Watershed Management Plan

2026 – 2036

SWWD

South Washington Watershed District

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MISSION STATEMENT

To manage water and related resources of the district in cooperation with our residents and communities.

Executive Summary & How to Use this Plan

The South Washington Watershed District (SWWD) is a special-purpose local government unit established to manage water resources across the southern end of Washington County. Its authorities and primary roles are established in Minnesota (MN) Statutes 103B and 103D, and MN Rules 8410. SWWD's activities and staff are managed by a five-member Board of Managers appointed by the Washington County Board of Commissioners and serve to meet the District's mission:

To manage water and related resources of the District in cooperation with our residents and communities.

SWWD implements a variety of programs, projects, and capital improvements focused on protecting and restoring its natural resources and improving the resiliency of stormwater management systems within the watershed. This Watershed Management Plan (Plan) has been developed to assess the resource priorities of the community and provide guidance as SWWD undertakes actions to address those priorities over the next ten years.

PART 1 | SWWD INTRODUCTION

Part 1 provides basic information about the watershed and its resources, including physical characteristics and natural history. It is intended to establish a historical context for how SWWD assesses and responds to priority issues later identified in Part 2 of the Plan. Monitoring data, trends, and management recommendations for the primary water resources within the watershed are in SWWD's Lake Management Plan found in Appendix A.

PART 2 | WATERSHED ISSUES

Part 2 identifies issues affecting the watershed and serves as the underlying basis for SWWD's implementation programs and goals established in Part 3. Additionally, it lays out the strategies SWWD will employ to address the issues facing the watershed today and over the next ten years. These priority issues were developed after a thorough input-gathering process involving the general public, SWWD partners, local governments, State agencies, SWWD's Board of Managers, and Community Advisory Committee.

PART 3 | IMPLEMENTATION

Part 3 establishes SWWD's implementation programs and lays out the process by which projects are developed to address issues identified in Part 2. Goals found in this section provide how SWWD can measure its success over the life of this Plan. Many of these goals address a variety of issues at once, reinforcing the interconnected nature of surface water, groundwater, and terrestrial resources. SWWD operates under the premise that healthy water requires healthy land. Readers of this Plan will find this emphasis sprinkled throughout SWWD's programs as it seeks to protect, preserve, and restore critical greenway corridors and lands associated with groundwater-dependent natural resources.

Board of Managers

Sharon Doucette, *President*
Cottage Grove

Andrea Date, *Vice President*
Woodbury

Emily Stephens, *Treasurer*
Cottage Grove

David Filipiak, *Secretary*
Woodbury

Kevin ChapdeLaine, *Manager*
Newport

Acknowledgments

The watershed plan update is a result of many contributers providing valuable input on behalf of their communities, organization, and agencies.

Technical Advisory Committee

Board of Water and Soil Resources, Minnesota Department of Health, Minnesota Department of Natural Resources, Minnesota Department of Transportation, Metropolitan Council, Minnesota Pollution Control Agency, SWWD local city partners, Washington County, and the Washington Conservation District.

Community Advisory Committee

Sam Behrends (Denmark Twp.), Laura Duffey (Newport), Patty Goertz (Denmark Twp.), Dan Henely (Woodbury), Sarah Lilja (Lake Elmo), Howard Markus (Woodbury), Jeff Mohr (Grey Cloud Island Twp), David Nuccio (Woodbury), Jay Sockness (Cottage Grove), and Bill Sumner (Newport).

View from Point Douglas Park at the St. Croix River
Photo by Sarah Lilja, SWWD Artist-in-Residence 2024

PART 1

SWWD Introduction

Edgewater Park at Colby Lake, Woodbury

Photo by Sarah Lilja, SWWD Artist-in-Residence 2024

1.1 | SWWD HISTORY & PLAN CONTEXT

The Minnesota Watershed Act, Minnesota State Statutes 103D, authorized the establishment of Watershed Districts and was passed in 1955. Established as local, special-purpose units of government, Watershed District boundaries follow the natural hydrological boundaries of a watershed. Often originally established for flood control or agricultural drainage improvement purposes, Watershed Districts are now increasingly focused on water quality issues, particularly in the Minneapolis-St. Paul metropolitan area since the development of Minnesota State Statutes 103B in the 1980s. The South Washington Watershed District (SWWD) is no different.

SWWD first began in 1984 as the Cottage Grove Ravine Watershed Management Organization (WMO) to help address inter-community flooding concerns. The WMO was based on a joint powers agreement among the cities of Afton, Cottage Grove, Lake Elmo, Oakdale, and Woodbury. A draft watershed management plan for the WMO was completed in April 1988. However, that plan was never approved or adopted by the WMO. The WMO was later disbanded, and, in 1993, the Cottage Grove Ravine Watershed District was formed in its place as Minnesota's 42nd watershed district. In 1995, the District changed its name to South Washington Watershed District (SWWD). By September of 1997, the first SWWD Watershed Management Plan (Plan) was completed and adopted. That first plan was heavily oriented toward inventory and assessment of District resources, and to address the inter-community flows and flooding concerns at the time. Since then, the District's focus has grown to include the protection and restoration of land and water resources.

Mississippi River flooding (1948)
Hennepin County Library

In April 2003, the SWWD petitioned the Minnesota Board of Water and Soil Resources (BWSR) to enlarge its boundary to include the former East Mississippi Watershed Management Organization (EMWMO), as recommended in the 1999 Washington County Water Governance Study. The EMWMO included all or portions of Grey Cloud Island Township, Cottage Grove, Woodbury, St. Paul Park, and Newport. The enlargement petition was approved by BWSR in May 2003.

In 2007, SWWD's second plan was adopted. Building on work completed under the first plan, the second plan emphasized implementation to address inter-community flow concerns and began to manage District land and water resources to protect and restore their value to watershed residents and visitors.

In May 2010, the SWWD again petitioned to enlarge its boundary to include three additional catchments from the former Lower St. Croix Watershed Management Organization (LSCWMO). The enlargement petition was approved in September 2010 by BWSR, making SWWD one of the few watershed districts to manage land and water resources within two major watershed basins.

Consequently, the now easternmost portion of SWWD lies within the Lower St. Croix River basin. The Lower St. Croix River Comprehensive Watershed Management Plan was approved in 2020 as part of the State's One Watershed One Plan (1W1P) program. The State's vision and purpose for this program is to align local water planning on major watershed boundaries with state strategies toward prioritized, targeted, and measurable implementation

plans. While the resulting Plan is comprehensive in that it includes improvements and protection for a variety of natural resources across a large geographic area, it also incorporates detail in its prioritization and targeting actions and outcomes for specific waterbodies. The Lower St. Croix 1W1P was developed through a memorandum of agreement and collaborative partnership among fifteen local governments, including four counties, five soil and water conservation districts (SWCD), two watershed management organizations (WMO), and four watershed districts (WD), including SWWD. SWWD strives to be an engaged and collaborative contributor to this regional partnership.

This current SWWD Plan once again builds on past work within the District. SWWD will also work toward addressing current and historical inequities in the management of land and water throughout the District. SWWD is committed to diversity, equity, and inclusion (DEI) principles, and continues to work toward incorporating DEI policies and practices within the context of strategic watershed management. The WMP is intended to serve SWWD and its residents for the next ten years while providing a sound base for future planning efforts over the decades to come.

1.2 | SWWD'S MUNICIPALITIES

SWWD's jurisdiction is located entirely within Washington County and covers 71,348 acres (or 111.5 square miles) at the confluence of the Mississippi and St. Croix Rivers (see Figure 1). The District includes portions of the Mississippi River and St. Croix River major watersheds, borders both of those rivers, and encompasses more than a dozen lakes, over 120 miles of piped and natural streams, and over 2,400 total acres of wetlands. SWWD manages these resources in partnership with Washington County and ten cities and townships, including Afton, Cottage Grove, Denmark Township, Grey Cloud Island Township, Hastings, Lake Elmo, Newport, Oakdale, St. Paul Park, and Woodbury. The watershed area and relative portions of the watershed contained within each of the municipalities are presented in Table 1 below.

Municipality	Acreage	Square Miles	% of SWWD
City of Cottage Grove*	23,993	37.5	33.6%
Denmark Township	19,240	30.1	27.0%
City of Woodbury*	16,828	26.3	23.6%
City of Afton	3,032	4.7	4.3%
City of Newport*	2,464	3.8	3.4%
City of St. Paul Park*	2,289	3.6	3.2%
Grey Cloud Island Township	1,953	3.1	2.8%
City of Oakdale*	656	1.0	0.9%
City of Lake Elmo*	619	1.0	0.9%
City of Hastings*	274	0.4	0.4%
Total	**71,348**	**111.5**	**100%**

* Indicates community covered by the Municipal Separate Storm Sewer System (MS4) General Permit issued and administered by MPCA

Table 1. Municipal land areas within SWWD.

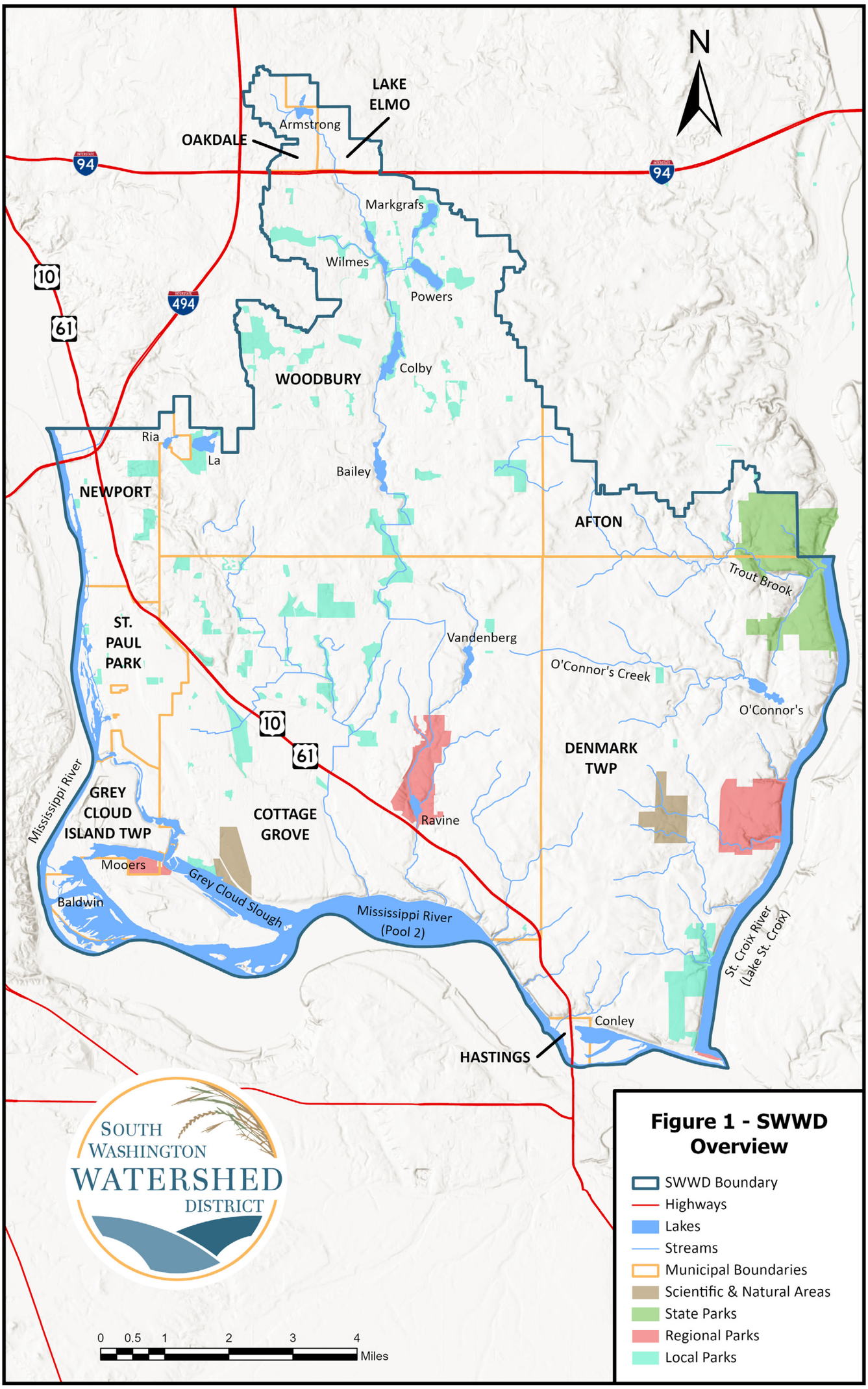


Figure 1: SWWD Overview. Significant geographic overview including municipal, and district boundaries, lakes and streams, highways, scientific and natural areas, and local, regional, and state parks.

1.3 | GEOLOGY, SOILS, & GROUNDWATER

Landforms and water resources in the SWWD largely reflect past glacial activity. Glacial processes and runoff from melting glaciers filled pre-glacial bedrock valleys, carved new bedrock valleys, and deposited till and outwash in varying forms across the District. Today, we can see several prominent remnants of that activity on the landscape. Topography data is available on the District's online interactive web viewer.

Soils in SWWD are all derived from glacial alluvium or till deposited along the Mississippi and St. Croix valleys. Soil types that dominate the Mississippi River drainage area of the District are of the Antigo-Chetek-Mahtomedi and Sparta-Dickman-Hubbard map units which were formed predominantly in outwash under deciduous hardwood forest or prairie. The Antigo-Chetek-Mahtomedi soils are well-drained to excessively drained, medium-textured to coarse-textured soils, typical on low convex side slopes or knolls, crests, and side slopes. The Sparta-Dickman-Hubbard soils are somewhat excessively drained and are coarser textured soils than the Antigo type. These soils occupy broad flats and knolls. The Copaston-Sparta map unit consists of and dominates medium-textured to coarse-textured soil types along the Mississippi River, primarily on the historic river terrace. In the eastern portion of the watershed that drains to the St. Croix River, common soil types include the Ostrander-Baytown-Ripon map unit and the Waukegan-Baytown-Ripon map unit. Both map units are formed in a silty mantle over bedrock or over glacial till or outwash. Soils are well-drained and medium-textured in the upland areas of the watershed.

Wetlands, once common in portions of the District with dense soils, have largely succumbed to development. However, remaining wetlands provide important ecological, aesthetic, recreational, and economic benefits. SWWD recognizes these values and actively works to protect remaining wetlands through implementation of development standards and its role in administering the State of Minnesota's Wetland Conservation Act (WCA).

All residents in the District rely on groundwater for drinking water, whether it is provided by public water suppliers or private wells. The quantity and quality of that groundwater, like that of District surface waters, is shaped by the region's geologic characteristics.

Advancing and retreating marine seas left behind a sequence of limestone, sandstone, and shale bedrock layers dating back to the Paleozoic Era (570 to 245 million years ago). Following these events, the bedrock was subjected to a long period of erosion. Following that period of erosion, a series of glaciers advanced and retreated across the county, shaping the bedrock and leaving in their wake formations of clay, silt, sand, and gravel on top of bedrock formations. Resulting layers of bedrock, sand and gravels, and silt form the various aquifers lying beneath the District and are responsible for its characteristically high infiltration rates and groundwater recharge potential. The bedrock configurations that make groundwater abundant also make it highly sensitive to pollution through high infiltration rates and the presence of karst features.

Furthermore, the quantity of groundwater is an increasing concern. Growing populations have resulted in increased pumping from aquifers, while simultaneously reducing the chance for groundwater aquifers to recharge. What is still somewhat unknown is how threats to groundwater translate to surface water resources which, to date, have been the focus of SWWD's management efforts.

1.4 | NATURAL HISTORY & LAND USE

Prior to the arrival of European settlement, plant communities were composed of a rich mosaic of grassland, wetland, woodland, and forested lands. On the rolling hills and level ground throughout the center of the District, tallgrass prairie dominated the landscape. These plant communities were maintained by periodic fire and large animal grazers, developing deep, rich soils resulting from the extensive underground root systems of native grasses and flowers. Fires occurred as both a natural phenomenon and a management practice of the Native peoples of the region. Natural disturbances kept trees and other woody vegetation small and scattered. Along the western slopes above the Mississippi River, dissected ravines in the south and east, and on upland ridges of the SWWD, bur oak or aspen savanna were

present. This community is considered a transitional type between forest and grassland with fire-adapted trees able to survive or rebound from the prairie disturbances. Forest communities dominated by maple and basswood, as well as lowland/floodplain forests of silver maple, elm, and cottonwood were present in protected, steep ravines or along the low river floodplains of the Mississippi River, and to a lesser degree, the St. Croix Valley.

The Mississippi and St. Croix Rivers played a prominent role in the settlement and transformation of the region. Prior to European settlement, the land currently within SWWD's jurisdictional boundary was home to Native peoples. There is a documented, long, varied, and vibrant history of living with and caring for this land by Native peoples, particularly Dakota tribes. The Treaty of 1837 resulted in the cession of all native lands east of the Mississippi River and islands within it (including all the modern-day SWWD) to the United States federal government, and the relocation of tribal villages to the western shore of the river and beyond. As large-scale land use and cover changes due to European settlement, Grey Cloud Island, with its long history of Native settlement, quickly became a center for trade along the Mississippi River. At the confluence of the Mississippi and St. Croix Rivers, Point Douglas (today part of Denmark Township) served and supported logging activity in the St. Croix basin and was also the starting point of Military Road, which crossed the District on its way to Fort Snelling and Fort Ripley. Throughout the District, trees were cleared, and land was utilized for row crops.

Despite these changes, the cultural significance of Dakota sites at Grey Cloud Island, Red Rock (modern-day Newport), Kaposia, and Wakan Tipi, as well as others in the area, remains today. SWWD and its current residents all have an important duty to honor and care for the watershed while respecting that history. However, that history is not SWWD's to interpret. Rather, it is best told by members of the communities themselves.

SWWD encourages residents to explore and understand the history of Native peoples in this area. For more information and/or interpretation of the history of Native peoples, please contact the following communities and organizations:

- **Prairie Island Indian Community (**https://prairieisland.org**)**
- **Shakopee Mdewakanton Sioux Community (**https://shakopeedakota.org**)**
- **Wakan Tipi Awanyankapi (**https://wakantipi.org**)**
- **Why Treaties Matter (**https://treatiesmatter.org**)**

Field of Birds Foot Violets on Grey Cloud Dunes overlooking the Mississippi River
Photo by Sarah Lilja, SWWD Artist-in-Residence 2024

The period from the River Transportation Era to the Railroad Transportation Era saw a shift from Grey Cloud and Point Douglas to rail cities such as Newport and St. Paul Park. Continued population growth and the eventual shift to the Automobile Transportation Era brought development to farming communities like Woodbury, Cottage Grove, Oakdale, and former resort areas like Lake Elmo. Today, SWWD includes industrial river towns along the Mississippi River bluff, picturesque townships, farmland, and one of the fastest-growing communities in the State, all of which face unique resource and management challenges.

While the District works to address water resource impacts related to past development, it also maintains a strong focus on preventing issues from ongoing development and land use changes. Development has greatly altered historic drainage and runoff patterns. These changes are reflected in increasing flood levels in lakes, streams, and ponds throughout the District. SWWD supplies its District modeling to the Federal Emergency Management Agency (FEMA), which compiles flood maps.

SWWD recognizes municipalities as the land-use authorities within the District. However, it also views its role in planning and resource protection as integral to municipal planning and development processes. SWWD fills a local planning void by taking a regional and resource-based focus. Its systematic and iterative process of assessment, planning, and implementation ensures that planned growth is accommodated while resources are protected and restored. To support ongoing development, municipalities rely on a growing system of storm sewers, ponds, and related infrastructure to manage and treat runoff. That system is regulated by the Minnesota Pollution Control Agency (MPCA) through its Municipal Separate Storm Sewer System (MS4) program. MPCA also regulates pollutant sources and wastewater discharges, both of which are present throughout the District. While the District is usually not directly involved in addressing regulated pollutants or wastewater, known sites routinely intersect District projects and must be considered. Known sites are mapped online in the MPCA's What's in My Neighborhood tool.

1.5 | MISSISSIPPI RIVER & BACKWATERS

The Mississippi River, which today marks the District's western and southern boundary, follows its pre-glacial valley carved into Cambrian and Ordovician bedrock. The valley bordering SWWD predates glaciation; however, repeated glaciations and melting shaped the valley we see today. It was repeatedly scoured during times of glacial melting, most prominently by Glacial River Warren, and filled during times of lower flow. This filled valley now forms the Mississippi River Terrace upon which the modern Mississippi River flows.

In a 2024 SWWD community survey, the Mississippi River was ranked the 2nd "most important local water body" after Colby Lake.

Barge on the Mississippi River in Newport, MN
Photo by Sarah Lilja, SWWD Artist-in-Residence 2024

Starting in 1927, the U.S. Army Corps of Engineers constructed Lock and Dam 2 at Hastings to facilitate commercial navigation. Still in operation, that dam impounded water upstream of Hastings and formed Pool 2. Pool 2 contains the Mississippi main channel, side channels, floodplain lakes, and backwaters that we know today as the Mississippi River. This resource also includes; the Grey Cloud Channel and Slough, Baldwin Lake, Conley Lake, and Mooers Lake, - face many challenges. The interconnected nature of the Mississippi River and its Pool 2 backwaters make resource management difficult, largely resulting in the entire area being managed regionally as a single basin. The impoundment of Pool 2 that formed them also speeds sedimentation by slowing flow. That filling process is accelerated by human activity including excessive sedimentation originating from the Minnesota River Valley. More recently, Pool 2 has been contaminated by Perfluoroalkyl substances (PFAS) leading to expanded fish consumption advisories and drinking water contamination concerns. Despite ongoing challenges though, it is important to recognize that the river does illustrate the success of the Federal Clean Water Act having significantly recovered from a history of untreated sewage and industrial waste. Today, the river now serves as a multibillion-dollar commerce transit-way, critical flyway, and recreation attraction.

In 2024, 42% of survey respondents stated that SWWD should prioritize "improving water quality in the Mississippi and St. Croix Rivers" in the next 10 years.

Unless otherwise specified, discussion of the Mississippi River throughout this plan is inclusive of the main channel, side channels, floodplain lakes, and backwaters.

1.6 | ST. CROIX RIVER

Lake St. Croix, forming the lower portion of the St. Croix River, marks the District's eastern boundary. It is formed by a natural impoundment at Point Douglas and the confluence with the Mississippi River; this causes the river to slow, widen, and deepen upstream. The river was formed by outflow of Glacial Lake Duluth which carved the valley through the Cambrian bedrock and into the underlying basalt. Today, much of the valley carved by glacial outflow has partially filled, forming the St. Croix River Terrace, upon which the modern-day Lake St. Croix lies.

Historically used as a conduit to transport logs from the Northwoods of Minnesota and Wisconsin to mills in and around Stillwater (upstream of SWWD), the river has experienced significant pollution and sedimentation from industrial activities and substantial land-use changes in the basin. Ongoing efforts aim to address these impacts. Reflecting this history, Lake St. Croix is listed as an impaired water by the Minnesota Pollution Control Agency (MPCA) due to excess nutrients. Despite these challenges, the river exhibits relatively high-water quality as compared to other metropolitan resources and the Mississippi River, while providing extensive habitat for native plant and animal communities. Today, the river serves as a tourism and recreation attraction. The National Wild and Scenic Rivers Act of 1968 and Lower St. Croix National Scenic Riverway Act of 1972 reflect this importance, designating the St. Croix as an Outstanding Resource Value Water.

1.7 | LAKES & STREAMS

Several of SWWD's lakes are also remnants of past glacial activity and are found exclusively in the Lake Elmo-Cottage Grove Outwash Plain. The District's most prominent lakes- the Woodbury chain of lakes, and Ravine Lake- lie within a bedrock valley through the central portion of the District. As the more recent glaciers retreated, that bedrock valley was filled in with sand and rock. It is likely that these lakes were formed by glacial ice blocks that were left buried in the filled bedrock valleys and later melted to form the existing basins. Today, these lakes are important recreational assets to residents of the District and are extensively used for active and passive recreation. Many of SWWD's lakes are currently listed as impaired waters, a reflection of changing modern land-use and land-cover, making them a focus of current management efforts.

After decades of declining water quality, SWWD's lakes are stabilizing and, in some cases, improving. Others require continued remediation due to excess nutrients in stormwater, which remains the largest cause of water quality degradation within the watershed. The primary sources of excess nutrients are soil erosion, increased impervious surfaces, and the interconnected nature of the District's subwatersheds. This combination has led to increased nuisance algal blooms, that have worsened due to earlier and longer growing seasons caused by ongoing climate change.

Nutrient concentrations peaked in the early 2000s and have since been slowly declining. That decline parallels the implementation efforts of the District and its local partners, through increased enforcement of water quality development rules, and slowing rates of development. SWWD's lakes are beginning to reflect the improvement in stormwater quality. Most notably, Colby, Wilmes, Markgrafs, and Ravine Lakes have shown substantial improvement in nutrient levels and water clarity over the past decade. La Lake was officially removed from the impaired waters list in 2024 because it's nutrient levels now meet State water quality standards. Additional information on basic lake attributes is included in Table 2 below, and more detailed management information on key District lakes can be found in SWWD's Lake Management Plan (Appendix A) and at http://swwdmn.gov. The most current impaired waters information can be found on the MPCA website.

SWWD's streams are concentrated along the Mississippi and St. Croix River bluffs, which were left largely untouched by the latest glaciation. What now makes up Trout Brook, O'Connor's Creek, and several smaller, unnamed streams is the result of centuries of stream action carving valleys through these bluffs. These large, broad valleys are now home to unique and important habitats, especially where the valley floors now intersect groundwater aquifers that provide cold water. The subwatersheds draining into these small streams are generally rural with a strong agricultural influence. As a result, the biggest issue causing concern is early-season runoff and field erosion before crops are fully canopied.

Frozen Colby Lake in Woodbury
Photo by Taylor Mills, SWWD Artist-in-Residence 2025

NAME & DNR ID#	AREA (ACRES)	WATERSHED AREA (ACRES)	MEAN DEPTH (ft)	MAX DEPTH (ft)	IMPAIRED WATER*	FISH CONSUMPTION ADVISORY
Armstrong Lake 82-0116	29	572	3	5	No	Not Tested
Markgrafs Lake 82-0089	44	425	3	7	Nutrients	Not Tested
N. Wilmes Lake 82-0090-01	19	2,413	7	21	Nutrients	Not Tested
S. Wilmes Lake 82-0090-02	20	615	8	18	Nutrients	Yes
Powers Lake 82-0092	61	1,263	19	36	No	Yes
Colby Lake 82-0094	73	2,924	5	10	Nutrients	Yes
Bailey Lake 82-0456	62	6,031	6	19	Nutrients	Not Tested
Vandenberg Lake 82-0084	45	785	N/A	N/A	No	Not Tested
Ravine Lake 82-0087	25	1,698	5	16	Nutrients	Yes
La Lake 82-0097	50	133	5	10	No	Not Tested
Ria Lake 82-0098	13	167	N/A	N/A	No	Not Tested
O'Connor's Lake 82-0020	59	6,305	4	13	No	Not Tested
Lake St. Croix 82-0001	8,393	N/A	N/A	78	Nutrients	Yes
Mississippi River 07010206-814	N/A	N/A	N/A	N/A	Nutrients TSS Aluminum E. coli	Yes
Mooers Lake 19-0005-04	122	N/A	N/A	N/A		Yes
Baldwin Lake 19-0005-04	462	N/A	N/A	N/A		Yes
Grey Cloud Slough 19-0005-05	428	N/A	N/A	N/A		Yes
Conley Lake 25-0017-07	120	N/A	N/A	N/A		Yes
Ravine Lake Outlet 07010206-517	N/A	2,284	N/A	N/A	Ammonia Biota (Fish)	Not Tested
Trout Brook 07030005-568	N/A	5,407	N/A	N/A	E. coli Biota (Fish)	Not Tested
O'Connor's Creek 07030005-607	N/A	6,305	N/A	N/A	E. coli	Not Tested

*Aquatic consumption impairments are not listed in Table 2.

Table 2. SWWD primary resources attributes.

1.8 | CLIMATE CHANGE & LOOKING AHEAD

In addition to challenges posed by development, the District faces several confounding impacts from a changing climate. Minnesota and the SWWD have a humid continental climate marked by cold winters and warm, humid summers, and a wide variability with extremes in all seasons. Data clearly show that Minnesota's climate is changing; annual temperatures and precipitation are increasing, storms are becoming more intense, snow and ice are melting earlier, and the growing season is increasing in length. Due to SWWD's location on the east side of the Twin Cities metropolitan area and Minnesota's geography, the District sees enhanced rainfall events when compared to our neighbors. All these changes have serious consequences for the District. Historically, plans and infrastructure in the District were developed and designed based on several assumptions. While the District and its communities have always been conservative in their assumptions, like planning for large rain events, many of those older assumptions are no longer valid. Consequently, older stormwater infrastructure is increasingly undersized, existing buildings are too close to lakes and streams, and algae have more time to proliferate in lakes, making them unusable during more of the year.

The natural and development history of the District, as well as current pressures from ongoing development and climate change, determine the quality of terrestrial and aquatic habitats. While the District borders the wild and scenic St. Croix River- which boasts extensive and abundant native fish communities-it is also home to several impaired waters that support only highly pollution-tolerant fish and plant species, like curly-leaf pondweed and Eurasian watermilfoil. Likewise, these influences have created a fractured terrestrial landscape that has largely pushed native wildlife communities. What remains of high-quality, natural communities, including threatened and endangered species, is generally concentrated in dedicated parkland and other open spaces. These remnants provide valuable recreational opportunities for residents. The District is committed to working with the Minnesota Department of Natural Resources (DNR) to help identify and protect species and natural communities of concern following that agency's rules and protocols. Additionally, residents can utilize the DNR's Recreational Compass tool to locate recreational opportunities.

To address these challenges, SWWD focuses on cooperative implementation in partnership with other local, regional, and state agencies. That approach is reflected in the District's mission statement. In practice, SWWD works closely with these partners to quickly identify issues and ensure uniform protection of water resources throughout the District. As a watershed district, executing programs identified in this plan, SWWD is uniquely able to quickly respond to emerging issues and often serves as the lead agency for local action.

PART TWO

Priority Watershed Issues & Strategies

Bailey School Forest Park, Newport

Photo by Taylor Mills, SWWD Artist-in-Residence 2025

PART TWO | PRIORITY WATERSHED ISSUES & STRATEGIES

Development of this plan included extensive outreach and engagement to identify priority issues for water resources within SWWD, as prescribed by Minnesota Rules 8410.045. SWWD began this process by evaluating its 2016 plan to assess progress and identified gaps to guide initial discussion and preliminary planning. Results of that analysis found that SWWD's 2016 plan, while comprehensive, did contain key gaps related to:

- Chloride pollution
- Polyflouro-alkyl substances (PFAS)
- Increasing restrictions on infiltration
- Lack of integration of SWWD resiliency planning into the WMP
- Increasing operations and maintenance needs
- Equity and environmental justice

All gaps identified are addressed in this WMP.

SWWD formally initiated development of this WMP with SWWD Board Resolution 2024-001. State review agencies were notified of the update in February 2024, and their input on priority issues was requested. SWWD received responses from:

- City of Woodbury
- Metropolitan Council
- MN Board of Water and Soil Resources
- MN Department of Health
- MN Department of Natural Resources
- MN Department of Transportion
- MN Pollution Control Agency
- Washington County

Initial stakeholder input identified a comprehensive range of priority issues including: regulatory consistency, infiltration and infiltration restrictions, surface water quality, flooding, groundwater sustainability, source water protection, operation and maintenance of stormwater infrastructure, communication and coordination, ecology and natural resources, chloride and other sources of pollution, climate change, equity and environmental justice, public health, and inter-governmental coordination and collaboration. All issues identified through this initial round of agency input have been carefully considered and are generally addressed throughout this Plan.

SWWD's Board of Managers held a public meeting in May 2024 to discuss initial input received and to kick off a period of community and partner engagement that lasted through the end of 2024. During that engagement period SWWD solicited input through a public web survey and a student survey of local sixth graders, and multiple public workshops. Additionally, the District collaborated with both the SWWD's Community Advisory Committee (CAC) and Technical Advisory Committee (TAC) through several issue-specific workshops.

SWWD's year-long issue identification and engagement process resulted in the issues prioritized here in Part 2 of this WMP. The issues that follow reflect the totality of input received and establish District priorities for the life of this plan.

Water resources are a reflection of their watersheds, and healthy, ecologically functioning landscapes provide direct benefits to healthy waters.

2.1 | WATERSHED ALTERATIONS

When a drop of water falls, it joins a watershed-flowing toward a lake or stream, guided by gravity and the shape of the landscape it falls upon. In an unaltered watershed, the drop will flow in one of two ways: Infiltration, soaking into the ground and becoming groundwater, or runoff, flowing over the land and directly into the waterbody. Conversely, in an altered watershed, drops of water encounter the unnatural barriers of human development

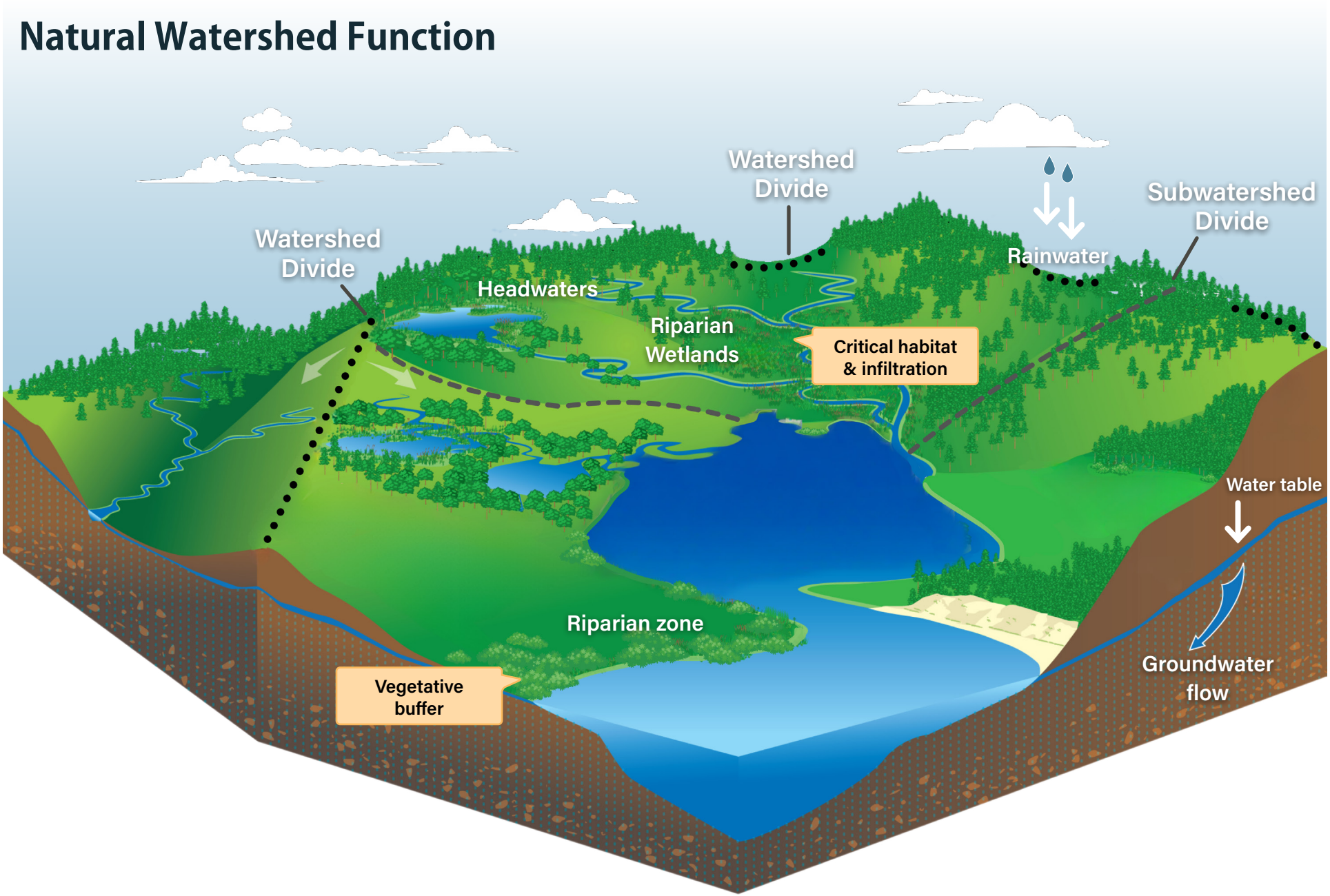


Figure 2: Natural Watershed Function. Watershed divides are points of high elevation on the landscape. Precipitation that lands within a watershed will flow down towards rivers, lakes, and wetlands. (Adapted from Michigan Sea Grant *How Watersheds Work*).

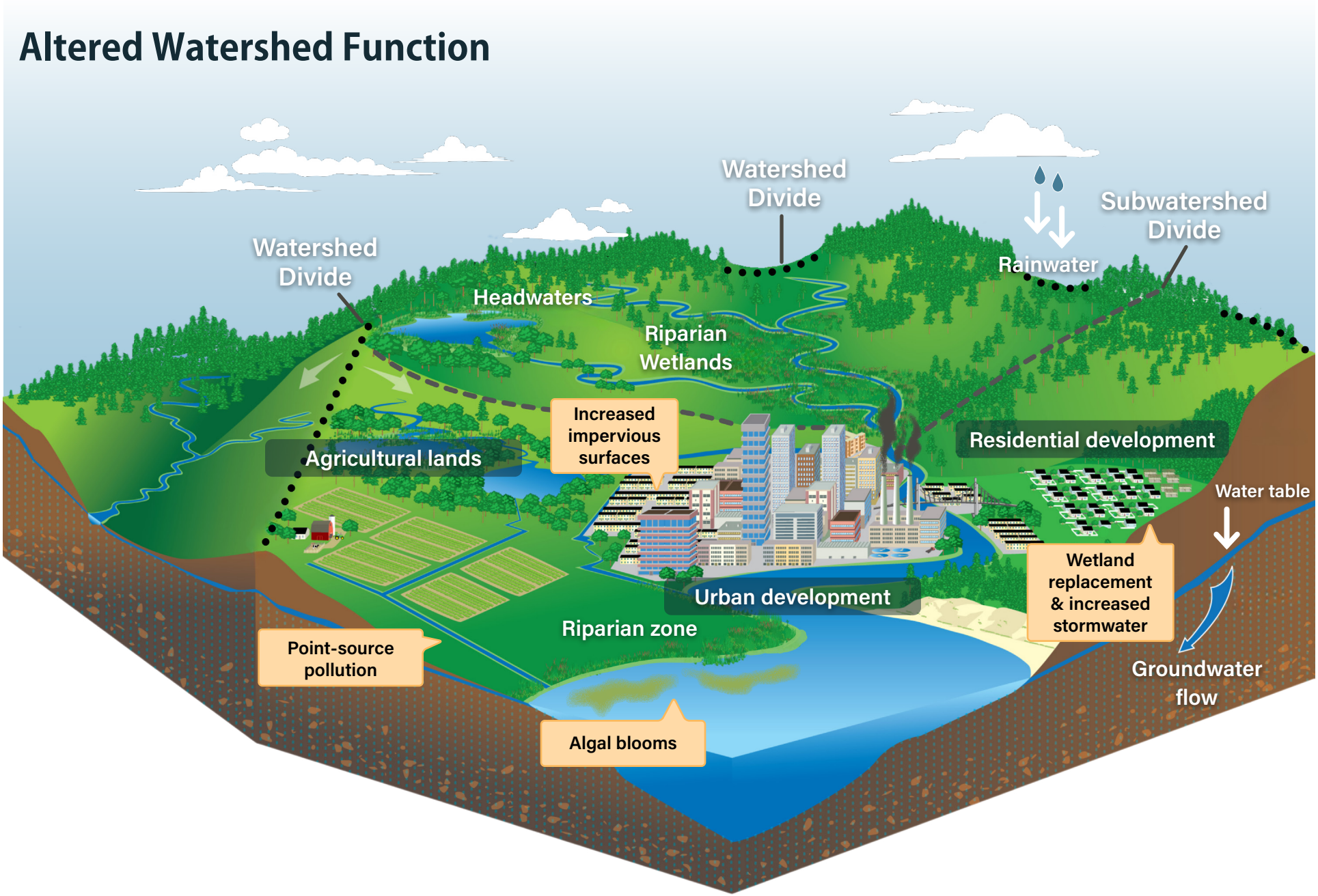


Figure 3: Altered Watershed Function. Urban, suburban and agriculutral development influence the quality of downstream water and alter the way water flows within a watershed. (Adapted from Michigan Sea Grant *How Watersheds Work*).

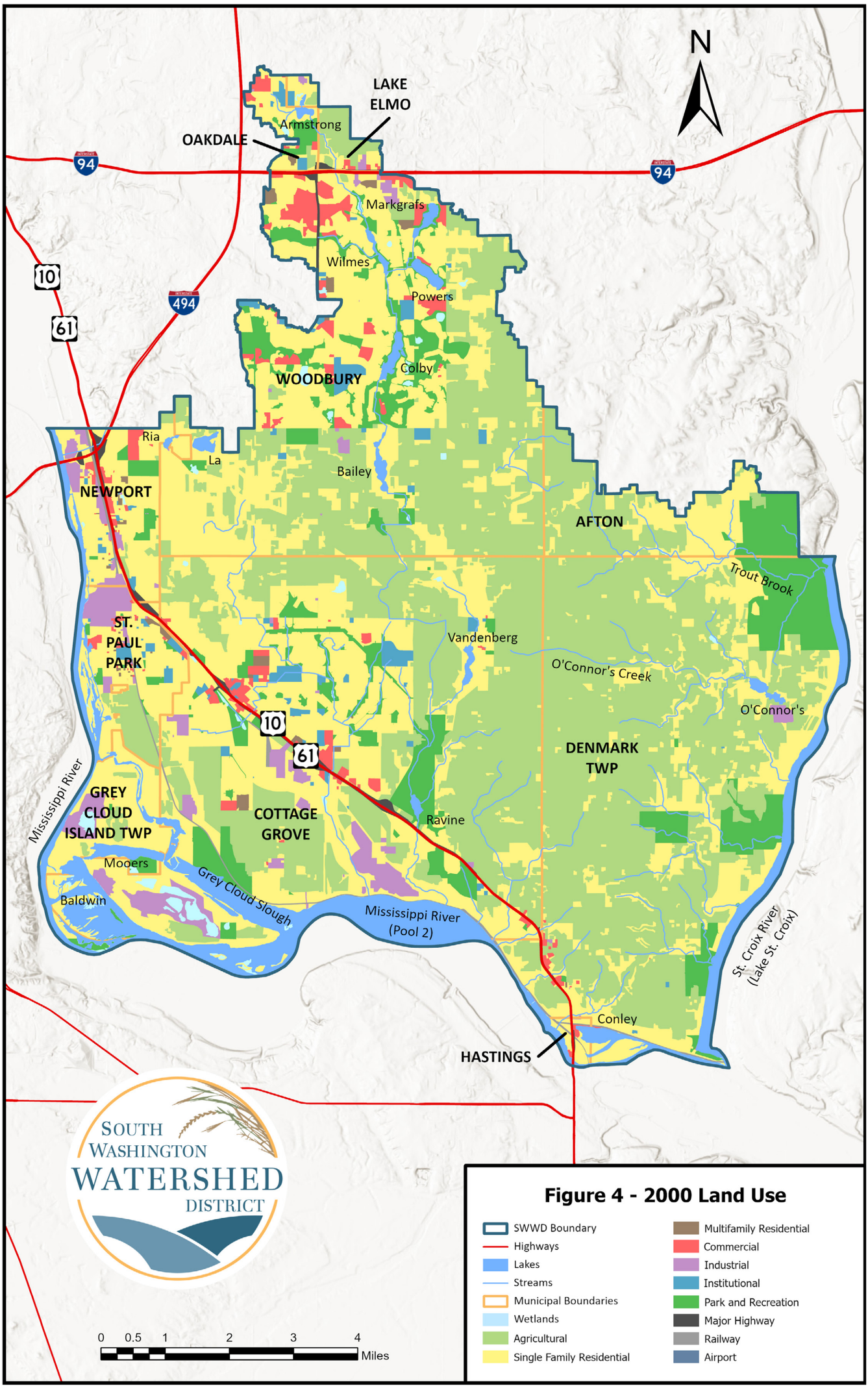


Figure 4: 2000 Land Use. A geographic overview of the landuse within the SWWD in the year 2000. Data provided by the Metropolitan Council.

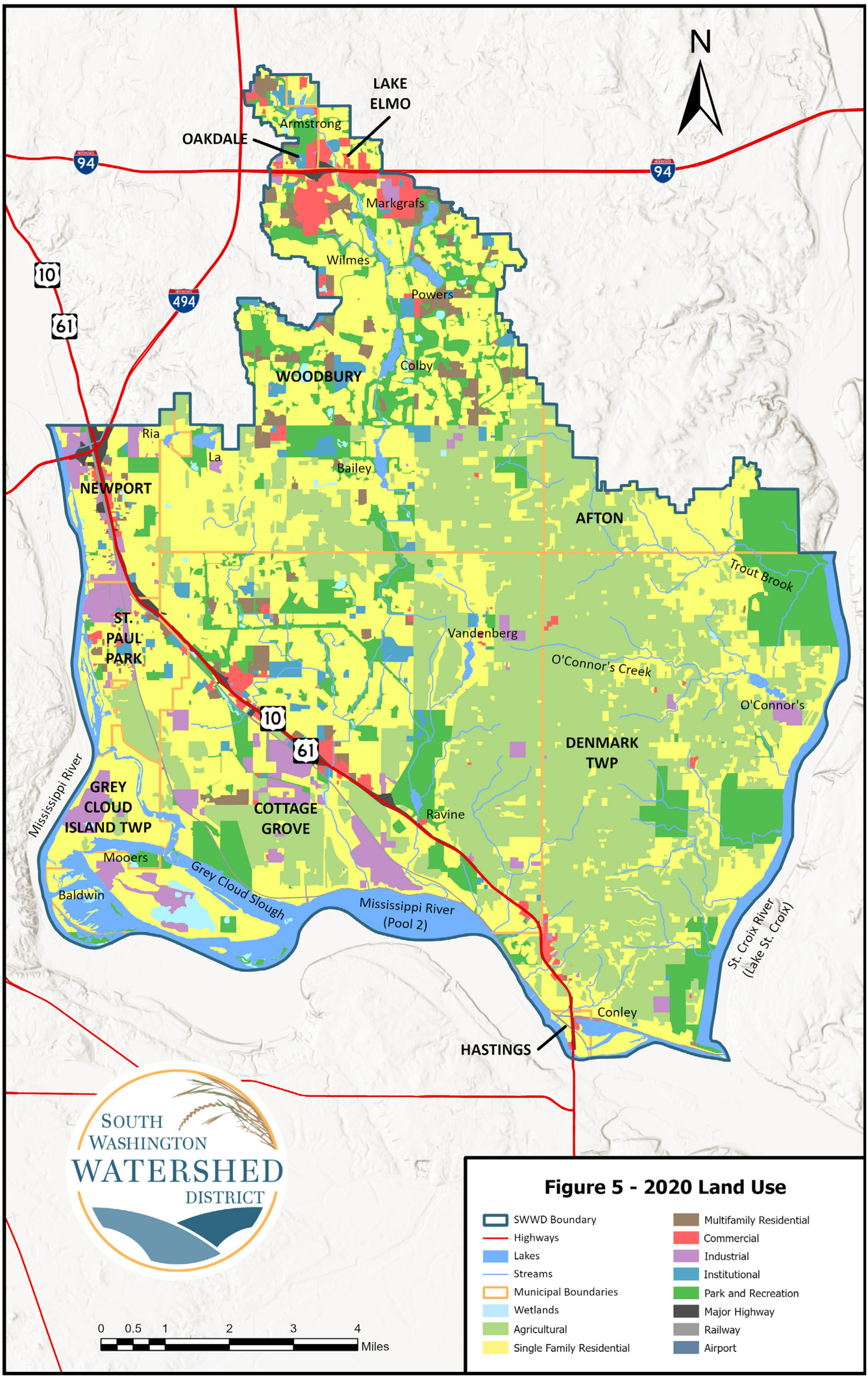


Figure 5: 2020 Land Use. A geographic overview of the landuse within the SWWD in the year 2020. Data provided by the Metropolitan Council.

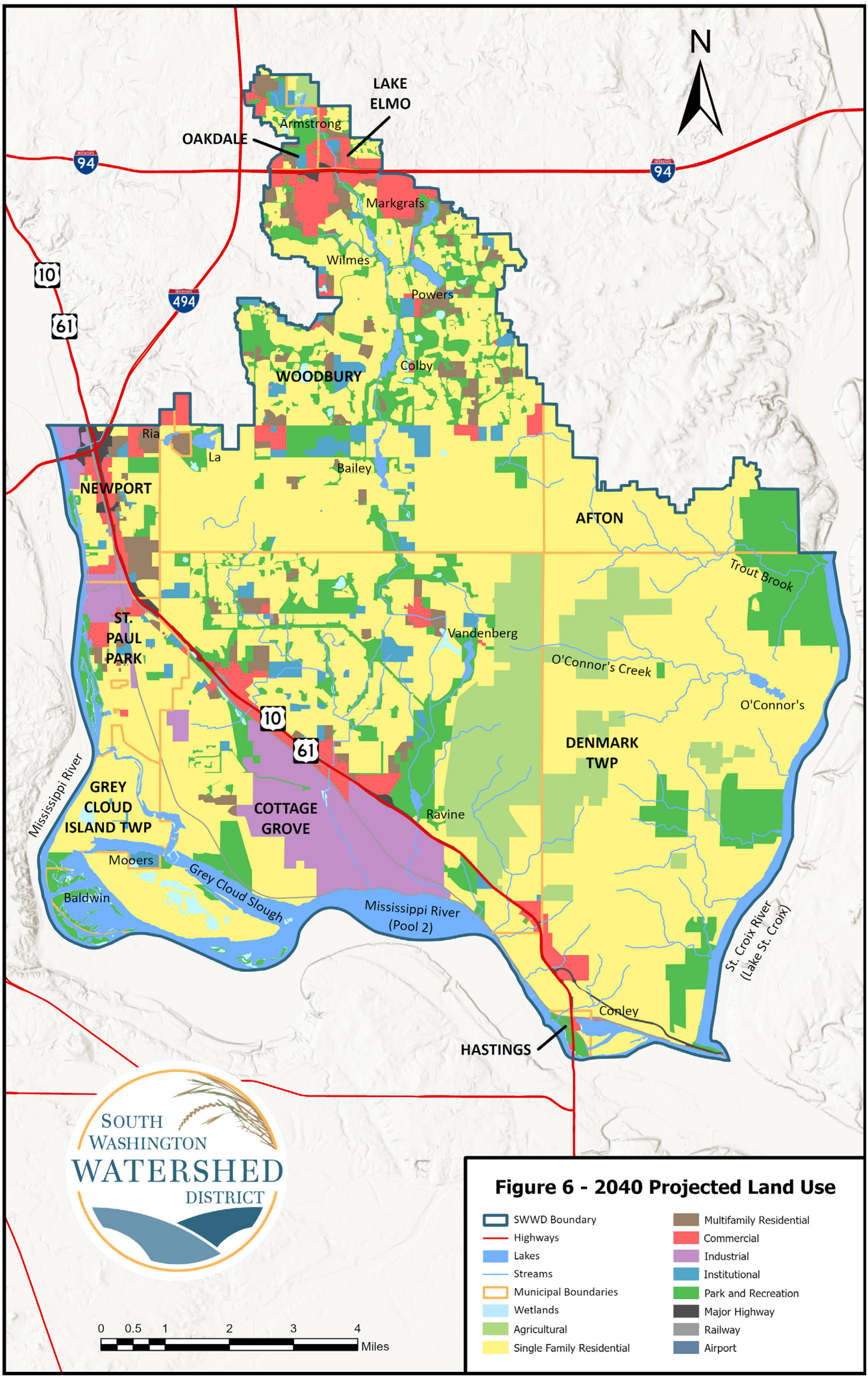


Figure 6: 2040 Land Use. A geographic overview of the projected landuse within the SWWD in the year 2040. Data provided by the Metropolitan Council.

that change how water moves across a watershed, what it carries, and what it deposits into its lake or stream.

2.1.1 | Landscape Alterations

Issue Statement: Landscape alterations significantly impact watershed health and resiliency.

Prior to European settlement, the watershed was composed of a rich mosaic of oak barrens, prairie, and savanna, with scattered wetlands and mesic forest in protected valleys. This landscape was maintained naturally by periodic fire and large grazing animals such as bison, elk, and white-tailed deer. As European settlement expanded and intensified in the late 1800s, natural landscapes were converted to large agricultural production, featuring tilled fields for grains and animal farming operations. Since then, the watershed has continued to transform, driven by the development of residential and commercial land-uses that we continue to see in the present day. Figures 4, 5, and 6 illustrate recent land-use changes across the watershed from 2000 to 2020, as well as projected changes by 2040. Currently, suburban and residential land-cover occupy roughly half of the watershed district, and is expected to grow. These land-use and land-cover changes have dramatically altered how water, sediment, and nutrients cycle through the watershed's land and water resources. Degradation of the natural landscapes has led to a variety of adverse effects, such as increased soil erosion, nutrient loading, and stormwater runoff rate and volume. Diminished soil health across the landscape has compromised the ability of our ecosystems to remain resilient against climate change and invasive species.

The modern developed landscape often removes the natural connections that tie components of natural, functioning landscapes together. When disrupted, these ecosystem services can cause compounding negative effects. For example, a lack of pervious ground surfaces and the removal of deep-rooted, native vegetation, increase the volume and velocity of stormwater runoff. This accelerates the transport of nutrients and eroded soils while interrupting essential ecosystem pathways for the healthy flow of organic material and organisms between natural spaces.

Capturing water where it falls and reconnecting these disconnected landscapes through greenways and connected stormwater treatment practices are some of the best and most cost-effective ways to improve watershed health. Large-scale landscape restoration can also be a powerful BMP, especially when greenway connections between restored sites can be achieved. Ultimately, improving soil health, infiltration potential, and stormwater retention through targeted landscape restoration can effectively mitigate the stresses placed on our ecosystems by land-use and land-cover change.

Riparian lands provide vital buffers between the developed landscape and our water resources, yet they remain among our most at-risk terrestrial resources. Because many of these areas within the watershed are publicly owned today, parks and trails offer residents easy access to view and recreate near water. However, human interaction with the landscape inevitably leads to increased erosion, pet waste, and littering-despite our collective best efforts to mitigate these impacts. Proactive landscape and water-access management is critical to the responsible stewardship of these fragile lands. In some cases, it may be highly advantageous to pursue strategic public acquisition of private riparian lands to further protect especially sensitive water resources from modern land-use pressures.

2.1.2 | Agriculture

Issue Statement: Agricultural land use across the watershed has caused increased runoff and pollutant loading to District water resources.

The active management of land for row crop agriculture has resulted in the continual annual disturbance of topsoil and ecosystems across thousands of acres of land within the watershed over many generations. While this disturbed landscape is critically necessary for the economic production of grains and food for human consumption, animal feed, and other commercial products, it has contributed to the degradation of the areas water resources. Tilled cropland is highly susceptible to losing valuable, nutrient-rich topsoil through runoff during rain events and early-season snowmelt. Over time, cropland tilling degrades soil health and structure, often increasing soil compaction compared to undisturbed soils.

A runoff test compares the contents of water runoff from conventionally tilled soil from a corn field (left), and soil from 2-years of pasture/hay plantings (right). The soil from the tilled field has less infiltration, and more runoff, which results in increased sediments and nutrients moving into the water. The soil from the perennial pasture/hay plantings has more infiltration, less runoff, and much less sediment and nutrients moving into the water.

These modifications result in reduced infiltration rates, increased surface runoff rates and volumes, and increased erosion of topsoil and nutrient loss. SWWD recognizes the importance of responsibly managing the remaining agricultural lands within our watershed. Working with farmers to increase implementation of structural and non-structural agricultural Best Management Practices (BMPs)- such as reduced tillage, cover crops, and nutrient management- can improve agricultural profitability. Simultaneously, these practices protect water resources by increasing the water-holding capacity of soil and reducing the transport of sediment, nutrients, pesticides, and other pollutants to streams and lakes.

Additional fertilizers added to farmland to boost crop production, can be lost through erosion to surface waters, thus contributing to nuisance conditions and algae blooms in our lakes and streams. Even today, SWWD lakes that are no longer surrounded by agricultural lands due to modern development remain subject to excess internal phosphorus loading. This ongoing impairment is driven from historic nutrient-rich sediments lost from cropped lands via erosion.

Excess nitrates, chlorides, and other compounds found in agricultural fertilizers also leach down into groundwater aquifers. This increases contaminant levels that threaten the quality and safety of drinking water supplied by public and private wells. Furthermore, many of the District's surface water resources are also supplied in part by shallow groundwater aquifers, expanding the scope and impact of groundwater contamination.

To achieve the District's goals for remaining agricultural lands, it is critical that SWWD work with its partners to promote conservation agriculture and soil health principles such as keeping soil covered, limiting disturbance, building diversity, maintaining living roots, and integrating livestock.

2.1.3 | Suburban Development

Issue Statement: Land use and land cover changes associated with suburban development have impacted the District's water resources and ecological integrity while reducing natural space connectivity across the watershed.

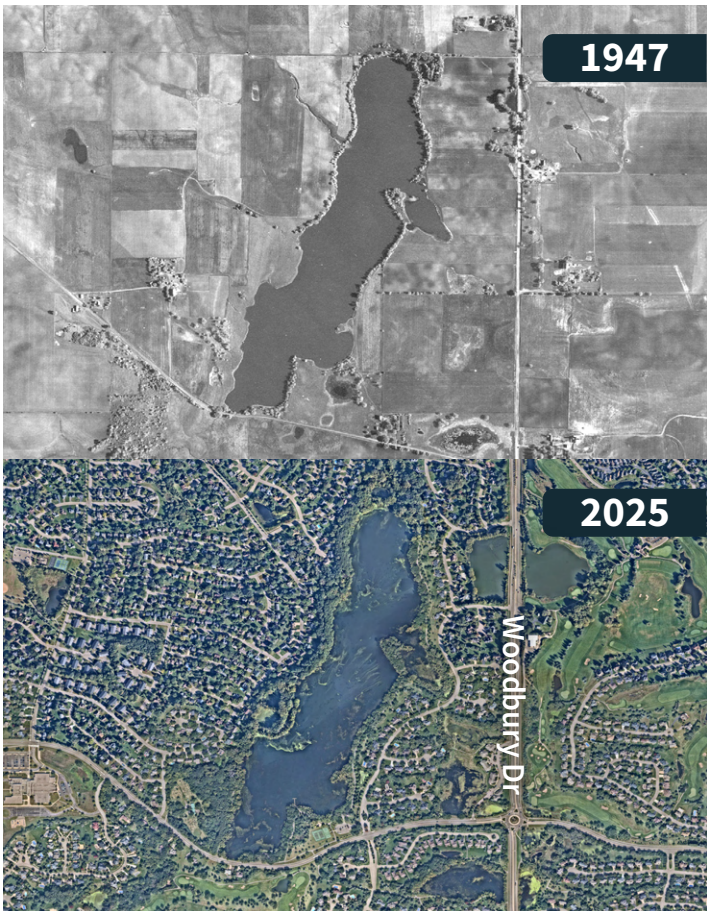
As populations have rapidly grown over time, suburban residential and commercial development have swallowed up large tracts of former agricultural lands. This conversion

further encroaches on remaining natural landscapes and water resources. Despite robust environmental regulations and controls, the extensive land disturbances associated with ongoing construction activity contribute excess sediments, nutrients, chlorides, and other pollutants to surface waters and major riverways. Development has also generated high percentages of impervious land cover - such as roads, parking lots, and buildings - that significantly increase runoff rates during storm events compared to natural or agricultural land covers. Even seemingly pervious vegetated areas that remain post-development, including residential yards and parkland, exhibit lower-than-expected infiltration rates due to heavy grading and soil compaction during construction. At a large scale, this leads to higher than anticipated runoff rates from newly developed neighborhoods.

State regulations, local municipal ordinances, and watershed rules have all established a vast network of pipes, ponds, and other treatment systems designed to manage stormwater and mitigate the effects of increased impervious land cover. While significant, the benefits of this stormwater infrastructure have not fully prevented degradation of the District's water resources. Excess nutrient and sediment loading from our increasingly suburban environment contributes to water quality impairments while extreme flow peaks contribute to flooding concerns. The District has found that work beyond the scope of traditional regulatory programs is required to protect and restore surface water quality and mitigate storm flows, ensuring these resources remain available for current and future generations. Prior to the adoption of the Minnesota Wetland Conservation Act (WCA) in 1991, the watershed was also highly susceptible to the loss of both wetland quantity and quality as a result of development. Although robust wetland protections exist today, development pressures still cause impacts, with mitigation frequently managed through Minnesota's wetland banking system. When aggregated regionally, this banking system can still result in localized losses of wetland habitat.

The combination of Minnesota's cold climate with suburban development has resulted in the heavy use of chloride-based deicers to manage ice buildup on roads, parking lots, and sidewalks in response to the public's winter safety concerns. The issue of chloride contamination will be discussed in greater detail later in this section.

Development and associated land-cover changes are expected to continue evolving, as reflected by the Metropolitan Council's 2050 Metropolitan Urban Service Area (MUSA). To counter the impacts from suburban land-use changes, SWWD will develop and implement resource management plans, regional Best Management Practices assessments, and feasibility studies that build upon the existing monitoring and modeling. These plans will establish implementation recommendations for capital improvement projects, programs, and best management practices. Furthermore, they will provide specific details and budgetary information required to refine and implement SWWD's Long-Range Work Plan (Section 3.10.8).



Following World War II, suburban development increased rapidly, expanding across agricultural land. As of 2025, the land cover of the Colby Lake subwatershed is 93.1% developed.

2.1.4 | Ecosystem Functions

As land development continues, SWWD protects its water resources by actively managing terrestrial resources. Achieving this requires collaborating with landowners, municipalities, and Washington County to provide guidance, planning, management framework, and funding.

Ecosystems are dynamic, constantly changing, and responding to disturbance. While some forms of disturbance are essential and beneficial to ecosystem function, others can be detrimental and or even catastrophic. As land cover has converted to agricultural or suburban environments, the watershed has suffered a substantial loss of ecosystem function and structure. Ultimately, this degradation drives a parallel decline in the valuable ecosystem services provided to the community.

