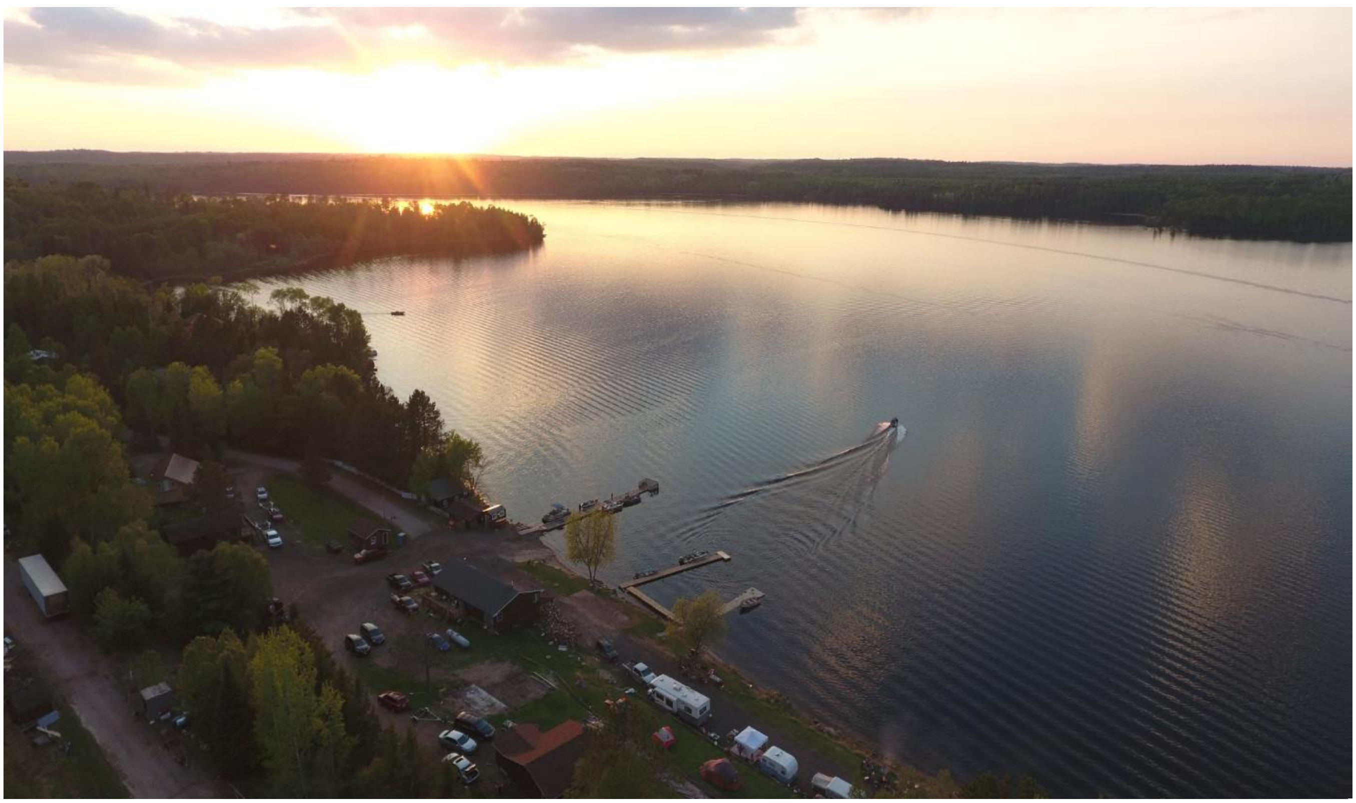
Watershed

January 2022

Vermilion River Watershed Total Maximum Daily Load Report

Myrtle Lake Total Maximum Daily Load



MINNESOTA POLLUTION CONTROL AGENCY

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Cover photo credit: Drone photo of Myrtle Lake at sunset showing boaters launching from the resort access (Brian Hacker)

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Abbreviations

1W1P	One Watershed, One Plan
AUID	assessment unit identification
BMP	best management practice
BWSR	Board of Water and Soil Resources
Chl-*a*	chlorophyll-*a*
CLMP	Citizen Lake Monitoring Program
CRP	Conservation Reserve Program
CREP	Conservation Reserve Enhancement Program
CSMP	Citizen Stream Monitoring Program
DNR	Minnesota Department of Natural Resources
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
HSPF	Hydrologic Simulation Program–Fortran
HUC	Hydrologic Unit Code
IBI	index of biotic integrity
ITPHS	imminent threat to public health and safety
IWM	intensive watershed monitoring
LA	load allocation
lb	pound
m	meter
MOS	margin of safety
MPCA	Minnesota Pollution Control Agency
MS4	municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PWP	Permanent Wetland Preserve
RIM	Reinvest in Minnesota
SDS	state disposal system
SID	stressor identification

SSTS	subsurface sewage treatment systems
SWCD	soil and water conservation district
TMDL	total maximum daily load
TP	total phosphorus
USFS	United States Forest Service
WLA	wasteload allocation
WPLMN	Watershed Pollutant Load Monitoring Network
WRAPS	Watershed Restoration and Protection Strategy
WRP	Wetland Reserve Program
µg/L	micrograms per liter

Executive summary

Section 303(d) of the federal Clean Water Act requires that total maximum daily loads (TMDLs) be developed for waters that do not support their designated uses. A TMDL study determines what is needed to attain and maintain water quality standards in waters that are not currently meeting them. A TMDL study identifies pollutant sources as specifically as possible and allocates pollutant loads among those sources. This TMDL study addresses the Myrtle Lake Watershed in the Vermilion River Watershed, located in St. Louis County, Minnesota. The cause of impairment is high levels of phosphorus resulting in excessive production of algae, as measured by chlorophyll-*a* (Chl-*a*). Elevated phosphorus affects the aquatic recreation designated use by fueling nuisance algae blooms.

Myrtle Lake is an 876-acre shallow lake in a forested watershed with moderate development along its south shore. In 2017, Myrtle Lake was assessed as not supporting its aquatic recreation designated use. Further investigation indicated increased inputs of sediment and phosphorus to the lake over the last 100 years and increased algal growth. However, historic mean TP concentrations inferred from fossil diatom analysis have not changed notably over time and fall within the current water quality standard. The primary phosphorus loads to Myrtle Lake are internal loading and watershed runoff. The estimate of internal loading potentially includes other sources (such as watershed loads, septic system loads, or altered trophic interactions) that were not quantified with the available data. The majority of the phosphorus sources to the lake are nonpermitted.

The phosphorus loading capacity was determined using the lake response model BATHTUB, an eutrophication model developed by the U.S. Army Corps of Engineers. Watershed runoff volumes and loads were derived from a Hydrologic Simulation Program–Fortran (HSPF) model of the watershed. The models were calibrated to monitored water quality data. A 10% explicit margin of safety (MOS) accounts for uncertainty. An estimated 29% reduction of total phosphorus (TP) is needed to meet water quality standards.

Reasonable assurance that pollutant targets will be achieved is provided through permit compliance, nonpermitted source reduction programs, statewide initiatives, and local planning and implementation efforts. Implementation strategies are recommended to address the high priority sources and to help achieve the Myrtle Lake TMDL. Implementation strategies include shoreline management, watershed runoff control, septic systems improvements, in-lake management, and education and outreach. Implementation will follow an adaptive management approach, with continued monitoring and adjustment of the implementation approach. Management activities will be changed or refined to meet the TMDL and lay the groundwork for de-listing the Myrtle Lake impairment.

Public participation included meetings with watershed stakeholders and regional water resource professionals. Public meetings were held to raise awareness of the impairment and encourage participation in water quality restoration and protection while meetings with resource professionals provided guidance for watershed restoration and protection strategy (WRAPS) and TMDL development.

This TMDL report is supported by previous work, including the *Vermilion River Watershed Monitoring and Assessment Report* (MPCA 2017), the *Vermilion River Stressor Identification (SID) Report* (MPCA 2019), *A Paleolimnological Study of Myrtle Lake, St. Louis Co., Minnesota* (Edlund et al. 2019), and various watershed modeling memos (RESPEC 2014, 2015a, 2015b, 2016; MPCA 2020a).

1. Project overview

1.1 Purpose

Section 303(d) of the federal Clean Water Act requires that TMDLs be developed for waters that do not support their designated uses. These waters are referred to as impaired and are listed in Minnesota's list of impaired water bodies. A TMDL study determines what pollutant reductions are needed to attain and maintain water quality standards in waters that are not currently meeting them. A TMDL study identifies pollutant sources as specifically as possible and allocates pollutant loads among those sources. The total of all allocations, including wasteload allocations (WLAs) for permitted sources, load allocations (LAs) for nonpermitted sources (including natural background), and the MOS, which is implicitly or explicitly defined, cannot exceed the maximum allowable pollutant load.

This TMDL study addresses the Myrtle Lake Watershed in the Vermilion River Watershed (U.S. Geological Survey Hydrologic Unit Code (HUC)-8 09030002; Figure 1), located in St. Louis County, Minnesota. This TMDL report is a component of a larger effort to develop WRAPS for the Vermilion River Watershed. Other components of the larger effort include the *Vermilion River Watershed Monitoring and Assessment Report* (MPCA 2018), *the Vermilion SID Report* (MPCA 2019), the Lake of the Woods Watershed hydrology and water quality model (RESPEC 2016, MPCA 2020a), the *Vermilion River WRAPS* (MPCA 2021), and *A Paleolimnological Study of Myrtle Lake, St. Louis Co., Minnesota* (Edlund et al. 2019).

1.2 Identification of water bodies

There are two lakes and one stream reach with an aquatic life or aquatic recreation impairment in the Vermilion River Watershed (Table 1). This TMDL report addresses the Myrtle Lake aquatic recreation impairment, which is due to nutrient/eutrophication biological indicators. Other impairments in the Vermilion River Watershed are listed in Table 1 (aquatic life and aquatic recreation impairments), Table 2 (aquatic consumption impairments), and Table 3 (sulfate impairments) and include the following:

- Echo Lake (69-0615-00): Based on detailed monitoring and watershed analysis, it was determined that the aquatic recreation impairment is due to natural conditions, and a TMDL does not need to be developed. Echo Lake is part of the long-term Sentinel Lakes Monitoring Program, a partnership by the Minnesota Department of Natural Resources (DNR) and the Minnesota Pollution Control Agency (MPCA) to improve understanding of how environmental change can affect lake chemistry and biology. The data collected for this program provided a robust dataset for assessment and natural background review (MPCA and DNR 2012). With a mean depth of 6 feet and area of 1,139 acres, the lake is small compared to its relatively large 30,929 acre watershed. Less than 1% of the watershed is developed, and wetlands dominate the watershed and contribute nutrients that support Echo Lake's high productivity (MPCA 2018).
- Unnamed creek, headwaters to Sand River (09030002-645), also known as Tributary to Sand River: This impairment was reviewed by the MPCA Assessment Consistency and Technical Team's Natural Background Review Committee. The committee concluded the aquatic life impairment based on fish bioassessments is due to natural conditions (MPCA 2019), and a TMDL does not

need to be developed. Wetland conditions and significant beaver impoundments dominate the contributing watershed, reducing dissolved oxygen (DO) and limiting the fish community.

- There are 36 water bodies with aquatic consumption impairments based on mercury in fish tissue (Table 2). Of these impairments, 20 mercury TMDLs were approved as part of the 2018 Mercury TMDL Appendix A. Revisions to Appendix A of the *Minnesota Statewide Mercury TMDL* (MPCA 2007) are submitted to the U.S. Environmental Protection Agency (EPA) every two years with the impaired waters list. Water resources with mercury concentrations greater than 0.572 mg/kg are not part of Appendix A, and TMDLs for these 16 water bodies are expected to be completed between 2025 and 2033.In 2021 the EPA added several waters to Minnesota's 2020 Impaired Waters List as impaired for sulfate, including 6 water bodies in the Vermilion River Watershed (Table 3). These water bodies exceed the sulfate standard of 10 mg/L applicable to waters used for production of wild rice (Minn. R. 7050.0224). Wild rice growth is negatively affected by excess sulfate that converts to sulfide in the sediment where the rice takes root. Sulfate sources can include discharges from mining operations, municipal wastewater treatment plants, industrial facilities, and natural sources. The MPCA is currently working to determine the next steps to address sulfate impairments in the Vermilion River Watershed and is committed to implementing the existing water quality standard to ensure these waters are restored.

The focus of the remainder of this report is the Myrtle Lake TMDL, which addresses the aquatic recreation impairment due to nutrient/eutrophication biological indicators (Table 1).

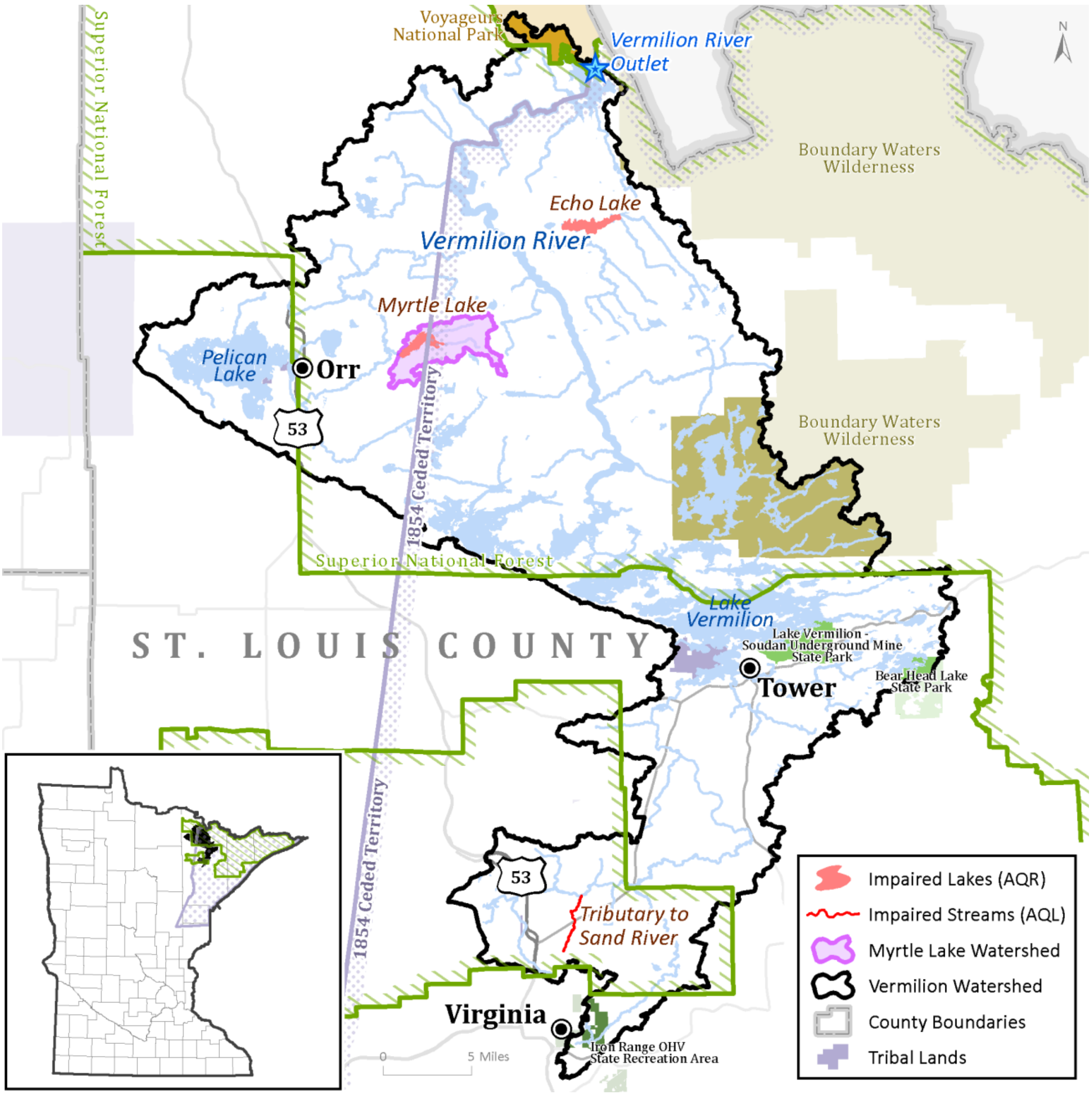

Figure 1. Vermilion River Watershed and water bodies with aquatic life or aquatic recreation impairments.

