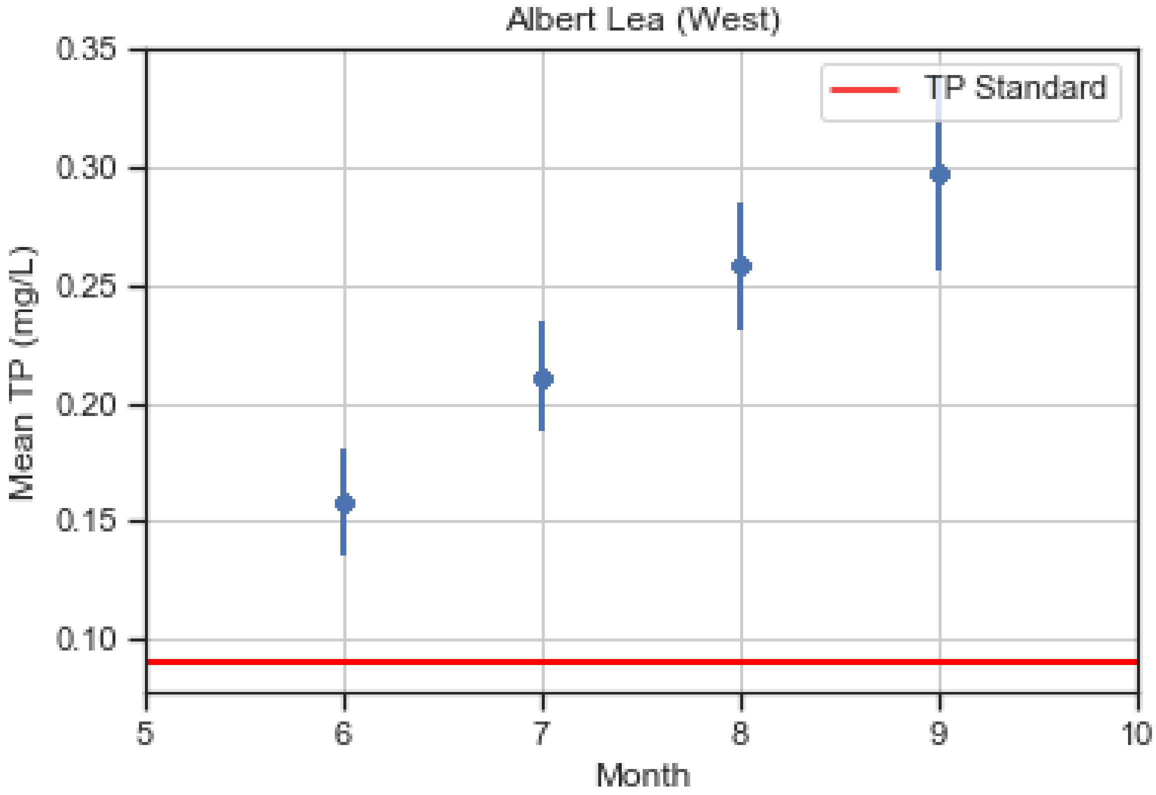


Figure A-13. Albert Lea Lake (west) growing season monthly mean chlorophyll-a.

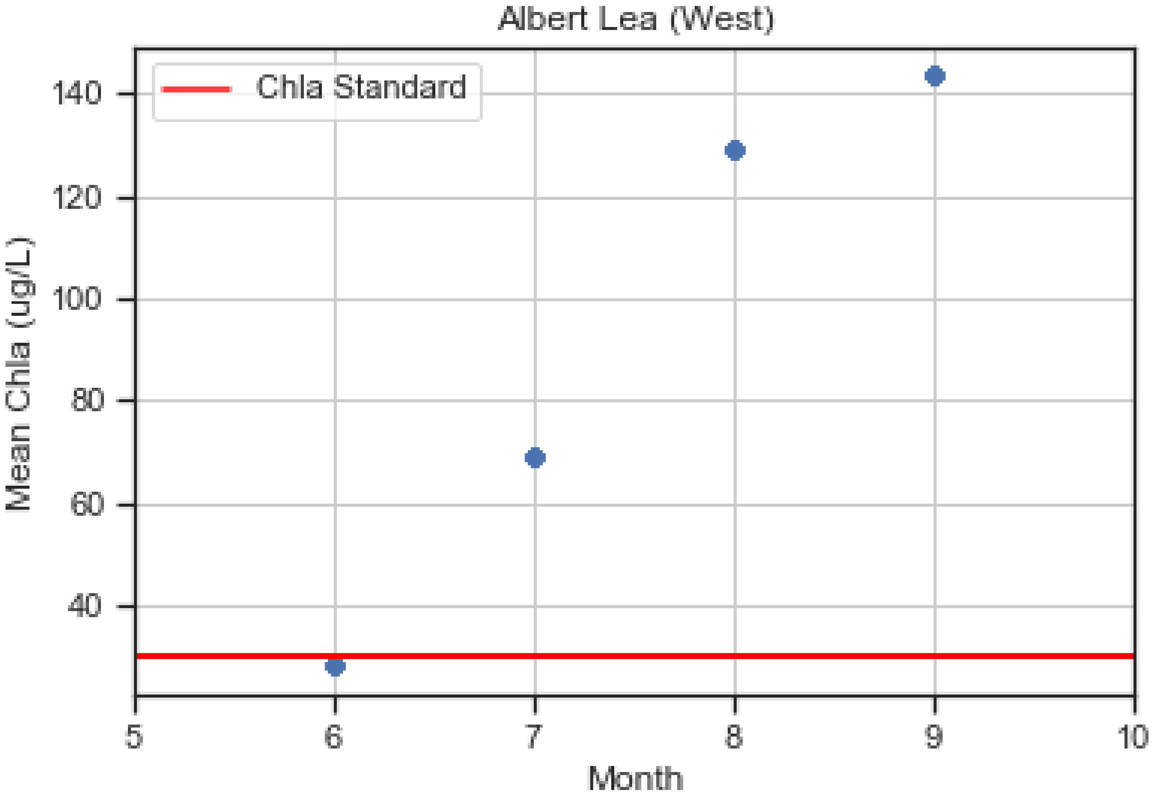


Figure A-14. Albert Lea Lake (west) monthly growing season mean Secchi disc depth.

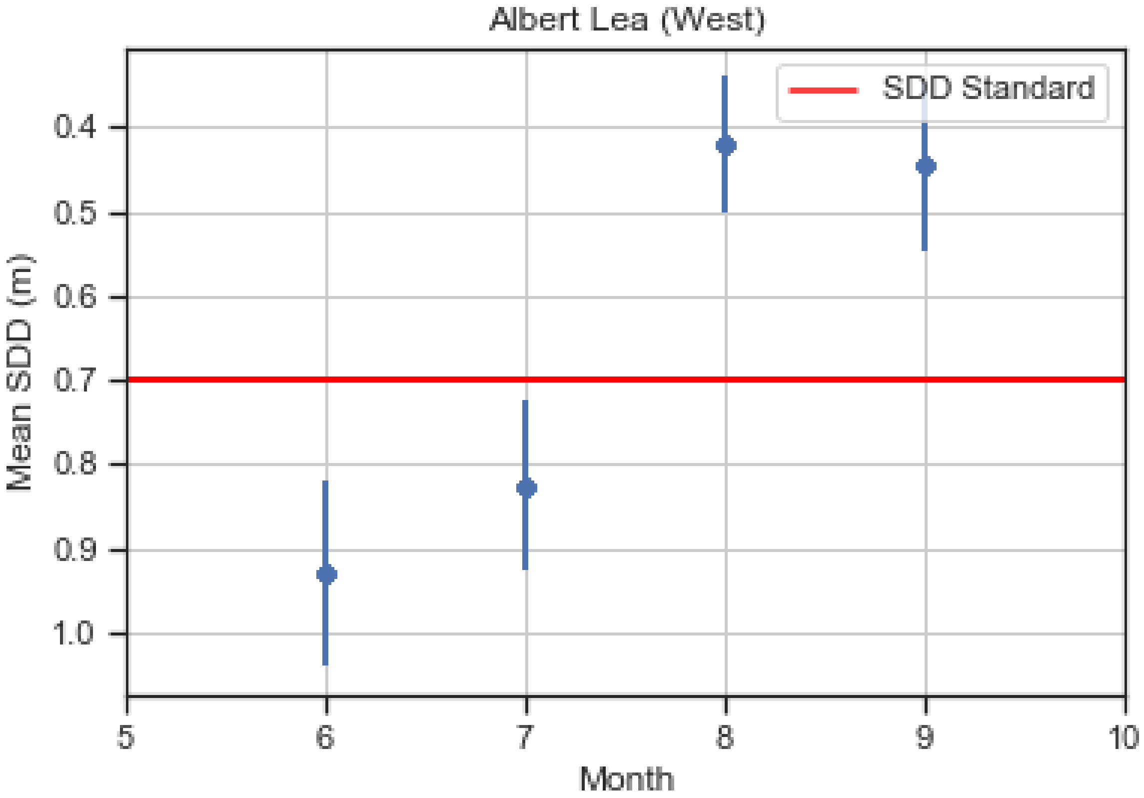


Figure A-15. Albert Lea Lake (central) growing season monthly mean total phosphorus.

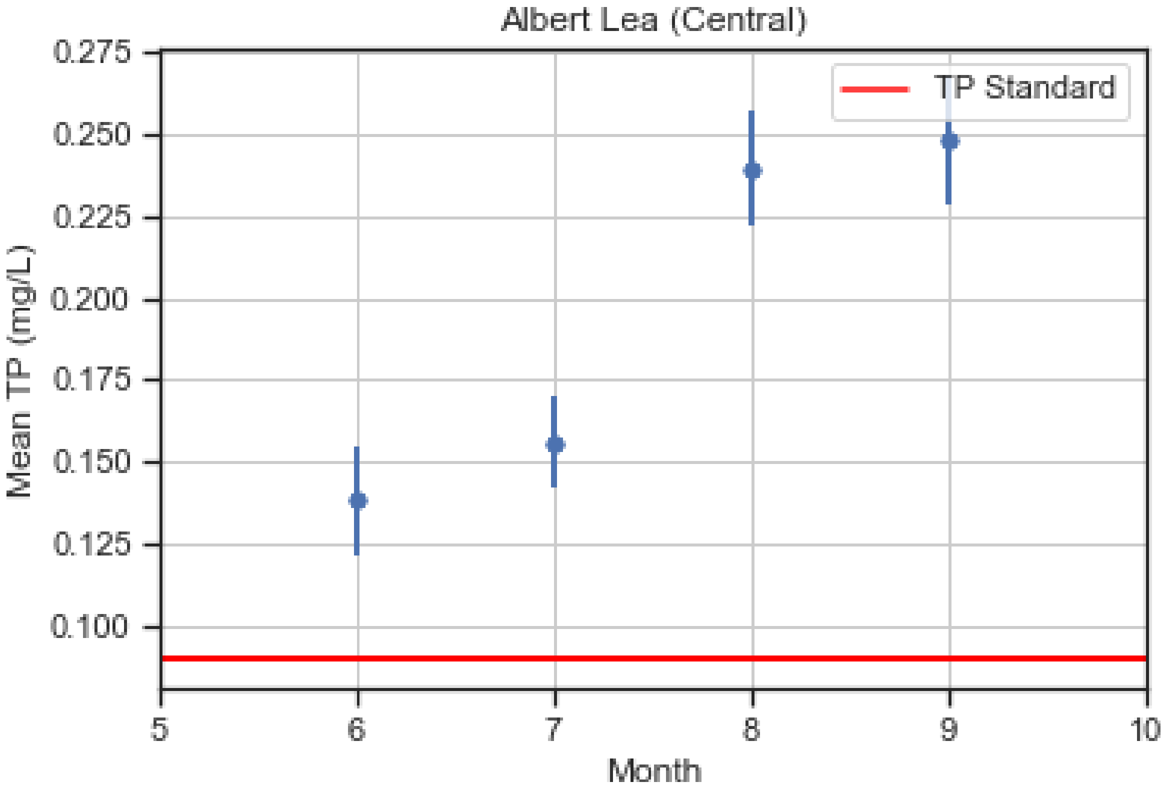


Figure A-16. Albert Lea Lake (central) growing season monthly mean chlorophyll-a.

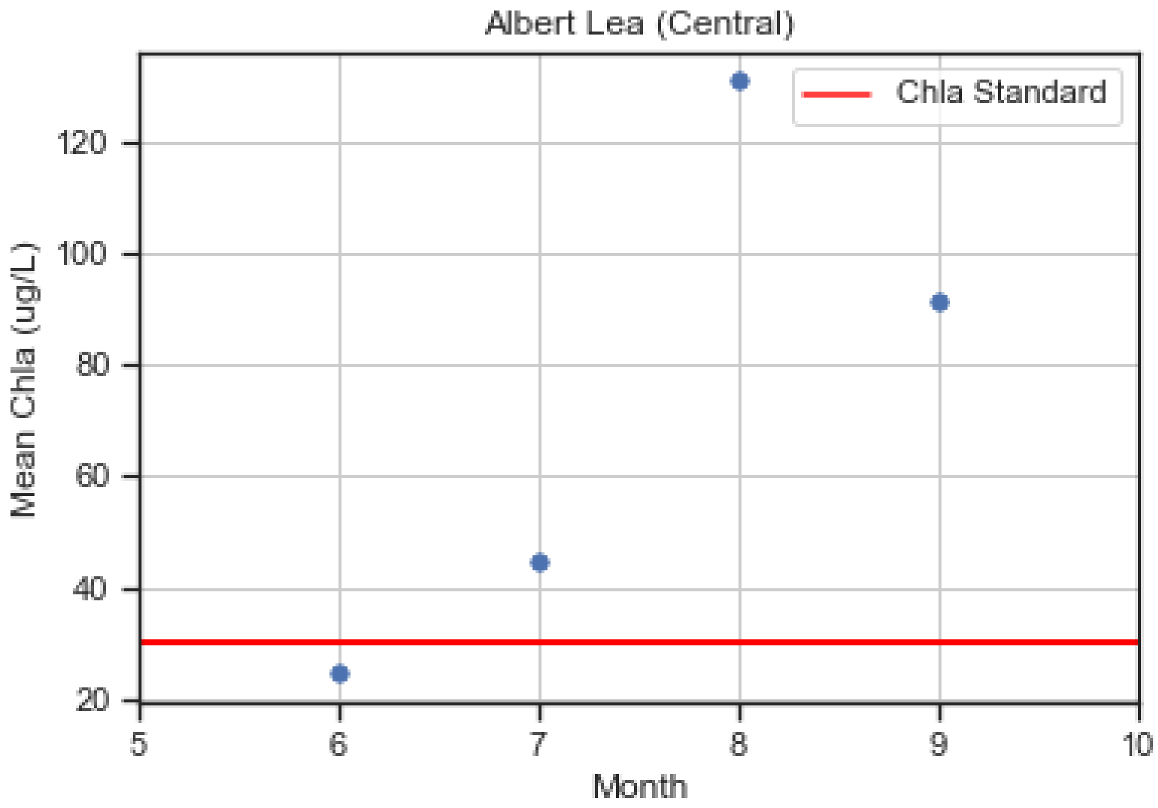


Figure A-17. Albert Lea Lake (central) monthly growing season mean Secchi disc depth.

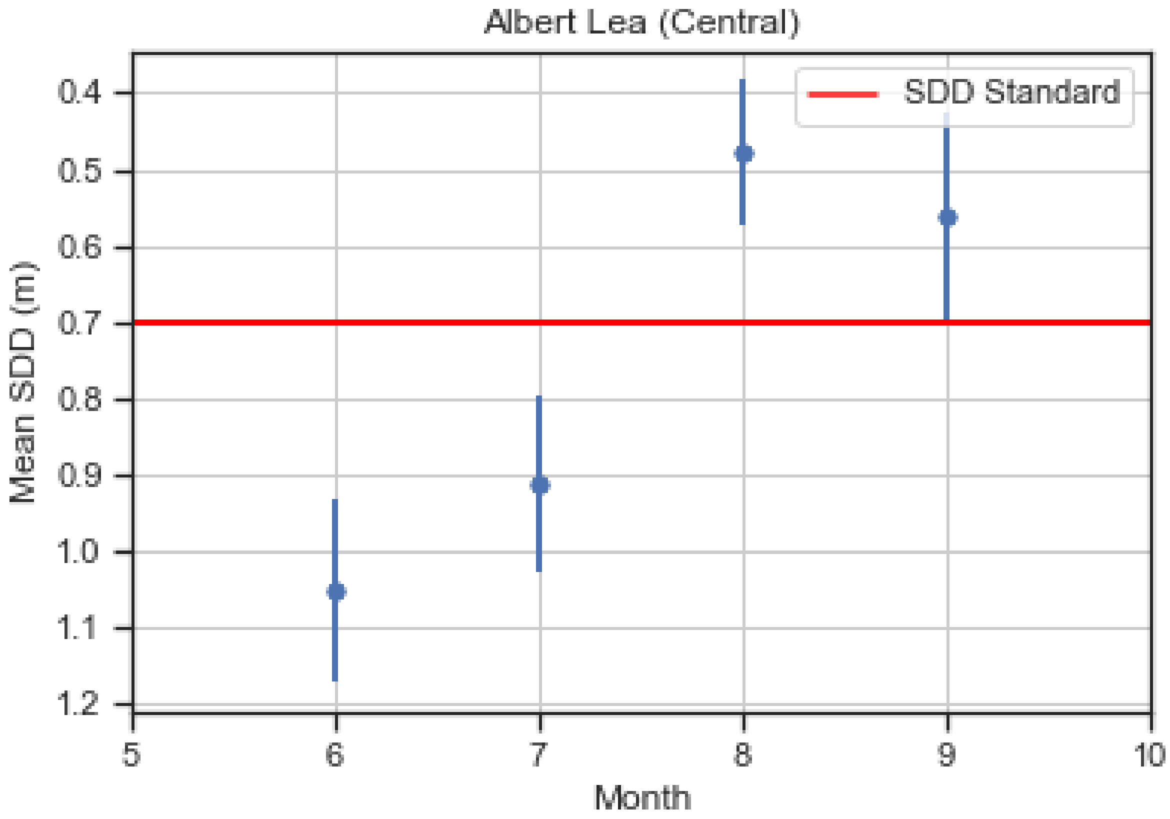


Figure A-18. Albert Lea Lake (east) growing season monthly mean total phosphorus.

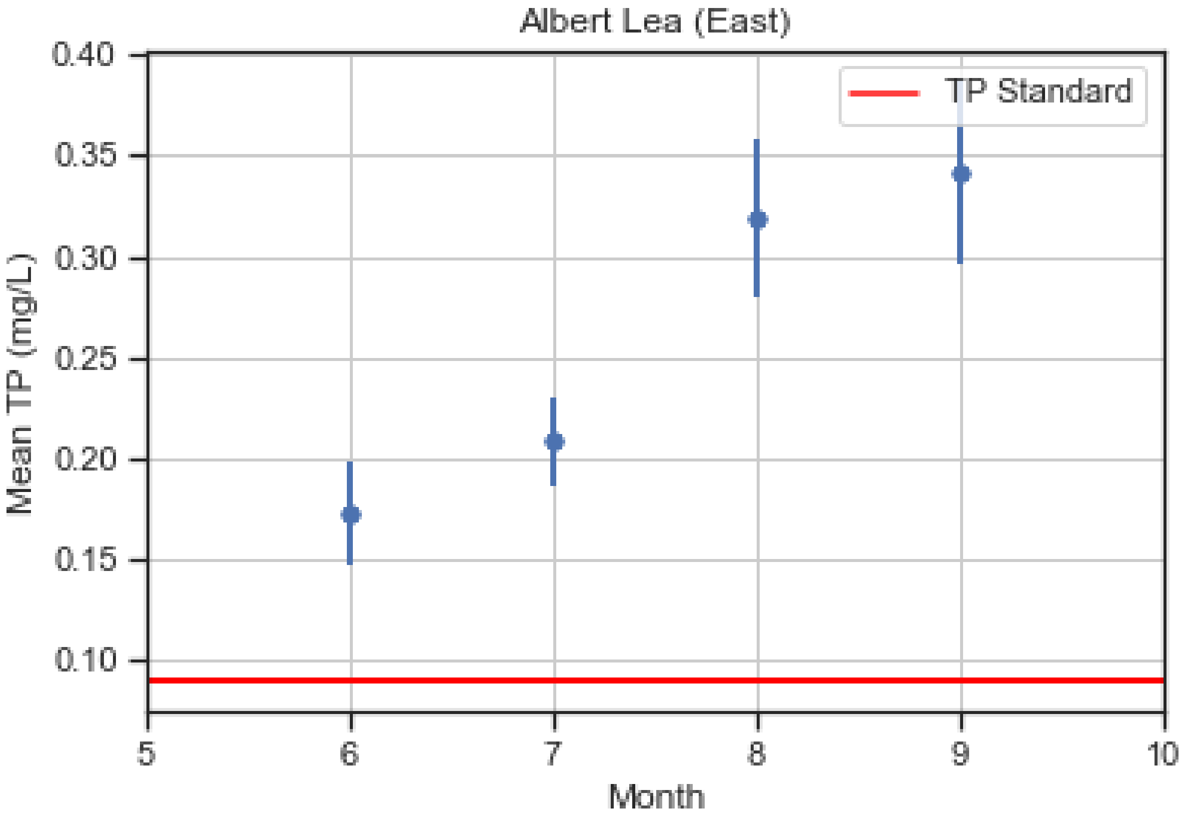


Figure A-19. Albert Lea Lake (east) growing season monthly mean chlorophyll-a.

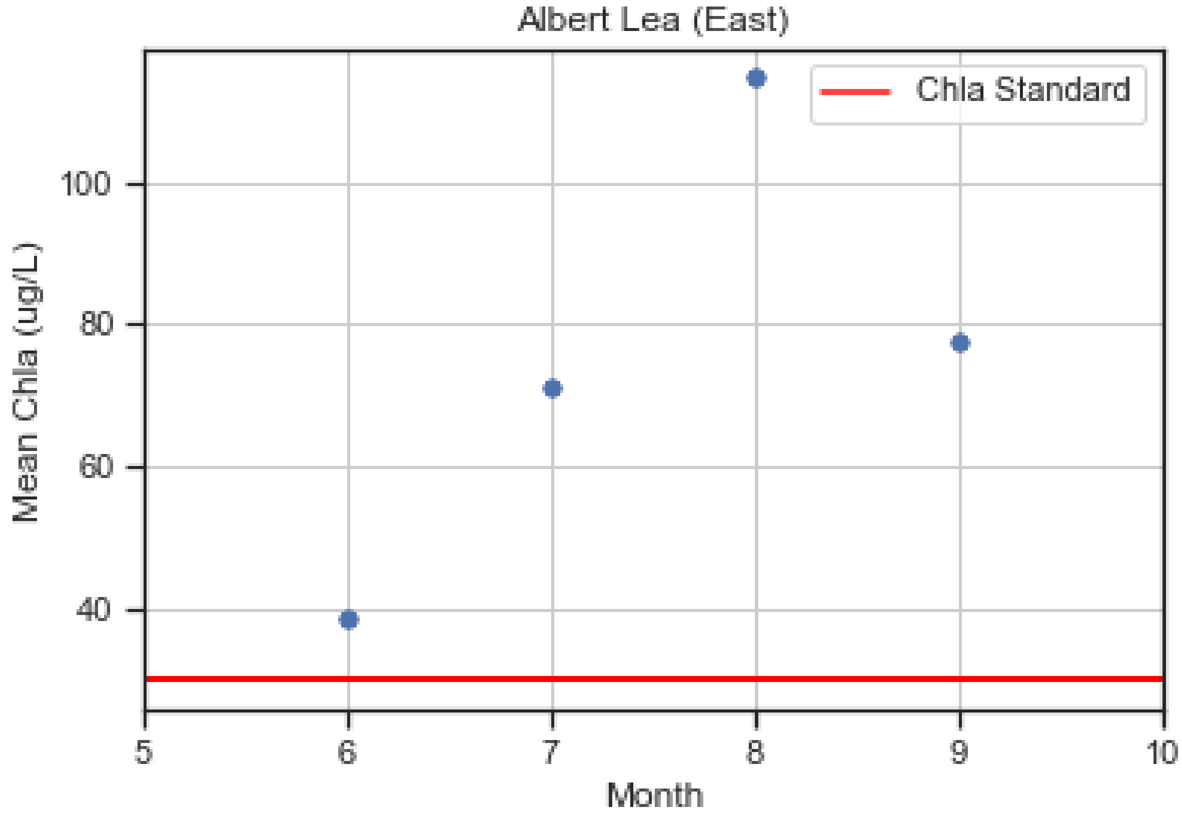
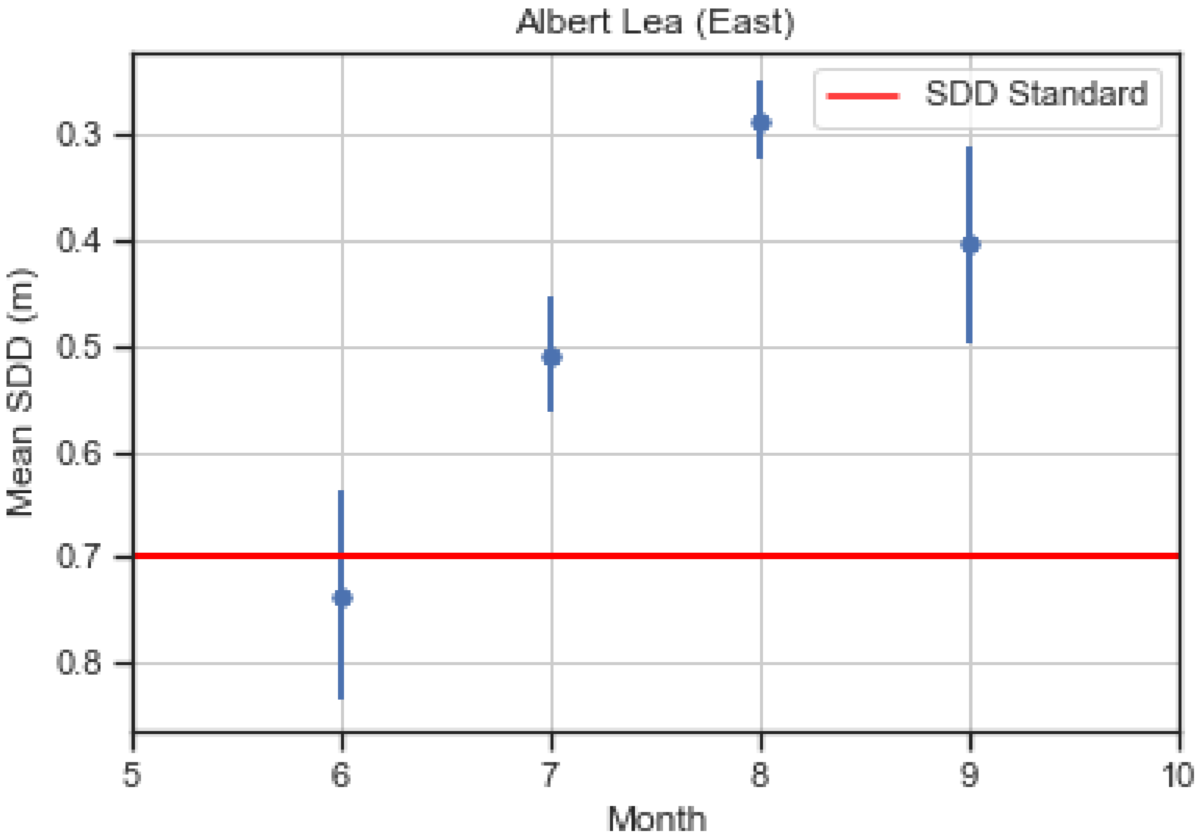


Figure A-20. Albert Lea Lake (east) monthly growing season mean Secchi disc depth.
Dissolved oxygen and temperature summary



Dissolved oxygen and temperature summary

DO and temperature data monitored by depth were examined in an effort to better define lake-mixing patterns affecting biological responses and lake phosphorus dynamics. DO and temp profile data were only available at impaired lakes between 2006 and 2008. Available profile data from each portion of the lake (western, central, and eastern) have been plotted in Figures A-8 through A-13 for temperature and DO.

Water temperature profiles indicate well-mixed conditions during most months in all portions of the lake as temperatures are relatively similar going from the surface to depth. Temperatures during the months of May and June are more variable as water cools with depth. DO profiles indicate occasional concentration losses with depth indicating large oxygen depletion rates are occurring. Albert Lea Lake exhibited clinograde-like oxygen patterns with values decreasing with depth with values less than 5 mg/L observed on several dates. The DO profiles often show a difference of more than 5 mg/L between the maximum and minimum measured DO concentrations.

Figure A-21. Albert Lea Lake (western) profiles for temperature at Site 24-0014-00-205.

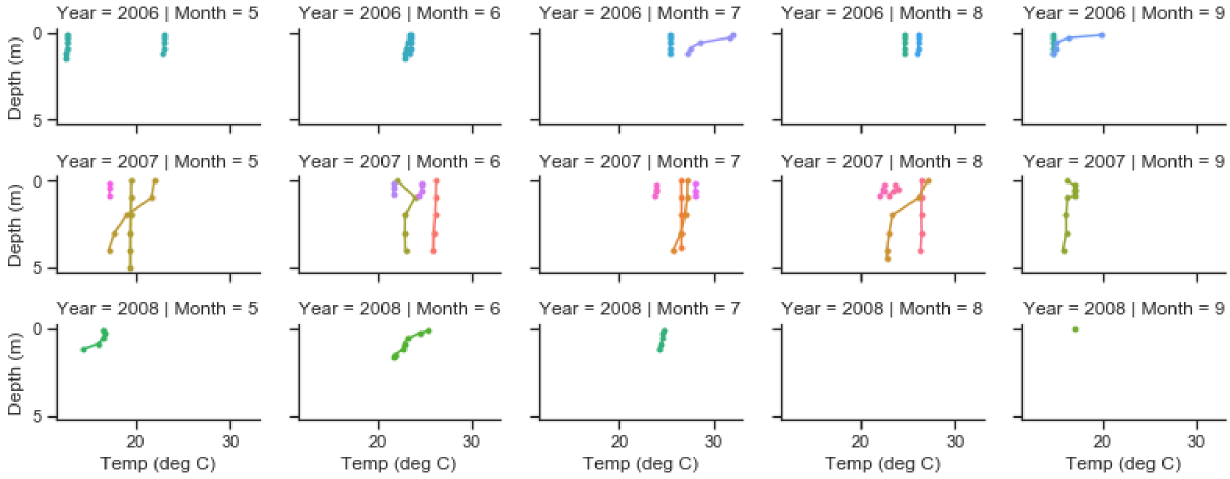


Figure A-22. Albert Lea Lake (central) profiles for temperature at Site 104.