Natural habitat areas provide valuable services that are essential for ecosystem health and the protection of water resources. They also benefit residents of the watershed by filtering air, providing groundwater recharge, and mitigating urban heat impacts. Suburban development has significantly fragmented native habitats across the watershed, relegating remaining natural areas to isolated islands of native plant communities. Because of this isolation, these habitats cannot effectively provide greenway corridors for wildlife or deliver full ecosystem services, leaving them increasingly vulnerable to climate change. Most remnant plant communities in the District have been fractured into small acreages that cannot support a high diversity of species, preventing recovery from both climate and natural impacts. Climate change affects these natural areas through both extreme events, such as flooding, and through gradual shifts, like rising winter minimum temperatures. Increases in insect populations and diseases that thrive in a changing climate are severely affecting vulnerable native tree species, such as green ash, oak, birch, maple, basswood, and white pine.

Due to these changes, the flows of energy, water, nutrients, and organisms function differently than they would under natural conditions. Introduced plant and animal species occupy new roles and find niches within these novel landscapes. These changes manifest themselves in a variety of ways, including:

- Altered nutrient inputs and flows
- Altered hydrology
- Disturbed and compacted soils
- Increased erosion and sedimentation
- Pollutants in the landscape
- Exotic and/ore invasive species
- Lost connectivity between natural communities

2.1.5 | District Strategies to Address Watershed Alterations

- Restore native ecosystems and their processes to support healthy water resources.
- Collaborate with partners to fund and implement land protection projects that protect and preserve land within designated greenway corridors and adjacent to scientific and natural areas.
- Develop natural resource inventories and management plans for protected properties and corridors.
- Educate community members about the value of natural area protection and the expansion of wildlife corridors.
- Promote, implement, and offer cost-share funding for structural and non-structural agricultural BMP's to reduce runoff rates and volume, and minimize the loss of nutrients and sediments from agricultural lands through collaboration with District partners, including the Washington Conservation District, and Lower St. Croix Watershed Partnership.
- Proactively coordinate with constituents and partners to manage and overcome the challenges of suburban development.
- Develop, implement, and enforce rules to protect water resources through collaboration with local government partners.
- Help municipal partners improve the effectiveness, efficiency, and resiliency of stormwater management infrastructure.
- Develop and maintain resource management plans and feasibility studies for all primary water resources of the District.
- Directly implement projects for primary water resources based on resource management plans and feasibility studies.

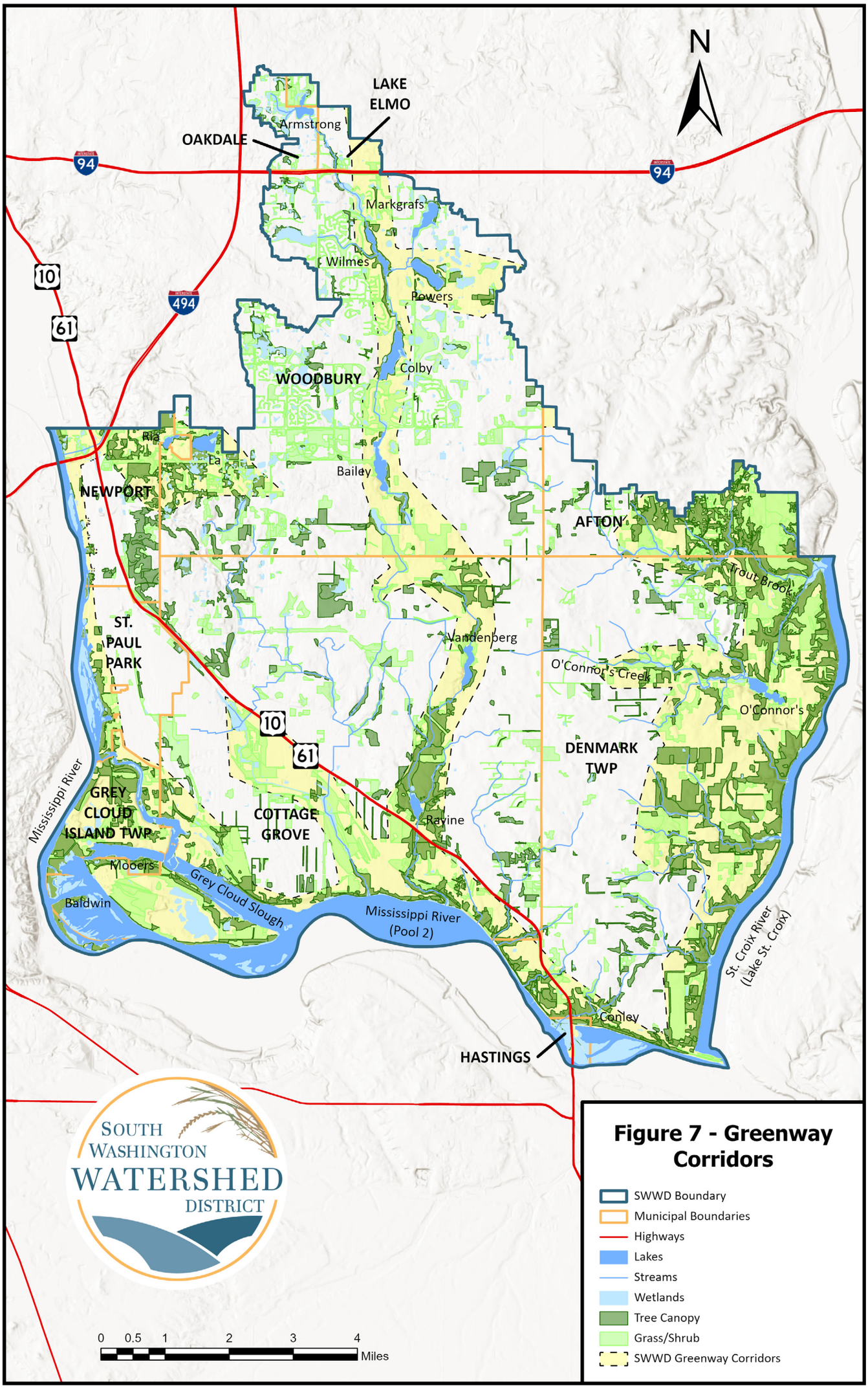


Figure 7: Greenway Corridors. Overview of exisitng greenway corridors present within the SWWD.

2.2 | COMMUNITY RESILIENCY IN A CHANGING CLIMATE

Issue Statement: Climate change challenges and stresses water resources and systems across the District. These ongoing changes make it increasingly difficult to prepare for and address issues like flooding, water quality degradation, and sustainability.

The effects of climate change complicate water resource management as rain events become more severe and frequent, while temperatures continue to rise. These conditions strain the capacity limits of older stormwater conveyance systems, worsen flooding risks, and accelerate sediment and nutrient loading to waterbodies. Rising surface water temperatures drive more frequent nuisance algae blooms, dissolved oxygen depletion, and fish kills. Crucially, the impacts of ongoing climate change are not felt the same across the District. Communities burdened by historical degradation or stressed infrastructure systems have reduced resilience and face a significantly higher risk.

Resilience is the capacity of individuals, communities, natural environments, and systems to anticipate, prepare for, withstand, and recover from natural or human-caused disruptions.

Southern Washington County is highly vulnerable to heavy precipitation, runoff, and flooding due to its geographical location in a particularly wet region of the state. These vulnerabilities are compounded by localized climate enhancements as the area sits directly downwind of the Twin Cities and its urban heat island.

As the climate changes, average temperatures and precipitation continue to rise, resulting in a warmer and wetter yearly climate in Minnesota. This shift manifests as a significant increase in the number of hot, rainy, summer days alongside heavier, and wetter, winter snowfalls. Together, these changing precipitation patterns elevate regional flood risks, presenting a critical test for community resiliency.

Increased warmth and precipitation have shrunk the lake ice season in Minnesota. Overall, lake ice duration in the state has decreased by up to 17 days over the last 50 years. Over the last 100 years, it has decreased as much as 27 days. Less ice cover on the lakes means there is more time for the water in those lakes to warm. The consequence of this, is an increase in overall lake temperatures, which has cascading effects on lake ecology. Warmer waters impact Minnesota's native fish species that depend upon deep and cold-water habitats. Less ice cover also benefits invasive aquatic plant species like curly leaf pondweed and Eurasian watermilfoil, which can grow more rapidly in a longer growing season.

While SWWD cannot mitigate global climate change locally, the District's resources are vulnerable to its ongoing effects. Increased climate variability, compounding weather extremes, and overall uncertainty further stress water resources across the District. These shifting conditions directly complicate the management of longstanding issues like flooding, water quality degradation, and groundwater sustainability.

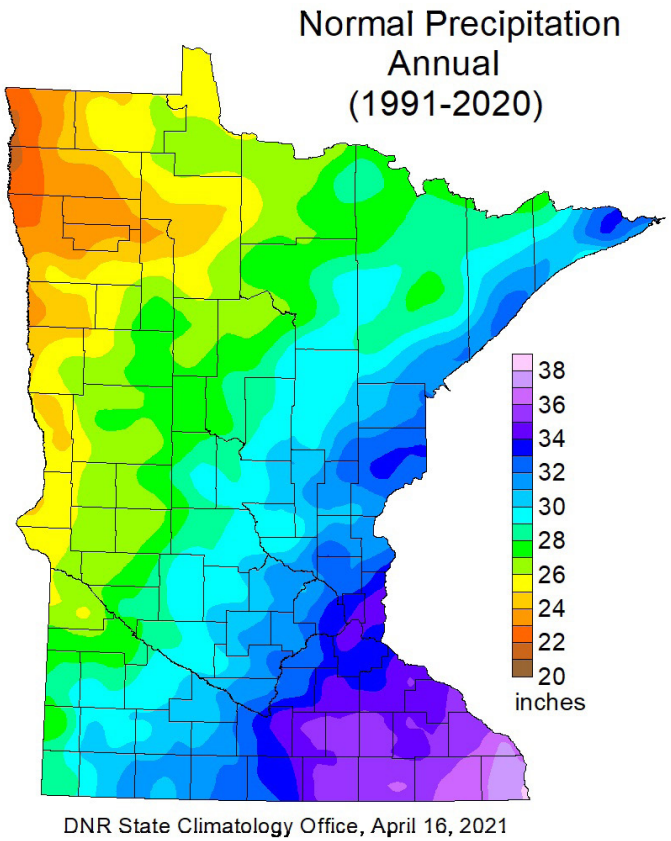


Figure 8: Normal Precipitation Annual (1991-2020)
Minnesota Department of Natural Resources

A watershed district's jurisdiction is based on natural hydrologic boundaries rather than political lines; thus, they play a pivotal role in leading regional climate adaptation. Supporting SWWD's partners will involve providing technical expertise, historical data, and adaptive management strategies as new information emerges regarding Minnesota's shifting climate. SWWD must continue to evaluate how the restoration and preservation of both terrestrial and aquatic – are affected by alterations in precipitation patterns, temperature, and shifts in seasonal variation. Cultivating ecological resilience against these stressors demands broad regional collaboration to understand and implement strategies that help native ecosystems thrive.

Risk Assessment Matrix

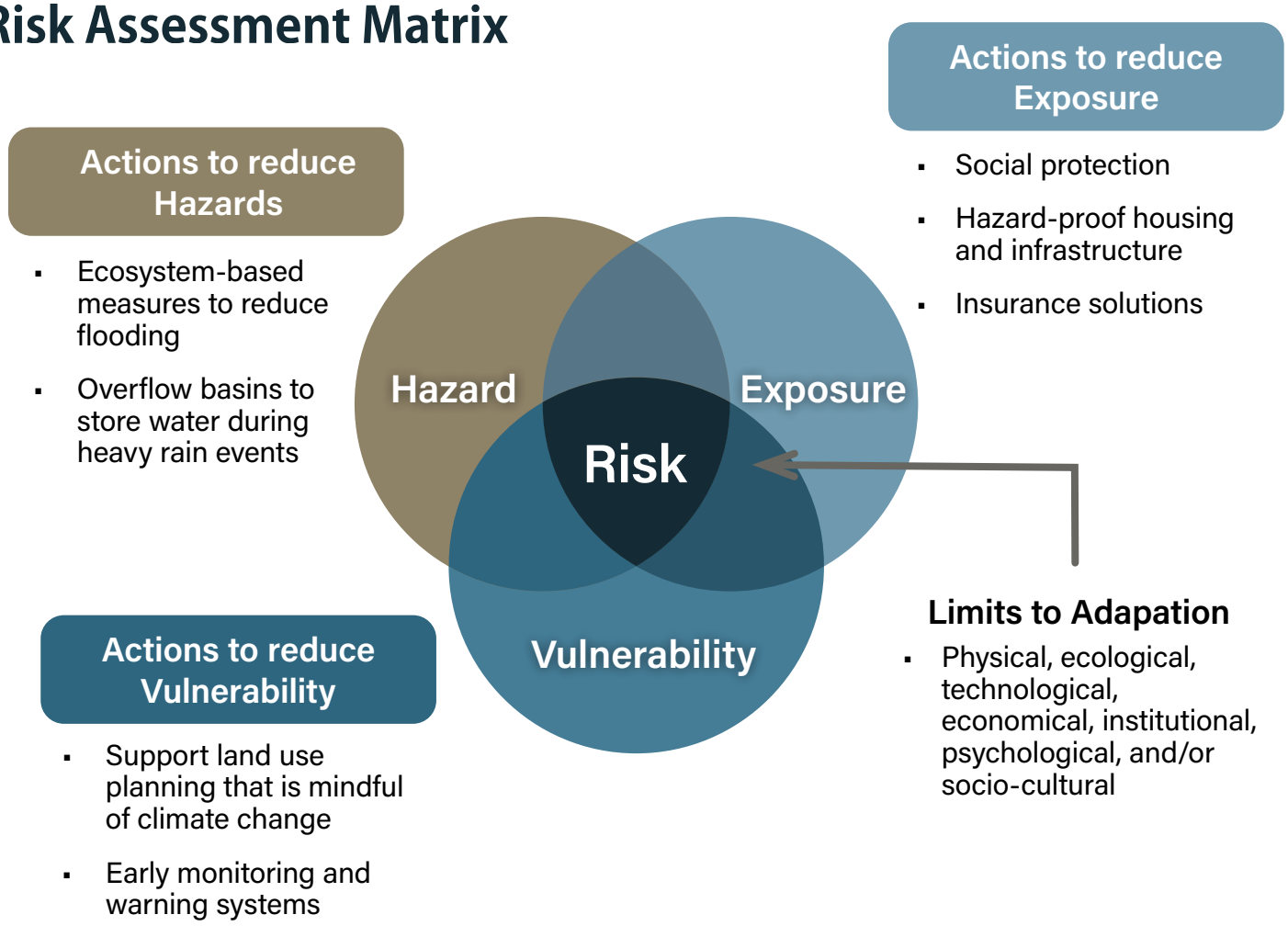


Figure 9: The Risk Assessment Matrix. The Risk Assessment Matrix demonstrates how a community's risk level is impacted by the unique hazards, vulnerability, and exposure that each member experiences. Figure adapted from the IPCC Risk Assessment Matrix.

2.2.1 | District Strategies to Address Climate Resiliency

- Maintain current knowledge of the latest scientific understanding of the effect of climate change on native ecosystems and adapt accordingly.
- Work with local partners to prepare for and address climate-related resource issues.
- Incorporate climate resiliency assessment into all District project development efforts.
- Support municipal partners in improving the effectiveness, efficiency, and resiliency of stormwater management infrastructure.

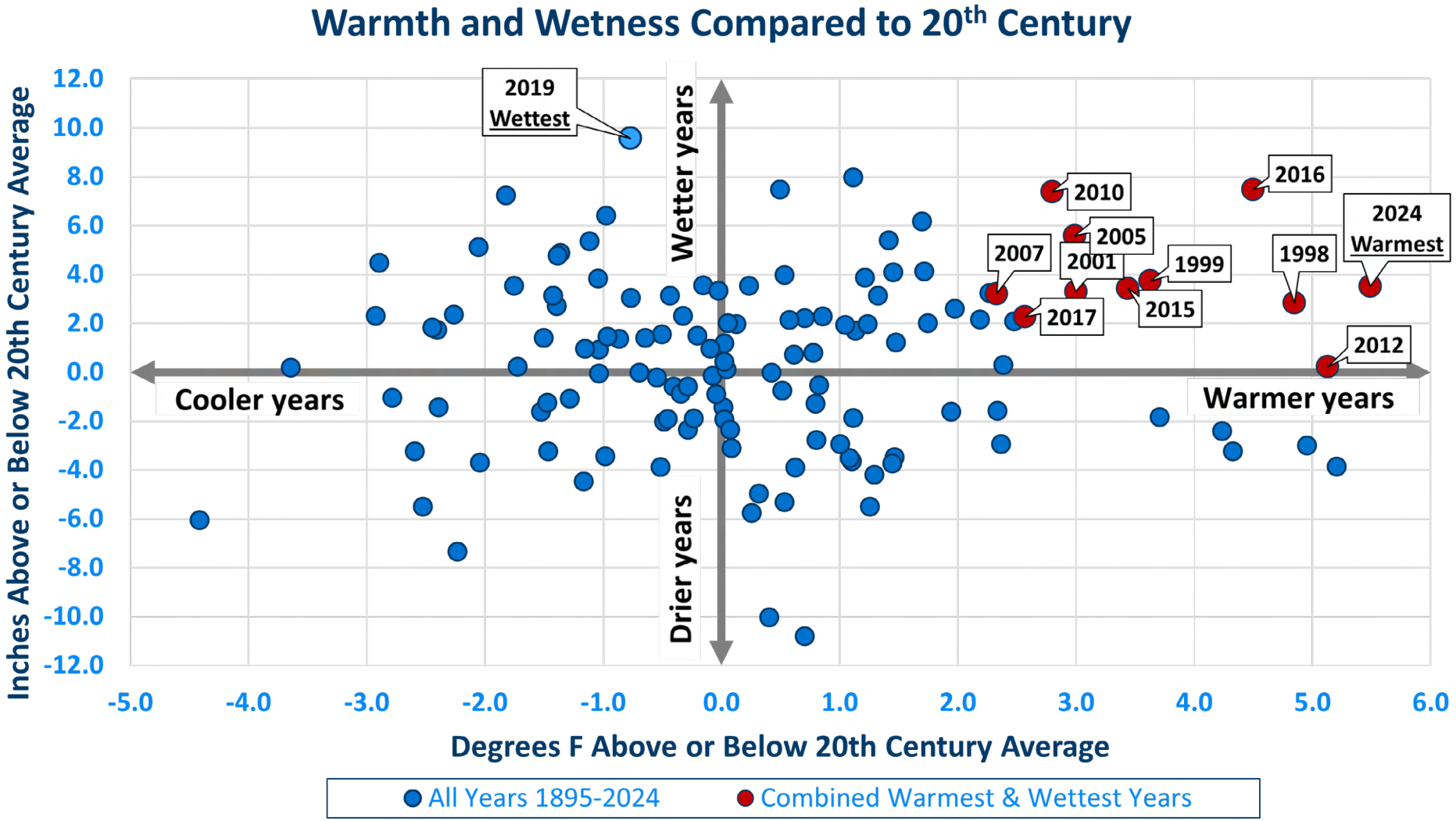


Figure 10: Warmth and Wetness Compared to 20th Century. Since the latter half of the 20th century, climate change has caused temperatures and precepitiation to increase. All of the warmest and wettest years recorded since 1895, have occured since 1998. Minnesota Department of Natural Resources State Climatology Office.

2.3 | FLOODING IMPACTS

Communities within the SWWD have long faced a variety of flooding issues, including:

- Localized flash flooding during and immediately after intense storm events.
- Regional flooding caused by strained stormwater systems unable to handle the volume of water draining to or through them following extreme events or during prolonged wet periods.
- River flooding of communities along the Mississippi and St. Croix Rivers.

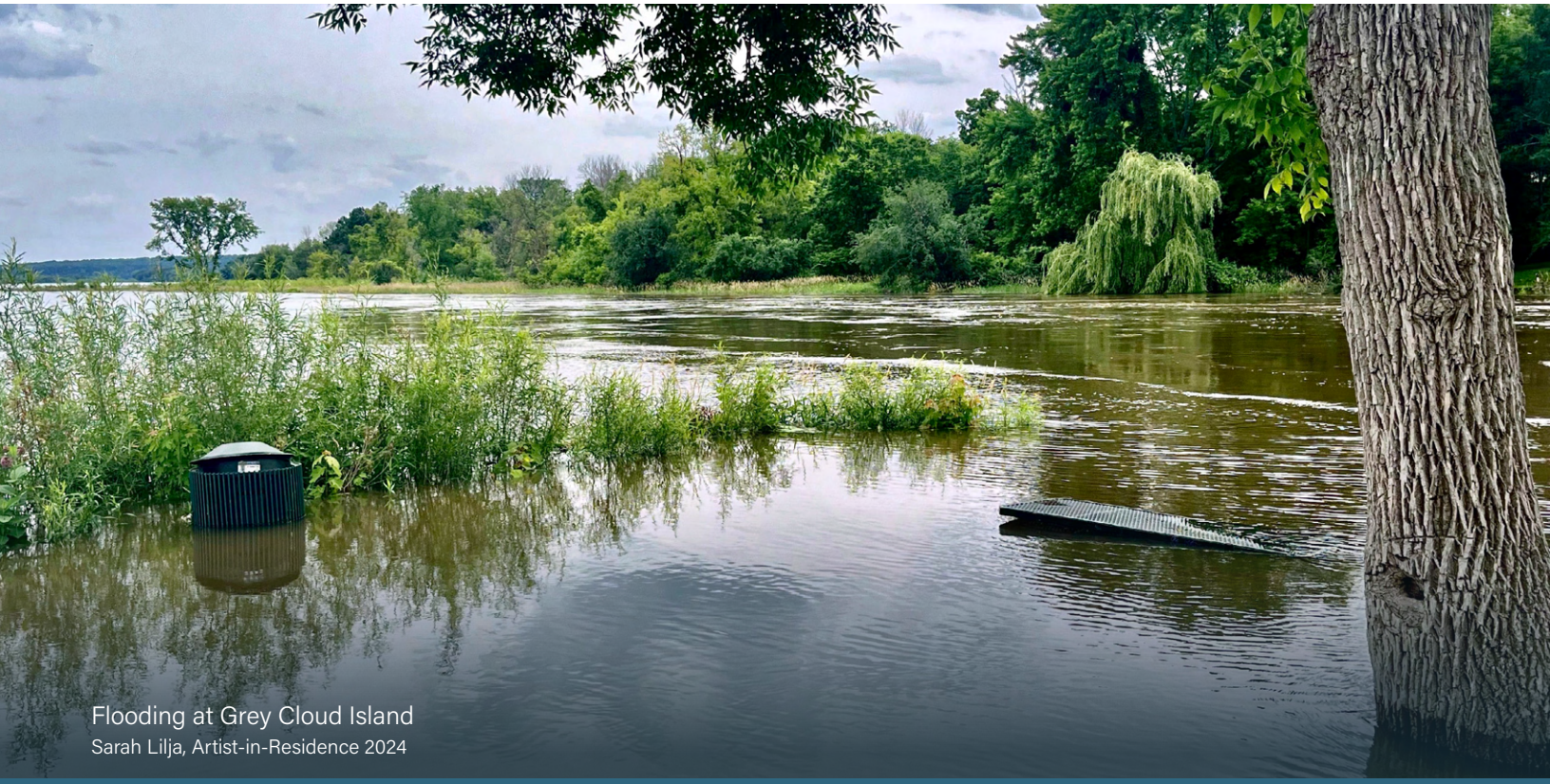
Climate change is also a flood risk escalator, increasing the frequency, severity, and overall impact of extreme precipitation events. Consequently, climate change trends add an additional consideration when planning and implementing any work to address or respond to flood events. When SWWD and its partners implement long-term flood mitigation projects, they must navigate heightened uncertainty over future hydrologic conditions.

During and following flood events, the primary responsibility for reacting lies with SWWD's county and municipal partners, who also oversee local shoreland and floodplain regulatory compliance. However, disaster risk is not equally shared across the watershed. Downstream and underserved communities with aging or undersized infrastructure face greater risk from flooding. The ability of communities to manage flood risk and respond to flood events also varies greatly. SWWD routinely supports local risk management and flood response efforts while also leading joint assessment and planning efforts to provide long-term solutions to known issues. The most high-profile example of this work is the District's Central Draw Storage Facility- now known as Glacial Valley Park- and the Central Draw Overflow. Both Central Draw systems were completed in 2020 and together provide regional detention and flood control for much of the City of Woodbury. Despite the success of the Central Draw infrastructure, other issues remain.

2.3.1 | Local Flash Flooding

Issue Statement: Localized flooding is often caused by a lack of or inadequate infrastructure.

Localized flooding issues continue to be observed across the watershed. These issues generally arise from aging, inadequate, or poorly maintained infrastructure. Moreover, those issues are exacerbated by Minnesota's ongoing shifting climate patterns that have modified prevailing



Flooding at Grey Cloud Island
Sarah Lilja, Artist-in-Residence 2024

precipitation patterns and further strained stormwater management systems. Primary responsibility for addressing localized flooding lies with local municipalities and Washington County. These entities collectively serve as the floodplain and shoreland regulatory authorities throughout SWWD. However, SWWD assists where possible, and maintains several programs to support maintenance, enhancement, or replacement of strained systems. SWWD will collaborate with municipal partners to explore and implement feasible management actions aimed at reducing flooding impacts. Thus, ensuring no negative impacts are realized elsewhere in the watershed.

Wilmes Lake | Woodbury

Wilmes Lake has a history of flash flooding, driven by intense rain events across the District's Northern Watershed. Runoff quickly drains through upstream lakes and into Wilmes Lake, where water levels can rise rapidly. When the City of Woodbury's outlet infrastructure for the lake cannot keep pace, or is blocked with debris, rising water levels can impact neighboring homes and roadways. The biggest flood event at Wilmes Lake occurred in October of 2005 following what – at the time – was considered a 100-year rainfall event. Several homes were impacted, leading SWWD to assist the City of Woodbury in evaluating the existing storm sewer system. Ultimately, SWWD and the city implemented several upstream projects to reduce or slow runoff reaching Wilmes Lake. Additionally, SWWD and Woodbury provided cost-share funding to impacted residents to flood-proof their homes. Although more recent flood events have not matched the impact of the 2005 event, flood risk remains. In fact, that risk has continued to grow over time as Minnesota's climate continues to change. In 2018, the National Oceanic and Atmospheric Administration (NOAA) updated its hydrological design guidance. Following the new guidance, the City of Woodbury updated Wilmes Lake flood modeling. The updated modeling, which reflected higher rainfall events, indicated additional risk to homes around Wilmes Lake, and a subsequent round of flood-proofing cost-share grants were offered to residents.

The City of Woodbury, supported by SWWD, previously established that increasing flow capacity at the Wilmes Lake outlet was not feasible due to cost and impact to downstream properties. However, new technologies have the potential to provide additional relief. Automated and predictive controls are increasingly being used to strategically draw down regional ponds or water bodies in advance of predicted extreme rainfall events. SWWD anticipates evaluating the feasibility of such technologies across its northern watershed to see if benefits can be achieved.

Wilmes Lake
Sarah Lilja, SWWD Artist-in-Residence 2024

Newport Bluffs | Newport

The bluff line dropping down from Woodbury and Cottage Grove into Newport is steep and highly erodible. Intense and prolonged rainfall events have caused the rapid erosion of that bluff. SWWD previously worked with the City of Newport to address significant erosion in the ravine behind the city's public works facility and is currently working with Washington County to address risk in the ravine along County Road 74 (65th Street). Recently, increased flood and erosion risks were identified along the drainage path from Ria Lake in Woodbury down to the Glen Road Pond in Newport. SWWD is leading efforts to evaluate those risks and develop an action plan to solve the problem. Implementation of identified projects and strategies will be a focus in this 10-year watershed management plan.

Cottage Grove Ravine Regional Park | Cottage Grove

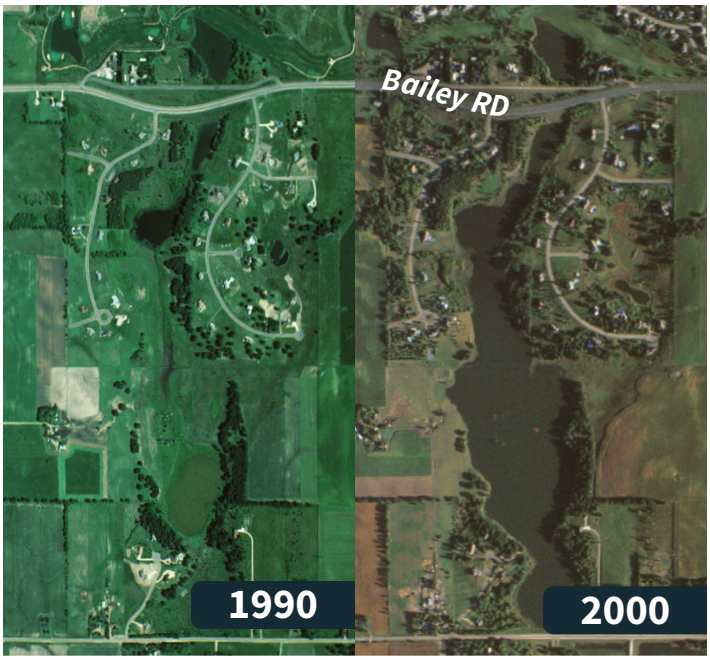
Cottage Grove Ravine Regional Park contains Ravine Lake and lies at the bottom of SWWD's East Ravine

subwatershed. Under normal climatic conditions, Ravine Lake has a relatively small watershed and maintains stable water levels. However, following an extreme rain event across the District's northern watershed, the District's Central Draw System outlets through the park and into Ravine Lake. Infrastructure in the park was designed and constructed to maintain ravine stability and safely convey regional floodwater. SWWD will continue to maintain that infrastructure and respond to any hydrological events.

2.3.2 | Closed Basins

Issue Statement: Closed basins across the watershed have the potential to cause flood damage to infrastructure and property.

Due to the highly variable glacial outwash topography across the watershed, multiple landlocked basins lack functional surface outlets, creating "closed" drainage areas where surface runoff terminates. These waterbodies can periodically experience flooding problems after large rain events or prolonged wet periods. Bailey Lake has historically served as the primary example; as the terminus of SWWD's northern watershed, it collects runoff from large, rapidly developing areas of Woodbury. However, with the construction of Woodbury's Bailey Lake Lift Station and the Central Draw Storage Facility (Glacial Valley Park) and Overflow, much of the concern about its status as a closed basin has been successfully mitigated.



Historical aerial images of the area that is now Bailey Lake
Minnesota Historical Aerial Photographs Online

SWWD closely monitors water levels in its closed basins and maintains District development rules requiring additional freeboard for adjacent structures. These rules are typically implemented and enforced by municipal partners.

Other known closed basin issues include:

La Lake and Ria Lake | Woodbury and Newport

While La Lake and Ria Lake do have overland outlets, they primarily operate as closed basins located at the border between the City of Woodbury and the City of Newport. These outlets do not commonly discharge downstream. However, when they do, the outflow has the potential to exceed the capacity of the downstream storm sewers and ponds in Newport. Please refer to Intercommunity Flow below for more discussion about these lakes.

O'Connor's Lake | Denmark Township

O'Connor's Lake, fed by O'Connor's Creek, is a closed-basin lake located in northern Denmark Township. Though the Lake has no outlet, it generally shows consistent water levels because water is primarily due to evaporation and infiltration into the highly permeable underlying geology. At times, the lake has filled beyond its ordinary high-water level and caused inundation of adjacent property. In 2020, O'Connor's Lake broke through a berm and flooded the quarry immediately to the south of the lake.

Vandenberg Lake | Cottage Grove

Vandenberg Lake lies upstream of Ravine Lake in SWWD's East Ravine subwatershed. Historically, this lake was quite small and confined to a shallow open water wetland in its southern extent. Recently, the lake has shown itself to be closely connected to surficial aquifer levels. During a prolonged wet period from 2015-2020, the lake's surface elevation rose over 20 feet, reflecting increasing local groundwater levels. The lake does not currently discharge to downstream surface waters. If it continues to rise, it will impact adjacent roadways and property.

Central Draw Overflow Station discharging north of Glacial Valley Park
Photo by Taylor Mills, SWWD Artist-in-Residence 2025

2.3.3 | Intercommunity Flow

Issue Statement: Intercommunity flow can lead to regional flooding and is difficult to manage at a municipal level.

Regional flooding, specifically caused by intercommunity flow, has long been a focus of the SWWD and was the primary reason the District was originally formed. By their very nature, these flooding issues cannot be addressed by a single municipality alone and often lead to conflicts among neighbors. SWWD typically leads assessment and implementation of feasible flood risk reduction and mitigation work to address regional flooding caused by intercommunity flow within the District. Often, these projects provide an opportunity to address localized flash flooding issues in the downstream communities while also increasing capacity to safely convey increased flow from upstream communities. SWWD's river communities along the Mississippi and St. Croix Rivers routinely experience flooding. While SWWD assists in flood risk reduction and mitigation work related to river flooding, the primary responsibility lies with those municipalities, Washington County, and state and federal government. Identified intercommunity flow management areas include:

Northern Watershed | Oakdale, Lake Elmo, Woodbury, and Cottage Grove

SWWD's northern watershed consists of a chain of Lakes beginning in Oakdale and Lake Elmo and flowing through Woodbury-Minnesota's eighth-most populated city and one of the fastest-growing communities in the state. Although cities carefully managed development and followed accepted design guidance, flooding issues were inevitable as development encroached on northern watershed lakes and as the storm sewer system was connected and built out. Today, primary flooding issues in this area stem from limited stormwater storage and inadequate storm sewer system capacity. Aging infrastructure built, using outdated hydrologic model assumptions, may now be undersized for the current climate. These issues are seen most acute at Wilmes Lake, where increasing runoff from development and climate change has increased the potential high-water

levels of the lake over the past several decades. An intense precipitation event in October 2005 caused the lake to exceed its emergency overflow, and several homes near the lake were impacted. SWWD and the City of Woodbury have taken many actions in the intervening years to maintain or add water storage in the watershed, assess infrastructure modifications, and assist impacted homes with several rounds of floodproofing. While flood risk remains in this area, adjacent homes are better able to withstand and recover from potential flooding events.

Glacial Valley Park and Central Draw Overflow | Woodbury and Cottage Grove

One of the primary reasons SWWD was formed, was to identify, design, and construct an outlet for the District's northern watershed. At the time, runoff from the northern watershed collected at Bailey Lake, which had no controlled outlet. Communities within the District recognized that Bailey Lake would not contain all the runoff from the watershed once the area was fully developed. Since that time, SWWD and its partners have worked to construct the Central Draw Storage Facility, now known as Glacial Valley Park, which includes 1,800 acre-feet of storage on 250 acres of land near the outlet of Bailey Lake. A City of Woodbury lift station pumps water from Bailey Lake to Glacial Valley Park. With storage available in Glacial Valley Park and rate/volume restrictions on development draining to Bailey Lake, the system is expected to be adequate to retain the runoff from a 6.3 inch, 24-hour rainfall event. However, due to design uncertainties, recent trends of extreme precipitation events, and the degree of safety necessary for flood management, SWWD also constructed a controlled overflow system. The Central Draw Overflow discharges stormwater to a large, reinforced ravine in Cottage Grove Ravine Regional Park, and flows eventually, and safely, to the Mississippi River. Though completed in 2020, this system will require ongoing routine maintenance to ensure long-term function.

Normal and Ordinary High-Water Levels:

Normal Water Level (NWL) is the surface water elevation established by the long-term presence of water. This level is directly indicated by hydrophytic plants or hydric soils or indirectly determined via hydrological models or analysis.

Ordinary High-Water Level (OHWL) for lakes is an elevation delineating the highest water level maintained for a sufficient period of time to leave a physical mark on the landscape. This boundary is commonly identified as the point where the natural vegetation changes from predominantly aquatic to predominantly terrestrial.

Ordinary High Water Level (OHWL) for streams and rivers is the specific elevation at the top of the bank of the channel.

Ordinary High Water Level (OHWL) for reservoirs and flowages is the operating elevation of the normal summer pool.

La Lake and Ria Lake to the Mississippi River | Woodbury and Newport

La Lake and Ria Lake both have established outlets positioned above their normal and ordinary high-water levels. When La Lake's surface rises high enough, it discharges water overland to Ria Lake. Generally, water levels in these lakes are not a concern as the contributing watersheds are quite small. Under typical conditions, the lakes fluctuate based on prevailing weather patterns – rising in wet years, and falling in dry years. However, during a prolonged wet period from 2015 to 2021, the lakes' surface elevations rose enough to reach their outlets. This event led to prolonged inundation of forested park land around La Lake and flooded private well and septic systems near Ria Lake. Additionally, overland discharge from Ria Lake caused downstream damage. SWWD is working with both cities to evaluate the lakes, their existing outlets, and the feasibility of modifying the outlets to better control lake levels during wet periods while managing existing

Debris jam at Grey Cloud Island bridge
Sarah Lilja, Artist-in-Residence 2024

downstream flooding concerns. SWWD anticipates that substantial improvements will be required over the next decade.

West Draw | Woodbury and Cottage Grove

In SWWD's West Draw subwatershed, water drains from southwest Woodbury into northwest Cottage Grove. Hydrologic modeling indicates downstream capacity to be inadequate for the amount of runoff generated from an intense storm event. Consequently, flooding of downstream ponds could impact homes and infrastructure. SWWD continues to coordinate efforts to evaluate these risks and coordinate planning and mitigation responses with both cities.

Major River Flooding | Newport, St. Paul Park, and Others

SWWD's river towns experience routine flooding of the Mississippi and St. Croix Rivers. These municipalities have grown resilient to repeated flood events and maintain effective response procedures. SWWD has typically assisted cities in pursuing the acquisition of properties that experience repeated losses.

2.3.4 | District Strategies to Address Flooding Impacts

- Minimize existing and potential property damage, risk to public safety, and water resources due to flood events.
- Build resilience within watershed communities, systems, and resources to withstand Minnesota's changing climate.
- Maintain scientifically sound design guidance.
- Ensure SWWD flood reduction efforts extend to historically underserved communities and neighborhoods.

2.4 | STORMWATER OPERATIONS & MAINTENANCE

Issue Statement: When stormwater conveyance and treatment infrastructure are not maintained, it threatens the public's investment and contributes to reduced community resiliency.

The majority of the District is covered by a variety of Municipal Separate Storm Sewer System (MS4) permittees. Responsibility for inspection and maintenance of storm sewer systems lies with the Local Government Unit (LGU) that owns and operates the system or BMP, unless alternative arrangements have been made through a formal agreement. In SWWD's remaining non-MS4 communities- Afton, Denmark Township, and Grey Cloud Island Township- storm sewer infrastructure is largely limited to culverts and systems owned and operated by Washington County under its MS4 general permit.

If water quality treatment BMPs are not maintained, water resources suffer, and beneficial uses of those resources are not provided to area residents. Consequently, SWWD focuses its investments on water quality improvements. Protecting these resources for future generations requires maintaining and upgrading existing structural BMPs, both through direct District action and partner support. These efforts ensure past public investments continue to deliver value. To address these maintenance needs, SWWD builds creative partnerships with local municipalities, leveraging the expertise and capacity of regional public works staff.

Many storm sewer pipes within the SWWD pass underneath roads and railroads. Structural failure of these crossing pipes can cause stormwater to back up behind embankments, potentially leading to roadway overtopping, severe erosion, embankment washouts, or structural collapse. These impacts cause a threat to public safety and have the potential to be more significant on major traffic routes. SWWD completed and adopted a Climate Resiliency Plan in 2018 to address this concern. This plan establishes a qualitative risk analysis for storm sewer infrastructure across the District, evaluating both the probability and the operational consequences of a failure. By combining these factors, SWWD generates a failure risk score to prioritize specific infrastructure for replacement or modification. SWWD encourages partner municipalities to leverage this risk assessment tool when collaborating on the planning and funding of future infrastructure maintenance projects.

Kraken stormwater filter at Nuevas Fronteras Elementary School

2.4.1 | District Strategies to Address Stormwater Operation & Maintenance

- Improve prioritization and targeting of MS4 inspection and maintenance activities through the promotion of SWWD's Storm Sewer Failure Risk Assessment.
- Establish and adequately fund maintenance agreements with municipalities for all SWWD initiated stormwater capital improvement projects.
- Identify gaps in municipal stormwater maintenance work and provide incentives to overcome barriers to implementation.
- Engage, educate, and assist homeowner's associations (HOAs) and other private landowners with stormwater maintenance activities.

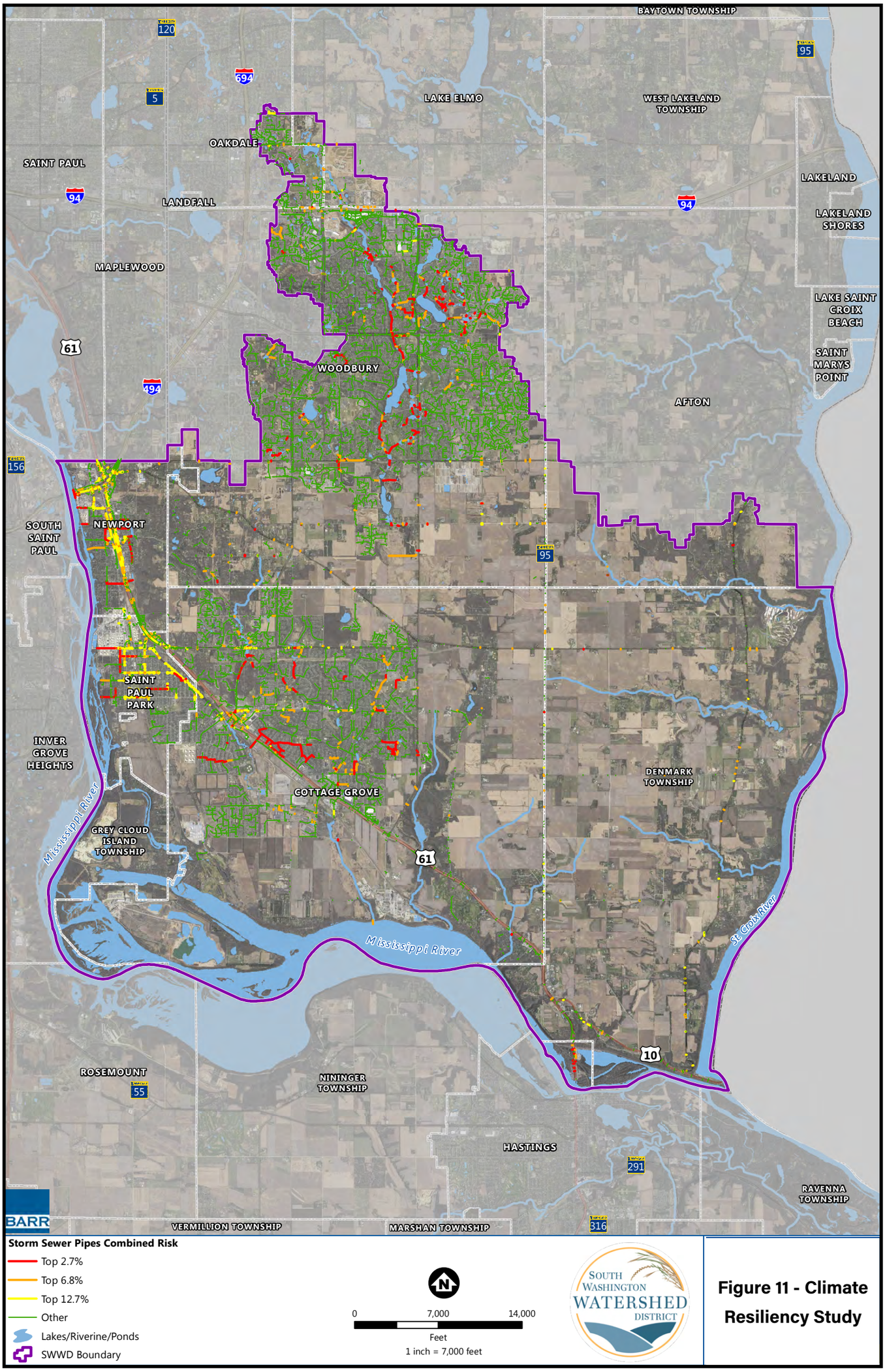


Figure 11: Climate Resiliency Study. The study was developed to understand the potential growing risk to the infrastructural integrity of storm sewer pipe within the SWWD.

2.5 | EROSION & SEDIMENTATION

Erosion and sedimentation are natural processes in which soil materials are dislodged, carried by wind, water, or ice, and deposited elsewhere, typically in downstream waterbodies. Human activities that disturb the natural landscape increase erosion and sedimentation rates far beyond natural conditions. Common sediment sources include construction sites, roads, parking lots, tilled agriculture fields, shorelines, streambanks, ravines, and other non-vegetated areas. Eroded sediment carries nutrients such as phosphorus and nitrogen, which fuel nuisance algae blooms in lakes and streams. It also carries other water pollutants including heavy metals and organic chemicals. Furthermore, sediment itself also acts as a direct pollutant itself, reducing water clarity and physically filling in waterbodies and floodplains.

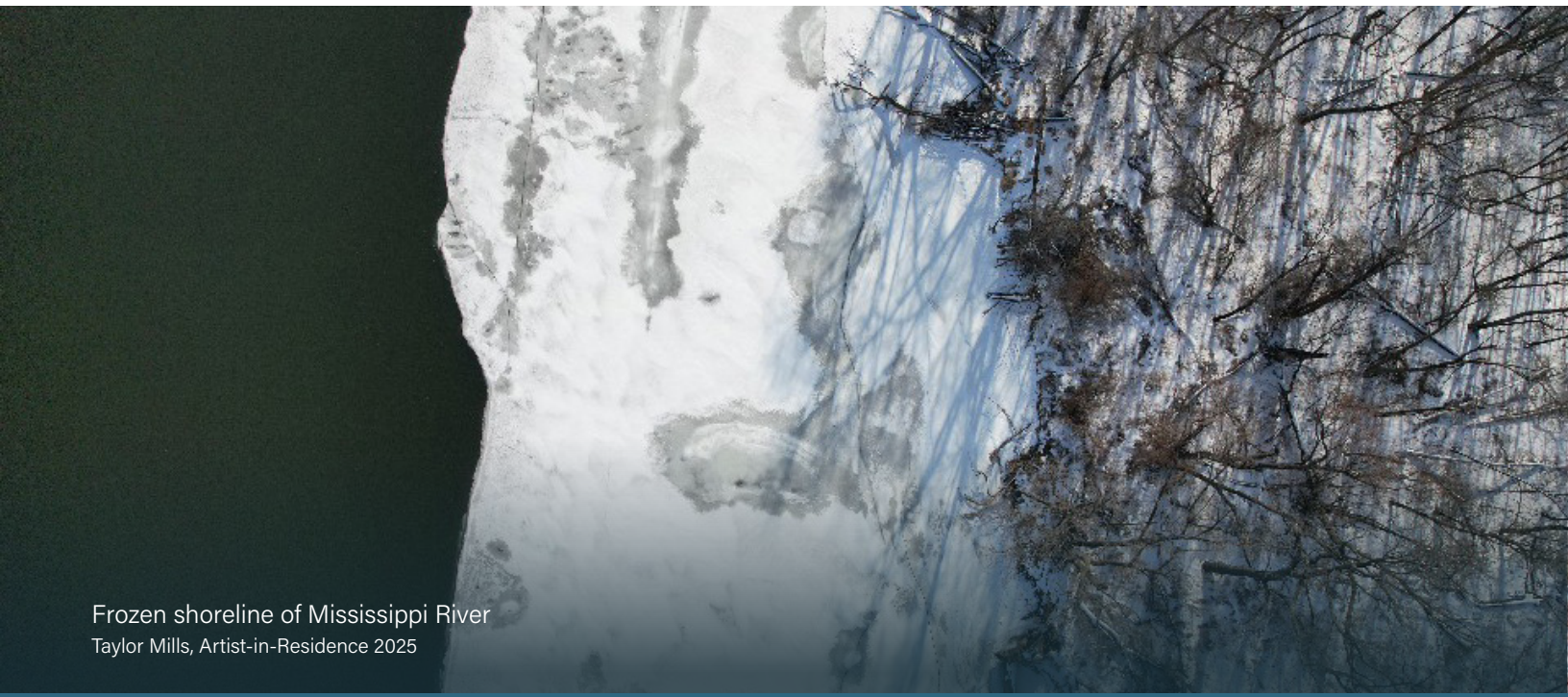
2.5.1 | Bluffs & Ravines

Issue Statement: Bluffs and ravines are prevalent across the watershed and are highly susceptible to erosion.

The SWWD borders the Mississippi and St. Croix Rivers. The historical actions of these rivers, combined with past glaciation events, have carved substantial floodplains into the surrounding bedrock. This geological process left steep bluffs along the entire perimeter of the watershed district, ranging from 100 to 300 feet in vertical height. As overland runoff flows from the central regions of the watershed toward the rivers, it cascades over the bluffs into the rivers. Over time, this concentrated flow has carved steep ravines and formed sediment deltas that shape the local river environment.

However, human activities have significantly altered the landscape - directly through farming, construction, and other landscape alterations, and indirectly through climate change. Consequently, runoff rates and volumes from the surrounding watershed have increased substantially. The frequency of large precipitation events, including "mega rain" events, has increased rapidly over the past 2 decades; a greater proportion of regional precipitation now occurs as heavy downpours rather than to slow, soaking events.

These hydrologic shifts have increased stress on the ravines, accelerating erosion through frequent slope failures and mass wasting. Once initiated, the process of erosion begins, this cycle typically becomes more severe over time due to highly erosive soils paired with high velocities and concentrations of flow commonly seen at these locations. Ravine vulnerability varies based on slope steepness, soil composition, drainage size, and surrounding vegetative cover. Ultimately, eroding ravines can cause property damage and deliver excess sediments and nutrients to downstream waterbodies. This directly impacts the Mississippi River, which is federally



Frozen shoreline of Mississippi River
Taylor Mills, Artist-in-Residence 2025

impaired for high turbidity, and the St. Croix River, which is impaired for excessive nutrients. Controlling stormwater runoff before it reaches these ravines is critical to prevent damage.

2.5.2 | Streambanks & Shorelines

Issue Statement: Streambanks and shorelands are highly susceptible to erosion.

Streambanks and shorelands are common places to find erosion due to the constant interaction of land and moving water. Even around relatively small lakes and ponds, wind and wave action generate sufficient energy to begin the erosion process independent of boat wakes. In the SWWD, there are no inland water resources with public boat launches or permitted motorized watercraft, and only a small percentage of lake shoreline is privately owned. Despite this, it remains a critical natural resource to protect and restore SWWD's shoreland areas.

Elevated peak runoff rates and volumes—driven by urban development and climate change—have accelerated channel flow velocities, extended flow durations, and raised water levels across local lakes and streams. These altered hydrologic conditions increasingly expose bare or unstable soils to erosive forces, driving accelerated sedimentation within regional waterbodies. These altered hydrologic conditions can expose bare or unstable soils to erosive forces, resulting in sedimentation within our waters. Maintaining the stability of streambank and shoreland areas is critical to limiting the impacts of erosion.

One of the simplest ways to prevent shoreland erosion is to maintain a buffer area around waterbodies. This helps to prevent erosion in two ways; intercepting and slowing the velocity of runoff and minimizing the concentration of flow and enhancing the structural stability of native shoreland soils. Most of the lakes and streams within SWWD are mapped on Minnesota DNR's Buffer Protection Map, subjecting adjacent lands to municipal or county shoreland ordinances and Minnesota's Buffer Law (M.S. 103F.48). Generally, a 50-foot buffer of perennial vegetation is required around public waters along public waters within the SWWD. The Minnesota Board of Water and Soil Resources (BWSR) estimates that Washington County is over 99% compliant with Minnesota's Buffer Law.

2.5.3 | Mississippi & St. Croix River Shorelands

Issue Statement: Variable flow velocities and seasonal flooding events complicate the management, protection, and restoration of river embankments and island complexes.

Strong currents, heavy boat traffic, and fluctuating seasonal water levels, combined with steep shorelines along these major waterways, create severe riverbank erosion. Consequently, local islands are constantly being reshaped or have been lost entirely. A review of historical aerial photography captured in 1930, when the U.S. Army Corps of Engineers established Pool 2 on the Mississippi River, reveals the total disappearance of entire landmasses. Since this severe loss stems from

Progression of Pool 2 landmass disappearance in the Mississippi River
Minnesota Historical Aerial Photographs Online

the erosive force of the river paired with wind and wave action in the newly created shallow backwaters.

While much of the District's riverfront and floodplain areas remain privately owned, several large regional parks provide critical public river access and protection to the fragile ecosystems they contain. Local municipalities have also begun acquiring select riverfront properties as they become available to enhance public water access. The municipalities have removed structures from recurring flood risk zones and undertake habitat and resource protection projects–often in partnership with SWWD. Recent acquisition examples include parcels in the City of Newport between 16th and 17th Streets, and at Mississippi Dunes Park Reserve in Cottage Grove. Washington County periodically expands its land holdings when opportunities arise as it works toward a future planned regional park on Lower Grey Cloud Island. However, ongoing aggregate mining and reclamation activities must cease in the area before the regional park can be developed.

In addition to supporting public riverfront protection projects, it is important for the District to make connections with remaining private landowners. Disturbed or improperly managed riverfront properties are more susceptible to severe erosion and mass wasting during flood events. SWWD provides public education and incentive-based financial assistance to promote restoration projects in these areas.

2.5.4 | Construction Site Erosion

Issue Statement: Construction site erosion creates excess sediment loading, which impacts area waterways.

While construction site erosion and sediment control remain a primary focus of programs housed at the Minnesota Pollution Control Agency (MPCA) and local municipalities, they continue to be a top concern to the SWWD and its residents. Despite widespread industry improvements driven by MPCA's National Pollutant Discharge Elimination System (NPDES) Construction Stormwater and Municipal Separate Storm Sewer System (MS4) permits, SWWD and its municipal partners still identify active construction sites in violation of these regulations every year. Although erosion at active construction sites is inevitable, the rigorous implementation of best management practices (BMPs) identified in a Storm Water Pollution Prevention Plan (SWPPP) can minimize the extent of that erosion and its impact on District resources. SWWD actively assists its municipalities in ensuring that construction sites comply with established erosion and sediment control standards and utilize appropriate BMPs.

Construction of Phase IV of the Central Draw Overflow project
SWWD

2.5.5 | District Strategies to Address Erosion & Sedimentation

- Inspect, monitor, and implement projects to address eroding bluffs and ravine areas along the Mississippi and St. Croix Rivers.
- Achieve and maintain stable shorelines and streambanks on all priority SWWD waterbodies.
- Protect shorelands, riverbanks, islands, and riparian floodplain corridors from excessive erosion due to non-natural or human-causes along the Mississippi and St. Croix Rivers.
- Prevent construction site erosion from degrading District water resources.

2.6 | WATER RESOURCE MANAGEMENT

Water resources directly reflect the characteristics of their surrounding watersheds. As detailed in Parts One and Two of this plan, the land within SWWD has an extensive history of land-use and land-cover restoration, driven by repeated and widespread landscape alterations. The impacts from these changes are reflected in the current conditions found within SWWD's lakes, streams, and wetlands. SWWD's lakes are universally small waterbodies characterized by variable hydraulic residence times and differing depth regimes. This internal diversity complicates environmental management, rendering one-size-fits-all restoration strategies ineffective. Consequently, multiple lakes within the District are currently listed on Minnesota's Section 303(d) Impaired Waters List due to excessive nutrient loading and related ecological impairments.

Today, many of SWWD's lakes are on Minnesota's Section 303(d) Impaired Waters List due to excess nutrients and/or other problems. To assist the District with water resource management planning and implementation, Barr Engineering Co. was commissioned to complete a Lake Management Plan in 2025 (Appendix A). This plan updated hydrologic modeling and assessed the major surface water resources within the watershed. The data analysis, technical findings, and recommendations contained within the report are explicitly incorporated and adopted as an official component of this Watershed Management Plan.

SWWD will evaluate the potential impacts of emerging contaminants and seek on-going guidance from state and regional agencies to address those water quality concerns.

2.6.1 | Pollutants and Impaired Waters

Issue Statement: Pollutants impact water resources and limit the beneficial uses they provide to residents and visitors of the watershed.

Nutrient Loading

Ongoing development, land-use changes, and climate change have significantly disrupted the watershed, increasing the natural flow of stormwater runoff and nutrient loading. This increased and prolonged nutrient loading drives the production of nuisance level vegetation growth and algal blooms. Enforcement of the SWWD's rules alone has proven insufficient to mitigate these impacts. The District must continue to actively pursue development of regional stormwater Best Management Practices (BMPs) to achieve its resource management goals. Successfully executing these large-scale projects requires continuous, active partnerships with local municipalities, Washington County, and private landowners.

While SWWD and its partners have made many improvements across the watershed to reduce ongoing nutrient loading to lakes and streams – and will continue to do so – targeted in-lake work is required to meet state and local water quality goals. Decades of historical nutrient loading have led to a severe accumulation of phosphorus and nitrogen within lake-bottom sediments.

Lakes experience naturally occurring anoxic conditions (oxygen-depletion) throughout the year. During this process, sediment releases bound nutrients back into the water column. This internal loading fuels severe algal blooms and accelerates the growth of both native and invasive aquatic vegetation. To break this cycle, SWWD will explore projects and management actions to reduce internal nutrient cycling across its lakes.

Chloride

Chloride is a naturally occurring chemical compound in our local water resources, however, excess concentrations have a negative impact on water quality. Excess chloride primarily stems from road salts, home water softening systems, fertilizer application, and industrial processes. In Minnesota, icy winter roads have been historically treated with road salts to maintain a certain level of transit service that commuters have come to expect.

In 2020, the Minnesota Pollution Control Agency (MPCA) developed the Statewide Chloride Management Plan. The plan framework helps local government units, winter maintenance professionals, decision-makers, and others, to take action to protect Minnesota's water resources from chloride pollution. Specifically, the plan assists stakeholders to understand sources of chloride,

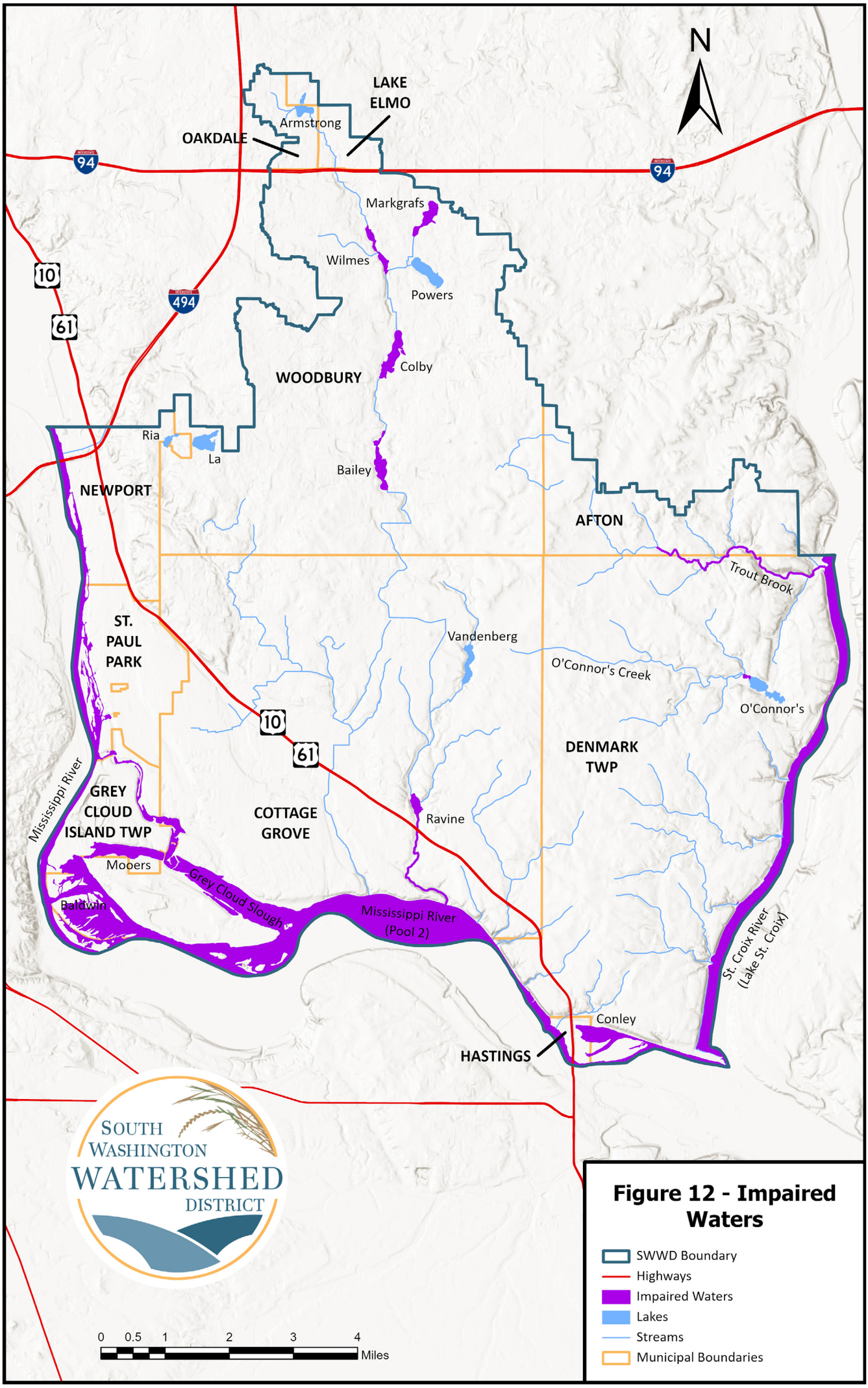


Figure 12: Near Impaired Waters. Today, many of SWWD's lakes are on Minnesota's Section 303(d) Impaired Waters List due to excess nutrients and/or other problems.