The Myrtle Lake Watershed is highlighted to show the focus of this TMDL report. See Table 1 for more information on the impaired water bodies.

Table 1. Water bodies in the Vermilion River Watershed with aquatic life or aquatic recreation impairments

Myrtle Lake, which is the only TMDL developed in this report, is highlighted in grey. The TMDL target completion year for Myrtle Lake is 2021.

Water Body Name	AUID [a]	Year Added to 303(d) List	Desig-nated Use Class	Affected Designated Use	Pollutant or Stressor	EPA category [b]	TMDL Developed in this Report
Echo Lake	69-0615-00	2010	2B, 3C	Aquatic Recreation	Nutrient/ eutrophication biological indicators	4D	N
Myrtle Lake	69-0749-00	2018	2B, 3C	Aquatic Recreation	Nutrient /eutrophication biological indicators	4A [c]	Y
Unnamed creek (Headwaters to Sand R)	09030002-645	2018	2Bg, 3C	Aquatic Life	Fishes bioassessments	4D	N

a. AUID = assessment unit identification

b. 4A: Impaired or threatened but a TMDL study has been approved by USEPA.
4D: Impaired or threatened but doesn't require a TMDL because the impairment is due to natural conditions with only insignificant anthropogenic influence.

c. Myrtle Lake will be 4A upon EPA-approval of this TMDL report.

Table 2. Water bodies in the Vermilion River Watershed with aquatic consumption impairments due to mercury in fish tissue

Water Body Name	Water Body Type	WID	Year Added to 303(d) List	Approved TMDL [a]
Armstrong	Lake	69-0278-00	2002	Y
Astrid	Lake	69-0589-00	1998	N
Ban	Lake	69-0742-00	1998	N
Bass	Lake	69-0446-00	2016	Y
Bell	Lake	69-0805-00	2012	N
Crane	Lake	69-0616-00	1998	N
Crellin	Lake	69-0459-00	1998	N
Eagles Nest #3	Lake	69-0285-03	1998	Y
Eagles Nest No. Four	Lake	69-0218-00	1998	Y
East Vermilion	Lake	69-0378-01	1998	Y
Echo	Lake	69-0615-00	1998	N
Elbow	Lake	69-0744-00	1998	N
Elephant	Lake	69-0810-00	1998	Y
Kabustasa	Lake	69-0679-00	2002	Y
Kjostad	Lake	69-0748-00	1998	N
Little Trout	Lake	69-0455-00	1998	Y
Marion	Lake	69-0755-00	1998	Y
Maude	Lake	69-0590-00	1998	N

Water Body Name	Water Body Type	WID	Year Added to 303(d) List	Approved TMDL [a]
Moose	Lake	69-0806-00	1998	N
Myrtle	Lake	69-0749-00	1998	Y
Nigh	Lake	69-0457-00	2002	N
Oriniack	Lake	69-0587-00	2006	Y
Pauline	Lake	69-0588-00	1998	N
Pelican	Lake	69-0841-00	1998	Y
Picket	Lake	69-0591-00	2004	Y
Pike Bay	Lake	69-0378-03	1998	Y
Pike River Flowage	Lake	69-0580-00	1998	N
Susan	Lake	69-0741-00	1998	Y
Trout	Lake	69-0498-00	1998	Y
Vermilion River (Hilda Cr to Pelican R)	Stream	09030002-529	2004	N
Vermilion River (Pelican R to Crane Lk)	Stream	09030002-531	2004	N
Vermilion River (Vermilion Lk to Hilda Cr)	Stream	09030002-527	2004	N
West Robinson	Lake	69-0217-00	2012	Y
West Vermilion	Lake	69-0378-02	1998	Y
Winchester	Lake	69-0690-00	2004	Y
Wolf	Lake	69-0582-00	1998	Y

a. Mercury TMDLs were approved as part of the 2018 Mercury TMDL Appendix A. Revisions to Appendix A of the *Minnesota Statewide Mercury TMDL* (MPCA 2007) are submitted to EPA every two years with the impaired waters list. Water resources with mercury concentrations greater than 0.572 mg/kg are not part of Appendix A, and TMDLs for these water bodies are not yet completed. These TMDLs are expected to be completed by 2033.

Table 3. Water bodies used for the production of wild rice in the Vermilion River Watershed with impairments due to excess sulfate

Water Body Name	Water Body Type	WID	Year Added to 303(d) List	TMDL Developed
East Vermilion	Lake	69-0378-01	2021	N
Vermilion; Pike Bay	Lake	69-0378-03	2021	N
Little Sandy Lake	Lake	69-0729-00	2021	N
Sandy Lake	Lake	69-0730-00	2021	N
Sand River	River	09030002--501	2021	N
Pike River	River	09030002--503	2021	N

1.3 Priority ranking

The MPCA's schedule for TMDL completions, as indicated on Minnesota's Section 303(d) impaired waters list, reflects Minnesota's priority ranking of this TMDL. The MPCA has aligned TMDL priorities with the watershed approach. The schedule for TMDL completion corresponds to the WRAPS report completion on the 10-year cycle. The MPCA developed a state plan Minnesota's TMDL Priority Framework Report to meet the needs of the EPA's national measure (WQ-27) under EPA's Long-Term Vision for Assessment, Restoration, and Protection under the CWA Section 303(d) Program. As part of these efforts, the MPCA identified water quality impaired segments to be addressed by TMDLs through the watershed approach.

2. Applicable water quality standards and numeric water quality criteria

The federal Clean Water Act requires states to designate beneficial uses for all waters and develop water quality standards to protect each use. Water quality standards consist of several parts:

- Beneficial uses—Identify how people, aquatic communities, and wildlife use our waters
- Numeric criteria—Amounts of specific pollutants allowed in a body of water that still protect it for the beneficial uses
- Narrative criteria—Statements of unacceptable conditions in and on the water
- Antidegradation protections—Extra protection for high-quality or unique waters and existing uses

Together, the beneficial uses, numeric and narrative criteria, and antidegradation protections provide the framework for achieving Clean Water Act goals. Minnesota's water quality standards are in Minn. R. chs. 7050 and 7052. All current state water rules administered by the MPCA are available on the Minnesota water rules webpage.

2.1 Beneficial uses

The beneficial uses for waters in Minnesota are grouped into one or more classes as defined in Minn. R. 7050.0140. All surface waters are protected for multiple beneficial uses. The classes and associated beneficial uses are:

- Class 1 – domestic consumption
- Class 2 – aquatic life and recreation
- Class 3 – industrial consumption
- Class 4 – agriculture and wildlife
- Class 5 – aesthetic enjoyment and navigation
- Class 6 – other uses and protection of border waters
- Class 7 – limited resource value waters

The aquatic life use class includes a tiered aquatic life uses framework for rivers and streams. The framework contains three tiers—exceptional, general, and modified uses.

2.2 Narrative and Numeric criteria and state standards

Narrative and numeric water quality criteria for all uses are listed for four common categories of surface waters in Minn. R. 7050.0220. The four categories are:

- Cold water aquatic life and habitat, also protected for drinking water: classes 1B; 2A, 2Ae, or 2Ag; 3; 4A and 4B; and 5

- Cool and warm water aquatic life and habitat, also protected for drinking water: classes 1B or 1C; 2Bd, 2Bde, 2Bdg, or 2Bdm; 3; 4A and 4B; and 5
- Cool and warm water aquatic life and habitat and wetlands: classes 2B, 2Be, 2Bg, 2Bm, or 2D; 3; 4A and 4B; and 5
- Limited resource value waters: classes 3; 4A and 4B; 5; and 7

The narrative and numeric water quality criteria for the individual use classes are listed in Minn. R. 7050.0221 through 7050.0227. The procedures for evaluating the narrative criteria are presented in Minn. R. 7050.0150.

The MPCA assesses individual water bodies for impairment for class 2 uses—aquatic life and recreation. Class 2A waters are protected for the propagation and maintenance of a healthy community of cold water aquatic life and their habitats. Class 2B waters are protected for the propagation and maintenance of a healthy community of cool or warm water aquatic life and their habitats. Protection of aquatic life entails the maintenance of a healthy aquatic community as measured by fish and macroinvertebrate indices of biotic integrity (IBIs). Fish and invertebrate IBI scores are evaluated against criteria established for individual monitoring sites by water body type and use subclass (exceptional, general, and modified).

Both class 2A and 2B waters are also protected for aquatic recreation activities including bathing and swimming, and the consumption of fish and other aquatic organisms. In streams, aquatic recreation is assessed by measuring the concentration of *Escherichia coli* (*E. coli*) in the water, which is used as an indicator species of potential waterborne pathogens. To determine if a lake supports aquatic recreational activities, its trophic status is evaluated using TP, Secchi depth, and Chl-*a* as indicators. The ecoregion standards for aquatic recreation protect lake users from nuisance algal bloom conditions fueled by elevated phosphorus concentrations that degrade recreational use potential.

2.3 Antidegradation policies and procedures

The purpose of the antidegradation provisions in Minn. R. ch. 7050.0250 through 7050.0335 is to achieve and maintain the highest possible quality in surface waters of the state. To accomplish this purpose:

- Existing uses and the level of water quality necessary to protect existing uses are maintained and protected.
- Degradation of high water quality is minimized and allowed only to the extent necessary to accommodate important economic or social development.
- Water quality necessary to preserve the exceptional characteristics of outstanding resource value waters is maintained and protected.
- Proposed activities with the potential for water quality impairments associated with thermal discharges are consistent with section 316 of the Clean Water Act, United States Code, title 33, section 1326.

2.4 Myrtle Lake water quality standards

This TMDL report addresses Myrtle Lake, which does not meet the standards for class 2B waters; class 2B waters are protected for aquatic life and recreation. The numeric eutrophication criteria for lakes in the Northern Lakes and Forests Ecoregion (Table 4) serve as targets for the Myrtle Lake TMDL. The Myrtle Lake TMDL was developed for phosphorus; the numeric target used to develop the TMDL is 30 micrograms per liter (µg/L) TP.

In addition to meeting phosphorus limits, Chl-*a* and Secchi transparency standards must be met. In developing the lake nutrient standards for Minnesota lakes (Minn. R. ch. 7050), 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 the response variables Chl-*a* and Secchi transparency. Based on these relationships it is expected that by meeting the phosphorus target in each lake, the Chl-*a* and Secchi standards (Table 4) will likewise be met.

Table 4. Eutrophication criteria for class 2B lakes, shallow lakes, and reservoirs in Northern Lakes and Forests Ecoregion

Parameter	Eutrophication Criterion
Phosphorus, total (µg/L)	≤ 30
Chlorophyll-a (µg/L)	≤ 9
Secchi Transparency (meters [m])	≥ 2.0

3. Watershed and water body characterization

Myrtle Lake is an 876-acre shallow lake located approximately seven miles east of the city of Orr (Figure 1), in Portage Township of Saint Louis County, Minnesota. The lake's scenic setting, high panfish production, and easy public access has made Myrtle Lake a popular recreation destination and an important resource for the area. This remote setting is accessed via County Highway 23, which skirts the southern edge of the lake and crosses five of Myrtle Lake's six tributaries. A public water access with a boat landing is located on the southeast shore.

Forty-six percent of the watershed is privately owned with most of the remainder under federal (20%) and state (34%) management (Table 5). Development is concentrated in the southwestern portion of the watershed including the southern shore of Myrtle Lake (Figure 2). The lake's southern shoreline is moderately developed with approximately 25 residences and cottages. The lake has one resort with four cabins, five RV sites, a primitive campground, and a bar and grill. Industrial activity within the watershed is minor and includes forest harvest and gravel mining.

Much of Myrtle Lake's shoreline and adjacent land is undeveloped. The majority of the northern shoreline is managed by the United States Forest Service (USFS; Figure 2). Here, the USFS operates three backcountry campsites on a 1,000-foot sandy beach. Boiled or filtered lake water is currently listed as a possible drinking water source for campers at these backcountry sites.

Although no part of the Myrtle Lake Watershed is located within the boundary of a Native American Reservation, about half of the watershed lies within the 1854 Treaty Authority Boundary (Figure 1). Wild rice, a culturally significant resource to Native Americans, has been documented on Myrtle Lake. Myrtle Lake is also listed in the MPCA's 2016 Wild Rice Waters database.

In 2017, Myrtle Lake was assessed as not supporting aquatic recreation with an average Chl-*a* concentration of 26 µg/L (MPCA 2018). Nuisance algal blooms were also frequently observed in Myrtle Lake by monitoring staff. Public and local partner input included anecdotal observations of regular blooms occurring in Myrtle Lake for decades, but it is unclear if these observations are becoming more frequent or represent Myrtle Lake's natural state.