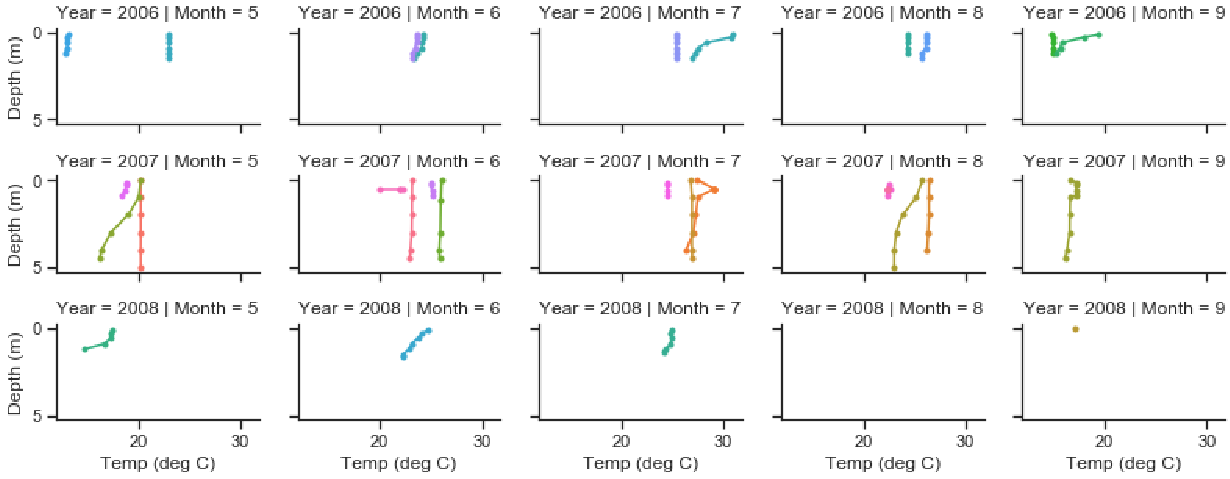


Figure A-23. Albert Lea Lake (eastern) profiles for temperature at Site 24-0014-00-206.

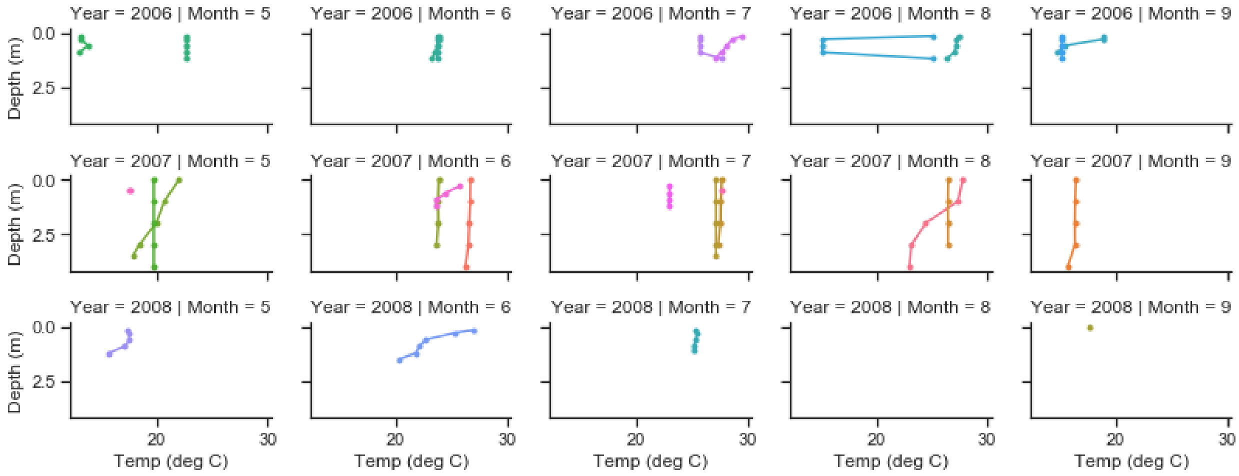


Figure A-24. Albert Lea Lake (eastern) profiles for temperature at Site 24-0014-00-206.

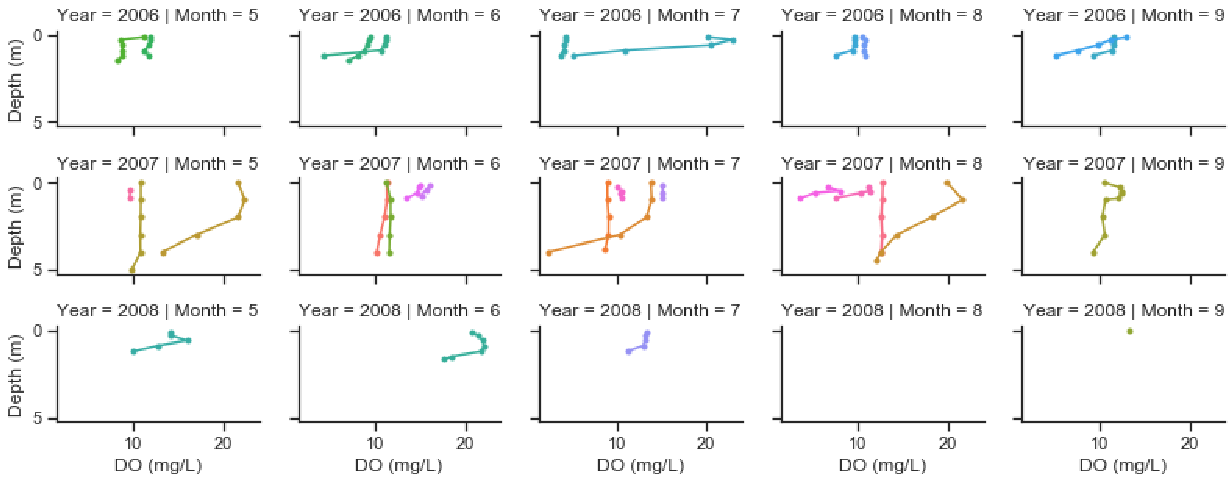


Figure A-25. Albert Lea Lake (western) profiles for dissolved oxygen at Site 24-0014-00-205.

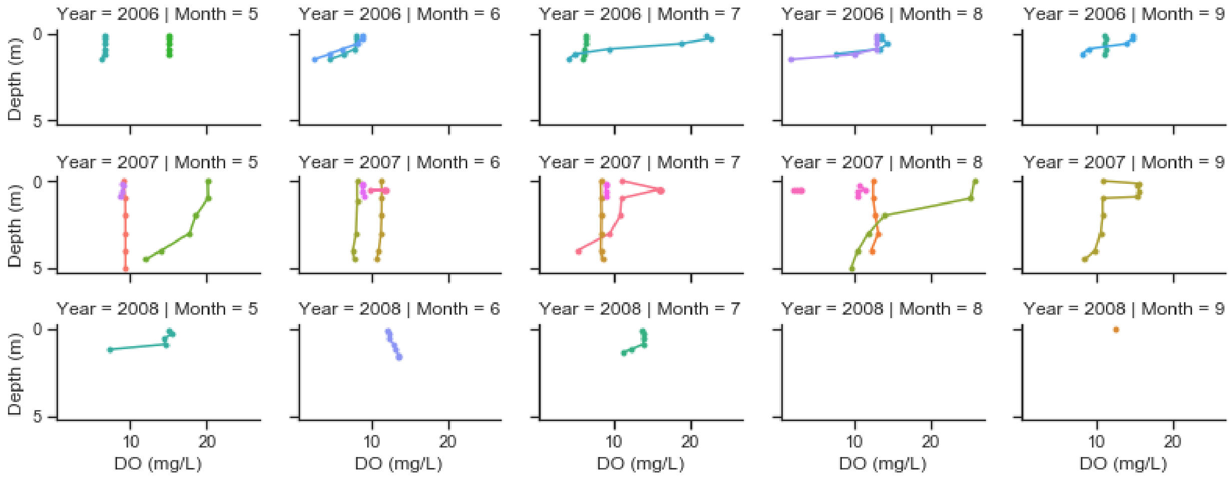


Figure A-26. Albert Lea Lake (central) profiles for dissolved oxygen at Site 24-0014-00-104.

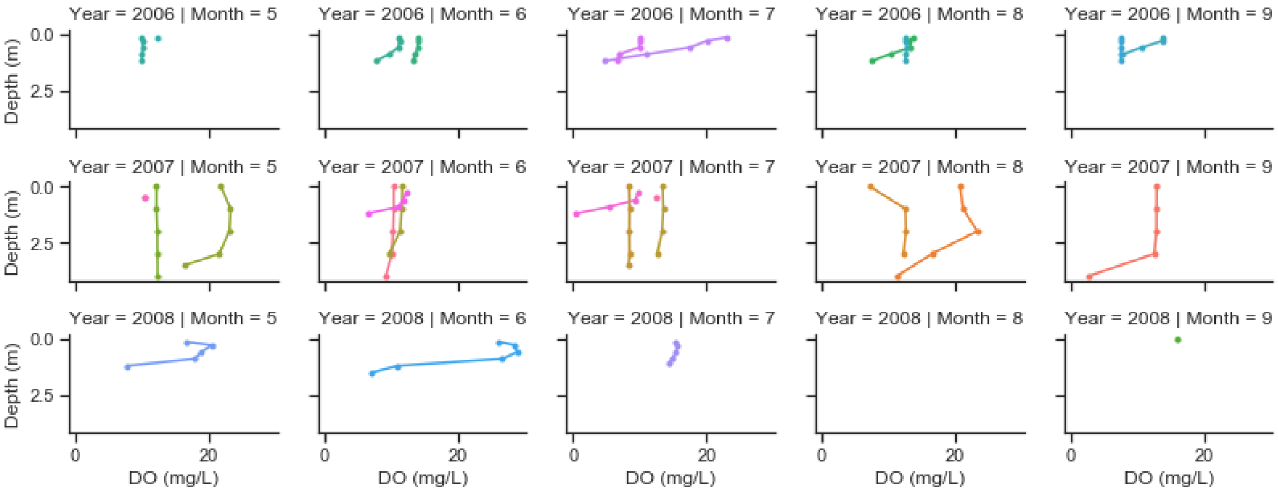
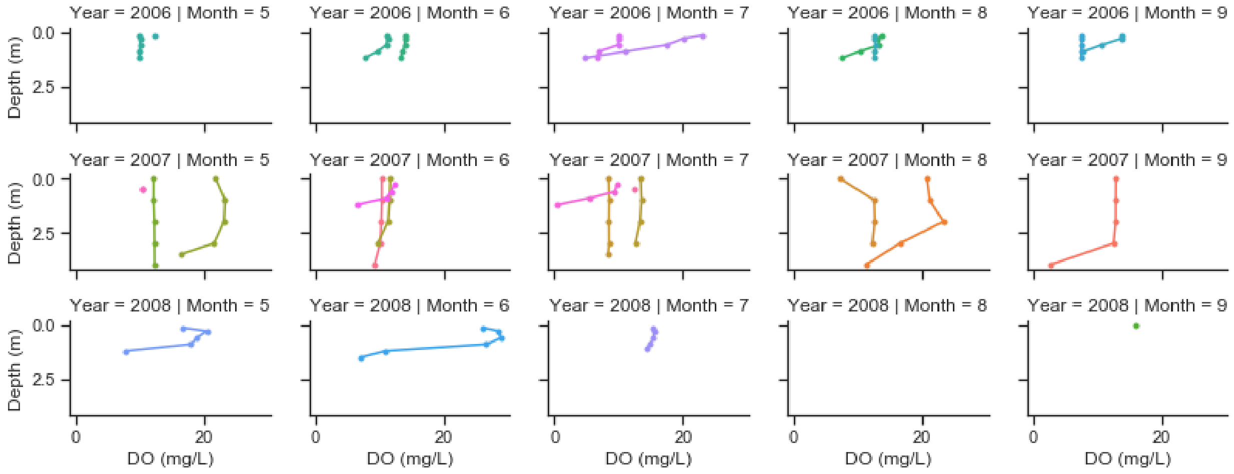


Figure A-27. Albert Lea Lake (eastern) profiles for dissolved oxygen at Site 24-0014-00-206.



Aquatic plants

Qualitative surveys of aquatic plants in Albert Lake were performed on July 16, 2002, June 20, 2005, June 14, 2010, and July 27, 2010, by the DNR. This summary focuses on the surveys that occurred during the TMDL time period (2009 through 2018). The June 14, 2010, survey had a taxa richness of 13 and a floristic quality index (FQI) of 18.9, and the July 27, 2010, survey had a taxa richness of 10 and an FQI of 15.8. The percent difference from the state threshold was positive for both metrics and both surveys. Lakes with positive percent difference from the thresholds are supporting aquatic life.

Additional DNR Wildlife Lake Habitat Surveys were completed on July 27, 2010, and August 11, 2014, for Albert Lea Lake. The exotic invasive species curly-leaf pondweed (Potamogeton Crispus) was present during both Wildlife Lake Habitat Surveys.

Fisheries

The DNR Fisheries surveyed Albert Lea Lake on June 22, 2015. The survey noted common carp (standard gill net CPUE of 19.67 and standard trap net CPUE of 6.33) and black bullhead (standard gill net CPUE of 97.17 and standard trap net CPUE of 59.50).

Appendix B: Fountain (24-0018-00)

Land cover

Land cover defined by the 2011 NLCD is summarized for the Fountain Lake Watersheds in Table B-1 with the majority of the land cover draining to the West Bay consisting of row crops (75.2%) and developed land (9.7%) and draining to the East Bay consisting of row crops (69.9%) and developed (13.9%).

Table B-1. Fountain Lake Watershed land cover.

Impairment	Developed (%)	Wetlands (%)	Open Water (%)	Forest (%)	Grassland (%)	Hay/ Pastures (%)	Row Crops (%)
Fountain (West Bay)	9.7	3.6	2.5	1.8	4.8	2.4	75.2
Fountain (East Bay)	13.9	4.0	2.9	2.0	5.4	2.0	69.9
Fountain (North Bay)	16.2	3.1	1.1	2.3	5.7	1.5	70.2

Physical characteristics

Fountain Lake is located on the northwest side of Albert Lea, Minnesota, in Freeborn County in the central portion of the Shell Rock River HUC 8. From a regulatory standpoint, Fountain Lake is categorized as a shallow WCBP ecoregion lake. Select lake morphometric and watershed physical characteristics are listed in Table B-2. Fountain Lake (West Bay) has one public access maintained by the city of Albert Lea that includes 1 concrete ramp, parking for approximately 18 boat trailers, and 1 dock. Fountain Lake (East Bay) has one public access maintained by the city of Albert Lea that includes 1 concrete ramp, parking for 30 boat trailers, and 1 dock. Figure B-1 shows aerial imagery of Fountain Lake. Figure B-3 shows lake level data from Fountain Lake.

Table B-2. Select lake morphometric and watershed characteristics of fountain lake.

Characteristic	Fountain Lake	Source
Lake Surface Area (acres)	521.5	DNR LakeFinder Fish Lake Surveys
Lake Littoral Area (acres)	521.3	DNR LakeFinder Fish Lake Surveys
Shore Length (miles)	14.54	DNR LakeFinder Fish Lake Surveys
Mean Depth (ft)	5	DNR LakeFinder Fish Lake Surveys, Calculated (*), or Estimated from Lake Map (**)
Maximum Depth (ft)	14	DNR LakeFinder Fish Lake Surveys
Average Water Clarity (ft)	1.4	DNR LakeFinder Fish Lake Surveys or Average Growing Season Secchi Disk Depth (*)
Recorded Water Level Range (ft)	3.19	DNR LakeFinder Water Level
Percent Lake Littoral Surface Area	100	Calculated
Number of Islands	3	DNR Lakefinder Map
Public Access Sites	2	DNR LakeFinder Water Access Sites
Drainage Area, Including Lake (acres)	11,4091	Model Subwatersheds
Watershed Area to Lake Area Ratio (X:1)	218.8	Calculated
Wetland Area (acres)	4,229.7	NLCD 2011
Number of Upland Lakes	37	DNR Hydro Layer
Number of Perennial Inlet Streams	5	NHD Flowlines Fcode 46006
Lake Volume (acre-feet)	1,946	Calculated
Maximum Fetch Length (ft)	6500	Measured Using ArcGIS Imagery
Lake Geometry Ratio (A^0.25/Dmax), A is surface area in m2 and Dmax is max depth in m	8.9	Calculated
Lake Geometry Classification	Shallow	Shallow>5.3, Medium1.6-5.3, Deep<0.9
Osgood Index (Dmean/sqrt(A)), A is surface area in km2 and Dmean is mean depth in m	1.0	Calculated
Osgood Index Category	Polymictic	Polymictic<4, Intermediate4-9,Dimictic>9
Estimated Water Residence Time (days)	23.0 West Bay, 17.1 East Bay	Calculated With Volume and 122Q10 From HSPF Simulated Flow

Figure B-1. Fountain Lake (West Bay) bathymetry and aerial imagery.

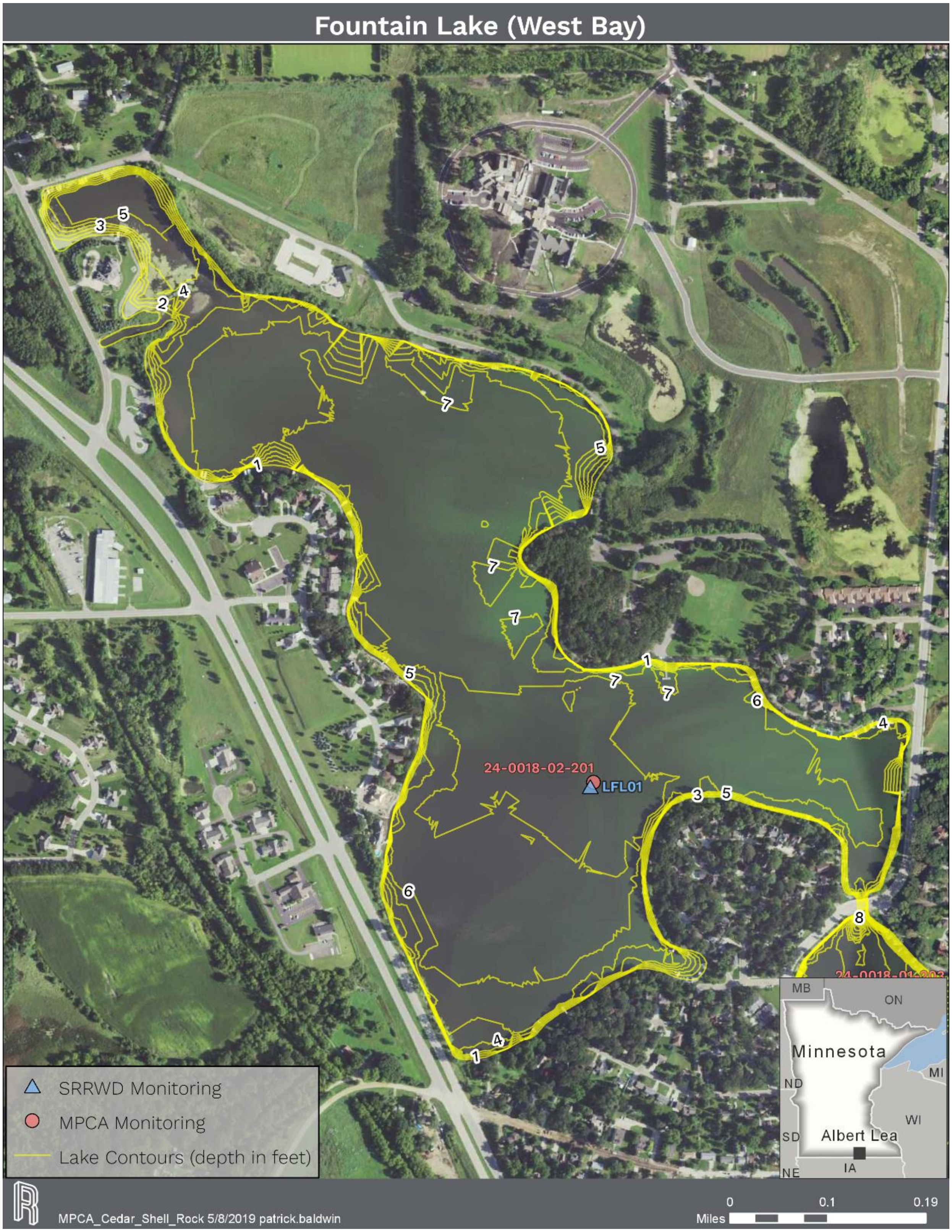


Figure B-2. Fountain Lake (East Bay) bathymetry and aerial imagery.

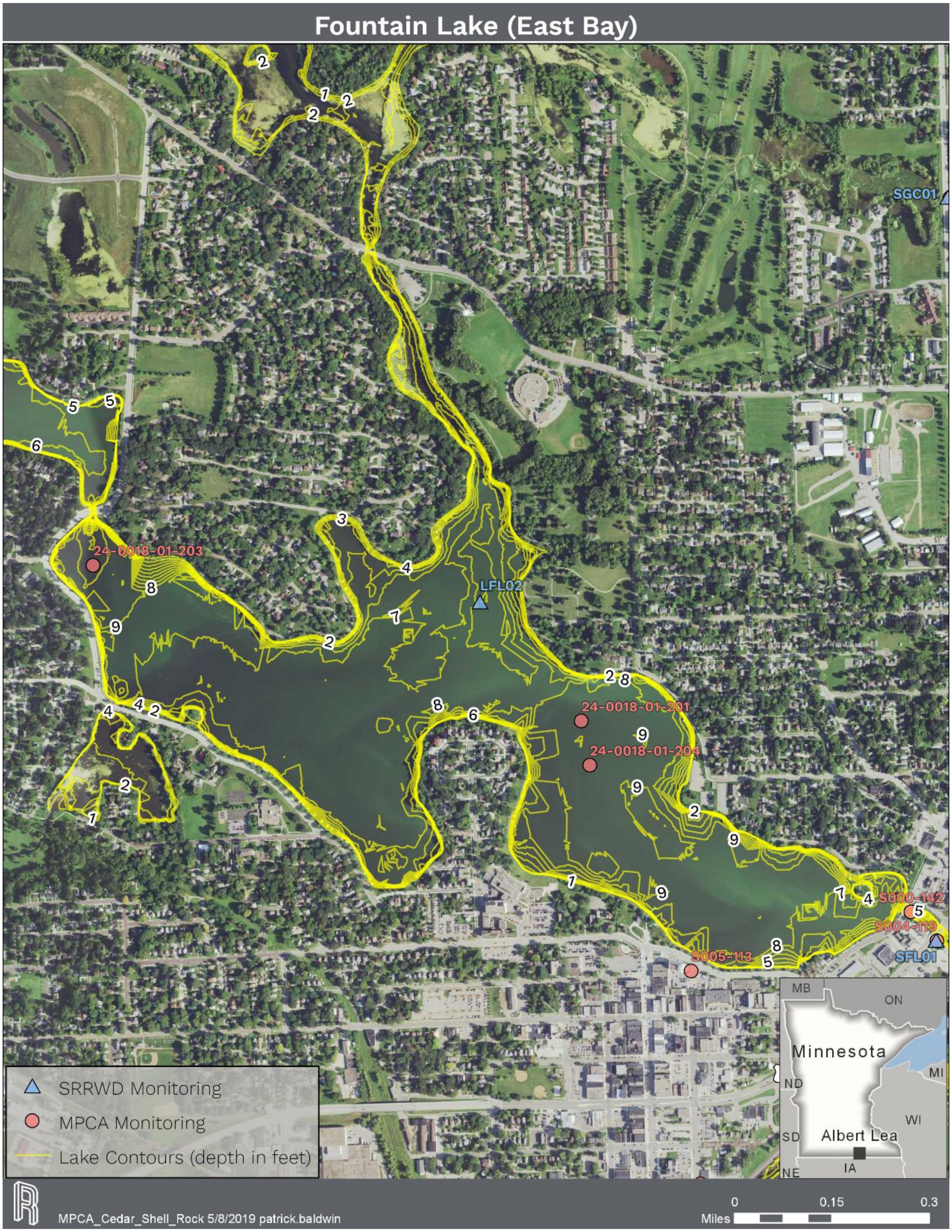
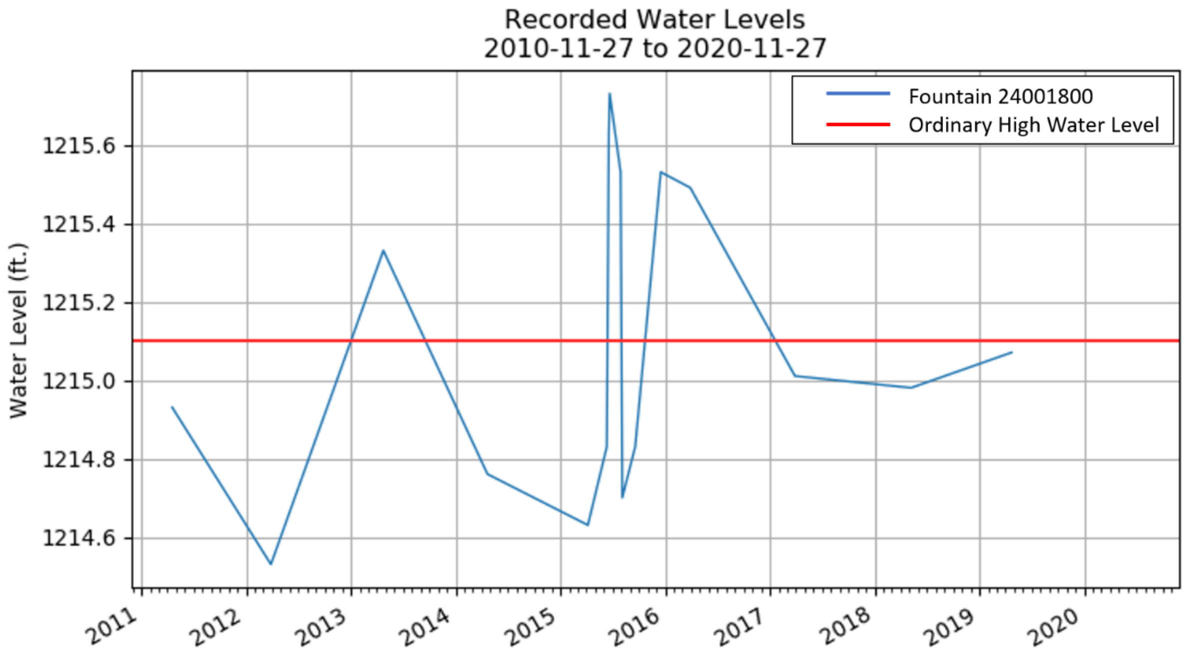


Figure B-3. Fountain Lake levels (DNR 2020b).



Water quality

Monitoring data annual sample counts are shown in Table B-3 and are summarized over the TMDL period (2009 through 2018) in Table B-4 as mean growing season values for TP, chl-*a*, and SDT. Corresponding lake water quality standards are also included. Mean values for TP and chl-*a*, are above the water quality standard. The overall mean SDT were above the water quality standard in both impaired portions of the lake (eastern and western). These data indicate that Fountain Lake exceeds the phosphorus (P) standard and will require reductions to achieve lake standards. Extremely high values of TP were over 900 micrograms per liter (µg/L) and were over 150 µg/L in both portions of Fountain Lake, while the lowest Secchi was 0.18 meter (m). Individual growing season means from data available between 2000 through 2018 for both impaired portions of Fountain Lake (western and eastern) were plotted in Figures B-4 to B-15 and show that water quality standards are exceeded most years with available data.

Table B-3. Growing season total phosphorus, chlorophyll-a, and Secchi disc depth number of samples annually.

Lake	Constituent	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Fountain (East Bay)	TP	14	13	8	6	6	9	8	7	7	6	84
	chlorophyll-a	14	13	8	6	6	9	8	7	7	6	84
	Secchi	11	12	8	6	6	9	8	7	22	18	107
Fountain (West Bay)	TP	7	6	8	7	6	9	8	7	8	7	73
	chlorophyll-a	7	6	8	7	6	9	8	7	8	6	72
	Secchi	7	6	8	7	6	9	8	7	8	6	72

Table B-4. Total phosphorus, chlorophyll-a, and Secchi disc depth growing season means.

	Parameter	Minimum	Mean	Maximum	Standard Deviation	Lake Standards
Fountain (East Bay)	TP (µg/L)	32.0	257.4	963.0	196.2	≤90
	Chlorophyll-a (µg/L)	1.1	65.9	256.0	47.5	≤30
	Secchi disk depth (m)	0.18	0.71	1.68	0.28	≥0.7
Fountain (West Bay)	TP (µg/L)	27.0	271.4	955.0	222.1	≤90
	Chlorophyll-a (µg/L)	1.0	39.6	167.0	33.0	≤30
	Secchi disk depth (m)	0.18	0.73	2.07	0.36	≥0.7

Multiyear growing season mean monthly water quality observations are summarized in Figures B-8 through B-13 for data available from 2009 through 2018 for both impaired portions of Fountain Lake (western and eastern). Plots of this mean monthly data indicate a better water quality in spring months and worse water quality in the summer months. Error bars in annual and monthly phosphorus and Secchi plots indicate standard error.