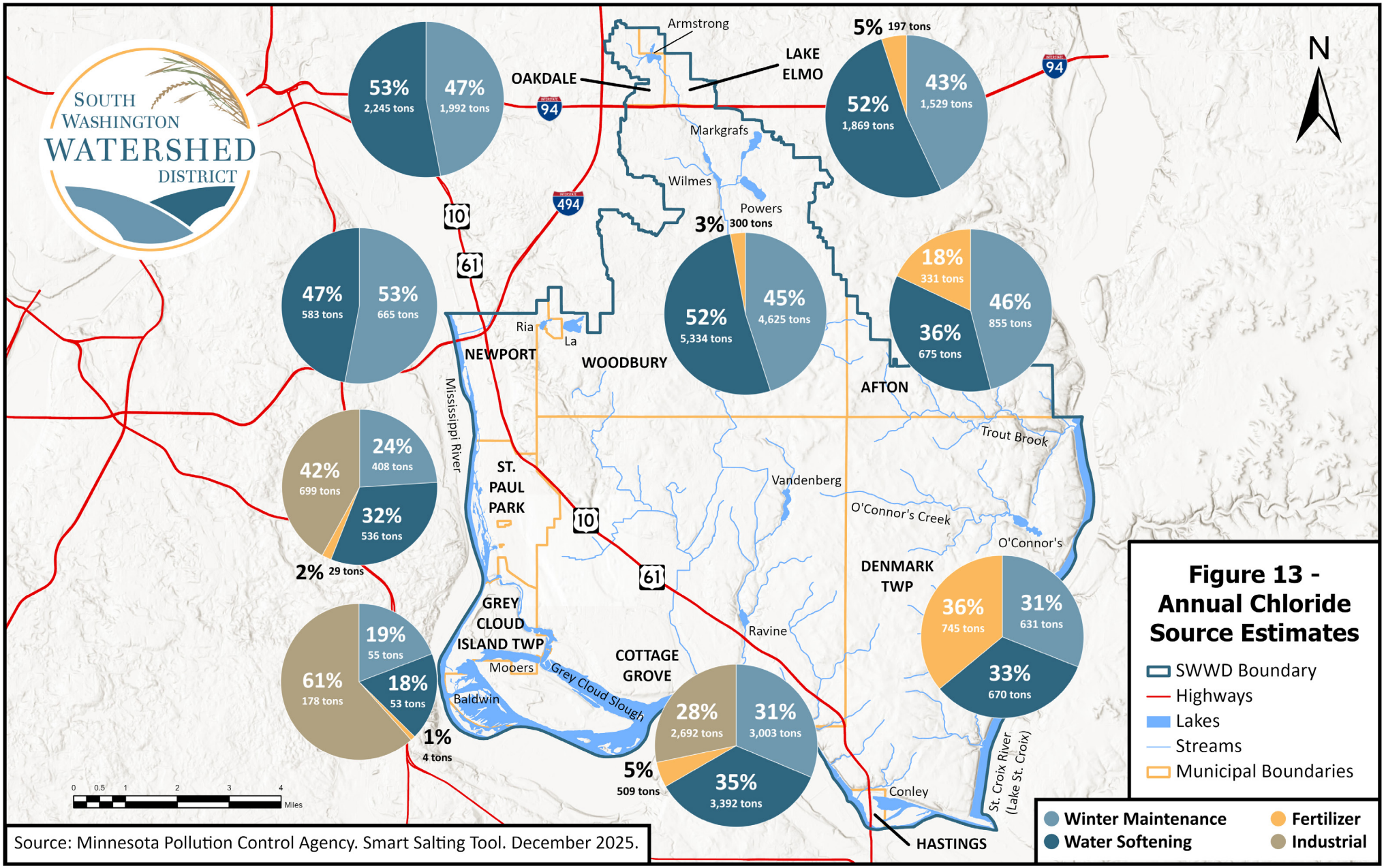


Figure 13: Annual Chloride Source Estimates. Overview of the sources of chloride pollution by city and pollution type across the SWWD.

see trends in chloride pollution statewide, prioritize critical areas for reducing salt use, and research and implement strategies to reach local goals.

Previous analysis of chloride in District resources has identified road salt as the primary driver of regional chloride contamination within the watershed. Chloride damages property, the aquatic species, and impacts drinking water quality and taste. Although chloride is not yet at severe widespread levels, monitoring data shows it is increasing significantly year after year. Currently, SWWD does not have a strong understanding of the movement of legacy chloride pollution within the area's groundwater resources, or how that movement may contribute to chloride levels in lakes and other surface waters. A strong relationship is suspected, but additional monitoring and modeling will be required to make resource management recommendations.

Several of SWWD's lakes could be added to State of Minnesota's Section 303(d) Impaired Waters List for chloride levels over the next decade if ongoing practices remain unchanged. Once chloride enters a waterbody, there is no cost-efficient way to remove it. The only feasible solution to ongoing chloride pollution is to aggressively reduce community salt use and pursue alternative deicing methods. SWWD has a strong history of supporting its partners with guidance and funding for chloride reduction projects and equipment. These initiatives will remain a core priority under this watershed management plan.

PFAS

Perfluoroalkyl substances (PFAS)- previously referred to as perfluorochemicals (PFCs)-represent a severe, long-standing contaminant issue in groundwater within the SWWD. Since the emergence of this pollutant, municipalities across the District have begun working to retrofit and construct new treatment plants to provide safe, clean, drinking water for their residents. As drinking water concerns are addressed, the focus is expected to shift to other impacted resources, including surface water. Many of SWWD's surface water resources receive substantial groundwater inflow, which carries PFAS into those lakes and streams. Once in the water, PFAS are highly persistent, resisting natural degradation and degradation and bioaccumulating into plants and animals. The bioaccumulation of PFAS in fish tissue is of particular concern and creates a unique dietary pathway to human consumption of PFAS. To monitor this risk, the Minnesota Department of Health (MDH) conducts fish tissue testing on some lakes, and publishes contamination advisories for PFAS, mercury, and polychlorinated biphenyls (PCBs). The public should be aware that several waterbodies within and adjacent to the SWWD are subject to special MDH fish consumption advisories that are stricter than existing general statewide guidelines. Current guidelines and site-specific restrictions are published on the MDH Fish Consumption Guidance website. SWWD and its partners will continue working to mitigate ongoing PFAS pollution, increase public awareness of the issue, and enhance the overall ecological resilience of District resources.

2.6.2 | Impaired Ecology

Issue Statement: Human activities have impacted water resources, altering ecosystems, spreading invasive species, and disrupting food webs across the watershed.

Impacts to natural resources from physical changes and water quality degradation ultimately become recognizable through ecological impairments. While residents may not track specific water quality metrics or statistics, they readily recognize the symptoms of an impaired system: excessive growth of native and invasive aquatic vegetation that impedes boating, harmful algal blooms that discourage swimming, and degraded fish communities that reduce angling success.

SWWD will continue watershed-wide work across both aquatic and terrestrial systems, to decrease ecological stressors. SWWD expects to take direct action within its lakes, streams, and wetlands to begin reversing historical degradation.

Preservation of Remnant Natural Areas

The SWWD contains a rich mosaic of landscape types which are largely influenced by geology, soil, and hydrology. These foundational features dictate the composition of natural community types, habitat connectivity, and ecological resiliency in the face of

environmental disturbances. Consequently, these qualities determine the most effective strategy for ecosystem protection. Groundwater protection, for instance, may be best supported through stormwater infiltration to recharge aquifers in some areas; conversely, soil and bedrock characteristics in other areas make direct infiltration practices a potential risk to these same resources. Nevertheless, protecting and restoring natural terrestrial ecosystems benefits water resources by enhancing soil structure. Healthy soil ecosystems provide intrinsic filtration benefits that remove nutrients and sustain diverse natural communities both above and below ground.

The characteristics of the natural landscapes within the SWWD reflect millennia of interactions between the biological and physical components of the land. Remnant natural communities retain critical ecological connections that restored or reconstructed habitats lack. Identifying natural, functioning wetlands and uplands for protection is a District priority. Wherever feasible, SWWD will also proactively seek to restore connections between these natural communities.

Keystone Process: A fundamental ecological process that maintains the structure and function of an ecosystem.

Natural Areas Restoration

Ecosystem restoration is the process of assisting in the recovery of ecosystems that have been degraded, damaged, or destroyed. Rather than attempting to rigidly recreate a historical snapshot in time—particularly within dynamic urban landscapes—restoration initiatives focus on rebuilding the critical ecological components and connections that have been compromised or lost. This process reestablishes the environmental structure, species composition, and natural processes of native communities, providing a wide array of benefits to overall watershed health. Using a nature-based approach to restore fully functioning ecosystems requires careful consideration of keystone processes. These foundational processes build highly resilient plant communities and reestablish their parts and connections.

Ecological restoration projects can range from a small backyard garden to multi-acre savannas. Expanding the geographic scale of restoration increases greater potential for more interactions between ecosystem components, directly enhancing core habitats, genetic diversity, soil health, water quality, and system resilience. This type of restoration allows additional opportunities to reintroduce keystone processes like prescribed fire or grazing as a management tool. SWWD prioritizes the restoration of large, contiguous natural landscapes while continuing to leverage smaller-scale projects primarily as valuable public outreach and resident education tools.

Supporting native species is essential, as these organisms represent the successful coevolution of ecosystem connections established in a particular place over millennia. Effective management must proactively balance ecological recovery with modern land-use realities, accounting for potential conflicts regarding public safety, surrounding infrastructure, and changing climate patterns.

Aquatic Vegetation

Aquatic vegetation is an extremely important part of healthy and balanced aquatic ecology. Abundant and diverse aquatic vegetation provides essential habitat for fish and other aquatic organisms and helps to reduce excessive algae blooms. All District lakes are productive, nutrient-rich lakes that should exhibit diverse and abundant native aquatic vegetation.

SWWD routinely surveys vegetation on District lakes and increasingly deploys active management strategies. Eurasian watermilfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) are aquatic invasive species (AIS) that are seen throughout the watershed. Where those species exist as parts of a balanced and diverse vegetative community, they are generally not a major concern. However, when aquatic systems are stressed and native vegetation is diminished, the invasive species can thrive and rapidly lead to a degraded habitat. To combat these adverse

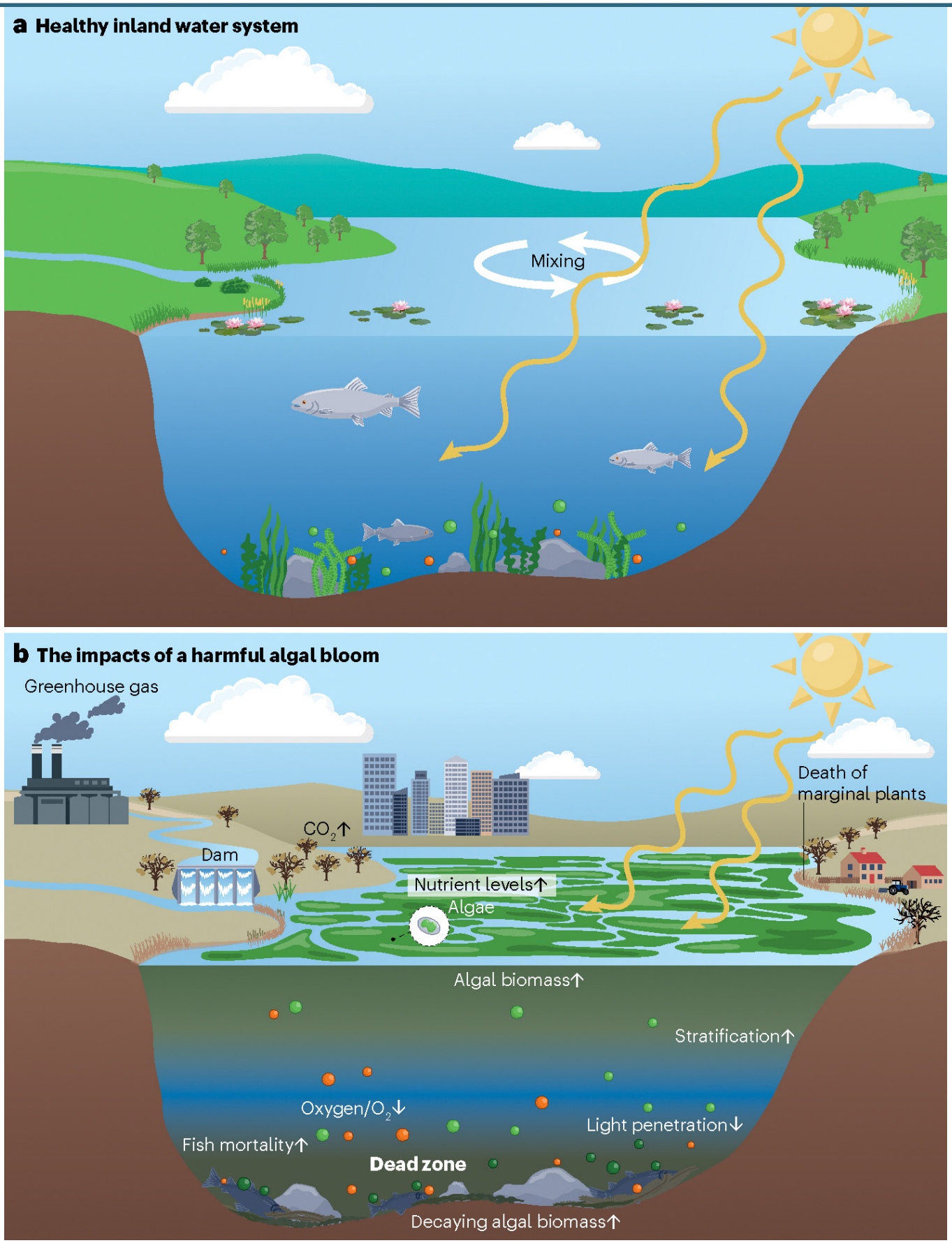


Figure 14: The Impact of Harmful Algal Blooms. Summary of the impact of harmful algal blooms on inland waters. (Feng, L., Wang, Y., Hou, X. et al. Harmful algal blooms in inland waters. Nat Rev Earth Environ 5, 631–644 (2024). https://doi.org/10.1038/s43017-024-00578-2).

conditions, SWWD has routinely treated District lakes where AIS is causing degraded habitat. As it is unlikely that AIS species could ever be fully eradicated, SWWD's goal is to control the abundance of AIS, and promote the growth of native species either through regrowth of remaining plants or through transplanting from lakes with healthy native vegetation communities.

Fish

Degraded aquatic habitats within District lakes and streams are inadequate to support healthy and abundant fish communities. In those resources, fish communities are made up of abundant small fish like bluegill, sunfish, and bullhead. These fish tend to feed on the lake bottoms, which can disturb sediment and increase internal nutrient cycling that leads to a cycle of further water quality and habitat degradation. As the District and its partners continue their work to improve habitat by restoring water quality and improving vegetation, the District will also work with the Minnesota Department of Natural Resources (DNR) to evaluate fish communities and pursue management where feasible to improve fish community balance. Several SWWD lakes are part of DNR's Fishing in the Neighborhood program through which the DNR works to increase angling opportunities, public awareness, and environmental stewardship through fish stocking and resource management.

Harmful Algal Blooms

While Algae are present in all aquatic ecosystems and serve as a critical part of a healthy food web, certain algae can grow to nuisance levels in SWWD lakes. Although most species are generally not a health concern, blue-green algae, however, can be harmful to pets and humans. Blue-green algae are not actually algae at all, as their name would suggest. They are, in fact, cyanobacteria. Harmful blooms of blue-green algae are increasing across the watershed and region as temperatures warm and water quality continues to degrade. It is not always easy to tell if an algae bloom is the harmful blue-green algae bloom or not. Visually, toxic blooms often resemble thick pea soup or spilled green paint on the water surface. If a harmful algal bloom is suspected, all physical contact with the water must be strictly avoided.

2.6.3 | Groundwater Quantity

Issue Statement: A combination of overuse, largely for irrigation purposes, and diminished natural recharge threatens the groundwater supply in southern Washington County.

Groundwater supply and pollution have been issues for southern Washington County, characterized by documented aquifer depletion and longstanding contamination concerns. SWWD views groundwater supply as a municipality-led issue, however, it does value its role in helping to preserve groundwater quality and quantity. Although many questions remain about how much water can be sustainably withdrawn from aquifers, there is a consensus on the need for conservation. SWWD encourages residents to review Washington County's Groundwater Plan, which serves as the primary local resource for information related to groundwater.

SWWD is committed to implementing and improving conservation efforts to ensure the long-term viability of groundwater resources in southern Washington County. Local water use for agricultural and landscape irrigation, industrial manufacturing, and pollution containment operations remains a high-priority regional concern. Municipalities have been working diligently to reduce groundwater demand by implementing irrigation restrictions and offering incentives for residents to reduce consumption. However, more work is needed to understand impacts of large industrial uses.

Infiltration of precipitation is the primary source of groundwater system recharge locally. Recharge is typically greater in areas of southwest Cottage Grove and St. Paul Park, where soils tend to be sandier. The amount of recharge that occurs each year is primarily dependent on the amount of precipitation received and when and where the precipitation occurs. Water can also enter the groundwater system via seepage from lakes and streams and infiltration stormwater practices. However, cumulatively, these processes make up a small fraction compared to recharge generated by broad areal infiltration across SWWD. Climate change increasingly alters the quantity and timing of groundwater recharge throughout the watershed. Warmer temperatures and

longer growing seasons can increase evapotranspiration and reduce recharge while also resulting in additional irrigation demand for agriculture and lawns. Currently, municipal groundwater demand in the summer months can be more than double winter demand, solely due to irrigation. Implementation of green infrastructure, stormwater infiltration practices, and reducing soil compaction from development can all help to offset these concerns to some degree.

Lakes, streams, and wetlands can interact with groundwater in several ways. Groundwater can flow into a surface waterbody (discharge). Surface waterbodies can also lose water to the groundwater system (recharge). Some lakes and wetlands have both groundwater flowing into the waterbody and water flowing out to the groundwater (flowthrough). These waterbodies can exhibit significant changes in surface elevation over time as groundwater levels rise and fall. Surface waters where a change in groundwater has little to no effect on the water balance are considered disconnected or perched. SWWD has all four types of resources present in different locations across the watershed.

Under future climate scenarios, groundwater-dependent natural resources could be affected in several ways. Potential reductions in groundwater recharge coupled with additional groundwater pumping, may alter the hydrology of these water resources. Lower groundwater levels and reductions in groundwater discharge to surface water, may result in smaller baseflow to streams, lower lake levels, and drying of groundwater-dependent wetlands. Water resources that contribute to groundwater recharge are also important to protect, as they can be direct vectors of groundwater contamination.

2.6.4 | Groundwater Quality

Issue Statement: Groundwater quality in southern Washington County has been impacted by land use practices, chemical storage facilities, waste disposal practices, and winter maintenance activities.

Maintaining clean, safe, drinkable groundwater is critical to human and environmental health, as well as the economic and social vitality of our communities. Whether served by a public water supplier or a private well, SWWD residents rely on groundwater for 100% of their water supply. Due to the geologic conditions of the watershed, most of its groundwater reserves are highly sensitive to contamination. Because of this, SWWD and its local partners place great emphasis on protecting groundwater resources from pollution. Ongoing contamination concerns have required many of our municipalities to implement extremely robust treatment systems to provide clean, safe drinking water for their residents. These efforts include wellhead protection (municipalities), special well construction areas (Lake Elmo/Oakdale), and pollution remediation (3M©). SWWD is committed to preventing groundwater pollution from stormwater BMPs and local operations (e.g. large-scale infiltration, de-icing operations, and karst). Additionally, there are several known direct connections between surface water and groundwater resources in the District. SWWD remains committed to continued assessment of those connections and the risks associated with them, as well as protection of groundwater-dependent natural resources.

Karst

The Minnesota DNR classifies groundwater pollution sensitivity across the SWWD as primarily "high" or "karst" (also considered high) (Figure 15). Karst is a landscape characterized by the dissolution of soluble rocks, including carbonates such as limestone and dolomite, and often exhibits features such as sinkholes and ground fractures. In Minnesota, karst is often present in areas where carbonated bedrock is found

Sinkhole in karst, Woodbury 2005
Image by MN Stormwater Manual

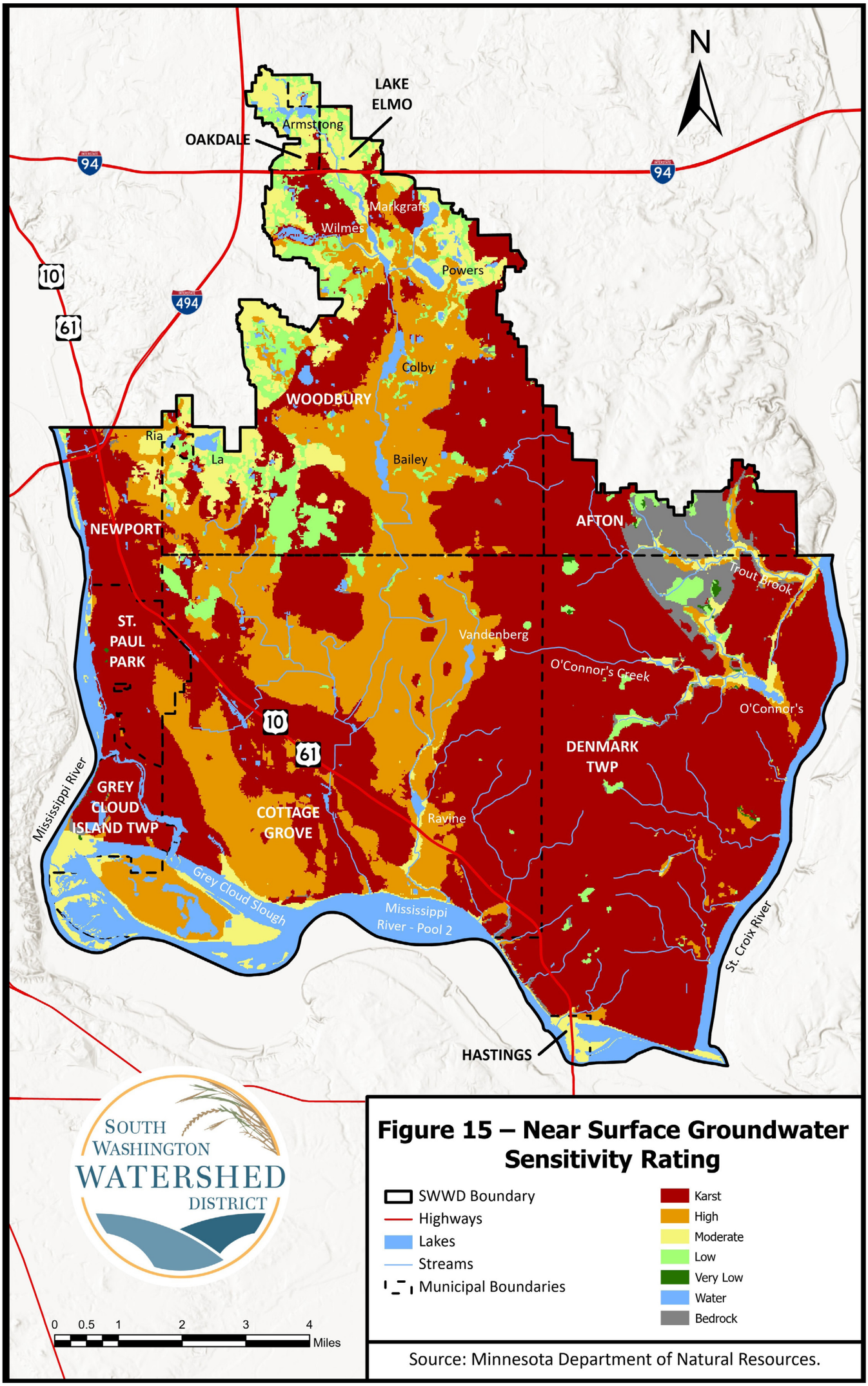


Figure 15: Near Surface Sensitivity Rating. Sensitivity of groundwater to pollution through surface infiltration.

within 50 feet of the ground surface. In areas of karst, contaminants from the surface can rapidly transport to bedrock aquifers. The high pollution sensitivity across much of the District makes groundwater vulnerable to contaminants from land practices at the surface, such as fertilizer or road salt application. Specifically, nitrate and chloride contamination are a growing concern.

Chloride

Chloride in groundwater can occur naturally, but in excess, it comes from road salt, water softening, fertilizer application, and industrial processes. While generally not considered a threat to human health, chloride can change the way water tastes when concentrations exceed 250 mg/L. More importantly, when groundwater with high chloride concentrations discharges to surface waters, it can be toxic to aquatic animals and plants. The State of Minnesota maintains a chronic chloride water quality standard of 230 mg/L and an acute water-quality standard of 860 mg/L to protect aquatic plants and animals. Unlike other contaminants, chloride in groundwater does not react or break down in a manner like other contaminants. The mass of chloride entering the groundwater system will eventually leave via seepage into surface waters or through water well pumping. Similarly, traditional BMPs cannot treat or filter chloride. SWWD does not currently have a comprehensive understanding of how legacy chloride pollution moves within local groundwater resources, or how that movement may contribute to chloride levels in lakes and other surface waters. While a strong relationship is suspected, additional monitoring and modeling will be required to make resource management recommendations. Even if chloride inputs from the surface were eliminated or drastically reduced, chloride already in the groundwater system would likely continue to discharging to surface waters for decades.

Nitrates

Nitrates in groundwater are a primary concern for the SWWD and its member communities. A major source of nitrate in groundwater is from the application of fertilizers for agricultural production and turf maintenance. Nitrogen fertilizers dissolve easily and readily through soil into aquifers. The southern portion of the SWWD is considered particularly vulnerable to nitrate contamination, with wells in Cottage Grove and Denmark Township being the most greatly impacted. Exposure to high nitrates in drinking water can cause methemoglobinemia (commonly known as blue baby syndrome) in infants and young children.

Per-and Polyfluoroalkyl Substances (PFAS)

Per- and Polyfluoroalkyl substances (PFAS)- previously referred to as perfluorochemicals (PFCs)- have been

Pile of de-icing salt on the sidewalk

detected in groundwater over a large area of southern Washington County. Historically PFAS were used to manufacture many commercial, industrial, and residential materials. Today, they are ubiquitous in most households, municipal waste streams, and in most landfills. They are also present in biosolids (in part from municipal sewer sludge) and used as amendments to soil in agricultural and landscaping operations. Locally, within the SWWD, 3M© manufactured PFAS at its Cottage Grove facility from the 1940s to 2002. Wastes from the manufacturing process were disposed of both on-site and at a disposal site near the Woodbury and Cottage Grove border. Consequently, cities within SWWD are modifying existing supply systems or constructing new treatment systems to provide the treatment necessary to meet current PFAS water quality standards. Much of this work is being funded by settlement funds from 3M©. While PFAS will remain an issue in SWWD's groundwater far into the future, these issues are known, and cities are actively addressing them.

2.6.5 | District Strategies to Address Water Resource Management

- Monitor, protect, and restore District resources to meet State standards and TMDL pollutant load reductions and limits, guided by the SWWD 2025 Lake Management Plan.
- Reduce internal nutrient-loading, guided by the SWWD 2025 Lake Management Plan.
- Reduce the use of chloride-based winter maintenance products across the District
- Protect District residents and resources from existing and emerging contaminants
- Protect and restore healthy aquatic habitats within District resources
- Promote and support efforts to conserve groundwater resources within SWWD
- Improve understanding of surface water-groundwater interactions within the District to advance groundwater protection efforts

2.7 | INFORMED COMMUNITY

Issue Statement: Informed residents and partners are essential for the establishment of reasonable resource expectations and successful implementation of District programs.

Since its formation, the District has worked to educate its constituents about the direct and indirect impacts human actions have on natural resources. These efforts continue and now involve more partners. The SWWD and other water management organizations in the area have long pooled resources toward a shared education program; the East Metro Water Resources Education Program (EMWREP). Increasingly, municipalities are joining that effort to achieve local resource goals and comply with Municipal Separate Storm Sewer System (MS4) permit requirements. The District intends to maintain its active partnerships to develop and deliver a coordinated and comprehensive education program. To that end, the SWWD maintains active partnership and involvement in EMWREP.

The District acknowledges that it has not historically interacted with all its communities in the same manner or to the same extent. Moving forward, outreach and education efforts will be tailored to meet community members where they are. This adaptive approach ensures that District messaging effectively reaches as many residents as possible, with a specific emphasis on connecting with historically underserved communities.

Volunteers harvesting invasive Garlic Mustard from Hasenbank Woods
Sarah Lilja, SWWD Artist-in-Residence 2024

2.7.1 | District Strategies to Address Informed Community

- Utilize the SWWD website to provide information to District residents about water resources status, watershed issues, implementation, management efforts, and emerging concerns.
- Work with partners, such as EMWREP, to develop and disseminate media to educate and inform District residents.
- Continue to pursue completion of the Glacial Valley Park Interpretive Center.
- Utilize an Artist-in-Residence program to support partner and resident engagement and fulfill identified Education & Outreach program needs.
- Engage with organizations to promote District activities and provide educational value to District community members.
- Pursue research opportunities that address identified information needs.
- Develop mechanisms to gauge effectiveness of educational programming efforts.

2.8 | EFFICIENCY AND ACCOUNTABILITY

Issue Statement: Resource management and program delivery should be efficient and accountable.

While the State of Minnesota boasts advanced water management, the state's multi-layered regulatory framework can lead to jurisdictional overlap and inefficiency. SWWD addresses this by prioritizing local-level implementation and cross-agency collaboration to maximize resources. By maintaining strict accountability through regular performance reviews, SWWD ensures public funds are directed only toward programs that demonstrate measurable progress. To do this, the District must use accurate, relevant assessment tools that enable the Board to evaluate progress toward goals and determine whether alternative projects, programs, or actions should be implemented.

2.8.1 | District Strategies to Address Efficiency and Accountability

- Limit duplication of planning and implementation efforts by the District and its State and local partners by improving collaboration and coordination of efforts.
- Foster innovation and efficiency through research and implementation partnerships.
- Implement effective board leadership through continued board education, proactive succession planning, and rigorous maintenance of foundational governing documents.
- Develop an annual plan and budget consistent with the Long Range Workplan that manages District funds to minimize year-to-year tax impact changes to District taxpayers.
- Pursue opportunities for grant funding for District projects and programs.
- Continue staff development through a blend of education and collaboration in an era of rapid technological changes.
- Follow all legal requirements applicable to watershed districts.
- Analyze the social, economic, and environmental justice impact of the District's projects and programs to ensure that SWWD remains equitable, sustainable, and inclusive.
- Amend the SWWD Watershed Management Plan as necessary to provide the District with programs and tools necessary to implement its identified strategies and meet its goals.

PART 3

Implementation

Trout Brook, Afton

Photo by Sarah Lilja, SWWD Artist-in-Residence 2024

PART THREE | IMPLEMENTATION

SWWD's programs reflect general requirements of Minnesota Rule 8410 and address the issues identified in Part Two of this plan through engagement with District residents and community partners. The District takes its general roles and responsibilities seriously, but tailors these programs to prioritize critical issues first. The following programs and goals reflect that commitment and establish the programmatic framework necessary to facilitate a community response to issues currently identified in this plan, as well as others that emerge during implementation. That focus is reflected in the District's mission statement:

To manage water and related resources of the District in cooperation with our residents and communities.

These programs and goals were developed and intended to meet District needs over the next decade. Each goal addresses one or more of the priority issues found in Part Two of the Plan. A reference table is included in section 3.10.9 to trace the relationships between implementation goals in Part Three and the issues defined in Part Two. The District routinely assesses its performance and will modify them as necessary to meet the District's needs effectively.

3.1 | PLANNING

Program Purpose: To provide current and scientifically sound guidance for the implementation of projects and programs identified in this Plan.

Adaptive Management is an iterative, systematic process for continually improving management strategies and practices by learning from the outcomes of previously employed actions. SWWD is committed to an adaptive management approach to watershed management to manage uncertainty. The use of an iterative decision-making process enables the District to work toward its goals while maximizing information gathering to better inform future efforts. This approach is highly valuable because it facilitates District action despite varying levels of uncertainty that are characteristic of environmental systems and exacerbated by ongoing alteration of the watershed and the changing climate. Additional information, strategies, and practices are modified as necessary to best manage the watershed. Through its various planning efforts, SWWD evaluates resource issues, risks, and uncertainty in formulating a strategy or identifying practices to address identified issues. The District routinely collects information to evaluate the success of implemented practices and better inform its understanding of resource issues. Using that information, the District routinely revisits planning efforts to revise strategies as necessary. Water resource management decisions are informed by the best available science. As plans or studies referenced in this plan are revised or new ones are completed, the contents of this Watershed Management Plan will be updated through an amendment.

Several planning efforts are already complete-or will be completed over the life of this Watershed Management Plan-to address identified issues related to water quality, flooding, climate change, groundwater sustainability, and natural resources. The scope and purpose of those plans are briefly described below.

3.1.1 | Resource Management Planning

The District has completed resource management plans for several lakes and streams that the District actively manages. Those plans were updated as a part of the 2026 Watershed Management Plan update and will be evaluated at the midpoint of this plan. The purpose of

the District's resource management plans is to identify improvements and actions necessary to achieve the District's resource goals. The plans include extensive watershed and in-lake modeling and provide the basis for additional watershed planning efforts.

The District utilizes an adaptive management approach to watershed and resource management. Key to that approach is obtaining reliable and relevant feedback data that accurately characterize District resources and changes in water quality and quantity. To manage its water resources, the District must first have an accurate view of the state of those resources. The District's monitoring program is key to those assessments and facilitate efforts to identify trends, problem areas, and emerging concerns. That data is also used to calibrate the District's models which guide implementation.

SWWD actively manages 10 lakes and 2 streams within the District—Armstrong Lake, Makgrafs Lake, Wilmes Lake (North and South), Colby Lake, Powers Lake, La Lake, Bailey Lake, Ravine Lake, O'Connor's Lake, Trout Brook, and O'Connor's Creek. To guide management efforts, the District has developed management plans which are included in Appendix A of this Plan. Management plans reflect the District's best understanding of these resources and will guide management over the life of this Plan. Management plans will be updated as part of SWWD's next 10-year plan update, or sooner, if necessary.

> **Goal 3.1.1.a. Update SWWD's Lake Management Plan near the end of this planning cycle in preparation for development of the 2036 SWWD Watershed Management Plan.**

3.1.2 | Total Maximum Daily Load Studies & Other Regional Plans

The Minnesota Pollution Control Agency (MPCA) defines a Total Maximum Daily Load (TMDL) as the maximum amount of a pollutant a waterbody can receive without violating water quality standards. When a waterbody is placed on Minnesota's impaired waters list, a TMDL study is typically conducted to establish this pollutant limit and allocate load reductions to the pollutant's sources. The TMDL process identifies all contributing pollutant sources and calculates the reductions necessary to achieve compliance. TMDL studies go through an extensive technical review and public process before they are approved by MPCA, after which the TMDL reports are submitted to the U.S. Environmental Protection Agency for final approval.

SWWD does not intend to lead any potential future TMDL establishment processes; however, the District will participate in and contribute to these efforts if undertaken by MPCA or another entity. Where appropriate, SWWD incorporates the pollutant limits and allocations from TMDL studies to guide resource protection goals within its regulations and watershed management planning efforts. To date, no TMDL studies have been established for impaired waters solely within the SWWD's jurisdiction. However, several regional TMDL studies and other statewide management plans apply directly to stormwater discharges leaving the watershed, as shown in Table 3.

SWWD recognizes completed TMDLs and other plans at the state, regional, or local levels that identify relevant or required implementation actions for the District or its partners. SWWD will evaluate and incorporate similar future plans and studies as they become available and relevant to District goals.

> **Goal 3.1.2.a. Participate in all future TMDL planning efforts affecting waters within or adjacent to SWWD's jurisdiction.**

3.1.3 | Project Prioritization & Targeting Studies

SWWD routinely develops regional or subwatershed assessments, feasibility studies, alternatives analyses, and other reports to prioritize and target future projects that will deliver measurable improvements to watershed resources. These studies are developed either internally by District staff or through external partnerships with the Washington Conservation District and private consultants. To generate detailed catchment-level pollutant loading estimates, these studies rely heavily upon existing topographical, land cover, soils, parcel, and storm sewer infrastructure data, alongside SWWD's established resource management plans and other models. Potential project concepts are proposed, modeled, and vetted to determine recommendations based on cost, benefit,

Study/Plan Title	Year	Author
Twin Cities Metro Area Chloride TMDL	2016	MPCA
South Metro Miss. River Total Suspended Solids TMDL	2016	MPCA
Lake St. Croix Nutrient TMDL	2012 (Updated 2019)	MPCA
Minnesota Statewide Chloride Management Plan	2020	MPCA
Lake Pepin and Mississippi River Eutrophication TMDL	2021	MPCA
Minnesota Nutrient Reduction Strategy	2025	MPCA

Table 3. TMDL and other Statewide management plans affecting SWWD.

feasibility, and maintenance requirements. SWWD uses these studies to inform much of its project and capital improvement planning and relies on them as invaluable resources when pursuing external funding for its projects.

Over time, specific studies may become outdated regarding estimated costs or project technologies proposed; however, their conclusions remain valuable to staff for identifying priority project locations and potential benefits. In some cases, a comprehensive study update may be warranted to account for completed project implementation and to ensure maximum planning value for the District. SWWD recognizes the list of completed assessments noted in Table 4 and incorporates them into this Plan.

Future studies will also guide project implementation and will be incorporated into this Plan, if needed, through a plan amendment. Because these studies often serve to refine the direction of the existing implementation programs and estimated budgets, they may not always require a formal plan amendment before being utilized by the District.

Goal 3.1.3.a. Complete five new or updated subwatershed assessments or regional feasibility studies.

Study/Plan Title	Year	Author
Top50P! Rural Subwatershed Analysis	2013	Washington SWCD
Wilmes Lake Subwatershed Retrofit Analysis	2016	Washington SWCD
Trout Brook Ravines Stormwater Retrofit Analysis	2017	Washington SWCD
Armstrong Lake Subwatershed Retrofit Analysis	2018	South Washington WD
Newport Subwatershed Retrofit Analysis	2018	South Washington WD
Northern SWWD Stormwater BMP Feasibility Study	2019	Barr Engineering
Lower Mississippi Ravines Stormwater Retrofit Analysis	2021	Washington SWCD
St. Paul Park Subwatershed Retrofit Analysis	2022	South Washington WD
Cottage Grove Ravine Park Site Assessment and Design Alternative Reports	2024	SRF Consulting
Markgrafs Lake Phosphorus Removal Feasibility Study	2024	SRF Consulting
Colby Lake Phosphorus Removal Feasibility Study	2025	SRF Consulting

Table 4. Existing SWWD subwatershed analyses and feasibility studies.

3.1.4 | Flood Risk Reduction and Mitigation

Historically, SWWD has assisted city-led efforts to mitigate flooding issues within the District (e.g., Wilmes Lake and the city of Newport). Those efforts will continue, focusing primarily on the District's northern watershed and communities bordering the Mississippi River. These communities are vulnerable to rising flood levels and aging infrastructure. SWWD may prioritize additional areas as needed following flood events or changing information. The purpose of SWWD's flood risk reduction and mitigation program is to identify vulnerable communities and evaluate feasibility of evolving management tools. Existing completed plans include:

Study/Plan Title	Year	Author
SWWD Flood Response Plan	2019	HDR Engineering
Bailey Lake Pump Station Operational Analysis	2021	Kimley-Horn

Table 5. Existing flood studies.

Planning work anticipated to occur during the life of this plan includes:

- La Lake and Ria Lake drainage study to evaluate the flood risk and damage along the drainage network between La Lake and Ria Lake downstream to the Mississippi River and potential structural solutions to reduce or mitigate that risk.
- Northern Watershed active water level control study to evaluate the potential benefit and feasibility of using active water level controls on basins throughout the District's northern watershed to mitigate flooding concerns throughout the City of Woodbury's chain of lakes.

Additionally, SWWD will actively monitor closed basins and areas known to have experienced flooding in the past. If conditions change, the District will lead additional flood risk reduction and mitigation planning efforts. Areas include:

- SWWD's West Draw subwatershed drains water from southwest Woodbury into Northwest Cottage Grove. Concerns have been identified from past modeling efforts but have not yet been realized.
- O'Connor's Lake currently has no outlet and has caused flooding of adjacent properties in the past.
- Vandenberg Lake currently has no active outlet. This basin exhibits a clear groundwater connection. Despite its small watershed, the lake has risen between 10-25 feet over the past decade as aquifer levels have fluctuated.

Goal 3.1.4.a. Complete flood risk reduction and mitigation study of the La and Ria Lakes drainage system from Woodbury through Newport.

Goal 3.1.4.b. Analyze outlet control infrastructure design, including automated level control systems throughout SWWD's Northern Watershed, to optimize in-lake and downstream flood elevations and flow rates surrounding large precipitation events.

Goal 3.1.4.c. Undertake flood risk reduction and mitigation studies for other watersheds as needed due to changing conditions and new information. SWWD involvement will be prioritized for locations where intercommunity flows exacerbate flood conditions and in historically underserved communities.

3.1.5 | Climate Adaptation

SWWD developed a Climate Resiliency Plan in 2018 through extensive engagement with its residents and partners. That plan evaluated risk management through the lens of community and resource resiliency, identifying a wide range of strategies to protect groundwater, natural resources, and stormwater infrastructure. Today the majority of that information and strategies are integrated into this Watershed Management Plan, and the District and its partners actively implement these strategies. For example, SWWD has collaborated with its partners to advance flood emergency response planning, participated in the Washington County all-hazard mitigation planning process, and modified District programs to support or incentivize actions that build community and resource resiliency.

Additionally, resiliency and climate adaptation will be considered as part of the design and development process for all future District projects.

Goal 3.1.5.a. Participate in all partner planning efforts involving climate adaptation.

Goal 3.1.5.b. Ensure climate change and adaptation opportunities are carefully considered as part of all District planning and project development efforts.

3.1.6 | Adaptive Management

Landscape alterations, site conditions, and surrounding land uses-compounded by climate change-present persistent challenges to the successful implementation of ecosystem restoration. SWWD recognizes these compounding stressors and proactively adapts its restoration strategies to ensure long-term ecological success.

Planning efforts and project implementation must incorporate strategies that acknowledge environmental uncertainties and changing climate conditions into the design process. Throughout project planning, implementation, and establishment, SWWD will monitor outcomes and adjust its practices based on effectiveness. This process of adaptive planning and implementation relies on careful project planning that acknowledges vulnerabilities, and establishes or reestablishes appropriate goals.

Integrating adaptive planning and implementation approaches into all restoration projects formally acknowledges the inherent uncertainty of working in the natural world. As illustrated in Figure 16, adaptation can happen at any time during the lifetime of a project. This framework emphasizes the need to proactively identify stressors and pitfalls ahead of time, while accepting that unforeseen factors will always play a role. Ultimately, an adaptive management approach improves outcomes on a given project but offers continual reevaluation and refinement of ongoing practices on all projects.

3.2 | MONITORING AND MODELING

Purpose: To ensure the availability of accurate and reliable field data and predictive modeling to establish trends and guide water resources management within the District.

Watershed and natural resource modeling is critical to support District planning, regulatory, and implementation initiatives. Developing and maintaining models allows the District to evaluate the feasibility and targeted benefits of proposed projects, proposed development work, and track positive and negative impacts to resources with improved accuracy and usefulness. Although model maintenance demands significant resources, SWWD is committed to updating and refining these computational tools throughout the 10-year lifespan of this Watershed Management Plan. SWWD models will be made available to District partners to promote unification of planning efforts and limit duplication of effort across agencies.

3.2.1 | Monitoring

Accurate resource information is critical for SWWD to understand how water, nutrients, and pollutants move through the watershed. This data allows the District to calibrate watershed models, evaluate feasibility and cost-effectiveness of potential projects, and measure the effectiveness of completed work. SWWD has operated a surface water monitoring program since 1996 and began limited groundwater monitoring in 2014. Additionally, the District routinely monitors aquatic vegetation in several lakes to inform and support ongoing management of

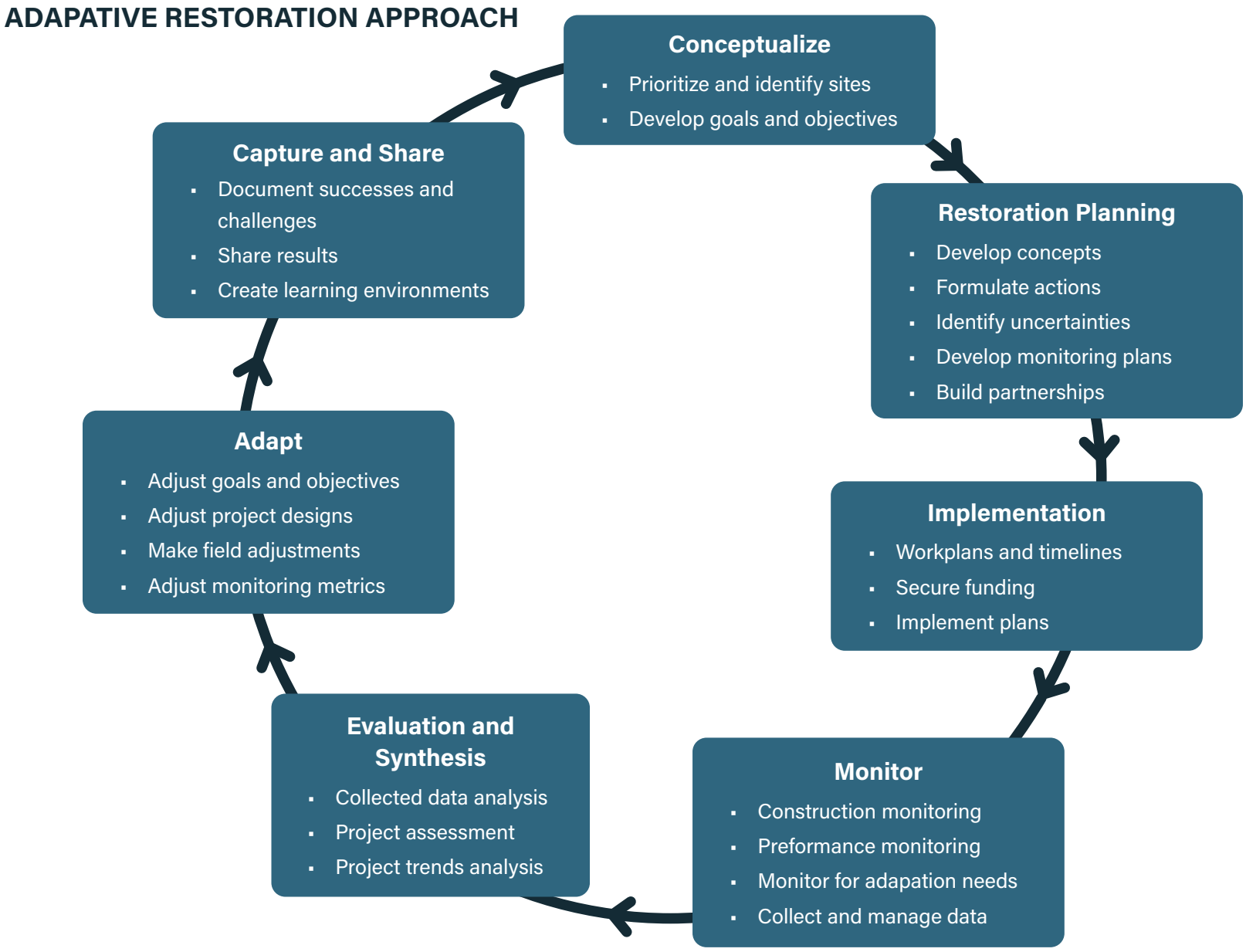


Figure 16: Adapative Restoration Approach. A cyclical approach to restoration that considers the lifecycle of a project that acknowledges the need for lasting maintenance.

aquatic invasive species. The District will continue these efforts throughout the life of this Watershed Management Plan. Details of the monitoring program are included in the updated SWWD monitoring plan, which is formally incorporated into the document as Appendix B.

Goal 3.2.1.a. Adopt and annually implement a monitoring plan sufficient to track resource water quality, evaluate effectiveness of ongoing management, and inform future District implementation efforts.

Goal 3.2.1.b. Annually report monitoring data and trend results to inform SWWD's community and partners on its water resources.

Goal 3.2.1.c. Incorporate all new capital water quality treatment projects into SWWD's monitoring program to track BMP performance.

3.2.2 | Watershed and Resource Modeling

SWWD has developed hydrologic and hydraulic (H&H) models for much of the District. These models simulate and predict the movement of water across and through the watershed, serving as the technical basis for evaluating impacts of ongoing watershed alterations and predicting localized flooding risks.

SWWD uses its H&H models to drive watershed water quality models that go a step further to simulate and predict movement of sediment and nutrients across the watershed. Watershed water quality models are used to evaluate the water quality impacts of ongoing watershed alterations. These specialized tools simulate the transport of sediment and nutrients, allowing the District to quantify the environmental impacts of regional development and accurately simulate how proposed capital improvement projects will alter pollutant loading into District water resources.

SWWD has also developed specific water quality models for its priority lakes and streams. These models simulate and predict a waterbody's response to watershed loading dynamics. Because all aquatic resources are unique and directly reflect the specific land areas draining to them, the District combines modeled characteristics from its watershed models with known in-resource characteristics to estimate precise water quality responses. The ability to predict resource response to changing watershed characteristics is important, as actual, measurable resource responses can take years or decades to show up in monitoring data.

Goal 3.2.2.a. Update and maintain H&H and water quality models to support District planning and management efforts as frequently as needed by major changes to the watershed.

Goal 3.2.2.b. Make District models available to, and promote use by, external partners.

3.2.3 | Groundwater Modeling

Unlike watershed and resource modeling, groundwater modeling occurs at larger scales because groundwater moves in dynamic and complex ways across a much larger geologic area. Currently, the Metropolitan Council (Met Council) leads the most comprehensive regional groundwater modeling effort, which encompasses aquifers within the District.

Met Council modeling serves as the basis for water supply planning across the Twin Cities metropolitan area. As of 2026, the Met Council is working to update its groundwater model. SWWD expects that model to provide limited use to the District, as it is not involved in water supply. However, it provides an underling base information for additional related modeling. SWWD will collaborate with Washington County to leverage this updated Met Council model to evaluate local surface water and groundwater interactions. Understanding these interactions is critical, as many District resources are known to have direct connection with groundwater. This collaborative modeling effort is expected to occur near the midpoint of this 10-year plan period.

Goal 3.2.3.a. Develop and maintain a groundwater model based off Metropolitan Council's metro groundwater model sufficient to understand local surface water-groundwater interactions and pollutant movements through the watershed.

3.3 | REGIONAL PLANNING

Purpose: To ensure government effectiveness, coordination, and cross-jurisdictional collaboration.

SWWD plays a critical role in a variety of regional resource planning efforts. While reviewing every partnership in this watershed management plan is impractical, several key initiatives require routine, recurring staff attention. This involves serving on steering committees, reviewing draft plans and reports, and helping administer external funding programs.

3.3.1 | One Watershed, One Plan

In 2015, the Minnesota Board of Water and Soil Resources (BWSR) began implementing the One Watershed, One Plan (1W1P) program. This initiative aligns local water planning across major watershed boundaries with state agencies to create prioritized, targeted, and measurable implementation plans. While the seven-county Twin Cities Metropolitan Area has mandated watershed-based planning for decades, non-metro areas historically lacked watershed district coverage. 1W1P aims to bridge this gap, ensuring statewide adoption of watershed-based planning by 2025. Because the metro area already has established watershed districts and watershed management organizations, it is largely exempt from the program. However, 1W1P boundaries overlap along the fringes of the metro, including portions of the SWWD.

Lower St. Croix Watershed Partnership

The Lower St. Croix River basin is part of the 1W1P program, covering a large portion of the eastern SWWD that drains directly to Lake St. Croix. Conversely, the central and western portions of SWWD are excluded from this regional planning effort.

Developed under the 1W1P program, the Lower St. Croix (LSC) Comprehensive Watershed Management Plan was formally adopted in October 2020. The plan was established through a memorandum of agreement among 14 local government partners collectively known as the Lower St. Croix Watershed Partnership (LSCWP).

Current members include:

- Counties: Chisago, Isanti, Pine, and Washington
- Soil and Water Conservation Districts (SWCDs): Anoka, Chisago, Isanti, Pine, and Washington
- Watershed Districts (WDs) & Management Organizations (WMOs): Brown's Creek WD, Carnelian-Marine-St. Croix WD, Comfort Lake-Forest Lake WD, Middle St. Croix WMO, and South Washington WD

SWWD is an active LSCWP partner. SWWD Board Members serve on the Policy Committee, while staff participate on the Steering and Planning Committee. The LSC Comprehensive Watershed Management Plan does not replace or supersede SWWD's own Watershed Management Plan. Rather, they operate in tandem, pursuing parallel yet distinct management and implementation goals. Within the overlapping Lower St. Croix comprehensive plan, the two frameworks align closely, providing mutual support for ongoing water resource projects and community outreach.

The LSCWP's committees establish policies and direct partnership dollars toward projects and programs that implement the comprehensive plan across the Lower St. Croix River basin. Currently, members are not required to pay dues or make financial contributions to the partnership. Instead, implementation funding is primarily provided by BWSR's Watershed-Based Implementation Funding (WBIF) program from the State of Minnesota's Clean Water Land & Legacy Amendment. BWSR allocates these funds separately to the rural and metro portions of the Lower St. Croix River basin. The metro area partners, including SWWD, have historically chosen to pool their WBIF allocations to the LSCWP for plan implementation, though they are under no legal obligation to do so.

Clean Water Land & Legacy Amendment logo

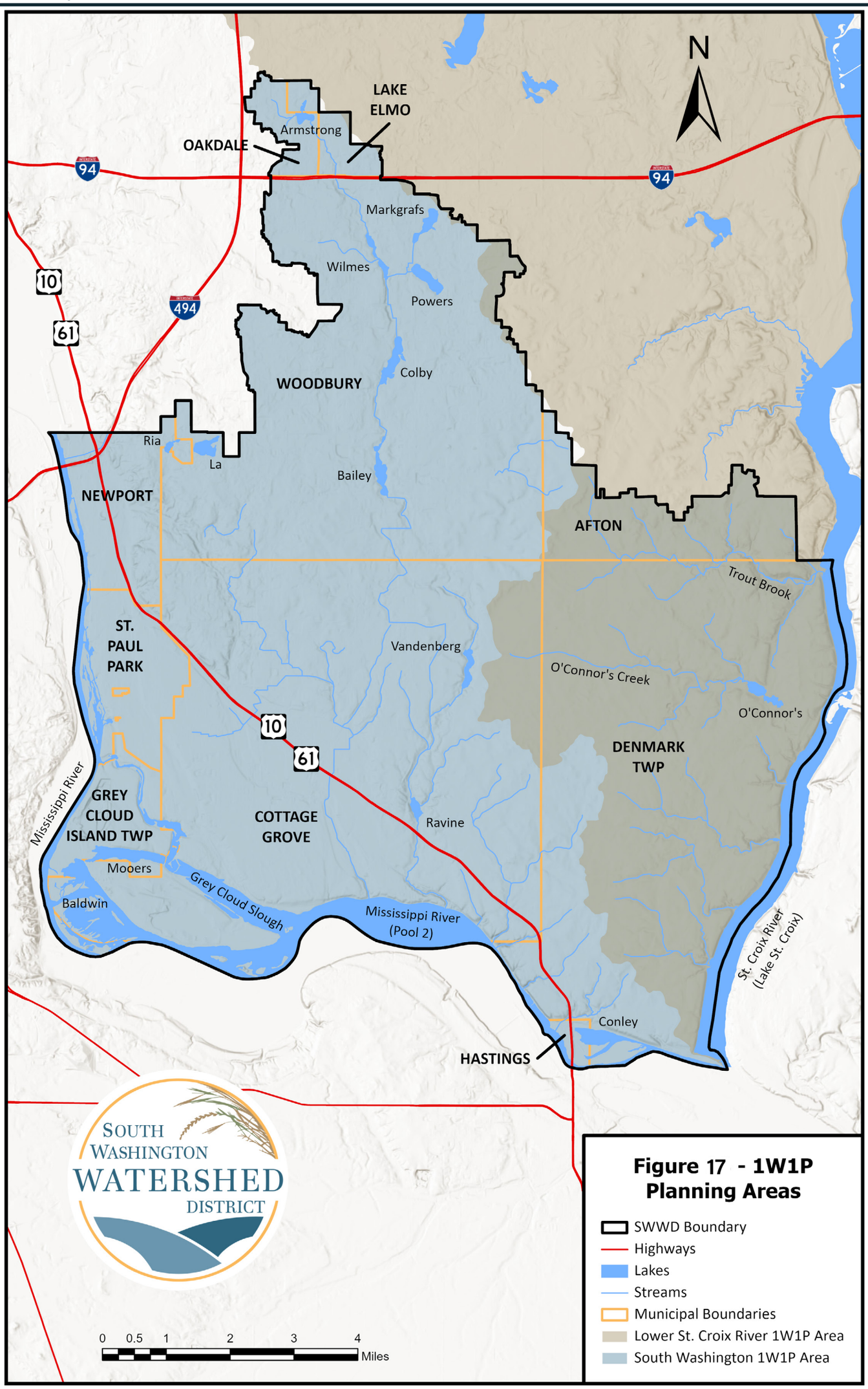


Figure 17: 1W1P Planning Areas. The metro area is largely exempt from 1W1P due to the long-standing existence of watershed districts and watershed management organizations, however, there are some areas of 1W1P overlap around the fringes of the metro, including within the SWWD.

BWSR Watershed-Based Implementation Funding

The primary funding mechanism for BWSR's 1W1P program is the Watershed-Based Implementation Funding program (WBIF). Designed as an alternative to traditional, competitive project-by-project grants, WBIF allows collaborating local governments within the 1W1P partnerships to deploy timely solutions to target the watershed's highest priority needs. Funding allocations are decided by a "convene committee" which is comprises of watershed district, county, and conservation district partners within the 1W1P area, along with two city representatives.

As an active LSCWP member, SWWD has access to 1W1P grant funds for projects within its Lower St. Croix River drainage area that simultaneously implement both SWWD and LSCWP priorities. LSC 1W1P funds have previously been secured for use on major SWWD projects, including the Trout Brook Restoration and McQuade Ravine Stabilization. SWWD also partnered with Washington County to leverage these funds for the St. Croix Bluffs Regional Park Ravine Stabilization. Moving forward, SWWD will continue to pursue 1W1P funds to assist with project implementation throughout the Lower St. Croix River basin.

Because BWSR treats metro watersheds as their own 1W1P allocation areas, a separate WBIF pool is allocated to the Mississippi River basin portion of the District under the South Washington Watershed allocation area. Historically, these funds have been used to accelerate implementation of priority projects identified in the SWWD's subwatershed assessments-particularly in areas lacking alternative funding or where external grants are difficult to secure, such as the direct drainage basins of the Mississippi River areas in the cities of Newport and St. Paul Park. SWWD routinely takes an active role to serve as the local facilitator for the WBIF planning process each biennium.

Goal 3.3.1.a. Maintain SWWD's role as an active partner in the Lower St. Croix Watershed Partnership.

Goal 3.3.1.b. Biennially facilitate and administer BWSR's South Washington Watershed WBIF convene committee and implementation efforts consistent with priorities established in this Plan, and/or other partners' eligible management plans.

3.3.2 | Municipal Local Water Planning

Following the completion and adoption of this Plan and its subsequent amendments, each municipality must either amend its existing Local Water Management Plan (LWMP) to conform to the requirements of this Plan or prepare a new LWMP to achieve full conformance. Municipalities may adopt any or all portions of this Plan by reference within their LWMP. The LWMP must include all requirements of this Plan, Minnesota Rules 8410.0160, and Minnesota Statutes 103B.235. Additionally, the LWMP should address the strategic elements recommended by the Metropolitan Council in its 2050 Water Policy Plan Update. The LWMP must be adopted within two years of the adoption of this Plan, but not more than two years before the Municipality's Comprehensive Plan is due.

As required in Minnesota Rules 8410.0160 subpart 3, municipalities must enact local controls within six months of LWMP approval. These local controls must reflect current SWWD Rules. Following the adoption of this Plan or subsequent amendments, and prior to the update of municipal local controls, SWWD will exercise its full permitting authority for development and redevelopment projects within that municipality. Once a municipality adopts conforming local controls, SWWD will cease issuing separate permits unless specified by the municipal LWMP. However, the District will continue to evaluate municipal permitting procedures as needed through routine audits, as outlined in the SWWD Rules.

Local Water Management Plans must include a mechanism for quantifying, evaluating, and amending their implementation plan as necessary. Following LWMP adoption, municipalities must report the results of their progress evaluations annually, within 120 days of the end of the calendar year. The reports must be readily available on the municipal website. Additionally, SWWD explicitly expects LWMPs to incorporate the following:

- Actively participate in SWWD planning efforts through the District's Technical Advisory Committee
- Adopt and enforce local controls consistent with this

plan and SWWD Rules, in addition to state buffer and shoreland requirements.

- Develop and implement a construction site erosion and sediment control program, including identifying staff positions responsible for implementing the program.
- Coordinate planned capital Improvements with the District to incorporate identified improvements
- Develop and utilize a formal mechanism for evaluating and reporting progress under the LWMP

Wellhead Protection Plans

Many SWWD's municipalities also serve as public water suppliers within their communities. The Minnesota Department of Health (MDH) requires public water suppliers to develop and maintain a Wellhead Protection Plan featuring strategies designed to prevent contamination of public water supply wells by managing surrounding land use. These plans mandate that public water suppliers delineate protection areas, assess aquifer vulnerability, and identify potential contaminant sources. As plans are updated or amended, SWWD is required to participate in the process. The District fulfills this by reviewing and commenting on the plans and providing new information that is relevant to the management of groundwater supplies in the Wellhead Protection Plan Area.

Goal 3.3.2.a. All ten Municipal Local Water Plans are locally adopted on a timeline consistent with Minnesota Rule 8410.

Goal 3.3.2.b. Provide comment or otherwise participate in the review of all Wellhead Protection Plans submitted to the District.

3.3.3 | Washington County Groundwater Plan

Washington County provides a county-wide structure for protection and conservation of groundwater resources by preparing, adopting, and implementing its Washington County Groundwater Plan. Developed in partnership with municipalities, state and local agencies, and community members, the plan was formally approved by the Minnesota Board of Water and Soil Resources. Washington County's current groundwater plan was adopted in 2025 to guide groundwater management through 2035. SWWD participated in its development.