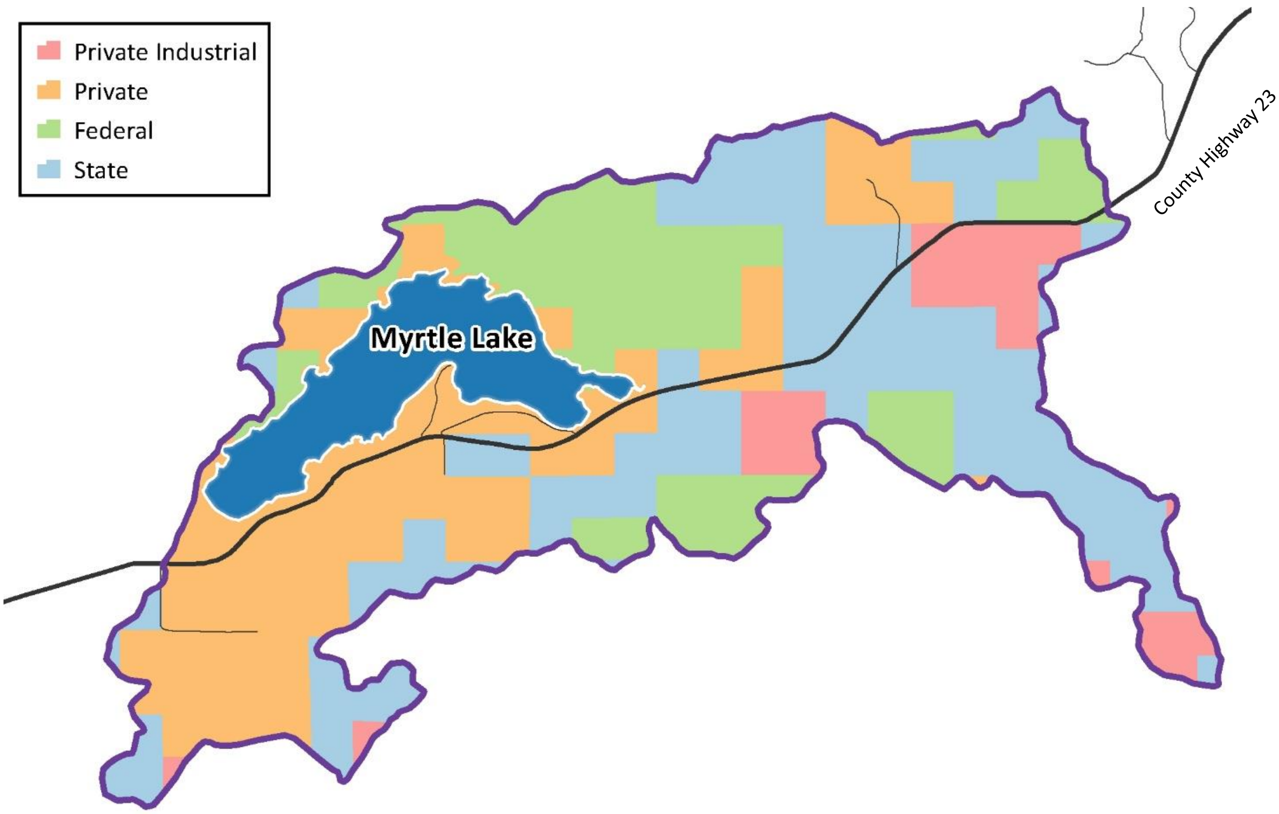

Figure 2. Map of land ownership in the Myrtle Lake Watershed
Data source: USGS GAP (Gap Analysis Project) Stewardship 2008

Table 5. Land ownership in the Myrtle Lake Watershed
Data source: USGS GAP Stewardship 2008

Ownership	Area (ac)	Area (%)
Federal	1,615	20%
State	2,701	34%
Private	3,092	38%
Private Industrial	608	8%
Total	8,016	100%

3.1 Lake and watershed morphometry

Myrtle Lake is a shallow lake in the Vermilion River Watershed with a mean depth of approximately 10 feet and surface area of 876 acres. Minn. R. 7050.0150 defines a shallow lake 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). . . 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."

Myrtle Lake has a maximum fetch of 2.8 miles at 225 degrees (DNR 2017). This orients the lake with the prevailing winds and allows for complete mixing of the water column. Intermittent stratification of this shallow lake has been documented under calm conditions (Edlund et al. 2019).

There are four small inlets and two larger inlets that exhibit wetland characteristics and were observed by field staff to stagnate at low flow events in the summer. The outlet of Myrtle Lake, locally known as the Myrtle River, is a ¾-mile tributary to the Pelican River and both are very low gradient with wetland characteristics. Anecdotal observations from some shoreline property owners suggest that the Myrtle River may stagnate or reverse flow, although this has not been measured or observed by field staff. These contributing wetlands may act as a nutrient source to the lake.

Much of the shoreline remains natural with a diverse aquatic plant community and abundant emergent and submergent vegetation near the outlet and eastern inlet (DNR 2018). However, development along the south shore has led to localized areas of disturbance along the shoreline.

Myrtle Lake morphometry data and watershed area are presented in Table 6. The Myrtle Lake Watershed, bathymetric contours, and the locations of monitoring stations are shown in Figure 3.

Table 6. Myrtle Lake morphometry and watershed area

Parameter	Value
Surface area	876 acres
Mean depth	10 ft
Maximum depth	20 ft
Littoral area (percent lake surface area less than 15 feet, or 4.6 m, deep)	97%
Watershed area (including lake surface area)	8,016 ac
Ratio of watershed area to lake area	9
Maximum fetch	2.8 mi, 225°
Hydraulic residence time (yr)	1.7

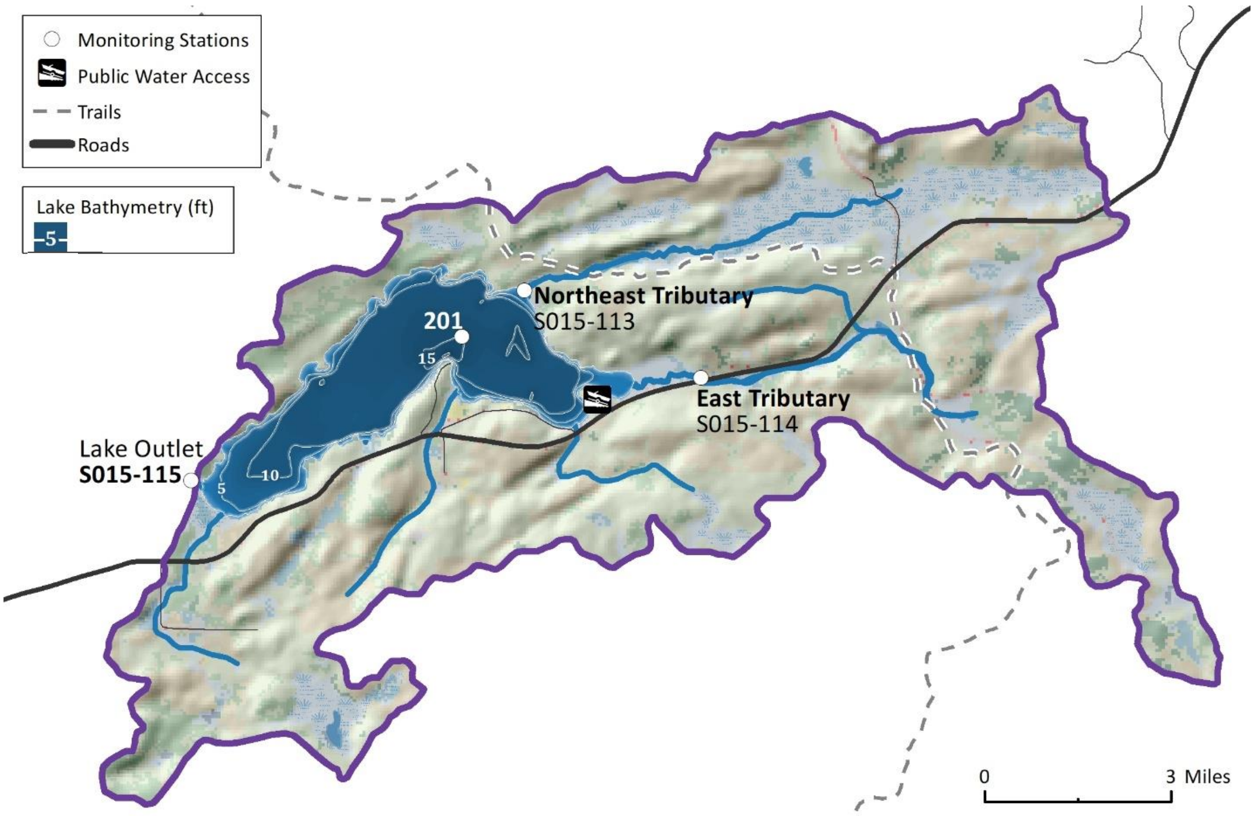

Figure 3. Myrtle Lake Watershed drainage, monitoring stations, and bathymetric contours

3.2 Fisheries

Myrtle Lake is known to have supported a diverse fishery of game fish since an initial survey in 1951 with walleye and black crappie described as principle game fish species (DNR 2017). The lake currently supports a cool/warm water fish community and is a popular local fishery. Black crappie and walleye continue to be supported in the lake along with additional game fish including bluegill, yellow perch, northern pike, smallmouth bass, and largemouth bass. Other fish species found in Myrtle Lake include black bullhead, brown bullhead, hybrid sunfish, pumpkinseed, rock bass, sunfish, white sucker, blacknose shiner, golden shiner, and tadpole madtom.

A 2017 DNR lake survey of Myrtle Lake yielded a record high black crappie catch. Crappies averaged 6.9 inches and were observed up to 13.4 inches (DNR 2018). Bluegill catch rates were also near a record high in 2017 (DNR 2017). Evaluated for spawning habitat in 1991, Myrtle Lake has fair to good spawning habitat for northern pike, walleye, bass, and panfish (DNR 2018).

Myrtle Lake has been stocked with walleye regularly since 1945. Recently, fingerlings have been stocked in odd years. In 2019 the DNR began stocking fry per the lake management plan (DNR 2018) in an effort to strengthen the walleye population in the lake. It is unknown if this recent change in stocking will affect trophic interactions in Myrtle Lake that could impact algae abundance. Past research on other lakes has indicated that walleye fry consume fry of other small fish reducing predation on planktivorous zooplankton, decreasing algae abundance (Potthoff et al. 2008). The existing populations of crappie, bluegill, and perch could be limiting zooplankton and enhancing algae production; however, this is not considered a primary source at of algae production at this time and more investigation would be needed to determine if trophic interactions are enhancing algae growth.

3.3 Land cover

According to the Marschner Presettlement Vegetation dataset, pre-European settlement land cover in the watershed was mostly aspen-birch forest trending to conifers (Figure 4). Mixed white and red pine forest surrounded much of Myrtle Lake. In 1907, large scale logging operations arrived in the region along with the expansion of rail (Wyatt 1999). Until then it was difficult to transport the remote timber to U.S. markets because nearby rivers flow north to the U.S. border with Canada. Virginia and Rainy Lake Company, headquartered in nearby Cusson, was one of two big lumber companies logging the area. They built the largest white pine sawmill in the world in Virginia, Minnesota. In 20 years of operation, the lumber company manufactured 2.5 billion feet of lumber. By 1920, all the profitable white pine had been harvested (Wyatt 1999). Forests regenerated as mixed deciduous and conifer forest.

Under existing conditions (2010), the majority of land cover in the Myrtle Lake Watershed is forested, followed by open water and wetlands (Table 7, Figure 5). Whereas developed areas overall represent a small percentage of the watershed, the developed areas are concentrated along the lake's southern shoreline.

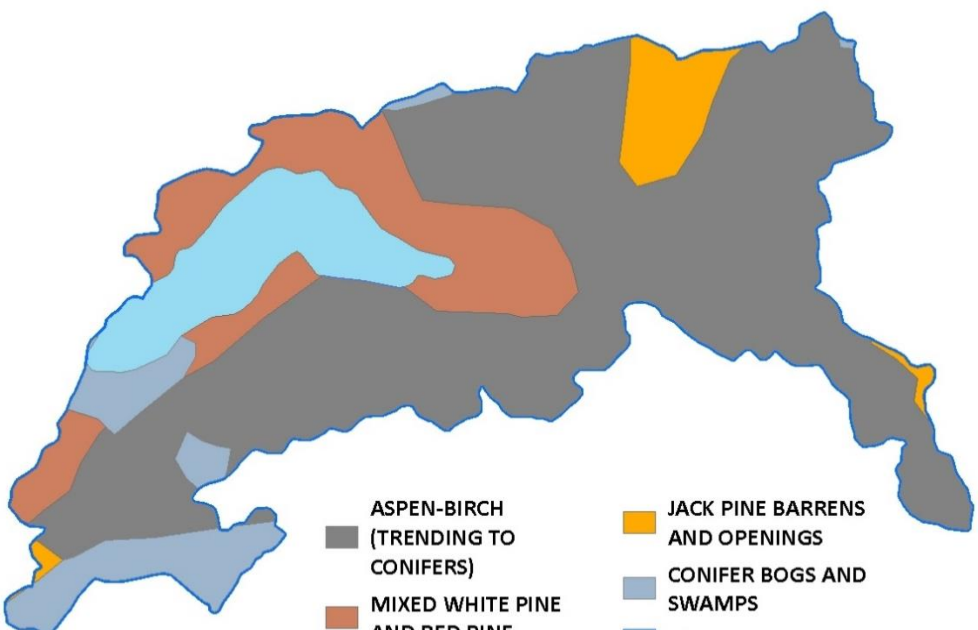

Figure 4. Presettlement land cover in the Myrtle Lake Watershed

Data source: Marschner Presettlement Vegetation, DNR

Table 7. Current Land cover in the Myrtle Lake Watershed

Data source: *Land Cover: Lake of the Woods 2010*[1]. Percentages rounded to the nearest whole number.

Land Cover	Area (ac)	Area (%)
Wetlands	893	11%
Open water	907	11%
Forest	5,825	73%
Hay and pasture	72	1%
Urban/developed	319	4%
Total	8,016	100%

[1] A 10-meter raster classification of ~2010 land cover for the Lake of the Woods/Rainy River Basin; developed by Department of Forest Resources, Remote Sensing and Geospatial Analysis Laboratory, University of Minnesota. Available from https://rs.umn.edu/datalayers.