Figure B-4. Fountain Lake (West Bay) annual growing season mean total phosphorus concentrations.

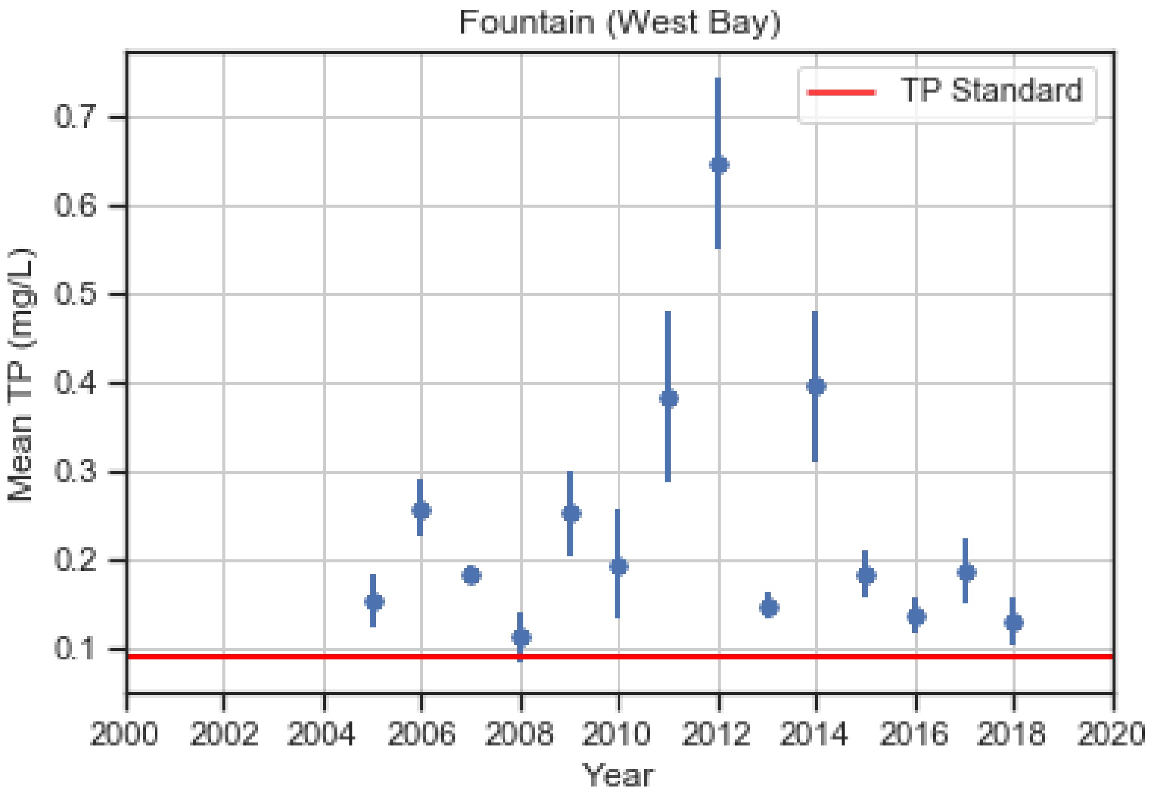


Figure B-5. Fountain Lake (West Bay) annual growing season mean chlorophyll-a concentrations.

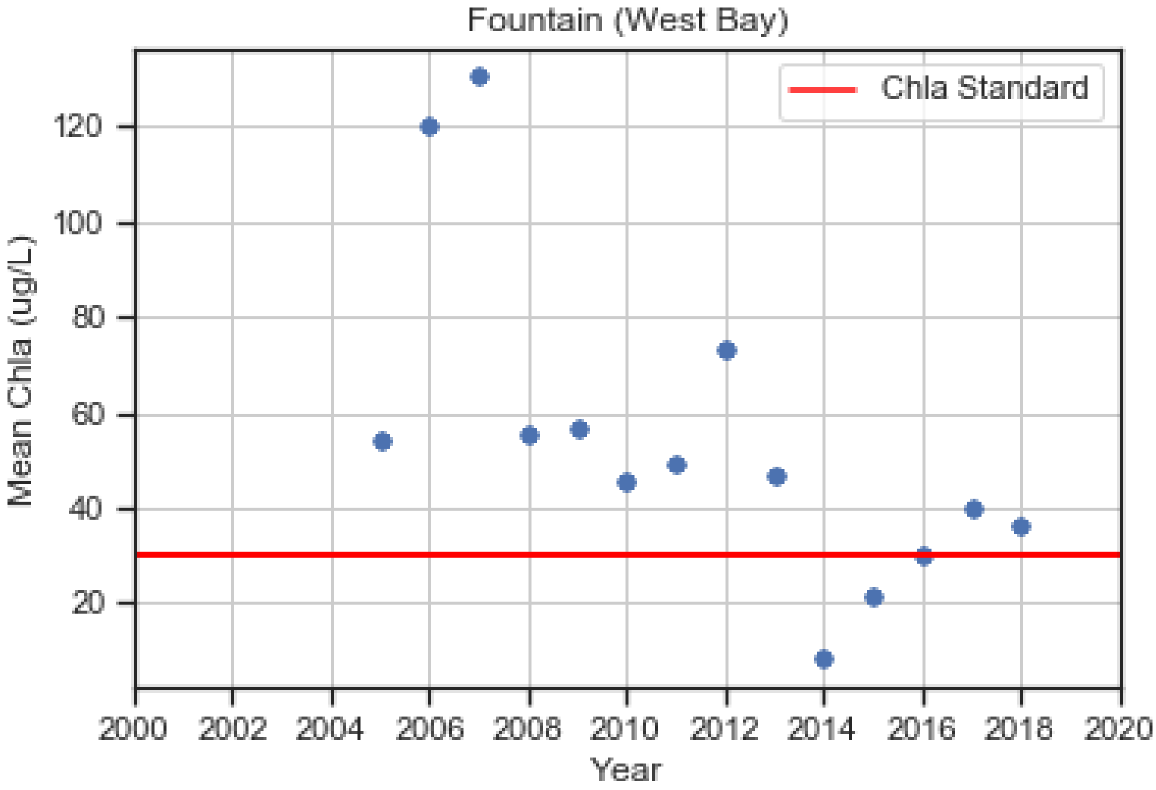


Figure B-6. Fountain Lake (West Bay) annual growing season mean Secchi disc depth.

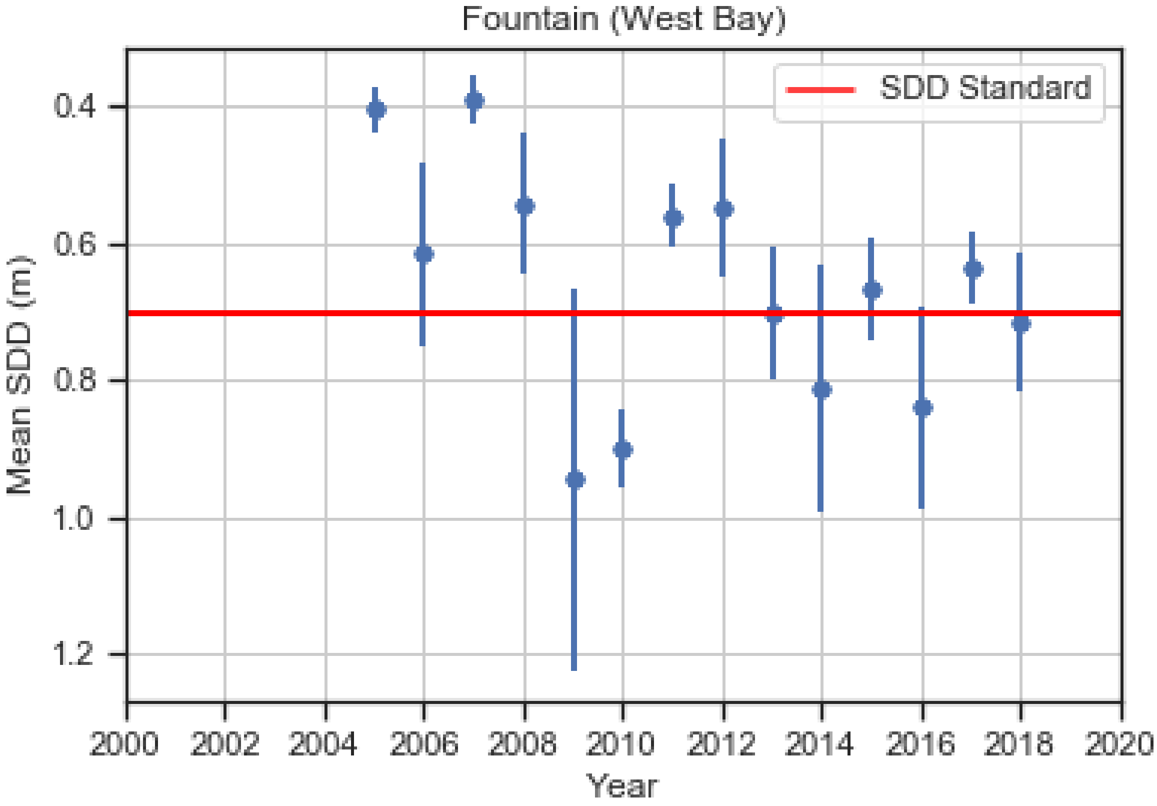


Figure B-7. Fountain Lake (East Bay) annual growing season mean total phosphorus concentrations.

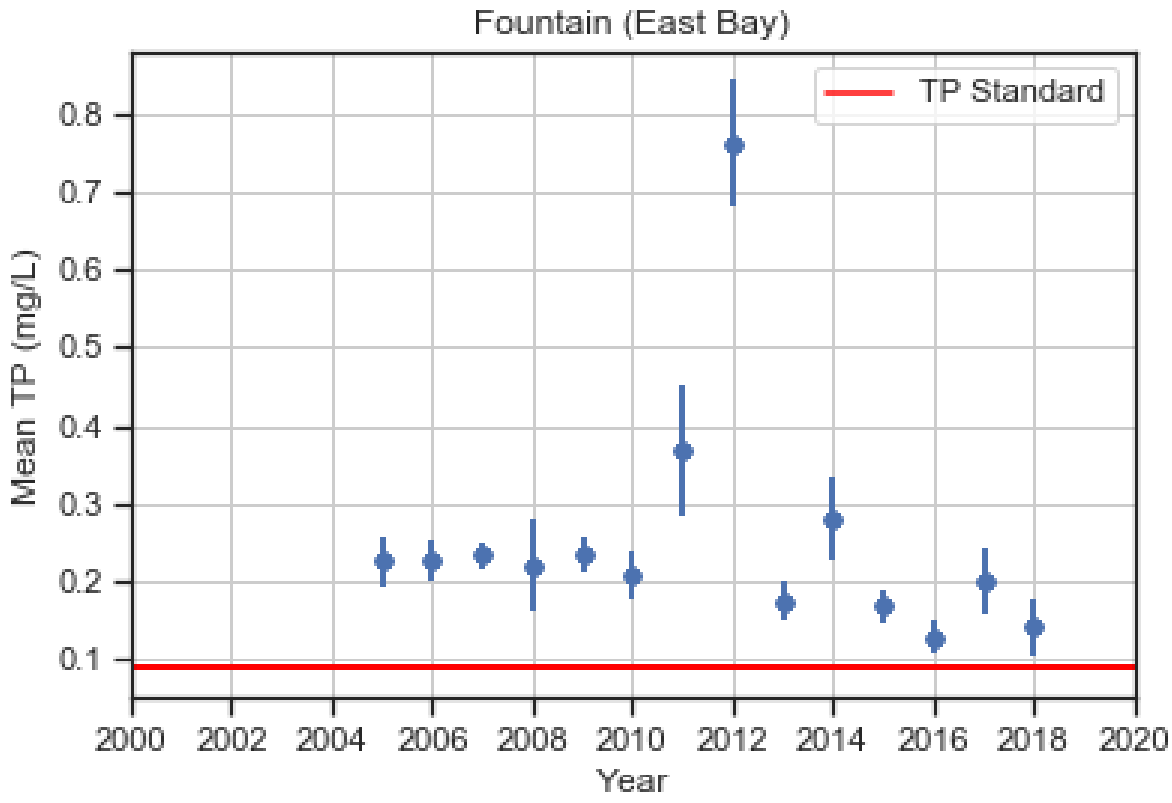


Figure B-8. Fountain Lake (East Bay) annual growing season mean chlorophyll-a concentrations.

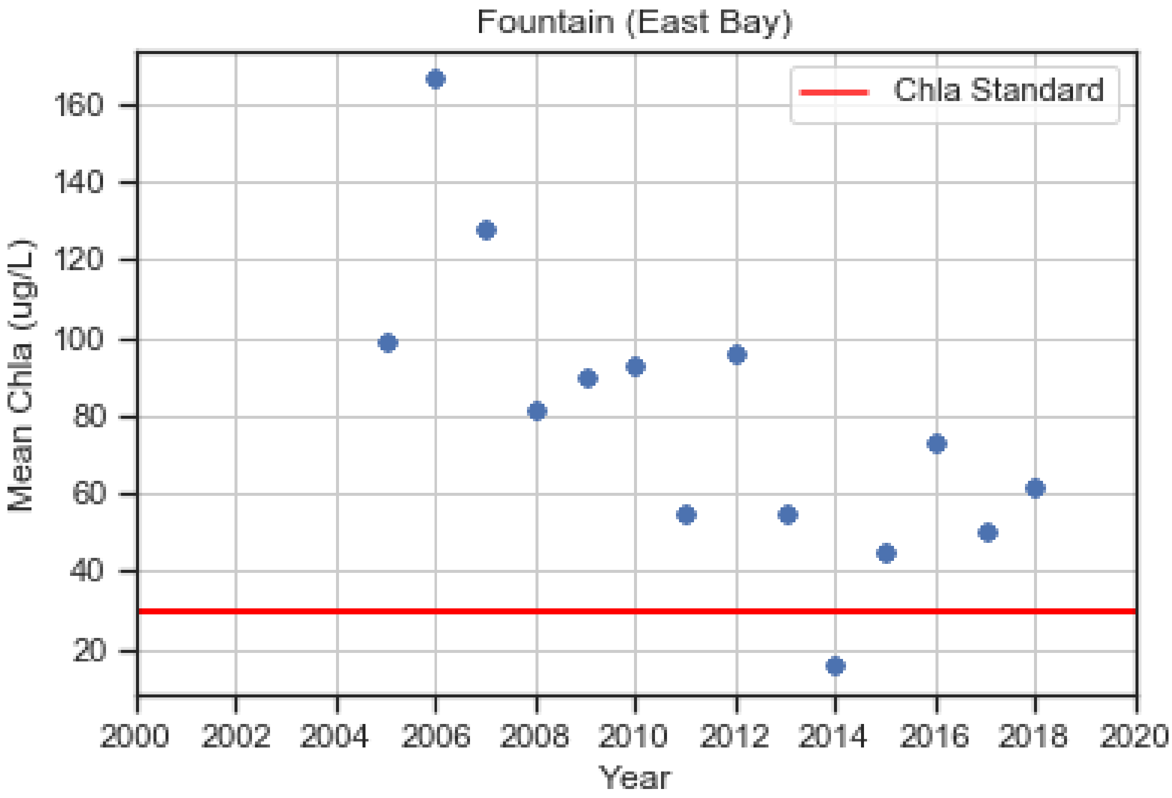


Figure B-9. Fountain Lake (East Bay) annual growing season mean Secchi disc depth.

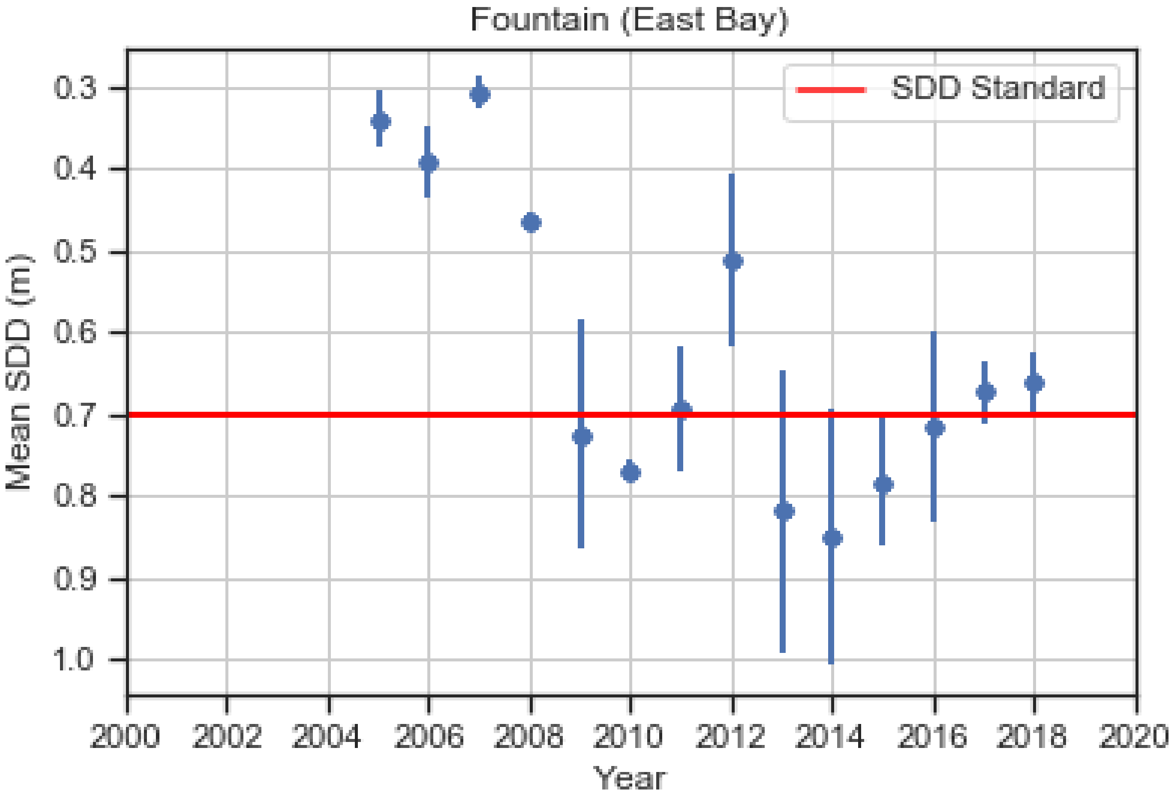


Figure B-10. Fountain Lake (West Bay) growing season monthly mean total phosphorus.

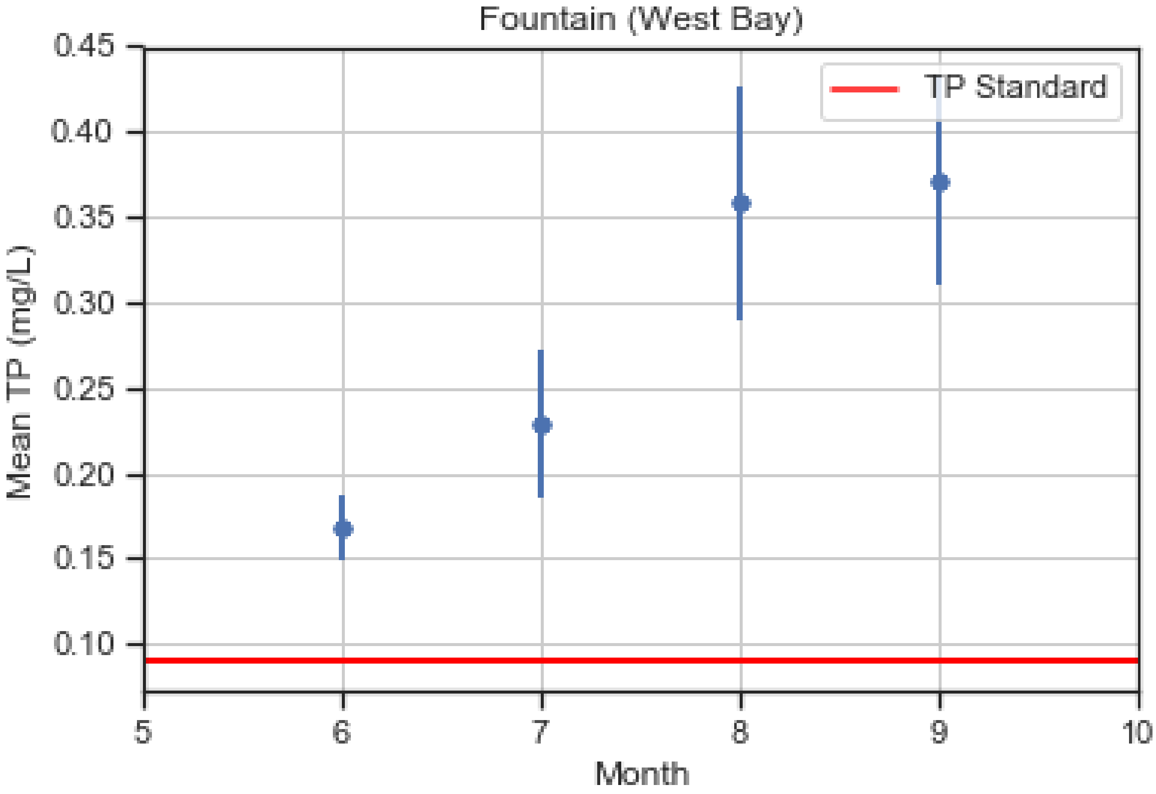


Figure B-11. Fountain Lake (West Bay) growing season monthly mean chlorophyll-a.

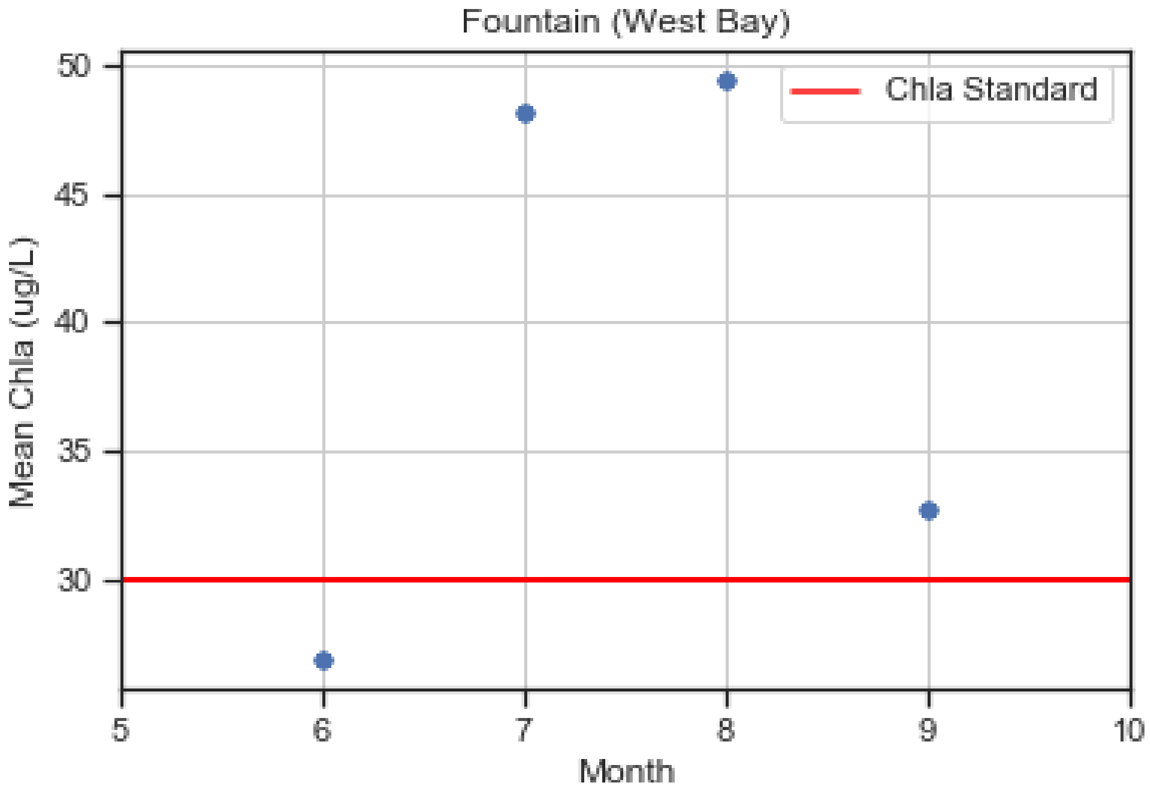


Figure B-12. Fountain Lake (West Bay) monthly growing season mean Secchi disc depth.

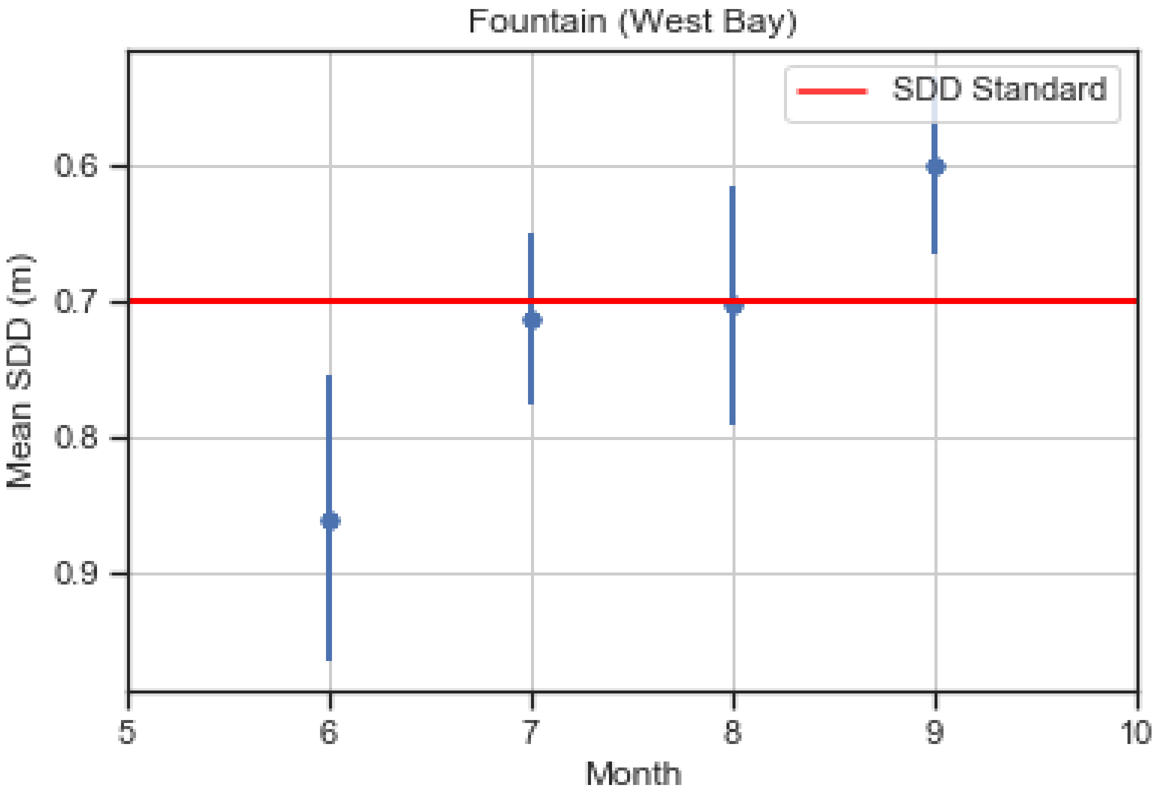


Figure B-13. Fountain Lake (East Bay) growing season monthly mean total phosphorus.

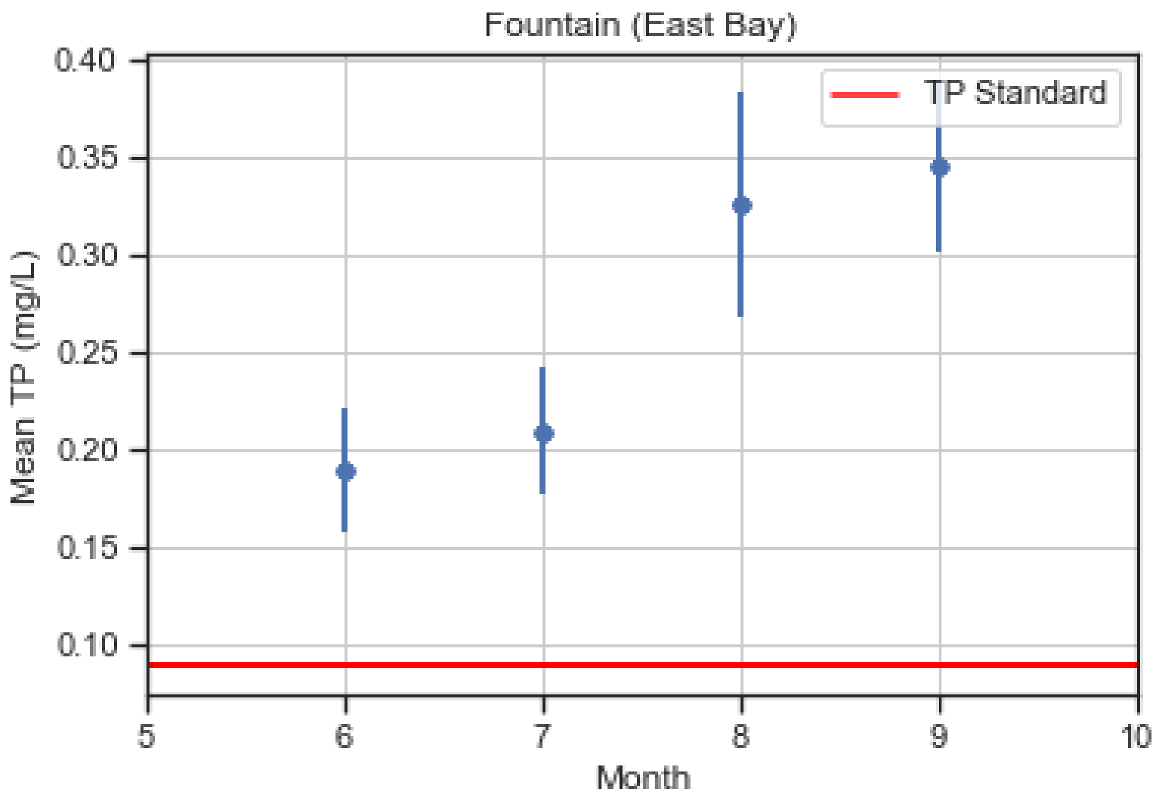


Figure B-14. Fountain Lake (East Bay) growing season monthly mean chlorophyll-a.