The Washington County Groundwater Plan establishes the following high-level goals:

- Groundwater Quality: Groundwater is safe to drink.
- Groundwater Quantity: Groundwater is plentiful to support human needs and a thriving natural environment.
- Groundwater Education: People who live and work in Washington County understand the importance of groundwater and adopt practices and behaviors that conserve and protect groundwater.
- Groundwater Governance: Groundwater management is coordinated, efficient, and effective.

To achieve these goals, the Washington County's Groundwater Plan prioritizes several strategies, actions, and identifies external partners-including SWWD and other Watershed Districts in the County. Specific implementation actions relevant to the SWWD are integrated within appropriate program sections throughout Part 3 of this Plan.

SWWD recognizes the County's leadership in groundwater protection and conservation throughout SWWD and Washington County. Moving forward, the District will continue to participate in the strategies identified in the County Groundwater Plan.

Goal 3.3.3.a. Participate in the Washington County Groundwater Plan Technical Advisory Committee.

Additional goals related to the Groundwater Plan are included under other program areas.

3.4 | REGULATORY

Purpose: To limit the effects of land alterations on water resources and protect the public health, welfare, and natural resources within the watershed.

Land alterations can affect the rate, volume, and quality of surface runoff that leads to degradation of District resources through several mechanisms. Sedimentation in lakes and streams from erosion processes and

construction activities reduces the hydraulic capacity of water bodies and degrades water quality. Projects that increase stormwater runoff or degrade water quality intensify the need for storage, aggravating existing water quality problems and create new ones. Projects that fill floodplain or wetland areas, can increase the need for storage and hydraulic capacity of water bodies and degrade water quality by eliminating the filtering capacity of such areas.

3.4.1 | SWWD Permit Program

Established under Minnesota Statute 103D, SWWD Rules limit the adverse land impacts to protect public health, welfare, and natural resources of the District. The SWWD's regulatory program achieves this by providing the following benefits:

- Reducing the need for additional flood storage capacity and construction of new or expanded systems to convey storm water
- Preservation of floodplains and wetland storage capacity
- Maintenance and improvement of the chemical and physical quality of surface waters and groundwater
- Reduction of sedimentation and preservation of the hydraulic and navigational capacity of waterbodies
- Preservation of natural shoreland features
- Minimization of public expenditures required to remediate or correct preventable problems

While the primary responsibility of water quality management and stormwater runoff lies with SWWD, the District recognizes that the primary control and determination of appropriate land-use is the responsibility of the municipalities. Accordingly, the District coordinates development permit application reviews directly with the appropriate municipality. SWWD expects municipalities to develop a Local Water Management Plan (LWMP) as rapidly as possible (see Section 3.3.2), to establish a coordinated system for managing surface water on a regional or subwatershed basis consistent with SWWD's Rules. Once a conforming LWMP is adopted, District Rule requirements met by the local plan are deemed satisfied upon the issuance of the municipal permit. In the absence of an approved municipal LWMP on a municipal or subwatershed level, SWWD will continue to require District-issued permits for projects involving land alteration or activities that trigger SWWD Rules.

The current SWWD Rules are available on the SWWD website. These Rules will be amended as necessary to address changing regulatory environments and development pressures across the watershed. All future SWWD Rule amendments will follow procedures required in Minnesota Statutes 103D.341.

SWWD develops and maintains a Standards Guidance Manual to assist landowners with complying with SWWD Rules and help its cities to interpret and enforce the rules. The manual is routinely updated to reflect amendments to the SWWD Rules, align with relevant regulatory programs, or address specific needs as identified by its cities. The current Standards Guidance Manual is available on the SWWD website.

During the development of this Plan update, several potential regulatory and guidance gaps were identified. The District will further identify those gaps in coordination with the District Technical Advisory Committee, and any new or modified provisions will be incorporated into SWWD's Rules through a future amendment process. Specific regulatory gaps identified in this Plan update process include:

- Chloride Management
- Wetland Buffer Use Restrictions
- Bluff Setback Consistency
- Karst Management
- Compliance with State Infiltration Restrictions
- Update to SWWD's Subwatershed Phosphorus Loading Standards
- Promotion of Soil Health Principles

> **Goal 3.4.1.a. Operate a permit program only in municipalities that have not adopted updated local controls as stringent as SWWD's Rules.**

> **Goal 3.4.1.b. Maintain updated rules, design standards, and guidance documents necessary to support municipal regulatory efforts that are reflective of ongoing climate concerns and changing precipitation patterns.**

Goal 3.4.1.c. Engage SWWD's Technical Advisory Committee at least once every two years to identify necessary Rule modifications, additional guidance needs, and to ensure consistency of regulations across watershed jurisdictions where possible.

Goal 3.4.1.d. Complete at least four annual random inspections of active development sites for SWWD Rule compliance, and report findings to the responsible municipality.

Goal 3.4.1.e. Operate all SWWD construction project sites as though an NPDES Construction Permit is required, whether a permit is required.

3.4.2 | Wetland Conservation Act

The Minnesota Wetland Conservation Act (WCA) is a State regulatory program that regulates wetlands in Minnesota that are not public waters. The program regulates excavation and placement of fill within wetlands that are not otherwise regulated as public waters by the Minnesota Department of Natural Resources (DNR). The WCA program is administered by local governments with oversight by the Minnesota Board of Water and Soil Resources (BWSR). SWWD and the Washington Conservation District partner together to administer the WCA program for jurisdictional wetlands within the District. Information about WCA is available on the BWSR WCA Program Guidance & Information page and contained in the SWWD's Rules. An inventory of known and suspected wetlands is available in the SWWD's Interactive Web Viewer. While the inventory is comprehensive, it is not exhaustive. It does not replace the need for site-specific investigation and wetland delineation.

Goal 3.4.2.a. Administer the Minnesota Wetland Conservation Act within SWWD.

Goal 3.4.2.b. Maintain staff or partner capacity necessary to locally administer the Minnesota Wetland Conservation Act.

Goal 3.4.2.c. Maintain a publicly available inventory of known and suspected wetlands within SWWD's jurisdiction.

3.4.3 | Groundwater Appropriation Permit Review

The Minnesota Department of Natural Resources (DNR) has jurisdiction over and requires permits for proposed groundwater appropriations exceeding 10,000 gallons per day or 1,000,000 gallons per year. All groundwater appropriation applications submitted to DNR within SWWD's jurisdiction are subsequently shared with the District. SWWD is expected to review and provide comments to DNR on these applications, all final decision-making authority remains with the DNR.

Goal 3.4.3.a. Review and submit comments to DNR on all groundwater appropriations permit applications shared with the District.

3.5 | WATER RESOURCES PROTECTION AND MANAGEMENT

Purpose: To prioritize and focus SWWD implementation efforts on actions that are likely to produce measurable improvements for targeted resources and issues.

3.5.1 | Targeted Watershed Implementation

Resource issues affecting the SWWD are as variable as the physical characteristics of the watershed. Because a one-size-fits-all approach rarely addresses the priorities established for each of SWWD's water resources, the SWWD developed water quality and resource management solutions and projects that target specific subwatersheds and geographic regions. While this localized strategy can reduce the efficiency of project prioritization and planning efforts, it ensures that these efforts achieve the specific outcomes desired for each resource.

District-Wide Implementation

The SWWD recognizes that certain implementation activities will be beneficial for all water resources within the District. Examples include long-term and project-specific water quality monitoring, implementation of enhanced street sweeping, and chloride reduction programs. Widespread, smaller-scale Best Management Practices (BMPs), such as

raingarden and shoreline stabilization projects-similarly benefit target waterbodies. The District pursues these efforts on a district-wide basis as opportunities arise, though active participation from interested private landowners is often required. The SWWD is unique in one way because most of its lake shoreline property is publicly owned, primarily by the City of Woodbury. This high level of public ownership simplifies partnership for lakeshore management and restoration. The SWWD Stewardship Grant program, described in more detail in Section 3.7.1, is a key implementation tool for these small BMPs.

Goal 3.5.1.a. Complete rapid shoreline condition assessments for the Woodbury chain of lakes within the first three years of the planning cycle.

Goal 3.5.1.b. Improve riparian habitat and buffers and stabilize eroding shorelines on city-owned property surrounding the Woodbury chain of lakes.

Goal 3.5.1.c. Complete streambank erosion inventories for accessible public lands throughout the District, and on private lands with permission, within the first three years of the planning cycle.

Goal 3.5.1.d. Increase the percentage of publicly owned or managed shoreline through fee title or easement acquisition, prioritizing groundwater-dependent resources.

Goal 3.5.1.e. Establish where missing, or maintain where existing, a 50-foot natural buffer around all public waters within the SWWD.

Goal 3.5.1.f. Decrease the number of Section 303(d) impaired waters within the SWWD and make progress toward meeting State water quality standards for all remaining impaired waters.

Goal 3.5.1.g. Identify vulnerable riverfront and bluff land properties along the Mississippi and St. Croix Rivers and work with municipalities and other landowners to improve and protect these important greenway corridors.

For each of the following resource management areas, this Plan discusses current SWWD implementation efforts and known initiatives for the ten-year Plan cycle.

Armstrong Lake

Proposed management actions for Armstrong Lake focus on reducing phosphorus, sediment, and chloride loads from the surrounding watershed. Because Armstrong Lake is a very shallow lake, it remains highly vulnerable to aquatic invasive species (AIS), a topic detailed in a subsequent section of this Plan. As a headwater resource in SWWD's flood-prone Northern Watershed, managing the lake outflow during large rain events is also of concern.

Goal 3.5.1.h. Implement stormwater treatment projects to reduce pollutant loading identified in the Armstrong Lake Subwatershed Retrofit Analysis and other BMP feasibility studies.

Goal 3.5.1.i. Continue research and data collection on the potential for phosphorus and chloride removal from cattail harvesting in the wetland west of Armstrong Lake.

Markgrafs Lake

Proposed management actions for Markgrafs Lake focus on reducing phosphorus, sediment, and chloride loads from the surrounding watershed. Concurrently, SWWD aims to deepen its understanding of how internal nutrient cycling and groundwater impact the lake's overall water quality. As a headwater resource in SWWD's flood-prone Northern Watershed, managing the lake outflow during large rain events is also of concern.

Goal 3.5.1.j. Implement stormwater treatment projects to reduce pollutant loading, building off the Markgrafs Lake Phosphorus Removal Feasibility Study.

Goal 3.5.1.k. Complete a detailed study of surface water-groundwater dynamics in Markgrafs Lake to understand suspected high groundwater inputs and how that affects nutrient and chloride cycling in the lake.

Powers Lake

Proposed management actions for Powers Lake focus on reducing phosphorus, sediment, and chloride loads from the surrounding watershed to preserve its typically good water quality. SWWD will monitor the water quality following the completed construction of the Hasenbank Stormwater Park in 2025. However, the lake remains vulnerable due to high internal phosphorus loading and aquatic invasive species (AIS), a topic detailed in subsequent sections of this Plan. As a land-locked basin, the outflow from Powers Lake is controlled by a City of Woodbury lift station. Runoff is pumped to Wilmes Lake when necessary to protect adjacent properties from localized flooding.

Goal 3.5.1.l. Implement stormwater treatment projects to reduce pollutant loading, building off the Powers Lake Stormwater Retrofit Assessment and other BMP feasibility studies.

Hasenbank Strormwater Park east of Powers Lake in Woodbury
Barr Engineering

Goal 3.5.1.m. Continue to operate and maintain the Hasenbank Stormwater Park in partnership with the City of Woodbury.

Wilmes Lake

Proposed management actions for Wilmes Lake focus on reducing phosphorus, sediment, and chloride loads from the surrounding watershed. Several large-scale regional Best Management Practices were recently constructed in the Wilmes Lake watershed, including the Seasons Park CC17 Filter and Wilmes Lake Alum Treatment Facility. SWWD will continue to monitor the water quality response before undertaking additional capital projects in this area.

However, the lake remains vulnerable due to high internal phosphorus loading and aquatic invasive species (AIS), a topic detailed in subsequent sections of this Plan. Given the basin's history of flash flooding, managing flows into and out of the lake during and after large rain events is also of concern.

Goal 3.5.1.n. Continue to operate and maintain the Wilmes Lake Alum Treatment Facility and the Seasons Park CC17 Filter in partnership with the City of Woodbury.

Goal 3.5.1.o. Complete construction of a redesigned CC17 filtration BMP on Schooner Way to replace the Wilmes Lake Iron-Enhanced Sand Filter

Goal 3.5.1.p. Complete a stream stability and restoration assessment for the open channel and surrounding corridor between Armstrong and Wilmes Lakes.

Colby Lake

Proposed management actions for Colby Lake focus on reducing phosphorus, sediment, and chloride loads from the surrounding watershed. The recent construction of the Wilmes Lake Alum Treatment Facility is anticipated to yield downstream water quality improvement to Colby Lake as Wilmes Lake improves. SWWD will monitor the water quality response because of this project. However, the lake remains vulnerable due to high internal phosphorus loading and aquatic invasive

species (AIS), a topic detailed in subsequent sections of this Plan. Furthermore, evaluating basin flooding risks within Colby Lake will be critical as the District analyzes active water-level controls across the Northern Watershed.

Goal 3.5.1.q. Implement stormwater treatment projects to reduce pollutant loading, building off the Colby Lake Phosphorus Removal Feasibility Study.

Goal 3.5.1.r. Explore and implement land management improvement opportunities focused on runoff control and water quality improvements at Eagle Valley Golf Course.

Goal 3.5.1.s. Inspect the Colby Lake raingardens every two years in partnership with the City of Woodbury and WCD, while encouraging annual resident maintenance.

Bailey Lake

Bailey Lake is SWWD's newest official lake, following a classification status change by the Minnesota Pollution Control Agency (MPCA) in 2024. What was once a mostly dry natural depression has filled permanently due to increased hydrology and runoff from surrounding development. Consequently, SWWD lacks the monitoring history for Bailey Lake. Much of the lake's direct drainage watershed has developed over the last 20 years under modern stormwater management standards.

As a land-locked basin, Bailey Lake serves as the natural terminus of the Northern Watershed. During large snowmelt and precipitation events, the City of Woodbury operates a large lift station to pump excess water from Bailey Lake into a large natural infiltration basin to the west. When full, the water overflows directly into SWWD's Central Draw Storage Facility (Section 3.5.3).

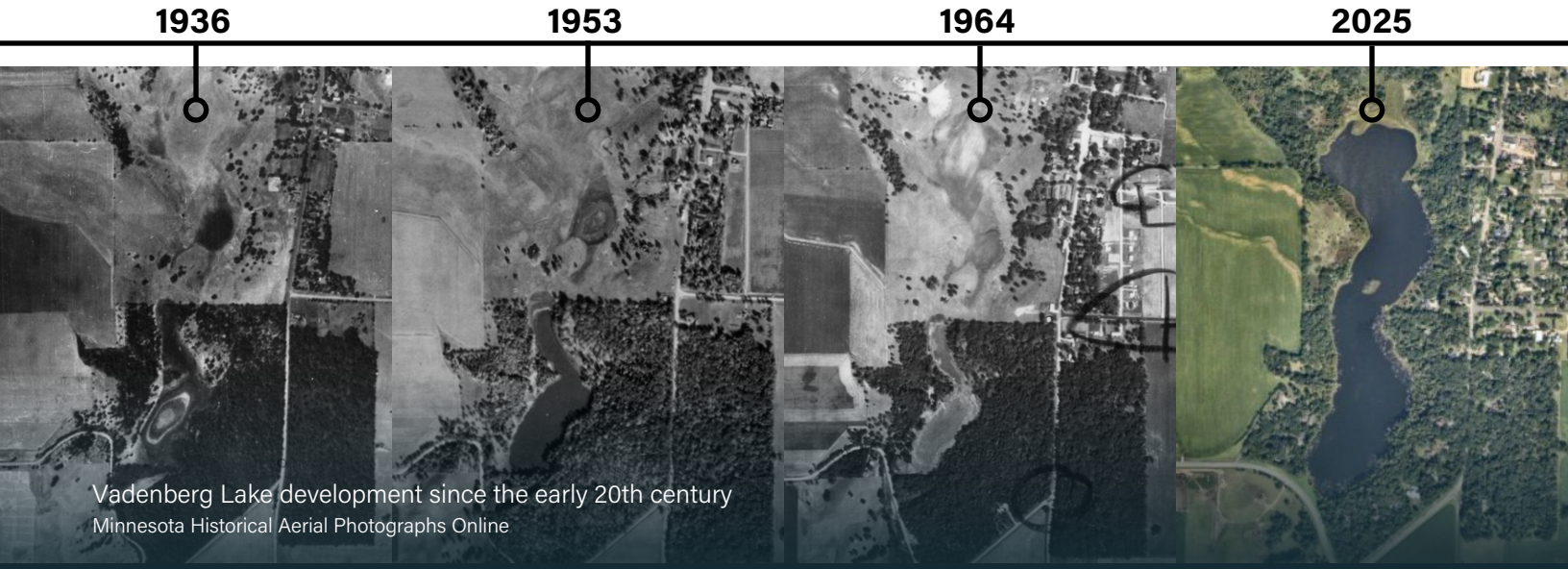
Proposed management actions for Bailey Lake focus on reducing phosphorus, sediment, and chloride loads from the surrounding watershed. Continued data collection remains a primary priority for SWWD.

Goal 3.5.1.t. Continue gathering information about Bailey Lake to guide future actions through ongoing water quality and aquatic vegetation monitoring.

Goal 3.5.1.u. Develop a stormwater retrofit assessment or other BMP feasibility study for Bailey Lake.

Vandenberg Lake

While not officially classified as a lake by the MPCA, Vandenberg Lake is a local water resource of specific interest to the SWWD. Originally a small public water wetland, Vandenberg Lake has grown substantially in recent years as local groundwater aquifers have risen. Thus, increasing the lake's elevation by roughly twenty feet. Consequently, the lake now spans 45 acres in size and would be classified as the SWWD's only other deep lake aside from Powers Lake. The obvious



Vadenberg Lake development since the early 20th century
Minnesota Historical Aerial Photographs Online

surface water – groundwater interactions occurring here, coupled with little to no surrounding development makes Vandenberg Lake a prime candidate for land protection efforts.

Very little is known about Vandenberg Lake at this time, as it remains completely under private ownership. While the majority of its direct drainage area consists of rural agricultural land, imminent development pressure may soon alter the landscape. For now, proposed management actions for the protection of Vandenberg Lake focus on land acquisition and riparian restoration. If access to the lake can be secured, the SWWD will begin water quality and aquatic invasive species (AIS) monitoring to guide efforts that may support other actions in the future.

Goal 3.5.1.v. Work with the Minnesota Land Trust, Washington County, and City of Cottage Grove to protect and restore riparian properties surrounding Vandenberg Lake through fee title or easement acquisition and landowner education.

Goal 3.5.1.w. Continue gathering information about Vandenberg Lake to guide future actions through ongoing water quality and aquatic vegetation monitoring.

Ravine Lake

Ravine Lake is located within Washington County's Cottage Grove Ravine Regional Park and is heavily influenced by surficial groundwater levels and inputs. Stormwater does not routinely present a major concern, as much of the directly contributing watershed consists of heavily forested parkland or rural agricultural land. However, should the SWWD need to open the Central Draw Overflow to discharge floodwaters from its Northen Watershed, those flows would route directly through Ravine Lake. Therefore, routinely inspecting and maintaining previous channel reinforcement and stabilization work north of the lake is critical to ensuring the integrity of the Central Draw Overflow system.

Proposed management actions for Ravine Lake focus largely on internal phosphorus load management, ravine stabilization, and aquatic invasive species (AIS) control, which are detailed in subsequent sections of this Plan. Ravine Lake's unique water chemistry is not yet fully understood by SWWD and is thought to drive the high ammonia levels present in both the lake and its outlet stream.

Goal 3.5.1.x. Continue gathering information about Ravine Lake to guide future actions through ongoing water quality and aquatic vegetation monitoring.

Goal 3.5.1.y. Complete inspections of the Central Draw Overflow system's open channel through Cottage Grove Ravine Regional Park north of Ravine Lake every three years.

La Lake and Ria Lake

Proposed management actions for protecting La Lake and Ria Lakes focus on land acquisition and riparian restoration efforts. Both lakes are small, land-locked basins with very small surrounding watersheds. Stormwater runoff does not present a major concern, with the exception of the City of Newport's Bailey Meadows neighborhood, which drains to Ria Lake and was developed under SWWD Rules. While SWWD maintains a monitoring history for La Lake, relatively little data exists for the smaller, privately owned Ria Lake. La Lake is currently managed for aquatic invasive species (AIS) control, which are detailed in subsequent sections of this Plan. Managing overland outflow from both lakes is a priority for the Cities of Woodbury and Newport. The SWWD ongoing flow analysis assistance is detailed in subsequent sections of this Plan.

Goal 3.5.1.z. Work with the City of Woodbury to opportunistically acquire and protect riparian properties within the La Lake subwatershed.

East Mississippi Direct Drainage

The SWWD remains committed to addressing water resource issues in its historically underserved Mississippi River communities. The cities of Newport and St. Paul Park occupy a unique geographical position within the District. Both municipalities sit on very shallow, occasionally exposed, bedrock, which makes traditional stormwater management practices difficult, cost-prohibitive, and impossible. Furthermore,

local stormwater infrastructure is very old and often undersized by modern standards, elevating the risks of nuisance flooding and property damage.

Proposed management actions include:

- Pursuing projects that reduce discharges of sediment, nutrients, and chlorides to the Mississippi River
- Mitigating local flooding risks
- Stabilizing and restoring Mississippi River shorelands
- Protecting bluff lands and ravines
- Building local partner capacity to implement, manage, and maintain stormwater projects and ecosystem services in the area.

SWWD capital projects in this region will focus on reducing sediment discharges and implementing the South Metro Mississippi River Total Suspended Solids TMDL. SWWD also intends to specifically promote its Storm Sewer Failure Risk Assessment within East Mississippi communities. This initiative will identify infrastructure risks and foster partnerships with those communities to make improvements (see Section 3.8.1). Many management actions identified above are detailed in subsequent sections of this Plan.

Goal 3.5.1.aa. Implement stormwater treatment projects to reduce pollutant loading, building off of the Newport and St. Paul Park Subwatershed Retrofit Analyses.

Grey Cloud Slough and Mississippi River Pool 2 Direct Drainage

In 2017, SWWD restored flow through Grey Cloud Channel, which had been blocked for decades by the County Road 75 causeway. This project has successfully restored water quality and oxygenation to the Mississippi River Pool 2 backwater known as Grey Cloud Slough. The District will continue to monitor channel depth and other geomorphic changes within Grey Cloud Channel and Slough as it prepares for future in-channel habitat, island, and floodplain restoration activities in partnership with Minnesota Department of Natural Resources, the U.S. Army Corps of Engineers, and local partners. Furthermore, the SWWD is positioned to provide technical assistance to the City of Cottage Grove and Washington County for local and regional park planning efforts in areas adjacent to Grey Cloud Slough, should they materialize.

Building the bridge at County Road 75
Photo by Barr Engineering Co.

A variety of ravines in the southern portion of the watershed contribute direct drainage to Pool 2 of the Mississippi River. An assessment was completed in 2021 to review the condition of the ravines and prioritize stabilization and restoration efforts in the area.

Goal 3.5.1.bb. Reengage property owners and begin implementation of the Lower Mississippi Ravines Stormwater Retrofit Analysis.

Goal 3.5.1.cc. Continue water quality and bathymetric monitoring of Grey Cloud Channel and Grey Cloud Slough every three years.

Goal 3.5.1.dd. Implement first phase of the Grey Cloud Slough Habitat Restoration Project in partnership with the US Army Corps of Engineers, MN Department of Natural Resources, and others.

Trout Brook

SWWD has invested substantial resources towards the multiphase stream and floodplain restoration in the lower reaches of Trout Brook within Afton State Park and Afton Alps Resort. These habitat improvements enabled the Minnesota Department of Natural Resources (DNR) to re-stock native brook trout back into the stream in 2024. Proposed management actions for protecting Trout Brook focus on maintaining previous restoration work and further reducing incoming phosphorus and sediment loads from the contributing watershed, including its headwater agricultural lands and forested ravines. SWWD will strive to ensure the goals of the Lake St. Croix Nutrient TMDL are achieved in the Trout Brook watershed. Projects aimed at reducing thermal increases within the stream are of particular importance given Trout Brook's status as a Minnesota DNR-designated trout stream. Additionally, the District continues to collaborate with both the state park and ski resort on chloride reduction practices to protect lower reaches of the stream.

Goal 3.5.1.ee. Implement ravine stabilization, runoff retention, and agricultural conservation projects in the Trout Brook watershed, building off the Trout Brook Ravines Stormwater Retrofit Analysis, Top50P! Rural Subwatershed Analysis, and other studies.

Trout Brook
Image by Sarah Lilja, SWWD Artist-in-Residence 2024

Goal 3.5.1.ff. Conduct routine inspections of previous Trout Brook restoration work and complete maintenance as warranted.

Goal 3.5.1.gg. Implement chloride reduction strategies at Afton State Park and Afton Alps Resort to protect Trout Brook and its aquatic inhabitants.

O'Connor's Creek & O'Connor's Lake

SWWD continues to collect water quality data from O'Connor's Creek and O'Connor's Lake. The entire watershed is privately held and largely managed for agricultural production. O'Connor's Lake has no outlet and is considered landlocked, as it discharges to groundwater aquifers rather than to the St. Croix River. Occasionally, during wet climactic periods, the lake has overflowed its basin and discharged eastward, impacting the adjacent mining operation. Proposed management actions for the protection of O'Connor's Creek and O'Connor's Lake focus on continuing water

quality monitoring efforts and promoting agricultural conservation projects aimed at reducing nutrient and sediment loads. While not anticipated in the near future, property or easement acquisition to protect these unique and sensitive water resources may be a future consideration.

Goal 3.5.1.hh. Continue gathering information about O'Connor's Creek and Lake to guide future actions through ongoing water quality monitoring and watershed investigation.

Lower St. Croix Direct Drainage

SWWD's direct drainage to the St. Croix River (excluding Trout Brook and O'Connor's Creek) consists of a variety of small watersheds characterized by agricultural bluff lands and steep forested ravines. Implementing agricultural conservation, runoff control, and ravine stabilization will be the primary focus of SWWD in these areas, in collaboration with Washington County, the Washington Conservation District, and the Lower St. Croix Watershed Partnership. SWWD has been an active partner, working with the county on improvement projects within St. Croix Bluffs Regional Park; This relationship is expected to continue during this ten-year Plan cycle.

Goal 3.5.1.ii. Implement ravine stabilization, runoff retention, and agricultural conservation projects in Lower St. Croix Direct Drainage watersheds, building off the Top50P! Rural Subwatershed Analysis, and other studies.

3.5.2 | In-Lake Restoration

SWWD's 2025 Lake Management Plan identifies several lakes with excessively high internal phosphorus loading. While projects have previously been-and will continue to be implemented to mitigate external watershed loading, controlling internal loads remains necessary to achieve State water quality standards and local goals. SWWD undertakes a variety of actions aimed at direct physical improvement of water resources from within. Responsible management of lake nutrient cycling can be achieved through multiple options including vegetation manipulation, fisheries management, chemical treatment, and material additives. Feasibility studies will be completed in advance of implementing any proposed in-lake management strategy.

Internal Nutrient Load Controls

Based on the Lake Management Plan, the District intends to implement projects to control internal phosphorus loading on Markgrafs, Powers, Wilmes, Colby, La, and Ravine Lakes.

Individual studies assessing internal control treatments, expected outcomes, feasibility, and implementation cost for each lake will be completed during the early years of this Plan. Anticipated cost estimates to implement these internal phosphorus controls are integrated into SWWD's long-range workplan and may be revised through future budgeting processes. Upward cost adjustments in proposed internal control projects that are based on completed feasibility studies, will only be updated through plan amendment if significant and if required, as described elsewhere in this Plan.

There is no internal phosphorus load control currently planned at Armstrong Lake. However, the District will continue to evaluate the feasibility and effectiveness of removing phosphorus and chloride from the adjacent western wetland basin through targeted cattail biomass harvesting. The initial results from the 2025 pilot project indicated these harvesting activities have the potential to achieve significant removal of both phosphorus and chloride from cattail biomasses. SWWD will pursue further harvesting efforts and research if data continues to show potential benefit to the watershed.

Goal 3.5.2.a. Complete internal nutrient loading feasibility studies for priority lakes as identified in the 2025 Lake Management Plan (Markgrafs, Powers, Wilmes, Colby, La, and Ravine Lakes).

Goal 3.5.2.b. Implement internal phosphorus control projects and achieve designed internal load reductions at Markgrafs, Powers, Wilmes, Colby, La, and Ravine Lakes if recommended by completed feasibility studies.

Aquatic Invasive Species

Aquatic invasive species (AIS), primarily plants and fish, are pervasive across the watershed. Several species of exotic aquatic vegetation routinely grow to nuisance levels on several District lakes. The presence of goldfish (*Carassius auratus*) and other disruptive, non-native fish has also been noted in multiple stormwater ponds and lakes in Woodbury and Cottage Grove in recent years. SWWD has worked with local partners to control nuisance AIS since 2022.

SWWD currently manages invasive aquatic vegetation on Markgrafs, Wilmes, Colby, La, and Ravine Lakes and expects this work to continue throughout the life cycle of this Plan. The District actively monitors aquatic vegetation on lakes throughout the watershed and will initiate additional AIS control efforts as needed. Furthermore, the SWWD is working directly with the City of Woodbury to address the spread of goldfish through its municipal storm sewer system and into District lakes. Primary efforts include resident outreach, physical or chemical control, and removal of goldfish. All aquatic vegetation and rough fish management work is permitted and coordinated with the Minnesota Department of Natural Resources (DNR).

To eventually reduce the abundance of nuisance AIS and the need for ongoing control efforts, SWWD has begun pilot initiatives to restore abundant native aquatic vegetation in District Lakes. The SWWD will continue to pursue aquatic vegetation restoration as efforts prove beneficial. All restoration efforts are permitted and coordinated as required with the DNR.

Goal 3.5.2.c. Continue annual aquatic invasive species monitoring at all lakes managed for AIS within the District.

Goal 3.5.2.d. Develop aquatic vegetation management plans for Armstrong and Powers Lakes to limit the spread of AIS and promote native plant reestablishment.

Goal 3.5.2.e. Reduce the presence of nuisance AIS in District lakes.

Goal 3.5.2.f. Achieve net gains in aquatic ecological health represented by native plant re-establishment at all lakes managed for AIS within the District.

Goal 3.5.2.g. Develop information and share updated metrics regarding AIS and ecological health in District lakes every three years.

3.5.3 | Flooding

To address the multitude of flooding issues identified in this Plan, SWWD employs adaptive management to thoroughly study and understand the known extent of the problem and devise a range of implementation alternatives. The District often engages directly with experienced consultants to describe and model flooding issues that involve multiple municipalities. For localized concerns, a municipal partner may take the lead with or without District funding support as appropriate. This plan anticipates the need for District funding to undertake continued and future studies to better understand known regional flooding issues.

Furthermore, this Plan schedules the implementation of flood risk reduction and mitigation projects resulting from these studies, specifically targeting the La Lake and Ria Lake to the Mississippi drainage system within SWWD's Northern Watershed. Both watersheds will be further evaluated during the early years of this Plan cycle. Anticipated cost estimates to implement expected projects for these project areas are included in SWWD's long-range workplan and may be revised through future budgeting processes.

Central Draw Storage Facility and Overflow

A 20-year construction effort to establish this system was successfully completed in 2020. During large snowmelt and precipitation events, the City of Woodbury operates a large lift station to pump excess water from Bailey Lake into a large natural infiltration basin to the west. When it is full, the water overflows into SWWD's Central Draw Storage Facility. The City of Woodbury is solely responsible for operation of the Bailey Lake Lift Station, though the District considers it to be critical watershed infrastructure from a community flooding and climate resiliency standpoint. The storage capacity of the Central

Draw Storage Facility, located in Glacial Valley Park, is expected to be adequate to retain the runoff from a 6.3-inch, 24-hour rainfall event from SWWD's Northern Watershed. While Glacial Valley Park is not often utilized for this purpose, maintaining the undisturbed natural space and its vital soil structure remains a critical priority to SWWD. Staff routinely monitor the area for encroachments from neighboring properties and evidence of off-trail vehicles, while ensuring above-grade culverts and spillways remain stable, clear and ready to convey flood flows. Additionally, the District periodically retains specialized contractors to complete inspection of the system's underground overflow pipe and access manholes in the City of Cottage Grove. The first full baseline inspection of the Central Draw Overflow system was completed in 2024, resulting in some minor maintenance recommendations. Currently, the system remains in good condition, and ongoing annual maintenance budgets are not expected to be significant during this ten-year Plan cycle.

La Lake and Ria Lake to the Mississippi River

In 2024, SWWD commissioned a hydrologic and hydraulic analysis of this intercommunity flow area. The analysis was conducted in response to a proposed City of Woodbury project to install outlet control structures for both lakes, aiming to alleviate uncontrolled outlet flows and periodic flooding around the functionally land-locked basins. Results of the study identified significant existing localized flooding downstream from the lakes in the City of Newport. Modeling of this area and the evaluation of proposed projects will continue during this Plan cycle, and proposed capital projects will be formally incorporated through plan amendments.

Northern Watershed Active Level Controls

SWWD and its municipal partners have previously studied flood extents and impacts within this subwatershed area as it has rapidly developed in recent decades. The most visible problems manifest at Wilmes Lake, where multiple rounds of flood risk mitigation grants have been offered to residents, in addition to other infrastructure interventions. Within this ten-year Plan cycle, SWWD's analysis of the situation will focus on the potential benefits and risks associated with deploying active water-level management controls and strategies. Any proposed capital projects will be incorporated through a plan amendment process.

Flood Risk Reduction and Mitigation

SWWD supports its communities that choose to implement flood risk reduction and mitigation cost-share programs. Additional information on the District's support of these municipal cost-share programs can be found in Section 3.7.4 of this Plan.

Goal 3.5.3.a. Maintain a fully operational Central Draw Storage Facility (Glacial Valley Park) and Central Draw Overflow indefinitely.

Goal 3.5.3.b. Implement at least one feasible capital project identified in each completed flood risk reduction and/or active level control study.

3.5.4 | Surface Water & Groundwater Interactions

There are a variety of locations around the watershed where pronounced interactions exist between surface water and groundwater resources. There are examples of this type of interaction throughout the watershed, such as lakes with highly variable surface water levels (Vandenberg Lake), spring seeps (Trout Brook or bluff land ravines), and landlocked basins (La Lake or O'Connor's Lake). Other locations are less visually obvious, such as SWWD's many karst regions, which rapidly contribute to local groundwater recharge.

SWWD will undertake studies, monitoring, and modeling efforts to identify and prioritize undeveloped properties where protection and preservation is expected to provide meaningful benefits for both surface water and groundwater resources. Specifically, the District intends to learn more about chloride loading hot spots and trace pollutant movement through surface waters and shallow groundwater aquifers. Results of these studies will guide future SWWD programs and projects.

Implementation goals associated with SWWD's ongoing groundwater pollution prevention activities-which primarily focused on reducing the introduction of chlorides into the environment- are described in Section 3.8.4.

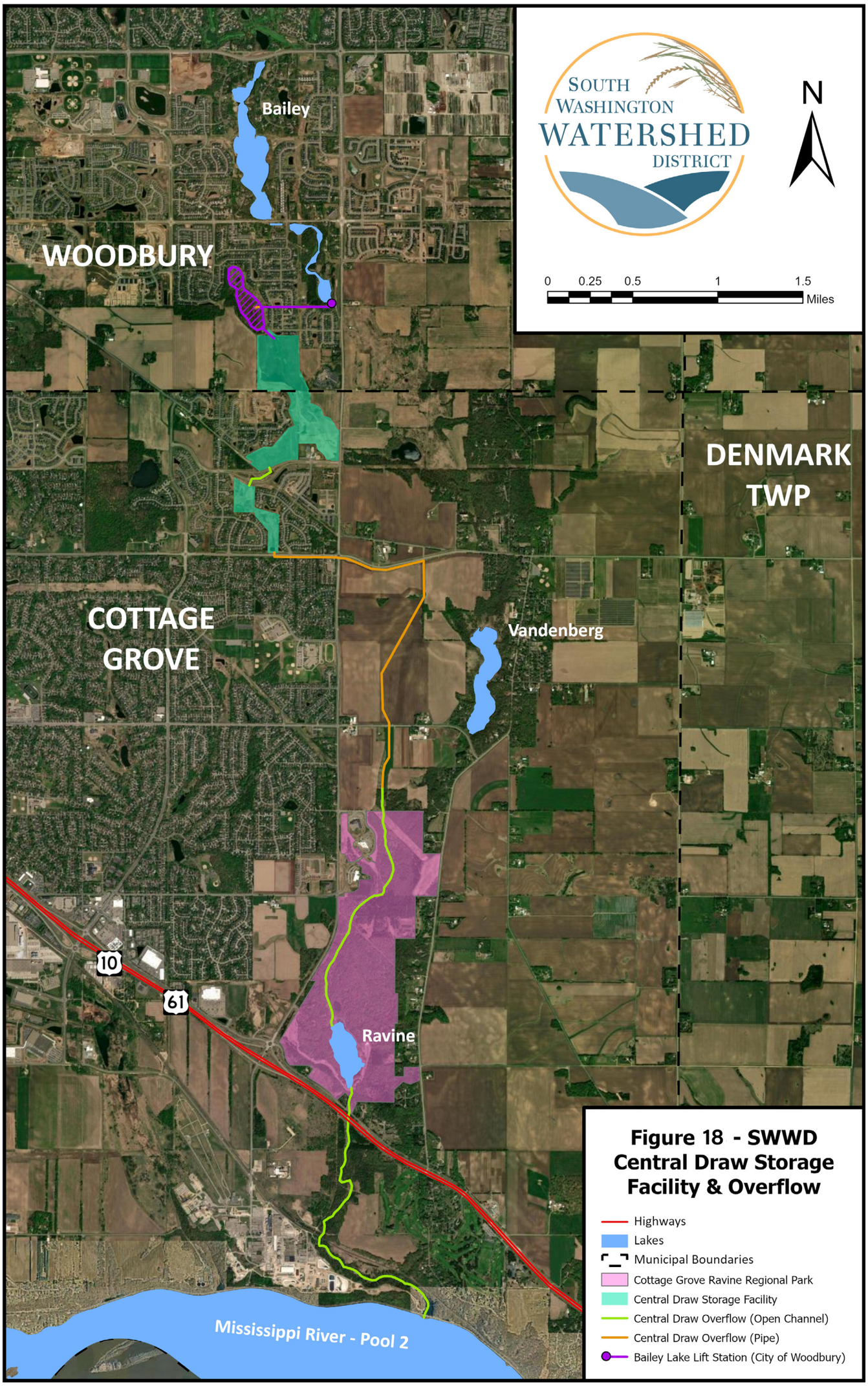


Figure 18: SWWD Central Draw Storage Facility & Overflow. This project. During large snowmelt and precipitation events, the City of Woodbury operates a large lift station to pump excess water from Bailey Lake into a large natural infiltration basin to the west which, when full, overflows into SWWD's Central Draw Storage Facility.

Additionally, a key groundwater modeling goal is included in Section 3.2.3.

> **Goal 3.5.4.a Identify, prioritize and pursue land protection efforts with partners aimed at locations with strong surface water-groundwater interactions.**

3.6 | WATERSHED RESILIENCY

Purpose: Build watershed resiliency through protection and restoration of priority lands and ecological connections with a focus on holistic watershed health.

The varied ecological components within a watershed interact with each other in ways that depend upon-and are often defined by-their connected space. The health of the entire system depends upon these functioning relationships, and recognizing this interconnectedness helps SWWD prioritize its support for ecosystem services and terrestrial land management.

Ongoing landscape and waterbody alterations across the District have interrupted ecological patterns and structures that evolved over millennia. These disruptions have resulted in fundamentally altered natural communities, driven by both human disturbance and the presence of invasive species. Even more significantly, we can observe changes in keystone ecological processes that regulate and maintain the relationship between species. A primary example is the historical suppression of wildfire and native grazing as natural land management processes in our region. The removal of these vital disturbance regimes can result in landscapes dominated by opportunistic species previously kept in check, leading to a loss of formerly common biodiversity interactions. As these altered communities establish themselves, displaced native plants and animals face diminishing resources. These ecological losses ripple outward, undermining comprehensive ecosystem functions and degrading local watershed and water resource health.

3.6.1 | Priority Lands Protection and Restoration

Within the SWWD, critical natural features remain that provide valuable insight into the pre-European settlement landscape. These spaces continue to support natural communities and the vital ecological benefits they provide. These include extensive floodplain and bluff lands along the Mississippi and St. Croix Rivers, DNR Scientific and Natural Areas, state, county, and city parks and non-profit nature centers that preserve native habitats. Additionally, various-sized natural areas persist on private lands throughout the District. SWWD remains committed to identifying these high-priority areas, building partnerships, and supporting programs that advance their long-term conservation and protection.

SWWD will develop specific criteria for a prioritization framework designed to identify interrelated factors that contribute to a healthy watershed. The Identification and protection of priority lands will emphasize how these parcels provide broad, overlapping benefits to the overall ecosystem. Evaluated characteristics will include, but are not limited to:

- Soil moisture holding capacity and infiltration potential
- Surface flows and groundwater connections
- The degree of landscape alteration
- Remnant natural communities, rare landscape features, or rare plant communities or species.
- Ecological connectivity between existing natural features
- Measurable benefits to human health and community well-being

This prioritization framework will evaluate how each identified components benefits comprehensive watershed health. Ultimately, it will guide how the SWWD can protect-either directly or by supporting local partners-key watershed features and properties that enhance overall system function, structure, pollutant load reductions, and ecosystem health.

The District will also pursue efforts to restore, mimic, reproduce, or preserve ecosystem functions, structures, and services across the landscape while establishing corridor connections between restored lands and existing natural spaces. In every case, the unique physical attributes (such as soil, geology, hydrology, plants and animals) and both biotic and abiotic components of the natural space will drive restoration efforts. A long-term

commitment to restoration of ecological function and structure remains vital to restoring natural landscapes and the overall watershed health. Accordingly, SWWD will continue to monitor established projects to ensure long-term success.

Goal 3.6.1.a Complete an Ecosystem Services Protection Assessment to identify methodologies and criteria to prioritize landscape protection.

Goal 3.6.1.b. Protect identified remnant natural lands through fee title or easement acquisition, either directly by the SWWD, with partners, or through other arrangements with private landowners.

Goal 3.6.1.c. Increase the number of acres of natural lands with actively implemented resource management plans.

3.6.2 | Management of Bluffs and Ravines

Steep bluff lands extend along both the Mississippi and St. Croix Rivers in the SWWD. Given their direct connection to these major rivers, these lands are considered globally significant as connected greenway corridors. They present a distinct set of challenges and opportunities for the district regarding promoting comprehensive watershed health. Beyond hosting unique plant and wildlife communities, these bluffs are important to the larger regional landscape with their unique plant and animal communities and continental flyways. However, their fragile slopes also represent potential sources of river sedimentation due to their immediate proximity to these important rivers.

Diverse native plant communities protect the rivers from sediment and nutrient loading by protecting the soils and slopes at their base. Some effective erosion prevention practices for bluffs and ravines can appear counterintuitive. For instance, strategic canopy thinning (the select removal of trees) opens the forest floor to increased solar penetration, which stimulates a robust understory and groundcover growth. Where present, aggressive buckthorn management and removal can be a critical first step to reestablishing a thriving forest groundcover community. In other locations, Water and Sediment Control Basins (WASCOBs) can be constructed above the head of a ravine to reduce incoming flow rates from agriculture fields or other large drainage areas. Ultimately, ensuring that these healthy natural communities maintain a dense, thriving native groundcover remains the most effective method to stabilize soils and mitigate many erosion concerns.

Bluff lands present many challenges to planning and implementation. Most of these areas are in private ownership, heavily forested, and composed of fragile, steep, and inaccessible slopes. To address these constraints, the District maintains a proactive approach, prioritizing the early identification of eroding ravines and bluffs while remaining equipped to respond rapidly to emerging issues as they are discovered.

Goal 3.6.2.a. Develop a comprehensive inventory and condition assessment of vulnerable bluff and ravine sites along the Mississippi and St. Croix Rivers.

Goal 3.6.2.b. Complete projects to stabilize identified actively eroding ravines contributing to downstream resource degradation.

3.6.3 | Protection of Riverine Riparian Zones

The SWWD is bound by two major rivers and prioritizes the comprehensive health of these critical water bodies. Upslope management practices that reduce nutrient and sediment are vital components of this conservation strategy. Healthy riparian zones within and along rivers offer a wide range of ecosystem services that provide local and regional benefits including:

- Flood attenuation
- Floodplain habitat for plant and animal species
- Improved fisheries
- Stable banks that reduce sediment loss
- Nutrient attenuation
- Soil building
- Groundwater recharge
- Recreational activities (fishing, boating, birding, etc...)

SWWD's floodplain protection efforts will account for the historic alteration of local river systems and operate within the limitations of their altered characteristics. For example, locks and dams constructed along the Mississippi River have modified natural flow dynamics within their pools, creating conditions that mimic large shallow lake settings. During high-water conditions, elevated flow rates and velocities return.

Where feasible, the reintroduction of features and processes lost to these structural alterations should be engineered to leverage the river's remaining forces. These critical forces include:

- Fluctuating river flows and hydraulic velocities
- Natural sediment transport and depositional patterns
- Native plant communities and understory dynamics

Recognizing both the limitations and opportunities of these altered river dynamics remains vital to developing successful regional restoration strategies.

Retaining and enhancing diverse native floodplain communities that include backwater channels, oxbows, lowland grassland, wetland, and forested communities provide a wide range of benefits needed to protect water resources within and beyond SWWD. Adapting SWWD's long-term planning to historic river alterations is essential to effectively build regional ecosystem resiliency in the face of climate change.

> **Goal 3.6.3.a. Protect and enhance existing natural floodplain ecosystems within major river corridors through stabilization and restoration projects and/or riparian land acquisition via fee title or easement.**

3.6.4 | Landscape Connectivity

To retain and improve valuable ecosystem functions, remnant natural areas within the District can be preserved and connected by expanding native plant communities through restoration. In urban, rural, and agricultural landscapes, natural areas are often fragmented by infrastructure and land-use practices. These disruptions create isolated habitat islands that lack the flows of energy, nutrients, water, and species to support the diverse functional traits of ecosystems. Establishing connecting corridors between natural areas helps restore the ecological integrity of the larger landscape. Furthermore, connected corridors facilitate wildlife and plant movement between remnant natural areas, producing enhanced diversity. Reinforcing existing corridors and establishing new ones will help preserve these valuable ecosystems while supporting resiliency in a changing climate. These connected corridors may consist of comprehensive natural area restoration projects, but they can also include targeted vegetative enhancements within public or utility right-of-ways, including utility corridors, roadways, trails, and drainage networks. Often, the establishment of greenway corridors provides multi-benefit outcomes that overlap and contribute to other District goals aimed at protecting both surface water and groundwater.

> **Goal 3.6.4.a. Reestablish and protect greenway corridor connections between priority natural lands as opportunities become available.**

3.6.5 | Partner Capacity

SWWD values collaboration with local partners in the development of green infrastructure and open space planning in support of watershed health. Municipalities, residents, non-profit organizations, state, county, and federal agencies, as well as farmers and other business interests, have a stake in creating a clean and healthy watershed. The SWWD will work to build the capacity of these partners through programs that offer support for the expansion and restoration of natural spaces and open space planning. SWWD projects and programs can function as a catalyst for protection through planning collaborations, financial support and incentives, staff expertise support, capacity building, and fostering connections among partners. Specifically, the SWWD will establish a wide variety of means to support our partners that may include:

- Financial support to build partner capacity in equipment and resources
- Planning support that focuses on landscape preservation, restoration and zoning to support watershed health initiatives
- Partner program support to acquire, restore and maintain identified priority properties and areas

- Continued collaboration and education programming on a variety of landscape management and restoration topics to help partners build in-house skills that support resiliency

Goal 3.6.5.a. Provide incentives to partners in the form of planning funds, staff expertise and availability, and/or equipment to improve their capacity to apply scientifically sound BMPs on restored and natural landscapes.

3.6.6 | Long-Term Management

The SWWD is committed to the long-term success of its projects and programs utilizing adaptive management to identify and address continuing and emerging resource needs during the planning phase. Ecological disturbance and other natural processes are as vital to the resilience of prairie and savanna ecosystems as are their specific physical and biological components. Accordingly, SWWD recognizes that prescribed fire burning, grazing, targeted use of herbicides, mowing, and other practices are essential and require sustained financial and material support to maintain resilient ecosystems in the face of broader landscape pressures. Pervasive invasive species, novel plant communities, deficient soils, fragmented landscapes, and the desiccation of woodland edges will continue to exert pressure on natural communities within an altered landscape. Once established, restored natural communities require significantly fewer inputs than manicured landscapes, but still require maintenance that ideally mimics historic natural processes.

Goal 3.6.6.a. Establish long-term maintenance programs and guidance for partners in all District projects.

Goal 3.6.6.b. All long-term management plans will incorporate keystone processes and adaptive management principles.

3.7 | INCENTIVE PROGRAMS

Purpose: SWWD offers incentive programs that provide grants to municipal partners and landowners in the watershed for actions that support its goals.

2025 stewardship grant recipent with compost
Image by receipent

3.7.1 | Stewardship Grants

SWWD's Stewardship Grant Program empowers residents, municipalities, institutions and businesses to use innovative practices to protect and improve water resources within the District. An education and outreach program at its heart, this program also provides important financial incentives to participants who are seeking to make positive changes to their properties. This program promotes water quality improvements by focusing on the reduction of phosphorus in stormwater runoff, reducing erosion and sedimentation, and preserving and restoring natural lands throughout the watershed.

The primary value of dispersed, small-scale Best Management Practices (BMPs) lies in the engagement with residents and other landowners. Educating the public about water resource protection and encouraging simple lifestyle and property management changes can lead to water quality improvements, which is the primary focus of this program. SWWD intends to work with partners such as the East Metro Water Education Program (EMWREP) and others to host workshops that will educate and empower its constituents to undertake projects on their own property and on their own time. Successful projects will help improve water quality, reduce

stormwater runoff, or increase ecosystem resiliency. Common project examples include, but are not limited to, rain barrels or cisterns, raingardens, pervious hard surfaces, native plantings, invasive species removal, natural lands restoration, and some chloride reduction practice. Registered program participants who complete their project and meet program criteria, may be eligible for small grant reimbursements consistent with an amount established by the SWWD Board. SWWD will work to minimize the barriers for residents to participate in this program, however, implementation may be periodically focused on specific subwatersheds or environmental justice areas to help achieve targeted goals.

When proposed projects are identified that have the potential to achieve substantial, measurable, or regional water quality, volume control, or ecosystem resiliency outcomes, SWWD may provide additional technical assistance or grant funding for project development and implementation.

This incentive program will utilize ad valorem levy funds, and the program budget will be set annually by the Board of Managers, not to exceed $150,000. Detailed guidelines for this program will be developed by staff and approved annually by the Board.

Goal 3.7.1.a. Work with WCD, EMWREP, and other partners to operate the Stewardship Grant program annually to engage and educate District residents.

Goal 3.7.1.b. Increase community participation in the Stewardship Grant program year-over-year in terms of the number of applications submitted, projects completed, and program budget utilized.

3.7.2 | Agricultural Incentives

Building on outreach work with local partners like the Washington Conservation District, Lower St. Croix Watershed Partnership, and EMWREP, SWWD will offer cost-share funding to landowners for practices–both structural and non-structural–that reduce runoff and help prevent the loss of nutrients and sediments from farmland.

Examples include, but are not limited to:

- Soil health BMPs
- Feedlot improvements
- Buffers
- Swales
- Water and sediment control basins (WASCOBs)

SWWD will also seek to support farmers pursuing operational modifications to improve sustainability, support resiliency against climate change, enrich long-term soil health, or all three. This will occur through the acquisition of specialized equipment or short-term incentive payments during operational transitions, such as reduced tillage or cover crops.

Project proposals will be developed and reviewed by a Washington Conservation District conservation specialist or a Lower St. Croix Watershed Partnership agronomist. This incentive program will utilize ad valorem levy funds, and the program budget will be set annually by the Board of Managers, not to exceed $200,000. Detailed guidelines for this program will be developed by staff and approved annually by the Board.

"Improved soil health is one area of agricultural conservation that both farmers and other land managers are realizing may be a critical issue. Soil health practices, such as reduced tillage and cover crops, have the potential to improve agricultural profitability while also protecting water resources by increasing the water holding capacity of soil and reducing the transport of pollutants to streams and lakes. Soil health improvement projects are one example of a practice that may be implemented through this Plan."

— Lower St. Croix River Comprehensive Watershed Plan, page 40.

Goal 3.7.2.a. Increase average annual number of SWWD agricultural landowners engaged through partnerships with WCD, EMWREP, LSCWP, and other partners over the course of this planning cycle.

Goal 3.7.2.b. Increase the number of operators and total acreage implementing non-structural agricultural and/or soil health practices over the course of this planning cycle.

Goal 3.7.2.c. Implement at least three designed structural agricultural practices over the course of this planning cycle.

3.7.3 | Resource Restoration & Resiliency (RR&R) Program

In addition to implementing actions to achieve its watershed resource goals, SWWD encourages its partners to work collaboratively on shared resource management issues. To foster these partnerships and provide direct assistance, the District makes grant funding available for local water resource capital improvement projects, non-routine maintenance, and other resource restoration and resiliency projects. Furthermore, funding is available for acquisition of equipment to bolster our partners' capacity to undertake important stormwater system and watershed management maintenance activities that are equally vital to the long-term success of these regional efforts and remains highly eligible for District funding. SWWD will offer its Resource Restoration and Resiliency (RR&R) grant program for the following purposes:

- Making progress toward achieving SWWD's water resource management goals including, but not limited to, nutrient, sediment, and volume reduction
- Mitigating and reducing the risk of flood damage in critical locations across the watershed
- Facilitating the exploration of water quality improvement, flood control, and climate resilience opportunities by SWWD partners and encouraging the incorporation of those concepts into long-term capital improvement plans, as well as routine infrastructure operation and maintenance projects.
- Fostering stormwater management innovation and demonstration of new ideas
- Reducing chloride use throughout the watershed while improving de-icing and anti-icing operational efficiency and public safety
- Enhancing partners' actions to increase the climate resiliency of the watershed's natural resources and stormwater management infrastructure
- Improving the capacity of SWWD's partners to maintain existing stormwater infrastructure, natural areas, and native vegetation within their respective jurisdictions
- Defraying local costs to address these watershed-wide interests

Each year, the SWWD Board of Managers will establish a budget for this program within its annual budget process pursuant to its assessment of needs and funding limitations, not to exceed $1,000,000 per year. Project applications may vary widely from year to year in terms of scope, cost, geographic location, or water resource benefits. As such, SWWD intends to primarily utilize ad valorem levy funds to operate this program. Generally, funding requests should not exceed $250,000 per project or 50% of the total cost of the project, whichever is lower. However, the SWWD Board reserves the right to consider applications that exceed these limits for large capital project proposals, or the Board may decide to fund them through other District programs. Other funding sources, such as regional, state, or federal grants, may be used to supplement (but not replace) the (RR&R) program if SWWD is awarded such grants for this purpose. A more detailed set of program guidelines and application instructions will be produced by staff and distributed each year to guide program implementation.

Goal 3.7.3.a. Solicit RR&R applications through a Request for Proposals process annually.

Goal 3.7.3.b. Maintain or increase the number of quality applications submitted to the RR&R program by providing proactive outreach and guidance to potential applicants.

Goal 3.7.3.c. Utilize the RR&R program to increase access to and use District capital funds for projects in historically underserved communities.

3.7.4 | Flood Risk Reduction and Mitigation

Under the State of Minnesota Floodplain Management Act, the Minnesota Department of Natural Resources (DNR) establishes statewide floodplain regulations. Counties and cities then implement those regulations through local zoning. Under this system, local floodplain managers work to:

- Preserve flood-prone areas as public open space

- Adopt protective regulatory standards to preserve lakes, rivers, and wetland areas
- Partner with neighboring and overlapping jurisdictions to address flooding
- Plan for flood preparation and response
- Implement flood risk reduction projects

While SWWD is not the local floodplain authority, it maintains a flood risk reduction and mitigation program to assist its local partners to address known flood hazards. The program is available to municipalities within the watershed that have identified ongoing flooding risks to private property. SWWD funding is made available to those municipalities who then distribute the funds via individual cost-share grants to landowners to make improvements to their property to reduce or mitigate the impacts of flooding. This incentive program will utilize ad valorem levy funds, and the program budget will be set annually by the Board of Managers, not to exceed $250,000 over the ten-year period of this plan.

Goal 3.7.4.a. At least twice within this planning cycle, solicit interest in the Flood Risk Reduction and Mitigation Program and provide funding as necessary to municipalities to support local flood risk reduction and mitigation incentive programs.

3.7.5 | Groundwater Conservation & Protection

SWWD does not supply water to District residents as this function is handled by municipalities in suburban areas or private wells in rural areas. However, to address the Districts goals of supporting partner efforts to conserve and protect groundwater resources within the watershed, SWWD maintains a Groundwater Conservation and Protection incentive program to assist its local partners. The program is available to any interested municipality within the watershed seeking to provide cost-share grants to landowners to make efficiency upgrades to irrigation systems, water softening systems, plumbing fixtures, or other approved end-user systems to reduce water use and protect valuable water resources. This incentive program will utilize ad valorem levy funds, and the program budget will be set annually by the Board of Managers, not to exceed $100,000.

Goal 3.7.5.a. Provide funding to municipalities in support of local groundwater conservation and protection incentive programs.

3.8 | STORMWATER OPERATION AND MAINTENANCE

Purpose: To empower SWWD partners to implement changes to operation and maintenance activities that improve and protect water resources and public infrastructure.

Generations of development and redevelopment of the expanding suburban landscape within the watershed have resulted in the buildout of vast networks of stormwater management infrastructure. Roadways, catch basins, pipes, ditches, culverts, ponds, lift stations, and other Best Management Practices (BMPs), provide the means to convey, store, and treat stormwater before it flows into area lakes and streams and the Mississippi and St. Croix Rivers. These systems have also been designed to prevent or mitigate local flooding during large storm events. Routine inspection and maintenance of these facilities are critical to their operation and longevity as well as protection of the public's investment in their construction.

However, most of the stormwater infrastructure in the watershed is owned and maintained by municipalities, Washington County, private landowners, or homeowners' associations. Ensuring proper attention is paid to systems owned by others is a much more difficult task.

SWWD will provide outreach to external storm sewer infrastructure managers and pursue partnerships whenever possible that encourage increased inspections and frequent maintenance for critical stormwater infrastructure. It will consider providing financial support for critical non-routine maintenance of stormwater systems at risk of failure when that failure would contribute to major water resource issues or flood damage risk.

3.8.1 | Storm Sewer Failure Risk Assessment

SWWD's 2018 Climate Resiliency Plan included a qualitative risk analysis for storm sewer infrastructure across the watershed. Direct outreach to communities

and partners by SWWD regarding the availability and results of this assessment is critical to ensuring they understand the risks that are present. The results of this Storm Sewer Failure Risk Assessment will be used as a tool to guide decisions regarding the use of SWWD funds for proposed storm sewer maintenance and improvement projects. Furthermore, SWWD will utilize its incentive and implementation programs to encourage and support proactive climate adaptation by addressing known storm sewer system failure risks.

Goal 3.8.1.a. Regularly promote SWWD's Storm Sewer Failure Risk Assessment to increase the number of stormwater system operators incorporating the report into routine inspection and maintenance planning.

Goal 3.8.1.b. Assist partners with implementation of at least one project annually through the RR&R program that addresses a critical stormwater infrastructure site at risk of failure.

3.8.2 | SWWD Capital Improvement Projects

While SWWD has been successful at providing capable staffing and funding for the development and implementation of many important and beneficial capital improvement projects, it does not maintain the staffing or equipment necessary to complete maintenance of these projects. Often, maintenance is either contracted out with private companies or completed through local municipalities. When feasible, municipal partnerships have proven to be the most economical, viable, and mutually beneficial option for SWWD. City public works departments have knowledgeable staff and the necessary equipment to carry out many of the maintenance tasks required for District projects. SWWD will seek partnership agreements that appropriately fund these types of municipal maintenance partnerships for all SWWD-initiated capital projects.

Goal 3.8.2.a. Establish adequately funded municipal operation and maintenance agreements on all SWWD capital projects.

3.8.3 | Enhanced Street Sweeping Programs

Street sweeping has been identified in studies across the Twin Cities metropolitan area as one of the most cost-effective Best Management Practices (BMPs) available for treating stormwater runoff in urban area waterbodies. Road authorities that are regulated by the NPDES MS4 program, including Washington County and several SWWD cities, are required to complete routine sweeping of streets and parking lots under their jurisdictional control. While this requirement is typically interpreted as twice per year (once each in spring and fall), expanding sweeping programs to include additional cycles throughout the summer—and even during winter months in high-priority areas—can significantly maximize pollutant removals. This proactive expansion protects local waterbodies and operational maintenance intervals of stormwater ponds and other BMPs.

Woodbury Street Sweeper *Obi-Wan Cleanobi*

SWWD began a pilot enhanced street sweeping program with the City of Woodbury in 2022 after the completion of the City's Enhanced Street Sweeping Plan earlier that year. Results were immediately promising. Since then, SWWD has partnered with the City of Woodbury to increase its fleet to three full-time, year-round sweepers. Enhanced street sweeping is currently underway with the City of Cottage Grove as well, and discussions have been held with the Cities of Newport, St. Paul Park, and Oakdale to increase their respective sweeping frequencies. SWWD

recognizes the additional cost of these programs to local communities and offers funding for equipment and operations of enhanced street sweeping programs on a case-by-case basis.

This program also accents the SWWD's education and outreach efforts. Street sweepers can function as slow-moving billboards throughout local neighborhoods. Outfitting them with vinyl wraps containing environmental messaging and SWWD's logo helps ensure name recognition for the agency and keep water resources on the minds of residents.

Goal 3.8.3.a. Partner with all SWWD's MS4 municipalities to develop and implement enhanced street sweeping programs.