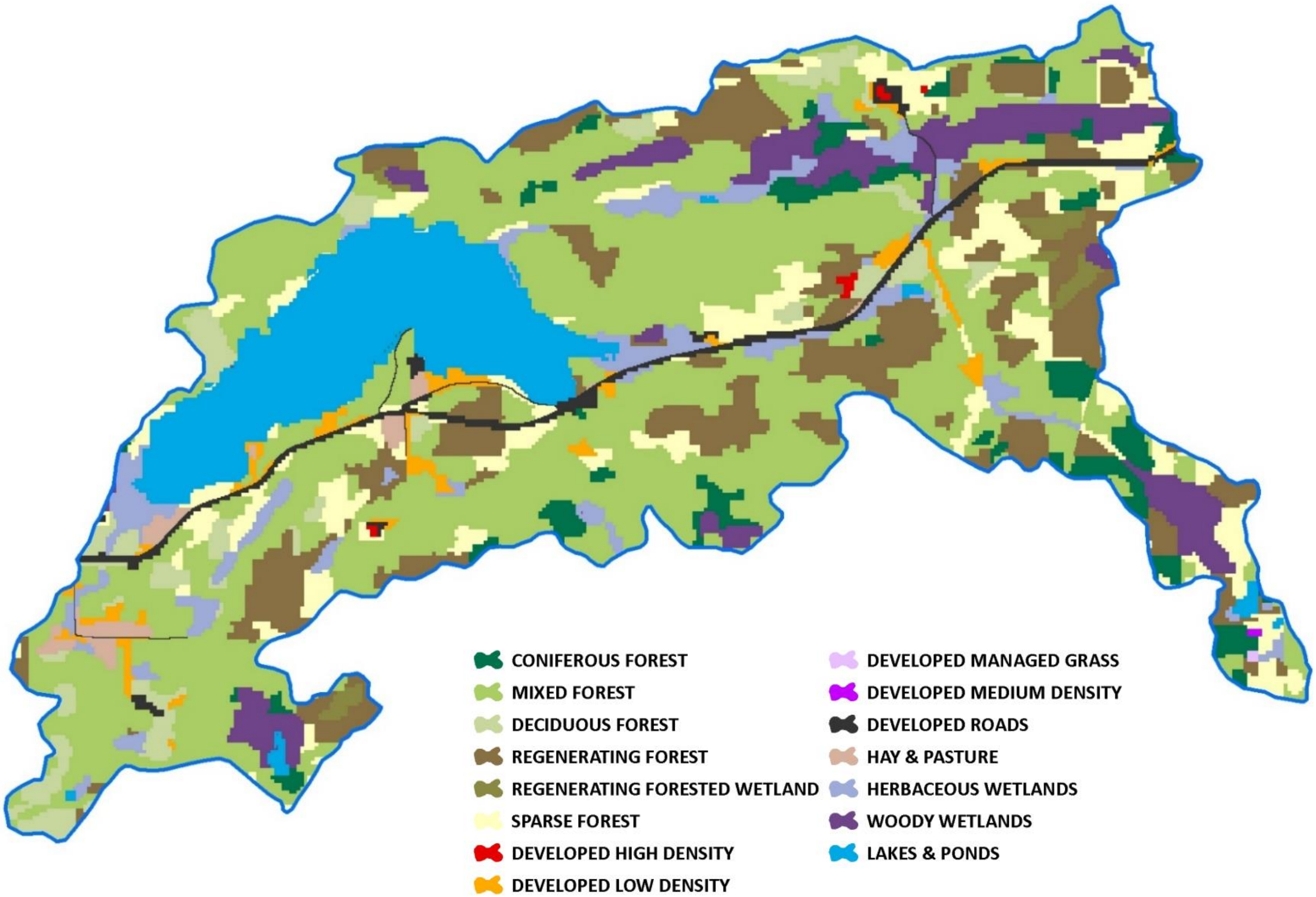

Figure 5. Current Land cover in the Myrtle Lake Watershed

(Data source: *Land Cover: Lake of the Woods 2010*)

3.4 Water quality

Myrtle Lake is a shallow, “bog-stained” lake (i.e., has high dissolved organic carbon) that experiences algal blooms. Algal blooms were observed by monitoring staff in 2016 and 2018, and a bloom was documented in 2017 by a Myrtle Lake resident (Figure 6). Although there are limited historical water quality data on the lake, public comments at meetings in 2018 and 2019 included observations of algae blooms as far back as residents could recall. A 1966 fisheries seining survey recorded “lake was very green with algae” in the survey notes.

Figure 6. Drone photo of nuisance algal bloom on Myrtle Lake, September 2017 (Brian Hacker)

Water quality data from Myrtle Lake (site 69-0749-00-201, see Figure 3) were downloaded from the MPCA’s Environmental Quality Information System (EQuIS) and summarized for TP, Chl-*a*, and Secchi transparency. Data were summarized over the entire period to evaluate compliance with the water quality standards (Table 8) and by year to evaluate trends in water quality (Figure 7). The summaries include monitoring data from the growing season (June through September); the water quality standards apply to growing season means. The average TP, Chl-*a*, and Secchi transparency violate the relevant standards. The low Secchi transparency readings may be partly due to the high dissolved organic carbon in the lake, which reduces transparency.

TP and Chl-*a* concentrations generally increase throughout the growing season in Myrtle Lake, as shown by data from 2018 (Figure 8). The poorest water quality was seen in mid-July to mid-August, corresponding to the peak of summer water temperatures, which is typical for Minnesota lakes.

Table 8. Myrtle Lake water quality data summary

Parameter	Average of Annual Growing Season Means (Jun–Sep) 2015, 2016, 2018	Water Quality Standard
TP (µg/L)	38	≤ 30
Chl-*a* (µg/L)	27	≤ 9
Secchi (m)	1.5	≥ 2.0

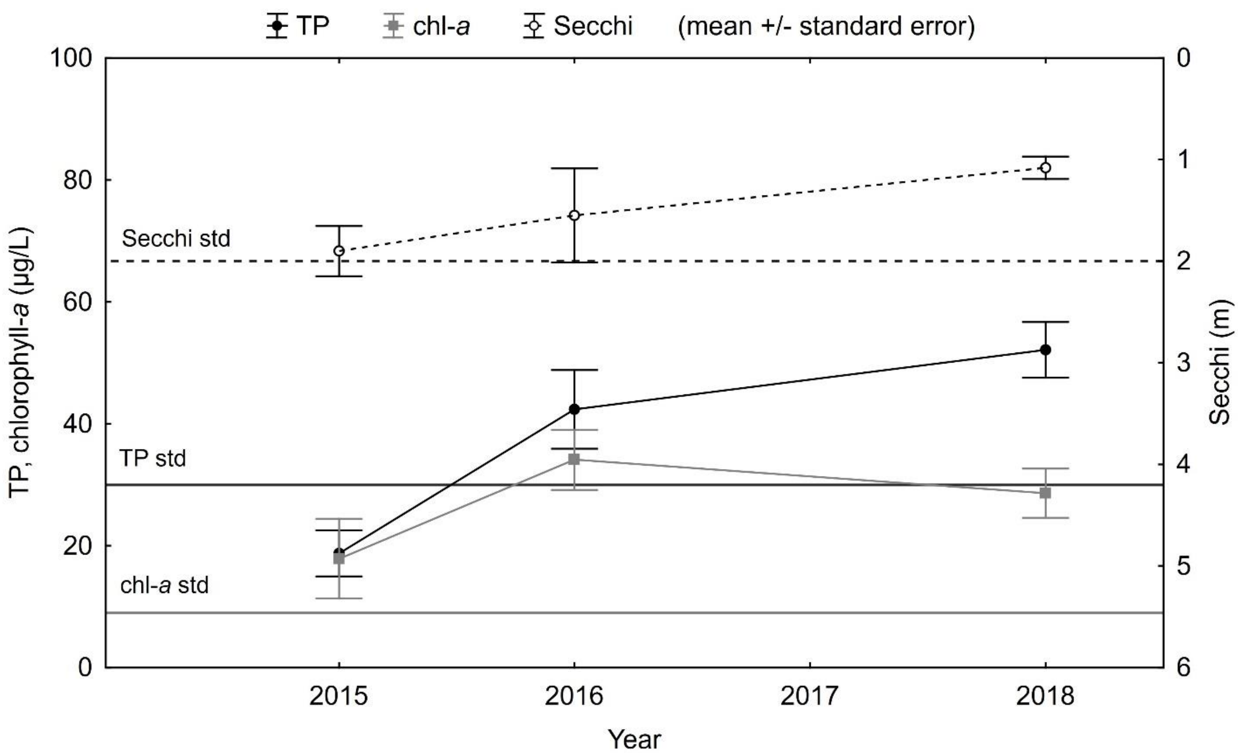

Figure 7. Mean TP, Chl-*a*, and Secchi depth in Myrtle Lake by year

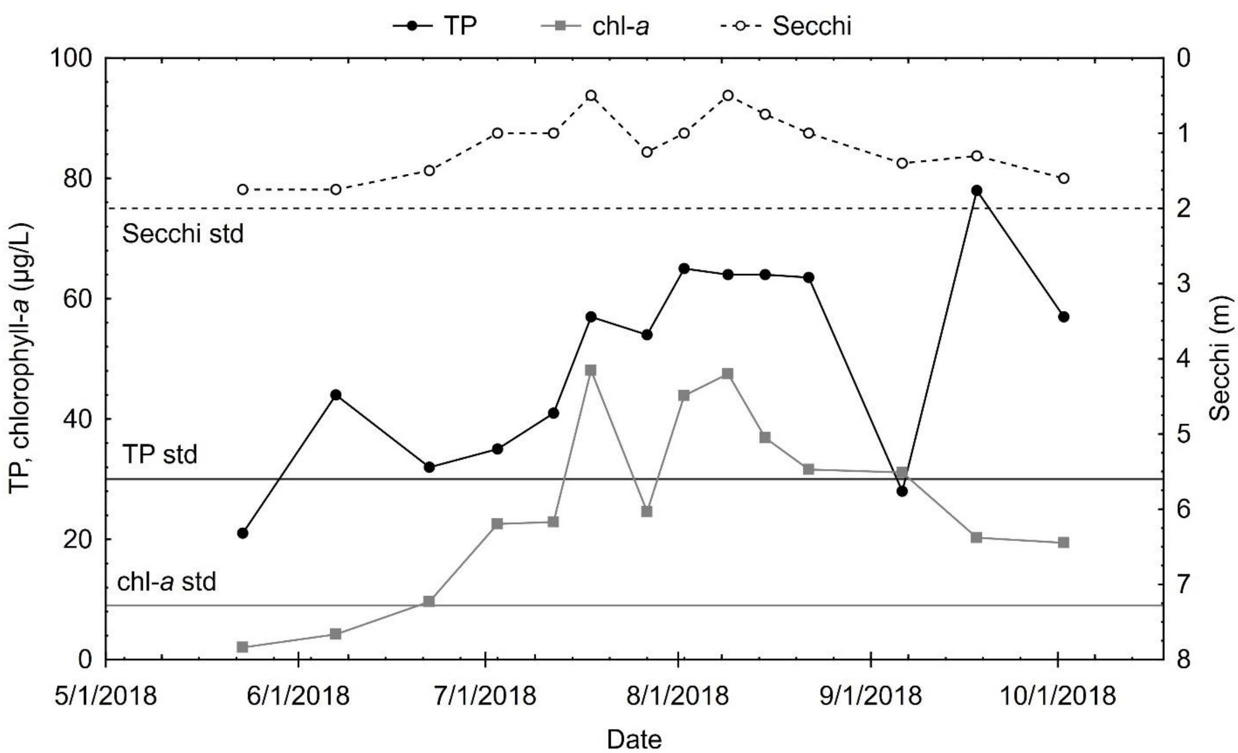

Figure 8. Scatterplot of TP, Chl-*a*, and Secchi depth in Myrtle Lake, 2018

With little historical water quality data, a paleolimnology study was performed to obtain a better understanding of historical conditions of Myrtle Lake. This paleolimnological study of Myrtle Lake provides information on historic sedimentation rates and water quality from the mid-1800s to the present (Edlund et al. 2019). In June 2018, one long sediment core and multiple short sediment cores were taken from the lake sediments and analyzed. Additionally, a high frequency monitoring buoy recorded water temperature and DO concentrations from June through October 2018. More details about the methods and results can be found in *A Paleolimnological Study of Myrtle Lake, St. Louis Co., Minnesota* (Edlund et al. 2019). The following summarizes the findings.

- Sedimentation rates. Compared to many Minnesota lakes, Myrtle Lake has relatively low sedimentation rates. Rates increased slightly after European settlement, and then increased again after the 1970s to over two times higher than the historical rates (Figure 9). The percent inorganic sediment in the lake increased during 1900 to 1950; this increase is likely due to increased erosion from initial logging and land clearance in the region. The accumulation rates of both organic and inorganic sediments increased from the late 1800s to the 1950s, and more rapid increases were observed after the 1970s. Increases in organic sediment are likely due to increased algae production in the lake.

  Biogenic silica concentration, which is a marker of diatom abundance, is high in Myrtle Lake. Diatoms are a type of single-celled algae that are common in Minnesota lakes. The rate of accumulation of biogenic silica suggests that diatom productivity was slightly greater in the early 1900s and then again in the 1970s through present (Figure 10).