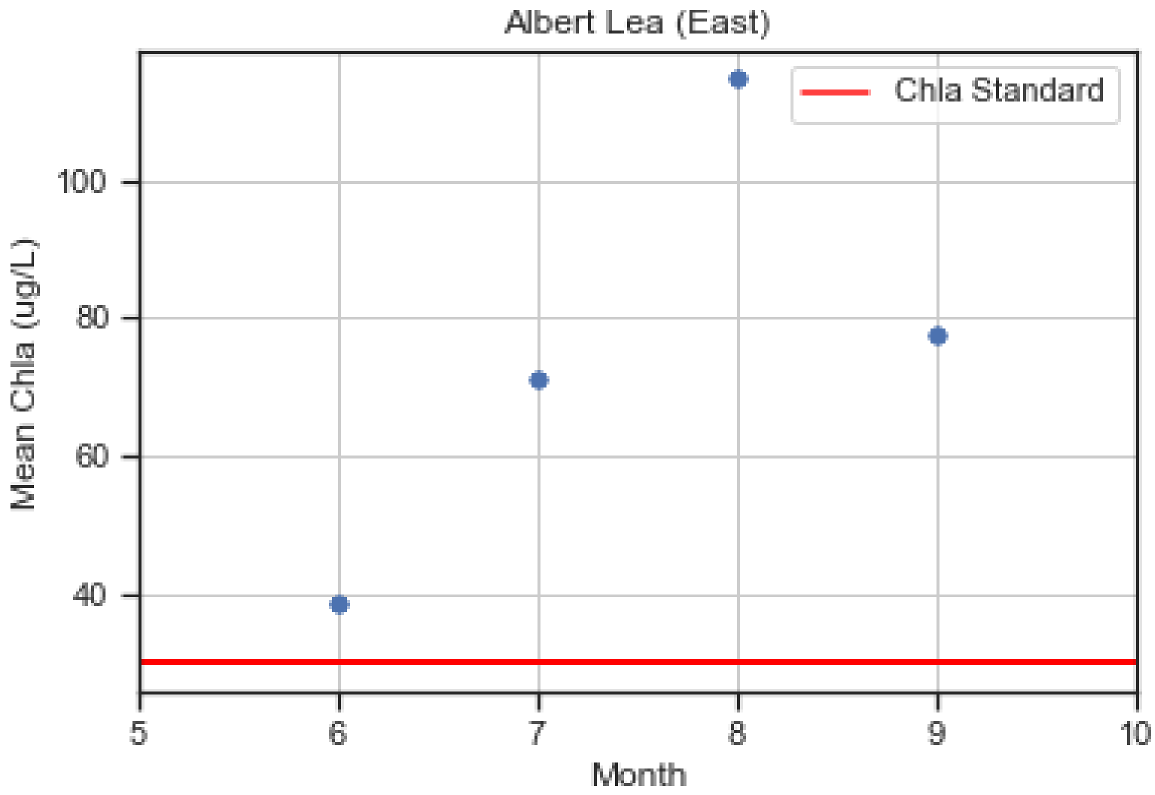
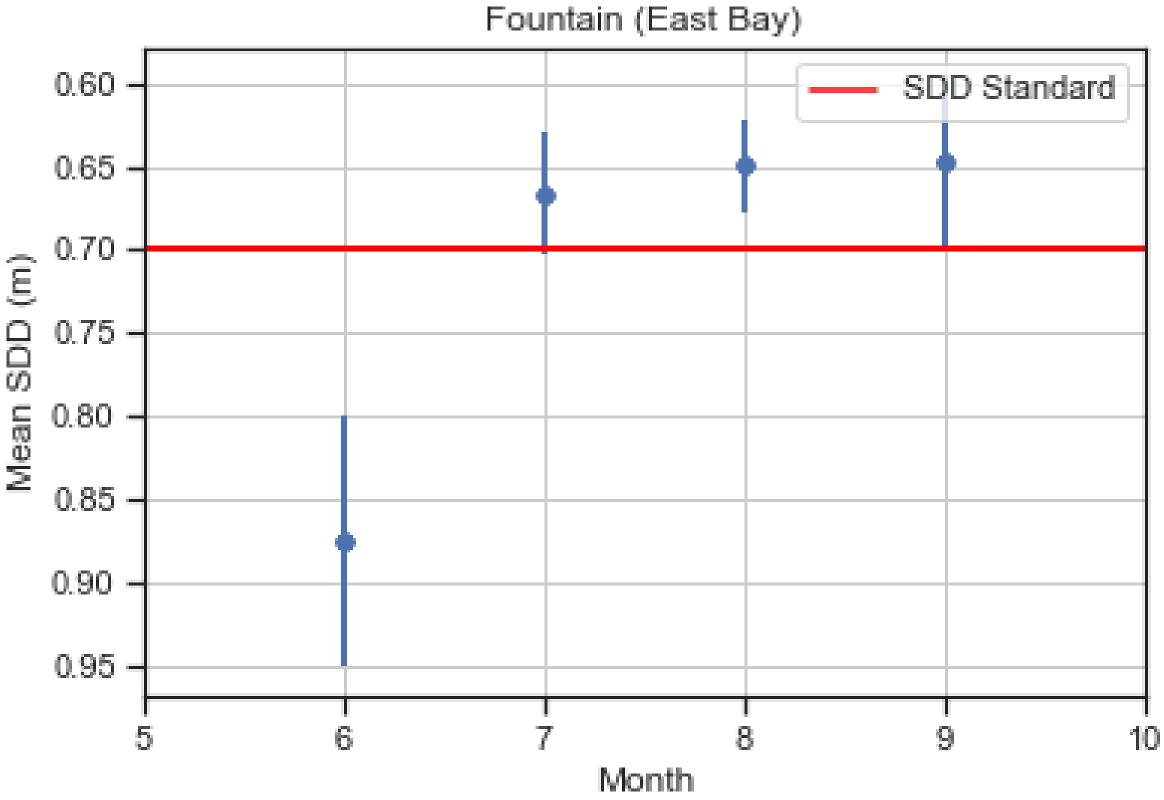


Figure B-15. Fountain Lake (East Bay) monthly growing season mean Secchi disc depth.



Dissolved oxygen and temperature summary

DO and temperature data monitored by depth were examined in an effort to better define lake-mixing patterns affecting biological responses and lake phosphorus dynamics. DO and temperature profile data were only available at impaired lakes between 2006 and 2008. Available profile data from all sites have been plotted in Figures B-16 through B-19 for temperature and DO.

Water temperature profiles indicate fairly consistent temperatures with depth in both the east and west portions of Fountain Lake. DO profiles indicate concentration losses with depth in both the east and west portions of Fountain Lake indicating large oxygen depletion rates are occurring. Fountain Lake exhibited clinograde-like oxygen patterns with values decreasing with depth with values near 0 mg/L observed occasionally. When oxygen concentrations approach zero along lake bottoms, internal phosphorus loading from sediments is expected. The DO profiles often show a difference of more than 5 mg/L between the maximum and minimum measured DO concentrations.

Figure B-16. Fountain Lake (West Bay) Profiles for Temperature at Site 24-0018-02-201.

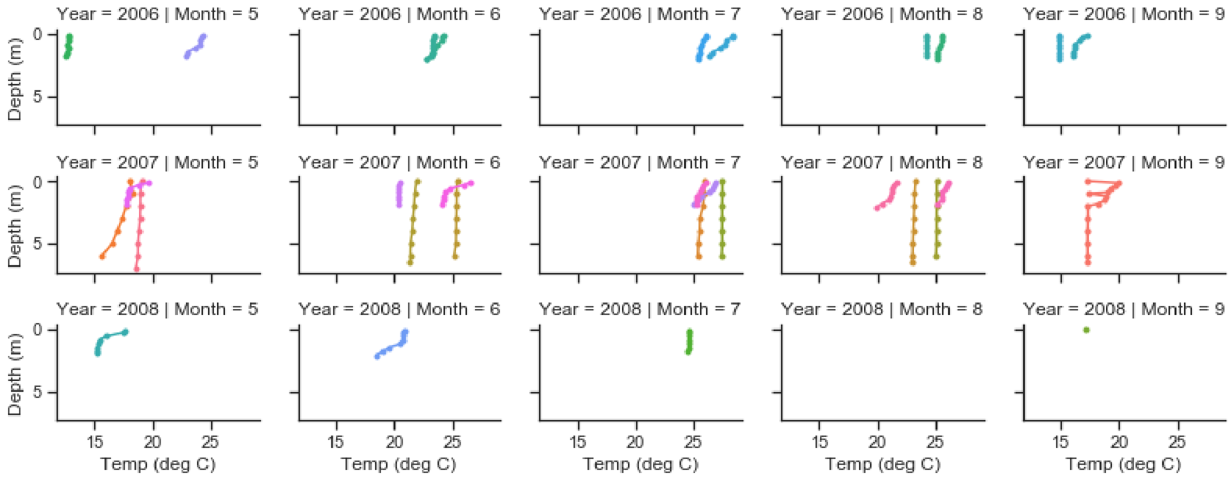


Figure B-17. Fountain Lake (West Bay) Profiles for DO at Site 24-0018-02-201.

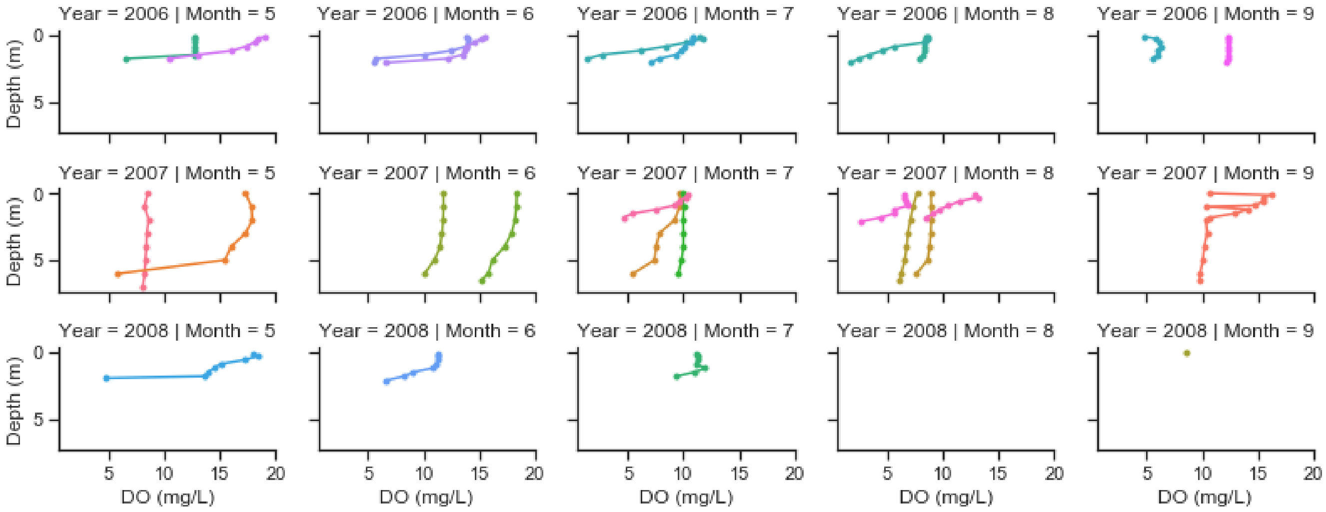


Figure B-18. Fountain Lake (East Bay) Profiles for Temperature at Site 24-0018-01-204.

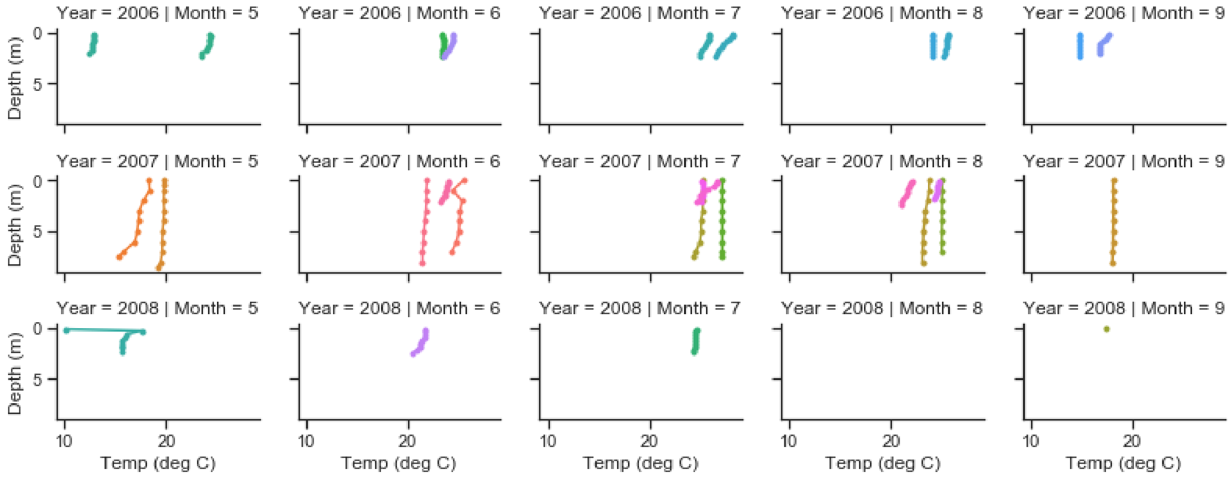
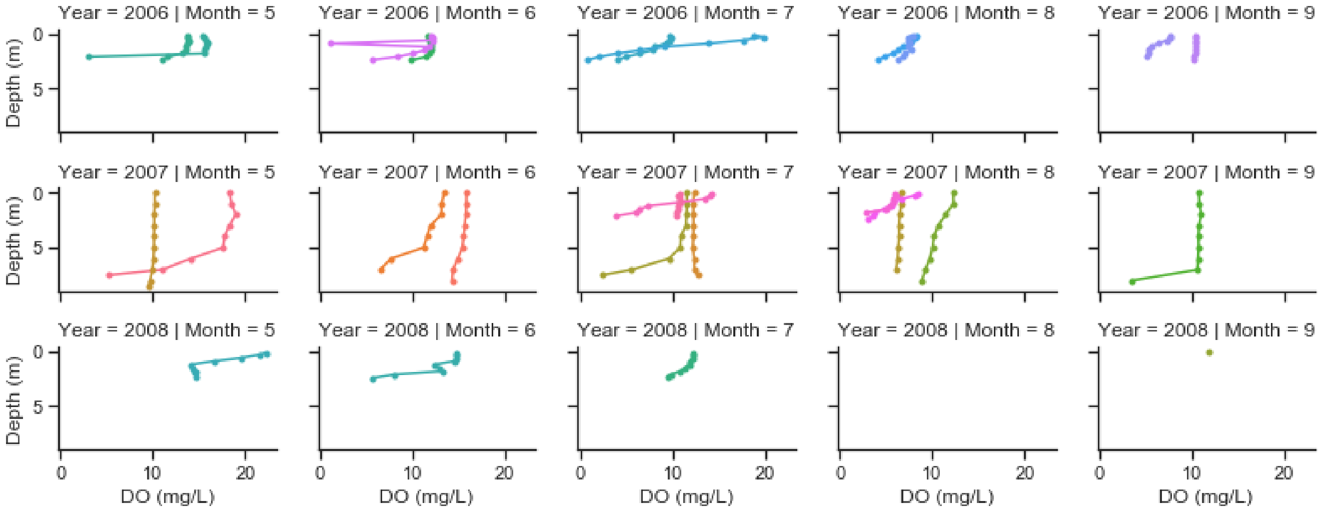


Figure B-19. Fountain Lake (East Bay) Profiles for DO at Site 24-0018-01-204.



Aquatic plants

Qualitative surveys of aquatic plants in Fountain Lake were performed on July 19, 1993, July 31, 2006, by the DNR. None of the surveys were taken during the TMDL time period (2009 through 2018) so this summary focuses on the most recent survey. The July 31, 2006, survey had a taxa richness of one and a FQI of six. The percent difference from the state threshold was negative for both metrics. Lakes with positive percent difference from the thresholds are supporting aquatic life.

A DNR Wildlife Lake Habitat Survey was completed on June 8, 2017, for Fountain Lake. The exotic invasive species curly-leaf pondweed (Potamogeton Crispus) was present during this Wildlife Lake Habitat Survey.

Fisheries

The DNR Fisheries surveyed Fountain Lake on August 3, 2015. The survey noted common carp (standard gill net CPUE of 1.00 and standard trap net CPUE of 1.08) and black bullhead (standard gill net CPUE of 12.71 and standard trap net CPUE of 1.33).

Appendix C: Pickeral (24-0025-00)

Land cover

Land cover defined by the 2011 NLCD is summarized for the Pickeral Lake Watershed in Table C-1 with the majority of the land cover consisting of row crops (48.8%) and developed lands (18.6%).

Table C-1. Pickeral Lake Watershed land cover.

Impairment	Developed (%)	Wetlands (%)	Open Water (%)	Forest (%)	Grassland (%)	Hay/ Pastures (%)	Row Crops (%)
Pickeral	18.6	10.1	13.8	0.0	6.7	1.9	48.8

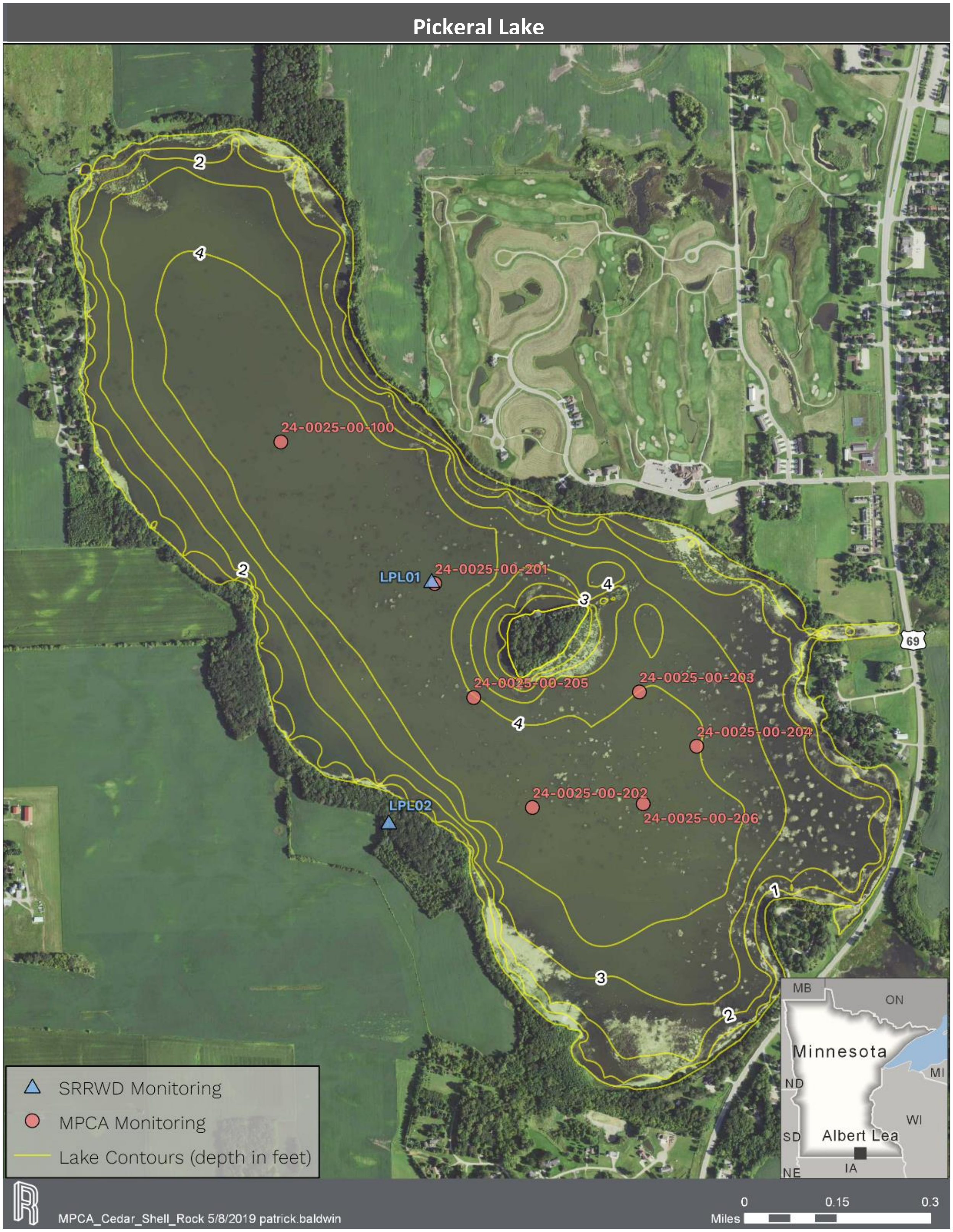
Physical characteristics

Pickeral Lake is located on the southwest edge of Albert Lea, Minnesota, in Freeborn County in the central portion of the Shell Rock River HUC 8. From a regulatory standpoint, Pickeral Lake is categorized as a shallow WCBP ecoregion lake. Select lake morphometric and watershed physical characteristics are listed in Table C-2. Pickeral Lake has one public access maintained by MNDOT that includes a new concrete plank boat ramp and parking for approximately 10 boat trailers. Figure C-1 shows aerial imagery of Pickeral Lake. Water levels measured have ranged from 1,234.5 ft in 1958 to 1,237.4 ft in 1993.

Table C-2. Select lake morphometric and watershed physical characteristics for Pickeral Lake.

Characteristic	Pickeral Lake	Source
Lake Surface Area (acres)	587.6	DNR LakeFinder Fish Lake Surveys
Lake Littoral Area (acres)	588	DNR LakeFinder Fish Lake Surveys
Shore Length (miles)	5.67	DNR LakeFinder Fish Lake Surveys
Mean Depth (ft)	3.5	DNR LakeFinder Fish Lake Surveys, Calculated (*), or Estimated from Lake Map (**)
Maximum Depth (ft)	6	DNR LakeFinder Fish Lake Surveys
Average Water Clarity (ft)	1.4	DNR LakeFinder Fish Lake Surveys or Average Growing Season Secchi Disk Depth (*)
Recorded Water Level Range (ft)	2.9	DNR LakeFinder Water Level
Percent Lake Littoral Surface Area	100	Calculated
Number of Islands	1	DNR Lakefinder Map
Public Access Sites	1	DNR LakeFinder Water Access Sites
Drainage Area, Including Lake (acres)	3702	Model Subwatersheds
Watershed Area to Lake Area Ratio (X:1)	6.3	Calculated
Wetland Area (acres)	374.7	NLCD 2011
Number of Upland Lakes	7	DNR Hydro Layer
Number of Perennial Inlet Streams	2*	NHD Flowlines Fcode 46006 or SRRWD (*)
Lake Volume (acre-feet)	2,027	Calculated
Maximum Fetch Length (ft)	9,400	Measured Using ArcGIS Imagery
Lake Geometry Ratio (A^0.25/Dmax), A is surface area in m2 and Dmax is max depth in m	21.5	Calculated
Lake Geometry Classification	Shallow	Shallow > 5.3, Medium1.6-5.3, Deep < 0.9
Osgood Index (Dmean/sqrt(A)), A is surface area in km^2 and Dmean is mean depth in m	0.7	Calculated
Osgood Index Category	Polymictic	Polymictic < 4, Intermediate4-9,Dimictic > 9
Estimated Water Residence Time (days)	1,082.0	Calculated With Volume and 122Q10 From HSPF Simulated Flow

Figure C-1 Pickeral Lake Bathymetry and Aerial Imagery.



Water quality

Monitoring data annual sample counts are shown in Table C-3 and are summarized over the TMDL period (2009 through 2018) in Table C-4 as mean growing season values for TP, chl-*a*, and SDT. Corresponding lake water quality standards are also included. Mean values for TP and chl-*a* are above the water quality standard. The mean SDT was above the water quality standard. The high TP and chl-*a* indicate that Pickeral Lake exceeds the phosphorus (P) standard and will require reductions to achieve lake standards. Extremely high values of TP and chl-*a* were 963 micrograms per liter (µg/L) and 300 µg/L, respectively, while the lowest Secchi reading was 0.15 meter (m). Individual growing season means from data available between 2000 through 2018 were plotted in Figures C-2 to C-4 and show that means TP has improved since 2010.

Table C-3. Growing season total phosphorus, chlorophyll-a, and Secchi disc depth number of samples annually.

Lake	Constituent	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Pickeral	TP	8	10	10	12	6	9	9	7	7	4	82
	chlorophyll-a	7	7	8	12	6	9	9	7	7	4	76
	Secchi	8	9	8	11	6	9	8	7	7	4	77

Table C-4. Total phosphorus, chlorophyll-a, and Secchi disc depth growing season means.

Parameter	Minimum	Mean	Maximum	Standard Deviation	Lake Standards
TP (µg/L)	32.0	257.4	963.0	196.2	≤90
Chlorophyll-a (µg/L)	1.0	34.6	300.0	56.7	≤30
Secchi disk depth (m)	0.15	1.02	1.68	0.45	≥0.7

Multiyear growing season mean monthly water quality observations are summarized in Figures C-5 through C-7 for data available from 2009 through 2018. Plots of this mean monthly data indicate a July typically has the highest TP and the SDT remains lower throughout the summer after July. Error bars in annual and monthly phosphorus and Secchi plots indicate standard error.

Figure C-2. Pickeral Lake Annual Growing Season Mean Total Phosphorus Concentrations.

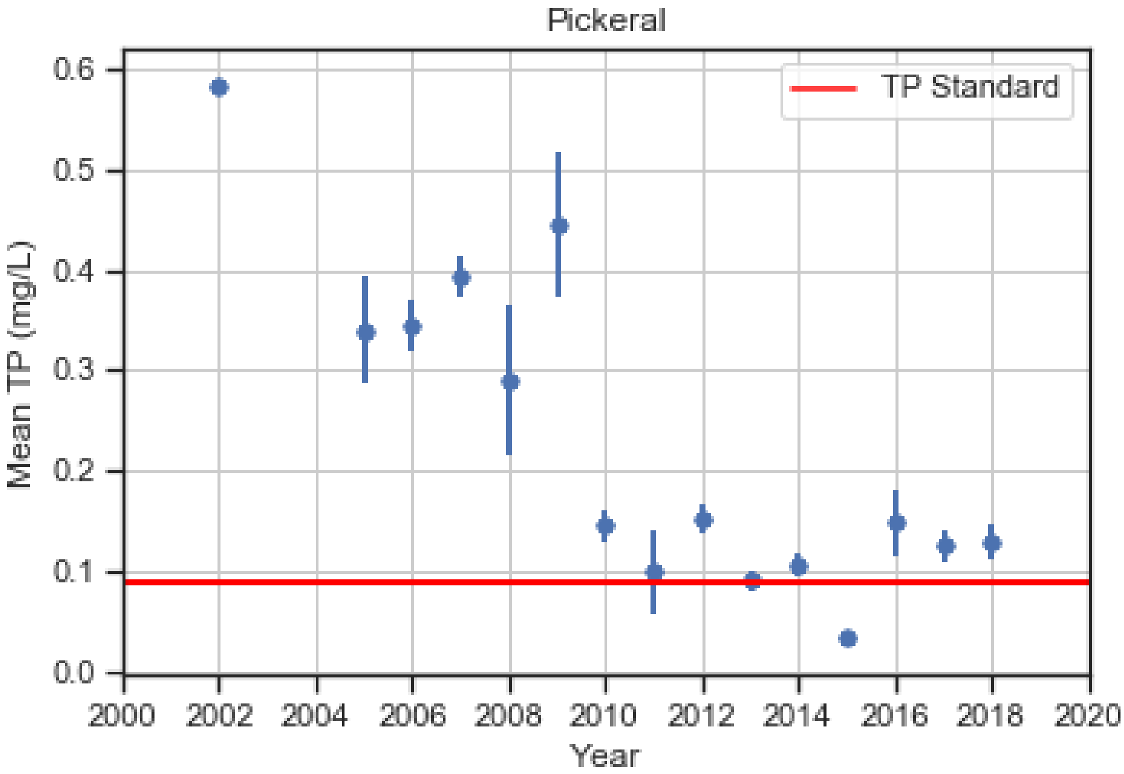


Figure C-3. Pickeral Lake Annual Growing Season Mean Chlorophyll-a Concentrations.