3.8.4 | Winter Maintenance Improvements

Chloride pollution of both surface water and groundwater resources continues to emerge as a growing threat within SWWD year after year. Salt applied for winter road and parking lot maintenance remains the largest single source of chloride in the developed areas of the environment. To achieve its chloride reduction goals, SWWD actively engages municipal partners, residents, and property managers to reduce the amount of salt applied for this purpose.

Goal 3.8.4.a. Assist MPCA's statewide efforts by subsidizing, hosting, and promoting at least one Smart Salting training within its jurisdiction annually.

Goal 3.8.4.b. Utilize the Statewide Chloride Management Plan and "Low Salt, No Salt Minnesota" resources in development of a SWWD chloride management plan and other winter maintenance outreach campaigns.

Goal 3.8.4.c. Provide grant funding through the Resource Restoration & Resiliency program for road authorities and municipal, institutional, and commercial property owners and managers for low salt equipment upgrades resulting in direct reductions in chloride application.

Goal 3.8.4.d. Ensure chloride reduction principles are carefully considered in all project designs developed or funded by SWWD.

Goal 3.8.4.e. Encourage land use authorities within SWWD to incorporate chloride reduction design guidance into local ordinances and plan review procedures and/or assess the feasibility of incorporating chloride reduction guidance into SWWD's Rules.

Goal 3.8.4.f. Fund the distribution of traction grit to residents and businesses across the watershed as a sustainable chloride alternative and see increased distribution rates year-over-year.

Goal 3.8.4.g. Support Statewide policy and legislative changes to require MPCA or similar smart salt certification for salt applicators, provide liability relief for MPCA or similar smart salt certified salt applicators, and other similar initiatives.

3.9 | EDUCATION AND OUTREACH

Purpose: SWWD will engage the public to educate, inform, and provide resources that protect the water resources of the District. SWWD is an instrumental part of outreach programming that connects members of the community to measurable and effective natural resources protection programs.

To effectively serve its residents, the District will analyze the demographic profile of the watershed's population. SWWD will conduct demographic research and develop targeted engagement plans to reach unengaged communities. The District will establish brand standards to ensure a consistent and recognizable water resource entity. Visually appealing communication tools including graphics, iconography, photos, videos, virtual immersion, and translated materials in some instances, will be regularly used to improve community engagement.

3.9.1 | Audience Engagement

The District will work to engage with all members of the watershed community, including those who have

been historically unengaged. Within the community, there are specific subgroups of individuals who have more direct impact on water resources due to their location, occupation, or life stage. The District will develop programming to prioritize targeting those individuals, including but not limited to:

- Riparian landowners
- Homeowners Associations (HOAs)
- School and youth groups
- Private well and septic system owners
- Municipal, commercial, and institutional property managers
- Agricultural landowners
- Construction site managers and operators

The District will work with Washington County and its municipal partners in outreach efforts surrounding groundwater, private wells, and septic systems within the watershed.

Goal 3.9.1.a. Annually increase engagement with target and historically unengaged audiences through partnerships with WCD, EMWREP, municipalities, and others.

Goal 3.9.1.b. Host at least six workshops, seminars or similar events annually to engage with priority audiences within the District.

Goal 3.9.1.c. Develop and biennially execute a routine survey effort to gauge resident perception of resource quality and understanding of issues.

Goal 3.9.1.d. Complete an annual survey of municipal public works supervisors to assess stormwater operation and maintenance gaps, needs, and barriers.

Goal 3.9.1.e. Annually promote NPDES and SWPPP training programs and opportunities to area contractors to improve onsite erosion and sediment control compliance.

3.9.2 | Experiential Education & Campus Greening

Experiential education offers hands-on learning experiences to students within the watershed. Through this program, students are exposed to information on water pollution, water quality, storm sewer networks, ways to clean stormwater, impacts of water quality on plant and animal life, and biotic and abiotic measurements of water quality. This learning takes place in the classroom and in the field through SWWD's partnership with Carpenter Nature Center. Engaging students early helps to cultivate a community that is deeply informed about environmental issues and society's long-term impacts on the watershed.

SWWD collaborates with local schools within the District to advance campus greening through conversion of mowed turf to prairie, woodland, or other natural landscapes and incorporate structural Best Management Practices (BMPs) where most beneficial. In pursuing this work, the District engages students, teachers, and leaders to

Middle school student catching macroinvertebrates for identification in the St. Croix River
Angie Hong

design campus greening projects that benefit both the campus and watershed health. This hands-on process provides students with invaluable, real-world learning opportunities. To sustain these projects, SWWD provides project leadership, limited funding, and technical guidance to help the school building maintenance team.

Goal 3.9.2.a. Provide experiential environmental education opportunities to South Washington County Schools students annually, so that all students are reached at least once during their K-12 career, through partnerships with WCD, EMWREP, and nature centers.

Goal 3.9.2.b. Begin partnerships with other schools within SWWD to provide experiential environmental education opportunities annually, through partnerships with WCD, EMWREP, and nature centers.

Goal 3.9.2.c. Engage South Washington County Schools to maintain existing, and pursue new, native landscape restoration projects on all school campuses within the watershed.

3.9.3 | Online Community Engagement

Online engagement meets members of the watershed community where they are and enables individuals to interact directly with the water resources that SWWD works to protect. Online community engagement is characterized by any outreach that occurs virtually, including SWWD's website, social media accounts, and email newsletter. It also includes streaming media by SWWD or its partners. The District will use these platforms to inform the community of at-home seasonal water quality best practices, upcoming events and opportunities, cost-share incentives, project and program announcements, and more.

The SWWD website is the primary tool for disseminating information to the watershed's communities. It serves as the informational and education hub for the projects, programs, and initiatives taking place within the watershed. The District website also includes an interactive mapping application that provides useful geospatial information about the watershed and its resources. Information on the website will be engaging, accessible, and relevant to the public. The website, however, is not intended to be a repository of all historical documentation for the South Washington Watershed District.

The website and all available materials will be compliant with current Web Content Accessibility Guidelines (WCAG). Resources will be made available to ensure that the website remains accessible to all members of the watershed.

It is the District's intention to serve as a primary source for information related to the condition and management of resources within the District. To facilitate that role, SWWD will continue to develop web applications and evaluate new technologies to incorporate into the District's website.

Goal 3.9.3.a. Increase resident engagement through web platforms year-over-year.

Goal 3.9.3.b. Distribute a quarterly email newsletter.

Goal 3.9.3.c. Maintain an updated and accessible District website and applications necessary to support District programs and disseminate information to the community.

3.9.4 | Artist-in-Residence

SWWD's Artist-in-Residence (AiR) program bridges the gap between art and science and forges another way to find meaning and connection with water resources. The SWWD AiR program enables the District to connect with new audiences through various artistic mediums. SWWD

Fine arts photographer Sarah Lilja, 2024 Artist-in-Residence, at the first SWWD Artist Exhibition held at the Carpenter Nature Center in southern SWWD

will continue to coordinate with the local artistic community and open the program for artists of varying disciplines. The program will also pursue public engagement opportunities, such as community workshops and events.

> **Goal 3.9.4.a. Offer a biennial Artist-in-Residence program to support partner and resident engagement, and fill identified Education & Outreach program needs.**

3.9.5 | Stewardship Grant Program

SWWD's Stewardship Grant Program is an engaging educational program that supports ongoing education and outreach initiatives of the District. The primary focus of the program is to engage watershed community members and provide education that accomplishes the following:

- Increased awareness of the importance of water quality in the District
- Greater understanding of individual and community impact on water quality and environmental health
- Empowered individuals and groups actively participating in water quality protection efforts
- Promotion of water quality improvements with incentives

The Stewardship Grant Program will be evaluated annually based upon the number of individuals and groups engaging in the program and the utilization of the District's annual program budget. Participants who engage in any of SWWD's informational workshops, have a site visit, or complete a project will be counted towards the yearly program evaluation.

As the watershed community grows and changes, so may implementation of the Stewardship Grant Program. The structure and specific guidelines of the program will be modified as necessary to reach larger and different audiences, and to most effectively provide education and outreach to the community. Targeted outreach campaigns to reach areas of the District not previously engaged will take place.

In instances where large scale water quality goals may be met by a more substantial project, SWWD will pursue those projects in partnership with the landowner and will utilize other appropriate District funding reserved for such instances. Additional details about SWWD's incentive programs can be found in Section 3.7.

> **Goal 3.9.5.a. Annually review and modify, if needed, SWWD incentive programs to effectively engage target community members.**

3.9.6 | Partnerships

Partnerships allow the SWWD to become more connected with the community it serves. The District values its relationships with its partners at all levels, including municipal and community organizations in the pursuit of water resource education.

SWWD is an active member of the East Metro Water Resource Education Program (EMWREP). EMWREP is a partnership formed in 2006 that serves 30 local units of government in the east metro area. The purpose of the shared education program is to provide education to District communities and their residents about the impacts of non-point source pollution such as nutrients and deicing chemicals on local lakes, rivers, streams, wetlands, and groundwater resources. Members of EMWREP seek to engage residents and communities in projects that will help to protect and improve water quality in the region. In 2025, Minnesota Watersheds recognized EMWREP as its Program of the Year. EMWREP staff are routinely utilized to carry out a variety of implementation initiatives contained within this Plan.

> **Goal 3.9.6.a. Actively support, participate in, and adequately fund EMWREP.**

3.9.7 | Glacial Valley Park Interpretive Center

Construction of an interpretive learning center at Glacial Valley Park was identified early in the planning efforts for the Central Draw Overflow and Storage Facility. A conceptual plan for a future learning center was completed in 2018 and includes a three-season shelter, restrooms, and interpretive signage. The passive use facility would double as a trailhead for Washington County's regional trail system, in addition to serving as an outreach hub for the District and its partners.

Completion of the Glacial Valley Park Interpretive Center

will further enhance the District's goal of increasing effective education and outreach. The learning center will be located among the restored prairie and will tell many stories about the history of the land and highlight the current ecology and active ecosystem restoration and management activities underway.

> **Goal 3.9.7.a. Complete construction and establishment of the Glacial Valley Park Interpretive Center once external funding resources are secured.**

3.9.8 | Research and Innovation

Much of SWWD's work is focused on direct implementation of programs and projects to improve water resources and educate the larger community about the watershed. However, it is important that the organization also continues to seek new knowledge and cultivate innovation in the world of stormwater and watershed management while participating in the larger scientific community found in Minnesota and across the Midwest.

SWWD will continue to pursue collaborative research opportunities and partnerships to address known gaps in stormwater management, water quality, ecosystem sustainability, and climate resiliency knowledge that are applicable to its local resource issues. There are numerous professional and academic organizations that are conducting critical research and work to transfer new understandings and technology advances to watershed managers and practitioners. Researchers occasionally reach out to SWWD and its local partners seeking direct funding or in-kind services to assist projects relevant to the work of the District. Other times, local staff's knowledge of adequate field research sites can be all the help necessary. Staff may also contribute their time serving on appropriate research councils or advisory committees where their expertise and experience can provide important technical input and maintain the District's position as a regional leader.

SWWD has established a modest budget, not to exceed $50,000 annually, to support approved research projects, partner organizations, and collaborative relationships that advance watershed management and climate resiliency science. Examples of organizations that SWWD may partner with include, but are not limited to, State and Federal agencies, Minnesota Stormwater Research Council (MSRC), Midwest Climate Adaptation Science Center (MW CASC), Minnesota Climate Adaptation Partnership (MCAP), and Cold Climate Center of Excellence for Stormwater Infrastructure Technologies (CCCESIT).

> **Goal 3.9.8.a. Pursue collaborative research opportunities addressing SWWD issues, strategies and goals through annual involvement and/or investment in research partnerships.**

3.10 | ADMINISTRATION

Purpose: The South Washington Watershed District is a special purpose local government unit (LGU) that manages water resources within portions of Washington County per authorities given in Minnesota Statutes 103B, Minnesota Statutes 103D, and Minnesota Rules 8410.

The Metropolitan Surface Water Management Act (Minnesota Statutes 103B.201–103B.255) states the purposes of watershed management organizations such as SWWD are to:

- Protect, preserve, and use natural surface and groundwater storage and retention systems.
- Minimize public capital expenditures needed to correct flooding and water quality problems.
- Identify and plan for means to effectively protect and improve surface and groundwater quality.
- Establish uniform local policies and official controls for surface and groundwater management.
- Prevent erosion of soil into surface water systems.
- Promote groundwater recharge.
- Protect and enhance fish and wildlife habitat and water recreational facilities.
- Secure the other benefits associated with the proper management of surface and groundwater.

3.10.1 | District Mission

The ongoing actions of the District, including the development and execution of this Plan, are intended to most effectively support the District's mission:

To manage water and related resources of the District in cooperation with our residents and communities.

3.10.2 | Board of Managers and Staff

The South Washington Watershed District is governed by a five-member Board of Managers appointed in staggered 3-year terms by the Washington County Board of Commissioners. Day-to-day operations implementing SWWD's watershed management plan are overseen by the South Washington Watershed District Administrator, who directs a small professional staff. To avoid duplication of efforts, SWWD routinely partners with its Cities, Washington County, Washington Conservation District, neighboring Watershed Districts, and non-governmental organizations to leverage external capacity before adding additional SWWD staff. However, SWWD will maintain staff levels necessary to implement work in this plan. SWWD will also maintain office and facility space necessary to support District operations as described in this plan.

Current Managers and Staff are identified on the District website at http://swwdmn.gov.

3.10.3 | Advisory Committees

SWWD utilizes two separate advisory committees to inform its planning efforts: a Community Advisory Committee (CAC), and a Technical Advisory Committee (TAC). The two committees are authorized in accordance with Minnesota Statutes 103D.331 and 103D.337, respectively.

Community Advisory Committee

SWWD will seek to maintain an active Community Advisory Committee (CAC) comprised of five to nine members. To the extent practicable, SWWD will seek to include on its CAC a representative from the Washington Conservation District, a member of a sporting organization, and a member of a farm organization. Should a federally recognized Tribal government establish interests within the watershed, SWWD will seek their participation in the CAC as well. Other engaged SWWD residents may be appointed at the discretion of SWWD's Board of Managers, who will strive for CAC members to be broadly distributed across the geographic area of the district and represent a broad range of interests.

CAC appointments are made by the Board of Managers annually in January, after a period of recruitment each fall. Vacancies that arise during the year may, however, be filled at any time at the discretion of the Board. Initial CAC member terms run through the appointed calendar year, although members are encouraged to commit to serving a minimum of two years. There is no limit on number of terms. The SWWD has adopted and will maintain guidelines for the CAC to guide its operation.

Goal 3.10.3.a. Maintain an active and engaged Community Advisory Committee that meets and provides input to the District at least quarterly.

CAC members Bill Sumner (left) and Jay Sockness (right) demonstrating an agricultural soil runoff test with Ellen Badger Hanson (center), Agriculture Outreach Specialist for the Lower St. Croix Watershed Partnership.

Technical Advisory Committee

The Technical Advisory Committee (TAC) serves to provide technical expertise and feedback on specific

SWWD planning and project development efforts to ensure that District operations are consistent with other local and state efforts. A key role of the TAC is to provide input on updates and amendments to SWWD's Watershed Management Plan. The TAC composition may vary by purpose, but typically consists of county, city, and state agency staff. The membership of SWWD's TAC is managed through invitation by SWWD staff. The TAC meets when necessary for the completion of any intended purpose; however, SWWD will strive to assemble its TAC at least annually to review recent and upcoming District planning, program, and project efforts.

Goal 3.10.3.b. Maintain an active and engaged Technical Advisory Committee that meets or otherwise provides input on District policies and programs at least annually.

3.10.4 | Reporting and Progress Evaluation

The District's administrative workload includes recurring annual activities designed to satisfy Minnesota Rule 8410 and other statutory regulations pertaining to the organization, administration, and coordination of SWWD programs, services, and facilities.

These duties include supporting the District's Board of Managers, preparing for Board workshops and meetings, developing the annual budget and levy, the annual audit, and preparation of an annual report of the previous year's activities and accomplishments. As part of its annual reporting, the District routinely evaluates progress toward goals as established in Part II of this plan. Progress toward achieving goals is reported in the annual report. Should lack of progress or changing conditions require it, a plan amendment will be initiated upon consultation with the District's advisory committees.

Goal 3.10.4.a. Complete annual report and audit as required.

Goal 3.10.4.b. Complete a progress evaluation and capital improvement program review at least every two years.

Goal 3.10.4.c. Complete BWSR Performance Review and Assistance Program (PRAP) review once per planning cycle as required.

Goal 3.10.4.d. Initiate Plan amendments as necessary to advance management of identified issues; at a minimum, complete one mid-point evaluation after 4-6 years of plan implementation.

3.10.5 | District Boundary

The current legal boundary of the SWWD is shown on Figure 1 and is available on the SWWD web viewer at http://swwdmn.gov. Legal descriptions of watershed boundaries are cumbersome to develop and adjust. Instead, the SWWD uses geospatial data established with Geographic Information System (GIS) to convey the legal boundary. Washington County upholds this established process for adjusting watershed legal boundaries. The SWWD annually reviews parcel data to verify existing properties and incorporate any new properties affecting the watershed, thus updating the legal boundary.

At times, proposed projects or issues occur within the legal boundary of the SWWD but outside of the hydrologic drainage area. These projects are approached on a case-by-case basis. Typically, the SWWD will assume the lead role on projects or issues which are within the legal boundary. Conversely, projects may be proposed that address issues manifesting outside of SWWD's legal boundary, but that affects resources within its hydrologic boundary. Similarly, the District will approach these situations on a case-by-case basis and may provide funding for such projects if they are otherwise consistent with the goals and objectives of this Plan. Generally, SWWD will coordinate with the appropriate adjacent watershed entity to ensure effective administration and project oversight.

Goal 3.10.5.a. Once this planning cycle, work with neighboring watershed districts, municipalities, and Washington County to maintain the District's legal boundary to reflect hydrologic boundaries as closely as possible.

3.10.6 | Ad Valorem Levy & Stormwater Utility Fees

SWWD works to distribute funds for programs and improvements equitably while minimizing administrative costs. To maintain that balance, SWWD uses a mix of the various funding mechanisms available to the organization under Minnesota State Statutes 103B and 103D, and 444.

SWWD funds its general operations and administration through funds authorized under Minnesota State Statutes 103B.241 and 103D.905. These funds can also be used for small projects and provide contingency funding. SWWD funds its District-wide programs through an ad valorem levy or stormwater utility authorized under Minnesota State Statutes 103B.241, 103D.729, and 444. Likewise, District projects are funded by a mix of ad valorem levy or stormwater utility fees. SWWD's budget process begins annually in June, and a public hearing is held in August to present the proposed ad valorem levy and stormwater utility expenditures, and stormwater utility fee rates. Stormwater utility fees are certified to Washington County by October 15th, and the final levy is certified in December. Assessed levies and fees appear on annual property tax statements.

SWWD collects utility fees within three separate management units, generally reflecting the three major subwatershed units across the District (Figure 19). Funds collected within each management unit are used to fund projects only within those management units and are not used for projects in other areas of the District.

The South Washington Management Unit, established in 2002, is the original jurisdictional area of SWWD and drains the central portion of the District, discharging to the Mississippi River in Cottage Grove. The East Mississippi Management Unit is the former East Mississippi Watershed Management Organization. The Management Unit was established during consolidation in 2003. It drains through several smaller piped and overland networks, discharging to the Mississippi River along the District's western boundary. The Lower St. Croix Management Unit is the former Lower St. Croix Watershed Management Organization and was established during consolidation in 2010. It drains through several smaller overland stream networks, discharging to the St. Croix River along the District's eastern boundary.

Fees are calculated to reflect the assumed runoff of a property from a 5-year precipitation event. All single-family residential, agricultural, and vacant properties are assumed to generate an equivalent amount of runoff and are charged a single Residential Equivalency Unit (REU). Condominium and townhome properties are charged 0.85 REU per individual unit. REUs for commercial, industrial, institutional, and multifamily properties are calculated based on parcel size and impervious surface coverage to reflect the greater amount of runoff generated. Government-owned properties are not charged. Property REU values are then converted to a total fee based on $/REU rates established by the District during its annual budgeting process as necessary to fund planned projects. Fees more closely reflect a property's impact on downstream resources than levy funds, however, they require more administrative effort to assess and track.

3.10.7 | Capital Improvement, Program, and Project Financing

SWWD balances equity and administrative efficiency by using a mix of its various funding authorities for District work, generally as follows:

- General District operations and administration are funded through ad valorem levy
- District-wide programs and non-capital projects are funded through ad valorem levy
- Small capital projects are funded by either ad valorem levy or stormwater utility fees
- Large capital projects are funded by stormwater utility fees
- Operation and Maintenance is funded by the same funding source as the initial project

District-wide programs include, but are not limited to, planning, monitoring, education and outreach, and various incentive programs. Non-capital District projects include but are not limited to studies, evaluations, natural resources management and property or easement acquisition. Small District capital projects are improvements to real property or equipment purchases costing less than $250,000. Generally, small capital projects requiring routine, ongoing operation and maintenance will be funded through stormwater utility fees, while those not

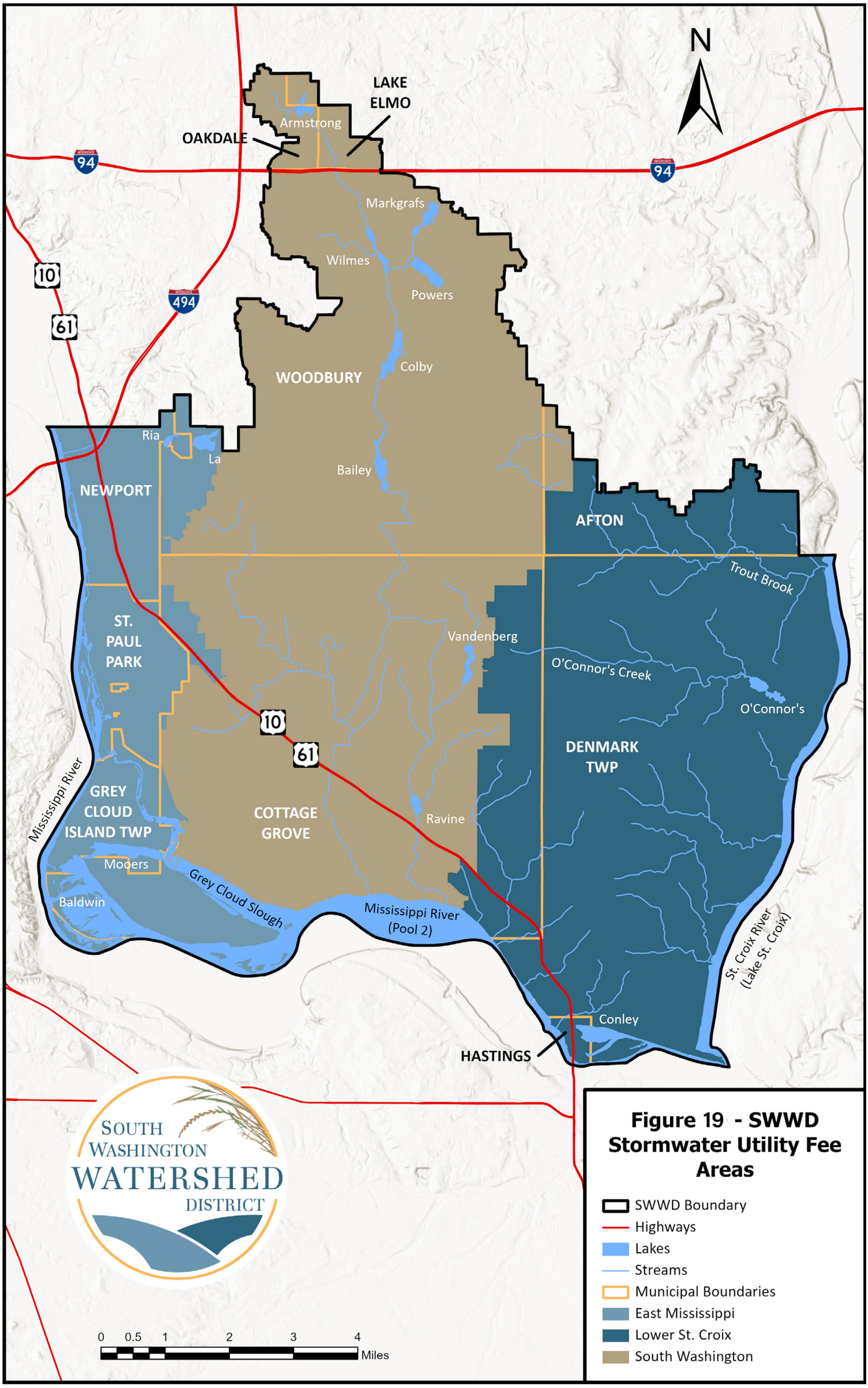


Figure 19: SWWD Stormwater Utility Fee Areas. The SWWD consists of three utility fee areas that directly support each area.

requiring routine, ongoing operation and maintenance will be funded through an ad valorem levy. Large District capital improvement projects are improvements to real property or equipment purchases costing more than $250,000. Projects funded through stormwater utility fees are financed by the management unit. That is, they are funded through fees collected only within the management unit where the project is occurring. Implementation programs that include anticipated capital improvement projects are identified in the District's Long-Range Work Plan in Section 3.10.8.

SWWD may deviate from the guidelines established above as needed to effectively and efficiently manage the watershed and its budget. Those deviations will be discussed and approved by its Board of Managers during the District's annual budgeting process.

When planned capital projects require funding beyond the capacity of annual District revenues, the District may issue bonds to fund the project in order to maintain consistent stormwater utility fee rates for its residents. Alternatively, the District prefers to accumulate funds in lieu of bonding as authorized under Minnesota State Statutes 103B.241 when possible.

The District works to maintain at least 12 months of reserve funding to efficiently and effectively manage its budget while avoiding large annual variations in assessed levies and fees. The District works to limit annual budget increases to maintain a low annual tax impact, or the overall real tax increase for an individual landowner.

3.10.8 | 2027-2036 Long-Range Workplan

Anticipated funding needs through the life of this plan are identified in SWWD's Long-Range Workplan. Annual budgeting and corresponding levy and utility fees are established through a budget process beginning in June of each preceding year. The budgeting process occurs during regular public meetings of the District's Board of Managers.

3.10.9 | Implementation Goals and Priority Issues Reference Table

Table 7 is intended as a quick reference guide to show connections between SWWD's implementation goals and the priority issues they are intended to address.

Program	Sub Program Area	Grants or External Funding Required	Capital Improvement?	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	10 Year Total
				$6,475,000	$10,464,200	$7,445,463	$7,353,870	$5,669,505	$6,652,456	$6,552,813	$6,950,671	$6,496,129	$6,394,289	$70,454,396
3.1 Planning	3.1.1 Resource Management Planning	N								$75,000	$75,000			$150,000
	3.1.2 TMDLs and Regional Plans	N												$-
	3.1.3 Project Prioritization & Targeting	N			$75,000		$75,000		$75,000		$75,000		$75,000	$375,000
	3.1.4 Flood Risk Reduction & Mitigation	Y		$150,000	$150,000	$75,000			$50,000			$50,000		$475,000
	3.1.5 Climate Adaptation	N												$-
	3.1.6 Adaptive Management	N												$-
3.2 Monitoring & Modeling	3.2.1 Monitoring	N		$280,000	$284,200	$288,463	$292,790	$297,182	$301,640	$306,164	$310,757	$315,418	$320,149	$2,996,762
	3.2.2 Watershed & Resource Modeling	N		$75,000			$50,000			$50,000	$50,000			$225,000
	3.2.3 Groundwater Modeling	Y						$75,000	$75,000					$150,000
3.3 Regional Planning	3.3.1 1W1P	N												$-
	3.3.2 Municipal Local Water Planning	N												$-
	3.3.3 Washington County GW Plan	N												$-
3.4 Regulatory	3.4.1 SWWD Permit Program	N		$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$250,000
	3.4.2 WCA	N		$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$50,000
	3.4.3 GW Appropriations	N												$-
3.5 Water Resources Protection & Management	3.5.1 Targeted Watershed Implementation													
	District-Wide Implementation	N												$-
	Armstrong Lake	N												$-
	Markgrafs Lake	Y	Y		$300,000		$500,000							$800,000
	Powers Lake	N	Y										$250,000	$250,000
	Wilmes Lake	N	Y	$350,000										$350,000
	Colby Lake	Y	Y			$150,000					$1,000,000	$850,000	$250,000	$2,250,000
	Bailey Lake	N												$-
	Vandenberg Lake	N		$600,000										$600,000
	Ravine Lake	N												$-
	La & Ria Lakes	N	Y			$50,000								$50,000
	East Mississippi Direct Drainage	Y	Y	$400,000	$300,000		$300,000		$300,000		$300,000		$300,000	$1,900,000
	Grey Cloud Slough & Miss. R. Pool 2	Y	Y		$4,000,000	$150,000	$250,000							$4,400,000
	Trout Brook	N				$150,000								$150,000
	O'Connor's Creek & Lake	N						$150,000						$150,000
	Lower St. Croix Direct Drainage	Y								$150,000				$150,000
	3.5.2 In-Lake Restoration	Y		$100,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$1,450,000
	3.5.3 Flooding	Y	Y			$1,000,000	$1,000,000		$1,000,000	$1,000,000				$4,000,000
	3.5.4 SW & GW Interactions	Y						$150,000			$150,000	$150,000		$450,000
3.6 Watershed Resiliency	3.6.1 Priority Lands Protection & Restoration	Y		$300,000	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000	$3,000,000
	3.6.2 Bluffs & Ravines	Y				$50,000	$50,000		$50,000	$50,000		$50,000	$50,000	$300,000
	3.6.3 Riverine Riparian Zones	Y		$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$250,000
	3.6.4 Landscape Connectivity	Y		$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$250,000
	3.6.5 Partner Capacity	N		$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$500,000
	3.6.6 Long-term Management	N												$-
3.7 Incentive Programs	3.7.1 Stewardship Grants	N		$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$1,500,000
	3.7.2 Agricultural Incentives	N		$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$2,000,000
	3.7.3 RR&R Program	N		$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$10,000,000
	3.7.4 Flood Risk Reduction & Mitigation	N		$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$250,000
	3.7.5 GW Conservation & Protection	N		$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$1,000,000
3.8 Stormwater Operation & Maintenance	3.8.1 Storm Sewer Failure Risk	N												$-
	3.8.2 SWWD CIP O&M	N		$260,000	$240,000	$265,000	$265,000	$290,000	$310,000	$320,000	$320,000	$345,000	$345,000	$2,960,000
	3.8.3 Enhanced Street Sweeping	N		$500,000	$500,000	$600,000	$600,000	$700,000	$700,000	$750,000	$750,000	$750,000	$750,000	$6,600,000
	3.8.4 Winter Maintenance	N		$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$250,000
3.9 Education & Outreach	3.9.1 Audience Engagement	N		$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$30,000	$300,000
	3.9.2 Experiential Ed & Campus Greening	N		$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$500,000
	3.9.3 Online Community Engagement	N		$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$250,000
	3.9.4 AiR	N		$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$150,000
	3.9.5 Incentives Program Engagement	N												$-
	3.9.6 Partnerships	N		$35,000	$40,000	$40,000	$40,000	$45,000	$45,000	$45,000	$50,000	$50,000	$50,000	$440,000
	3.9.7 Glacial Valley Park Interpretive Center	Y		$100,000	$750,000	$750,000								$1,600,000
	3.9.8 Research & Innovation	N		$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$250,000
3.10 Admin & District Operations	Admin & Operations	N		$1,250,000	$1,300,000	$1,352,000	$1,406,080	$1,462,323	$1,520,816	$1,581,649	$1,644,915	$1,710,711	$1,779,140	$15,007,634
	Debt Service	N		$300,000	$300,000	$300,000	$300,000	$275,000						$1,475,000

Table 6: Long Range Work Plan

Goal #	Description	Metric	Priority	Applicable Issues
3.1.1.a.	Update SWWD's Lake Management Plan near the end of this planning cycle in preparation for development of the 2036 SWWD Watershed Management Plan.	Yes / No	High	2.6.1
3.1.2.a.	Participate in all future TMDL planning efforts affecting waters within or adjacent to SWWD's jurisdiction.	% (100%)	Low	2.6.1
3.1.3.a.	Complete five new or updated subwatershed assessments or regional feasibility studies.	Count (5)	Medium	2.6.1
3.1.4.a.	Complete flood risk reduction and mitigation study of the La and Ria Lakes drainage system from Woodbury through Newport.	Yes / No	High	2.3.2 2.3.3
3.1.4.b.	Analyze outlet control infrastructure design, including automated level control systems throughout SWWD's Northern Watershed, to optimize in-lake and downstream flood elevations and flow rates surrounding large precipitation events.	Yes / No	High	2.3.1 2.3.2 2.3.3
3.1.4.c.	Undertake flood risk reduction and mitigation studies for other watersheds as needed due to changing conditions and new information. SWWD involvement will be prioritized for locations where intercommunity flows exacerbate flood conditions and in historically underserved communities.	Count	Low	2.3.1 2.3.2 2.3.3
3.1.5.a.	Participate in all partner planning efforts involving climate adaptation.	% (100%)	Low	2.2 2.4
3.1.5.b.	Ensure climate change and adaptation opportunities are carefully considered as part of all District planning and project development efforts.	% (100%)	Medium	2.2
3.2.1.a.	Adopt and annually implement a monitoring plan sufficient to track resource water quality, evaluate effectiveness of ongoing management, and inform future District implementation efforts.	Yes / No	High	2.2 2.6.1
3.2.1.b.	Annually report monitoring data and trend results to inform SWWD's community and partners on its water resources.	Yes / No	High	2.7
3.2.1.c.	Incorporate all new capital water quality treatment projects into SWWD's monitoring program to track BMP performance.	% (100%)	High	2.6.1
3.2.2.a.	Update and maintain H&H and water quality models to support District planning and management efforts as frequently as needed by major changes to the watershed.	Count	Low	2.3 2.6
3.2.2.b.	Make District models available to, and promote use by, external partners.	Yes / No	Low	2.3
3.2.3.a.	Develop and maintain a groundwater model based off Metropolitan Council's metro groundwater model sufficient to understand local surface water-groundwater interactions and pollutant movements through the watershed.	Yes / No	Medium	2.6.3 2.6.4
3.3.1.a.	Maintain SWWD's role as an active partner in the Lower St. Croix Watershed Partnership.	Yes / No	High	2.1.1 2.1.2 2.5.1 2.5.3
3.3.1.b.	Biennially facilitate and administer BWSR's South Washington Watershed WBIF convene committee and implementation efforts consistent with priorities established in this Plan, and/or other partners' eligible management plans.	Count (5)	High	2.1.3 2.5.3 2.6.1
3.3.2.a.	All ten Municipal Local Water Plans are locally adopted on a timeline consistent with Minnesota Rule 8410.	Count (10)	High	2.8
3.3.2.b.	Provide comment or otherwise participate in the review of all Wellhead Protection Plans submitted to the District.	% (100%)	Low	2.6.4
3.3.3.a.	Participate in the Washington County Groundwater Plan Technical Advisory Committee.	Yes / No	Low	2.6.3 2.6.4
3.4.1.a.	Operate a permit program only in municipalities that have not adopted updated local controls as stringent as SWWD's Rules.	Yes / No	Low	2.1.3
3.4.1.b.	Maintain updated rules, design standards, and guidance documents necessary to support municipal regulatory efforts that are reflective of ongoing climate concerns and changing precipitation patterns.	Yes / No	High	2.1.3 2.2
3.4.1.c.	Engage SWWD's Technical Advisory Committee at least once every two years to identify necessary Rule modifications, additional guidance needs, and to ensure consistency of regulations across watershed jurisdictions where possible.	Count (5)	Medium	2.7 2.8
3.4.1.d.	Complete at least four annual random inspections of active development sites for SWWD Rule compliance, and report findings to the responsible municipality.	Count (40)	Low	2.5.4
3.4.1.e.	Operate all SWWD construction project sites as though an NPDES Construction Permit is required, whether a permit is required.	% (100%)	Medium	2.5.4
3.4.2.a.	Administer the Minnesota Wetland Conservation Act within SWWD.	Yes / No	Medium	2.1.1 2.1.3
3.4.2.b.	Maintain staff or partner capacity necessary to locally administer the Minnesota Wetland Conservation Act.	Yes / No	Medium	2.1.1 2.1.3
3.4.2.c.	Maintain a publicly available inventory of known and suspected wetlands within SWWD's jurisdiction.	Yes / No	Low	2.1.1
3.4.3.a.	Review and submit comments to DNR on all groundwater appropriation permit applications shared with the District.	% (100%)	Low	2.6.3
3.5.1.a.	Complete rapid shoreline condition assessments for the Woodbury chain of lakes within the first three years of the planning cycle.	Count (5)	High	2.5.2
3.5.1.b.	Improve riparian habitat and buffers and stabilize eroding shorelines on city-owned property surrounding the Woodbury chain of lakes.	Score (Increase)	Medium	2.5.2
3.5.1.c.	Complete streambank erosion inventories for accessible public lands throughout the District, and on private lands with permission, within the first three years of the planning cycle.	Count (3)	High	2.5.2
3.5.1.d.	Increase the percentage of publicly owned or managed shoreline through fee title or easement acquisition, prioritizing groundwater-dependent resources.	% (Increase)	Medium	2.5.2
3.5.1.e.	Establish where missing, or maintain where existing, a 50-foot natural buffer around all public waters within the SWWD.	% (100%)	Low	2.5.2
3.5.1.f.	Decrease the number of Section 303(d) impaired waters within the SWWD and make progress toward meeting State water quality standards for all remaining impaired waters.	Count (Decrease)	High	2.6.1
3.5.1.g.	Identify vulnerable riverfront and bluff land properties along the Mississippi and St. Croix Rivers and work with municipalities and other landowners to improve and protect these important greenway corridors.	Yes / No	Medium	2.5.1 2.5.3
3.5.1.h.	Implement stormwater treatment projects to reduce pollutant loading identified in the Armstrong Lake Subwatershed Retrofit Analysis and other BMP feasibility studies.	Count	Low	2.6.1
3.5.1.i.	Continue research and data collection on the potential for phosphorus and chloride removal from cattail harvesting in the wetland west of Armstrong Lake.	Yes / No	High	2.6.1
3.5.1.j.	Implement stormwater treatment projects to reduce pollutant loading, building off the Markgrafs Lake Phosphorus Removal Feasibility Study.	Count	High	2.6.1
3.5.1.k.	Complete a detailed study of surface water-groundwater dynamics in Markgrafs Lake to understand suspected high groundwater inputs and how that affects nutrient and chloride cycling in the lake.	Yes / No	Medium	2.6.1 2.6.4
3.5.1.l.	Implement stormwater treatment projects to reduce pollutant loading, building off the Powers Lake Stormwater Retrofit Assessment and other BMP feasibility studies.	Count	Low	2.6.1
3.5.1.m.	Continue to operate and maintain the Hasenbank Stormwater Park in partnership with the City of Woodbury.	Yes / No	High	2.4 2.6.1
3.5.1.n.	Continue to operate and maintain the Wilmes Lake Alum Treatment Facility and the Seasons Park CC17 Filter in partnership with the City of Woodbury.	Yes / No	High	2.4 2.6.1
3.5.1.o.	Complete construction of a redesigned CC17 filtration BMP on Schooner Way to replace the Wilmes Lake Iron-Enhanced Sand Filter.	Yes / No	High	2.4 2.6.1
3.5.1.p.	Complete a stream stability and restoration assessment for the open channel and surrounding corridor between Armstrong and Wilmes Lakes.	Yes / No	Low	2.5.2
3.5.1.q.	Implement stormwater treatment projects to reduce pollutant loading, building off the Colby Lake Phosphorus Removal Feasibility Study.	Count	High	2.6.1
3.5.1.r.	Explore and implement land management improvement opportunities focused on runoff control and water quality improvements at Eagle Valley Golf Course.	Count	Low	2.1.1 2.1.4 2.6.1
3.5.1.s.	Inspect the Colby Lake Raingardens every two years in partnership with the City of Woodbury and WCD, while encouraging annual resident maintenance.	Count (5)	Low	2.4 2.6.1
3.5.1.t.	Continue gathering information about Bailey Lake to guide future actions through ongoing water quality and aquatic vegetation monitoring.	Yes / No	Medium	2.3.2 2.6.1 2.6.2
3.5.1.u.	Develop a stormwater retrofit assessment or other BMP feasibility study for Bailey Lake.	Yes / No	Medium	2.6.1
3.5.1.v.	Work with the Minnesota Land Trust, Washington County, and City of Cottage Grove to protect and restore riparian properties surrounding Vandenberg Lake through fee title or easement acquisition and landowner education.	% Protected	High	2.1.3 2.1.4 2.5.2 2.6.1
3.5.1.w.	Continue gathering information about Vandenberg Lake to guide future actions through ongoing water quality and aquatic vegetation monitoring.	Yes / No	Medium	2.3.2 2.6.1 2.6.2
3.5.1.x.	Continue gathering information about Ravine Lake to guide future actions through ongoing water quality and aquatic vegetation monitoring.	Yes / No	Medium	2.6.1 2.6.2
3.5.1.y.	Complete inspections of the Central Draw Overflow system's open channel through Cottage Grove Ravine Regional Park north of Ravine Lake every three years.	Count (3)	High	2.3.3 2.4
3.5.1.z.	Work with the City of Woodbury to opportunistically acquire and protect riparian properties within the La Lake subwatershed.	% Protected	High	2.1.3 2.1.4 2.5.2 2.6.1
3.5.1.aa.	Implement stormwater treatment projects to reduce pollutant loading, building off of the Newport and St. Paul Park Subwatershed Retrofit Analyses.	Count	High	2.5.3 2.6.1
3.5.1.bb.	Reengage property owners and begin implementation of the Lower Mississippi Ravines Stormwater Retrofit Analysis.	Count	Medium	2.1.2 2.5.1 2.6.1
3.5.1.cc.	Continue water quality and bathymetric monitoring of Grey Cloud Channel and Grey Cloud Slough every three years.	Count (3)	High	2.5.3 2.6.1
3.5.1.dd.	Implement first phase of the Grey Cloud Slough Habitat Restoration Project in partnership with the US Army Corps of Engineers, MN Department of Natural Resources, and others.	Yes / No	High	2.1.1 2.2 2.5.3 2.6.1 2.6.2
3.5.1.ee.	Implement ravine stabilization, runoff retention, and agricultural conservation projects in the Trout Brook watershed, building off the Trout Brook Ravines Stormwater Retrofit Analysis, Top50P! Rural Subwatershed Analysis, and other studies.	Count	Medium	2.1.2 2.5.1 2.5.2 2.6.1
3.5.1.ff.	Conduct routine inspections of previous Trout Brook restoration work and complete maintenance as warranted.	Count (10)	High	2.1.1 2.1.4 2.4 2.5.2
3.5.1.gg.	Implement chloride reduction strategies at Afton State Park and Afton Alps Resort to protect Trout Brook and its aquatic inhabitants.	Yes / No	Medium	2.6.1 2.6.4
3.5.1.hh.	Continue gathering information about O'Connor's Creek and Lake to guide future actions through ongoing water quality monitoring and watershed investigation.	Yes / No	Medium	2.1.2 2.3.2 2.6.1 2.6.2 2.6.3 2.6.4
3.5.1.ii.	Implement ravine stabilization, runoff retention, and agricultural conservation projects in Lower St. Croix Direct Drainage watersheds, building off the Top50P! Rural Subwatershed Analysis, and other studies.	Count	Medium	2.1.2 2.5.1 2.5.2 2.5.3 2.6.1
3.5.2.a.	Complete internal nutrient loading feasibility studies for priority lakes as identified in the 2025 Lake Management Plan (Markgrafs, Powers, Wilmes, Colby, La, and Ravine Lakes).	Count (6)	High	2.6.1 2.6.2
3.5.2.b.	Implement internal phosphorus control projects and achieve designed internal load reductions at Markgrafs, Powers, Wilmes, Colby, La, and Ravine Lakes if recommended by completed feasibility studies.	Count	High	2.6.1 2.6.2
3.5.2.c.	Continue annual aquatic invasive species monitoring at all lakes managed for AIS within the District.	% (100%)	High	2.1.1 2.2 2.6.2
3.5.2.d.	Develop aquatic vegetation management plans for Armstrong and Powers Lakes to limit the spread of AIS and promote native plant reestablishment.	Yes / No	Medium	2.1.1 2.2 2.6.2
3.5.2.e.	Reduce the presence of nuisance AIS in District lakes.	Score (Decrease)	Medium	2.1.1 2.2 2.6.2
3.5.2.f.	Achieve net gains in aquatic ecological health represented by native plant re-establishment at all lakes managed for AIS within the District.	Score (Increase)	Medium	2.1.1 2.2 2.6.2
3.5.2.g.	Develop information and share updated metrics regarding AIS and ecological health in District lakes every three years.	Yes / No	Medium	2.7
3.5.3.a.	Maintain a fully operational Central Draw Storage Facility (Glacial Valley Park) and Central Draw Overflow indefinitely.	Yes / No	High	2.3.2 2.4
3.5.3.b.	Implement at least one feasible capital project identified in each completed flood risk reduction and/or active level control study.	Count	High	2.3.1 2.3.2 2.3.3
3.5.4.a.	Identify, prioritize and pursue land protection efforts with partners aimed at locations with strong surface water-groundwater interactions.	Count	High	2.1.1 2.1.4 2.6.1 2.6.3 2.6.4
3.6.1.a.	Complete an Ecosystem Services Protection Assessment to identify methodologies and criteria to prioritize landscape protection.	Yes / No	High	2.1.1 2.1.3 2.1.4 2.2 2.6.2 2.6.3 2.6.4
3.6.1.b.	Protect identified remnant natural lands through fee title or easement acquisition, either directly by the SWWD, with partners, or through other arrangements with private landowners.	Count	Medium	2.1.1 2.1.3 2.1.4 2.2 2.6.2
3.6.1.c.	Increase the number of acres of natural lands with actively implemented resource management plans.	Count (Increase)	Medium	2.1.4 2.2 2.6.2
3.6.2.a.	Develop a comprehensive inventory and condition assessment of vulnerable bluff and ravine sites along the Mississippi and St. Croix Rivers.	Yes / No	Medium	2.5.1
3.6.2.b.	Complete projects to stabilize identified actively eroding ravines contributing to downstream resource degradation.	Count	Medium	2.5.1 2.6.1
3.6.3.a.	Protect and enhance existing natural floodplain ecosystems within major river corridors through stabilization and restoration projects and/or riparian land acquisition via fee title or easement.	Count	Medium	2.5.3
3.6.4.a.	Reestablish and protect greenway corridor connections between priority natural lands as opportunities become available.	Count	Low	2.1.4 2.2
3.6.5.a.	Provide incentives to partners in the form of planning funds, staff expertise and availability, and/or equipment to improve their capacity to apply scientifically sound BMPs on restored and natural landscapes.	Count	Medium	2.1.4 2.2
3.6.6.a.	Establish long-term maintenance programs and guidance for partners in all District projects.	Yes / No	Low	2.2 2.4
3.6.6.b.	All long-term management plans will incorporate keystone processes and adaptive management principles.	% (100%)	Medium	2.1.4 2.2 2.4 2.6.2
3.7.1.a.	Work with WCD, EMWREP, and other partners to operate the Stewardship Grant program annually to engage and educate District residents.	Yes / No	Medium	2.6.1 2.7
3.7.1.b.	Increase community participation in the Stewardship Grant program year-over-year in terms of the number of applications submitted, projects completed, and program budget utilized.	Count (Increase)	Medium	2.6.1 2.7
3.7.2.a.	Increase average annual number of SWWD agricultural landowners engaged through partnerships with WCD, EMWREP, LSCWP, and other partners over the course of this planning cycle.	Count (Increase)	Medium	2.1.2
3.7.2.b.	Increase the number of operators and total acreage implementing non-structural agricultural and/or soil health practices over the course of this planning cycle.	Count (Increase)	Medium	2.1.2
3.7.2.c.	Implement at least three designed structural agricultural practices over the course of this planning cycle.	Count (3)	High	2.1.2
3.7.3.a.	Solicit RR&R applications through a Request for Proposals process annually.	Count (10)	High	2.2 2.3.1 2.4 2.6.1
3.7.3.b.	Maintain or increase the number of quality applications submitted to the RR&R program by providing proactive outreach and guidance to potential applicants.	Count (Increase)	Medium	2.2 2.3.1 2.4 2.6.1
3.7.3.c.	Utilize the RR&R program to increase access to and use District capital funds for projects in historically underserved communities.	Count	Medium	2.2 2.3.1 2.4 2.6.1
3.7.4.a.	At least twice within this planning cycle, solicit interest in the Flood Risk Reduction and Mitigation Program and provide funding as necessary to municipalities to support local flood risk reduction and mitigation incentive programs.	Count (2)	Low	2.3.1 2.3.2 2.3.3
3.7.5.a.	Provide funding to municipalities in support of local groundwater conservation and protection incentive programs.	Count	Medium	2.2 2.6.3 2.6.4
3.8.1.a.	Regularly promote SWWD's Storm Sewer Failure Risk Assessment to increase the number of stormwater system operators incorporating the report into routine inspection and maintenance planning.	Count (10)	High	2.1.3 2.2 2.4
3.8.1.b.	Assist partners with implementation of at least one project annually through the RR&R program that addresses a critical stormwater infrastructure site at risk of failure.	Count (10)	High	2.1.3 2.2 2.4
3.8.2.a.	Establish adequately funded municipal operation and maintenance agreements on all SWWD capital projects.	% (100%)	Medium	2.4
3.8.3.a.	Partner with all SWWD's MS4 municipalities to develop and implement enhanced street sweeping programs.	Count (8)	High	2.4 2.6.1
3.8.4.a.	Assist MPCA's statewide efforts by subsidizing, hosting, and promoting at least one Smart Salting training within its jurisdiction annually.	Count (10)	Medium	2.6.1 2.6.4
3.8.4.b.	Utilize the Statewide Chloride Management Plan and "Low Salt, No Salt Minnesota" resources in development of a SWWD chloride management plan and other winter maintenance outreach campaigns.	Yes / No	Medium	2.6.1 2.6.4
3.8.4.c.	Provide grant funding through the Resource Restoration & Resiliency program for road authorities and municipal, institutional, and commercial property owners and managers for low salt equipment upgrades resulting in direct reductions in chloride application.	Yes / No	Medium	2.6.1 2.6.4
3.8.4.d.	Ensure chloride reduction principles are carefully considered in all project designs developed or funded by SWWD.	% (100%)	High	2.6.1 2.6.4
3.8.4.e.	Encourage land use authorities within SWWD to incorporate chloride reduction design guidance into local ordinances and plan review procedures and/or assess the feasibility of incorporating chloride reduction guidance into SWWD's Rules.	Yes / No	Low	2.6.1 2.6.4
3.8.4.f.	Fund the distribution of traction grit to residents and businesses across the watershed as a sustainable chloride alternative and see increased distribution rates year-over-year.	Count (Increase)	Medium	2.6.1 2.6.4
3.8.4.g.	Support statewide policy and legislative changes to require MPCA or similar smart salt certification for salt applicators, provide liability relief for MPCA or similar smart salt certified salt applicators, and other similar initiatives.	Yes / No	Medium	2.6.1 2.6.4
3.9.1.a.	Annually increase engagement with target and historically unengaged audiences through partnerships with WCD, EMWREP, municipalities, and others.	Count (Increase)	Medium	2.7
3.9.1.b.	Host at least six workshops, seminars or similar events annually to engage with priority audiences within the District.	Count (60)	Medium	2.7
3.9.1.c.	Develop and biennially execute a routine survey effort to gauge resident perception of resource quality and understanding of issues.	Count (5)	Medium	2.7
3.9.1.d.	Complete an annual survey of municipal public works supervisors to assess stormwater operation and maintenance gaps, needs, and barriers.	Count (10)	Medium	2.4
3.9.1.e.	Annually promote NPDES and SWPPP training programs and opportunities to area contractors to improve onsite erosion and sediment control compliance.	Count (10)	Low	2.5.4
3.9.2.a.	Provide experiential environmental education opportunities to South Washington County Schools students annually, so that all students are reached at least once during their K-12 career, through partnerships with WCD, EMWREP, and nature centers.	Yes / No	High	2.7
3.9.2.b.	Begin partnerships with other schools within SWWD to provide experiential environmental education opportunities annually, through partnerships with WCD, EMWREP, and nature centers.	Count	Medium	2.7
3.9.2.c.	Engage South Washington County Schools to maintain existing, and pursue new, native landscape restoration projects on all school campuses within the watershed.	% (100%)	Medium	2.1.1 2.1.4 2.2
3.9.3.a.	Increase resident engagement through web platforms year-over-year.	Count (Increase)	Medium	2.7
3.9.3.b.	Distribute a quarterly email newsletter.	Count (40)	Medium	2.7
3.9.3.c.	Maintain an updated and accessible District website and applications necessary to support District programs and disseminate information to the community.	Yes / No	High	2.7 2.8
3.9.4.a.	Offer a biennial Artist-in-Residence program to support partner and resident engagement, and fill identified Education & Outreach program needs.	Count (5)	Low	2.7
3.9.5.a.	Annually review and modify, if needed, SWWD incentive programs to effectively engage target community members.	Yes / No	Low	2.7
3.9.6.a.	Actively support, participate in, and adequately fund EMWREP.	Count (10)	High	2.7
3.9.7.a.	Complete construction and establishment of the Glacial Valley Park Interpretive Center once external funding resources are secured.	Yes / No	High	2.1.4 2.2 2.6.2 2.7
3.9.8.a.	Pursue collaborative research opportunities addressing SWWD issues, strategies and goals through annual involvement and/or investment in research partnerships.	Count (10)	Medium	2.2 2.4
3.10.3.a.	Maintain an active and engaged Community Advisory Committee that meets and provides input to the District at least quarterly.	Count (40)	High	2.7 2.8
3.10.3.b.	Maintain an active and engaged Technical Advisory Committee that meets or otherwise provides input on District policies and programs at least annually.	Count (10)	High	2.7 2.8
3.10.4.a.	Complete annual report and audit as required.	Count (10)	High	2.8
3.10.4.b.	Complete a progress evaluation and capital improvement program review at least every two years.	Count (5)	Medium	2.8
3.10.4.c.	Complete BWSR Performance Review and Assistance Program (PRAP) review once per planning cycle as required.	Yes / No	Low	2.8
3.10.4.d.	Initiate Plan amendments as necessary to advance management of identified issues; at a minimum, complete one mid-point evaluation after 4-6 years of plan implementation.	Yes / No	Low	2.8
3.10.5.a.	Once this planning cycle, work with neighboring watershed districts, municipalities, and Washington County to maintain the District's legal boundary to reflect hydrologic boundaries as closely as possible.	Yes / No	Low	2.8

Table 7: Watershed Management Plan Goals

APPENDIX A

SWWD Lake Management Plan

Colby Lake, Woodbury

Photo by Sarah Lilja, SWWD Artist-in-Residence 2024

South Washington Watershed District Lake Management Plan

Modeling and Assessment

Prepared for
South Washington Watershed District

Prepared by
Barr Engineering Co.

December 2025

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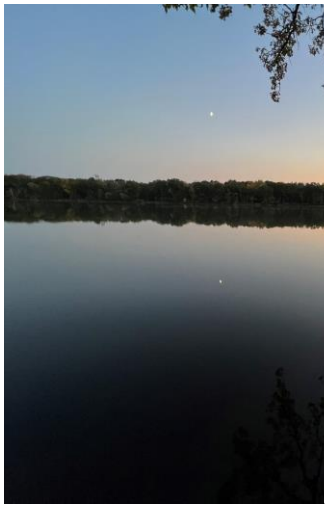

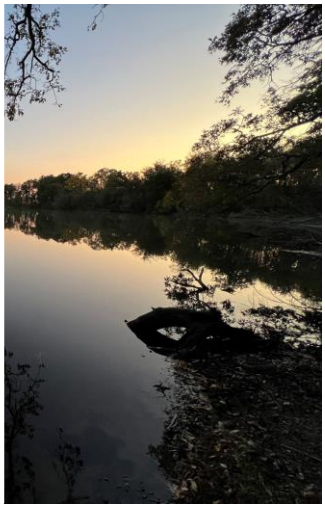

South Washington Watershed District Lake Management Plan

December 2025

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Appendices

Appendix A Sediment Coring Locations
Appendix B In-lake Model Calibration Plots
Appendix C Trout Brook and O'Conners Creek WQ Plots

Abbreviations

CAMP	Community Aided Lake Monitoring Program
cfs	cubic feet per second
CPUE	Catch per Unit Effort
EPA	Environmental Protection Agency
FiN	Fishing in the Neighborhood
FOO	Frequency of Occurrence
FQI	Floristic Quality Index
IBI	Index of Biological Integrity
lbs	pounds
MNDNR	Minnesota Department of Natural Resources
Mobile-P	Mobile Phosphorus Fraction (Sediment)
mg/L	milligrams per liter
MPCA	Minnesota Pollution Control Agency
NCHF	North Central Hardwood Forest
NLCD	National Land Cover Database
Organic-P	Organically-bound Phosphorus Fraction (Sediment)
P8	Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds
SWWD	South Washington Watershed District
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USGS	United States Geological Survey
µg/L	micrograms per liter
WCBP	Western Corn Belt Plains

1 Introduction

The South Washington Watershed District (SWWD) is located in the eastern metropolitan area of the Twin Cities and covers two major drainage areas. Water in the western and central portions of the SWWD (or District) flows south and west, ultimately discharging to the Mississippi River; while waters in the eastern portion flow east and south and are part of the Lower Saint Croix River Watershed. Central and western portions of the District are drained via storm sewer and dotted with often interconnected lakes and wetlands. The eastern portion of the District is more rural in nature, and waters flow toward the St. Croix River via creeks, streams, and groundwater.

The SWWD actively monitors and has developed lake management plans for several waterbodies within the District. As part of their on-going efforts to continually improve understanding of water quality conditions and to help inform future management strategies to improve and protect water quality within the District's waters, the SWWD performed a study to evaluate existing conditions in ten lakes and 2 creeks within the watershed. This study involved developing updates to existing watershed and lake water quality models, plus the creation of new models for areas previously unstudied, for nine suburban lakes within the Cities of Oakdale, Woodbury, Cottage Grove, and Newport – Armstrong Lake, Markgrafs Lake, Wilmes Lake (North and South), Colby Lake, Powers Lake, La Lake, Ravine Lake, and Bailey Lake. Five of the waterbodies are currently listed as impaired for excess nutrients by the MN Pollution Control Agency (MPCA). Monitoring data for three of the other waterbodies shows nutrient concentrations that exceed state standards. The MPCA has also recently listed the stream that outlets from Ravine Lake as impaired for ammonia.

The study also involved the analysis of available water quality and flow data for two creeks and one lake in the eastern portion of the watershed within the City of Afton and Denmark Township – Trout Brook, O'Conners Creek, and O'Conners Lake. These waterbodies are located within the Lower Saint Croix River Watershed. The O'Conners subwatershed is considered a landlocked system. Trout Brook discharges into Lake Saint Croix, which is listed as impaired for excess nutrients.

2 SWWD Goals for Lake Management

2.1 Minnesota State Standards and Thresholds

As part of their water resource management programs, the SWWD recognizes and implements strategies to pursue the attainment of state standards for water quality and ecological conditions within the waterbodies that it manages. Table 2-1 summarizes the lake water quality standards and ecological thresholds used by the State of Minnesota to assess lake health. These standards and thresholds are referenced throughout the report and shown on summary plots and figures.

- **Minnesota Lake Eutrophication Standards** -- The MPCA has developed deep and shallow lake eutrophication standards for waterbodies within the state, based on ecoregion. The SWWD is located within the North Central Hardwood Forest (NCHF) and Western Corn Belt Plains (WCBP) ecoregions. However, the MPCA has decided that the NCHF water quality standards will apply to lakes within the WCBP ecoregion, given the proximity to the NCHF ecoregion and the primary characteristics of the watershed (e.g., Ravine Lake). As such, the SWWD has adopted the relevant lake eutrophication standards (phosphorus, chlorophyll-*a*, Secchi disk transparency) for the NCHF ecoregion for all lakes that are managed by the district.

- **Minnesota Chloride Standards** -- Because high concentrations of chloride can harm fish and plant life, the MPCA has established acute and chronic exposure chloride standards. A lake is considered impaired if two or more exceedances of chronic criterion (230 mg/L or less) occur within a three-year period or one exceedance of acute criterion (860 mg/L) is measured.

- **Minnesota Aquatic Plant Thresholds** – The Minnesota Department of Natural Resources (MNDNR) has developed Lake Plant Eutrophication Index of Biological Integrity (IBI) thresholds for assessing the health of aquatic plant communities. The Lake Plant Eutrophication IBI includes two metrics to measure the response of a lake plant community to eutrophication. The first metric is species richness—the estimated number of species in a lake. The second metric is floristic quality index (FQI), which distinguishes the quality of the plant community and can be a reflection of the quantity of nutrients in the lake. Lakes that score below the thresholds contain degraded plant communities and are likely stressed from cultural eutrophication. The IBI thresholds are designated by ecoregion. Ravine Lake is the only lake in this study that falls under the WCBP ecoregion thresholds. All other lakes fall under the NCHF ecoregion thresholds.

Table 2-1 State of Minnesota water quality standards and aquatic plant thresholds used to assess lake health

Type	Parameter	North Central Hardwood Forest Ecoregion[1]		Western Corn Belt Plains Ecoregion[2]
		Shallow Lakes[3]	Deep Lakes	Shallow Lakes
Water Quality[4]	Total Phosphorus (summer average, µg/L)	≤ 60	≤ 40	N/A
	Chlorophyll-*a* (summer average, µg/L)	≤ 20	≤ 14	N/A
	Secchi Disk Transparency (summer average, µg/L)	≥ 1.0	≥ 1.4	N/A
	Chloride (mg/L)	≤ 230 (chronic) ≤ 860 (acute)		
Aquatic Plants (macrophytes)	Species richness (number of species)	≥ 11	≥ 12	≥ 4
	Floristic Quality Index (FQI)	≥ 17.8	≥ 18.6	≥ 7.7

[1] All lakes in the District are compared to the NCHF ecoregion standards regardless of location.
[2] Ravine Lake is the only lake in the District that falls in the Western Corn Belt Plains ecoregion for MNDNR Plant Eutrophication Index of Biological Integrity (IBI) thresholds.
[3] Shallow lakes have a maximum depth less than 15 feet or littoral area greater than 80% of the total lake surface area.
[4] The summer average is the mean of the concentrations observed between June 1 – September 30.