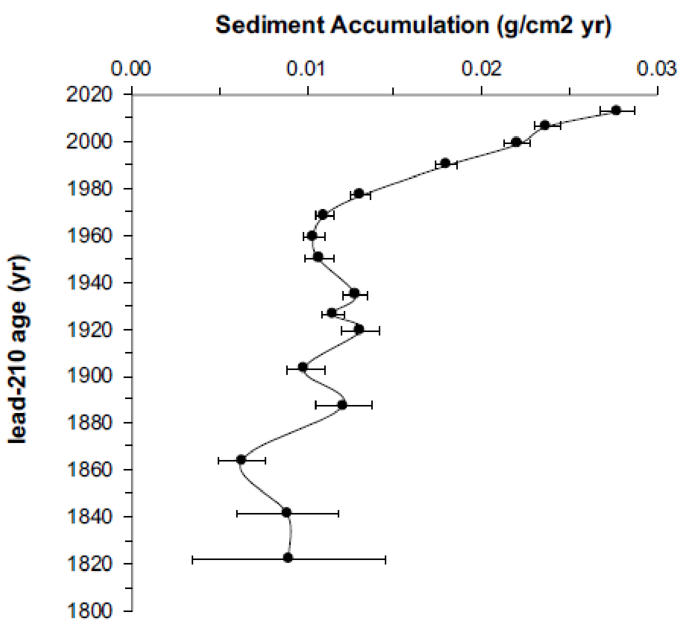

Figure 9. Sedimentation rates in Myrtle Lake
Figure from Edlund et al. (2019)

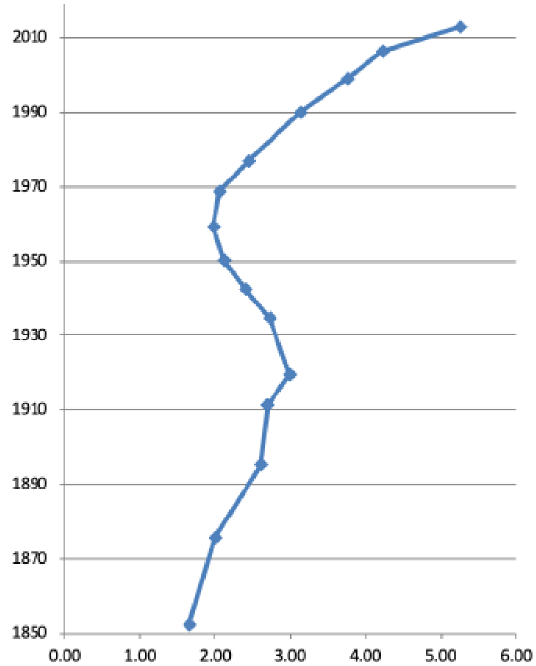

Figure 10. Biogenic silica accumulation rate (mg/cm^2-yr) by core date in Myrtle Lake.

Figure from Edlund et al. (2019)

- Sediment phosphorus. Sediment phosphorus concentrations were higher towards the top of the core. Two forms of phosphorus—labile organic and iron-bound—were abundant across the entire basin; this pool of phosphorus can contribute to internal loading when the bottom waters have low oxygen. Sediment phosphorus release rates were measured with cores from multiple sites in the lake basin. Release rates were higher under anaerobic conditions than under aerobic conditions. Release rates varied across the different lake sites, with the highest rates in eastern part of the lake.

- Diatoms and inferred phosphorus concentrations. The diatom assemblage in Myrtle Lake includes species that are characteristic of meso-eutrophic, shallow lakes. There has been little historical change in the diatom assemblage, but some evidence suggests that the more recent assemblage (post-1995) has shifted in response to increased nitrogen availability. The diatom assemblages found in the core were used to infer historical TP concentrations in the lake. The TP reconstructions suggest that mean surface TP concentrations have not changed notably in the last 150 years. The diatom-inferred TP is approximately 25 to 30 µg/L.

- Cyanobacteria. Cyanobacteria have long been present in Myrtle Lake. Before 1940, the cyanobacteria assemblage contained abundant colonial cyanobacteria and was potentially dominated by deeper and/or attached forms. The assemblage shifted after 1940; this shift may be related to higher dissolved organic carbon in the lake that resulted after initial logging of the region. A very slight increase in recent sediments of one pigment, myxoxanthophyll, could indicate an increase in colonial cyanobacteria, including toxic planktonic cyanobacteria bloom-formers that were observed in a June 2018 bloom.

- Water temperature and dissolved oxygen. The monitoring buoy provided high frequency measurements of water temperature and DO concentrations throughout the 2018 growing season, showing that the water column intermittently stratified. At least six instances of short-term water column stratification led to low DO in the bottom waters of the lake. These low DO concentrations likely led to pulses of phosphorus release from the sediments. These phosphorus pulses appear to have contributed to the gradual rise in phosphorus and chlorophyll over the 2018 growing season (Figure 11), which was an extreme cyanobacteria abundance year.

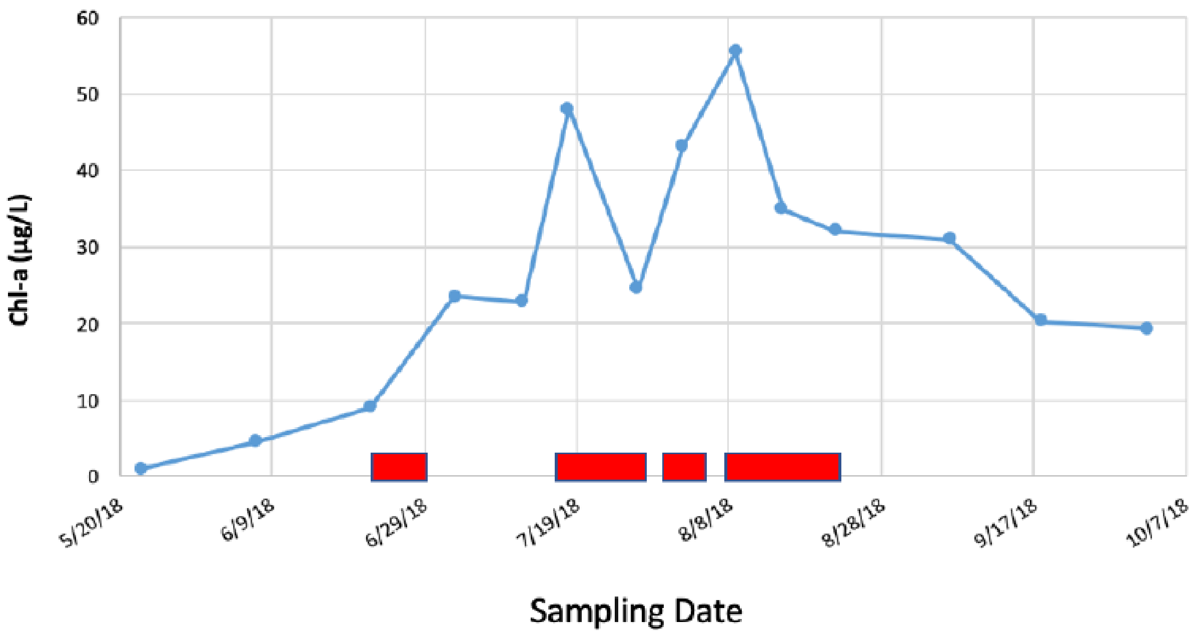

Figure 11. Chlorophyll-*a* concentrations and stratification events in Myrtle Lake, 2018.

Figure from Edlund et al. (2019). Red shaded blocks represent periods when stratification events greater than a week long led to hypoxic/anoxic bottom waters conducive to diffusive internal loading.

In summary, sedimentation rates increased slightly after European settlement and then again after the 1970s. Diatom production increased in the early 1900s and then again in the 1970s through present. The analysis of the diatom assemblage suggests that the long term average TP concentration in Myrtle Lake is approximately 25 to 30 µg/L. The average TP concentrations in recent years (2015 through 2018) ranged from 19 to 52 µg/L (Figure 7); however, it is not known if these higher concentrations represent a trend of poorer water quality or if they simply represent fluctuations that typically occur in lakes that are not discernable in the sediment core. Cyanobacteria, which are typically part of algae blooms, have long been present in Myrtle Lake, but the types and balance of cyanobacteria species in the lake shifted after 1940.

Sediment phosphorus concentrations and experiments show that the sediments in Myrtle Lake have the potential to contribute to internal loading. This, in combination with intermittent stratification of the water column, likely led to pulses of phosphorus release from the sediments in 2018 which contributed to the algal blooms observed that season. Because Myrtle Lake is shallow and often experiences prolonged calm conditions, the water can warm relatively quickly, and algal bloom species can take advantage of the warm water and abundant nutrients to quickly increase growth rates. Nutrients are particularly abundant after temporary stratification events.

Climate change could also be affecting water quality in Myrtle Lake. Climate change can result in a longer ice-free season, stronger thermal stratification, and increased inputs of dissolved organic carbon. These phenomena have been observed in other studies including a shallow lake study in Quebec, Canada that documented climate change enhanced stratification that led to massive cyanobacteria blooms (Bartosiewicz et al. 2019). Whereas these phenomena have not been studied in Myrtle Lake, historical and recent land use change combined with climate change could lead to higher rates of internal loading and algal growth.

3.5 Phosphorus source summary

Phosphorus is an essential nutrient for aquatic and terrestrial life and is found naturally throughout a watershed. There are several potential sources of phosphorus contributing excess amounts to impaired water bodies. A description of phosphorus sources is provided below and includes watershed runoff, subsurface sewage treatment systems (SSTS), internal loading, atmospheric deposition, and natural background. The only National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS)-permitted source of phosphorus in the watershed is industrial stormwater; the remaining sources are nonpermitted. The phrase "nonpermitted" does not indicate that the pollutants are illegal, but rather that they do not require an NPDES/SDS permit. Some nonpermitted sources are unregulated, and some nonpermitted sources are regulated through nonNPDES programs and permits such as state and local regulations.

There are no NPDES/SDS permitted sources such as wastewater treatment facilities, permitted animal feeding operations, permitted municipal separate storm sewer systems (MS4s) or permitted construction stormwater sites in the Myrtle Lake Watershed.

3.5.1 Phosphorus sources

3.5.1.1 Permitted industrial stormwater runoff

Industrial stormwater is regulated through an NPDES/SDS permit when stormwater discharges have the potential to come into contact with materials and activities associated with the industrial activity. Phosphorus loading from industrial stormwater is inherently incorporated in the watershed runoff estimates (Section 3.5.1.2). There is one site that is permitted through the Industrial Stormwater Multi-Sector and Nonmetallic Mining/Associated Activities General Permit (MNG490000). Given that the permitted site is surrounded by natural vegetation, is not adjacent to a receiving surface water, and is a small percent of the watershed, industrial stormwater is not considered a significant source.

3.5.1.2 Watershed runoff

Precipitation that falls in a watershed drains across the land surface, and a portion of it eventually reaches lakes and streams. Pollutants such as sediment and phosphorus are carried with the runoff water and delivered to surface water bodies. The sources of pollutants in watershed runoff may include soils, fertilizer, vegetation, release from wetlands, and pet and wildlife waste.

The Myrtle Lake Watershed is relatively undeveloped with little overall disturbance. However, the development that exists (4% of the watershed, Table 7) is concentrated along the lakeshore and therefore has the potential to have a more direct effect on the lake's water quality than sources distributed throughout the watershed. Lakeshore development includes houses around the perimeter of the lake, which are densest on the south shore of the lake. A resort is also located along the south shoreline.

Although wetlands are natural components of the watershed, wetlands can be a source of phosphorus to surface waters. Under low oxygen conditions, wetland sediment can release phosphorus to the water column; the phosphorus is then transported downstream. The extent of the phosphorus contribution to Myrtle Lake from wetlands is not known.

Monitoring data indicate that phosphorus concentrations in the east tributary are on average higher than concentrations in the northeast tributary. Phosphorus data were collected from the two tributaries in 2018 (Figure 12; see Figure 3 for monitoring site locations). Although the highest concentration was observed in the northeast tributary (490 µg/L on August 15), this sample is so high that it is likely an error. When that observation is removed, the concentration on average is higher in the east tributary than in the northeast tributary (paired t-test, $P<0.05$). The higher concentrations in the east tributary were observed in July and August when flows are typically low and water temperatures are high, suggesting that the increased phosphorus could be from wetland release. Sediment phosphorus release rates were also higher in the eastern part of the lake (Section 3.4); these higher release rates could be linked to the higher phosphorus concentrations in the east tributary. However, because tributary data are limited, additional data are needed to verify this relationship.

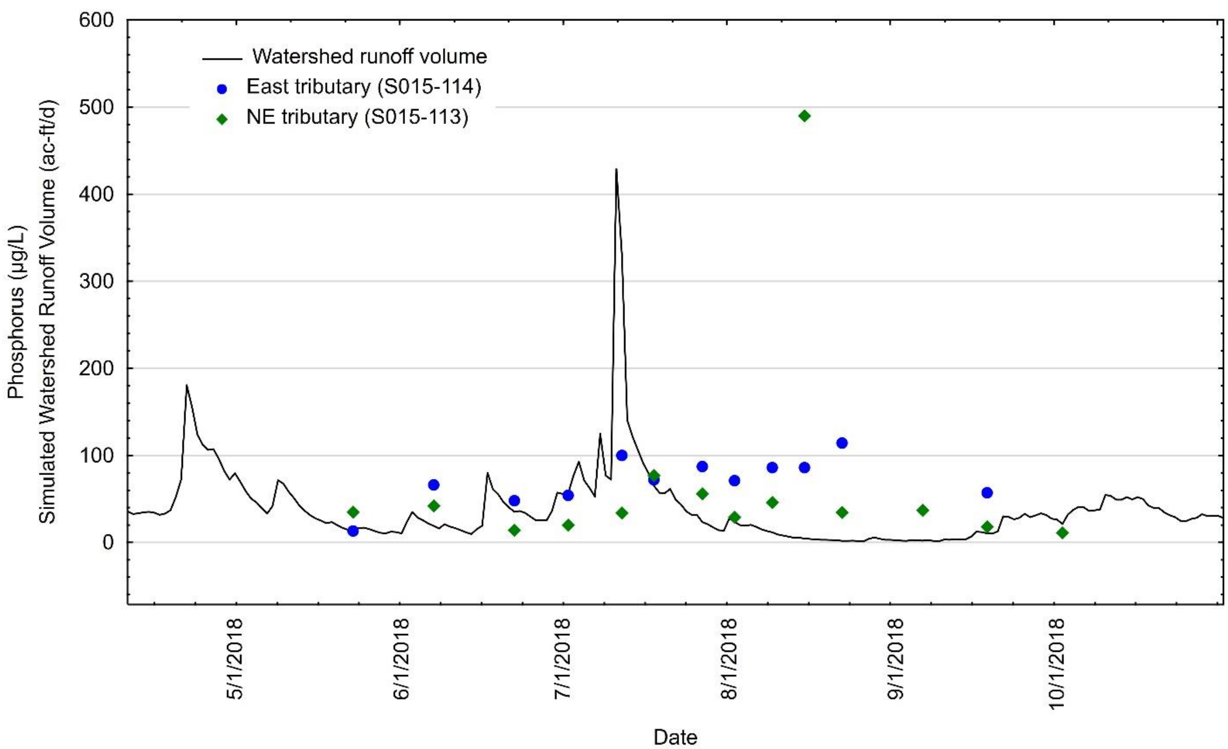

Figure 12. Phosphorus concentrations in Myrtle Lake tributaries and HSPF modeled watershed runoff volume

Watershed runoff volumes are simulated with the HSPF model; simulated tributary flows are not available due to the scale of the model.