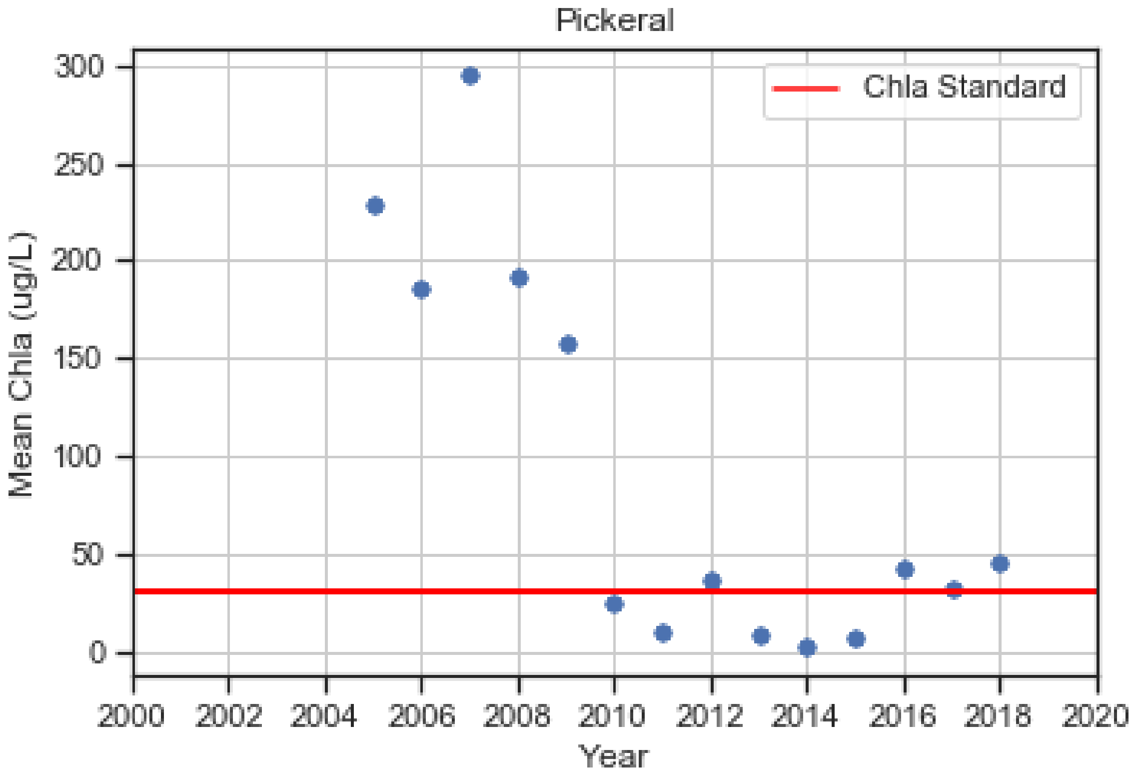


Figure C-4. Pickeral Lake Annual Growing Season Mean Secchi disc depth.

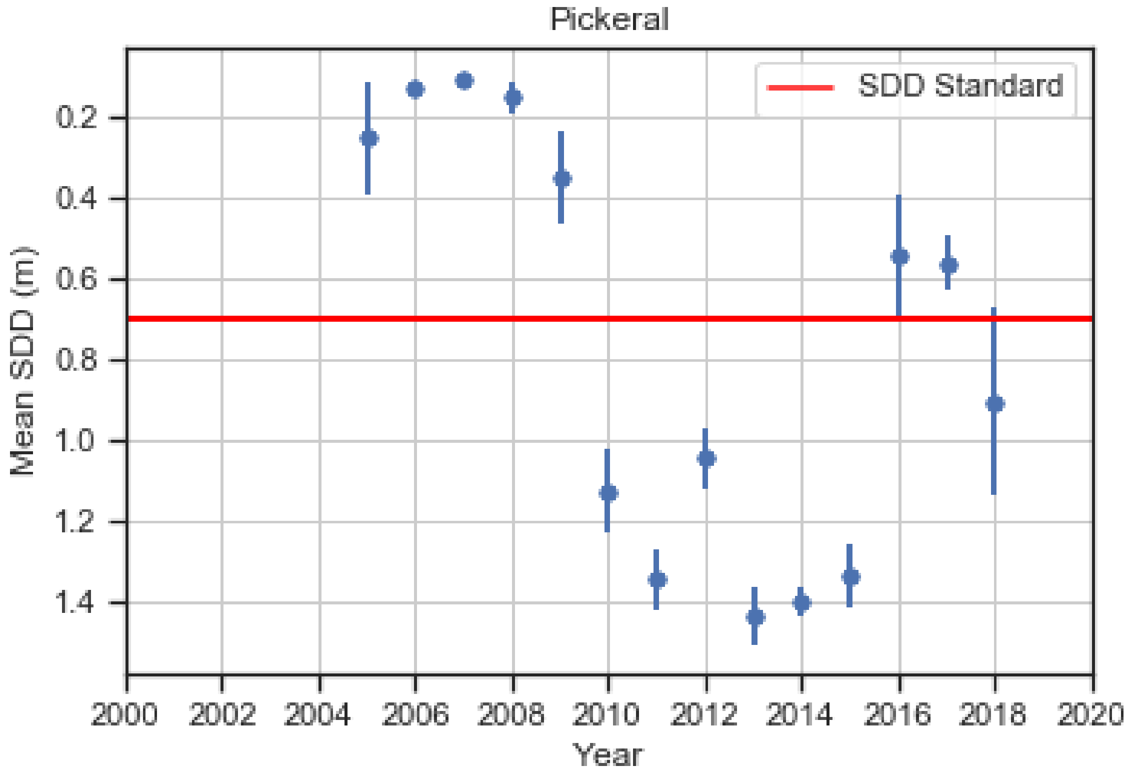


Figure C-5. Pickeral Lake Growing Season Monthly Mean Total Phosphorus.

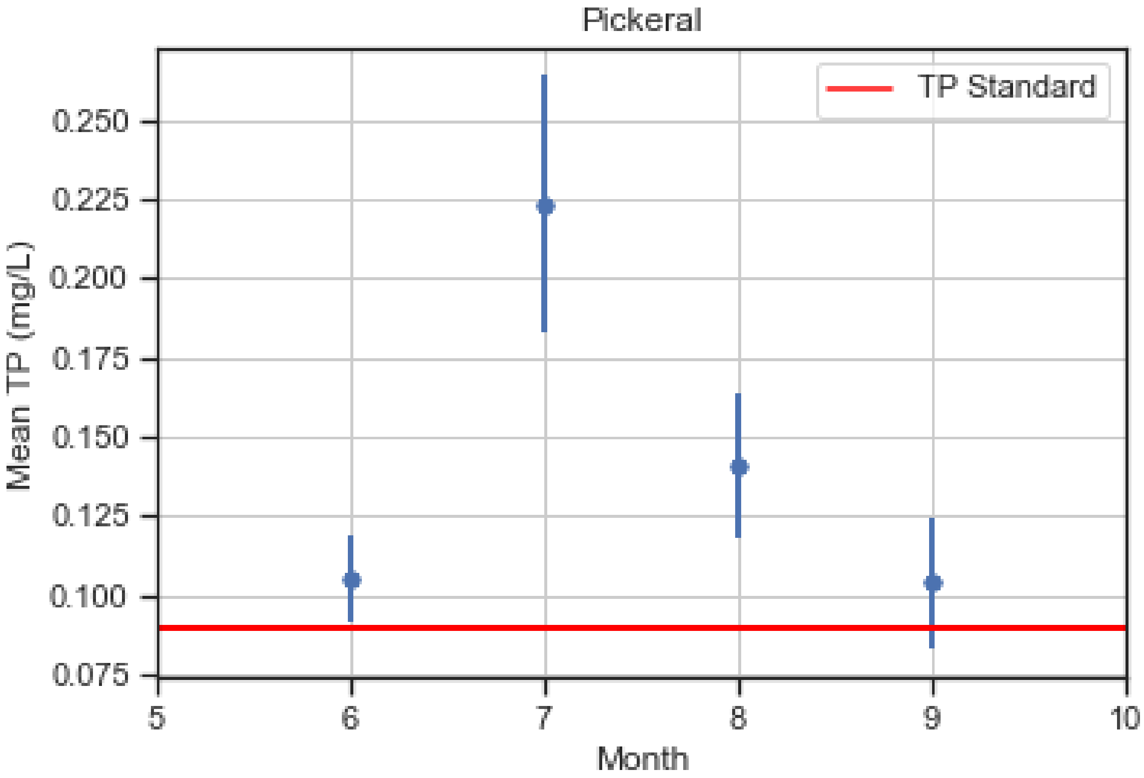


Figure C-6. Pickeral Lake Growing Season Monthly Mean Chlorophyll-a.

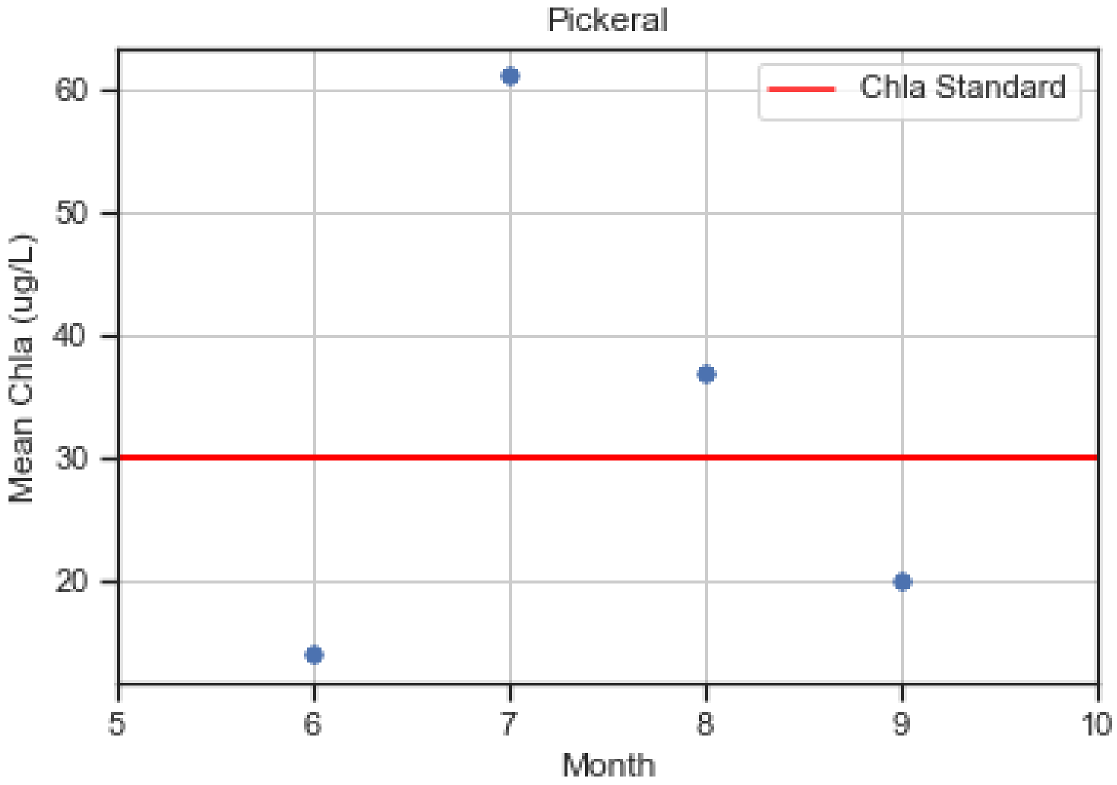
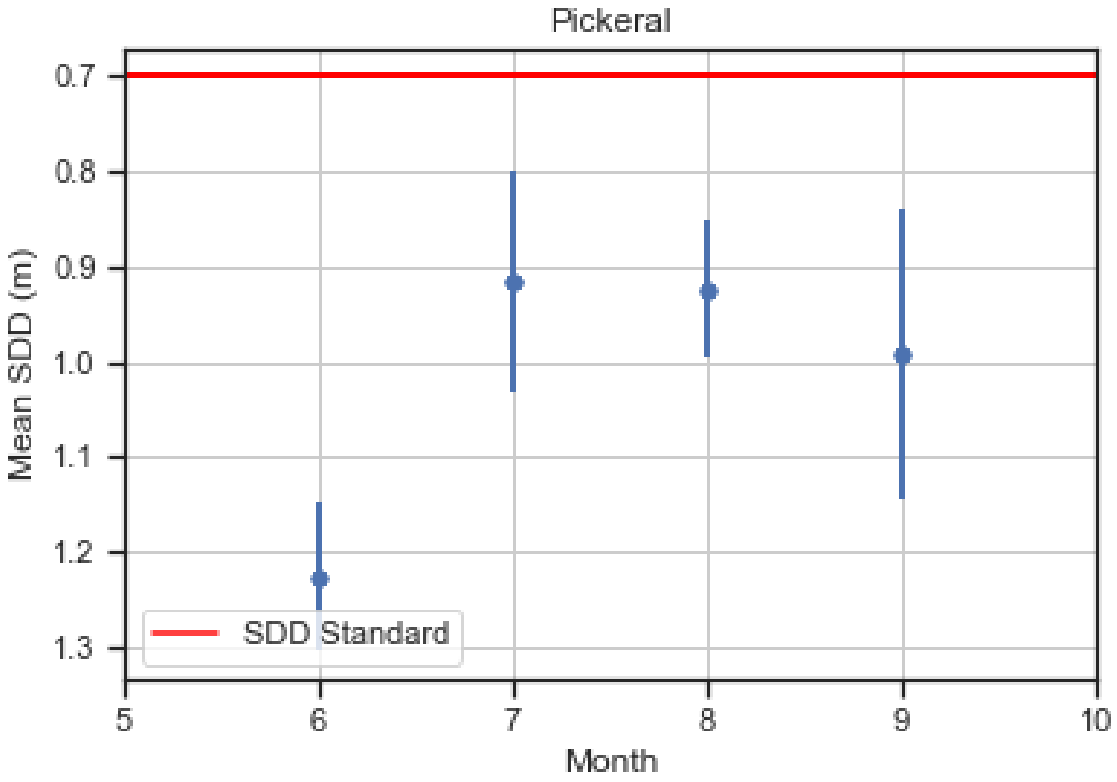


Figure C-7. Pickeral Lake Monthly Growing Season Mean Secchi disc depth.



Dissolved oxygen and temperature summary

DO and temperature data monitored by depth were examined in an effort to better define lake-mixing patterns affecting biological responses and lake phosphorus dynamics. DO and temp profile data were only available at impaired lakes between 2006 and 2008. Available profile data from all sites have been plotted in Figures C-8 through C-9 for temperature and DO.

Water temperature profiles indicate fairly consistent temperature with depth between May and September. DO profiles indicate concentration losses with depth indicating oxygen depletion is occurring. Pickeral Lake exhibited clinograde-like oxygen patterns with values decreasing with depth with values less than 5 mg/L observed on several dates. The DO profiles often show a difference of more than 5 mg/L between the maximum and minimum measured DO concentrations.

Figure C-8. Pickeral Lake Profiles for Temperature at Site 24-0025-00-201.

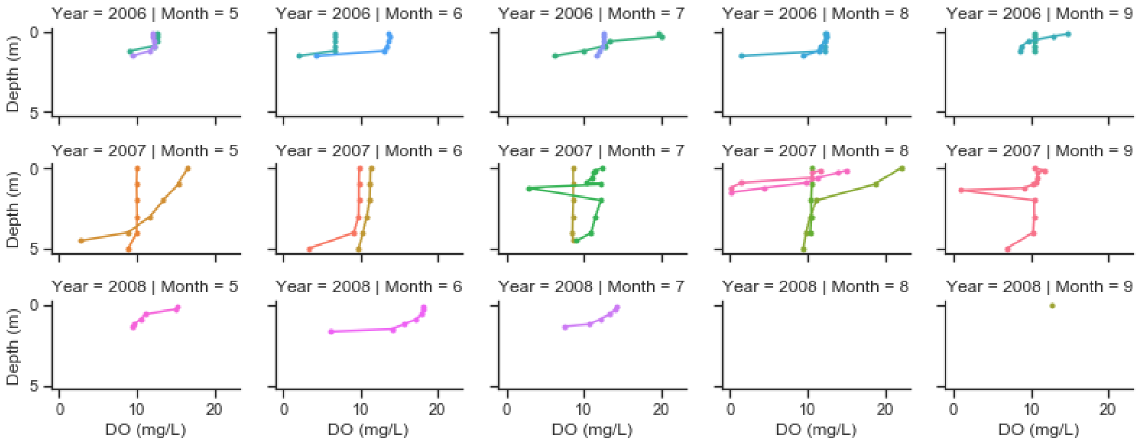
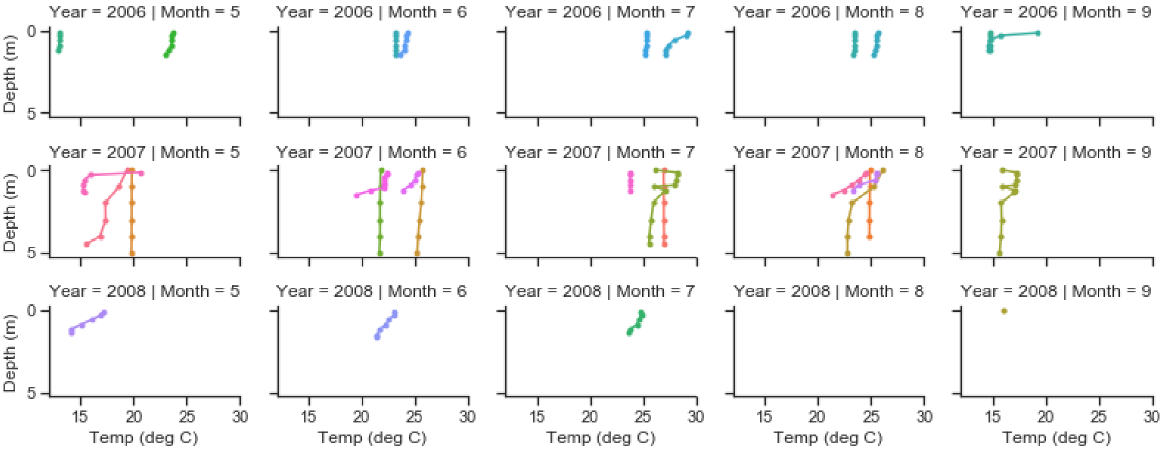


Figure C-9. Pickeral Lake Profiles for DO at Site 24-0025-00-201.



Aquatic plants

Qualitative surveys of aquatic plants in Pickeral Lake were performed on July 15, 2010, and September 8, 2011, by the DNR. This summary focuses on both surveys because they both occurred during the TMDL time period (2009 through 2018). The July 15, 2010, survey had a taxa richness of 0 and a FQI of 0, and the September 8, 2011, survey had a taxa richness of 2 and an FQI of 6.4. The percent difference from the state threshold was negative for both metrics and both surveys. Lakes with positive percent difference from the thresholds are supporting aquatic life.

Additional DNR Wildlife Lake Habitat Surveys were completed on July 28, 2009; June 14, 2010; August 5, 2010; September 13, 2010; August 3, 2011; August 7, 2012; July 11, 2013; July 14, 2015; August 1, 2016; and August 28, 2017; for Pickeral Lake. The exotic invasive species curly-leaf pondweed (Potamogeton Crispus) was present during all Wildlife Lake Habitat Surveys between August 5, 2010; and July 14, 2015.

Fisheries

The DNR Fisheries surveyed Pickeral Lake on July 15, 2013. The survey noted black bullhead (standard gill net CPUE of 281.5 and standard trap net CPUE of 42.36).

Appendix D: White (24-0024-00)

Land cover

Land cover defined by the 2011 NLCD is summarized for the Pickeral Lake Watershed in Table D-1 with the majority of the land cover consisting of row crops (29.4%), grassland (18.9%), pasture/hay (16.5%), and open water (15.7%).

Table D-1. White Lake Watershed land cover.

Impairment	Developed (%)	Wetlands (%)	Open Water (%)	Forest (%)	Grassland (%)	Hay/ Pastures (%)	Row Crops (%)
White	10.2	9.2	15.7	0.0	18.9	16.5	29.4

Physical characteristics

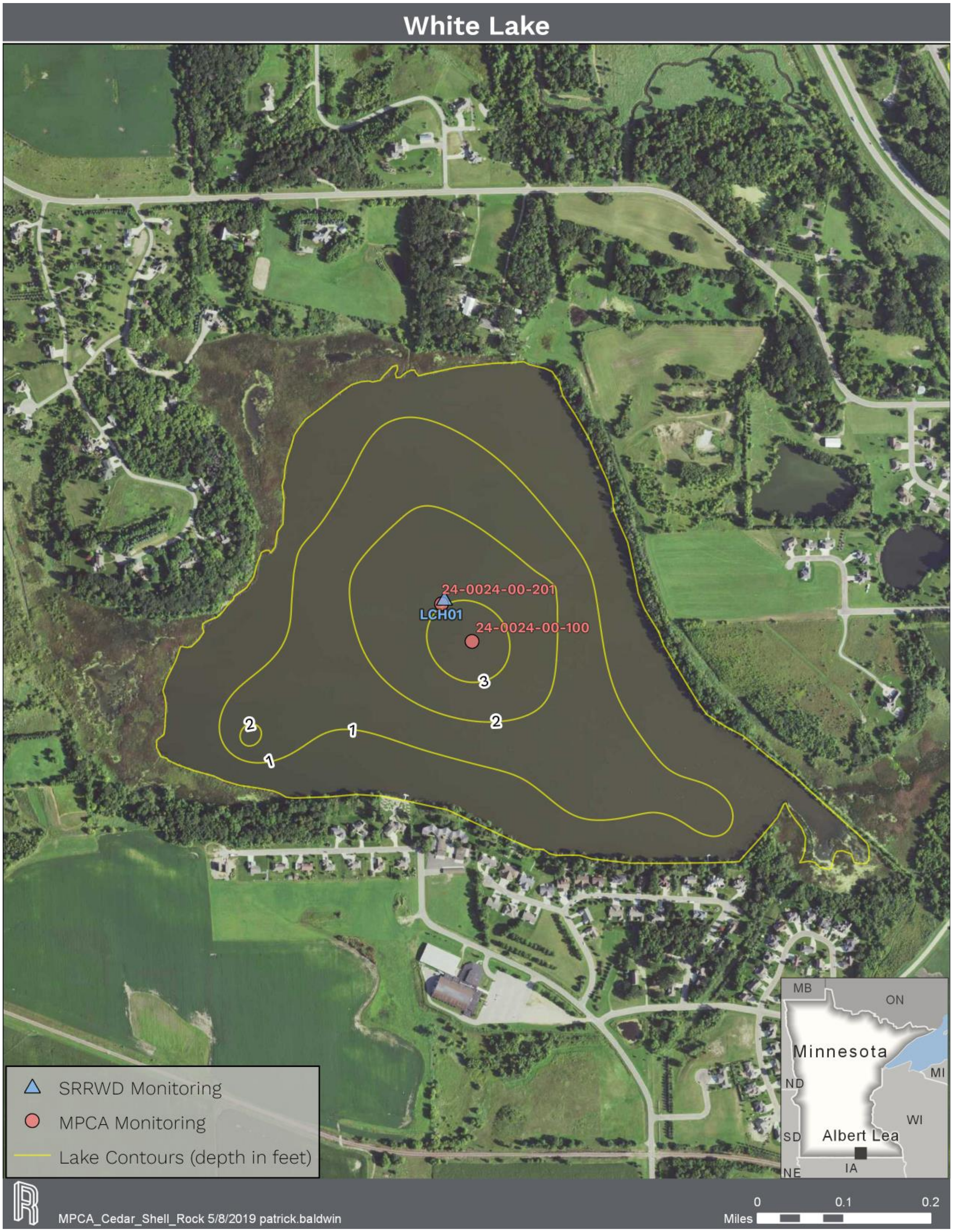
White Lake is located on the northwest edge of Albert Lea, Minnesota in Freeborn County in the central portion of the Shell Rock River HUC 8. From a regulatory standpoint, White Lake is categorized as a shallow WCBP ecoregion lake. Select lake morphometric and watershed physical characteristics are listed in Table D-2. White Lake does not have any public access sites. Figure D-1 shows aerial imagery of White Lake. Water levels measured included 1,221.00 ft in 2001 to 1,221.02 in 1994.

Table D-2. Select lake and watershed physical characteristics for White Lake.

Characteristic	White Lake	Source
Lake Surface Area (acres)	168.1	DNR LakeFinder Fish Lake Surveys
Lake Littoral Area (acres)	100*	DNR LakeFinder Fish Lake Surveys, Assumed Based on Max Depth (*)
Shore Length (miles)	2.46	DNR LakeFinder Fish Lake Surveys
Mean Depth (ft)	2**	DNR LakeFinder Fish Lake Surveys, Calculated (*), or Estimated from Lake Map (**)
Maximum Depth (ft)	3	DNR LakeFinder Fish Lake Surveys
Average Water Clarity (ft)	<3**	DNR LakeFinder Fish Lake Surveys, Average Growing Season Secchi Disk Depth (*), or SRRWD (**)
Recorded Water Level Range (ft)	0.02	DNR LakeFinder Water Level
Percent Lake Littoral Surface Area	–	Calculated
Number of Islands	0	DNR Lakefinder Map
Public Access Sites	0	DNR LakeFinder Water Access Sites
Drainage Area, Including Lake (acres)	1179	Model Subwatersheds
Watershed Area to Lake Area Ratio (X:1)	7.0	Calculated
Wetland Area (acres)	108.8	NLCD 2011
Number of Upland Lakes	1	DNR Hydro Layer
Number of Perennial Inlet Streams	0	NHD Flowlines Fcode 46006
Lake Volume (acre-feet)	405	Calculated

Characteristic	White Lake	Source
Maximum Fetch Length (ft)	5200	Measured Using ArcGIS Imagery
Lake Geometry Ratio (A^0.25/Dmax), A is surface area in m2 and Dmax is max depth in m	31.4	Calculated
Lake Geometry Classification	Shallow	Shallow>5.3, Medium1.6-5.3, Deep<0.9
Osgood Index (Dmean/sqrt(A)), A is surface area in km^2 and Dmean is mean depth in m	0.7	Calculated
Osgood Index Category	Polymictic	Polymictic<4, Intermediate4-9,Dimictic>9
Estimated Water Residence Time (days)	573.1	Calculated With Volume and 122Q10 From HSPF Simulated Flow

Figure D-1. White Lake aerial imagery.



Water quality

Monitoring data annual sample counts are shown in Table D-3 and are summarized over the TMDL period (2009 through 2018) in Table D-4 as mean growing season values for TP, chl-*a*, and SDT. Corresponding lake water quality standards are also included. Mean values for TP and chl-*a* are above the water quality standard. Similarly, the mean SDT did not meet the water quality standard. These data indicate that White Lake exceeds the phosphorus standard and will require reductions to achieve lake standards. Extremely high values of TP and chl-*a* were 963 micrograms per liter (µg/L) and 267 µg/L, respectively, while the lowest Secchi reading was 0.12 meter (m). Individual growing season means from data available between 2000 through 2018 were plotted in Figures D-2 to D-4 and show that TP has been improving since 2010.

Table D-3. Growing Season total phosphorus, chlorophyll-a, and Secchi disc depth number of samples annually.

Lake	Constituent	2009	2010	2011	2012	2013	2014	2015	**2016**	**2017**	**2018**	**Total**
White	TP	18	1	7	5	7	8	9	8	9	7	79
	Chlorophyll-a	18	0	6	5	7	8	9	8	9	7	77
	Secchi	18	1	13	10	15	14	11	12	13	11	118

Table D-4. Total phosphorus, chlorophyll-a, and Secchi disc depth growing season means.

Parameter	Minimum	Mean	Maximum	Standard Deviation	Lake Standards
TP (µg/L)	32.0	257.4	963.0	196.2	≤90
Chlorophyll-a (µg/L)	1.0	71.5	267.0	83.3	≤30
Secchi disk depth (m)	0.12	0.56	2.13	0.35	≥0.7

Multiyear growing season mean monthly water quality observations are summarized in Figures D-5 through D-7 for data available between 2009 and 2018. Plots of this mean monthly data indicate poor water quality during the warm summer months. Error bars in annual and monthly phosphorus and Secchi plots indicate standard error.

Figure D-2. White Lake annual growing season mean total phosphorus concentrations.

Figure D-3. White Lake annual growing season mean chlorophyll-a concentrations.

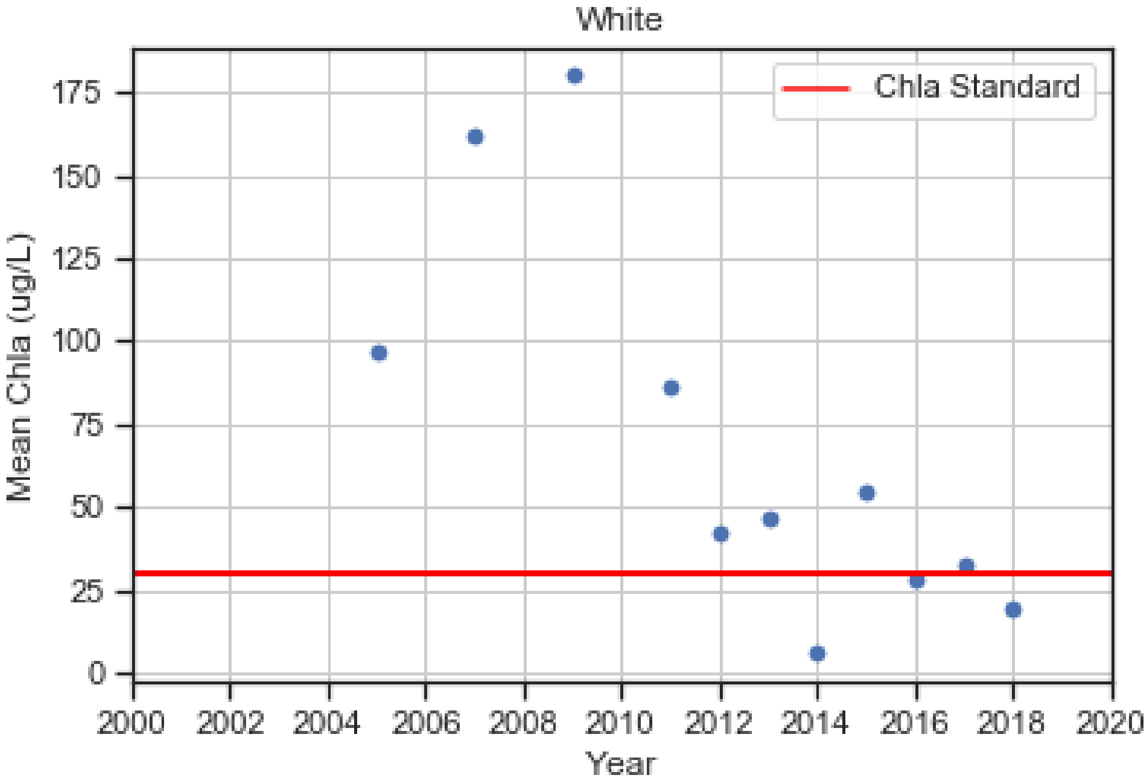


Figure D-4. White Lake annual growing season mean Secchi disc depth.