3 Lake and Watershed Characteristics

Ten lakes – Armstrong, Markgrafs, Powers, Wilmes (North and South), Colby, Bailey, Ravine, La, and O'Conners Lakes – were included in this study. Armstrong Lake is located within the Cities of Lake Elmo and Oakdale. O'Conners Lake is located within Denmark Township, and Ravine Lake is located in Cottage Grove. The other six lakes are located within the City of Woodbury.

3.1 Lakes Summary

Table 3-1 summarizes the lake classification, total watershed area, lake surface area, watershed:surface area ratio, impairment status, and downstream waterbody for each of the lakes included within the study. Five of the lakes are on the Minnesota 303(d) list of impaired waters for excess nutrients.

Most of the lakes included in this study are classified as shallow lakes. The State of Minnesota defines a shallow lake as any lake having a maximum depth less than 15 feet or a littoral area greater than 80% of the total lake surface area. The littoral area of a waterbody is the zone where sunlight can penetrate to the bottom of the lake, allowing aquatic plants to grow. Powers Lake is the only lake that doesn't fit this definition and, as such, is classified as a deep lake.

Healthy shallow lakes are expected to support abundant submerged and floating plant communities throughout most of the lake area. Aquatic plants provide habitat for aquatic insects, zooplankton, fish, waterfowl, and other wildlife. Aquatic plants also compete for nutrients and can shade portions of the waterbody reducing habitable environments for algae.

Table 3-1 Lake characteristics summary for lakes included in study

Lake	Shallow/ Deep	Total Watershed Area (acres)	Lake Surface Area (acres)	Watershed: Surface Area Ratio	Impairment Status	Downstream Waterbody
Armstrong	Shallow	572	10	57:1	Not listed on impaired waters list	North Wilmes
Markgrafs	Shallow	425	44	10:1	Impaired for nutrients since 2006	South Wilmes
Powers	Deep	1,263	61	21:1	Not listed on impaired waters list	South Wilmes
Wilmes Lake (North)	Shallow	2,985	19	157:1	Impaired for nutrients since 2006	South Wilmes
Wilmes Lake (South)	Shallow	5,288	20	264:1		Colby
Colby	Shallow	8,212	73	112:1	Impaired for nutrients since 2006	Bailey
Bailey	Shallow	14,243	62	230:1	Impaired for nutrients since 2024	Central Draw Storage Facility
Ravine	Shallow	1,698	25	68:1	Impaired for nutrients since 2006	Mississippi River
La	Shallow	133	50	3:1	Delisted for nutrients in 2024	Landlocked under typical hydrologic conditions
O'Conners	Shallow	6,305	59	107:1	Not listed on impaired waters list	Landlocked

3.2 Watershed Summary

Table 3-2 summarizes the total watershed area, direct watershed area, and primary land use(s) for each of the waterbodies. The predominant land uses for many of the lakes in this study are residential (single-family and multi-family), agricultural, undeveloped, and open space (e.g., park, recreational, or preserve).

Figure 3-1 and Figure 3-2 show the various land use classifications within the major watersheds of the District, summarized into major categories of developed, park, recreational, or preserve, agricultural, undeveloped, and water.

Table 3-2 Watershed summary for lakes included in study

Lake	Total Watershed Area (acres)	Direct Watershed Area (acres)	Primary Land Uses
Armstrong	572	572	Undeveloped, Single Family Residential, Parks
Markgrafs	425	425	Retail/Commercial, Single Family Residential, Parks
Powers	1,263	1,263	Single Family Residential, Parks
Wilmes Lake (North)	2,985	2,413	Single Family Residential, Retail/Commercial, Parks
Wilmes Lake (South)	5,288	615	Single Family Residential, Parks
Colby	8,212	2,924	Single Family Residential, Parks, Golf Course
Bailey	14,243	6,031	Agricultural, Single Family Residential, Parks
Ravine	1,698	1,698	Agricultural, Undeveloped, Parks
La	133	133	Open Water, Undeveloped, Parks
O'Conners	6,305	6,305	Agricultural, Undeveloped, Single Family Residential

Armstrong Lake
Armstrong
MS-1
94
Markgrafs
Markgrafs Lake
Wilmes
Wilmes Lake
Powers
Powers Lake
16
Colby Lake
Colby
19
18
La Lake
Bailey Lake
Bailey
13
20
494
Mississippi River
Pool 2
38
61
22
39
95
Trout Brook
21
O'Connors Creek at 38th St

Watersheds
SWWD Monitoring Sites
SWWD Legal Boundary
Impaired Lakes
Public Waters Watercourse
Public Waters Basin

Met Council Land Use (2020)
Developed
Park, Recreational, or Preserve
Agricultural
Undeveloped
Water

N

0 1 2
Miles

Land Use
Metropolitan Council (2020)
Lake Management Plan
South Washington Watershed District

FIGURE 3-1

BARR

Barr Footer: ArcGISPro, 8/7/2025 4:48 PM File: I:\Client\South_Washington_WD\Work_Orders\Lakes_and_Creek_Mgmt_Plan_Update_23821336\Users\TAO2\SWWD_Lakes_Report_Figures.aprx Layout: Fig3-1_Upper Lakes Land Use User: TAO2

Bailey
Trout Brook
O'Connors Creek at 30th St
Ravine
Mississippi River
St. Croix River
13
20
22
19
95
21
28
61

Watersheds
SWWD Monitoring Sites
SWWD Legal Boundary
Impaired Lakes
Public Waters Watercourse
Public Waters Basin

Met Council Land Use (2020)
Developed
Park, Recreational, or Preserve
Agricultural
Undeveloped
Water

N

0 0.5 1
Miles

Land Use
Metropolitan Council (2020)
Lake Management Plan
South Washington Watershed District

FIGURE 3-2

BARR

Barr Footer: ArcGISPro, 8/7/2025 4:47 PM File: I:\Client\South_Washington_WD\Work_Orders\Lakes_and_Creek_Mgmt_Plan_Update_23821336\Users\TAO2\SWWD_Lakes_Report_Figures.aprx Layout: Fig3-2_Lower Lakes Land Use User: TAO2

4 Lake Monitoring Data Background

The physical (water quantity, sediment), chemical (water quality, sediment), and biological (plants, fish, algae, zooplankton) processes within a lake are all linked. Having an understanding of each of these components can give a holistic overview of lake health. The subsections below summarize the monitoring data that was available for use within this study, and the sources for the various datasets.

4.1 Water Quality

Water quality monitoring data was provided for this study by the SWWD. The SWWD collects water quality data for lakes within the District through (1) partnership with the Washington Conservation District, and (2) the Metropolitan Council's Community Aided Lake Monitoring Program (CAMP). CAMP uses volunteers to collect surface water quality data. The data collected through the CAMP program includes total Kjeldahl nitrogen, total phosphorus, chlorophyll-*a*, Secchi transparency depth, and temperature. Qualitative perceptions of a lake's physical and recreational condition at the time of sampling are also noted. Monitoring performed by the Washington Conservation District includes all the parameters monitored through CAMP as well as the collection of chloride concentrations and profile monitoring data (e.g., dissolved oxygen, temperature, and pH at various depths throughout the lake water column).

4.2 Water Quantity

Lake water surface elevations are also monitored by the Washington Conservation District, typically on a bi-weekly to monthly basis between ice-off and late October.

4.3 Aquatic Plants

In 2021 and 2024, the SWWD subcontracted with Stantec to perform aquatic plant community assessments of eight lakes in the district (Stantec, 2021, 2025). To assess the presence, abundance, and health of each lake's aquatic vegetation, Stantec performed point-intercept surveys in June and August of each year, where all submerged, floating leaf, and emergent species were identified at each survey point. The point-intercept survey data were used to calculate various metrics and indices to assess the health of the plant communities. A selection of these plant metrics is summarized in each lake section. Other plant health metrics can be referenced in the 2021 and 2024 Aquatic Vegetation Survey Results reports (Stantec, 2021, 2025).

4.4 Fisheries

Powers, Ravine, and Colby Lakes are included in the Fishing in the Neighborhood (FiN) program run by the MNDNR, which is aimed at increasing angling opportunities, public awareness, and environmental stewardship within the seven-county Twin Cities metro area. The MNDNR FiN program is actively involved in managing the sport and recreational fish populations of these three lakes and, as such, the fish communities are surveyed at a regular frequency, and fishing stocking reports are available. A summary of the most recent fish surveys in each lake, as well as available stocking reports within the last decade, is provided in each lake section.

Markgrafs and La Lakes have historically been used as walleye rearing waterbodies; however, recent fish surveys are unavailable to assess current population abundance.

4.5 Phytoplankton

Phytoplankton (algae) data has not been historically collected on SWWD lakes. Phytoplankton can be single cell, filamentous, or community-based organisms. Understanding the type and abundance of phytoplankton present in a lake can be important for understanding ecological health. An inadequate phytoplankton population can limit a lake's zooplankton population and indirectly limit fish production. However, excess phytoplankton from a high amount of nutrients can reduce water clarity, impact aquatic plant growth, and possibly cause human health concerns. Cyanobacteria, also known as blue-green algae, often outcompete other phytoplankton groups due to ecological advantages. Identifying the specific species present can improve estimates of the potential benefits or limitations of management efforts, support informed decision-making, and help set realistic expectations.

4.6 Zooplankton

Zooplankton data has also not been historically collected on SWWD lakes. Understanding the type and abundance of zooplankton present in a lake can be important for understanding ecological health. Zooplankton are microscopic aquatic animals that drift and move throughout the lake water column. They play major roles in the aquatic food web by consuming algae and are primary food sources for larger organisms such as fish.

4.7 Groundwater

Several of the lakes within the SWWD are known to receive groundwater inflow or lose water into the surrounding groundwater system. Understanding the potential for groundwater interactions and the water quality of shallow groundwater within the vicinity of these lakes is necessary to predict potential in-lake water quality impacts. Unfortunately, available data on groundwater elevations and water quality within the SWWD is limited. This study used publicly available data from the National Water Quality Monitoring Council's Water Quality Portal (National Water Quality Monitoring Council, 2025) to assess groundwater quality. This portal summarizes available data from the United States Geological Survey (USGS), the Environmental Protection Agency (EPA), and over 400 state, federal, tribal, and local agencies. Shallow groundwater wells included within this database, and located within the SWWD, were typically monitored annually. The groundwater total phosphorus concentrations used in the applicable in-lake models were derived from this data. The calculated groundwater concentration for each applicable lake is detailed in its respective section.

4.8 Sediment

Phosphorus release from lake bottom sediments can be a significant contributor to excess nutrient concentrations in lakes. Phosphorus in lake bottom sediment is often bound to a range of different elements such as iron and manganese (often referred to as mobile phosphorus (mobile-P)), aluminum, or calcium. The mobile-P fraction can be released from sediment during low oxygen conditions caused by microbial activity. Phosphorus can also be found incorporated into organic matter in the sediment (organically bound phosphorus (organic-P)). A portion of the organic-P is released into the water column from lake sediments through mineralization by microbes, but typically at a slower rate than mobile-P. The mineralization release rate is controlled by lake water temperature and can occur under aerobic or anaerobic conditions. Phosphorus release from sediment is typically termed as "internal phosphorus loading" or "internal loading".

Sediment cores were collected from eight of the SWWD lakes in October 2024 and used to evaluate the internal phosphorus loading potential of the mobile-P and organic-P fractions. The sediment coring locations are shown on maps in Appendix A. In the top 6 cm of each core, 2 cm slices were cut to analyze the variation in sediment parameters. Table 4-1 summarizes the average concentration and ranges of concentrations of mobile-P and organic-P in the top 6 centimeters of the sediment cores. Table 4-1 also summarizes the average concentration and range of concentrations of extractable iron in the top 6 centimeters of the cores. A higher concentration of extractable iron indicates more iron is available to bind phosphorus in the sediment under aerobic conditions. Table 4-2 provides the calculated average maximum potential mobile-P internal loading rates for the sediment cores collected in 2024 and compares the values with other lakes in the metro area. The calculated average maximum potential mobile-P internal loading rates use a methodology described in Pilgrim et. al. (Pilgrim, Huser, & Brezonik, 2007).

Similar to the observations from lake sediment studies completed in District lakes in 2016 and 2017 (WENCK, 2018), the 2024 sediment coring data indicates that the SWWD lakes with high potential mobile-P loading rates include North and South Wilmes, Ravine, Powers, Colby, and Bailey. The SWWD lakes with moderate mobile-P loading signatures include Armstrong and Markgrafs. All of the SWWD lakes sampled in 2024 had moderate organic phosphorus fractions in their sediment cores, except Ravine (Table 4-1). The sediment core data collected from Ravine Lake indicates that internal phosphorus loading from organic-P could be a considerable source of phosphorus. Previously, research has focused heavily on mobile-P acting as the main mechanism of internal phosphorus loading. However, recent research and monitoring data indicate that organic-P, especially organic-P fractions that are susceptible to biological or chemical decomposition (e.g, phosphate esters, phospholipids), can be a significant source of phosphorus and can maintain high productivity in lakes (Wei, et al., 2022).

Sediment cores were not collected from La or O'Conners Lakes in October 2024. Sediment cores were previously collected in La Lake in 2017. Laboratory release rate experiments conducted on the La Lake sediment cores indicated relatively low anaerobic phosphorus release rates with an average of approximately 1.7 mg/m^2/day (WENCK, 2018). However, even a low internal phosphorus loading rate can notably increase phosphorus concentrations in the lake water column, especially in shallow lakes with small water volumes per surface area of lake bottom.

Table 4-1 Average, Maximum, and Minimum mobile-P, organic-P, and extractable iron concentrations in the top 6 cm of sediment cores collected in 2024

Lake	Number of Sediment Cores	Mobile Phosphorus Concentrations per Volume (µg P/cm^3) Average (Range)	Organic Phosphorus Concentrations per Volume (µg P/cm^3) Average (Range)	Extractable Iron (µg Fe/ cm^3) Average (Range)
Armstrong	1	35 (14 – 65)	25 (19 – 32)	482 (295 – 761)
Markgrafs	2	25 (16 – 34)	68 (59 – 76)	513 (360 - 653)
Powers	1	73 (20 – 120)	42 (36 – 51)	515 (253 - 645)
North Wilmes	1	229 (173 – 260)	61 (30 – 112)	1,754 (1,080 – 2,141)
South Wilmes	1	117 (95 – 160)	56 (46 – 62)	936 (601 – 1,244)
Colby	3	41 (12 – 94)	47 (31 – 66)	853 (417 – 1,346)
Bailey	2	139 (39 – 268)	65 (42 – 93)	824 (445 – 1,348)
Ravine	1	149 (95 – 203)	328 (209 – 498)	1,165 (709 – 1,792)

Table 4-2 Maximum potential mobile-p internal loading rates compared to other Twin Cities Metro Area lakes

Lake	Maximum Potential Internal Phosphorus Load from Mobile-P ($mg/m^2/d$)[8]
North Wilmes	**>12.0**
Ravine	**>12.0**
Bailey	**>12.0**
Kohlman[1]	>12.0
South Wilmes	**>12.0**
Isles (pre-alum, deep hole)[2]	>12.0
Harriett (pre-alum, deep hole)[2]	11.1
Calhoun/Bde Maka Ska (pre-alum, deep)[2]	10.8
Fish E[3]	10.5
Powers	**10.3**
Cedar (pre-alum)[2]	9.3
Fish W[3]	8.1
Como[3]	7.6
North Cornelia (pre-alum)[4]	7.6
Calhoun/Bde Maka Ska (pre-alum, shallow)[3]	5.6
Colby	**5.5 (1.6 – 9.2)**
Armstrong	**4.5**
Keller[1]	3.5
Parkers[3]	3.5
Markgrafs	**3.1 (2.2 – 4.0)**
Phalen[3]	2.3
McCarrons[3]	2.0
La Lake[7]	**1.7**
Bryant[3]	1.5
South Cornelia (pre-alum)[4]	1.3
Mirror Lake[6]	1.0
Smetana[5]	0.7
Minnewashta[3]	0.2

Sources:
[1] (Barr Engineering Co., 2007)
[2] (Huser & Pilgrim, 2014)
[3] (Pilgrim, Huser, & Brezonik, 2007)
[4] (Barr Engineering Co., 2018)
[5] (Barr Engineering Co., 2020)
[6] (Barr Engineering Co., 2023)
[7] Average measured anaerobic release rate (WENCK, 2018)
[8] (Pilgrim, Huser, & Brezonik, 2007)

5 P8 Watershed Modeling Methodology – Suburban Lakes

5.1 P8 Model Runoff and Phosphorus Loading Background

Central to a lake water quality analysis is the use of a water quality model that has the capacity to predict the amount of water and pollutants that reach a lake via stormwater runoff (i.e., watershed or external loading). The P8 (Program for Predicting Polluting Particle Passage through Pits, Puddles, and Ponds) modeling software was used to estimate watershed loads to nine of the lakes within this study (I.E.P, Inc., 1990). P8 incorporates hourly precipitation and daily temperature data. Barr utilized P8 to calculate the daily water volume and nutrient loads introduced from each tributary subwatershed in each of the suburban lakes modeled.

The following subsections describe the methodology Barr utilized for the P8 models.

5.2 Previous Watershed P8 Modeling Efforts

Watershed water quality models were previously developed for the following lakes within the SWWD (WENCK, 2018):

- Armstrong
- North Wilmes
- South Wilmes
- Markgrafs
- Powers
- Colby
- La
- Ravine

Barr reviewed each of these models to understand how they compare to current conditions in the watershed and identify any updates necessary to accurately represent loading to each lake. The updates made to these existing models are described in Section 5.3.

5.3 P8 Model Updates

5.3.1 Data Collection

At the initiation of the study, Barr requested data from the SWWD and its member cities within the study area to assist in updating the P8 models with information on new developments since 2016, when the existing P8 models were developed. This information request included:

- Storm sewer GIS data within areas draining to the modeled lakes, including dimension information (e.g., structure inverts, pipe diameters, upstream/downstream inverts, etc.)

- Supplementary record drawings detailing complex features (e.g., lake/pond outlet structures, pump and lift station information)
- BMP inventory information:
    - Spatial data indicating where BMPs exist within the study area
    - BMP design information, such as what was submitted for permit applications, including drainage area, routing, inlets/outlets, storage volumes, infiltration/filtration rates, etc.
    - Estimated BMP pollutant reduction benefits
    - Record drawings of BMPs
    - Operations and maintenance information for actively managed BMPs
- Bathymetric data for lakes, stormwater ponds, and wetlands
- Hydrologic and climatic monitoring data (e.g., precipitation gauge data)
- Development data:
    - Spatial data showing site stormwater permit locations from 2016-2024
    - Site plans within the study area for new developments since 2016 showing proposed watershed divides, storm sewer, and proposed BMPs
    - Development models (e.g., HydroCAD, XPSWMM, P8) if available for new developments since 2016
    - Recent land use/land cover data

A variety of data was received and reviewed by Barr to help inform the necessary P8 model updates. Those updates are described further in Section 5.3.2.

5.3.2 Model Updates

Generally, the P8 modeling updates made by Barr fall within the following categories:

- Climate data
- Watershed hydrology
- Conveyance/routing
- Best management practices

Table 5-1 summarizes specific model updates that were made to each of the study area lakes' contributing P8 model(s), as well as the data sources or assumptions for each of the model updates. Additionally, Figure 5-1 shows the developments throughout the watershed district that were reviewed for updating the previously developed P8 models.

Table 5-1 Water balance outlet rating curve and groundwater flow assumptions

Lake	P8 Model Updates	Data Source / Assumption
Armstrong	Added additional ponds	Oakdale HydroCAD model, GIS storm sewer, LiDAR, assumed depths (if unavailable)
	Updated precipitation files	Oakdale CoCoRaHS Station (2019) and Woodbury M Health Sports Center Gauge (2012-2018, 2020-2022)
	Updated TP and TSS scaling factors	Calibration (see Section 5.3.3)
Markgrafs	Added additional ponds around shoreline of Markgrafs Lake	Woodbury pond inventory, LiDAR, assumed depths (if unavailable), GIS storm sewer
	Updated imperviousness assumptions	Metropolitan Council 2020 Generalized Land Use
	Updated precipitation files	Woodbury M Health Sports Center Gauge
Powers	Added new development information	Woodbury development plans, GIS storm sewer, LiDAR
	Updated precipitation files	Woodbury M Health Sports Center Gauge
North Wilmes	Added new development information	Woodbury development plans, GIS storm sewer, LiDAR
	Updated imperviousness assumptions	Metropolitan Council 2020 Generalized Land Use
	Updated precipitation files	Woodbury M Health Sports Center Gauge
South Wilmes	Added Seasons Park BMP	SWWD Seasons Park final design P8 model
	Updated precipitation files	Woodbury M Health Sports Center Gauge
Colby	Updated imperviousness assumptions	Metropolitan Council 2020 Generalized Land Use
	Added stormwater ponds on west side of Colby Lake	Woodbury pond inventory, LiDAR, assumed depths (if unavailable), GIS storm sewer
	Updated precipitation files	Woodbury M Health Sports Center Gauge
La	Added new development information	Woodbury development plans, GIS storm sewer, LiDAR
	Updated pervious curve number and imperviousness assumptions	Metropolitan Council 2020 Generalized Land Use
	Updated precipitation files	Woodbury M Health Sports Center Gauge
Ravine	Added new development information	Cottage Grove development plans, GIS storm sewer, LiDAR
	Updated precipitation files	Woodbury M Health Sports Center Gauge

In the existing P8 models, Barr did not make updates to the BMPs that were previously modeled, nor were updates made to naming conventions from the source models. It was also noted that the existing P8 models did not remove open water area from subwatershed or impervious areas. Where Barr updated hydrologic inputs to the P8 models, we utilized the same methodology to remain consistent with the previous modeling approach.

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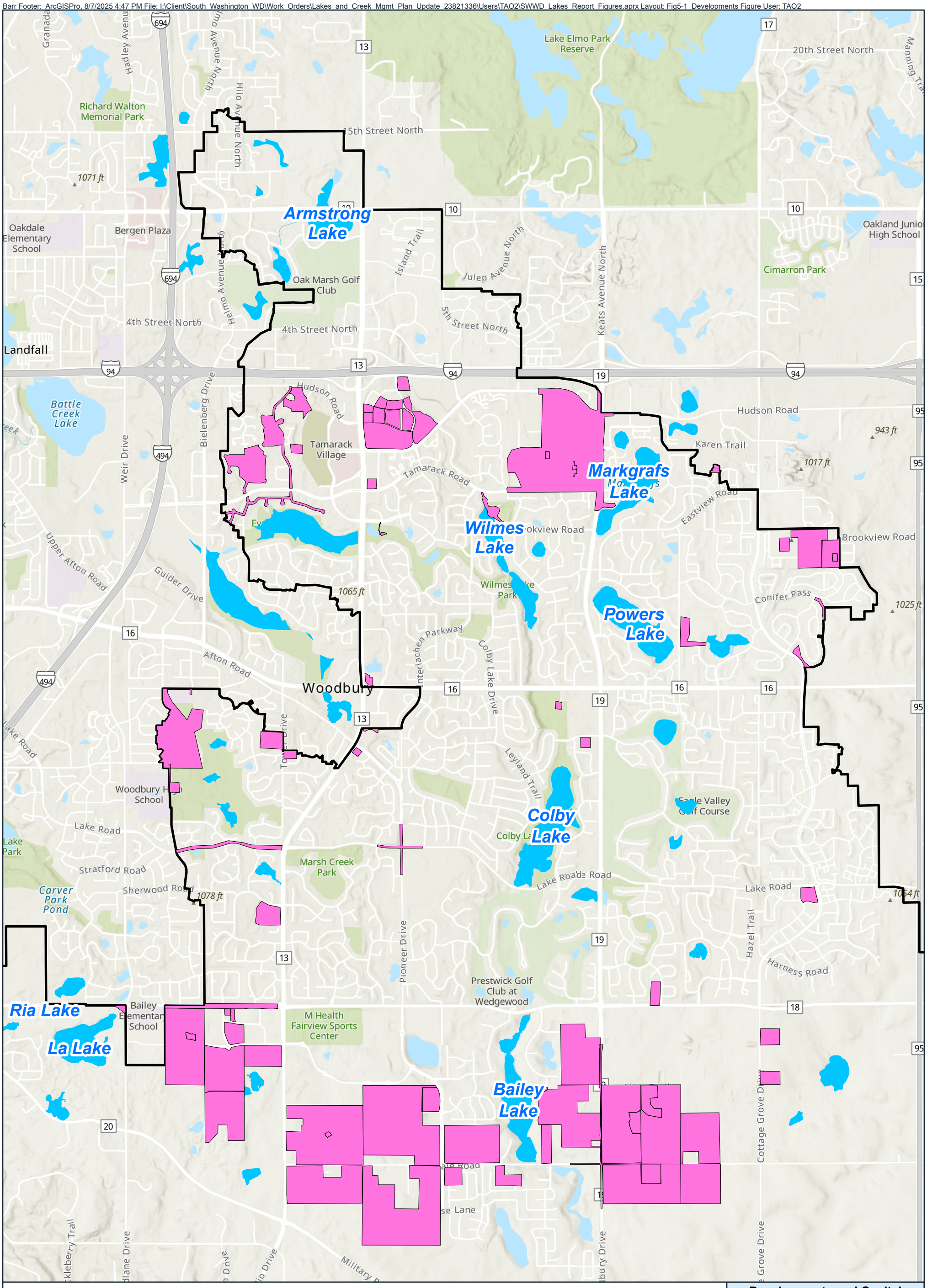


Developments and Capital Projects Reviewed for Model Incorporation*

Lakes and Ponds

SWWD Legal Boundary

*Not shown is Cottage Grove HERO Center, City Hall, and Washington County Service Center in the Ravine Lake Subwatershed

0 2,000 4,000

Feet

Developments and Capital Projects Reviewed for Model Incorporation

Lakes Management Plan

South Washington Watershed District

FIGURE 5-1

BARR

5.3.3 P8 Model Calibration

As part of the previous P8 modeling efforts, four of the P8 models were calibrated to the District's monitoring stations. These models were calibrated to observed annual TP loads and total annual volume at the monitoring stations (Wenck, 2018).

Barr verified the volume calibration using more recently collected monitoring data at MS-1, which is located near the intersection of Interstate 94 and Radio Drive and upstream of North Wilmes. For 2019, the modeled total annual volume at MS-1 was within 8% of the observed volume. For 2022, the modeled total volume was within 11% of the observed volume. Updated monitoring data was not available for the other stations used in the original calibration, so Barr could not confirm whether those calibrations remain valid for recent years.

Barr also calibrated the P8 models during the water balance and water quality calibration of the in-lake models (see Sections 6.2.1 and 6.2.2, respectively). P8 uses scaling factors to adjust the amount of particulate pollutant loading being washed off of a watershed and contributing to runoff loading. Barr updated the TP scaling factor for Armstrong Lake to reduce watershed TP loading to the lake during calibration of the in-lake models (see Section 6.4) and to match the monitored in-lake TP concentrations. P8 calculates runoff and associated pollutant loading from directly and indirectly connected impervious surfaces separately from pervious surfaces. Prior modeling efforts assigned a generalized ratio of indirectly connected impervious area to directly connected impervious area across each of the contributing drainage areas to the lakes. Using the Metropolitan Council's 2020 Generalized Land Use layer to calculate imperviousness, Barr updated this assumption within several of the models by calculating specific indirectly vs. directly connected impervious fractions for each individual catchment within the P8 models.

The existing and updated calibration factors are summarized in Table 5-2 below.

Table 5-2 P8 calibration factors

Lake	Existing TP Scale Factor	Updated TP Scale Factor	Existing Indirectly Connected / Directly Connected Imperviousness Ratio	Updated Indirectly Connected / Directly Connected Imperviousness Ratio
Armstrong	2.25	1	45/55	Land use based by subwatershed
Markgrafs	0.9	0.9	75/25	Land use based by subwatershed
Powers	0.89	0.89	24/76	24/76
North Wilmes	0.9	0.9	75/25	Land use based by subwatershed
South Wilmes	0.9	0.9	75/25	75/25
Colby	1.5	1.5	50/50	Land use based by subwatershed
La	1	1	100/0	Land use based by subwatershed
Ravine	1	1	30/70	30/70

5.4 P8 Model Creation – Bailey Lake

Barr developed the Bailey Lake watershed loading model using P8, version 3.5. Utilizing information from SWWD's XPSWMM model (Houston Engineering Inc., 2017) and development data provided by the City of Woodbury, Barr developed the Bailey Lake P8 model using methodology and assumptions outlined in the following subsections.

5.4.1 Hydrology

P8, unlike XPSWMM, is designed for long-term simulation of watershed runoff and pollutant transport; hydrologic modeling in P8 uses a more simplistic methodology than that used in XPSWMM. Subwatersheds developed for XPSWMM modeling were also used for P8 modeling. For the majority of hydrologic parameters required in P8, XPSWMM modeled hydrologic parameters were used directly to ensure consistency between the two models (e.g., imperviousness). However, P8 utilizes both directly and indirectly connected imperviousness for generating pollutant loading. To estimate the indirectly connected imperviousness, Barr utilized the assumed ratio of directly connected imperviousness to indirectly connected imperviousness shown in Table 5-3, which are based on land use categories from the Metropolitan Council's 2020 Generalized Land Use dataset.

Table 5-3 Directly connected and indirectly connected imperviousness ratio by land use

Land Use	Directly Connected Imperviousness Fraction	Indirectly Connected Imperviousness Fraction
Agricultural	0.01	0.99
Farmstead	0.12	0.88
Golf Course	0.05	0.95
Industrial and Utility	0.72	0.28
Institutional	0.4	0.6
Major Highway	0.5	0.5
Mixed Use Residential	0.37	0.63
Multifamily	0.37	0.63
Office	0.72	0.28
Open Water	1	0
Park, Recreational, or Preserve	0.05	0.95
Retail and Other Commercial	0.85	0.15
Single Family Attached	0.30	0.7
Single Family Detached	0.2	0.8
Undeveloped	0	1

Barr also updated the imperviousness for watersheds where new development has occurred since the creation of the SWWD XPSWMM model. These developments are shown in Figure 5-1. For these developments, Barr utilized the impervious assumptions outlined in the NWS and CDSF modeling report (Houston Engineering Inc., 2017), which are included in Table 5-4 below.

Table 5-4 Development imperviousness assumptions for Bailey Lake P8 model

Land Use	Percent Impervious
Medium Density Residential	50.7%
Low Density Residential	35.6%
Park	8.6%

The only parameter required for P8 modeling not included in the hydrologic parameters generated for the XPSWMM model is the pervious curve number. Barr developed the pervious curve number utilizing a weighted approach for various curve numbers based on the hydrologic soil group for underlying soils within each subwatershed. The assumed curve numbers for each hydrologic soil group are included in Table 5-5.

Table 5-5 Pervious Curve Numbers for hydrologic soil groups

Hydrologic Soil Group	Pervious Curve Number
A	39
B	61
C	74
D	80
A/D	80
B/D	80
C/D	80
<Null>	61

5.4.2 Water Quality Device Hydraulics

In P8, runoff generated from subwatersheds, along with associated sediment and pollutant loads, is routed to “devices” which determine how and where flow is hydraulically routed throughout the model. Pipe devices are used for routing and do not provide any runoff volume reduction or water quality treatment, while devices representing water quality treatment BMPs (e.g., ponds, infiltration basins, etc.) have the potential to remove runoff volume and pollutants via particle settling and filtration.

The inputs for each P8 device in the existing XPSWMM model (e.g., pond, infiltration device, pipe, etc.) were developed using storage and outlet hydraulic information directly from the XPSWMM model, including:

- Device outlet types were assigned from the XPSWMM storm sewer utility network

- Storage volume for all above ground features (including the permanent pool and live storage volume for wet ponds) was calculated from stage-area data from the XPSWMM model
- Infiltration rates for infiltrating BMP devices were assumed based on underlying SSURGO soil data or best available information

Barr also included device hydraulics information provided by the City of Woodbury for developments that were constructed after 2017 when the XPSWMM model was built (see Figure 5-1).

Pipe devices were modeled at key locations throughout the watershed so that pollutant loading results could be summarized at these locations. Bailey Lake was also modeled as a pipe device to summarize the watershed inflows for the in-lake modeling.

5.4.3 Precipitation and Temperature

The P8 model was developed using hourly precipitation and daily average temperature data recorded at the Woodbury MnHealth Sports Center Gauge.

5.4.4 Pollutant Loading

Barr utilized the default NURP50 particle scale file to assign particle characteristics and water quality components assumptions used to define particle loading and associated pollutant loading within the Bailey Lake watershed.

6 In-lake Modeling Methodology – Suburban Lakes

6.1 In-lake Model Background

The purpose of in-lake modeling is to establish a relationship between the amount of nutrients that enter a lake and the concentration of these nutrients within the lake water column. Generally, for freshwater lakes, phosphorus is the main nutrient of concern and is typically the most limiting nutrient for algal growth. As such, phosphorus modeling is discussed in greater detail in this report. However, nitrogen also plays a role in limiting algal growth in lakes and is touched on in individual lake sections as appropriate.

There are several processes that dynamically increase or decrease the concentration of phosphorus in the lake water column, including the following listed below (the "-" or "+" indicates that the mechanism generally either reduces or increases phosphorus). The extent to which each of the processes can be modeled is dependent on which model is being used and the monitoring data available to accurately calibrate the process.

- **Watershed Runoff (+):** Phosphorus enters the lake through natural channels, stormwater runoff from surrounding properties, and discharge from storm sewer pipes following precipitation or snow melt events.
- **Upstream Lakes (+):** Outflow from upstream lakes introduces phosphorus into the downstream lakes.
- **Atmospheric Deposition (+):** Phosphorus deposits into the water body from the atmosphere.
- **Settling (-)**: Phosphorus in phytoplankton and attached to particles settles out of the lake water column to the sediments.
- **Flushing (-)**: Typically represents the phosphorus that is discharged through an outlet structure. For landlocked lakes and/or lakes with a high connection to groundwater, flushing includes phosphorus that is discharged to groundwater.
- **Lake Bottom Sediment Loading (+)**: Mobile phosphorus from lake bottom sediments may release into the water column during low oxygen conditions. Organic phosphorus will release as bacteria breakdown debris in the lake sediment that contains phosphorus (e.g., decaying leaves, plants, and algae). Phosphorus release from lake bottom sediments is also known as internal loading.
- **Benthivorous (bottom-feeding) fish (+):** Although not always modeled as a separate internal load, benthivorous fish are presumed to cause additional internal phosphorus loading during certain periods due to stirring of the bottom sediments. Fish defecation can also create nutrient loads.
- **Phytoplankton and macrophyte growth (-):** Phosphorus will be removed from the water column and the sediment through uptake by phytoplankton and macrophytes during the growth phase.
- **Phytoplankton and macrophyte die-off and decay (+):** Phosphorus in the phytoplankton and plant tissues is released into the water column when the species die and decay.

- **Curly-leaf pondweed die-off and decay (+)**: Phosphorus in the plant tissue is released into the water column when curly-leaf pondweed dies and decays. Curly-leaf pondweed die-off and decay occurs much earlier than other native plant species (typically in late June and July), so this species is typically modeled separately when included in a nutrient mass balance.

Two different in-lake models were used within this study to model a selection of the in-lake processes listed above. Model selection and the selected processes incorporated in the models were generally based on the monitoring data available for calibration as well as the desired level of model detail (e.g., better understanding of algal growth and nitrogen dynamics).

6.1.1 Finite Difference Spreadsheet Model

The finite difference spreadsheet model was used for La, Armstrong, Powers, and Bailey Lakes. This phosphorus mass balance model, which was developed by Barr Engineering Co., is an Excel spreadsheet model that calculates daily phosphorus concentrations in the lake water column based upon phosphorus inputs (internal and watershed loading) and phosphorus losses (settling and outflows). The model operates on a daily time step and assumes that every input to the model is completely mixed both vertically and horizontally in the lake water volume. The spreadsheet inputs for the SWWD lakes simulated with this model included:

- Climatic Inputs
    - Air temperature
    - Wind
    - Humidity
- Water Balance
    - Surface water inflows and outflows
    - Direct precipitation
    - Evaporation (estimated from climatic inputs)
    - Groundwater inflows and outflows
    - Water level and volume
- In-lake Physical Parameters
    - Water temperature
    - Dissolved oxygen concentration
- Nutrient Balance
    - Phosphorus (total phosphorus)
- Lake Bottom Sediment Processes
    - Phosphorus release as a function of dissolved oxygen in the lake water column

6.1.2 Barr Shallow Lake Model

The Barr Shallow Lake Model was used for North Wilmes, South Wilmes, Markgrafs, Colby, and Ravine Lakes. This mass balance and ecological model, which was developed by Barr Engineering Co., is a Python programming language-based model that uses inputs from multiple Excel spreadsheets.

The Barr Shallow Lake Model provides a more accurate representation of lake function as it includes phytoplankton growth, nutrient limitation resulting from nitrogen and phosphorus, transformation and losses of nutrients as a function of phytoplankton growth and die-off, simulation of internal phosphorus loading based upon phosphorus composition and concentration in the lake bottom sediments, and calculation of internal loading based upon dissolved oxygen and temperature conditions that vary hourly in the model. The model incorporates the effects of climate on in-lake nutrients and phytoplankton, and hence, an improved understanding of the effect of climatic variability on the expected range of management outcomes can be estimated. This model is considered to be zero-dimensional, meaning it is assumed that every input to the model is completely mixed both vertically and horizontally in the lake water column. The model inputs for the SWWD lakes simulated with this model included:

- Climatic Inputs
    - Air temperature
    - Wind
    - Sunlight
    - Humidity
- Water Balance
    - Surface water inflows and outflows
    - Direct precipitation
    - Evaporation (estimated from climatic inputs)
    - Groundwater inflows and outflows
    - Water level and volume
- In-lake Physical Parameters
    - Water temperature
    - Dissolved oxygen concentration
- Nutrient Balance
    - Phosphorus (ortho-phosphate, dissolved and particulate organic phosphorus, particulate inorganic phosphorus)
    - Nitrogen (nitrate, nitrite, ammonia, dissolved and particulate organic nitrogen)
- Lake Bottom Sediment Processes

    - Phosphorus release from iron-bound phosphorus as a function of dissolved oxygen in the lake water column
    - Phosphorus release from organically-bound phosphorus as a function of lake water temperature

- Phytoplankton Processes
    - Dissolved phosphorus and nitrogen uptake with growth
    - Phytoplankton settling
    - Particulate phosphorus and nitrogen release with mortality
    - Growth can be phosphorus, nitrogen, temperature, or light limited

Each of the processes listed above occurs at different magnitudes throughout the model duration and hence the processes are quantified (e.g., calibrated) by matching model results with the field-measured parameters. Macrophyte (plant) growth, die-off, and decay processes, as well as rough fish activities, are not simulated in the model.

6.2 In-lake Model Calibration

6.2.1 Water Balance

The first step in model calibration was to simulate the growing season (May 1 – September 30) water balances around each of the lakes. Two years of observed data – one representing a wet year and one representing a dry year – were selected to allow for assessment of in-lake conditions under different climatic conditions. Model year 2019 was selected for modeling a wet year condition, and model year 2022 was selected for modeling a dry year condition. The growing season precipitation totals for model years 2019 and 2022 are summarized in Table 6-1 (sources: Woodbury MnHealth Sports Center Gauge and Oakdale, MN CoCoRaHS Station (Community Collaborative Rain, Hail & Snow Network)). Watershed contributions under existing land use conditions were estimated for model years 2019 and 2022 from P8 modeling as described in Section 5.

Table 6-1 Modeled precipitation amounts for 2019 and 2022 growing seasons

Model Year	Growing Season (May 1 through Sept 30) Precipitation (inches)	
	Armstrong Lake	All other suburban lakes
2019	24.8	24.8
2022	12.3[1]	10.3

[1] Climate data from various precipitation gauges in the SWWD indicated that storm events in May 2022 had notably variable precipitation depths dependent on location in the District. To better match the observed water level conditions on Armstrong Lake during model year 2022, precipitation data from the CoCoRaHS station in Oakdale was used for model calibration.

Water balances were developed for all nine suburban lakes using either the finite difference spreadsheet or Barr Shallow Lake models. The models use estimated daily or bi-hourly watershed runoff inflows (predicted by P8 models), daily precipitation, daily evaporation, estimated groundwater inflow or outflow, outflow rating curves (e.g., pumps, outlet control structure), and observed lake levels to estimate changes in the water level of the lake. Changes in lake water volumes over time were calibrated by matching the modeled lake surface elevations to observed elevations.

Figure 6-1 and Figure 6-2 show example water balance calibrations that were completed for South Wilmes for the 2019 and 2022 growing seasons. The model predicted water levels, shown by the orange line on the plot, were calibrated to match as closely as possible to observed water levels collected bi-weekly from May through September, indicated by the blue circles. Model calibration indicated groundwater outflow in both modeled years for South Wilmes. Figure 6-3 shows the 2019 and 2022 water balance volume comparisons for South Wilmes for all modeled inflows (direct watershed, precipitation, upstream lakes) and outflows (evaporation, discharge through outlet, groundwater discharge), where the total volume is the amount of water that moved through the lake in each year within the May through September time period.

The water balance calibrations and summary pie charts for all nine suburban lakes can be reviewed in Appendix B. Table 6-2 and Table 6-3 provide a summary of the inflow and outflow water balance quantities for each modeled lake for 2019 and 2022, respectively.

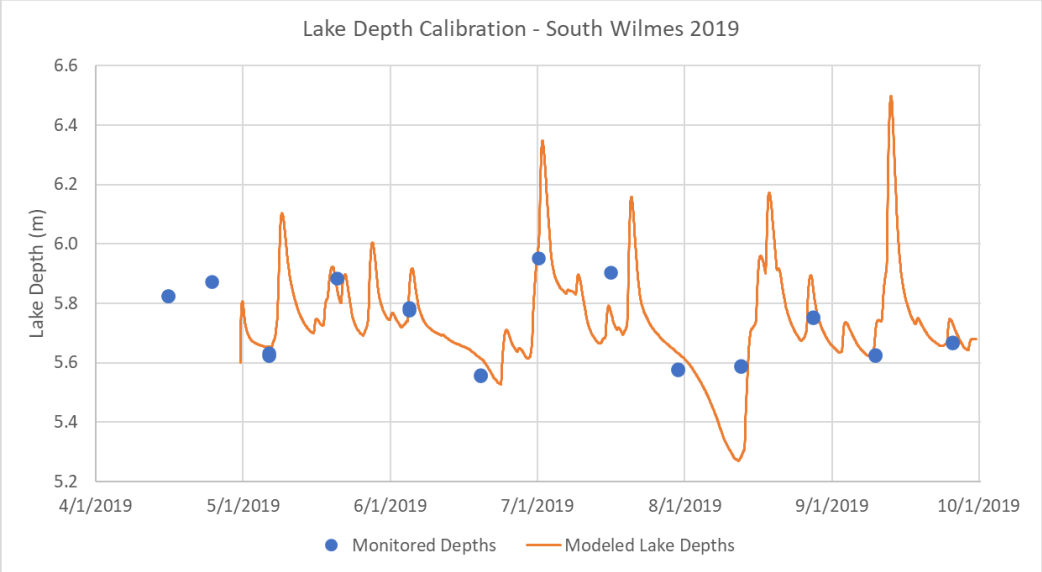


Figure 6-1 South Wilmes Lake 2019 water balance calibration

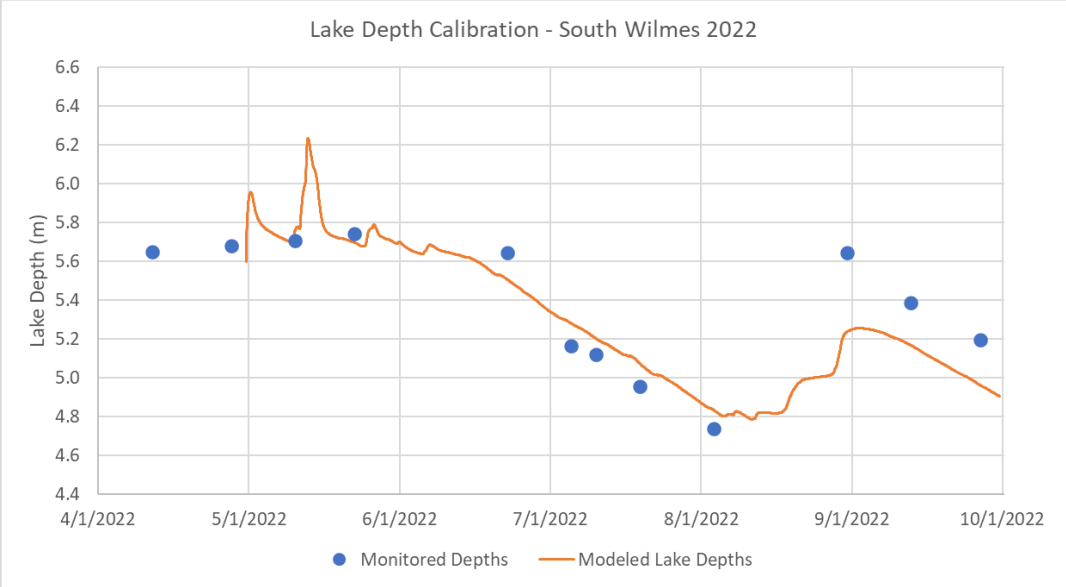


Figure 6-2 South Wilmes Lake 2022 water balance calibration

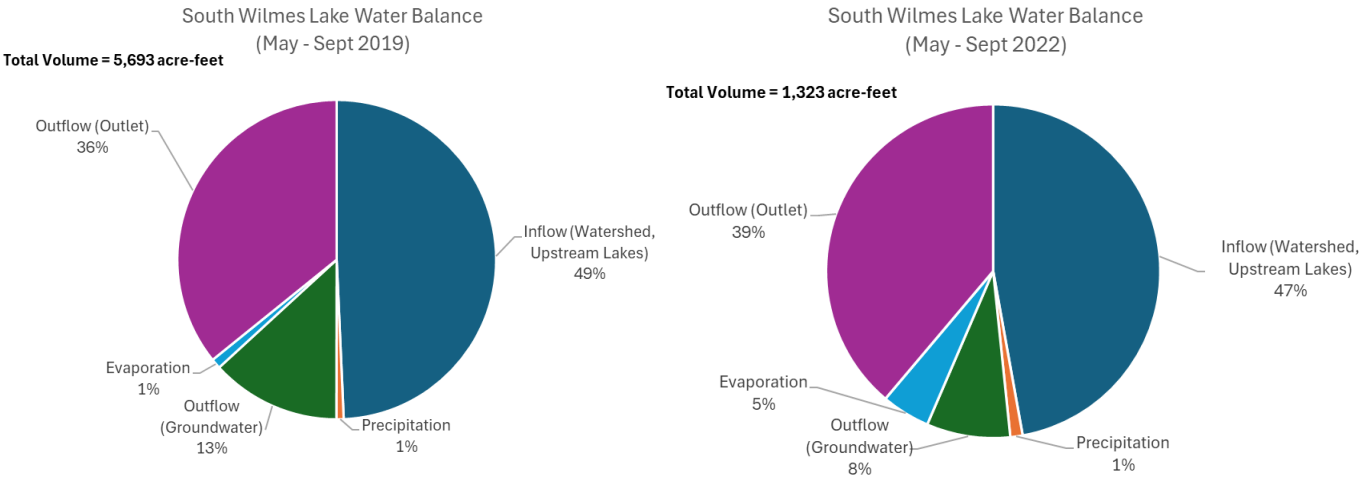


Figure 6-3 South Wilmes Lake water balance summaries

Table 6-2 Suburban lakes 2019 water balance summary

Lake	Total Volume (ac-ft)	% Inflow		% Outflow		% Inflow (I) or Outflow (O)
		Watershed, Upstream Lake	Precipitation	Outlet	Evaporation	Groundwater
Armstrong	409	41%	9%	46%	4%	-
Markgrafs	1,785	13%	5%	45%	7%	29% (I)
Powers	1,990	44%	6%	44%	6%	-
North Wilmes	2,104	48%	2%	48%	2%	-
South Wilmes	5,693	49%	1%	36%	1%	13% (O)
Colby	6,166	47%	3%	47%	3%	-
Bailey	6,663	48%	2%	46%	2%	2% (O)
La	222	2%	52%	-	29%	17% (I)
Ravine	838	18%	6%	42%	8%	26% (I)

Table 6-3 Suburban lakes 2022 water balance summary

Lake	Total Volume (ac-ft)	% Inflow		% Outflow		% Inflow (I) or Outflow (O)
		Watershed, Upstream Lake	Precipitation	Outlet	Evaporation	Groundwater
Armstrong	188	37%	8%	29%	7%	19% (O)
Markgrafs	604	12%	6%	31%	24%	28% (I)
Powers	819	37%	6%	24%	19%	14% (O)
North Wilmes	723	45%	2%	31%	8%	14% (O)
South Wilmes	1,323	47%	1%	39%	5%	8% (O)
Colby	1,793	44%	3%	40%	13%	-
Bailey	1,693	47%	3%	35%	8%	7% (O)
La	143	3%	28%	-	46%	24% (I)
Ravine	504	12%	4%	35%	17%	32% (I)

6.2.1.1 Water Balance Assumptions

Table 6-4 summarizes the outlet rating curve and groundwater assumptions for each of the nine urban lake water balances. In general, groundwater flow is the main water balance calibration parameter for each of the lake models; as such, results for estimates of groundwater flow also include any error that is resultant within the water balance equation from the other parameters. Simulated groundwater inflow/outflow rates within the models were varied on a multi-week to seasonal basis. Groundwater flows were not adjusted daily to precisely match monitored water surface elevations, as doing so would likely not represent actual groundwater flow conditions.

Table 6-4 Water balance outlet rating curve and groundwater flow assumptions

Lake	Outlet Rating Curve Assumptions	Groundwater Flow Assumptions
Armstrong	• The outlet rating curve from the SWWD XPSWMM model was adjusted up to match the elevation of a highpoint surveyed in the channel upstream of the outlet pipes • Between May 13–23, 2022 an additional constant discharge of 0.65 cfs was needed to calibrate the water balance. It is unclear how or why this additional outflow occurred as a portion of the outflow occurred below the outlet invert elevation.	• Model year 2019 required no groundwater inflow or outflow to match the monitored water surface elevations • Model year 2022 groundwater outflows ranged from 0 – 0.15 cfs
Markgrafs	• The outlet rating curve from the SWWD XPSWMM model was referenced	• The monitored water surface elevations remain above the outlet control elevation for extended durations. High volumes of groundwater inflow were required for water balance calibration. • Model year 2019 groundwater inflows ranged from 1.6 – 1.8 cfs • Model year 2022 groundwater inflows ranged from 0.1 – 1.6 cfs
Powers	• Two pumps control the water surface elevations on Powers Lake, each with “pump on” and “pump off” elevations • The reported “pump on” and “pump off” elevations were used when practical; however, there appeared to be periods when pump operations varied from typical operating procedures. Pump operations were adjusted in the model to match monitored water surface elevations when applicable.	• Model year 2019 required no groundwater inflow or outflow to match the monitored water surface elevations • Model year 2022 groundwater outflows ranged from 0.2 – 1.0 cfs
North Wilmes	• The outlet rating curve from the SWWD XPSWMM model was referenced	• Model year 2019 required no groundwater inflow or outflow to match the monitored water surface elevations. • Model year 2022 groundwater outflows ranged from 0.1 – 0.5 cfs

Lake	Outlet Rating Curve Assumptions	Groundwater Flow Assumptions
South Wilmes	• The outlet rating curve from the SWWD XPSWMM model was referenced	• Model year 2019 groundwater outflow was 2.5 cfs • Model year 2022 groundwater outflow was 0.3 cfs
Colby	• The outlet rating curve from the SWWD XPSWMM model was referenced	• Model years 2019 and 2022 required no groundwater inflow or outflow to match the monitored water surface elevations
Bailey	• Up to five pumps control the water surface elevations on Bailey Lake, each with operating procedures for “pump on” and “pump off” elevations • The reported “pump on” and “pump off” elevations were used when practical; however, there appeared to be periods when pump operations varied from typical operating procedures. Pump operations were adjusted in the model to match monitored water surface elevations when applicable. • Available historical pump records were provided by City of Woodbury staff for reference, but no records after 2018 are available. The pump records demonstrated that pump operating procedures may vary.	• Model years 2019 and 2022 groundwater outflow was estimated at 0.4 cfs based on dry climatic conditions in 2022. • There is uncertainty associated with groundwater outflow assumptions in 2019 given that no pump records were available to confirm the pump outflow assumptions used in the model.
La	• Land-locked, no outlet rating curve modeled	• Model year 2019 groundwater inflows ranged from 0.1 – 0.2 cfs • Model year 2022 groundwater inflows ranged from 0.1 – 0.15 cfs
Ravine	• High uncertainty in the Ravine Lake water balance due to beaver dams frequently observed at the Ravine Lake outlet. While field notes provide some information on beaver dam observations, there are no detailed records available for model years 2019 and 2022. • The outlet rating curve from the SWWD XPSWMM model was adjusted up to the estimated top of a beaver dam based on the monitored water surface elevations	• Ravine Lake is known to have sizable groundwater inflow; however, there are no detailed monitoring records available on groundwater inflow rates. The observed water surface elevations and water quality monitoring data were critically assessed to make the best possible assumptions about groundwater inflow rates. • Model year 2019 groundwater inflows were estimated at 0.7 cfs • Model year 2022 groundwater inflows ranged from 0.3 – 0.7 cfs

6.2.2 Water Quality Parameters

Calibration of water quality parameters requires a process in which model parameters and coefficients are reasonably adjusted such that the model predictions are similar to in-lake measurements. The lakes

that were modeled using the finite difference spreadsheet were calibrated to match monitored total phosphorus concentrations (Armstrong, Powers, Bailey, La). The lakes that were modeled using the Barr Shallow Lake model were calibrated to the following parameters when monitoring data was available (Markgrafs, South Wilmes, Colby, Ravine).

- Total Phosphorus (TP)
- Chlorophyll-*a*
- Total Kjeldahl Nitrogen (TKN)

Other parameters that are typically calibrated when using the Barr Shallow Model include orthophosphate and nitrate + nitrite concentrations. While these parameters were estimated in the models, calibrations could not be performed because no monitoring data were available.

Additionally, in-lake modeling performed for North Wilmes Lake as a part of this study is high level and has a high amount of relative uncertainty, given no monitoring data is currently available for the lake. Model results were verified for relative accuracy as part of calibrating downstream lake models. Water quality monitoring in North Wilmes will be necessary to develop accurate nutrient loading predictions.

Example in-lake model calibrations for South Wilmes Lake are provided below. The orange line in each plot represents the modeled in-lake concentrations, and the blue circles represent the monitored concentrations.

Plots showing all calibrated parameters for each suburban lake can be found in Appendix B.

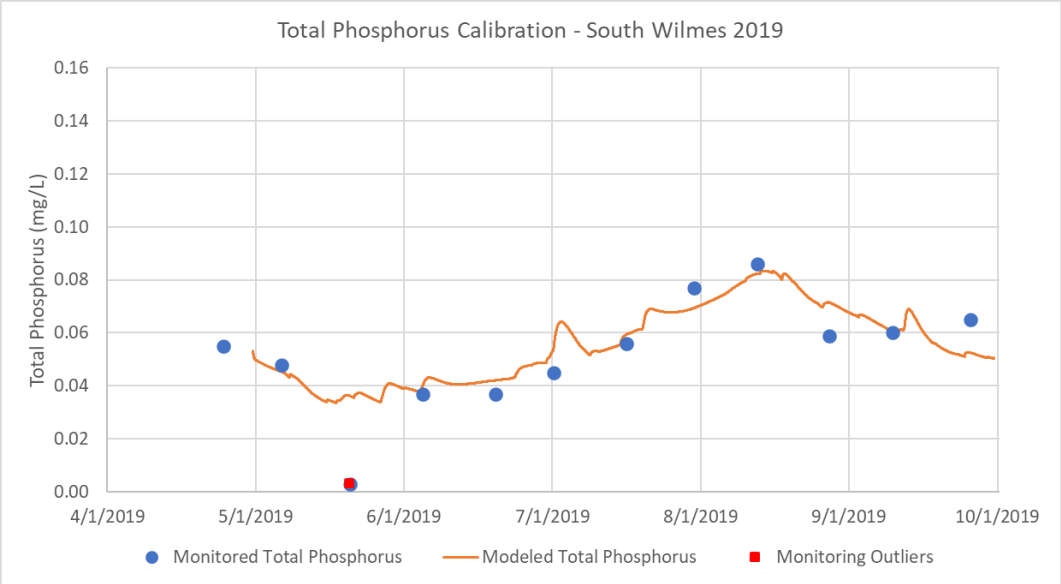


Figure 6-4 South Wilmes 2019 in-lake total phosphorus calibration

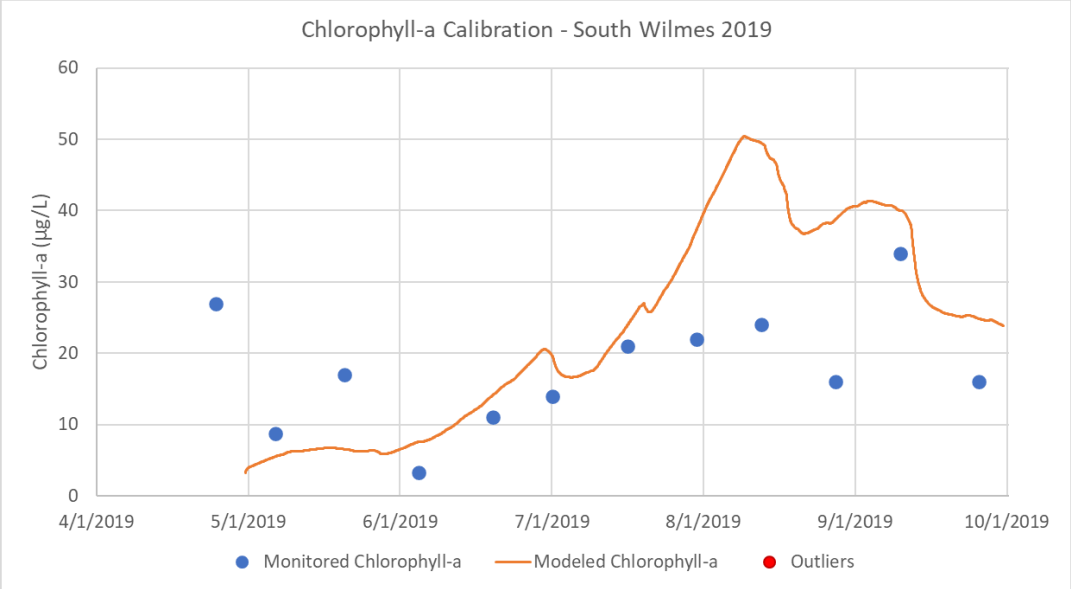


Figure 6-5 South Wilmes 2019 in-lake chlorophyll-*a* calibration

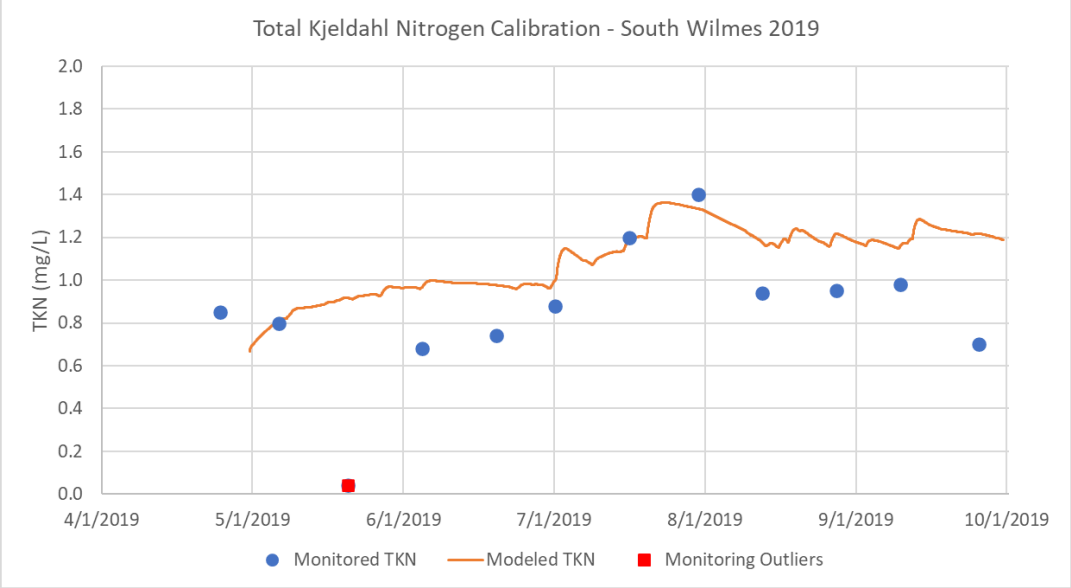


Figure 6-6 South Wilmes 2019 in-lake Total Kjeldahl Nitrogen calibration

6.3 Phosphorus Loading Summaries

After the in-lake water quality model calibrations were finalized, phosphorus loading summaries were developed. The following lake sections summarize the estimated 2019 and 2022 total phosphorus loads to each of the nine suburban lakes between June 1 – September 30 from the watershed (external loads), internal loading from lake bottom sediment (internal loads), and loading from upstream lakes and groundwater inflow, if applicable. Model assumptions and observations are also discussed. Table 6-5 provides a summary of the total phosphorus load quantities for each modeled lake for 2019 and 2022.

Table 6-5 Total phosphorus loading estimates for SWWD suburban lakes: June 1 – September 30

Lake	2019 Total Phosphorus Loads (lbs, June – Sept)				2022 Total Phosphorus Loads (lbs, June – Sept)			
	Watershed	Upstream Lake(s)	Internal Loading from Lake Bottom Sediment	Groundwater	Watershed	Upstream Lake(s)	Internal Loading from Lake Bottom Sediment	Groundwater
Armstrong	65	-	14	-	17	-	35	-
Markgrafs	58	-	135	26	14	-	50	4
Powers	259	-	171	-	73	-	70	-
North Wilmes[1]	209	41	36	-	49	0	33	-
South Wilmes	34	405	55	-	6	12	32	-
Colby	383	263	377	-	102	3	261	-
Bailey	78	603	110	-	17	15	146	-
La	3	-	34	7	<1	-	57	6
Ravine	80	-	67	12	37	-	127	9

[1] Water quality monitoring data has not historically been collected for North Wilmes Lake. As such, water quality model calibration could not be completed. Water quality modeling was based on high level assumptions, approximations from similar lake models, and efforts to calibrate downstream South Wilmes Lake. Water quality monitoring is recommended to better estimate the total phosphorus loads to North Wilmes Lake.