Phosphorus loads from watershed runoff were quantified with HSPF. HSPF is a comprehensive model of watershed hydrology and water quality that allows the integrated simulation of point sources, land and soil contaminant runoff processes, and in-stream hydraulic and sediment-chemical interactions. The results provide hourly runoff flow rates, sediment concentrations, and nutrient concentrations, along with other water quality constituents, at the outlet of any modeled subwatershed. Within each subwatershed, the upland areas are separated into multiple land use categories, and loads generated from these land cover categories were tabulated from the HSPF model. Model documentation contains details about the model development and calibration (RESPEC 2016, MPCA 2020a). Watershed runoff load estimates are presented in Section 3.5.2.

3.5.1.3 Subsurface sewage treatment systems

SSTSs can contribute phosphorus to nearby waters. SSTSs can fail for a variety of reasons, including excessive water use, poor design, physical damage, and lack of maintenance. Common limitations that contribute to failure include seasonal high water table, fine-grained soils, bedrock, and fragipan (i.e., altered subsurface soil layer that restricts water flow and root penetration). Septic systems can fail hydraulically through surface breakouts or hydrogeologically from inadequate soil filtration. Failure potentially results in higher levels of phosphorus loading to nearby surface waters.

Septic systems that are conforming and are appropriately sited still discharge small amounts of phosphorus. Failing septic systems do not protect groundwater from contamination. Septic systems that discharge untreated sewage to the land surface or directly to streams are considered imminent threats to public health and safety (ITPHS) and can contribute phosphorus directly to surface waters. ITPHS typically include straight pipes (i.e., no treatment), effluent ponding at ground surface, effluent backing up into home, unsafe tank lids, electrical hazards, or any other unsafe condition deemed by a certified SSTS inspector. Therefore, not all of the ITPHSs discharge pollutants directly to surface waters.

There are approximately 40 to 50 SSTS in the Myrtle Lake Watershed, over half of which are seasonal. There are records of nonconforming systems; however, the exact extent is unknown. Overall estimated percentages of ITPHS in St. Louis County were low (2%) in 2018, and approximately 25% of the systems in St. Louis County were estimated as failing to protect groundwater (compliance data from counties compiled annually by MPCA). These percentages are reported as estimates by local units of government for planning purposes and general trend analysis. These values may be inflated due to relatively low total SSTS estimated per jurisdiction. Additionally, estimation methods for these figures can vary depending on local unit of government resources available.

Other human-derived sources of pollutants in the watershed may include straight pipe discharges, earthen pit outhouses, and land application of septage. Straight pipe systems are unpermitted and illegal sewage disposal systems that transport raw or partially treated sewage directly to a lake, stream, drainage system, or the ground surface. Straight pipe systems are required to be addressed 10 months after discovery (Minn. Stat. § 15.55, subd. 11). Outhouses, or privies, are legal disposal systems and are regulated under Minn. R. 7080.2150, subp. 2F and Minn. R. 7080.2280.

It was assumed that SSTSs from shoreline properties contribute phosphorus to Myrtle Lake, and the number of SSTSs and the compliance status were estimated from county records. A conforming shoreline system is estimated to contribute on average 20% of the phosphorus that is found in the system, and nonconforming systems (both failing and ITPHS) along the shoreline contribute 43% of the phosphorus (assumptions from Barr Engineering 2004). Phosphorus loads were estimated with a spreadsheet approach using the MPCA's *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds* (Barr Engineering 2004). Total loading is based on the number of conforming and failing SSTSs, an average of 2.1 people per household (Barr Engineering 2004), and an average value for phosphorus production per person per year (MPCA 2014). Loading estimates are provided in Section 3.5.2.

3.5.1.4 Internal loading

Internal phosphorus loading from lake bottom sediments can be a substantial component of the phosphorus budget in lakes. The sediment phosphorus originates as an external phosphorus load that settles out of the water column to the lake bottom. There are multiple mechanisms by which phosphorus can be released back into the water column as internal loading:

- Low oxygen concentrations (also called anoxia) in the water overlying the sediment can lead to phosphorus release. In a shallow lake such as Myrtle Lake that undergoes intermittent mixing of the water column throughout the growing season, the released phosphorus can mix with surface waters throughout the summer and become available for algal growth. In 2018, intermittent stratification was observed at least six times in Myrtle Lake coupled with low DO in the bottom waters of the lake. These low DO concentrations likely led to pulses of phosphorus release from the sediments (Edlund et al. 2019).
- Bottom-feeding fish such as black bullhead forage in lake sediments. This physical disturbance can release phosphorus into the water column. Fisheries data available on the DNR's LakeFinder website indicate that black bullhead are present in Myrtle Lake; however, it is unknown if they are contributing to the impairment.
- Wind energy in shallow depths can mix the water column and disturb bottom sediments, which leads to phosphorus release.
- Other sources of physical disturbance, such as motorized boating in shallow areas, can disturb bottom sediments and lead to phosphorus release.

Additionally, high densities of panfish such as black crappie, bluegill, and perch can affect the trophic interactions in a lake. For example, if panfish consumption of large-bodied zooplankton is high, zooplankton grazing on algae can be reduced and can lead to higher levels of algae.

To estimate internal loads, an additional phosphorus load was added to the Myrtle Lake phosphorus budget to calibrate the lake response model (see Section 4.1.1); this load was attributed to internal loading and/or other sources (such as watershed loads, septic system loads, or altered trophic interactions) that were not quantified with the available data. The lake response model inherently includes an internal load that is typical of lakes in the model development data set. For Myrtle Lake, the data suggest that internal loads are greater than what would be expected in the lake.

3.5.1.5 Atmospheric deposition

Phosphorus is bound to atmospheric particles that settle out of the atmosphere and are deposited directly onto surface water. Phosphorus loading from atmospheric deposition to the surface area of Myrtle Lake was estimated using the average for the Rainy River basin (0.17 pounds [lb] per acre per year, Barr Engineering 2007).

3.5.1.6 Natural background sources

"Natural background" is defined in both Minnesota statute and rule. The Clean Water Legacy Act (Minn. Stat. § 114D.15, 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." Minn. R. 7050.0150, subp. 4 states, "'Natural causes' means the multiplicity of factors that determine the physical, chemical, or biological conditions that would exist in a water body in the absence of measurable impacts from human activity or influence."

Natural background sources are inputs that would be expected under natural, undisturbed conditions. Natural background sources can include inputs from natural geologic processes such as soil loss from upland erosion and stream development, atmospheric deposition, background levels of internal loading, and loading from forested land, wetlands, and wildlife. For Myrtle Lake, natural background levels are implicitly incorporated in the water quality standards used by the MPCA to assess impairment, and therefore natural background is accounted for and addressed through the MPCA's water body assessment process. Natural background conditions were evaluated within the source assessment portion of this study. These source assessment exercises indicate that natural background inputs are generally low compared to internal loading above background levels, SSTS, watershed runoff, and other anthropogenic sources. Based on the MPCA's water body assessment process and the TMDL source assessment exercises, there is no evidence at this time to suggest that the impairment is primarily due to natural background sources.

3.5.2 Summary of phosphorus sources

The primary phosphorus loads to Myrtle Lake are internal loading and watershed runoff (Table 9). The estimate of "internal and unidentified" loading includes other sources that may not have been quantified with the available data in the source assessment. For example, watershed loads or septic system loads in addition to those estimated in the source assessment would be lumped in with the "internal and unidentified" load estimate in Table 9. Although loads from developed areas represent only 5% of the total load, development is concentrated along the lakeshore and therefore has the potential to have a more direct effect on the lake's water quality than sources distributed throughout the watershed.

Table 9. Summary of phosphorus loads to Myrtle Lake

Source		**TP Load**	
		lb/yr	**%**
Watershed runoff	Wetland	18	1%
	Developed	71	5%
	Forest	319	21%
	Grasslands	9	1%
SSTS		29	2%
Internal and unidentified		900	60%
Atmospheric deposition		151	10%
Total		*1,497*	*100%*

4. TMDL development

A water body's TMDL represents the loading capacity, or the amount of pollutant that a water body can assimilate while still meeting water quality standards. The loading capacity is allocated to the water body's pollutant sources. The allocations include WLAs for NPDES-permitted sources, LAs for nonpermitted sources (including natural background), and an MOS, which is implicitly or explicitly defined. The sum of the allocations and MOS cannot exceed the loading capacity, or TMDL.

4.1 TMDL development approach

Details on the approaches used to develop the TMDL components are provided in the following sections.

4.1.1 Loading capacity and percent reductions

Allowable phosphorus loads to Myrtle Lake were determined using the lake response model BATHTUB. BATHTUB is a steady state model that predicts eutrophication response in lakes based on empirical formulas developed for nutrient balance calculations and algal response (Walker 1987). The model was developed by the U.S. Army Corps of Engineers and has been used extensively in Minnesota and across the Midwest for lake nutrient TMDLs. A spreadsheet version of the BATHTUB model was used for the Myrtle Lake TMDL. The BATHTUB model requires nutrient loading inputs from the upstream watershed and atmospheric deposition (Section 3.5.1), lake morphometric data (Table 6), and estimated mixed depth. Watershed runoff volumes and loads were derived from the HSPF model (RESPEC 2016, MPCA 2020a; see Section 3.5.1.2 for a brief description of the model).

The BATHTUB model was calibrated to the average lake phosphorus concentration, consisting of all data from 2015, 2016, and 2018, which were the only data collected in the 10-year period of 2010 through 2019 (Table 8). The models within BATHTUB inherently include an internal load that is typical of lakes in the model development data set. For Myrtle Lake, the data suggest that internal loads are greater than the average rates inherent in BATHTUB, and an additional internal load was added during model calibration (see *Internal loading* in Section 3.5.1.4).

After the model was calibrated, the TMDL scenario was developed according to the following:

- Watershed load reductions were based on the load reduction (31 lb/yr) that would be achieved if the average phosphorus concentration in the east tributary were the same as in the northeast tributary. The reduction was doubled (62 lb/yr) to account for potential reductions that could be achieved from other areas of the watershed.
- All SSTSs are conforming.
- No changes to loading from atmospheric deposition.
- The remaining load reductions needed to meet the water quality standard are from internal loading or unidentified sources.

The total load to the lake in the TMDL scenario represents the loading capacity, and the percent reduction needed to meet the TMDL was calculated as the existing load minus the loading capacity divided by the existing load. The estimated percent reduction provides a rough approximation of the overall reduction needed for Myrtle Lake to meet the TMDL. The percent reduction should not be construed to mean that each of the separate sources listed in the TMDL table needs to be reduced by that amount. An additional table with percent reductions by source is provided in Table 11 of the implementation strategy summary in Section 8. Model inputs and outputs are presented in Appendix A.

4.1.2 Wasteload allocation methodology: construction and industrial stormwater

The WLA is allocated to existing or future NPDES/SDS-permitted pollutant sources. WLAs are assigned to permitted construction and industrial stormwater to account for existing (i.e., the one permitted industrial stormwater site, see Section 3.5.1.1) and potential future sources in these sectors. This is based on the assumption that small, short-term construction and industrial stormwater permits might be required at a future date.

Construction stormwater is regulated through an NPDES permit (MNR100001). Untreated stormwater that runs off of a construction site often carries sediment to surface water bodies. Phase II of the stormwater rules adopted by the EPA requires an NPDES permit for a construction activity that disturbs one acre or more of soil; a permit is needed for smaller sites if the activity is either part of a larger development or 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. Although there are no permitted construction stormwater sites within the Myrtle Lake Watershed, the annual average area under construction in the entire Vermilion River Watershed is 0.08% (2015 through 2019 average). To allow for future permitted construction stormwater activities, the WLA for construction stormwater was calculated as 0.08% multiplied by the TMDL minus the MOS.

Industrial stormwater is regulated through NPDES permits (MNR050000 and MNG490000) when stormwater discharges have the potential to come into contact with materials and activities associated with the industrial activity. To allow for current and future permitted industrial stormwater activities, the WLA for industrial stormwater was calculated as equal to the construction stormwater WLA: 0.08% multiplied by the TMDL minus the MOS.

4.1.3 Load allocation methodology

The LA represents the portion of the loading capacity that is allocated to existing or future nonpermitted pollutant sources. The LA was calculated as the loading capacity minus the MOS minus the WLAs.

Natural background conditions were also evaluated, where possible, within the modeling and source assessment (Section 3.5.1.6). Natural background sources are implicitly included in the LA portion of the TMDL allocation tables, and TMDL reductions should focus on the major human-attributed sources identified in the source assessment.

4.1.4 Margin of safety

The MOS accounts for uncertainty concerning the relationship between load and WLAs and water quality. The MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as a load set aside). An explicit MOS of 10% was included in the Myrtle Lake phosphorus TMDL to account for these uncertainties. The use of an explicit MOS accounts for uncertainty in water quality monitoring, calibration and validation of the HSPF watershed model and BATHTUB model, and environmental variability in flow and phosphorus loading.

This MOS is considered to be sufficient given the robust dataset and the calibration results of the HSPF model. The Lake of the Woods Watershed model was calibrated and validated using 32 stream flow gaging stations (RESPEC 2015a), with 30 stations with TP monitoring data in the Vermilion River Watershed (RESPEC 2015b).

Calibration results indicate that the HSPF model is a valid representation of hydrology and water quality in the watershed. Simulated phosphorus loads from the model were used to estimate watershed loads to Myrtle Lake. The Myrtle Lake BATHTUB model generally shows good agreement between the observed lake water quality and the water quality predicted by the lake response model (Appendix A). The watershed loading model and lake response model reasonably reflect the watershed and lake conditions.

4.1.5 Seasonal variation and critical conditions

The CWA requires that TMDLs take into account seasonal variation and critical conditions for flow, loading, and water quality parameters as part of the analysis of loading capacity. Seasonal variations are addressed in the Myrtle Lake TMDL by assessing conditions during the summer growing season, which is when the water quality standards apply (June 1 through September 30). The frequency and severity of nuisance algal growth in Minnesota lakes is typically highest during the growing season. The nutrient standards set by the MPCA—which are a growing season concentration average, rather than an individual sample (i.e., daily) concentration value—were set with this concept in mind. Additionally, by setting the TMDL to meet targets established for the most critical period (summer), the TMDL will inherently be protective of water quality during all other seasons.

4.1.6 Baseline year

The monitoring data used to calculate the percent reductions are from 2015 through 2018. Because projects undertaken recently may take a few years to influence water quality, the baseline year for crediting load reductions for Myrtle Lake is 2016, the midpoint of the time period. Any activities implemented during or after the baseline year that led to a reduction in pollutant loads to Myrtle Lake may be considered as progress towards meeting the TMDL.