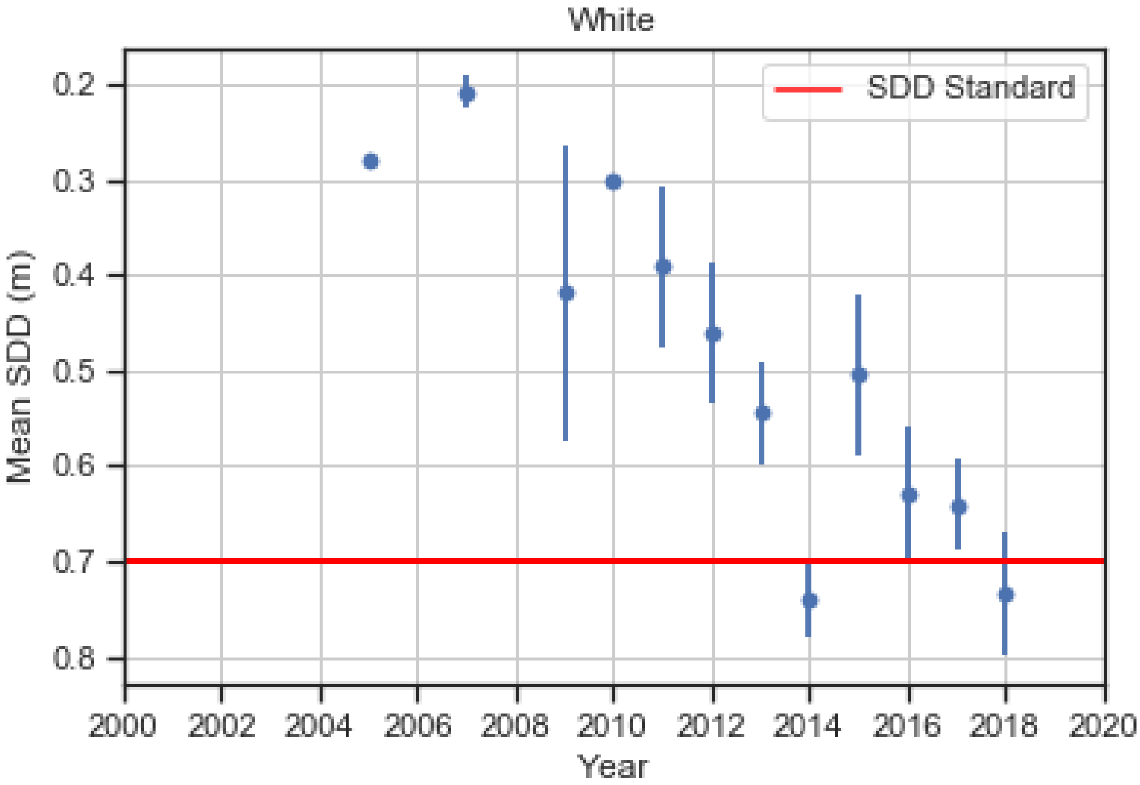


Figure D-5. White Lake growing season monthly mean total phosphorus.

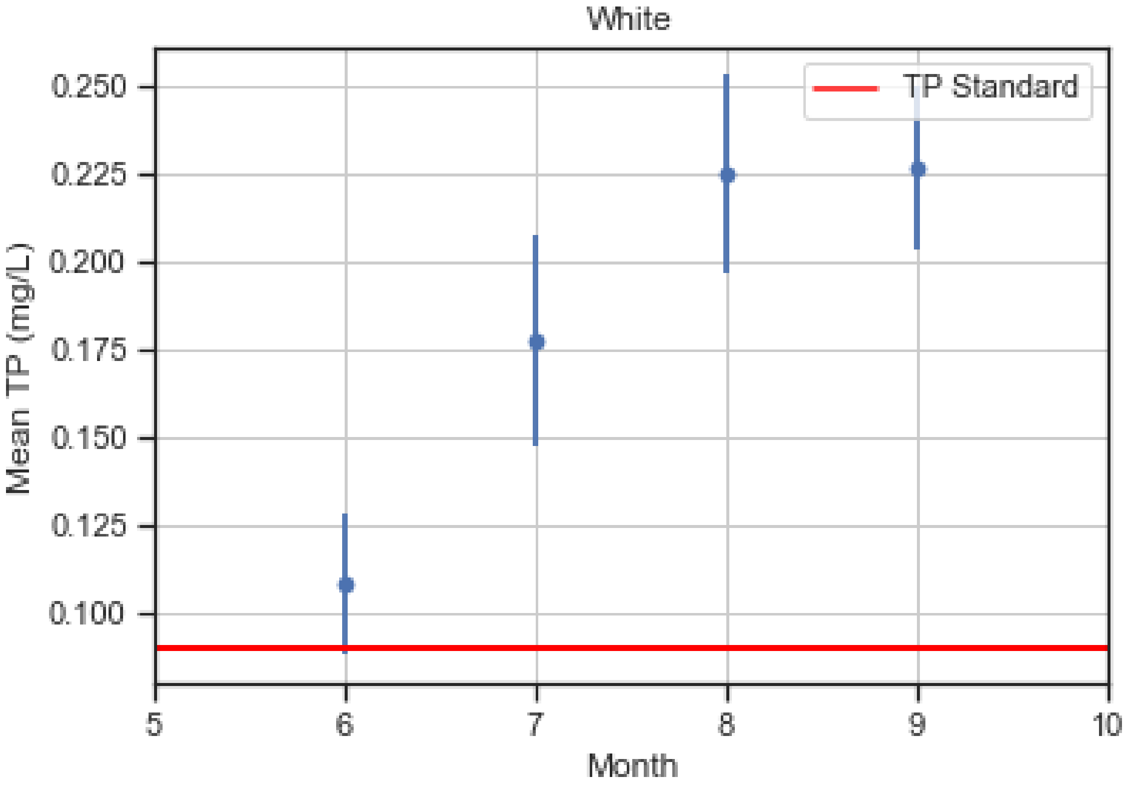


Figure D-6. White Lake growing season monthly mean chlorophyll-a.

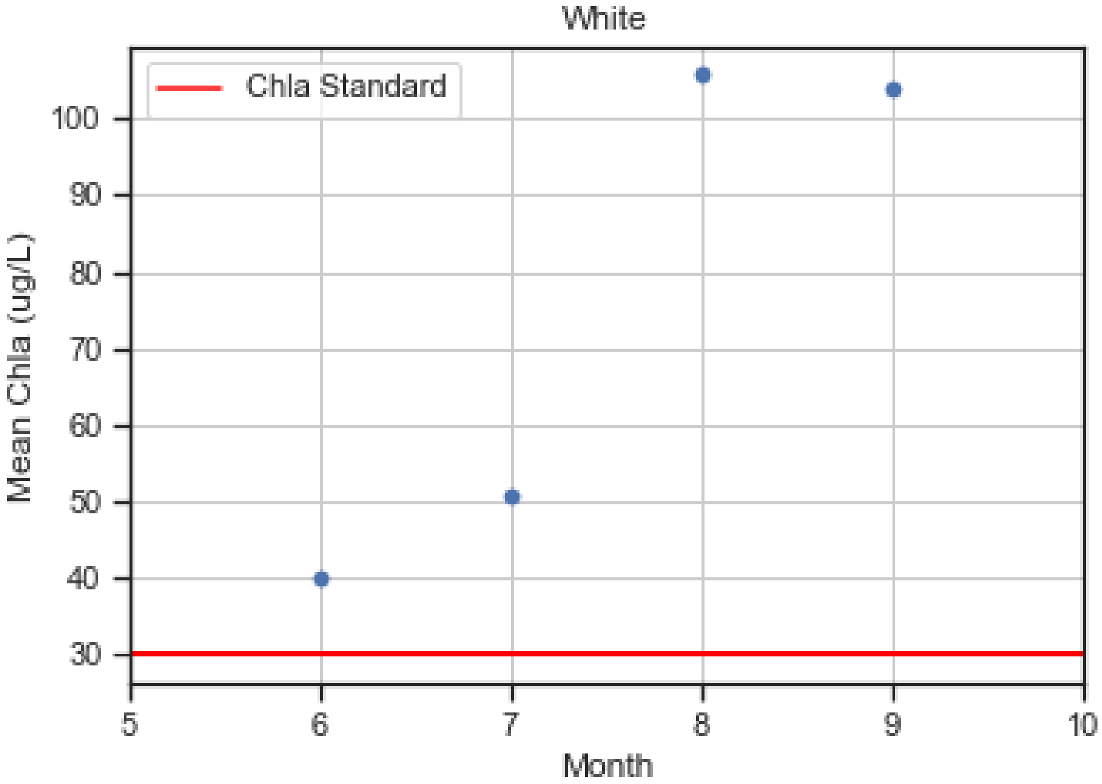
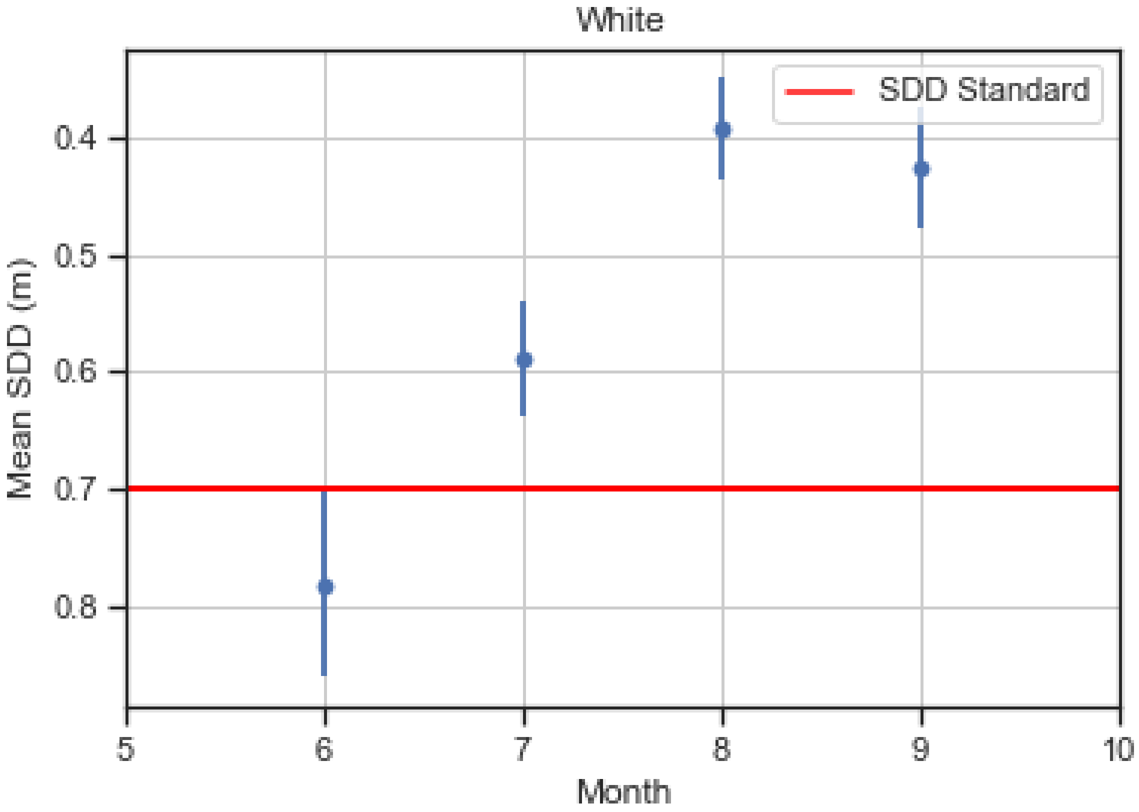


Figure D-7. White Lake monthly growing season mean Secchi disc depth.



Dissolved oxygen and temperature summary

DO and temperature data monitored by depth were examined in an effort to better define lake-mixing patterns affecting biological responses and lake phosphorus dynamics. DO and temp profile data were only available at impaired lakes between 2006 and 2008. Available profile data from all sites from have been plotted in Figures D-8 through D-9 for temperature and DO.

Water temperature profiles indicate fairly consistent temperatures with depth in White Lake between May and September. DO profiles indicate concentration also remains fairly consistent with depth from May through September.

Figure D-8. White Lake Profiles for Temperature at Site 24-0024-00-201.

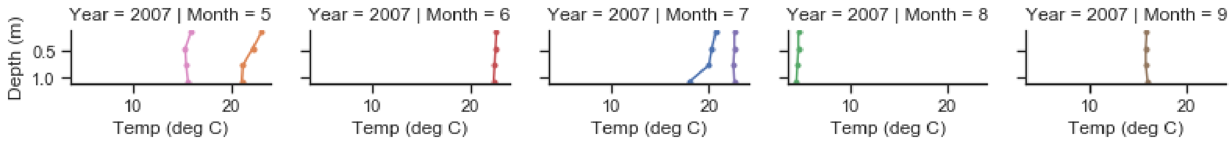
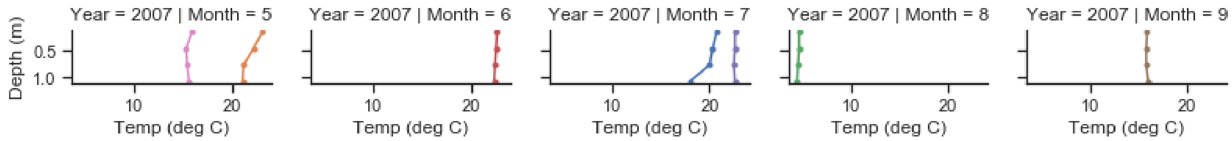


Figure D-9. White Lake Profiles for Dissolved Oxygen at Site 24-0024-00-201.



Aquatic plants

Qualitative surveys of aquatic plants in White Lake were performed on June 27, 2002; July 28, 2009; June 14, 2010; August 5, 2010; September 13, 2010; August 3, 2011; August 7, 2012; and July 11, 2013, by the DNR. This summary focuses on surveys that occurred during the TMDL time period (2009 through 2018). The 2009 through 2013 surveys had a taxa richness ranging from 0 to 9 and a FQI ranging from 0 to 15.3, and the September 8, 2011, survey had a taxa richness of 2 and an FQI of 6.4. Since the August 5, 2010 survey, all of the percent difference values from the state threshold were positive for both metrics. Lakes with positive percent difference from the thresholds are supporting aquatic life.

Additional DNR Wildlife Lake Habitat Surveys were completed on July 15, 2010, and September 18, 2011, for White Lake. The exotic invasive species curly-leaf pondweed (Potamogeton Crispus) was not present during either Wildlife Lake Habitat Survey.

Fisheries

The DNR Fisheries surveyed White Lake on July 6, 2015. The survey noted black bullhead (standard gill net CPUE of 10.00 and standard trap net CPUE of 70.89). A fish survey in September 2011 noted the presence of bullhead and common carp.

Appendix E: Maps

Figure E-1. Flow monitoring locations.

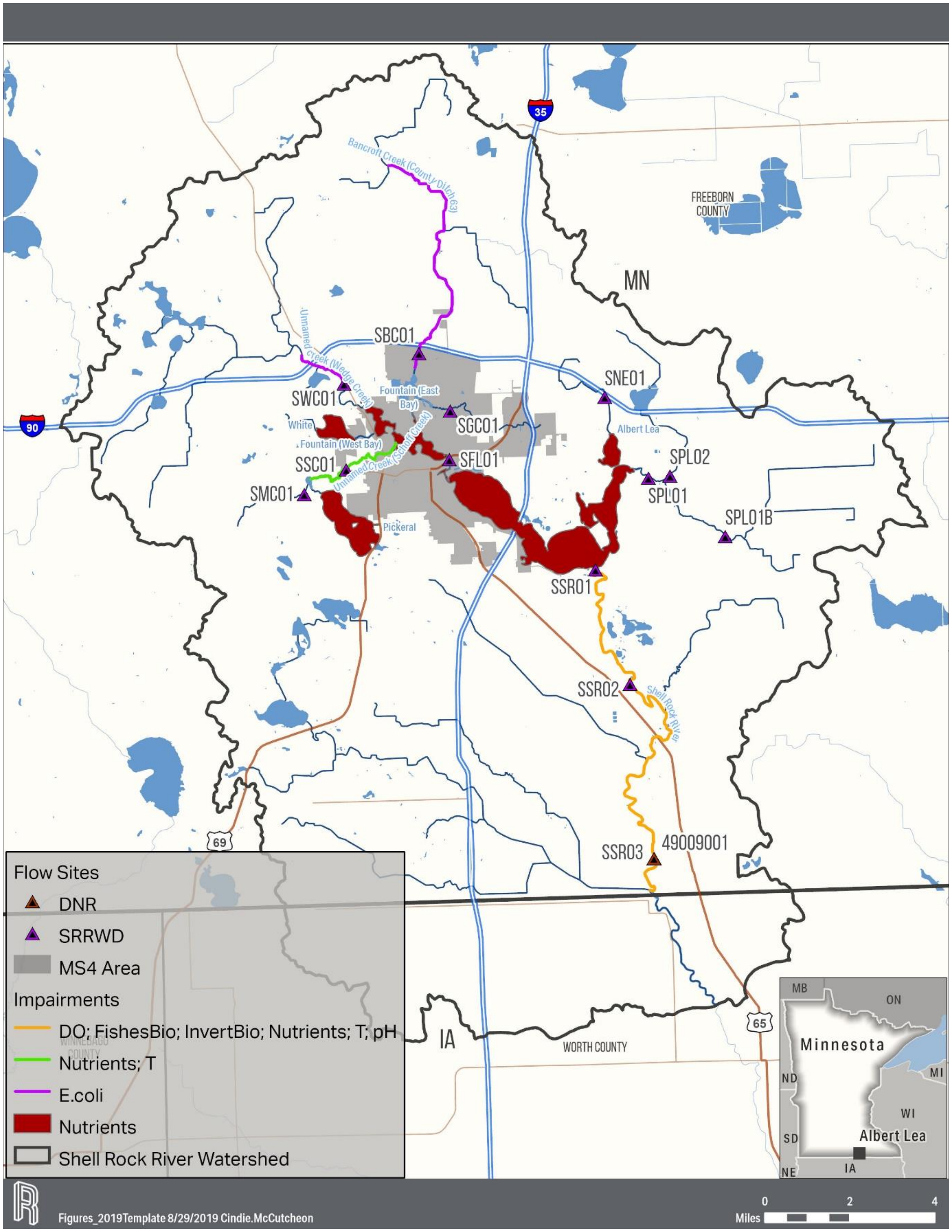


Figure E-2. Water quality monitoring locations.

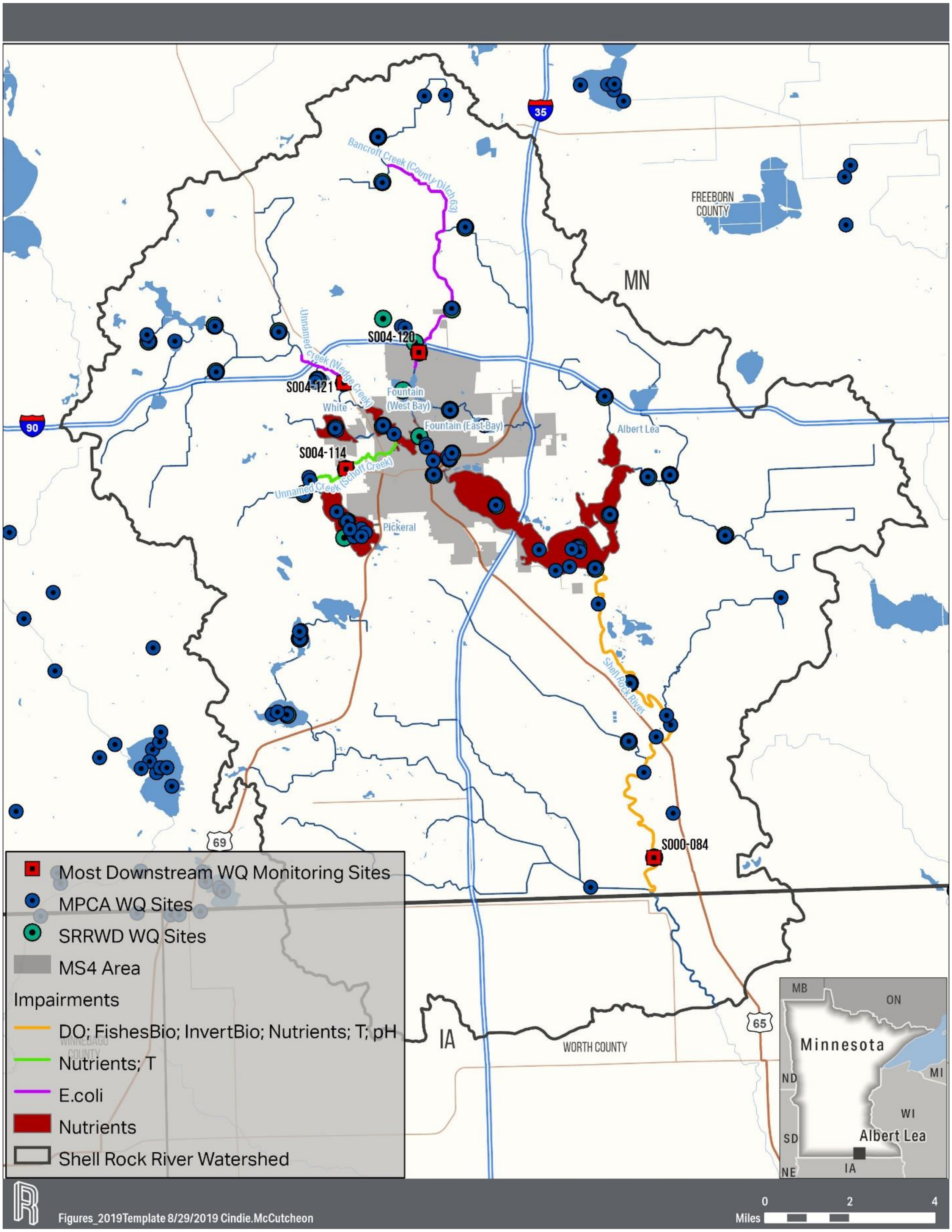


Figure E-3. Shell Rock River water quality monitoring locations with point source discharge locations. Grey-shaded arrows indicate general location of point source discharge.

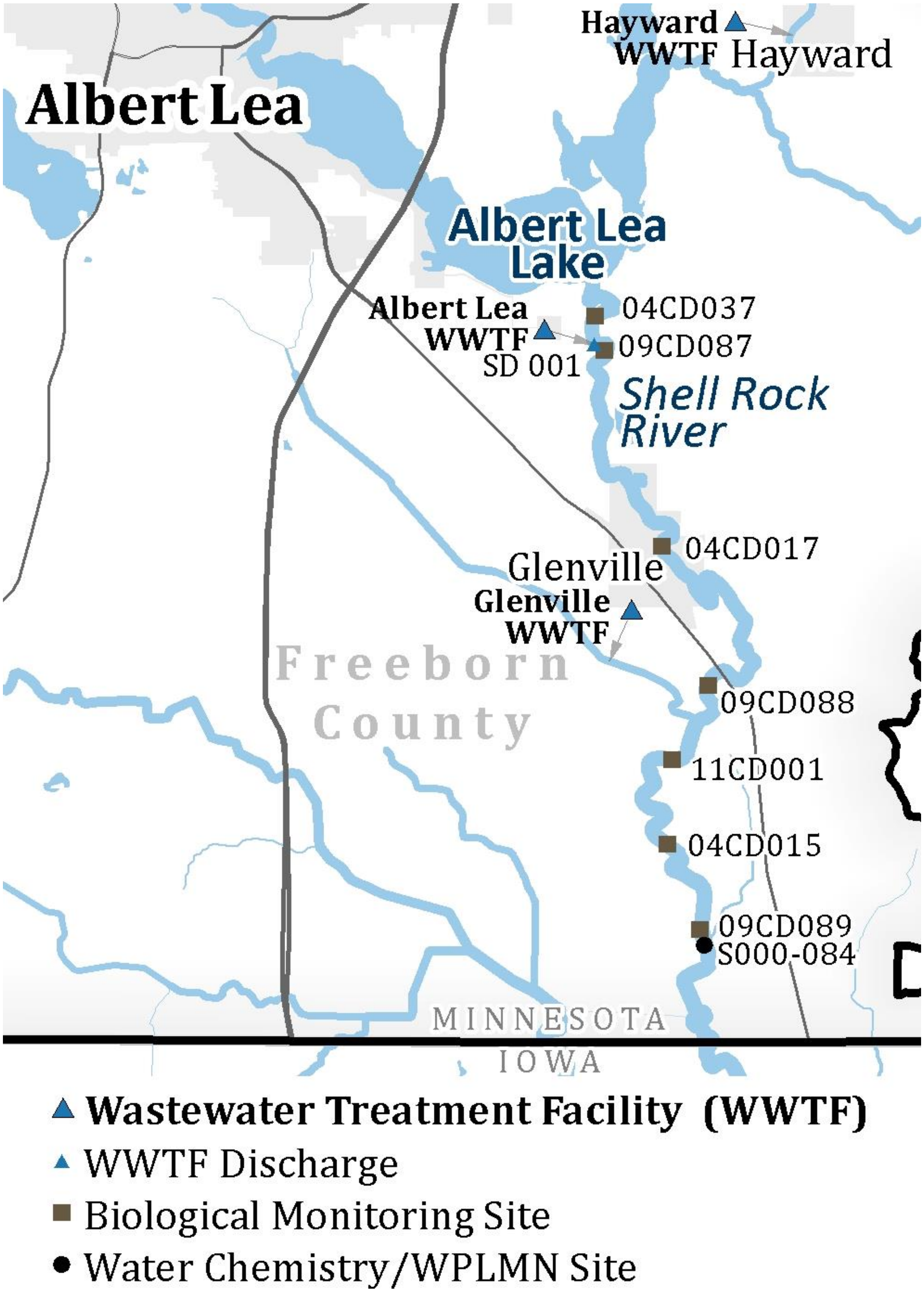


Figure E-4. Point sources with wasteload allocation.

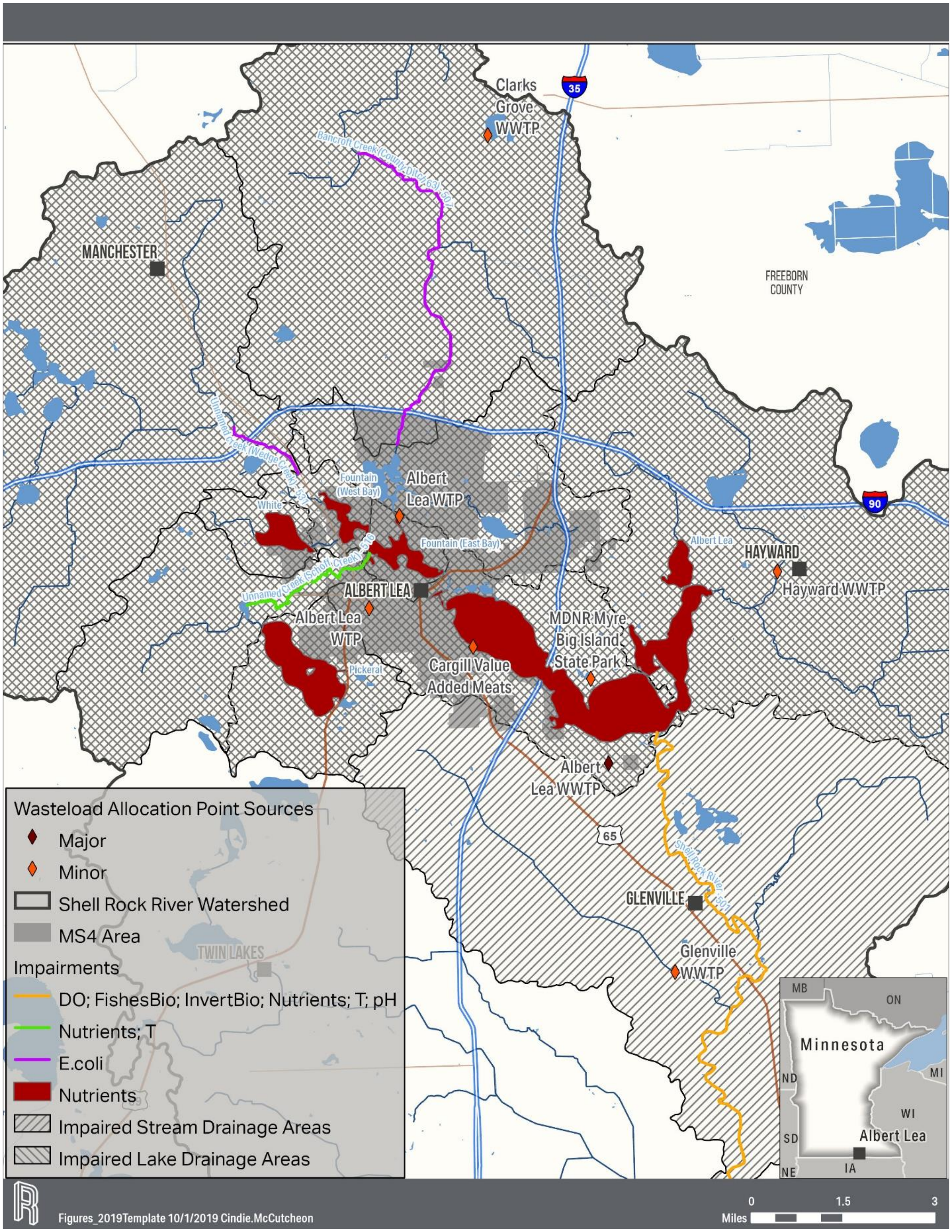


Figure E-5. Feedlot locations.