6.4 Proposed Management Practices Modeling

To help inform the District's planning for future management activities, the calibrated in-lake models were used to predict the effects of implementing best management practices on in-lake water quality. For the purpose of this exercise, the District was interested in understanding the expected impact of implementing sediment phosphorus inactivation projects to address internal loading. To do this, the calibrated models were modified as described below, as applicable, for each waterbody.

For each of the lakes, two separate sediment inactivation scenarios were created: one to represent a high efficacy treatment and the second to represent low efficacy. For lakes that the modeling showed additional nutrient reductions (beyond internal treatment) would be needed to decrease simulated phosphorus and chlorophyll-a concentrations to below the state standard, a reduction in watershed load was also simulated.

The results of the conceptual treatment strategy models can be viewed in each individual lake section (Sections 8 - 14).

<u>For lakes modeled with the Barr Shallow Lake Model, the following assumptions were made:</u>

- Scenario: Sediment Inactivation (low and high efficacy)
    - In the Barr shallow lake model, the two primary sediment P fractions are modeled separately: mobile-P and organic-P
    - For both the high and low efficacy scenarios, the mobile-P loading rate was decreased by 85% to represent impacts from a sediment treatment. This reduction is based on monitoring data from sediment inactivation projects that Barr has completed previously, one year after project completion.
    - The organic-P loading rate was decreased by 50% (low efficacy scenario) and 70% (high efficacy scenario) based on best professional judgement and results from the sediment core sampling. A range of efficacy was utilized for simulating impacts to the organic-P loading rate due to additional uncertainty regarding the effectiveness of sediment treatments in reducing organic driven internal loading, depending on project type (alum, alum/iron, or aeration).
- Scenario: Sediment Inactivation (low) + Watershed Load Reduction
    - For this scenario, the mobile-P and organic-P loading rates were decreased by 85% and 50% respectively.
    - A percent reduction was applied to the calibrated watershed loads in each model until the simulated in-lake summer average total phosphorus and chlorophyll-*a* concentrations met or were lower than state standards.

<u>For lakes modeled with the Finite Difference Spreadsheet Model, the following adjustments were made:</u>

- Scenario: Sediment Inactivation (low and high efficacy)
    - In the finite difference spreadsheet model, the sediment P fractions are not modeled separately. Because of this, for these scenarios the overall internal loading rate was

decreased by 60% (low efficacy) and 80% (high efficacy) based on monitoring data from sediment inactivation projects that Barr's completed previously one year after project completion. A range of efficacies was utilized to reflect some uncertainty in the effectiveness of sediment treatments in reducing organic driven internal loading, depending on project type (alum, alum/iron, or aeration).

The models developed for this study represent in-lake conditions and expected impacts from management strategies for a single growing season. Therefore, the estimated in-lake response to each of the conceptual treatment scenarios represent the predicted in-lake water quality improvements for that period only and do not account for longer-term water quality impacts. For example, once implemented sediment inactivation efficacy is known to vary over time. Monitoring data from Twin Cities metro lakes indicate that efficacy declines in the years following initial treatment due to product aging, new watershed inflows, and burial from rough fish activity, which can again increase internal loading over time. Conversely, if water quality management projects improve water clarity, some lakes may experience a greater abundance and extent of submerged plants. Increased plant growth can reduce sediment resuspension, enhance nutrient uptake, and create increased competition with algae, leading to improved water quality. If the increased plant growth is associated with aquatic invasive species, however, this can cause additional concerns for water quality and may warrant the consideration of additional management strategies related to vegetation management.

While modeling provides useful estimates of the expected scale of impacts of water quality management strategies, post-project monitoring is essential to track changes in lake water quality and adjust management plans as needed to continue benefits over time.

7 Armstrong Lake (South Basin)

7.1 Water Quality

Shallow/Deep	Shallow
Location	Oakdale
Surface Area	10 acres
Average/Maximum Depth	1 foot / 5.5 feet
Watershed Area	572 acres
Watershed:Lake Surface Area	57:1
Impairment Status	Not listed on impaired waters list
Downstream Waterbody	North Wilmes Lake

Armstrong Lake is the most upstream of the multi-lake system that was included in this study. The lake is divided into two separate basins, connected by a 36" culvert extending under County Highway 10. The north basin is located in the City of Lake Elmo, and the south basin is in the City of Oakdale. The lake is used primarily for wildlife viewing. When water levels are high enough, water discharges via gravity flow from Armstrong Lake through a storm sewer system, which ultimately discharges to North Wilmes Lake. Only the south basin of Armstrong Lake was considered for this study. This basin is where the lake's monitoring data is being collected and more field data is available for this area of the lake. The north basin is represented in the watershed p8 model, but an in-lake model was not developed for the north basin.

The south basin of Armstrong Lake has a water surface area of approximately 10 acres, a maximum depth of 5.5 feet, and a mean depth of approximately 1 foot. Armstrong Lake is shallow enough for aquatic plants to grow over the entire waterbody and for the lake to mix many times per year (polymictic lake).

The State of Minnesota uses three water quality parameters to assess eutrophication standards within lakes—total phosphorus, chlorophyll-*a*, and Secchi disk transparency—to assess waterbody health and track water quality changes. These three parameters were measured in Armstrong Lake by the SWWD between 1998-2023 (Figure 7-1). Monitoring data collected in 2014 and between 2021 – 2023 was collected at a reduced frequency from other monitored years. Not enough measurements were collected to calculate summer averages for those years. During the monitored years with adequate data, summer average total phosphorus concentrations were better than the state standard between 2004 – 2005, 2010 - 2011, and in 2016. All other monitored years were worse than the state standard summer average concentration. Summer average chlorophyll-*a* concentrations were better than the state standard between 2001 – 2006, 2008 – 2018, and in 2020. Summer average Secchi depths met or were slightly better than the state standard in 2002, 2004-2005, 2008-2009, and 2011-2013. Since 2014, summer average Secchi depths have been worse than the state standard. At the time of this study, Armstrong Lake was not listed as impaired on the Minnesota impaired waters list.

Chloride concentrations were measured by the SWWD between 2002 - 2007 and 2010-2023 (generally between April and September). In the historical record, one observed chloride concentration in October 2023 exceeded the MPCA chronic standard of 230 mg/L. All other observed chloride concentrations were below the chronic standard. Chloride concentrations within Armstrong Lake have been on a steady rise over the past 21 years; with average annual observed concentrations increasing from 54 mg/L to 202 mg/L between 2002 and 2023.

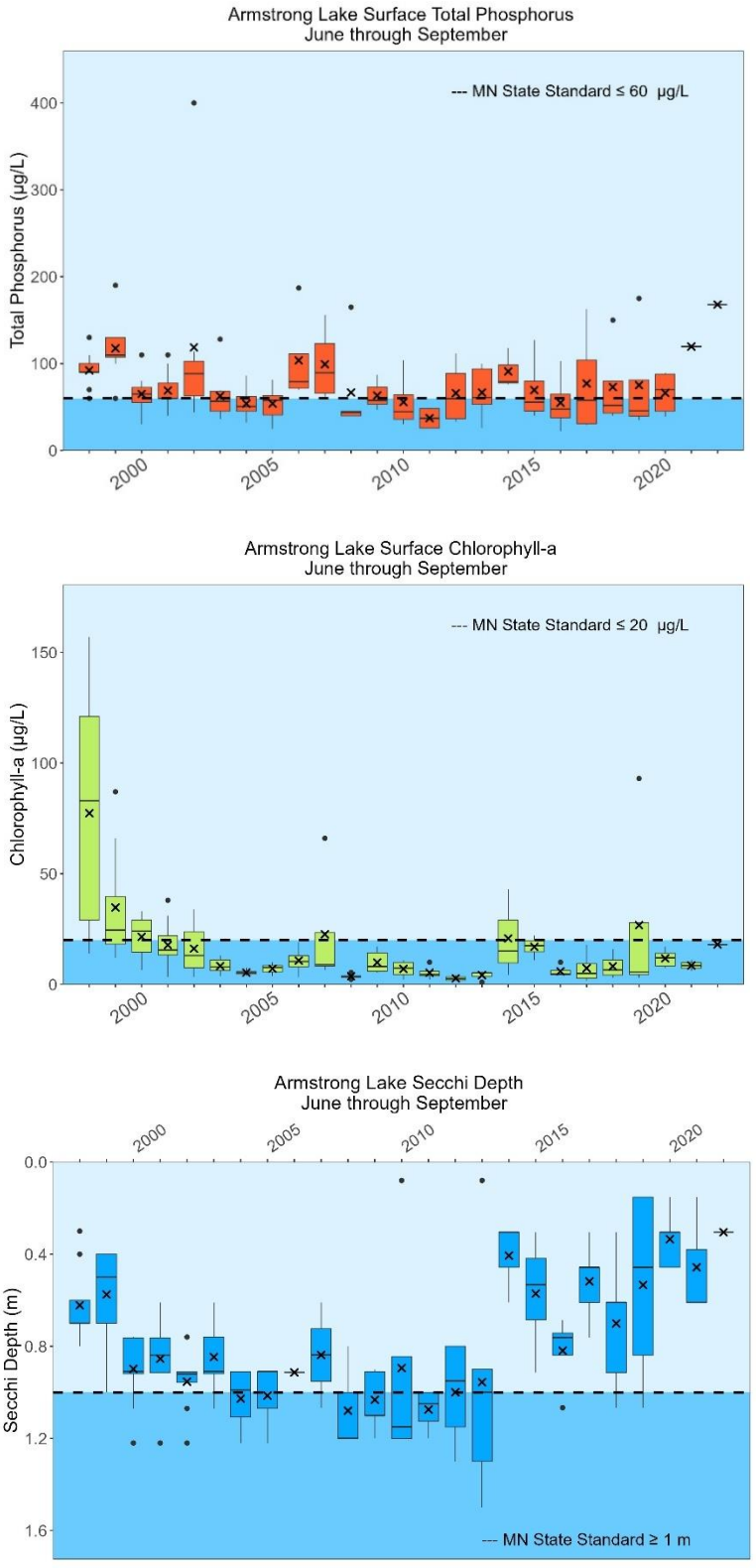


Figure 7-1 Armstrong Lake eutrophication monitoring data (June – September)
Summer averages are shown by x's in the box plots
**Notably high total phosphorus and chlorophyll-a outliers in 2000 are not shown on the plots*

7.2 Ecological Health

7.2.1 Aquatic Plants

Table 7-1 summarizes the calculated Lake Plant Eutrophication IBI values for Armstrong Lake based on point-intercept plant surveys completed in 2021 and 2024. Armstrong Lake scored above both plant IBI metrics in June 2021, June 2024, and August 2024. Water levels were too low in August 2021 to complete a survey. Table 7-1 also summarizes the percentage of the littoral area where aquatic plants were found and lists observed aquatic invasive species, their frequency of occurrence (FOO), and current management practices as applicable. Other plant health metrics can be referenced in the 2021 and 2024 Aquatic Vegetation Survey Results reports (Stantec, 2021, 2025).

Table 7-1 Armstrong Lake aquatic plants overview

Lake	Parameter	June 2021[1]	August 2021[1]	June 2024[2]	August 2024[2]	MnDNR Threshold	Invasive Species Management
Armstrong	Species Richness	14	-	14	14	>11	
	Floristic Quality Index (FQI)	18.2	-	20	19.4	>17.8	
	% Littoral with Vegetation	100%	-	100%	100%		
	Curly-leaf Pondweed FOO	6%	-	2%	-		No management to date
	Purple Loosestrife FOO	P	-	-	-		Managed naturally by leaf eating beetles

[1] (Stantec, 2021 Aquatic Vegetation Survey Results, 2021)
[2] (Stantec, 2025)

7.2.2 Fisheries

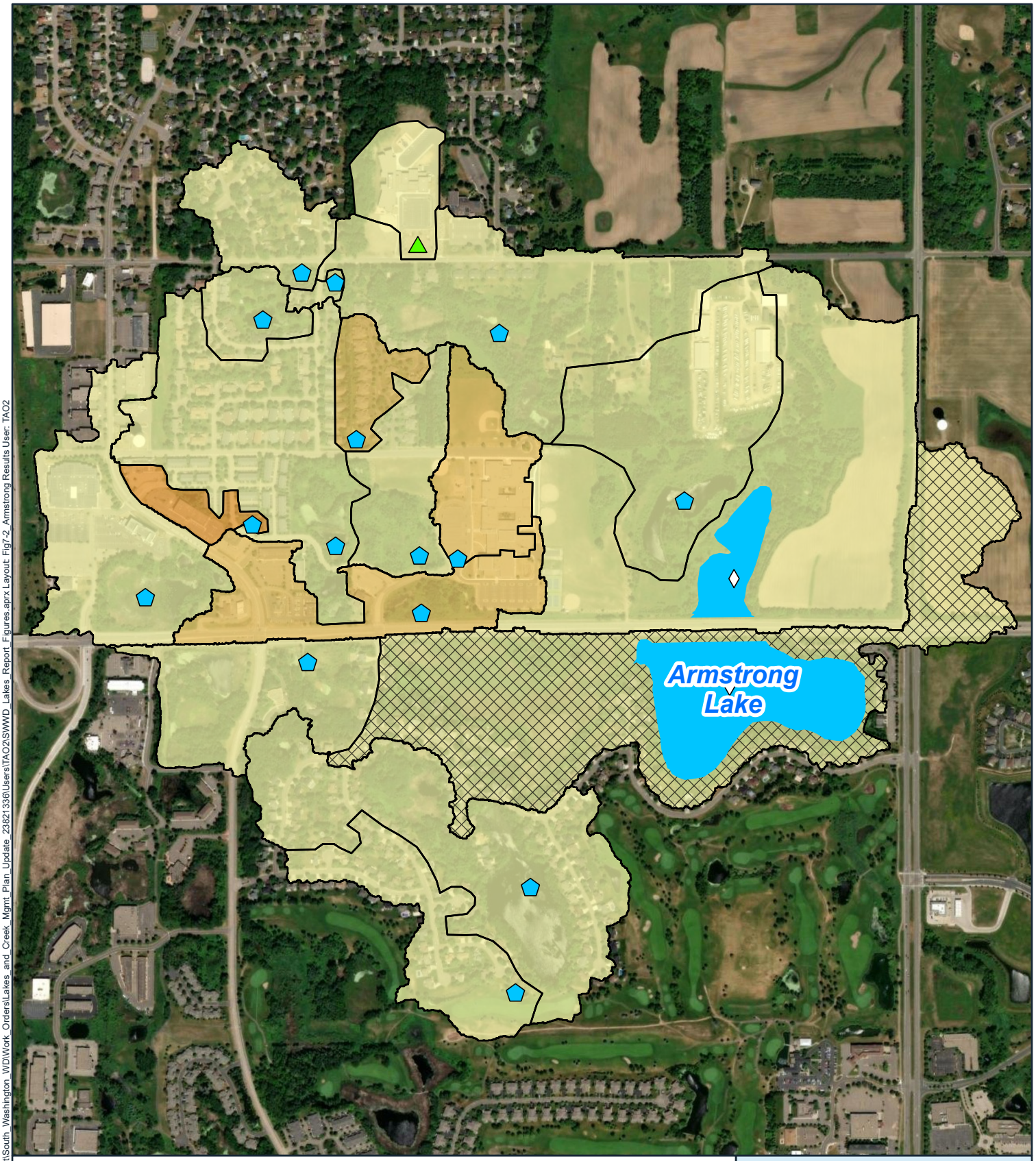
There are no MNDNR fish survey or stocking data available for Armstrong Lake.

7.3 Watershed Total Phosphorus Loads

The P8 model was run for the water years 2019 and 2022 for the purposes of developing the in-lake models. To estimate 10-year average total phosphorus loads to each lake, the P8 models were run from 2012 – 2022.

P8 modeling shows low to moderate watershed total phosphorus loads to Armstrong Lake, with higher loads coming from denser residential areas (e.g., multi-family housing), streets, and commercial areas within the watershed. The map in Figure 7-2 shows the effective areal phosphorus loading by subwatershed, modeled BMPs, and untreated subwatersheds in the Armstrong Lake contributing area. The effective phosphorus load represents the loading rate after pollutant removal by BMPs within the watershed and is reflective of the loading that actually makes it into the receiving waterbody from a given location. The effective phosphorus loads for Armstrong Lake subwatersheds range from 0.0 pounds per acre per year to 0.7 pounds per acre per year, based on the 10-year modeling period (2012-2022).

The direct drainage area to the southern basin of Armstrong Lake does not receive treatment before entering the lake. For the purposes of the P8 modeling, the large wetland west of the southern basin was not modeled as a pond device and is therefore not simulated as providing pollutant removal.



Lake

P8 Device Type

- Infiltration Basin
- Pipe
- Wet Pond

TP Effective Load (lbs/ac/yr)

- 0.0 - 0.3
- 0.3 - 0.6
- 0.6 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0
- Area Not Treated by BMP

N

0 300 600

Feet

Armstrong Lake
Effective TP Loading
Lake Management Plan
South Washington
Watershed District

FIGURE 7-2

BARR

Barr Footer: ArcGISPro, 8/7/2025 4:47 PM File: I:\Client\South_Washington_WD\Work_Orders\Lakes_and_Creek_Mgmt_Plan_Update_23821336\Users\TAO2\SWWD_Lakes_Report_Figures.aprx Layout: Fig7-2_Armstrong Results User: TAO2

7.4 In-lake Total Phosphorus Loads

Results of the in-lake modeling for Armstrong Lake showed that during the summer of 2019 (representing a wet year), phosphorus loading into the lake was dominated by loading from the tributary watershed, representing 82% (65 lbs) of the total phosphorus loading from major sources (Figure 7-3). Internal loading that same year was estimated to be 18% (14 lbs) of the total phosphorus load. During the drier summer of 2022, the estimated phosphorus loading into the lake from watershed runoff was notably lower, representing 33% (17 lbs) of total phosphorus loading to the lake. Internal loading in 2022 was notably higher than 2019, representing 67% (35 lbs) of the phosphorus load.

Unfortunately, water quality monitoring data in Armstrong Lake was limited in 2022 (i.e., monitoring data only available April – June and October). As such, Barr can only postulate potential reasons why internal loading was markedly different between 2019 and 2022. Possible reasons for higher internal loading from lake bottom sediment in 2022 could include:

- Longer periods of stronger lake stratification may have led to lower dissolved oxygen concentrations over larger portions of the lake bottom, resulting in phosphorus release from the mobile-phosphorus fraction from larger areas of sediment.
- Changes in the extent and depth of lake mixing.
- Warmer lake temperatures may have led to increased microbial activity, which could have resulted in lower dissolved oxygen levels at the lake bottom and/or enhanced mineralization of organic phosphorus in the sediment.

Phosphorus fractionation data gathered from sediment cores collected in 2024 indicated a moderate potential for internal phosphorus loading. Additional details on the sediment core data can be found in Section 4.8.

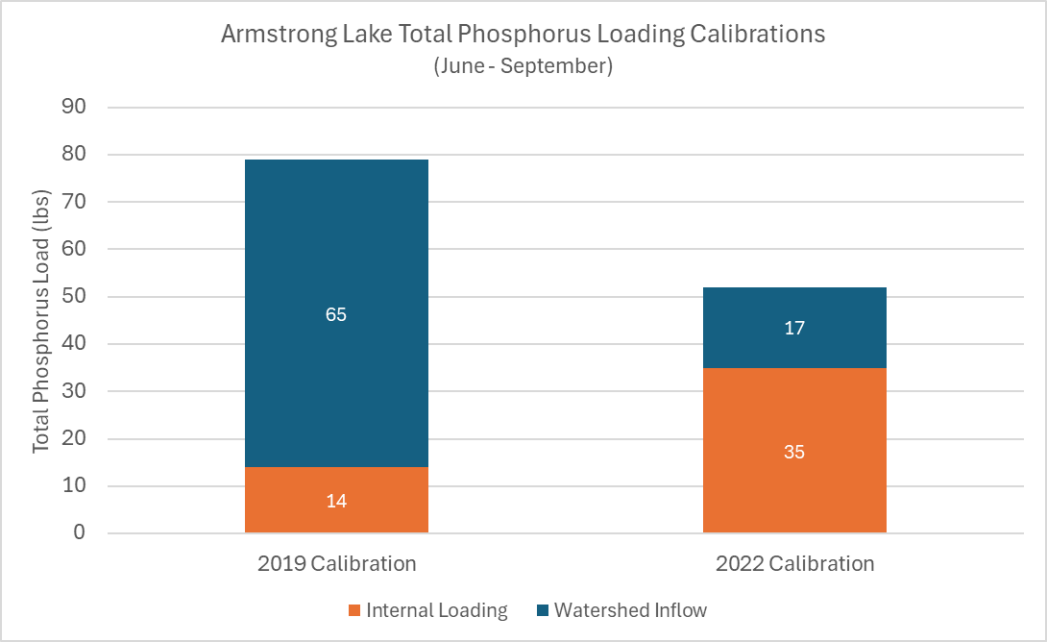


Figure 7-3 Armstrong Lake total phosphorus load estimates – 2019 & 2022

7.5 Management Recommendations

Monitoring of Armstrong Lake between 2017 - 2020 showed that total phosphorus and Secchi depth were worse than state standards. Limited water quality data was collected between 2021 – 2023. The aquatic plant community in June 2021 was relatively diverse with high quality. However, the aquatic invasive species, curly-leaf pondweed, was observed and could be a threat to the native plant community. Given this, future management efforts should focus on improving lake water quality and ecosystem health, monitoring for changes, and continuing water quality and ecosystem health protection measures as improvements are achieved. Table 7-2 summarizes the recommended management strategies that could be considered for Armstrong Lake to help improve water quality conditions and ecological health.

Table 7-2 Armstrong Lake management recommendations

Management/Protection Action		Basis
Address external watershed loads	Enhanced street sweeping program	Consider partnering with the cities of Lake Elmo and Oakdale to implement enhanced street sweeping programs to reduce pollutant loading to stormwater runoff
	Stormwater BMPs	Consider retrofitting or installing new stormwater BMPs in subwatersheds that are currently untreated or undertreated Implement site scale BMPs as opportunities arise
	Chloride	Consider applying chloride reduction strategies such as education and implementation assistance to member cities and other stakeholders
Aquatic Plants	Invasive species management	Continue to monitor invasive species growth (e.g., curly-leaf pondweed) and consider management if the invasive species starts to negatively impact water quality or native plant densities and distribution
	Promote native aquatic plant growth	Encourage native plant reestablishment to promote clear water conditions and competition with algae
Fisheries	Fisheries Monitoring	Consider collecting fish community data
Phytoplankton and Zooplankton	Phytoplankton/Zooplankton Monitoring	Consider monitoring phytoplankton and zooplankton as part of routine monitoring
Water Quality	Water Quality Monitoring	Continue monitoring in-lake water quality and assessing for eutrophication Continue to identify/track chloride levels from winter salt use

8 Markgrafs Lake

8.1 Water Quality

Markgrafs Lake is located in the City of Woodbury and is used for active and passive recreation and wildlife viewing. Markgrafs Lake is one of the upstream lakes in the multi-lake system included in this study. When water levels are high enough, water discharges via gravity flow from Markgrafs Lake through a storm sewer system, which ultimately discharges to South Wilmes Lake. During extreme storm events (e.g., 100-year flow events), water can be pumped to Powers Lake. Lake level monitoring data indicates that water levels on Markgrafs Lake can sit above the control outlet elevation for extended periods of time due to high volumes of groundwater inflow.

Shallow/Deep	Shallow
Location	Woodbury
Surface Area	44 acres
Average/Maximum Depth	3 feet / 7 feet
Watershed Area	425 acres
Watershed:Lake Surface Area	10:1
Impairment Status	Impaired for nutrients since 2006
Downstream Waterbody	South Wilmes Lake

Markgrafs Lake has a water surface area of approximately 44 acres, a maximum depth of 7 feet, and a mean depth of approximately 3 feet. Markgrafs Lake is shallow enough for aquatic plants to grow over the entire waterbody and for the lake to mix many times per year (polymictic lake).

The State of Minnesota uses three water quality parameters to assess eutrophication standards within lakes—total phosphorus, chlorophyll-*a*, and Secchi disk transparency—to assess waterbody health and track water quality changes. These three parameters were measured in Markgrafs Lake by the SWWD between 1994-2023 (Figure 8-1). During the monitored years, summer average total phosphorus concentrations have consistently exceeded the state standard, ranging between 69 – 241 µg/L. Summer average chlorophyll-*a* concentrations were better than the state standard in 1995 and 1996. Otherwise, summer average chlorophyll-*a* concentrations have exceeded the state standard, ranging between 23 - 173 µg/L. Summer average Secchi depths met or were slightly better than the state standard between 1994 – 1996, 2000, 2014, 2019, and 2022-2023. During all other monitored years, summer average Secchi depths have been worse than the state standard. Markgrafs Lake was added to the Minnesota impaired waters list in 2006 as impaired for nutrients.

Chloride concentrations were measured by the SWWD between 2013-2023 (generally between April and September). In the historical record, three observed chloride concentrations in monitoring year 2023 exceeded the MPCA chronic standard of 230 mg/L ranging between 235-248 mg/L. All other observed chloride concentrations were below the chronic standard.

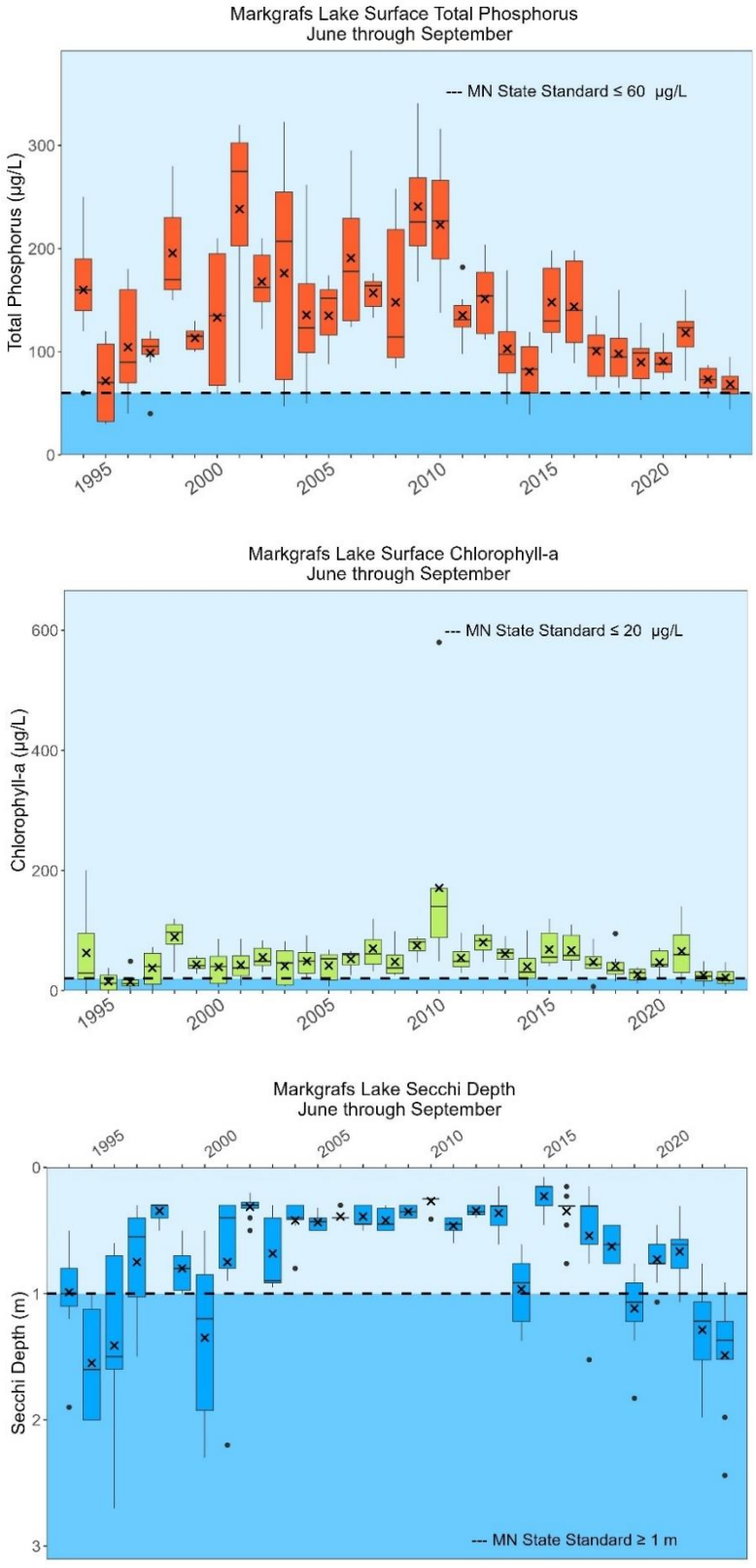


Figure 8-1 **Markgrafs Lake eutrophication monitoring data (June – September)**
Summer averages are shown by x's in the box plots

8.2 Ecological Health

8.2.1 Aquatic Plants

Table 8-1 summarizes the calculated Lake Plant Eutrophication IBI values for Markgrafs Lake based on point-intercept plant surveys completed in 2021 and 2024. Markgrafs Lake scored below both plant IBI metrics in June and August in 2021 and 2024, indicating a degraded plant community that is likely stressed from cultural eutrophication. Table 8-1 also summarizes the percentage of the littoral area where aquatic plants were found and lists observed aquatic invasive species, their frequency of occurrence (FOO), and current management practices. Other plant health metrics can be referenced in the 2021 and 2024 Aquatic Vegetation Survey Results reports (Stantec, 2021, 2025).

Table 8-1 Markgrafs Lake aquatic plants overview

Lake	Parameter	June 2021[1]	August 2021[1]	June 2024[2]	August 2024[2]	MnDNR Threshold	Invasive Species Management
Markgrafs	Species Richness	7	10	7	8	>11	
	Floristic Quality Index (FQI)	11.9	15.4	8.25	10.4	>17.8	
	% Littoral with Vegetation	94%	73%	94%	86%		
	Curly-leaf Pondweed FOO	10%	2%	14%	-		Herbicide applications in 2023 & 2025

[1] (Stantec, 2021 Aquatic Vegetation Survey Results, 2021)
[2] (Stantec, 2025)

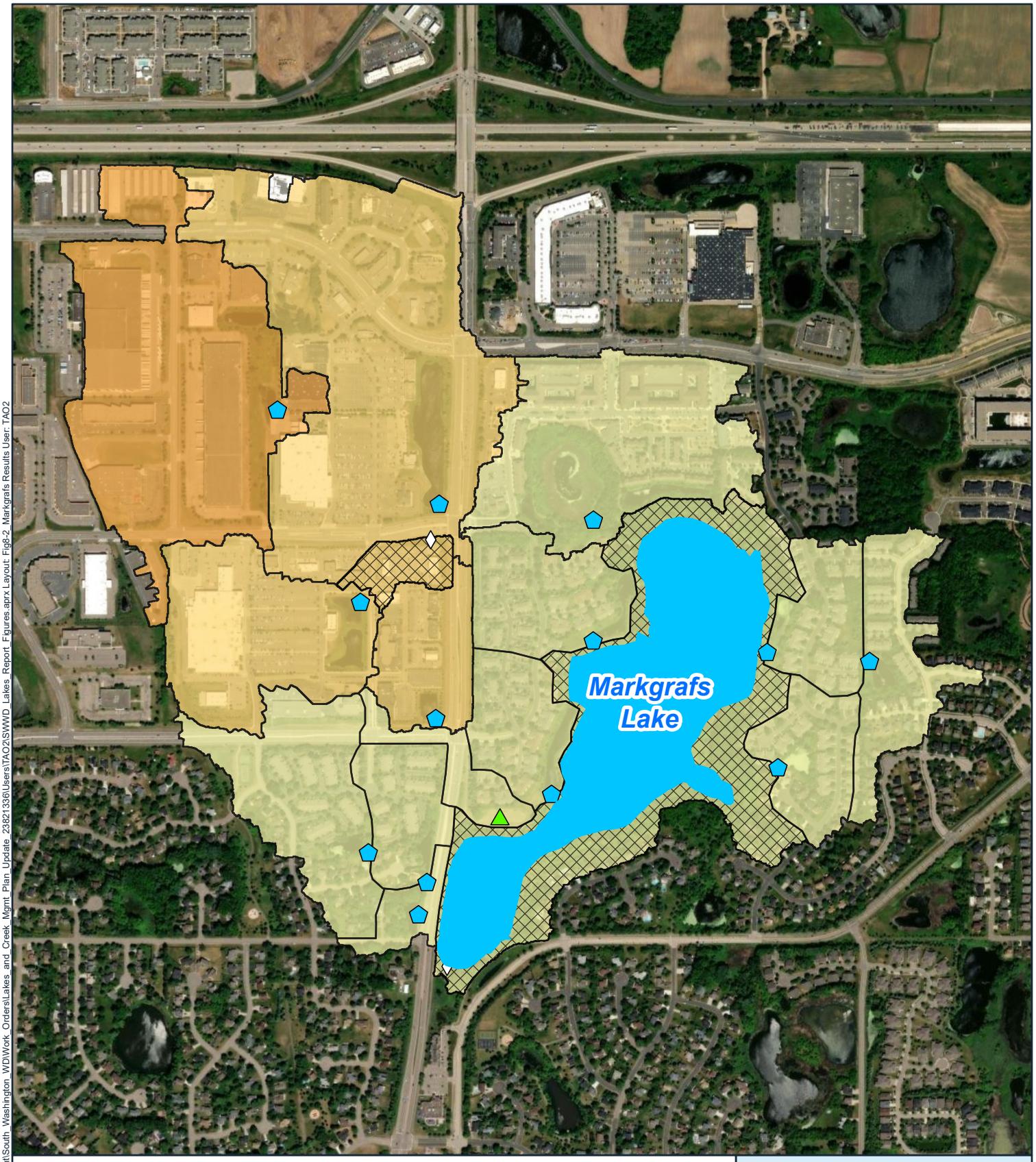
8.2.2 Fisheries

While Markgrafs Lake has historically been used as a walleye rearing waterbody, the absence of recent fish survey data prevents an assessment of current walleye abundance. There are no MNDNR fish survey or stocking data available for Markgrafs Lake.

8.3 Watershed Total Phosphorus Loads

P8 modeling shows low to moderate watershed phosphorus loading to Markgrafs Lake, with higher loads coming from the western portion of the watershed where there are large commercial properties (e.g., Sam's Club, Target), some of which are untreated by BMPs before discharging to Markgrafs Lake. Figure 8-2 shows the effective areal phosphorus load by subwatershed, the modeled BMPs, and untreated subwatersheds. The effective phosphorus load represents the loading rate after pollutant removal by BMPs throughout the watershed and is reflective of the loading that actually makes it into the receiving waterbody from a given location. The effective phosphorus loads for the Markgrafs Lake subwatersheds range from 0.09 pounds per acre per year to 0.6 pounds per acre per year, based on a 10-year modeling period (2012-2022).

The direct drainage area to Markgrafs Lake receives treatment from several small stormwater (sedimentation) ponds around the lake. These basins were added to the P8 model to better represent loading to the lake. However, land directly adjacent to Markgrafs Lake does not receive any treatment before runoff discharges to the lake.



Lake

P8 Device Type

- Pipe
- Dry Pond
- General Device
- Wet Pond
- Infiltration Basin

Effective TP Load (lbs/ac/yr)

- 0.0 - 0.3
- 0.3 - 0.6
- 0.6 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0
- Area Not Treated by BMP

N

0 300 600

Feet

Markgrafs Lake
Effective TP Loading
Lake Management Plan
South Washington
Watershed District

FIGURE 8-2

BARR

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8.4 In-lake Total Phosphorus Loads

Results of the in-lake modeling for Markgrafs Lake showed that during both wet (2019) and dry (2022) summers, the phosphorus loading into Markgrafs Lake was dominated by internal loading, representing 62% (135 lbs) of the phosphorus load in 2019 and 74% (50 lbs) in 2022 (Figure 8-3). Model calibration indicates that internal phosphorus loading was notably higher in 2019 than in 2022. Sediment cores collected in 2024 showed that the average concentration of organically bound phosphorus in the top four to six centimeters of sediment was higher than the mobile phosphorus fraction. It is the mobile phosphorus fraction that can be released from sediment during low oxygen conditions. Organically bound phosphorus also releases from lake sediment, but typically at a slower rate than mobile phosphorus, and the release rate is generally controlled by lake water temperature or other environmental parameters that may influence microbial activity. The release rate from the organically bound phosphorus fraction was decreased in the 2022 in-lake model to match monitored in-lake conditions. It's possible that environmental factors influenced the microbial degradation rates of the organic phosphorus fraction in 2022.

The higher estimated groundwater influence on Markgrafs Lake also contributes to uncertainty in the internal loading estimates. Limited groundwater water quality monitoring data is available from wells in the vicinity of Markgrafs Lake. For the purposes of this study, a total phosphorus groundwater concentration of 23 μg/L was assumed based on the 10-year average annual monitoring data available from well 798057 (National Water Quality Monitoring Council, 2025). If the assumed groundwater total phosphorus concentration was too low during the modeled periods, then the internal load is overestimated in the lake calibrations. Conversely, if the assumed groundwater concentration was too high, then the internal load is underestimated in the lake calibrations. Since groundwater inflow is a major component of the Markgrafs Lake water balance, more detailed groundwater monitoring is recommended to confirm the extent of groundwater inflow impacts on in-lake phosphorus concentrations. Assuming a groundwater inflow total phosphorus concentration of 23 μg/L, the total phosphorus load from groundwater in 2019 and 2022 represented 12% (26 lbs) and 6% (4 lbs) of the total phosphorus load, respectively.

The total phosphorus load from watershed runoff was also a notable contribution to Markgrafs Lake, especially during the summer of 2019 (representing a wet year) where watershed runoff represented 26% (58 lbs) of the total phosphorus load. During the drier summer of 2022, the watershed runoff total phosphorus load represented 21% (14 lbs) of the total load.

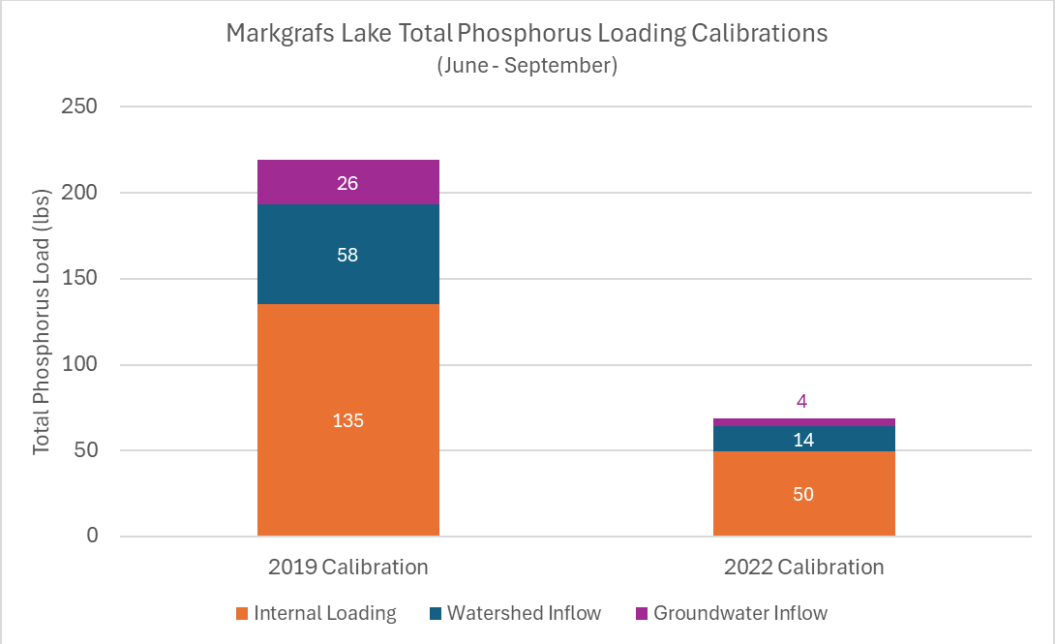


Figure 8-3 Markgrafs Lake total phosphorus load estimates – 2019 & 2022

8.5 Predicted Benefits from Implementing Management Practices

One of the study goals was to estimate the potential impact of lake sediment inactivation projects and how they could be used to improve in-lake water quality. The calibrated in-lake models were used to estimate the impact of implementing a sediment treatment project in Markgrafs Lake.

Table 8-2 summarizes the estimated phosphorus load reduction from two scenarios: sediment inactivation (low efficacy) and sediment inactivation (high efficacy). Results from the in-lake modeling predict a reduction of 32 – 100 pounds of total phosphorus loading into Markgrafs Lake through implementation of sediment inactivation practices for a wet (2019) and dry (2022) year. This reduction in phosphorus loading translates to a reduction in the in-lake total phosphorus concentrations. Model results estimate that the 2019 summer average total phosphorus concentration of 95 µg/L would reduce to 49 - 59 µg/L with the implementation of sediment treatments; and the 2022 summer average total phosphorus concentration of 74 µg/L would reduce to 41 - 48 µg/L (Table 8-2). Figure 8-4 and Figure 8-5 summarize the predicted reductions in in-lake total phosphorus concentrations for the 2019 and 2022 model years, respectively, for each of the sediment inactivation scenarios.

Table 8-2 Summer growing period estimated reductions in phosphorus loads and in-lake concentrations in Markgrafs Lake with the proposed management practices

Scenario	Modeled Summer Total Phosphorus Loading (lbs)					Summer Average Total Phosphorus (µg/L)[1]	Summer Average Chlorophyll-a (µg/L)[1]
	Watershed Inflow	Groundwater Inflow	Internal Loading	Total	Load Reduction		
2019 Existing	58	26	135	219	-	95	26
2019 Sediment Inactivation Low	58	26	56	140	-79	59	19
2019 Sediment Inactivation High	58	26	36	120	-100	49	17
2022 Existing	14	4	50	68	-	74	28
2022 Sediment Inactivation Low	14	4	18	36	-32	48	15
2022 Sediment Inactivation High	14	4	12	31	-38	41	14

[1] Existing conditions summer average concentrations are calculated from calibrated in-lake models

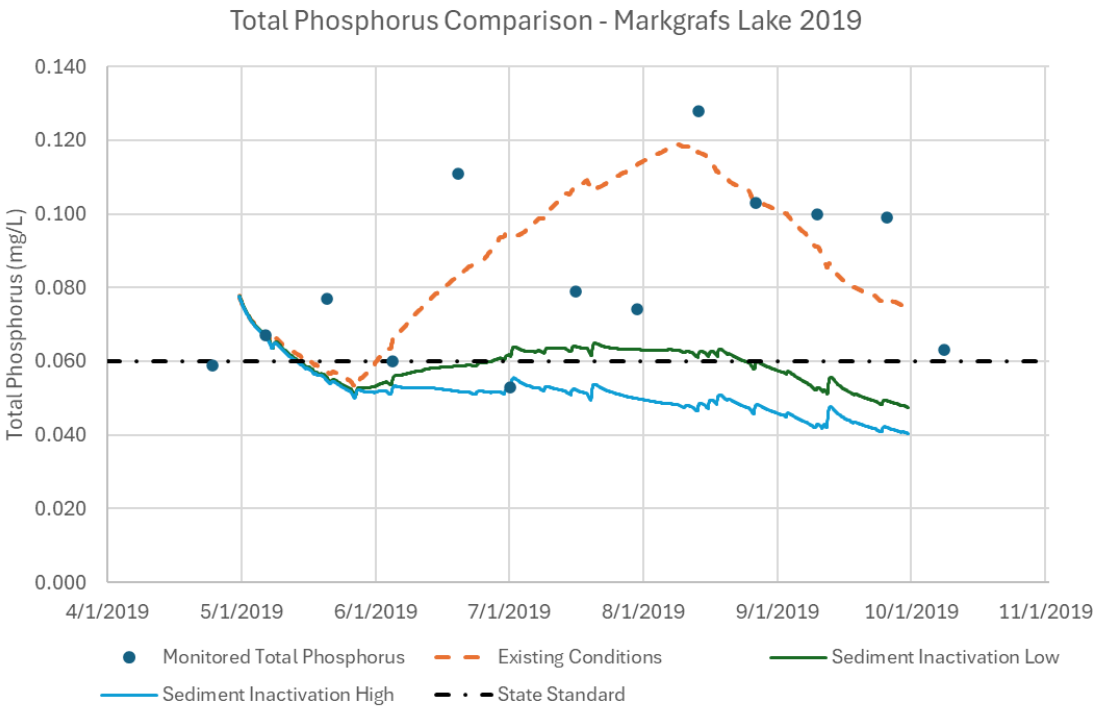


Figure 8-4 **Model-predicted reductions in 2019 total phosphorus concentrations in Markgrafs Lake with the proposed management practices**

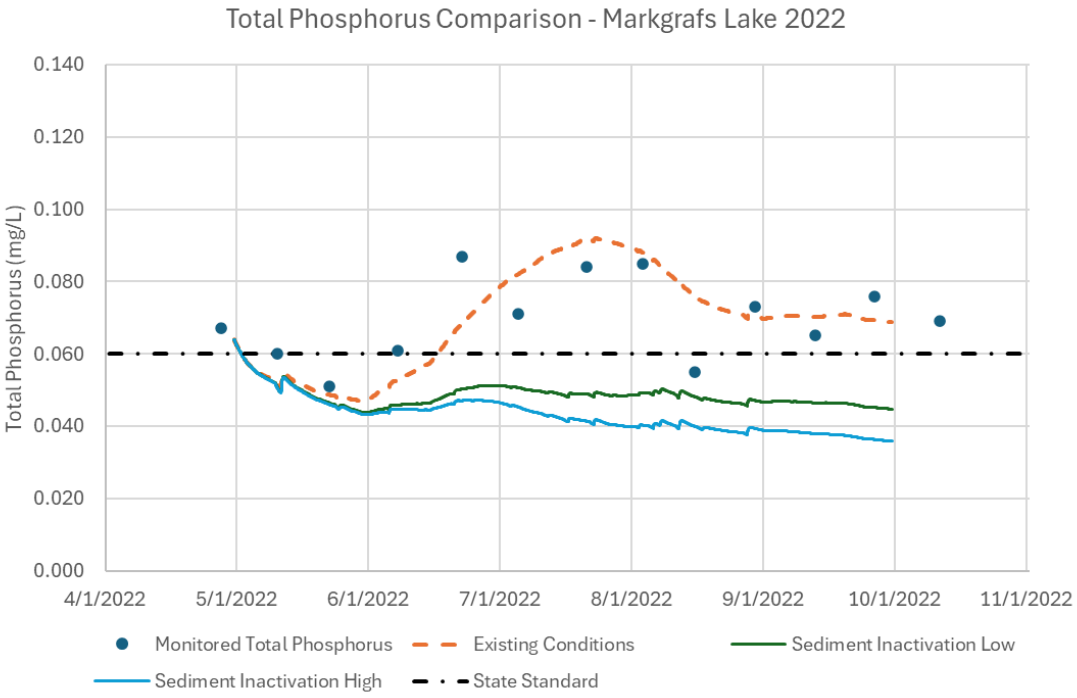


Figure 8-5 **Model-predicted reductions in 2022 total phosphorus concentrations in Markgrafs Lake with the proposed management practices**

Based on these results, it's predicted that implementing sediment inactivation practices within Markgrafs Lake could be sufficient to reduce summer average in-lake concentrations for total phosphorus and chlorophyll-*a* to below the state standards. As noted earlier, the in-lake model results represent the expected lake response to a reduction in internal phosphorus loading from lake bottom sediments during the 2019 and 2022 growing seasons if those management practices had been in place. The various model scenarios incorporate a range of assumed sediment-treatment efficacies to account for application variability and the fact that the specific treatment approach (alum, alum/iron, or aeration) has not yet been selected. Assumed efficacies were informed by monitoring data from comparable Barr sediment-inactivation projects one year post-implementation.

Monitoring of past projects shows that sediment inactivation efficacy can vary and is expected to decline over time due to product aging, new watershed inflows, and/or burial from rough fish activity. As such, results presented in this report provide an estimate of the expected scale of treatment impacts within a given growing season, but do not account for longer-term changes within the system and how that may impact benefits over time. For more information on the sediment inactivation modeling assumptions see Section 6.4.

8.6 Management Recommendations

Monitoring of Markgrafs Lake indicates degraded water quality and shows that the lake has not met water quality standards for most of the historical record. Aquatic plant monitoring from 2021, indicates a degraded plant community that is likely stressed from cultural eutrophication and threatened by the aquatic invasive species, curly-leaf pondweed. Given this, future management efforts should focus on improving lake water quality and ecosystem health, monitoring for changes, and continuing water quality and ecosystem health protection measures as improvements are achieved. Table 8-3 summarizes the recommended management strategies that could be considered for Markgrafs Lake to help improve water quality conditions and ecological health.

Table 8-3 Markgrafs Lake management recommendations

Management/Protection Action		Basis
Address external watershed loads	Enhanced street sweeping program	Continue to work with the City of Woodbury to refine an enhanced street sweeping program to reduce pollutant loading to stormwater runoff
	Stormwater BMPs	Consider retrofitting or installing new stormwater BMPs in subwatersheds that are currently untreated or undertreated Implement site scale BMPs as opportunities arise
	Chloride	Consider applying chloride reduction strategies such as education and implementation assistance to the City of Woodbury and other stakeholders.
Address internal loads	Sediment inactivation treatment	Review and implement a sediment inactivation treatment to reduce lake bottom sediment phosphorus loads
Aquatic Plants	Invasive species management	Continue to monitor invasive species growth (e.g., curly-leaf pondweed) and continue management as needed
	Promote native aquatic plant growth	Encourage native plant reestablishment to promote clear water conditions and competition with algae
Fisheries	Fisheries Monitoring	Consider collecting fish community data
Phytoplankton and Zooplankton	Phytoplankton/Zooplankton Monitoring	Consider monitoring phytoplankton and zooplankton as part of routine monitoring
Water Quality	Water quality monitoring	Continue monitoring in-lake water quality and assessing for eutrophication Continue to identify/track chloride levels from winter salt use Collect additional information on groundwater contributions into the lake (water quality, groundwater-surface water interactions) to confirm impacts

9 Powers Lake

9.1 Water Quality

Powers Lake is located in the city of Woodbury and is used for active and passive recreation and wildlife viewing. Powers Lake is one of the upstream lakes in the multi-lake system included in this study. When water levels are high enough, water discharges via a pumped outlet system from Powers Lake through a storm sewer system, which ultimately discharges to South Wilmes Lake.

Shallow/Deep	Deep
Location	Woodbury
Surface Area	61 acres
Average/Maximum Depth	19 feet / 36 feet
Watershed Area	1,263 acres
Watershed:Lake Surface Area	21:1
Impairment Status	Not listed on impaired waters list
Downstream Waterbody	South Wilmes Lake

Powers Lake has a water surface area of approximately 61 acres, a maximum depth of 36 feet, and a mean depth of approximately 19 feet. Powers Lake is deep enough that aquatic plants will only grow in the photic zone of the lake and the lake will typically only mix to full depth twice per year (dimictic lake).

The State of Minnesota uses three water quality parameters to assess eutrophication standards within lakes—total phosphorus, chlorophyll-*a*, and Secchi disk transparency—to assess waterbody health and track water quality changes. These three parameters were measured in Powers Lake by the SWWD between 1994-2023 (Figure 9-1). Monitoring data collected in 2000 and 2001 was collected at a reduced frequency from other monitored years. Not enough measurements were collected to calculate summer averages for those years. During the monitored years with adequate data, summer average total phosphorus concentrations were better than the state standard between 1994-2004, 2008-2009, 2012-2021, and 2023. Summer average chlorophyll-*a* concentrations were better than the state standard between 1994-1996, 2008, 2012-2013, 2018-2019, and 2021-2023. Otherwise, summer average chlorophyll-*a* concentrations have exceeded the state standard, ranging between 15 - 35 µg/L. Summer average Secchi depths met or were better than the state standard for all monitored years except 2005. At the time of this study, Powers Lake was not listed on the Minnesota impaired waters list.

Total phosphorus concentrations in the hypolimnion (deep waters) of Powers Lake can be notably higher than the concentrations observed in the epilimnion (surface waters) due to strong stratification during the summer months. For example, the 2019 summer average total phosphorus concentrations observed in the epilimnion was 32 µg/L as compared to a summer average of 712 µg/L in the hypolimnion. Phosphorus that is released from lake bottom sediment during this time of the year can remain largely confined in the hypolimnion due to strong lake stratification and reduced lake mixing.

Chloride concentrations were measured by the SWWD between 2003-2023 (generally between April and September) at various depths in Powers Lake. In the historical record, all observed chloride concentrations were below the MPCA chronic standard of 230 mg/L. Observed chloride concentrations in the epilimnion ranged from 11 – 94 mg/L throughout the monitoring period. Observed chloride concentrations in the hypolimnion ranged from 38 – 209 mg/L. However, monitoring year 2019 was an outlier and had notably higher hypolimnion chloride concentrations than any other monitored year, ranging from 55 – 209 mg/L. Most of the observed hypolimnion chloride concentrations are less than 60 mg/L.

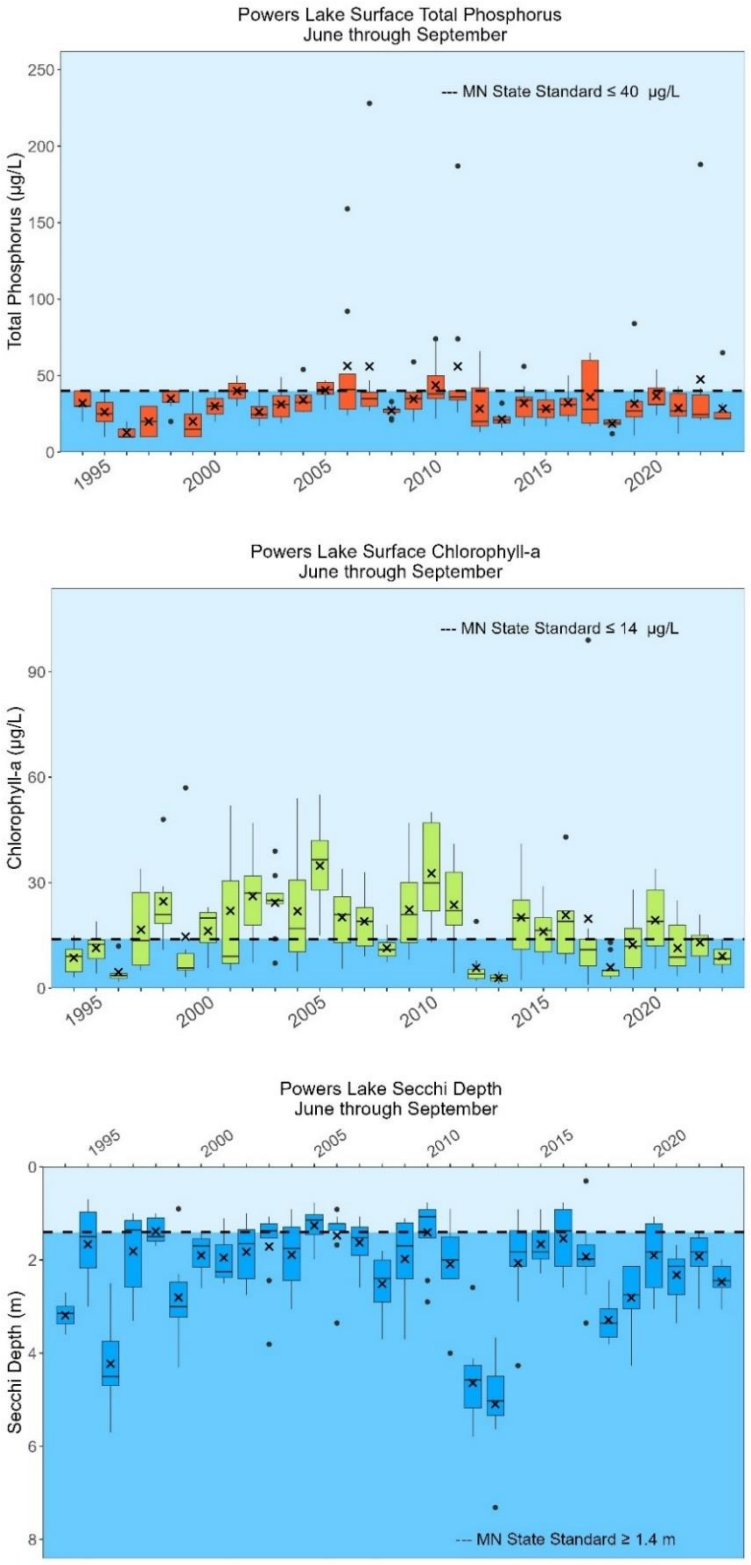


Figure 9-1 **Powers Lake eutrophication monitoring data (June-September)**
Summer averages are shown by x's in the box plots

9.2 Ecological Health

9.2.1 Aquatic Plants

Table 9-1 summarizes the calculated Lake Plant Eutrophication IBI values for Powers Lake based on point-intercept plant surveys completed in 2021 and 2024. Powers Lake scored below both plant IBI metrics in June 2021 and August 2024. However, in August 2021, Powers Lake scored just above both plant IBI metrics. In June 2024, Powers Lake met the species richness threshold, but fell below the FQI threshold. Table 9-1 also summarizes the percentage of the littoral area where aquatic plants were found and lists observed aquatic invasive species, their frequency of occurrence (FOO), and current management practices. At the time of this study, SWWD had not actively managed curly-leaf pondweed or Eurasian watermilfoil. Other plant health metrics can be referenced in the 2021 and 2024 Aquatic Vegetation Survey Results reports (Stantec, 2021, 2025).

Table 9-1 Powers Lake aquatic plants overview

Lake	Parameter	June 2021[1]	August 2021[1]	June 2024[2]	August 2024[2]	MnDNR Threshold	Invasive Species Management
Powers	Species Richness	10	13	12	10	>12	
	Floristic Quality Index (FQI)	16.3	19.2	17	14.2	>18.6	
	% Littoral with Vegetation	86%	85%	88%	77%		
	Curly-leaf Pondweed FOO	46%	18%	42%	-		No management to date
	Eurasian Watermilfoil FOO	3%	9%	36%	53%		No management to date
	Purple Loosestrife FOO	P	P	-	-		Managed naturally by leaf eating beetles

[1] (Stantec, 2021 Aquatic Vegetation Survey Results, 2021)
[2] (Stantec, 2025)

9.2.2 Fisheries

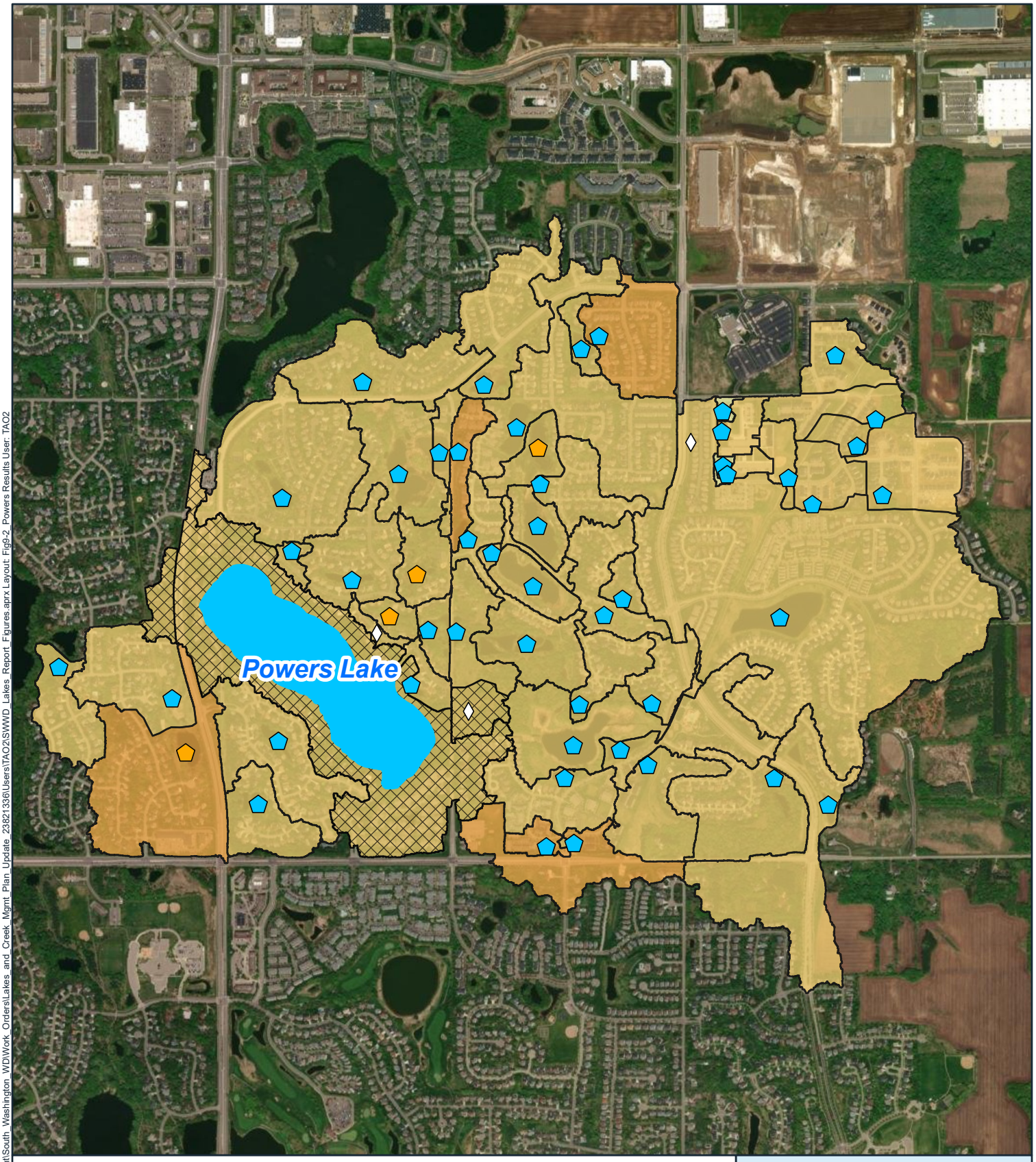
Powers Lake is included in the Fishing in the Neighborhood (FiN) program run by the MNDNR, which is aimed at increasing angling opportunities, public awareness, and environmental stewardship within the seven-county Twin Cities metro area. The MNDNR FiN program is actively involved in managing the sport fish populations of Powers Lake and as such the fish community is surveyed at a regular frequency. Table 9-2 summarizes the fish community data from the most recent survey conducted in July 2022 (MNDNR, LakeFinder, 2022).