4.2 Myrtle Lake TMDL

Overall, a 29% reduction in phosphorus loading to Myrtle Lake is needed to meet water quality standards (Table 10). See Table 11 in Section 8: *Implementation strategy summary* for target loads and load reductions by source and Appendix A for lake modeling inputs and outputs.

Table 10. Myrtle Lake (69-0749-00) phosphorus TMDL summary

- Listing year or proposed year: 2018
- Baseline year(s): 2016
- Numeric standard used to calculate TMDL: 30 µg/L TP
- TMDL and allocations apply January through December

TMDL Parameter	TMDL TP Load	
	lb/yr	lb/day
WLA for construction stormwater (MNR100001)	0.77	0.0021
WLA for industrial stormwater (MNR050000 and MNG490000)	0.77	0.0021
Load allocation	956	2.6
Margin of safety	106	0.29
Loading capacity	1,064	2.9
Other		
Existing load	1,497	4.1
Percent load reduction	29%	29%

Loads are rounded to two significant digits, except in the case of values greater than 100, which are rounded to the nearest whole number.

5. Future growth considerations

Land cover in the Myrtle Lake Watershed is predominantly forested, with private residences and a resort along the lake shoreline. St. Louis County is projected to decrease in population by 2.5% by year 2050 (per data from Minnesota State Demographic Center), and a substantial increase in population in the Myrtle Lake Watershed is not expected. While development has slowed and is projected to decrease on average, the St. Louis County, Minnesota 2010 through 2020 Water Plan reports that development near lakes, rivers, and streams in the county increased during the last decade. The Water Plan projects that shoreland areas, especially on large popular lakes, will continue to be in demand for development.

5.1 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. 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.
2. 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.
3. A new MS4 or other stormwater-related point source is identified and is covered under a NPDES permit. In this situation, a transfer must occur from the LA.

Load transfers will be based on methods consistent with those used in setting the allocations in this TMDL. In cases where an allocation is transferred to a regulated MS4, the permittees will be notified of the transfer and have an opportunity to comment.

6. Reasonable assurance

A TMDL requires reasonable assurance that pollutant reduction targets will be achieved. Pollutant reduction needs in the Myrtle Lake Watershed are primarily from nonpermitted sources. There is "reasonable assurance" that elements are in place, for both permitted and nonpermitted sources, that are making (or will make) progress toward needed pollutant reductions. Restoration of Myrtle Lake will occur as part of local, regional, state, and federal efforts and will be led as appropriate by St. Louis County, North St. Louis Soil and Water Conservation District (SWCD), state and federal agencies, nonprofit organizations, and residents.

6.1 Reduction of permitted sources

6.1.1 Permitted construction stormwater

Regulated construction stormwater was given a categorical WLA is this study. Construction activities disturbing one acre or more are required to obtain NPDES permit coverage through the MPCA. Compliance with TMDL requirements are assumed when a construction site owner/operator meets the conditions of the Construction General Permit and properly selects, installs, and maintains all best management practices (BMPs) required under the permit, including any applicable additional BMPs required in Section 23 of the Construction General Permit for discharges to impaired waters, or compliance with local construction stormwater requirements if they are more restrictive than those in the State General Permit.

6.1.2 Permitted industrial stormwater

Industrial stormwater was given a categorical WLA in this study. Industrial activities require permit coverage under the state's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) or NPDES/SDS Nonmetallic Mining/Associated Activities General Permit (MNG490000). If a facility owner/operator obtains stormwater coverage under the appropriate NPDES/SDS permit and properly selects, installs, and maintains BMPs sufficient to meet the benchmark values in the permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL report.

6.2 Reduction of nonpermitted sources

Several nonpermitted reduction programs exist to support implementation of nonpoint source reduction BMPs in the Vermilion River Watershed. These programs identify BMPs, provide means of focusing BMPs, and support their implementation via state initiatives, ordinances, and/or dedicated funding. The North Saint Louis SWCD is active in the project area, and provides technical and financial assistance on topics such as shoreline protection and restoration, septic system assistance, and stormwater and sediment control.

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

6.2.1 SSTS program

SSTS are regulated through Minn. Stat. §§ 115.55 and 115.56. SSTS specific rule requirements can be found in Minn. R. 7080 through 7083. Regulations include the following:

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

Each county maintains an SSTS ordinance, in accordance with Minn. Stat. §§ 115.55 and 115.56 and Minn. R. 7080 through 7083, establishing minimum requirements for regulation of SSTS, for the treatment and dispersal of sewage within the applicable jurisdiction of the county, to protect public health and safety, to protect groundwater quality, and to prevent or eliminate the development of public nuisances. Ordinances serve the best interests of the county's citizens by protecting health, safety, general welfare, and natural resources. In addition, each county zoning ordinance prescribes the technical standards that on-site septic systems are required to meet for compliance and outlines the requirements for the upgrade of systems found not to be in compliance. This includes systems subject to inspection at transfer of property, upon the addition of living space that includes a bedroom and/or a bathroom, and at discovery of the failure of an existing system. Since 2002, St. Louis County has, on average, replaced over 300 systems per year (Figure 13).

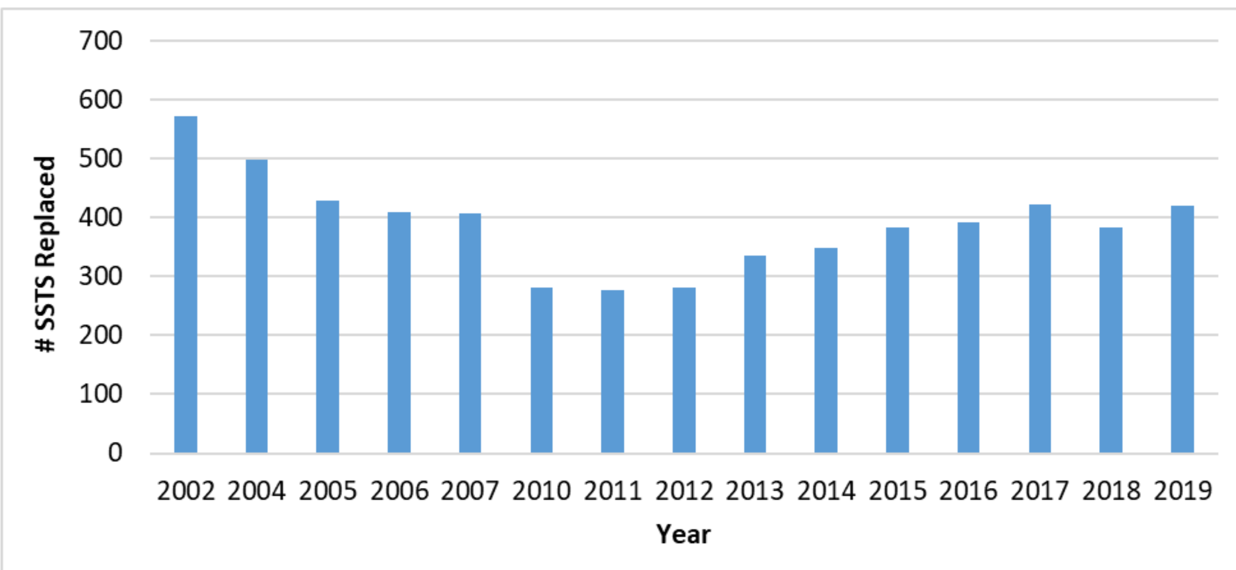

Figure 13. SSTS replacements in St. Louis County by year

Data not reported on replacements in 2003, 2008, and 2009

All known SSTS that are ITPHS are recorded in a statewide database by the MPCA. From 2006 to 2019, 797 alleged straight pipes were tracked by the MPCA statewide, 765 of which were abandoned, fixed, or were found not to be a straight pipe system. The remaining known, unfixed, straight pipe systems have received a notice of noncompliance and are currently within the 10-month deadline to be fixed, have been issued Administrative Penalty Orders, or are docketed in court. The MPCA, through the Clean

Water Partnership Loan Program, has awarded over $157,400 to St. Louis County to provide low interest loans for SSTS upgrades since 1998. More information on SSTS financial assistance can be found at the following address: https://www.pca.state.mn.us/water/ssts-financial-assistance.

6.2.2 Minnesota buffer law

Minnesota's buffer law (Minn. Stat. § 103F.48) requires perennial vegetative buffers of up to 50 feet along lakes, rivers, and streams and buffers of 16.5 feet along ditches. These buffers help filter out phosphorus, nitrogen, and sediment. Alternative practices are allowed in place of a perennial buffer in some cases. Amendments enacted in 2017 clarify the application of the buffer requirement to public waters, provide additional statutory authority for alternative practices, address concerns over the potential spread of invasive species through buffer establishment, establish a riparian protection aid program to fund local government buffer law enforcement and implementation, and allowed landowners to be granted a compliance waiver until July 1, 2018, when they filed a compliance plan with the appropriate SWCD.

The Board of Water and Soil Resources (BWSR) provides oversight of the buffer program, which is primarily administered at the local level. Compliance with the buffer law ranges from 94% to 100% in St. Louis County as of January 2020 (data available on BWSR website under Buffer Program Update).

6.2.3 Minnesota Nutrient Reduction Strategy

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

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

Included within the strategy discussion are alternatives and tools for consideration by drainage authorities, information on available tools and approaches for identifying areas of 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. The strategy has set a reduction of 10% for phosphorus and 13% for nitrogen in the Lake Winnipeg Basin (relative to 2003 conditions).

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 (IWM)
- 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.

6.3 Summary of local plans

Minnesota has a long history of water management by local government, which included developing water management plans along county boundaries since the 1980s. The BWSR-led One Watershed, One Plan (1W1P) program is rooted in work initiated by the Local Government Water Roundtable (Association of Minnesota Counties, Minnesota Association of Watershed Districts, and Minnesota Association of SWCDs). The Roundtable recommended that local governments organize to develop focused implementation plans based on watershed boundaries. That recommendation was followed by the legislation (Minn. Stat. § 103B.801) that would establish the 1W1P program, which provides policy, guidance, and support for developing comprehensive watershed management plans:

- Align local water planning purposes and procedures on watershed boundaries to create a systematic, watershed-wide, science-based approach to watershed management.
- Acknowledge and build off of existing local government structure, water plan services, and local capacity.
- Incorporate and make use of data and information, including WRAPS.
- Solicit input and engage experts from agencies, citizens, and stakeholder groups; focus on implementation of prioritized and targeted actions capable of achieving measurable progress.
- Serve as a substitute for a comprehensive plan, local water management plan, or watershed management plan developed or amended, approved, and adopted.

St. Louis County has decided to participate in the 1W1P process and intends to begin planning within the next several years. The Myrtle Lake Watershed will be incorporated into the 1W1P for the combined Vermilion River and Rainy River–Rainy Lake HUC-8 watersheds. The 1W1P planning boundaries are found at the following link: https://bwsr.state.mn.us/one-watershed-one-plan-participating-watersheds.

Until the completion of a comprehensive watershed management plan in the Myrtle Lake Watershed, the St. Louis County Water Plan (2010–2020) remains in effect per the Comprehensive Local Water Management Act (Minn. Stat. § 103B.301). The plan expiration date may be extended pending future participation in the 1W1P program. Restoring waters in the county listed as “impaired” on the state 303(d) list is a priority concern addressed in the current water plan. Action items to address impaired waters include developing protection strategies and implementing projects and actions directed at reducing sources of nonpoint pollution. Reduction of nonpoint pollution is also addressed in the St. Louis County Comprehensive Land Use Plan, which includes actionable language that addresses wastewater issues related to failing septic systems and the protection of lakes and watercourses through setbacks/buffering.

6.4 Examples of pollution reduction efforts

In addition to consulting resource professionals to determine appropriate approaches to improving Myrtle Lake's water quality, North Saint Louis SWCD and the MPCA have reached out to local residents through public meetings and workshops. North Saint Louis SWCD has previously led projects to improve water quality elsewhere in the Vermilion River Watershed, and similar efforts are expected to occur in the Myrtle Lake Watershed in the future.

- In 2018, North Saint Louis SWCD offered a shoreline BMPs workshop in Orr, Minnesota. This workshop targeted Myrtle Lake shoreland owners and included a demonstration of the NRCS rainfall simulator.
- In 2019, North Saint Louis SWCD offered an SSTS workshop in Cook, Minnesota.
- Between 2017 and 2020, there has been an on-going effort to communicate water quality and stream restoration and protection efforts in the Vermilion River Watershed, including the Myrtle Lake Subwatershed. These include no fewer than 4 public meetings and 10 watershed project team meetings consisting of regional natural resource professionals at the local, county, state, and federal government levels. Outreach at these meetings included requesting enrollment of a volunteer citizen lake monitor. Property owners at the meetings indicated interest in enrolling in the citizen monitoring program.
- North Saint Louis SWCD actively works with landowners, including those on nearby Lake Vermilion and Pelican Lake, to enhance water quality through shoreline protection and restoration including aerial photo ranking of shoreline habitat, shoreline stabilization, stormwater and sediment control, and SSTS outreach. Similar future outreach efforts are anticipated in the Myrtle Lake Watershed.

6.5 Funding

Funding sources to implement TMDLs can come from local, state, federal, and/or private sources. Examples include BWSR's Watershed-based Implementation Funding, Clean Water Fund Competitive Grants (e.g., Projects and Practices), USFS, and conservation funds from the Natural Resources Conservation Service (NRCS) (e.g., Environmental Quality Incentives Program and Conservation Stewardship Program).

Watershed-based implementation funding is a noncompetitive process to fund water quality improvement and protection projects for lakes, rivers/streams, and groundwater. This funding allows collaborating local governments to pursue timely solutions based on a watershed's highest priority needs. The approach depends on the completion of a comprehensive watershed management plan developed under the 1W1P program or the Metropolitan Surface Water framework to provide assurance that actions are prioritized, targeted, and measurable.

BWSR has begun the transition of moving toward watershed-based implementation funding to accelerate water management outcomes, enhance accountability, and improve consistency and efficiency across the state. This approach allows more clean water projects to be implemented and helps local governments spend limited resources where they are most needed.

Watershed-based implementation funding assurance measures are based on fiscal integrity and accountability for achieving measurable progress towards water quality elements of comprehensive watershed management plans. Assurance measures will be used as a means to help grantees meaningfully assess, track, and describe use of these grant funds to achieve clean water goals through prioritized, targeted, and measurable implementation. The following assurance measures are supplemental to existing reporting and on-going grant monitoring efforts:

- Understand contributions of prioritized, targeted, and measurable work in achieving clean water goals.
- Review progress of programs, projects, and practices implemented in identified priority areas.
- Complete Clean Water Fund grant work on-schedule and on-budget.
- Leverage funds beyond the state grant.