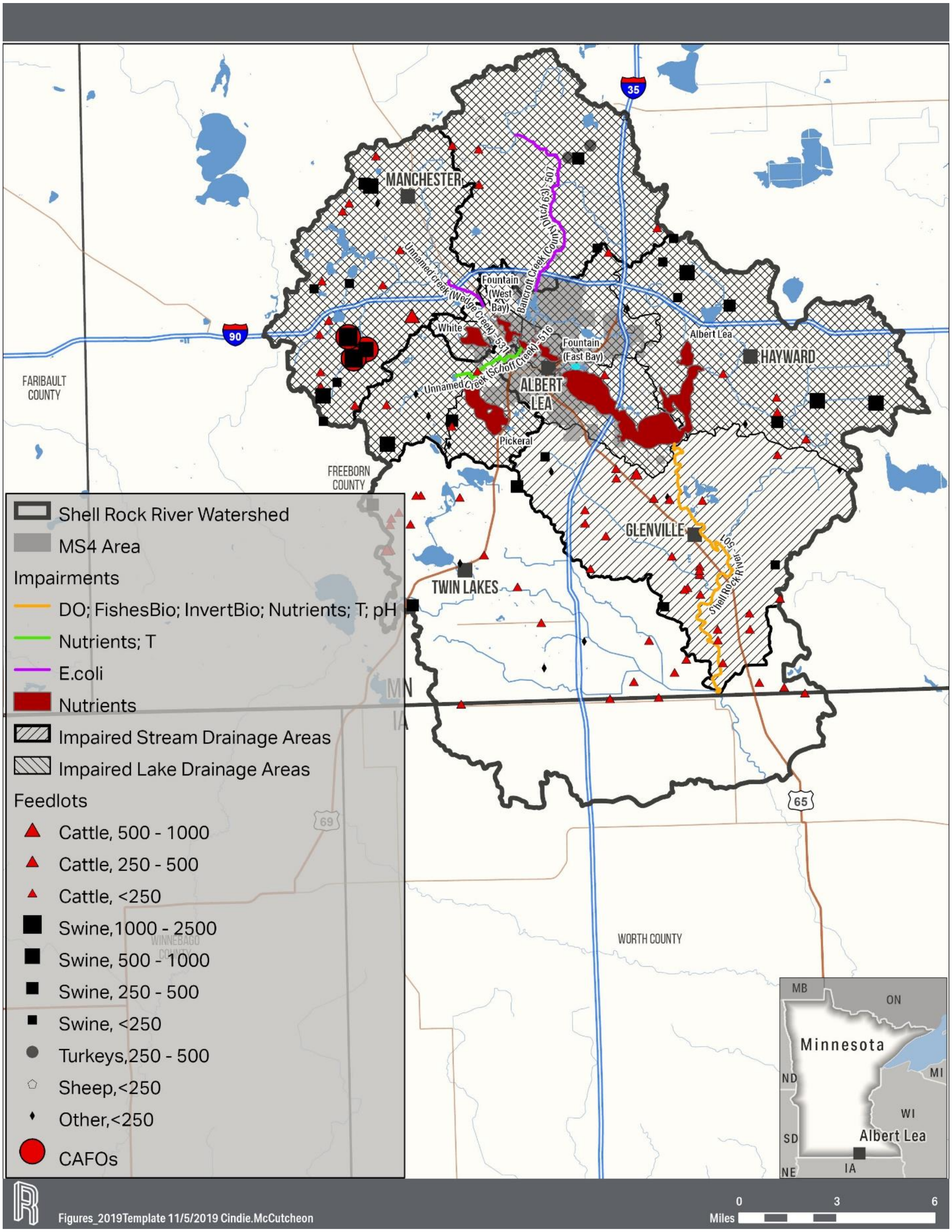
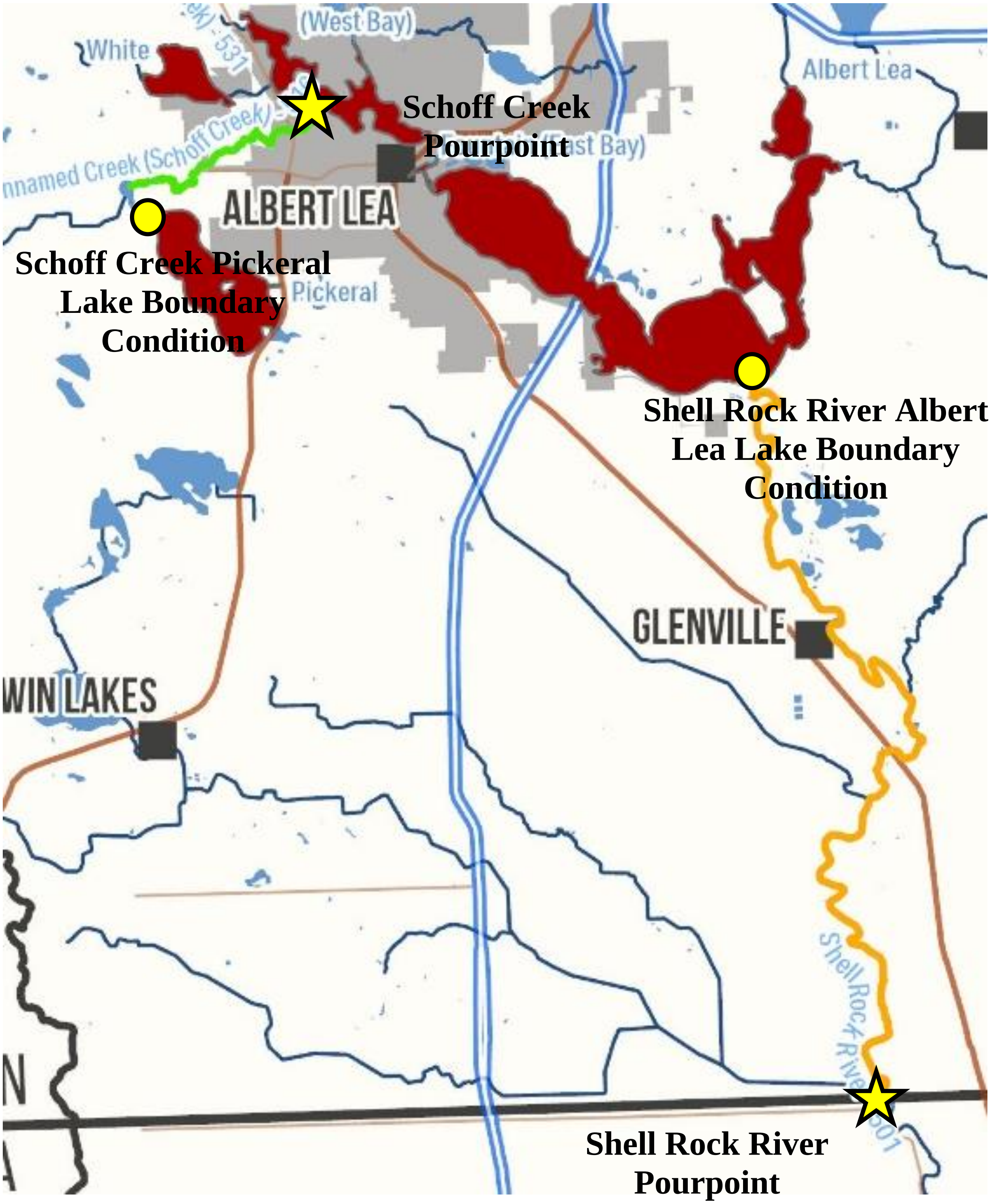


Figure E-6. Boundary condition and pourpoint locations.



Appendix F: BATHTUB input and model summary

Table F-1. BATHTUB model lake summary.

Lake	BATHTUB Models Employed		
	Phosphorus	Chlorophyll-*a*	Secchi
White	7	4	1
Pickeral	7	4	1
Fountain (West Bay)	7	2	1
Fountain (East Bay)	7	4	1
Albert Lea	7	4	1

Phosphorus Model 7: Settling Velocity

Chlorophyll-a Model 4: Linear

*Chlorophyll-a Model 2: P. Light, T**

Secchi Model 1: Chlorophyll-a and turbidity

This appendix includes the text files that correspond to the calibrated BATHTUB models for existing conditions and for proposed conditions. A text editor can be used to save the text from this appendix as two separate .btb files, which can then be read by BATHTUB.

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White Proposed

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12,"FLUSHING EFFECT",1,0
13,"CHLOROPHYLL-A CV",.62,0
14,"Avail Factor - TP",.33,0
15,"Avail Factor - Ortho P",1.93,0
16,"Avail Factor - TN",.59,0
17,"Avail Factor - Inorganic N",.79,0
5,"Atmospheric Loads"
1,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",46.9,.5
3,"TOTAL N",1000,.5
4,"ORTHO P",23.45,.5
5,"INORGANIC N",500,.5
1,"Segments"
1,"Pickeral Lake",0,1,2.38,1.07,2.8,1,.12,0,.5,.12,1.48,0,0
1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",.227,0
1,"TOTAL N",0,0
1,"CONSERVATIVE SUB",0,0,1,0
1,"TOTAL P MG/M3",147.68,.1,.8667916,0
1,"TOTAL N MG/M3",0,0,1,0
1,"CHL-A MG/M3",34.58,.19,.8362678,0
1,"SECCHI M",1.02,.05,1,0
1,"ORGANIC N MG/M3",0,0,1,0
1,"TP-ORTHO-P MG/M3",0,0,1,0
1,"HOD-V MG/M3-DAY",0,0,1,0
1,"MOD-V MG/M3-DAY",0,0,1,0
5,"Tributaries"
1,"Lakeshed",1,1,12.59,3.659,.13,0
1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",199.73,.07
1,"TOTAL N",0,0
1,"ORTHO P",105.12,.09
1,"INORGANIC N",0,0
1,"LandUses",0,0,0,0,0,0,0,0
2,"MS4",1,1,1.63,.644,.5,0
2,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",92.46,.5
2,"TOTAL N",0,0
2,"ORTHO P",39.8,.5
2,"INORGANIC N",0,0
2,"LandUses",0,0,0,0,0,0,0,0
3,"SSTS",1,1,.01,.001,.5,0
3,"CONSERVATIVE SUBST.",0,0
3,"TOTAL P",10000,.5
3,"TOTAL N",0,0
3,"ORTHO P",10000,.5
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3,"INORGANIC N",0,0
3,"LandUses",0,0,0,0,0,0,0,0
4,"Outlet",1,4,2.28,6.51,.15,0
4,"CONSERVATIVE SUBST.",0,0
4,"TOTAL P",44.01,.05
4,"TOTAL N",0,0
4,"ORTHO P",18.1,.15
4,"INORGANIC N",0,0
4,"LandUses",0,0,0,0,0,0,0,0
5,"Reach 191",1,1,6.18,2.22,.13,0
5,"CONSERVATIVE SUBST.",0,0
5,"TOTAL P",223.89,.08
5,"TOTAL N",0,0
5,"ORTHO P",134.12,.1
5,"INORGANIC N",0,0
5,"LandUses",0,0,0,0,0,0,0,0
0,"Channels"
8,"Land Use Export Categories"
1,"landuse1"
1,"Runoff",0,0
1,"CONSERVATIVE SUBST.",0,0
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1,"TOTAL N",0,0
1,"ORTHO P",0,0
1,"INORGANIC N",0,0
2,"landuse2"
2,"Runoff",0,0
2,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",0,0
2,"TOTAL N",0,0
2,"ORTHO P",0,0
2,"INORGANIC N",0,0
3,"landuse3"
3,"Runoff",0,0
3,"CONSERVATIVE SUBST.",0,0
3,"TOTAL P",0,0
3,"TOTAL N",0,0
3,"ORTHO P",0,0
3,"INORGANIC N",0,0
4,"landuse4"
4,"Runoff",0,0
4,"CONSERVATIVE SUBST.",0,0
4,"TOTAL P",0,0
4,"TOTAL N",0,0
4,"ORTHO P",0,0
4,"INORGANIC N",0,0
5,""
5,"Runoff",0,0
5,"CONSERVATIVE SUBST.",0,0
5,"TOTAL P",0,0
5,"TOTAL N",0,0
5,"ORTHO P",0,0
5,"INORGANIC N",0,0
6,""
6,"Runoff",0,0
6,"CONSERVATIVE SUBST.",0,0
6,"TOTAL P",0,0
6,"TOTAL N",0,0
6,"ORTHO P",0,0
6,"INORGANIC N",0,0
7,""
7,"Runoff",0,0
7,"CONSERVATIVE SUBST.",0,0
7,"TOTAL P",0,0
7,"TOTAL N",0,0
7,"ORTHO P",0,0
7,"INORGANIC N",0,0
8,""
8,"Runoff",0,0
8,"CONSERVATIVE SUBST.",0,0
8,"TOTAL P",0,0
8,"TOTAL N",0,0
8,"ORTHO P",0,0
8,"INORGANIC N",0,0
"Notes"
Pickeral Lake existing conditions model
```

End of BATHTUB file – do not include this line in the .btb file. The “Notes” line near the end of the .btb file should be Line 154, and 11 empty lines should follow Line 154 (155–165) at the end of the file. Tests showed that removing these lines from the .btb file resulted in an “Input File Error” from BATHTUB.

Pickeral Proposed

```
Vers 6.14f (04/28/2015)
Pickeral Lake Existing
4,"Global Parmameters"
1,"AVERAGING PERIOD (YRS)",1,0
2,"PRECIPITATION (METERS)",.92,.07
3,"EVAPORATION (METERS)",.7,.5
4,"INCREASE IN STORAGE (METERS)",0,.5
12,"Model Options"
1,"CONSERVATIVE SUBSTANCE",0
2,"PHOSPHORUS BALANCE",7
3,"NITROGEN BALANCE",0
4,"CHLOROPHYLL-A",4
5,"SECCHI DEPTH",1
6,"DISPERSION",1
7,"PHOSPHORUS CALIBRATION",2
8,"NITROGEN CALIBRATION",2
9,"ERROR ANALYSIS",1
10,"AVAILABILITY FACTORS",0
11,"MASS-BALANCE TABLES",1
12,"OUTPUT DESTINATION",2
17,"Model Coefficients"
1,"DISPERSION RATE",1,.7
2,"P DECAY RATE",1,.45
3,"N DECAY RATE",1,.55
4,"CHL-A MODEL",1,.26
5,"SECCHI MODEL",1,.1
6,"ORGANIC N MODEL",1,.12
7,"TP-OP MODEL",1,.15
8,"HODV MODEL",1,.15
9,"MODV MODEL",1,.22
10,"BETA M2/MG",.025,0
11,"MINIMUM QS",.1,0
12,"FLUSHING EFFECT",1,0
13,"CHLOROPHYLL-A CV",.62,0
14,"Avail Factor - TP",.33,0
15,"Avail Factor - Ortho P",1.93,0
16,"Avail Factor - TN",.59,0
17,"Avail Factor - Inorganic N",.79,0
5,"Atmospheric Loads"
1,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",46.9,.5
3,"TOTAL N",1000,.5
4,"ORTHO P",23.45,.5
5,"INORGANIC N",500,.5
1,"Segments"
1,"Pickeral Lake",0,1,2.38,1.07,2.8,1,.12,0,.5,.12,1.48,0,0
```

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1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",.04,0
1,"TOTAL N",0,0
1,"CONSERVATIVE SUB",0,0,1,0
1,"TOTAL P MG/M3",147.68,.1,.8667916,0
1,"TOTAL N MG/M3",0,0,1,0
1,"CHL-A MG/M3",34.58,.19,.8362678,0
1,"SECCHI M",1.02,.05,1,0
1,"ORGANIC N MG/M3",0,0,1,0
1,"TP-ORTHO-P MG/M3",0,0,1,0
1,"HOD-V MG/M3-DAY",0,0,1,0
1,"MOD-V MG/M3-DAY",0,0,1,0
5,"Tributaries"
1,"Lakeshed",1,1,12.59,3.659,.13,0
1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",93.04,.07
1,"TOTAL N",0,0
1,"ORTHO P",105.12,.09
1,"INORGANIC N",0,0
1,"LandUses",0,0,0,0,0,0,0,0
2,"MS4",1,1,1.63,.644,.5,0
2,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",80,.5
2,"TOTAL N",0,0
2,"ORTHO P",39.8,.5
2,"INORGANIC N",0,0
2,"LandUses",0,0,0,0,0,0,0,0
3,"SSTS",1,1,.01,.001,.5,0
3,"CONSERVATIVE SUBST.",0,0
3,"TOTAL P",.1,.5
3,"TOTAL N",0,0
3,"ORTHO P",.1,.5
3,"INORGANIC N",0,0
3,"LandUses",0,0,0,0,0,0,0,0
4,"Outlet",1,4,2.28,6.51,.15,0
4,"CONSERVATIVE SUBST.",0,0
4,"TOTAL P",44.01,.05
4,"TOTAL N",0,0
4,"ORTHO P",18.1,.15
4,"INORGANIC N",0,0
4,"LandUses",0,0,0,0,0,0,0,0
5,"Reach 191",1,1,6.18,2.22,.13,0
5,"CONSERVATIVE SUBST.",0,0
5,"TOTAL P",150,.08
5,"TOTAL N",0,0
5,"ORTHO P",134.12,.1
5,"INORGANIC N",0,0
5,"LandUses",0,0,0,0,0,0,0,0
0,"Channels"
8,"Land Use Export Categories"
1,"landuse1"
1,"Runoff",0,0
1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",0,0
1,"TOTAL N",0,0
1,"ORTHO P",0,0
1,"INORGANIC N",0,0
2,"landuse2"
2,"Runoff",0,0
2,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",0,0
2,"TOTAL N",0,0
2,"ORTHO P",0,0
2,"INORGANIC N",0,0
3,"landuse3"
3,"Runoff",0,0
3,"CONSERVATIVE SUBST.",0,0
3,"TOTAL P",0,0
3,"TOTAL N",0,0
3,"ORTHO P",0,0
3,"INORGANIC N",0,0
4,"landuse4"
4,"Runoff",0,0
4,"CONSERVATIVE SUBST.",0,0
4,"TOTAL P",0,0
4,"TOTAL N",0,0
4,"ORTHO P",0,0
4,"INORGANIC N",0,0
5,""
5,"Runoff",0,0
5,"CONSERVATIVE SUBST.",0,0
5,"TOTAL P",0,0
5,"TOTAL N",0,0
5,"ORTHO P",0,0
5,"INORGANIC N",0,0
6,""
6,"Runoff",0,0
6,"CONSERVATIVE SUBST.",0,0
6,"TOTAL P",0,0
6,"TOTAL N",0,0
6,"ORTHO P",0,0
6,"INORGANIC N",0,0
7,""
7,"Runoff",0,0
7,"CONSERVATIVE SUBST.",0,0
7,"TOTAL P",0,0
7,"TOTAL N",0,0
7,"ORTHO P",0,0
7,"INORGANIC N",0,0
8,""
8,"Runoff",0,0
8,"CONSERVATIVE SUBST.",0,0
8,"TOTAL P",0,0
8,"TOTAL N",0,0
8,"ORTHO P",0,0
8,"INORGANIC N",0,0
"Notes"
Pickeral Lake existing conditions model
```

End of BATHTUB file – do not include this line in the .btb file. The “Notes” line near the end of the .btb file should be Line 154, and 11 empty lines should follow Line 154 (155–165) at the end of the file. Tests showed that removing these lines from the .btb file resulted in an “Input File Error” from BATHTUB.

Fountain West Existing

```
Vers 6.14f (04/28/2015)
Fountain Lake Existing Conditions
4,"Global Parmameters"
1,"AVERAGING PERIOD (YRS)",1,0
2,"PRECIPITATION (METERS)",.95,.06
3,"EVAPORATION (METERS)",.7,.5
4,"INCREASE IN STORAGE (METERS)",0,.5
12,"Model Options"
1,"CONSERVATIVE SUBSTANCE",0
2,"PHOSPHORUS BALANCE",7
3,"NITROGEN BALANCE",0
4,"CHLOROPHYLL-A",2
5,"SECCHI DEPTH",1
6,"DISPERSION",1
```

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7,"PHOSPHORUS CALIBRATION",2
8,"NITROGEN CALIBRATION",2
9,"ERROR ANALYSIS",1
10,"AVAILABILITY FACTORS",0
11,"MASS-BALANCE TABLES",1
12,"OUTPUT DESTINATION",2
17,"Model Coefficients"
1,"DISPERSION RATE",1,.7
2,"P DECAY RATE",1,.45
3,"N DECAY RATE",1,.55
4,"CHL-A MODEL",1,.26
5,"SECCHI MODEL",1,.1
6,"ORGANIC N MODEL",1,.12
7,"TP-OP MODEL",1,.15
8,"HODV MODEL",1,.15
9,"MODV MODEL",1,.22
10,"BETA M2/MG",.025,0
11,"MINIMUM QS",.1,0
12,"FLUSHING EFFECT",1,0
13,"CHLOROPHYLL-A CV",.62,0
14,"Avail Factor - TP",.33,0
15,"Avail Factor - Ortho P",1.93,0
16,"Avail Factor - TN",.59,0
17,"Avail Factor - Inorganic N",.79,0
5,"Atmospheric Loads"
1,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",46.9,.5
3,"TOTAL N",1000,.5
4,"ORTHO P",23.45,.5
5,"INORGANIC N",500,.5
1,"Segments"
1,"FL West Bay",0,1,.58,1.42,1.53,1.4,.12,0,.5,.39,.33,0,0
1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",7.133,0
1,"TOTAL N",0,0
1,"CONSERVATIVE SUB",0,0,1,0
1,"TOTAL P MG/M3",272.03,.1,1,0
1,"TOTAL N MG/M3",0,0,1,0
1,"CHL-A MG/M3",39.26,.1,.7104861,0
1,"SECCHI M",.73,.06,1,0
1,"ORGANIC N MG/M3",0,0,1,0
1,"TP-ORTHO-P MG/M3",0,0,1,0
1,"HOD-V MG/M3-DAY",0,0,1,0
1,"MOD-V MG/M3-DAY",0,0,1,0
9,"Tributaries"
1,"Lakeshed W",1,1,1.86,.227,.11,0
1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",96.17,.03
1,"TOTAL N",0,0
1,"ORTHO P",39.74,.04
1,"INORGANIC N",0,0
1,"LandUses",0,0,0,0,0,0,0,0
2,"Reach 70",1,1,89.84,31.847,.12,0
2,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",239.92,.06
2,"TOTAL N",0,0
2,"ORTHO P",123.85,.08
2,"INORGANIC N",0,0
2,"LandUses",0,0,0,0,0,0,0,0
3,"MS4 from 70",1,1,.1,.0557,0,0
3,"CONSERVATIVE SUBST.",0,0
3,"TOTAL P",75.509,0
3,"TOTAL N",0,0
3,"ORTHO P",0,0
3,"INORGANIC N",0,0
3,"LandUses",0,0,0,0,0,0,0,0
4,"Reach 73",1,1,5.12,.0343,.14,0
4,"CONSERVATIVE SUBST.",0,0
4,"TOTAL P",97.38,.13
4,"TOTAL N",0,0
4,"ORTHO P",28.36,.23
4,"INORGANIC N",0,0
4,"LandUses",0,0,0,0,0,0,0,0
5,"MS4 W",1,1,1.25,.531,.5,0
5,"CONSERVATIVE SUBST.",0,0
5,"TOTAL P",85.68,.5
5,"TOTAL N",0,0
5,"ORTHO P",36.3,.5
5,"INORGANIC N",0,0
5,"LandUses",0,0,0,0,0,0,0,0
6,"SSTS W",1,1,.01,.0008,.5,0
6,"CONSERVATIVE SUBST.",0,0
6,"TOTAL P",10000,.5
6,"TOTAL N",0,0
6,"ORTHO P",10000,.5
6,"INORGANIC N",0,0
6,"LandUses",0,0,0,0,0,0,0,0
7,"Outlet",1,4,248.49,34.43,.13,0
7,"CONSERVATIVE SUBST.",0,0
7,"TOTAL P",182.47,.08
7,"TOTAL N",0,0
7,"ORTHO P",68.5,.15
7,"INORGANIC N",0,0
7,"LandUses",0,0,0,0,0,0,0,0
8,"MS4 from 73",1,1,.1,.098,0,0
8,"CONSERVATIVE SUBST.",0,0
8,"TOTAL P",104,0
8,"TOTAL N",0,0
8,"ORTHO P",0,0
8,"INORGANIC N",0,0
8,"LandUses",0,0,0,0,0,0,0,0
9,"White Lake",1,1,.1,1.66,0,0
9,"CONSERVATIVE SUBST.",0,0
9,"TOTAL P",178.77,0
9,"TOTAL N",0,0
9,"ORTHO P",0,0
9,"INORGANIC N",0,0
9,"LandUses",0,0,0,0,0,0,0,0
0,"Channels"
8,"Land Use Export Categories"
1,"landuse1"
1,"Runoff",0,0
1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",0,0
1,"TOTAL N",0,0
1,"ORTHO P",0,0
1,"INORGANIC N",0,0
2,"landuse2"
2,"Runoff",0,0
2,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",0,0
2,"TOTAL N",0,0
2,"ORTHO P",0,0
2,"INORGANIC N",0,0
3,"landuse3"
3,"Runoff",0,0
3,"CONSERVATIVE SUBST.",0,0
3,"TOTAL P",0,0
3,"TOTAL N",0,0
3,"ORTHO P",0,0
3,"INORGANIC N",0,0
4,"landuse4"
4,"Runoff",0,0
4,"CONSERVATIVE SUBST.",0,0
4,"TOTAL P",0,0
4,"TOTAL N",0,0
4,"ORTHO P",0,0
4,"INORGANIC N",0,0
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5,""
5,"Runoff",0,0
5,"CONSERVATIVE SUBST.",0,0
5,"TOTAL P",0,0
5,"TOTAL N",0,0
5,"ORTHO P",0,0
5,"INORGANIC N",0,0
6,""
6,"Runoff",0,0
6,"CONSERVATIVE SUBST.",0,0
6,"TOTAL P",0,0
6,"TOTAL N",0,0
6,"ORTHO P",0,0
6,"INORGANIC N",0,0
7,""
7,"Runoff",0,0
7,"CONSERVATIVE SUBST.",0,0
7,"TOTAL P",0,0
7,"TOTAL N",0,0
7,"ORTHO P",0,0
7,"INORGANIC N",0,0
8,""
8,"Runoff",0,0
8,"CONSERVATIVE SUBST.",0,0
8,"TOTAL P",0,0
8,"TOTAL N",0,0
8,"ORTHO P",0,0
8,"INORGANIC N",0,0
"Notes"
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End of BATHTUB file – do not include this line in the .btb file. The "Notes" line near the end of the .btb file should be Line 181, and 11 empty lines should follow Line 181 (182–192) at the end of the file. Tests showed that removing these lines from the .btb file resulted in an "Input File Error" from BATHTUB.

Fountain West Proposed

```
Vers 6.14f (04/28/2015)
Fountain Lake Existing Conditions
4,"Global Parmameters"
1,"AVERAGING PERIOD (YRS)",1,0
2,"PRECIPITATION (METERS)",.95,.06
3,"EVAPORATION (METERS)",.7,.5
4,"INCREASE IN STORAGE (METERS)",0,.5
12,"Model Options"
1,"CONSERVATIVE SUBSTANCE",0
2,"PHOSPHORUS BALANCE",7
3,"NITROGEN BALANCE",0
4,"CHLOROPHYLL-A",2
5,"SECCHI DEPTH",1
6,"DISPERSION",1
7,"PHOSPHORUS CALIBRATION",2
8,"NITROGEN CALIBRATION",2
9,"ERROR ANALYSIS",1
10,"AVAILABILITY FACTORS",0
11,"MASS-BALANCE TABLES",1
12,"OUTPUT DESTINATION",2
17,"Model Coefficients"
1,"DISPERSION RATE",1,.7
2,"P DECAY RATE",1,.45
3,"N DECAY RATE",1,.55
4,"CHL-A MODEL",1,.26
5,"SECCHI MODEL",1,.1
6,"ORGANIC N MODEL",1,.12
7,"TP-OP MODEL",1,.15
8,"HODV MODEL",1,.15
9,"MODV MODEL",1,.22
10,"BETA M2/MG",.025,0
11,"MINIMUM QS",.1,0
12,"FLUSHING EFFECT",1,0
13,"CHLOROPHYLL-A CV",.62,0
14,"Avail Factor - TP",.33,0
15,"Avail Factor - Ortho P",1.93,0
16,"Avail Factor - TN",.59,0
17,"Avail Factor - Inorganic N",.79,0
5,"Atmospheric Loads"
1,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",46.9,.5
3,"TOTAL N",1000,.5
4,"ORTHO P",23.45,.5
5,"INORGANIC N",500,.5
1,"Segments"
1,"FL West Bay",0,1,.58,1.42,1.53,1.4,.12,0,.5,.39,.33,0,0
1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",0,0
1,"TOTAL N",0,0
1,"CONSERVATIVE SUB",0,0,1,0
1,"TOTAL P MG/M3",272.03,.1,1,0
1,"TOTAL N MG/M3",0,0,1,0
1,"CHL-A MG/M3",39.26,.1,.7104861,0
1,"SECCHI M",.73,.06,1,0
1,"ORGANIC N MG/M3",0,0,1,0
1,"TP-ORTHO-P MG/M3",0,0,1,0
1,"HOD-V MG/M3-DAY",0,0,1,0
1,"MOD-V MG/M3-DAY",0,0,1,0
9,"Tributaries"
1,"Lakeshed W",1,1,1.86,.227,.11,0
1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",90,.03
1,"TOTAL N",0,0
1,"ORTHO P",39.74,.04
1,"INORGANIC N",0,0
1,"LandUses",0,0,0,0,0,0,0,0,0
2,"Reach 70",1,1,89.84,31.847,.12,0
2,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",80.598,.06
2,"TOTAL N",0,0
2,"ORTHO P",123.85,.08
2,"INORGANIC N",0,0
2,"LandUses",0,0,0,0,0,0,0,0,0
3,"MS4 from 70",1,1,.1,.0557,0,0
3,"CONSERVATIVE SUBST.",0,0
3,"TOTAL P",70,0
3,"TOTAL N",0,0
3,"ORTHO P",0,0
3,"INORGANIC N",0,0
3,"LandUses",0,0,0,0,0,0,0,0,0
4,"Reach 73",1,1,5.12,.0343,.14,0
4,"CONSERVATIVE SUBST.",0,0
4,"TOTAL P",90,.13
4,"TOTAL N",0,0
4,"ORTHO P",28.36,.23
4,"INORGANIC N",0,0
4,"LandUses",0,0,0,0,0,0,0,0,0
5,"MS4 W",1,1,1.25,.531,.5,0
5,"CONSERVATIVE SUBST.",0,0
5,"TOTAL P",75,.5
5,"TOTAL N",0,0
5,"ORTHO P",36.3,.5
5,"INORGANIC N",0,0
5,"LandUses",0,0,0,0,0,0,0,0,0
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6,"SSTS W",1,1,.01,.0008,.5,0
6,"CONSERVATIVE SUBST.",0,0
6,"TOTAL P",.1,.5
6,"TOTAL N",0,0
6,"ORTHO P",.1,.5
6,"INORGANIC N",0,0
6,"LandUses",0,0,0,0,0,0,0,0
7,"Outlet",1,4,248.49,34.43,.13,0
7,"CONSERVATIVE SUBST.",0,0
7,"TOTAL P",182.47,.08
7,"TOTAL N",0,0
7,"ORTHO P",68.5,.15
7,"INORGANIC N",0,0
7,"LandUses",0,0,0,0,0,0,0,0
8,"MS4 from 73",1,1,.1,.098,0,0
8,"CONSERVATIVE SUBST.",0,0
8,"TOTAL P",75,0
8,"TOTAL N",0,0
8,"ORTHO P",0,0
8,"INORGANIC N",0,0
8,"LandUses",0,0,0,0,0,0,0,0
9,"White Lake",1,1,.1,1.66,0,0
9,"CONSERVATIVE SUBST.",0,0
9,"TOTAL P",90,0
9,"TOTAL N",0,0
9,"ORTHO P",0,0
9,"INORGANIC N",0,0
9,"LandUses",0,0,0,0,0,0,0,0
0,"Channels"
8,"Land Use Export Categories"
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1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",0,0
1,"TOTAL N",0,0
1,"ORTHO P",0,0
1,"INORGANIC N",0,0
2,"landuse2"
2,"Runoff",0,0
2,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",0,0
2,"TOTAL N",0,0
2,"ORTHO P",0,0
2,"INORGANIC N",0,0
3,"landuse3"
3,"Runoff",0,0
3,"CONSERVATIVE SUBST.",0,0
3,"TOTAL P",0,0
3,"TOTAL N",0,0
3,"ORTHO P",0,0
3,"INORGANIC N",0,0
4,"landuse4"
4,"Runoff",0,0
4,"CONSERVATIVE SUBST.",0,0
4,"TOTAL P",0,0
4,"TOTAL N",0,0
4,"ORTHO P",0,0
4,"INORGANIC N",0,0
5,""
5,"Runoff",0,0
5,"CONSERVATIVE SUBST.",0,0
5,"TOTAL P",0,0
5,"TOTAL N",0,0
5,"ORTHO P",0,0
5,"INORGANIC N",0,0
6,""
6,"Runoff",0,0
6,"CONSERVATIVE SUBST.",0,0
6,"TOTAL P",0,0
6,"TOTAL N",0,0
6,"ORTHO P",0,0
6,"INORGANIC N",0,0
7,""
7,"Runoff",0,0
7,"CONSERVATIVE SUBST.",0,0
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7,"TOTAL N",0,0
7,"ORTHO P",0,0
7,"INORGANIC N",0,0
8,""
8,"Runoff",0,0
8,"CONSERVATIVE SUBST.",0,0
8,"TOTAL P",0,0
8,"TOTAL N",0,0
8,"ORTHO P",0,0
8,"INORGANIC N",0,0
"Notes"
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End of BATHTUB file – do not include this line in the .btb file. The “Notes” line near the end of the .btb file should be Line 181, and 11 empty lines should follow Line 181 (182–192) at the end of the file. Tests showed that removing these lines from the .btb file resulted in an “Input File Error” from BATHTUB.

Fountain East Existing

```
Vers 6.14f (04/28/2015)
Fountain Lake Existing Conditions
4,"Global Parmameters"
1,"AVERAGING PERIOD (YRS)",1,0
2,"PRECIPITATION (METERS)",.95,.06
3,"EVAPORATION (METERS)",.7,.5
4,"INCREASE IN STORAGE (METERS)",0,.5
12,"Model Options"
1,"CONSERVATIVE SUBSTANCE",0
2,"PHOSPHORUS BALANCE",7
3,"NITROGEN BALANCE",0
4,"CHLOROPHYLL-A",4
5,"SECCHI DEPTH",1
6,"DISPERSION",1
7,"PHOSPHORUS CALIBRATION",2
8,"NITROGEN CALIBRATION",2
9,"ERROR ANALYSIS",1
10,"AVAILABILITY FACTORS",0
11,"MASS-BALANCE TABLES",1
12,"OUTPUT DESTINATION",2
17,"Model Coefficients"
1,"DISPERSION RATE",1,.7
2,"P DECAY RATE",1,.45
3,"N DECAY RATE",1,.55
4,"CHL-A MODEL",1,.26
5,"SECCHI MODEL",1,.1
6,"ORGANIC N MODEL",1,.12
7,"TP-OP MODEL",1,.15
8,"HODV MODEL",1,.15
9,"MODV MODEL",1,.22
10,"BETA M2/MG",.025,0
11,"MINIMUM QS",.1,0
12,"FLUSHING EFFECT",1,0
13,"CHLOROPHYLL-A CV",.62,0
14,"Avail Factor - TP",.33,0
15,"Avail Factor - Ortho P",1.93,0
```

```
16,"Avail Factor - TN",.59,0
17,"Avail Factor - Inorganic N",.79,0
5,"Atmospheric Loads"
1,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",46.9,.5
3,"TOTAL N",1000,.5
4,"ORTHO P",23.45,.5
5,"INORGANIC N",500,.5
1,"Segments"
1,"FL East Bay",0,1,1.01,1.55,1.67,1.55,.12,0,.5,.08,1.73,0,0
1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",10.488,0
1,"TOTAL N",0,0
1,"CONSERVATIVE SUB",0,0,1,0
1,"TOTAL P MG/M3",259.72,.09,1,0
1,"TOTAL N MG/M3",0,0,1,0
1,"CHL-A MG/M3",63.27,.08,.8700187,0
1,"SECCHI M",.71,.04,1.179843,0
1,"ORGANIC N MG/M3",0,0,1,0
1,"TP-ORTHO-P MG/M3",0,0,1,0
1,"HOD-V MG/M3-DAY",0,0,1,0
1,"MOD-V MG/M3-DAY",0,0,1,0
8,"Tributaries"
1,"Reach 80 (FLW)",1,1,96.82,34.599,.13,0
1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",272.0061,.08
1,"TOTAL N",0,0
1,"ORTHO P",68.5,.15
1,"INORGANIC N",0,0
1,"LandUses",0,0,0,0,0,0,0,0
2,"Reach 87",1,1,39.49,15.20468,.13,0
2,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",146.1075,.06
2,"TOTAL N",0,0
2,"ORTHO P",75.15,.11
2,"INORGANIC N",0,0
2,"LandUses",0,0,0,0,0,0,0,0
3,"Reach 102",1,1,111.79,35.72888,.12,0
3,"CONSERVATIVE SUBST.",0,0
3,"TOTAL P",225.3271,.07
3,"TOTAL N",0,0
3,"ORTHO P",88.04,.12
3,"INORGANIC N",0,0
3,"LandUses",0,0,0,0,0,0,0,0
4,"MS4 E",1,1,2.85,1.273,.5,0
4,"CONSERVATIVE SUBST.",0,0
4,"TOTAL P",76.697,.5
4,"TOTAL N",0,0
4,"ORTHO P",35.7,.5
4,"INORGANIC N",0,0
4,"LandUses",0,0,0,0,0,0,0,0
5,"Outlet",1,4,248.1,91.77,.12,0
5,"CONSERVATIVE SUBST.",0,0
5,"TOTAL P",162.35,.08
5,"TOTAL N",0,0
5,"ORTHO P",48.99,.16
5,"INORGANIC N",0,0
5,"LandUses",0,0,0,0,0,0,0,0
6,"Albert Lea WTP SD 002",1,1,.01,.0225786,0,0
6,"CONSERVATIVE SUBST.",0,0
6,"TOTAL P",139.9525,0
6,"TOTAL N",0,0
6,"ORTHO P",0,0
6,"INORGANIC N",0,0
6,"LandUses",0,0,0,0,0,0,0,0
7,"Clarks Grove WWTP",1,1,.01,.1519332,0,0
7,"CONSERVATIVE SUBST.",0,0
7,"TOTAL P",848.0569,0
7,"TOTAL N",0,0
7,"ORTHO P",0,0
7,"INORGANIC N",0,0
7,"LandUses",0,0,0,0,0,0,0,0
8,"MS4 from 102",1,1,.1,5.657536,0,0
8,"CONSERVATIVE SUBST.",0,0
8,"TOTAL P",98.93732,0
8,"TOTAL N",0,0
8,"ORTHO P",0,0
8,"INORGANIC N",0,0
8,"LandUses",0,0,0,0,0,0,0,0
0,"Channels"
8,"Land Use Export Categories"
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1,"Runoff",0,0
1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",0,0
1,"TOTAL N",0,0
1,"ORTHO P",0,0
1,"INORGANIC N",0,0
2,"landuse2"
2,"Runoff",0,0
2,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",0,0
2,"TOTAL N",0,0
2,"ORTHO P",0,0
2,"INORGANIC N",0,0
3,"landuse3"
3,"Runoff",0,0
3,"CONSERVATIVE SUBST.",0,0
3,"TOTAL P",0,0
3,"TOTAL N",0,0
3,"ORTHO P",0,0
3,"INORGANIC N",0,0
4,"landuse4"
4,"Runoff",0,0
4,"CONSERVATIVE SUBST.",0,0
4,"TOTAL P",0,0
4,"TOTAL N",0,0
4,"ORTHO P",0,0
4,"INORGANIC N",0,0
5,""
5,"Runoff",0,0
5,"CONSERVATIVE SUBST.",0,0
5,"TOTAL P",0,0
5,"TOTAL N",0,0
5,"ORTHO P",0,0
5,"INORGANIC N",0,0
6,""
6,"Runoff",0,0
6,"CONSERVATIVE SUBST.",0,0
6,"TOTAL P",0,0
6,"TOTAL N",0,0
6,"ORTHO P",0,0
6,"INORGANIC N",0,0
7,""
7,"Runoff",0,0
7,"CONSERVATIVE SUBST.",0,0
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7,"TOTAL N",0,0
7,"ORTHO P",0,0
7,"INORGANIC N",0,0
8,""
8,"Runoff",0,0
8,"CONSERVATIVE SUBST.",0,0
8,"TOTAL P",0,0
8,"TOTAL N",0,0
8,"ORTHO P",0,0
8,"INORGANIC N",0,0
"Notes"
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End of BATHTUB file – do not include this line in the .btb file. The “Notes” line near the end of the .btb file should be Line 174, and 11 empty lines should follow Line 174 (175–185) at the end of the file. Tests showed that removing these lines from the .btb file resulted in an “Input File Error” from BATHTUB

Fountain East Proposed

```
Vers 6.14f (04/28/2015)
Fountain Lake Existing Conditions
4,"Global Parmameters"
1,"AVERAGING PERIOD (YRS)",1,0
2,"PRECIPITATION (METERS)",.95,.06
3,"EVAPORATION (METERS)",.7,.5
4,"INCREASE IN STORAGE (METERS)",0,.5
12,"Model Options"
1,"CONSERVATIVE SUBSTANCE",0
2,"PHOSPHORUS BALANCE",7
3,"NITROGEN BALANCE",0
4,"CHLOROPHYLL-A",4
5,"SECCHI DEPTH",1
6,"DISPERSION",1
7,"PHOSPHORUS CALIBRATION",2
8,"NITROGEN CALIBRATION",2
9,"ERROR ANALYSIS",1
10,"AVAILABILITY FACTORS",0
11,"MASS-BALANCE TABLES",1
12,"OUTPUT DESTINATION",2
17,"Model Coefficients"
1,"DISPERSION RATE",1,.7
2,"P DECAY RATE",1,.45
3,"N DECAY RATE",1,.55
4,"CHL-A MODEL",1,.26
5,"SECCHI MODEL",1,.1
6,"ORGANIC N MODEL",1,.12
7,"TP-OP MODEL",1,.15
8,"HODV MODEL",1,.15
9,"MODV MODEL",1,.22
10,"BETA M2/MG",.025,0
11,"MINIMUM QS",.1,0
12,"FLUSHING EFFECT",1,0
13,"CHLOROPHYLL-A CV",.62,0
14,"Avail Factor - TP",.33,0
15,"Avail Factor - Ortho P",1.93,0
16,"Avail Factor - TN",.59,0
17,"Avail Factor - Inorganic N",.79,0
5,"Atmospheric Loads"
1,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",46.9,.5
3,"TOTAL N",1000,.5
4,"ORTHO P",23.45,.5
5,"INORGANIC N",500,.5
1,"Segments"
1,"FL East Bay",0,1,1.01,1.55,1.67,1.55,.12,0,.5,.08,1.73,0,0
1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",0,0
1,"TOTAL N",0,0
1,"CONSERVATIVE SUB",0,0,1,0
1,"TOTAL P MG/M3",259.72,.09,1,0
1,"TOTAL N MG/M3",0,0,1,0
1,"CHL-A MG/M3",63.27,.08,.8700187,0
1,"SECCHI M",.71,.04,1.179843,0
1,"ORGANIC N MG/M3",0,0,1,0
1,"TP-ORTHO-P MG/M3",0,0,1,0
1,"HOD-V MG/M3-DAY",0,0,1,0
1,"MOD-V MG/M3-DAY",0,0,1,0
8,"Tributaries"
1,"Reach 80 (FLW)",1,1,96.82,34.599,.13,0
1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",90,.08
1,"TOTAL N",0,0
1,"ORTHO P",68.5,.15
1,"INORGANIC N",0,0
1,"LandUses",0,0,0,0,0,0,0,0,0
2,"Reach 87",1,1,39.49,15.20468,.13,0
2,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",146.1075,.06
2,"TOTAL N",0,0
2,"ORTHO P",75.15,.11
2,"INORGANIC N",0,0
2,"LandUses",0,0,0,0,0,0,0,0,0
3,"Reach 102",1,1,111.79,35.72888,.12,0
3,"CONSERVATIVE SUBST.",0,0
3,"TOTAL P",40.535,.07
3,"TOTAL N",0,0
3,"ORTHO P",88.04,.12
3,"INORGANIC N",0,0
3,"LandUses",0,0,0,0,0,0,0,0,0
4,"MS4 E",1,1,2.85,1.273,.5,0
4,"CONSERVATIVE SUBST.",0,0
4,"TOTAL P",50,.5
4,"TOTAL N",0,0
4,"ORTHO P",35.7,.5
4,"INORGANIC N",0,0
4,"LandUses",0,0,0,0,0,0,0,0,0
5,"Outlet",1,4,248.1,91.77,.12,0
5,"CONSERVATIVE SUBST.",0,0
5,"TOTAL P",162.35,.08
5,"TOTAL N",0,0
5,"ORTHO P",48.99,.16
5,"INORGANIC N",0,0
5,"LandUses",0,0,0,0,0,0,0,0,0
6,"Albert Lea WTP SD 002",1,1,.01,.05528,0,0
6,"CONSERVATIVE SUBST.",0,0
6,"TOTAL P",500,0
6,"TOTAL N",0,0
6,"ORTHO P",0,0
6,"INORGANIC N",0,0
6,"LandUses",0,0,0,0,0,0,0,0,0
7,"Clarks Grove WWTP",1,1,.01,.160312,0,0
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7,"TOTAL P",2000,0
7,"TOTAL N",0,0
7,"ORTHO P",0,0
7,"INORGANIC N",0,0
7,"LandUses",0,0,0,0,0,0,0,0,0
8,"MS4 from 102",1,1,.1,5.657536,0,0
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8,"TOTAL N",0,0
8,"ORTHO P",0,0
8,"INORGANIC N",0,0
8,"LandUses",0,0,0,0,0,0,0,0,0
0,"Channels"
8,"Land Use Export Categories"
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1,"Runoff",0,0
1,"CONSERVATIVE SUBST.",0,0
1,"TOTAL P",0,0
1,"TOTAL N",0,0
1,"ORTHO P",0,0
1,"INORGANIC N",0,0
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2,"TOTAL N",0,0
2,"ORTHO P",0,0
2,"INORGANIC N",0,0
3,"landuse3"
3,"Runoff",0,0
3,"CONSERVATIVE SUBST.",0,0
3,"TOTAL P",0,0
3,"TOTAL N",0,0
3,"ORTHO P",0,0
3,"INORGANIC N",0,0
4,"landuse4"
4,"Runoff",0,0
4,"CONSERVATIVE SUBST.",0,0
4,"TOTAL P",0,0
4,"TOTAL N",0,0
4,"ORTHO P",0,0
4,"INORGANIC N",0,0
5,""
5,"Runoff",0,0
5,"CONSERVATIVE SUBST.",0,0
5,"TOTAL P",0,0
5,"TOTAL N",0,0
5,"ORTHO P",0,0
5,"INORGANIC N",0,0
6,""
6,"Runoff",0,0
6,"CONSERVATIVE SUBST.",0,0
6,"TOTAL P",0,0
6,"TOTAL N",0,0
6,"ORTHO P",0,0
6,"INORGANIC N",0,0
7,""
7,"Runoff",0,0
7,"CONSERVATIVE SUBST.",0,0
7,"TOTAL P",0,0
7,"TOTAL N",0,0
7,"ORTHO P",0,0
7,"INORGANIC N",0,0
8,""
8,"Runoff",0,0
8,"CONSERVATIVE SUBST.",0,0
8,"TOTAL P",0,0
8,"TOTAL N",0,0
8,"ORTHO P",0,0
8,"INORGANIC N",0,0
"Notes"
```

End of BATHTUB file – do not include this line in the .btb file. The “Notes” line near the end of the .btb file should be Line 174, and 11 empty lines should follow Line 174 (175–185) at the end of the file. Tests showed that removing these lines from the .btb file resulted in an “Input File Error” from BATHTUB.

Albert Lea Existing

```
Vers 6.14f (04/28/2015)
Albert Lea Lake
4,"Global Parmameters"
1,"AVERAGING PERIOD (YRS)",1,0
2,"PRECIPITATION (METERS)",.917412,6.513922E-02
3,"EVAPORATION (METERS)",.7,.5
4,"INCREASE IN STORAGE (METERS)",0,.5
12,"Model Options"
1,"CONSERVATIVE SUBSTANCE",0
2,"PHOSPHORUS BALANCE",7
3,"NITROGEN BALANCE",0
4,"CHLOROPHYLL-A",4
5,"SECCHI DEPTH",1
6,"DISPERSION",1
7,"PHOSPHORUS CALIBRATION",2
8,"NITROGEN CALIBRATION",2
9,"ERROR ANALYSIS",1
10,"AVAILABILITY FACTORS",0
11,"MASS-BALANCE TABLES",1
12,"OUTPUT DESTINATION",2
17,"Model Coefficients"
1,"DISPERSION RATE",1,.7
2,"P DECAY RATE",1,.45
3,"N DECAY RATE",1,.55
4,"CHL-A MODEL",1,.26
5,"SECCHI MODEL",1,.1
6,"ORGANIC N MODEL",1,.12
7,"TP-OP MODEL",1,.15
8,"HODV MODEL",1,.15
9,"MODV MODEL",1,.22
10,"BETA M2/MG",.025,0
11,"MINIMUM QS",.1,0
12,"FLUSHING EFFECT",1,0
13,"CHLOROPHYLL-A CV",.62,0
14,"Avail Factor - TP",.33,0
15,"Avail Factor - Ortho P",1.93,0
16,"Avail Factor - TN",.59,0
17,"Avail Factor - Inorganic N",.79,0
5,"Atmospheric Loads"
1,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",46.9,.5
3,"TOTAL N",1000,.5
4,"ORTHO P",23.45,.5
5,"INORGANIC N",500,.5
4,"Segments"
1,"Seg 1",2,1,3.53,.54,3.08,.5,.12,0,0,.08,4.35,0,0
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1,"TOTAL P",1,0
1,"TOTAL N",0,0
1,"CONSERVATIVE SUB",0,0,1,0
1,"TOTAL P MG/M3",225.1127,6.594668E-02,.8863004,0
1,"TOTAL N MG/M3",0,0,1,0
1,"CHL-A MG/M3",88.26842,.1479127,1.400344,0
1,"SECCHI M",.6780733,8.212404E-02,1.550539,0
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1,"TP-ORTHO-P MG/M3",0,0,1,0
1,"HOD-V MG/M3-DAY",0,0,1,0
1,"MOD-V MG/M3-DAY",0,0,1,0
2,"Seg 2",0,1,4.25,.67,2.55,.65,.12,0,0,.08,3.66,0,0
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2,"TOTAL P",0,0
2,"TOTAL N",0,0
2,"CONSERVATIVE SUB",0,0,1,0
2,"TOTAL P MG/M3",190.2895,5.201923E-02,.7489983,0
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2,"CHL-A MG/M3",71.0612,.1538687,1.333537,0
2,"SECCHI M",.7739989,8.195446E-02,1.436404,0
2,"ORGANIC N MG/M3",0,0,1,0
2,"TP-ORTHO-P MG/M3",0,0,1,0
2,"HOD-V MG/M3-DAY",0,0,1,0
2,"MOD-V MG/M3-DAY",0,0,1,0
3,"Seg 3",2,1,2.41,.34,3.33,.3,.12,0,0,.17,1.52,0,0
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3,"TOTAL P",4,0
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3,"CONSERVATIVE SUB",0,0,1,0
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3,"TOTAL N MG/M3",0,0,1,0
3,"CHL-A MG/M3",74.61069,.1003372,1.055105,0
3,"SECCHI M",.4923255,8.348484E-02,1,0
3,"ORGANIC N MG/M3",0,0,1,0
3,"TP-ORTHO-P MG/M3",0,0,1,0
3,"HOD-V MG/M3-DAY",0,0,1,0
3,"MOD-V MG/M3-DAY",0,0,1,0
4,"Seg 4",3,1,.65,.23,1.24,.2,.12,0,0,.08,.2,0,0
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4,"TOTAL P",0,0
4,"TOTAL N",0,0
4,"CONSERVATIVE SUB",0,0,1,0
4,"TOTAL P MG/M3",0,0,1,0
4,"TOTAL N MG/M3",0,0,1,0
4,"CHL-A MG/M3",0,0,1,0
4,"SECCHI M",0,0,1,0
4,"ORGANIC N MG/M3",0,0,1,0
4,"TP-ORTHO-P MG/M3",0,0,1,0
4,"HOD-V MG/M3-DAY",0,0,1,0
4,"MOD-V MG/M3-DAY",0,0,1,0
18,"Tributaries"
1,"120 1 (FLE)",1,1,252.32,92.89,.1248589,0
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1,"TOTAL P",259.735,.0841177
1,"TOTAL N",0,0
1,"ORTHO P",48.98729,.1604346
1,"INORGANIC N",0,0
1,"LandUses",0,0,0,0,0,0,0,0,0
2,"Albert Lea WTP SD001",1,1,.01,1.637601E-02,0,0
2,"CONSERVATIVE SUBST.",0,0
2,"TOTAL P",139.9285,0
2,"TOTAL N",0,0
2,"ORTHO P",0,0
2,"INORGANIC N",0,0
2,"LandUses",0,0,0,0,0,0,0,0,0
3,"Cargill Value Added Meats SD 001",1,1,.01,2.835415E-02,0,0
3,"CONSERVATIVE SUBST.",0,0
3,"TOTAL P",587.181,0
3,"TOTAL N",0,0
3,"ORTHO P",0,0
3,"INORGANIC N",0,0
3,"LandUses",0,0,0,0,0,0,0,0,0
4,"Lakeshed 1",1,1,14,1.766,.5,0
4,"CONSERVATIVE SUBST.",0,0
4,"TOTAL P",151.7,.5
4,"TOTAL N",0,0
4,"ORTHO P",0,0
4,"INORGANIC N",0,0
4,"LandUses",0,0,0,0,0,0,0,0,0
5,"MS4 1",1,1,8.86,3.878,.5,0
5,"CONSERVATIVE SUBST.",0,0
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End of BATHTUB file – do not include this line in the .btb file. The “Notes” line near the end of the .btb file should be Line 283, and 11 empty lines should follow Line 283 (284–294) at the end of the file. Tests showed that removing these lines from the .btb file resulted in an “Input File Error” from BATHTUB.

Albert Lea Proposed

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Vers 6.14f (04/28/2015)
Albert Lea Lake
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End of BATHTUB file – do not include this line in the .btb file. The “Notes” line near the end of the .btb file should be Line 283, and 11 empty lines should follow Line 283 (284–294) at the end of the file. Tests showed that removing these lines from the .btb file resulted in an “Input File Error” from BATHTUB.

Summary of Input Concentrations and Flows for BATHTUB Models

Table F-2. Pickeral Lake BATHTUB inputs.

PRELIMINARY DRAFT Pickeral Lake Source Flows and Concentrations		Existing Conditions		Proposed	
		hm^3/yr	µg/L	hm^3/yr	µg/L
Wasteload	*MS4 from Lakeshed*	*0.64*	*92.46*	0.64	*80.0*
Load	*Lakeshed*	*3.66*	199.73	3.66	93.04
	Reach 191 (Unnamed)	*2.22*	223.89	2.22	150.0
	Internal Loading	–	–	–	–
	SSTS	*0.0010*	10000	0.0010	0
	Atmospheric deposition	*2.19*	–	2.19	–

Table F-3. White Lake BATHTUB inputs.

PRELIMINARY DRAFT White Lake Source Flows and Concentrations		Existing Conditions		Proposed	
		hm^3/yr	µg/L	hm^3/yr	µg/L
Wasteload	*MS4 from Lakeshed*	*0.27*	*89.63*	0.27	*75.00*
Load	*Lakeshed*	*1.23*	147.01	1.23	90.19
	Internal Loading	–	–	–	–
	SSTS	*0.0005*	10000	0.0005	0
	Atmospheric deposition	*0.63*	–	0.63	–

Table F-4. Fountain Lake (West Bay) BATHTUB inputs.

PRELIMINARY DRAFT Fountain Lake East Bay Source Flows and Concentrations		Existing Conditions		Proposed	
		hm^3/yr	µg/L	hm^3/yr	µg/L
Wasteload	*Albert Lea WTP SD 002*	*0.02*	*139.95*	0.06	*500*
	Clarks Grove WWTP	*0.15*	*848.06*	0.16	*2000*
	MS4 from Lakeshed	*1.27*	*76.7*	1.27	*50*
	MS4 from Trib 87	*0.42*	*91.63*	0.42	*91.63*
	MS4 from Trib 102	*5.66*	*98.94*	5.66	*50*
Load	*Tributary 80 (Fountain Lake West Bay) BC*	*34.6*	272.01	34.6	79.2
	Tributary 87 (Shoff Creek -516) BC	*14.8*	147.61	14.8	79.2
	Tributary 102 (Bancroft Creek)	*35.7*	225.33	35.7	79.2
	Internal Loading	–	–	–	–
	Atmospheric deposition	*0.96*	–	0.96	–

Table F-5. Fountain Lake (East Bay) BATHTUB inputs.

PRELIMINARY DRAFT Fountain Lake East Bay Source Flows and Concentrations		**Existing Conditions**		**Proposed**	
		hm^3/yr	**µg/L**	**hm^3/yr**	**µg/L**
Wasteload	*Albert Lea WTP SD 002*	*0.02*	*139.95*	0.06	*500*
	Clarks Grove WWTP	*0.15*	*848.06*	0.16	*2000*
	MS4 from Lakeshed	*1.27*	*76.70*	1.27	*50*
	MS4 from Trib 102	*5.66*	*98.94*	5.66	*50*
Load	*Tributary 80 (Fountain Lake West Bay) BC*	*34.60*	272.01	34.60	90.00
	Tributary 87 (Shoff Creek -516) BC	*15.20*	146.11	15.20	146.11
	Tributary 102 (Bancroft Creek)	*35.73*	225.33	35.73	40.53
	Internal Loading	–	–	–	–
	Atmospheric deposition	*0.96*	–	0.96	–

Table F-6. Albert Lea Lake BATHTUB inputs.

PRELIMINARY DRAFT Albert Lea Lake Source Flows and Concentrations		**Existing Conditions**		**Proposed**	
		hm^3/yr	**µg/L**	**hm^3/yr**	**µg/L**
Wasteload	*Albert Lea WTP SD001*	*0.02*	*139.93*	0.06	*500.0*
	Cargill Value Added Meats SD 001	*0.03*	*587.18*	0.08	*500.0*
	DNR Myre Big Island State Park SD 001	*0.01*	*223.65*	0.01	*1000.0*
	Hayward WWTP	*0.04*	*564.17*	0.36	*171.89*
	MS4 from Lakeshed	*4.36*	*85.09*	4.36	*80.000*
Load	*Tributary 120 (Fountain Lake) BC*	*92.89*	259.73	92.89	90.00
	Tributary 147 (Peter Lund Creek -512)	*26.19*	225.21	25.87	120.38
	Tributary 131 (CD 16 -513)	*3.93*	196.87	3.93	150.00
	Lakeshed	*7.34*	142.79	7.34	90.00
	Internal Loading	–	–	–	–
	SSTS	*0.0010*	10000	0.0010	0
	Atmospheric deposition	*9.94*	–	9.94	–