6.6 Other partners and organizations

The Natural Resource and Water Management program at Vermilion Community College of Ely, Minnesota was engaged in water quality and watershed data collection efforts in the Myrtle Lake Watershed in 2018. In addition, a paleolimnology study by the Minnesota Science Museum's Saint Croix Watershed Research Station (Edlund et al. 2019) provided a greater understanding of Myrtle Lake's historic water quality condition. Their efforts were a key contribution to the data presented in this TMDL.

Future partnerships with nearby lake associations, such as the Vermilion Lake Association and the Pelican Lake Association, should be encouraged to foster the organization and engagement of Myrtle Lake lakeshore owners with the potential to assemble a lake association for Myrtle Lake. With much of the shoreline under USFS management, the USFS is also an important partner that can assist with monitoring, planning, and projects.

6.7 Reasonable assurance conclusion

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

7. Monitoring

7.1 Monitoring

Monitoring in the Myrtle Lake Watershed is expected to occur through the following programs:

- **Monitoring approach**: IWM at the HUC-8 watershed scale is part of the MPCA's watershed approach to restoring and protecting water quality. Monitoring occurs in each HUC-8 watershed approximately every 10 years and consists of a 2-year intensive monitoring program of lakes and streams in which the MPCA determines their overall health and identifies impaired waters. The next round of IWM in the Vermilion River Watershed will begin in 2025, and Myrtle Lake will be a priority candidate for follow-up monitoring.

- **Citizen water monitoring:** The MPCA coordinates two programs aimed at encouraging long term citizen surface water monitoring: the Citizen Lake Monitoring Program (CLMP) and the Citizen Stream Monitoring Program (CSMP). Having citizen volunteers monitor a given lake or stream station monthly and from year to year can provide long-term data needed to help evaluate current status and trends. Citizen monitoring is especially effective at helping to track water quality changes that occur in the years between intensive monitoring years. This program has been promoted at public meetings for the Myrtle Lake Watershed and some landowners have expressed interest in participating.
- **Watershed Pollutant Load Monitoring Network:** The MPCA's WPLMN measures and compares pollutant load data from Minnesota's rivers and streams and tracks water quality trends. Two WPLMN sites are located on the Vermilion River, bracketing the entry of the Pelican River downstream from Myrtle Lake. These long term sites are expected to be monitored yearly throughout the monitoring season and can help with future calibration of the HSPF model for the Vermilion River Watershed (RESPEC 2016, MPCA 2020a).

7.2 Optional monitoring

Monitoring can also be used to further evaluate the Myrtle Lake impairment and phosphorus sources to the lake. These recommendations are optional and will be dependent on priorities and available resources.

- Flow and load monitoring of tributaries to Myrtle Lake to quantify watershed loads and improve the phosphorus mass balance. Multiple sites along the east tributary could be monitored to help determine why phosphorus concentrations may be elevated (as they were in 2018) compared to concentrations in the northeast tributary.
- Additional high frequency buoy monitoring to better understand the link between climate/meteorological conditions and summer stratification and internal loading in Myrtle Lake. This data collection could be paired with inflow, outflow, and lake monitoring. See Edlund et al. (2019) for more information on monitoring recommendations.
- Evaluate relationship between high panfish densities, walleye stocking practices, zooplankton assemblages, and water quality to determine if trophic interactions are contributing to high Chl-*a* concentrations (see Section 3.2: Fisheries).

8. Implementation strategy summary

This section summarizes implementation strategies that could be used to help achieve the Myrtle Lake TMDL. Achieving water quality goals in Myrtle Lake is dependent on reductions from nonpermitted sources. Overall, a 29% reduction in phosphorus loading to Myrtle Lake is needed to meet water quality standards. Load reductions are needed from watershed runoff, SSTS, and internal loading (Table 11).

This section provides an overview of implementation strategies and example BMPs that may be used to improve the water quality in Myrtle Lake. The strategies and BMPs included here are not exhaustive, and implementation will proceed based on principles of adaptive management (Section 8.4).

Phosphorus reduction can have unintended consequences including increased vegetation and changing fish community composition. These possibilities should be clearly communicated to lake stakeholders prior to proceeding (MPCA 2020b).

Table 11. Myrtle Lake (69-0749-00) phosphorus load reductions by source

Source	Existing Load (lb/yr)	Target Load (lb/yr)	Load Reduction Needed (lb/yr)	% Reduction
Watershed	417	355	62	15%
SSTS	29	26	3	10%
Internal and unidentified	900	532	368	41%
Atmospheric deposition	151	151	0	0%
Total	*1,497*	*1,064*	*433*	*29%*

8.1 Permitted sources

8.1.1 Construction stormwater

The WLA for stormwater discharges from sites where there is construction activity reflects the potential 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 Section 23 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.

8.1.2 Industrial stormwater

The WLA for stormwater discharges from sites where there is industrial activity reflects the potential number of sites in the watershed for which NPDES/SDS 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. Minnesota's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) and NPDES/SDS Nonmetallic Mining/Associated Activities General Permit (MNG490000) establish benchmark concentrations for pollutants in industrial stormwater discharges. If a facility owner/operator obtains stormwater coverage under the appropriate NPDES/SDS Permit and properly selects, installs, and maintains BMPs sufficient to meet the benchmark values in the permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL report. Industrial activity must also meet all local government stormwater requirements.

8.2 Nonpermitted sources

Achieving water quality goals in Myrtle Lake will require reductions in nonpermitted sources. Load reductions are needed from watershed runoff, SSTS, and internal loading (Table 11), which are all nonpermitted sources. The implementation strategies presented below (Table 12) address these priority sources.

Watershed runoff: Work with landowners to encourage the protection and maintenance of healthy vegetative buffers along the shoreline and assist with restoration in areas that lack a protective vegetative buffer. Encourage landowners to use lawn management practices that minimize nutrient loading to the lake. Install rain gardens to enhance runoff infiltration and nutrient uptake. Protect healthy buffers on tributaries to the lake. Assess road crossings and roads adjacent to tributaries for erosion, pollutant runoff, and flow restriction, and work with road authorities and landowners to make improvements where appropriate.

Septic system improvements: Complete an updated inventory of SSTS in the Myrtle Lake Watershed, identifying total number of systems and compliance status. Prioritize SSTS according to compliance status; identify all ITPHS systems as high priority for maintenance and replacement. Work with private landowners to achieve compliance.

Internal loading: Consider addressing internal loading reductions in addition to external loading reductions. If external loading is not adequately addressed, in-lake treatment efforts will be short-lived. Costs of in-lake treatments such as alum (aluminum sulfate) should consider the longevity of effectiveness as recurring applications may be needed to sustain water quality. Treatments tend to be shorter lived on shallow lakes like Myrtle Lake, lasting from 1 to 11 years (MPCA 2020b). Treatment would likely need to occur across the entire lake basin as shown by the sediment core transect described in Section 3.4. Sediment core incubations and DO and temperature monitoring (Section 3.4) suggest internal loading is likely a major contributor to phosphorus loading, and internal load management may be required to achieve water quality goals.

Fisheries management: Collaborate with the DNR to verify that fish populations are not contributing to impairment through trophic interactions that enhance algae growth. Because other nutrient sources are also driving algae production, fisheries management should only be considered in the context of a comprehensive watershed management plan that includes nutrient reductions from other sources.

Education and outreach: Provide education and outreach for pollution reduction activities. Provide information or hands-on workshops to landowners on septic system maintenance, lawn care, and maintaining healthy vegetative shoreline buffers.

Table 12. Example BMPs for nonpermitted phosphorus sources

Target Source Type	Implementation Strategy	BMP Examples
Watershed runoff	Shoreline management	Shoreline buffers Improved lawn management practices Rain gardens
	Watershed runoff control	Assess road crossings and roads adjacent to tributaries for erosion, pollutant runoff, and flow restriction, and work with proper authority to correct. Protect healthy buffers on tributaries.
SSTS	SSTS improvements	SSTS inventory, maintenance, and replacement
Internal loading	In-lake management [a]	Alum treatment Fisheries management
All	Education and outreach	Distribute information to landowners Workshops with landowners

a. See *Minnesota State and Regional Government Review of Internal Phosphorus Load Control* (MPCA 2020b) for more information on selecting internal load management practices.

8.3 Cost

TMDLs are required to include an overall approximation of implementation costs (Minn. Stat. 114D.25). Costs to implement the activities outlined in the strategy are approximately $300,000 to $2 million over the next 10 years to address nonpermitted sources. The cost estimate is based on historical project costs and best professional judgement. The cost estimate includes watershed runoff BMPs, assisting homeowners with SSTS maintenance and upgrades, and internal loading management. The cost includes increasing local capacity to oversee implementation in the watershed and the voluntary actions needed to achieve necessary TMDL reductions.

Education and outreach are not included in the cost estimate, nor are stream crossing upgrades and SSTS maintenance and upgrades. Upgrading stream crossings is assumed to be part of regular road construction activities. Replacement and maintenance of SSTS systems were not considered in the overall cost calculation because their costs are already accounted for in existing programs. The cost includes increasing local capacity to oversee implementation in the watershed and the voluntary actions needed to achieve necessary TMDL reductions.

8.4 Adaptive management

This list of implementation elements and the more detailed WRAPS report (MPCA 2021), which was prepared concurrently with this TMDL report, are based on the principle of adaptive management (Figure 14). Continued monitoring and “course corrections” responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in this TMDL report. Management activities will be changed or refined as appropriate over time to efficiently meet the TMDL and lay the groundwork for de-listing Myrtle Lake.

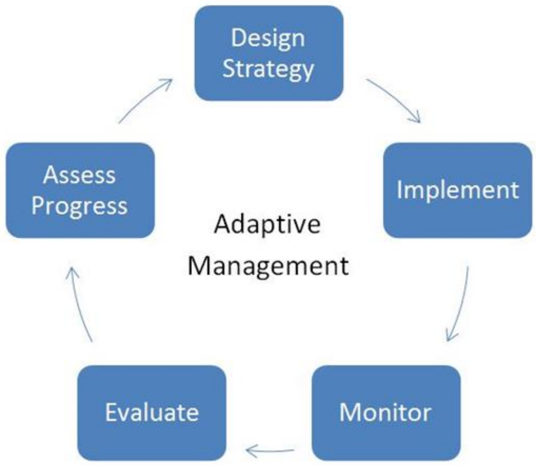

Figure 14. Adaptive management

9. Public participation

Two public meetings targeted at the local community and lakeshore owners were held to raise awareness of the Myrtle Lake nutrient impairment and encourage participation in water quality restoration and protection. Other objectives of these meetings included obtaining local knowledge of the watershed and observed historical water quality and feedback from residents on water quality concerns. Some meeting participants noted no change in water quality over recent decades while others felt water quality had worsened in recent years. There was concern for impacts to recreation on the lake for residents and those who visit the resort. Recreational fishing is important to area residents and visitors, and some use the lake for swimming. Some participants shared images of blooms they witnessed, one brought a water sample from a tributary to the lake, and one shared that he had had a skin reaction to contact with a bloom. There was also concern for how algae blooms might impact wildlife and fish. Most participants were residents, and most had a desire to improve water quality on the lake.

Myrtle Lake impairment meetings were held on the following dates:

- Orr, Minnesota: August 3, 2018
- Orr, Minnesota: July 19, 2019

Two additional public stakeholder meetings were held as part of the Vermilion River WRAPS process. The meetings provided an overview of the MPCA's watershed approach, details on impairments within the Vermilion River Watershed, and an introduction to WRAPS. After a presentation, participants asked questions about the process and shared concerns about protecting the Vermilion River Watershed. The Myrtle Lake impairment was discussed at these meetings alongside the water quality in the rest of the Vermilion River Watershed.

Vermilion River WRAPS Meetings were held on the following dates:

- Orr, Minnesota: November 13, 2017
- Ely, Minnesota: November 16, 2017

Three additional meetings were held with area organizations including the Vermilion Lake Association, A core team of regional resource professionals met ten times to provide their professional judgement on water quality issues within the watershed and provide guidance to WRAPS and TMDL development. This core team included representatives from various entities:

- North Saint Louis SWCD
- DNR
- 1854 Treaty Authority
- MPCA
- Minnesota BWSR
- Minnesota Department of Health
- USFS

Public notice

An opportunity for public comment on the draft TMDL report was provided via a public notice in the State Register from August 30, 2021 through October 29, 2021. During this time two public meetings were held to inform the public about the Report and how to comment. These were held on September 8, 2021 and October 8, 2021. There were no comment letters received as a result of the public comment period.

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Appendix A: Myrtle Lake BATHTUB Model

Global variables		
Averaging period (yrs)	1	
Precipitation (m)	0.73	
Evaporation (m)	0.73	
Atmospheric TP Load (kg/km2-yr)	19.3	
Model options		
P balance	CB-LAKES	
P calibration	decay rates	
Model coefficients		
TP	1.00	
TP Availability Factor	1.00	
Segment	**Baseline**	**TMDL**
Area (ac)	876	
Mean depth (m)	2.97	
Mean depth of mixed layer (m)	2.97	
Segment observed TP (µg/L)	38	
Segment TP calibration factor	1	
Target TP (µg/L)	30	
TP internal load release rate (mg/m2-d)	3.4	2.0
TP internal load time of release (days)	34	34
Hydraulic residence time (yr)	1.7	
Overflow rate (m/yr)	1.8	

Segment mass balance: Baseline	**Flow (hm3/yr)**	**% Flow**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Watershed	6.26	71%	417	28%	30
SSTS	0.00464	0.05%	29	2%	2,833
Precipitation	2.59	29%	151	10%	26
Internal	0	0%	900	60%	
Total inflow	8.85	100%	1,497	100%	77
Evaporation	2.59	29%	0	0%	
Retention	0	0%	969	65%	
Total outflow	6.26	71%	528	35%	38

Segment mass balance: TMDL	**Flow (hm3/yr)**	**% Flow**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Watershed	6.26	71%	355	33%	26
SSTS	0.00464	0.05%	26	2%	2,540
Precipitation	2.59	29%	151	14%	26
Internal	0	0%	532	50%	
Total inflow	8.85	100%	1,064	100%	55
Evaporation	2.59	29%	-	0%	
Retention	0	0%	650	61%	
Total outflow	6.26	71%	414	39%	30