Table 9-2 Powers Lake fish survey report - 2022 (MNDNR, LakeFinder, 2022)

Catch Method	Fish Species	Catch per Unit Effort (CPUE)	Normal CPUE Range	Count
Standard trap nets	Black crappie	22.0	1.8 – 18.1	110
	Bluegill	42.2	6.5 – 59.6	211
	Golden shiner	0.2	0.2 – 1.4	1
	Hybrid sunfish	0.4	N/A	2
	Largemouth bass	0.4	0.3 – 0.8	2
	Northern pike	0.2	N/A	1
	Pumpkinseed	0.8	0.8 – 5.3	4
	Walleye	0.4	0.3 – 1.2	2
	Yellow perch	0.4	0.3 – 1.5	2
Standard gill nets	Northern pike	2.0	2.5 – 7.9	2
	Yellow perch	6.0	1.5 – 12.8	6
Standard electrofishing	Largemouth bass	176.8	N/A	193

9.3 Watershed Total Phosphorus Loads

P8 modeling shows low to moderate watershed phosphorus loading to Powers Lake, with higher loads coming from areas of more dense residential development south of Powers Lake and pockets of single-family home neighborhoods that may have undersized treatment. The map in Figure 9-2 shows the estimated effective areal phosphorus loading by subwatershed, the modeled BMPs, and untreated subwatersheds. The effective phosphorus load represents the loading rate after pollutant removal by BMPs within the watershed and is reflective of the loading that actually makes it into the receiving waterbody from a given location. The effective phosphorus loads for the Powers Lake subwatersheds range from 0.3 pounds per acre per year to 0.8 pounds per acre per year, based on a 10-year modeling period (2012-2022). The direct drainage area to Powers Lake does not receive any treatment before runoff discharges to the lake. Additionally, the model results for 2012-2022 do not include treatment from stormwater BMPs at Hasenbank Park, east of Powers Lake across St. Johns Drive. More information on how the BMPs at Hasenbank Park are expected to impact Powers Lake are included in Section 9.5.



Lake

P8 Device Type

Dry Pond

Wet Pond

Pipe

Effective TP Load (lbs/ac/yr)

0.0 - 0.3

0.3 - 0.6

0.6 - 1.0

1.0 - 1.5

1.5 - 2.0

> 2.0

Area Not Treated by BMP

N

0 500 1,000

Feet

Powers Lake
Effective TP Loading
Lake Management Plan
South Washington
Watershed District

FIGURE 9-2

BARR

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9.4 In-lake Total Phosphorus Loads

The in-lake model was developed to simulate water quality conditions within the fully mixed epilimnion volume (surface waters) of Powers Lake given that Powers Lake is a deep lake and typically experiences long durations of stratification during the growing season with a distinct epilimnion mixing layer, thermocline, and hypolimnion. The profile monitoring data was used to estimate the volume of the epilimnion throughout the model period. The total phosphorus loading estimates provided in Figure 9-3 represent the phosphorus loads to the mixed, epilimnion layer of Powers Lake. As such, the reported phosphorus load from lake bottom sediment represents the phosphorus load from shallow sediment located in the epilimnion zone as well as phosphorus that migrated to the epilimnion from the hypolimnion via diffusion or mixing events. Phosphorus load estimates to the hypolimnion were not estimated as a part of this study.

Results of the in-lake modeling for Powers Lake show that during the summer of 2019 (representing a wet year), the phosphorus loading to Powers Lake from watershed runoff was greater than the contribution from internal loading. Phosphorus originating from watershed runoff represented 60% (259 lbs) of the phosphorus loading to the lake during summer 2019 (Figure 9-3). Internal loading in summer 2019 was estimated to be 40% (171 lbs) of the phosphorus load to the lake. During the drier summer of 2022, the phosphorus loading to Powers Lake from watershed runoff was notably lower at 73 lbs, representing 51% of the phosphorus loading to the lake. Internal loading in 2022 was also notably lower than 2019 at 70 lbs, representing 49% of the phosphorus load.

Differences in annual lake stratification can influence lake mixing potential as well as the anoxic area over lake bottom sediment, which ultimately influences the potential total phosphorus load that reaches surface waters from lake bottom sediment. Biweekly profile monitoring data is typically collected from Powers Lake between April and October, including the collection of temperature and dissolved oxygen concentrations. The data indicates that Powers Lake can have temperature stratification as early as late April or early May most years, and typically remains stratified until fall. When large storm events occur, there is potential for partial lake mixing, which may result in higher phosphorus concentrations from the metalimnion or hypolimnion reaching the surface waters (epilimnion). Comparing the profile monitoring data between model years 2019 and 2022 indicates that Powers Lake mixed to greater depths in 2019. Intensified lake mixing to deeper depths could be a reason why there was increased internal phosphorus load observed in the 2019 Powers Lake in-lake model. Phosphorus fraction data gathered from sediment cores collected from Powers Lake in 2024 indicated a high potential for internal phosphorus loading. Additional details on the sediment core data can be found in Section 4.8.

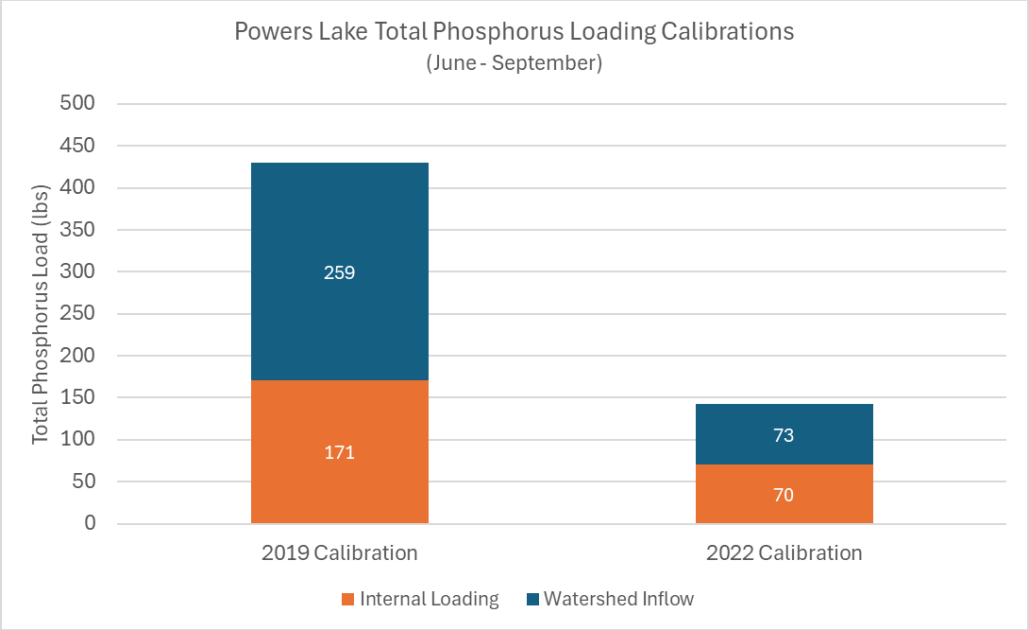


Figure 9-3 Powers Lake total phosphorus load estimates – 2019 & 2022

9.5 Predicted Benefits from Recent Capital Projects

One of the goals of the SWWD with this study was to understand how newly constructed BMPs within the District can be anticipated to impact water quality within downstream receiving waterbodies. The calibrated in-lake models for Powers Lake were used to estimate the impact of the stormwater BMPs within the Hasenbank Park Project on lake water quality. Although the project wasn't operational until 2025, to gain some understanding of how the project can be expected to impact water quality, the BMPs were turned on in the p8 model to simulate watershed nutrient reductions for model years 2019 and 2022.

Table 9-3 summarizes the estimated phosphorus load reduction from watershed inputs during the 2019 and 2022 summer growing periods, assuming the installation of BMPs at Hasenbank Park. A reduction of 14 – 44 pounds of total phosphorus loading to Powers Lake is estimated based on model results for a wet (2019) and dry (2022) year. This reduction in phosphorus load translates to a reduction in the total phosphorus concentration in the lake, with the 2019 summer average total phosphorus concentration of 38 µg/L reduced to 36 µg/L and the 2022 summer average total phosphorus concentration of 26 µg/L reduced to 25 µg/L (Table 9-5). Figure 9-4 and Figure 9-5 summarize the predicted reductions in in-lake total phosphorus concentrations for the 2019 and 2022 model years, respectively.

Evaluating watershed BMPs over a single growing season provides an incomplete picture of their effectiveness. A multi-year perspective better captures the cumulative nutrient reduction benefits that watershed BMPs offer to downstream waterbodies. However, the in-lake modeling completed as a part of this study does not support a long-term benefits analysis.

Although this was not quantified using the in-lake models, it's expected that the Hasenbank Park Project will result in water quality improvements to downstream waterbodies. Reducing total phosphorus concentrations in Powers Lake will decrease phosphorus outflows downstream, creating positive impacts for South Wilmes, Colby, and Bailey Lakes.

Table 9-3 **Summer growing period estimated reductions in phosphorus loads and in-lake concentrations with the construction of the Hasenbank Park Project**

Year	Pounds of Phosphorus Removed (June – Sept)	Summer Average Concentration (µg/L)		
		Existing[1]	With Hasenbank	Reduction
2019 (wet summer)	-44	38	36	-2
2022 (dry summer)	-14	26	25	-1

[1] Existing conditions summer average concentrations are calculated from calibrated in-lake models

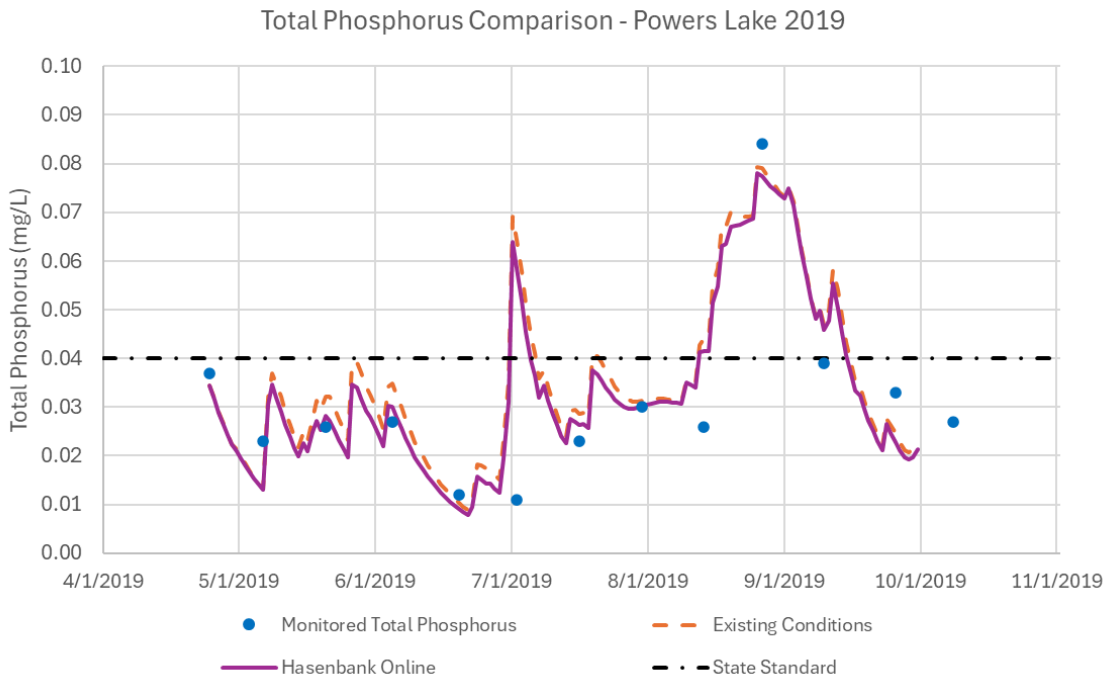


Figure 9-4 **Model predicted reductions in 2019 total phosphorus concentrations in Powers Lake assuming the Hasenbank Park projects were online**

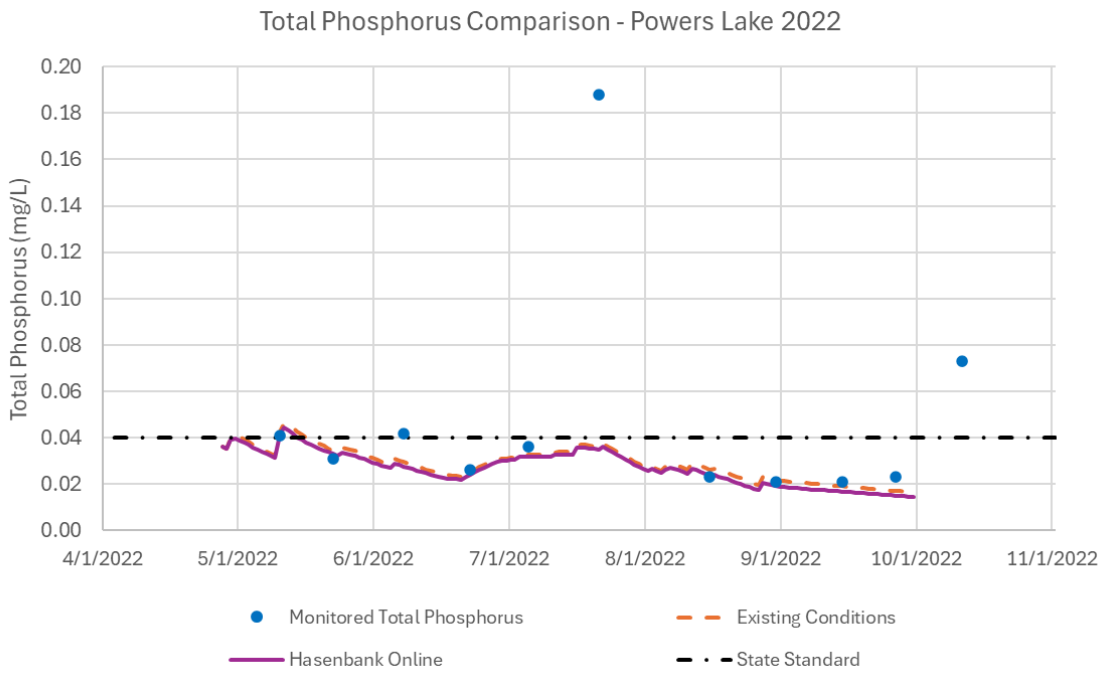


Figure 9-5 Model predicted reductions in 2022 total phosphorus concentrations in Powers Lake assuming the Hasenbank Park projects were online

SWWD has also recently launched a partnership with the City of Woodbury to perform enhanced street sweeping throughout city streets with the goal of reducing phosphorus loads to receiving waterbodies. As of the writing of this report, the City of Woodbury was planning to sweep all city streets once per month with a high efficiency vacuum sweeper. Based on a study completed in 2022, the estimated additional benefit of moving from a typical street sweeping schedule to monthly sweeping within the Powers Lake watershed would result in an additional approximately 7 lbs of TP removal from the estimated watershed loading to Powers Lake each year (Emmons & Olivier Resources (EOR), 2022). The 2022 report notes that estimated load reductions from additional sweeping should not be used for relative comparisons of total loadings due to their planning-level nature. Estimated watershed loading into Powers Lake for 2019 and 2022 is shown in Figure 9-3.

9.6 Predicted Benefits from Implementing In-lake Management Practices

Another study goal was to estimate the potential impact of lake sediment inactivation projects and how they could be used to improve in-lake water quality within the SWWD suburban lakes. The in-lake models that were modified to include the Hasenbank Park Project (Section 9.5) were used to estimate the impact of implementing sediment treatment projects in Powers Lake.

Table 9-4 summarizes the estimated phosphorus load reduction from three scenarios: Hasenbank Park Project only and Hasenbank Park Project coupled with sediment inactivation projects (low and high efficacies). Results from the in-lake modeling predict a reduction of 42 – 137 pounds of total phosphorus loading into Powers Lake through implementation of sediment inactivation practices for a wet (2019) and dry (2022) year. This reduction in phosphorus loading translates to a reduction in the in-lake total phosphorus concentrations. Model results estimate that the 2019 epilimnetic summer average total

phosphorus concentration of 38 µg/L would reduce to 23 - 25 µg/L with the implementation of sediment treatments and with the Hasenbank Park Project online; and the 2022 epilimnetic summer average total phosphorus concentration of 26 µg/L would reduce to 18 - 20 µg/L (Table 9-4). The existing summer average total phosphorus concentrations within Powers Lake already meet state standards, but implementing sediment inactivation projects would offer opportunities to further reduce phosphorus concentrations. Figure 9-6 and Figure 9-7 summarize the predicted reductions in in-lake total phosphorus concentrations for the 2019 and 2022 model years, respectively, for each of the proposed BMP scenarios.

Table 9-4 Summer growing period estimated reductions in phosphorus loads and in-lake concentrations in Powers Lake with the proposed management practices

Scenario	Modeled Summer Total Phosphorus Loading (lbs)				Summer Average Total Phosphorus (µg/L)[1]
	Watershed Inflow	Internal Loading	Total	Load Reduction	
2019 Existing	259	171	430	--	38
2019 Hasenbank Online	215	171	386	-44	36
2019 Hasenbank Online + Sediment Inactivation Low	215	68	283	-147	25
2019 Hasenbank Online + Sediment Inactivation High	215	34	249	-181	23
2022 Existing	73	70	143	--	26
2022 Hasenbank Online	59	70	129	-14	25
2022 Hasenbank Online + Sediment Inactivation Low	59	28	87	-56	20
2022 Hasenbank Online + Sediment Inactivation High	59	14	73	-70	18

[1] Existing conditions summer average concentrations are calculated from calibrated in-lake models

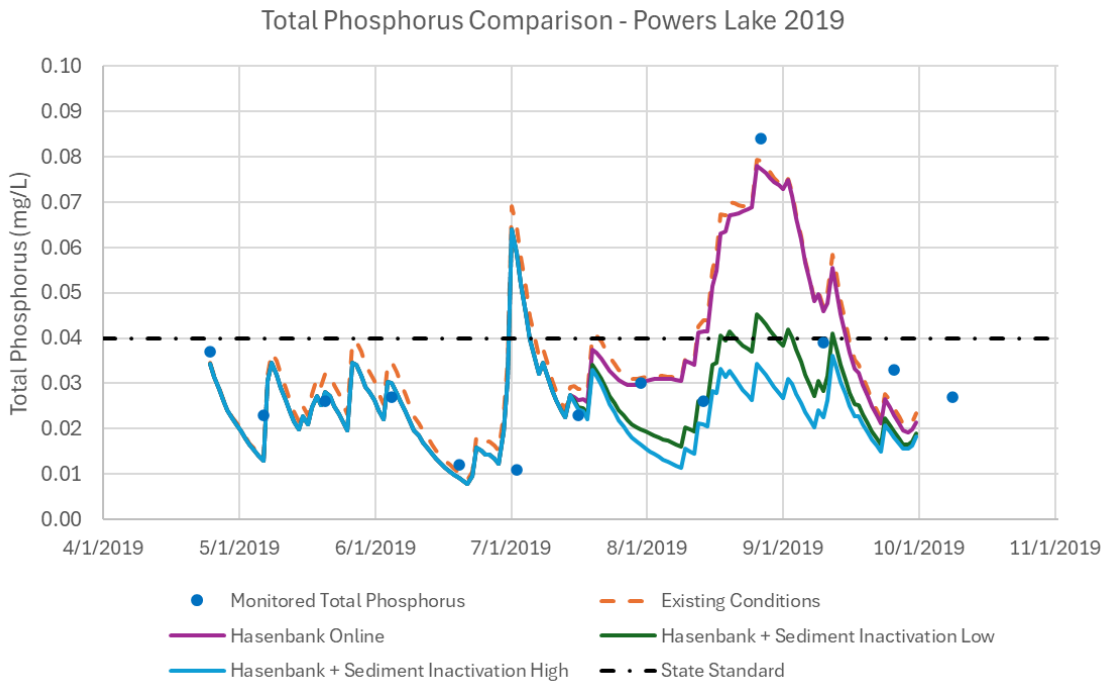


Figure 9-6 **Model-predicted reductions in 2019 (epilimnetic) total phosphorus concentrations in Powers Lake with the proposed management practices**

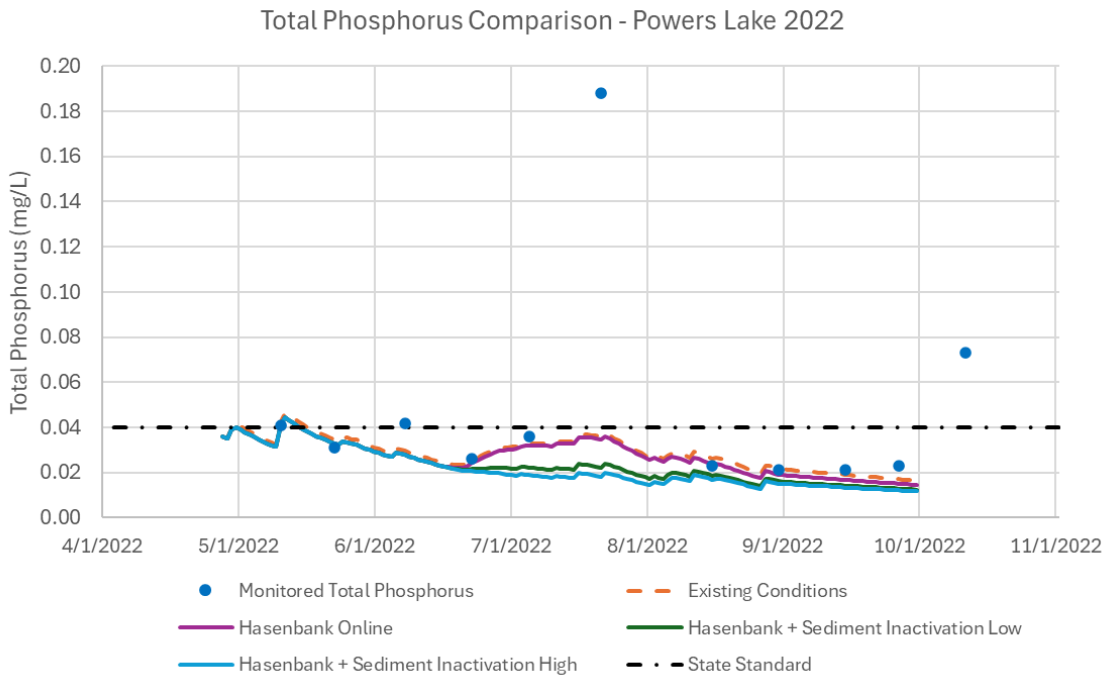


Figure 9-7 **Model-predicted reductions in 2022 (epilimnetic) total phosphorus concentrations in Powers Lake with the proposed management practices**

Model results estimating the in-lake response to reduced phosphorus loading—both from internal treatments and the Hasenbank Park Project—reflect the estimated impacts to in-lake conditions during the 2019 and 2022 growing seasons if those practices had been in place. The modeling incorporates a range of assumed sediment-treatment efficacies to account for application variability and the fact that the specific treatment approach (alum, alum/iron, or aeration) has not yet been selected. Assumed efficacies were informed by monitoring data from comparable Barr sediment-inactivation projects one year post-implementation. Monitoring of past projects shows that sediment inactivation efficacy can vary and is expected to decline over time due to product aging, new watershed inflows, and/or burial from rough fish activity. As such, results presented in this report provide an estimate of the expected scale of treatment impacts within a given growing season, but do not account for longer-term changes within the system and how that may impact benefits over time. For more information on the sediment inactivation modeling assumptions see Section 6.4.

9.7 Management Recommendations

Monitoring of Powers Lake in recent years indicates that the surface waters (epilimnion) are typically meeting state water quality standards. However, monitoring of the deep waters (hypolimnion) shows that total phosphorus concentrations can be more than 50 times the concentrations measured in the surface waters due to high internal loading from lake bottom sediment. Powers Lake also has a threatened native aquatic plant community due to the notable growth of the aquatic invasive species Eurasian water milfoil and curly-leaf pondweed. Given this, future management efforts should focus on protecting lake water quality and improving ecosystem health, monitoring for changes, and continuing water quality and ecosystem health protection measures as improvements are achieved. Table 9-5 summarizes the recommended management strategies that could be considered for Powers Lake to help improve water quality conditions and ecological health.

Table 9-5 Powers Lake management recommendations

Management/Protection Action		Basis
Address external watershed loads	Enhanced street sweeping program	Continue to work with the City of Woodbury to refine an enhanced street sweeping program to reduce pollutant loading to stormwater runoff
	Stormwater BMPs	Consider retrofitting or installing new stormwater BMPs in subwatersheds that are currently untreated or undertreated Implement site scale BMPs as opportunities arise
	Chloride	Consider applying chloride reduction strategies such as education and implementation assistance to the City of Woodbury and other stakeholders
Address internal loads	Sediment inactivation treatment	Review and consider implementing a sediment inactivation treatment to reduce lake bottom sediment phosphorus loads
Aquatic Plants	Invasive species management	Continue to monitor invasive species growth (e.g., curly-leaf pondweed, Eurasian watermilfoil) Consider herbicide management of curly-leaf pondweed and Eurasian watermilfoil to improve native aquatic plant health
	Promote native aquatic plant growth	Encourage native plant reestablishment during and following aquatic invasive species management
Phytoplankton and Zooplankton	Phytoplankton/Zooplankton monitoring	Consider monitoring phytoplankton and zooplankton as part of routine monitoring
Water Quality	Water quality monitoring	Continue monitoring in-lake water quality and assessing for eutrophication Continue to identify/track chloride levels from winter salt use

10 Wilmes Lake

10.1 Lake Water Quality

10.1.1 North Wilmes Lake

Wilmes Lake is located in the City of Woodbury and consists of two basins, North and South. North Wilmes is used primarily for wildlife viewing and passive recreation. When water levels are high enough, water discharges via gravity flow from North Wilmes Lake through a storm sewer culvert to South Wilmes Lake.

Shallow/Deep	Shallow
Location	Woodbury
Surface Area	19 acres
Average/Maximum Depth	7 feet / 21 feet
Direct Watershed Area	2,413 acres
Total Watershed Area	2,985 acres
Watershed:Lake Surface Area	157:1
Impairment Status	Impaired for nutrients since 2006
Downstream Waterbody	South Wilmes Lake

North Wilmes Lake has a water surface area of approximately 19 acres, a maximum depth of 21 feet, and a mean depth of approximately 7 feet. The MNDNR defines a shallow lake as a lake with a maximum depth of 15 feet or with 80% or more of the lake area shallow enough to support emergent and submerged rooted aquatic plants. North Wilmes Lake falls under the MNDNR classification of a “shallow lake” given that the lake’s littoral area is greater than 80%. North Wilmes Lake is deep enough that it’s feasible that prolonged periods of lake stratification could occur during the growing season. This could not be confirmed as part of this study as no monitoring data is currently being collected in this lake.

In-lake modeling performed for North Wilmes Lake as a part of this study is high level and has a high amount of relative uncertainty, given no monitoring data is currently available for the lake. Model results were verified for relative accuracy as part of calibrating downstream lake models.

10.1.2 South Wilmes Lake

Similar to the north basin, South Wilmes Lake is used primarily for wildlife viewing and passive recreation. When water levels are high enough, water discharges via gravity flow from South Wilmes Lake through a storm sewer system, which ultimately discharges to Colby Lake.

Shallow/Deep	Shallow
Location	Woodbury
Surface Area	20 acres
Average/Maximum Depth	8 feet / 18 feet
Direct Watershed Area	615 acres
Total Watershed Area	5,288 acres
Watershed:Lake Surface Area	264:1
Impairment Status	Impaired for nutrients since 2006
Downstream Waterbody	Colby Lake

South Wilmes Lake has a water surface area of approximately 20 acres, a maximum depth of 18 feet, and a mean depth of approximately 8 feet. South Wilmes Lake falls under the MNDNR classification of a “shallow lake” given that the lake’s littoral area is greater than 80% the total lake area. South Wilmes Lake is deep enough that prolonged periods of lake stratification occur during the growing season. Profile monitoring data collected within the lake supports this finding.

The State of Minnesota uses three water quality parameters to assess eutrophication standards within lakes—total phosphorus, chlorophyll-*a*, and Secchi disk transparency—to assess waterbody health and track water quality changes. These three parameters were measured in the south basin of Wilmes Lake by the SWWD between 1994-2023 (Figure 10-1). During the monitored years, summer average total phosphorus concentrations were better than the state standard in 1994, 2004, 2008, 2017 – 2020, and 2022 - 2023. All other monitored years exceeded the state standard summer average concentration. Summer average chlorophyll-*a* concentrations met or were better than the state standard in 1994, 2009 - 2011, 2016, and 2018 – 2019. Summer average Secchi depths met or were better than the state standard between 1994 – 1996, 1998 – 2000, 2003 – 2004, 2006 – 2012, 2014, 2016, and 2018 – 2023. Wilmes Lake was added to the Minnesota impaired waters list for nutrients in 2006 based on the monitoring data collected from the south basin.

Chloride concentrations were measured by the SWWD between 2013 - 2023 (generally between April and September). In the historical record, all observed chloride concentrations were below the MPCA chronic standard of 230 mg/L. The highest observed chloride concentration was 225 mg/L in May 2023.

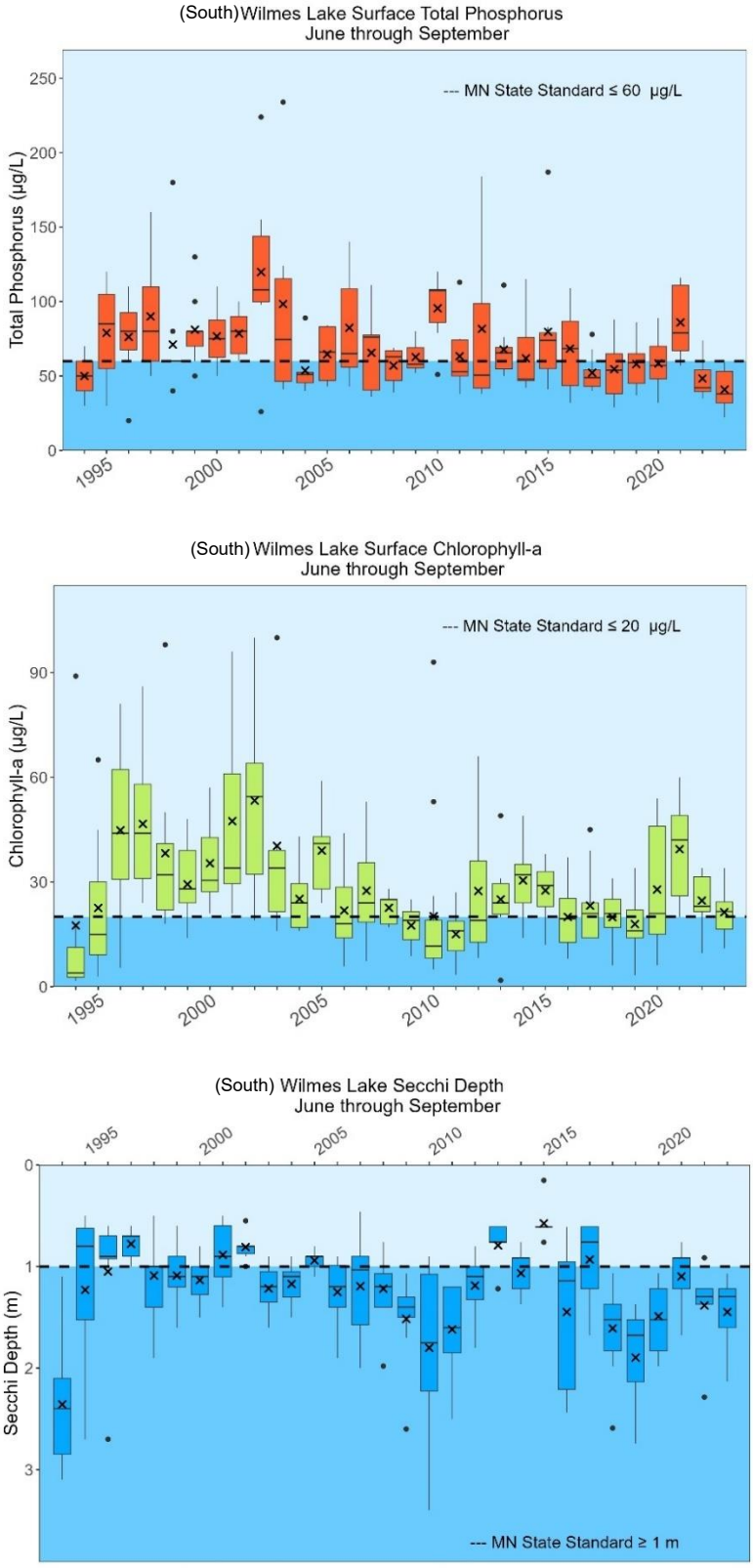


Figure 10-1 South Wilmes Lake eutrophication monitoring data (June – September)
Summer averages are shown by x's in the box plots

10.2 Ecological Health

10.2.1 Aquatic Plants

Table 10-1 summarizes the calculated Lake Plant Eutrophication IBI values for Wilmes Lake based on point-intercept plant surveys completed in 2021 and 2024. Wilmes Lake scored below both plant IBI metrics in June and August 2021 and in August 2024 indicating a degraded plant community that is likely stressed from cultural eutrophication. Table 10-1 also summarizes the percentage of the littoral area where aquatic plants were found and lists observed aquatic invasive species, their frequency of occurrence (FOO), and current management practices. Other plant health metrics can be referenced in the 2021 and 2024 Aquatic Vegetation Survey Results reports (Stantec, 2021, 2025).

Table 10-1 Wilmes Lake aquatic plants overview

Lake	Parameter	June 2021[1]	August 2021[1]	June 2024[2]	August 2024[2]	MnDNR Threshold	Invasive Species Management
Wilmes (N & S)	Species Richness	10	6	12	9	>11	
	Floristic Quality Index (FQI)	13.9	10.2	16.4	13.2	>17.8	
	% Littoral with Vegetation	75%	79%	75%	59%		
	Curly-leaf Pondweed FOO	23%	-	10%	-		Treated North Basin for CLP in 2024 & 2025
	Eurasian Watermilfoil FOO	27%	12%	25%	17%		Treated South Basin for EWM in 2024 & 2025

[1] (Stantec, 2021 Aquatic Vegetation Survey Results, 2021)
[2] (Stantec, 2025)

10.2.2 Fisheries

There are no MNDNR fish survey or stocking data available for Wilmes Lake.

10.3 Watershed Total Phosphorus Loads

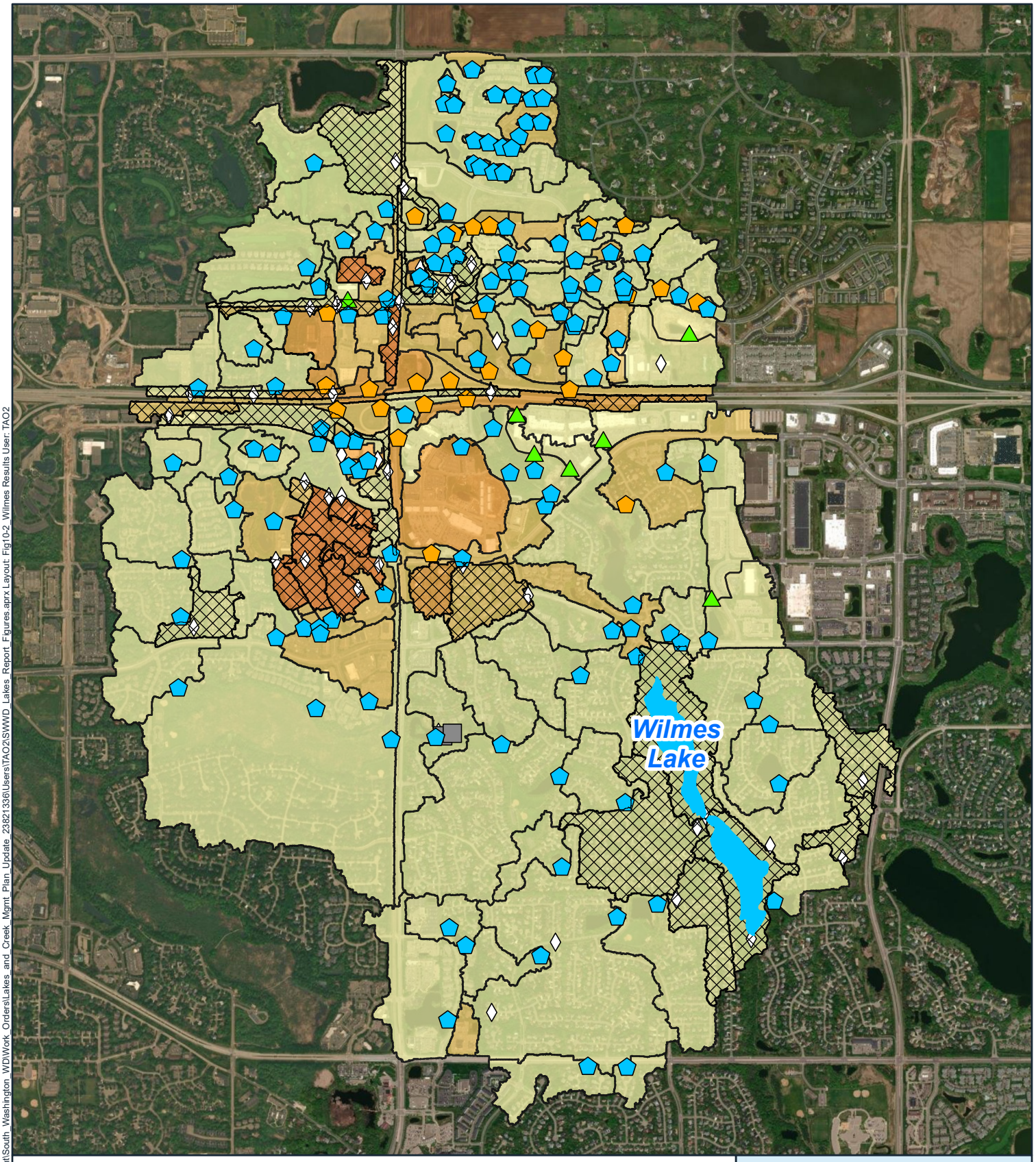
10.3.1 North Wilmes Lake

P8 modeling shows low to high watershed phosphorus loads to North Wilmes Lake, with higher loads coming from commercial areas north of Interstate 94, some of which are untreated by regional stormwater BMPs before entering the storm sewer system and discharging to North Wilmes Lake. The map in Figure 10-2 shows the effective areal phosphorus load by subwatershed, modeled BMPs, and the untreated subwatersheds. The model results include the Seasons Park CC17 filter, which is located within the North Wilmes Lake subwatershed. The effective phosphorus load represents the loading rate after pollutant removal by BMPs within the watershed and is reflective of the loading that actually makes it into the receiving waterbody from a given location. The effective phosphorus loads for the North Wilmes Lake subwatersheds range from 0.01 pounds per acre per year to 1.3 pounds per acre per year, based on a 10-year modeling period (2012-2022).

The model results for 2012-2022 do not include treatment from the Kargel Park Alum Treatment Facility, which is scheduled to go online in 2025. The alum facility will draw water flowing into the north end of North Wilmes Lake and treat it with alum before discharging treated water back into the lake. More information on how the Kargel Park Alum Treatment Facility is expected to impact North Wilmes Lake is included in Section 10.5.

10.3.2 South Wilmes Lake

P8 modeling shows low watershed phosphorus loads to South Wilmes Lake, given that the majority of the drainage area contributing to the lake is single-family residential properties. Some portions of the contributing drainage area are untreated before entering the storm sewer system and reaching the lake or have small rate control or energy dissipation BMPs that were designed to slow flows but not intended to provide significant water quality treatment. The map in Figure 10-2 shows the effective areal phosphorus load by subwatershed, modeled BMPs, and the untreated subwatersheds within this area. The effective phosphorus load represents the loading rate after pollutant removal by stormwater BMPs within the watershed and is reflective of the loading that actually makes it into the receiving waterbody from a given location. The effective phosphorus loads from the South Wilmes Lake subwatersheds range from 0.07 pounds per acre per year to 0.3 pounds per acre per year, based on a 10-year modeling period (2012-2022).



Lake

P8 Device Type

- Pipe
- Dry Pond
- General Device
- Wet Pond
- Infiltration Basin

Effective TP Load (lbs/ac/yr)

- 0.0 - 0.3
- 0.3 - 0.6
- 0.6 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0
- Area Not Treated by BMP

N

0 500 1,000
Feet

Wilmes Lake
Effective TP Loading
Lake Management Plan
South Washington
Watershed District

FIGURE 10-2

BARR

Barr Footer: ArcGISPro, 8/7/2025 4:47 PM File: I:\Client\South_Washington_WD\Work_Orders\Lakes_and_Creek_Mgmt_Plan_Update_23821336\Users\TAO2\SWWD_Lakes_Report_Figures.aprx Layout: Fig10-2_Wilmes Results User: TAO2

10.4 In-lake Total Phosphorus Loads

10.4.1 North Wilmes Lake

The in-lake model for North Wilmes Lake could not be calibrated as water quality data has not historically been collected within this lake. The North Wilmes in-lake model was developed using high level assumptions and extrapolations from other similar lake models. Outputs from the North Wilmes model were ultimately used to help calibrate the in-lake model for South Wilmes Lake.

Based on the high-level assumptions developed for the North Wilmes models, during the summer of 2019 (representing a wet year), the phosphorus loading into North Wilmes Lake was dominated by loading from the surrounding watershed, representing 73% (209 lbs) of the phosphorus load from major sources (Figure 10-3). Internal loading in 2019 was estimated to be 13% (36 lbs) of the phosphorus load to the lake. Total phosphorus loads from upstream Armstrong Lake were estimated to represent 14% (41 lbs) of the total phosphorus load to North Wilmes in 2019. During the drier summer of 2022, the phosphorus loading to the lake from watershed runoff was notably lower, representing 60% (49 lbs) of the phosphorus load into the lake. Internal loading in 2022 represented 40% (33 lbs) of the phosphorus load. In the summer of 2022, Armstrong Lake did not discharge to North Wilmes due to low water levels. Therefore, no phosphorus load was attributed to upstream Armstrong Lake in summer 2022 (0%, 0 lbs).

The total phosphorus loading estimates for North Wilmes Lake (presented in Figure 10-3) have a high level of uncertainty associated with them, given that no monitoring data was available for model calibration. If water quality monitoring data is collected in the future, it is recommended that the North Wilmes Lake model be revisited.

Given that the maximum depth of North Wilmes Lake is 21 feet, it's likely that the lake moderately to strongly stratifies during the summer growing season. The collection of lake profile data is recommended as part of future efforts to better estimate the influence of internal loading on lake water quality conditions. Understanding the role of lake stratification in internal loading dynamics will be important should the District decide to move forward with developing sediment inactivation strategies. The collection of profile water quality data is especially critical since the sediment core phosphorus fractionation data indicated a high potential for internal phosphorus loading from lake bottom sediment within North Wilmes Lake (Section 4.8).

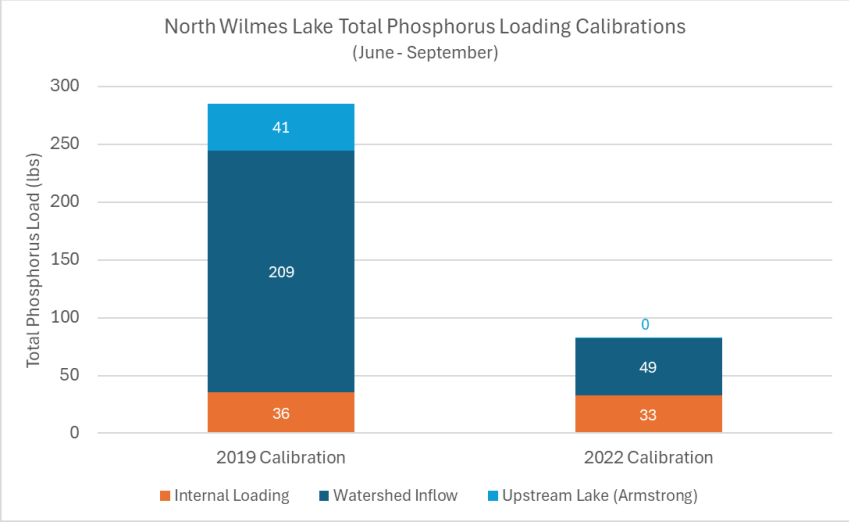


Figure 10-3 North Wilmes Lake total phosphorus load estimates – 2019 & 2022

10.4.2 South Wilmes Lake

Results of the in-lake modeling for South Wilmes Lake showed that during the summer of 2019 (representing a wet year), the phosphorus loading into South Wilmes Lake was dominated by upstream lake inputs, representing 82% (405 lbs) of the phosphorus loading from major sources (Figure 10-4). South Wilmes Lake is unique and is the only lake in this study with multiple upstream lakes. Figure 10-5 summarizes the estimated total phosphorus load from each upstream lake. In 2019, 34% (166 lbs) of the phosphorus load to South Wilmes was from North Wilmes Lake, 31% (156 lbs) from Markgrafs Lake, and 17% (83 lbs) from Powers Lake. Smaller total phosphorus loads were from internal loading (11%, 55 lbs) and watershed runoff (7%, 34 lbs).

During the drier summer of 2022, the phosphorus loading to South Wilmes Lake from upstream lakes was notably lower, representing 23% (12 lbs) of the phosphorus load into the lake. The phosphorus loading from upstream lakes in 2022 was 97% less than the phosphorus load estimated in 2019. In 2022, 16% (8 lbs) of the phosphorus load to South Wilmes was from Markgrafs Lake, 6% (3 lbs) from North Wilmes Lake, and 2% (1 lb) from Powers Lake. Total phosphorus loading from watershed runoff was also notably lower in 2022, representing 13% (6 lbs) of the load to South Wilmes Lake. Internal phosphorus loading estimates in 2022 were similar to 2019, representing 63% (32 lbs) of the phosphorus load.

Biweekly profile monitoring data is typically collected in South Wilmes Lake between April and October of each year, including the collection of temperature and dissolved oxygen concentrations. The data provided for this study indicates that South Wilmes Lake can have temperature stratification as early as late-April or early-May most years and typically remains stratified until fall. This was also observed in the in-lake model. To simulate lake stratification, model calibration parameters were adjusted to suppress the amount of internal phosphorus load reaching the surface waters during the growing season. Given that the monitoring data demonstrates strong lake stratification during the summer, the collection of water quality parameters at multiple depths is recommended to better estimate internal loading influence on surface water conditions (e.g., collecting phosphorus near the surface, at the thermocline, and near the bottom). Understanding how lake stratification influences internal loading will be essential for developing effective sediment inactivation strategies and demonstrating benefits, should the District decide to pursue this type of treatment. The collection of water quality parameters at multiple depths is especially important as sediment core phosphorus fractionation data indicate a high potential for phosphorus release from lake bottom sediment (Section 4.8).

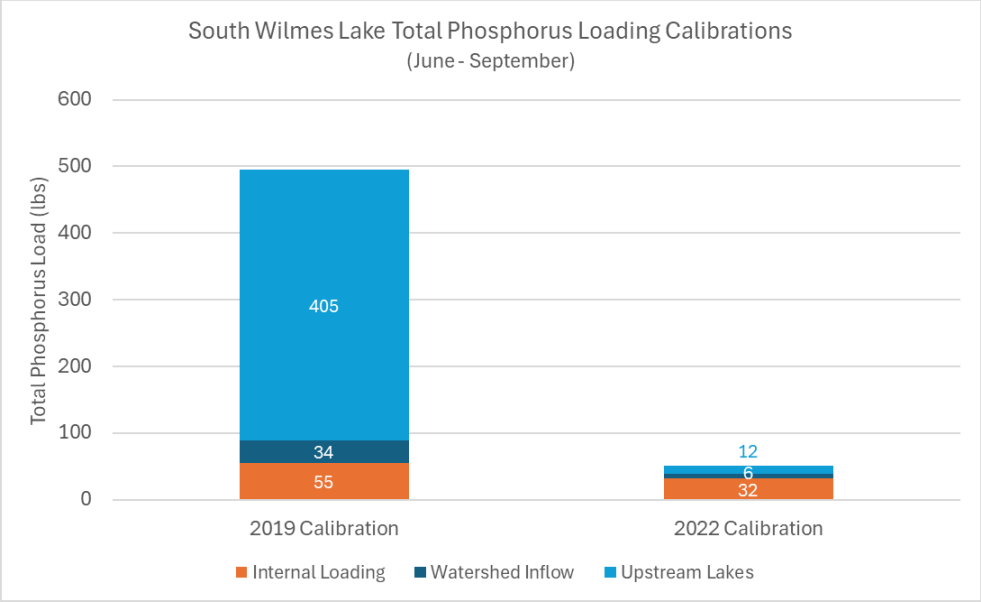


Figure 10-4 South Wilmes 2019 & 2022 estimated total phosphorus loads (June – Sept)

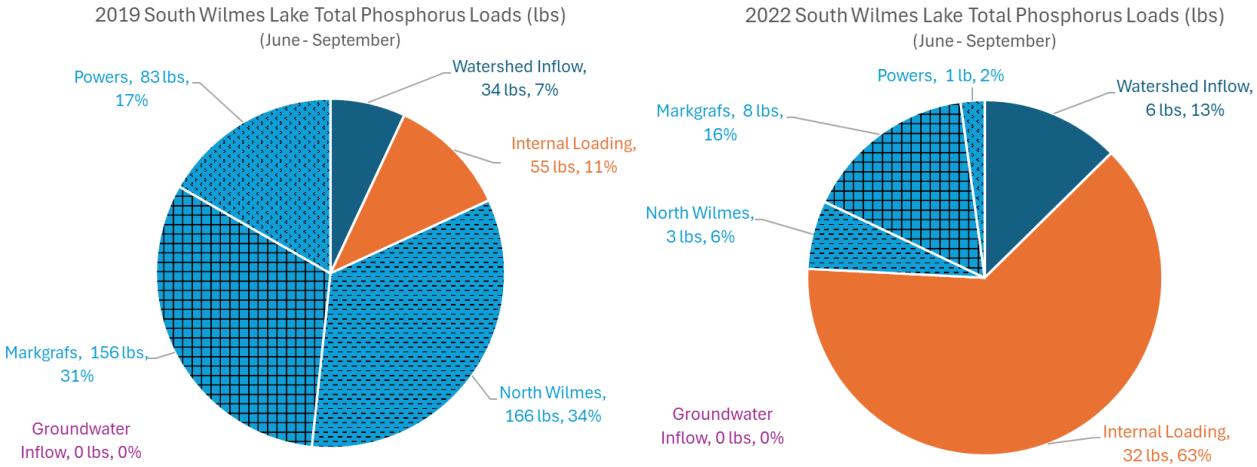


Figure 10-5 South Wilmes estimated total phosphorus loads per source (detailed)

10.5 Predicted Benefits from Recent Capital Projects

One goal of the SWWD with this study was to understand how newly constructed BMPs within the District can be anticipated to impact water quality within downstream receiving waterbodies. The in-lake models for North Wilmes Lake were used to estimate the impact of the Kargel Park alum treatment facility on lake water quality. Although the alum treatment facility was not put online until 2025, the predicted nutrient reductions of the facility (HRGreen, 2020) were used to simulate watershed nutrient reductions for model years 2019 and 2022, as a representation of performance under wet and dry conditions.

Table 10-2 summarizes the estimated phosphorus load reduction from watershed inputs during the 2019 and 2022 summer growing periods using assumptions identified within the 2020 HRGreen design memo for the facility (HRGreen, 2020). A reduction of 21 – 52 pounds of total phosphorus loading to North Wilmes Lake is estimated based on model results for a wet (2019) and dry (2022) year. This reduction in phosphorus load translates to a reduction in the estimated total phosphorus concentration to be expected in the lake, with the 2019 summer average total phosphorus concentration of 71 µg/L reduced to 57 µg/L and the 2022 summer average total phosphorus concentration of 57 µg/L reduced to 45 µg/L (Table 10-2). Figure 10-6 and Figure 10-7 summarize the predicted reductions in in-lake total phosphorus concentrations for the 2019 and 2022 model years, respectively.

Evaluating watershed BMPs over a single growing season provides an incomplete picture of their effectiveness. A multi-year perspective would better capture the cumulative nutrient reduction benefits that watershed BMPs can be expected to offer downstream waterbodies. The in-lake modeling completed as a part of this study does not support a long-term benefits analysis. The District could consider analyzing expected long-term benefits as part of future work.

Although it was not quantified as part of this study, it is expected that the Kargel Park alum treatment facility will also result in water quality improvements to waterbodies downstream of North Wilmes. Reducing total phosphorus concentrations in North Wilmes Lake will decrease phosphorus outflows, creating positive impacts for South Wilmes, Colby, and Bailey Lakes.

Table 10-2 Summer growing period estimated reductions in phosphorus loads and in-lake concentrations with the construction of the alum treatment facility

Year	Pounds of Phosphorus Removed (June – Sept)	In-lake Summer Average TP Concentration (µg/L)		
		Existing[1]	With Alum Treatment Facility	Reduction
2019 (wet summer)	-52	71	57	-14
2022 (dry summer)	-21	57	45	-12

[1] Existing conditions summer average concentrations are calculated from in-lake models

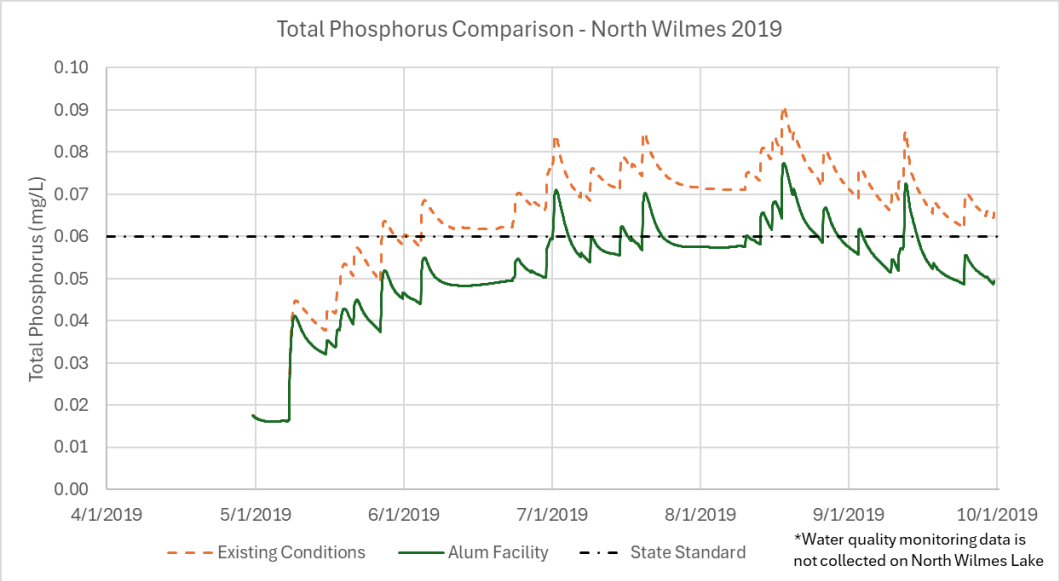


Figure 10-6 Model predicted reductions in 2019 total phosphorus concentrations in North Wilmes Lake assuming operation of the alum treatment facility

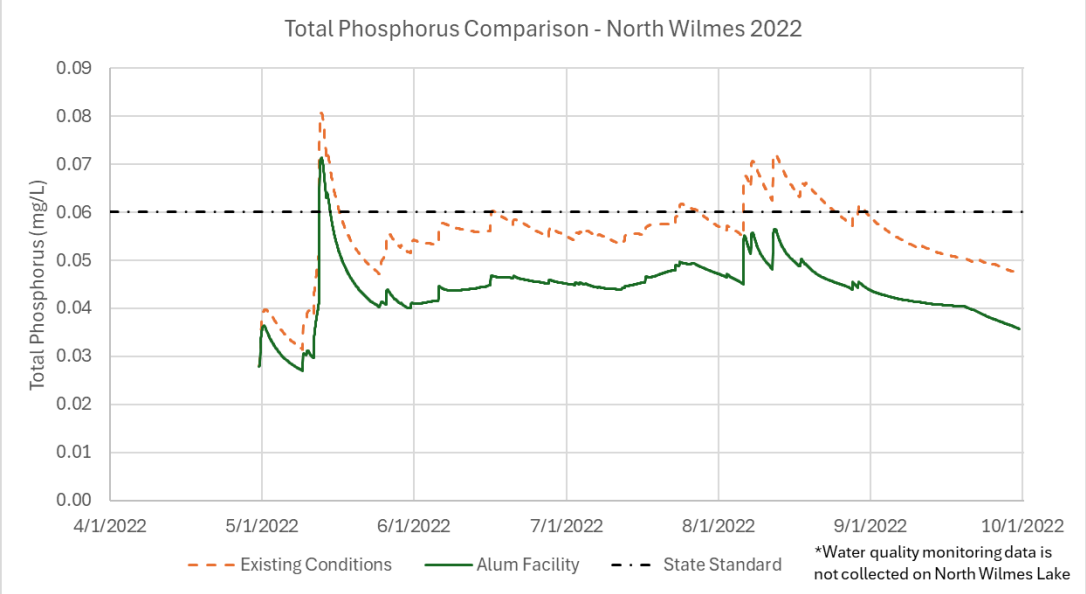


Figure 10-7 Model predicted reductions in 2022 total phosphorus concentrations in North Wilmes Lake assuming operation of the alum treatment facility

SWWD has also recently launched a partnership with the City of Woodbury to perform enhanced street sweeping throughout city streets with the goal of reducing phosphorus loads to receiving waterbodies. As of the writing of this report, the City of Woodbury was planning to sweep all city streets once per month with a high efficiency vacuum sweeper. Based on a study completed in 2022 (EOR, 2022) the estimated additional benefit of moving from a typical street sweeping schedule to monthly sweeping within the North Wilmes Lake watershed would result in an additional approximately 9 lbs of TP removal from the estimated watershed loading to North Wilmes Lake each year. The 2022 report notes that estimated load reductions from additional sweeping should not be used for relative comparisons of total loadings due to their planning-level nature. Estimated watershed loading into North Wilmes Lake for 2019 and 2022 is shown in Figure 10-3.

10.6 Predicted Benefits from Implementing Management Practices

10.6.1 North Wilmes Lake

Another of the study goals was to estimate the potential impact of lake sediment inactivation projects and how they could be used to improve in-lake water quality. The in-lake models that were modified to include the Kargel Park alum treatment facility (Section 10.5) were used to estimate the impact of implementing sediment treatment projects in North Wilmes Lake. For North Wilmes Lake, additional watershed load reductions were also analyzed to assess joint impacts on further improving in-lake conditions to meet state standards. Specific watershed BMPs were not modeled; instead, a percent reduction was applied to the watershed loading estimates across the watersheds directly tributary to North Wilmes Lake.

Table 10-3 summarizes the estimated phosphorus load reduction from four scenarios: the Kargel Park alum treatment facility being active; Kargel Park alum treatment facility coupled with sediment inactivation (low and high efficacies); Kargel Park alum treatment facility with sediment inactivation (low) and watershed load reductions. Results from the in-lake modeling predict a reduction of 27 – 30 pounds of total phosphorus loading into North Wilmes Lake through implementation of sediment inactivation practices for a wet (2019) and dry (2022) year. This reduction in phosphorus loading translates to a reduction in the in-lake total phosphorus concentrations. Model results estimate that the 2019 summer average total phosphorus concentration of 71 µg/L would reduce to 44 µg/L with the implementation of sediment treatments and the alum treatment facility; and the 2022 summer average total phosphorus concentration of 57 µg/L would reduce to 27 - 28 µg/L (Table 10-3).

Table 10-3 Summer growing period estimated reductions in phosphorus loads and in-lake concentrations in North Wilmes Lake with the proposed management practices

Scenario	Modeled Summer Total Phosphorus Loading (lbs)					Summer Average Total Phosphorus (µg/L)[1]	Summer Average Chlorophyll-a (µg/L)[1]
	Watershed Inflow	Upstream Lake	Internal Loading	Total	Load Reduction		
2019 Existing	209	41	36	285	--	71	27
2019 Alum Facility	158	41	36	234	-52	57	27
2019 Alum Facility + Sediment Inactiv. Low	158	41	7	205	-80	44	22
2019 Alum Facility + Sediment Inactiv. High	158	41	6	204	-81	44	22
2019 Alum Facility + Sediment Inactiv. Low + Watershed Reductions	129	41	7	176	-109	38	20
2022 Existing	49	0	33	82	--	57	51
2022 Alum Facility	28	0	33	62	-21	45	42
2022 Alum Facility + Sediment Inactiv. Low	28	0	6	35	-48	28	18
2022 Alum Facility + Sediment Inactiv. High	28	0	6	34	-48	27	17

[1] Existing conditions summer average concentrations are calculated from calibrated in-lake models

Based on these results, it's predicted that implementing sediment inactivation practices alone would not be sufficient to reduce summer average concentrations for total phosphorus and chlorophyll-*a* to below the state standards, especially in a wet year. To estimate the additional total phosphorus load reduction needed from watershed management practices to achieve standards for both parameters, we applied a percent reduction to the calibrated watershed loading model results in model year 2019. For this scenario, watershed load reductions were coupled with the Kargel Park alum treatment facility and sediment inactivation (low) assumptions to be conservative. During a wet year (2019), the modeling predicts that an additional 29 pounds of total phosphorus would need to be reduced to meet both total phosphorus and chlorophyll-*a* concentrations in North Wilmes Lake. Figure 10-8 and Figure 10-9 summarize the predicted reductions in in-lake total phosphorus concentrations for the 2019 and 2022 model years, respectively, for each of the proposed BMP scenarios.

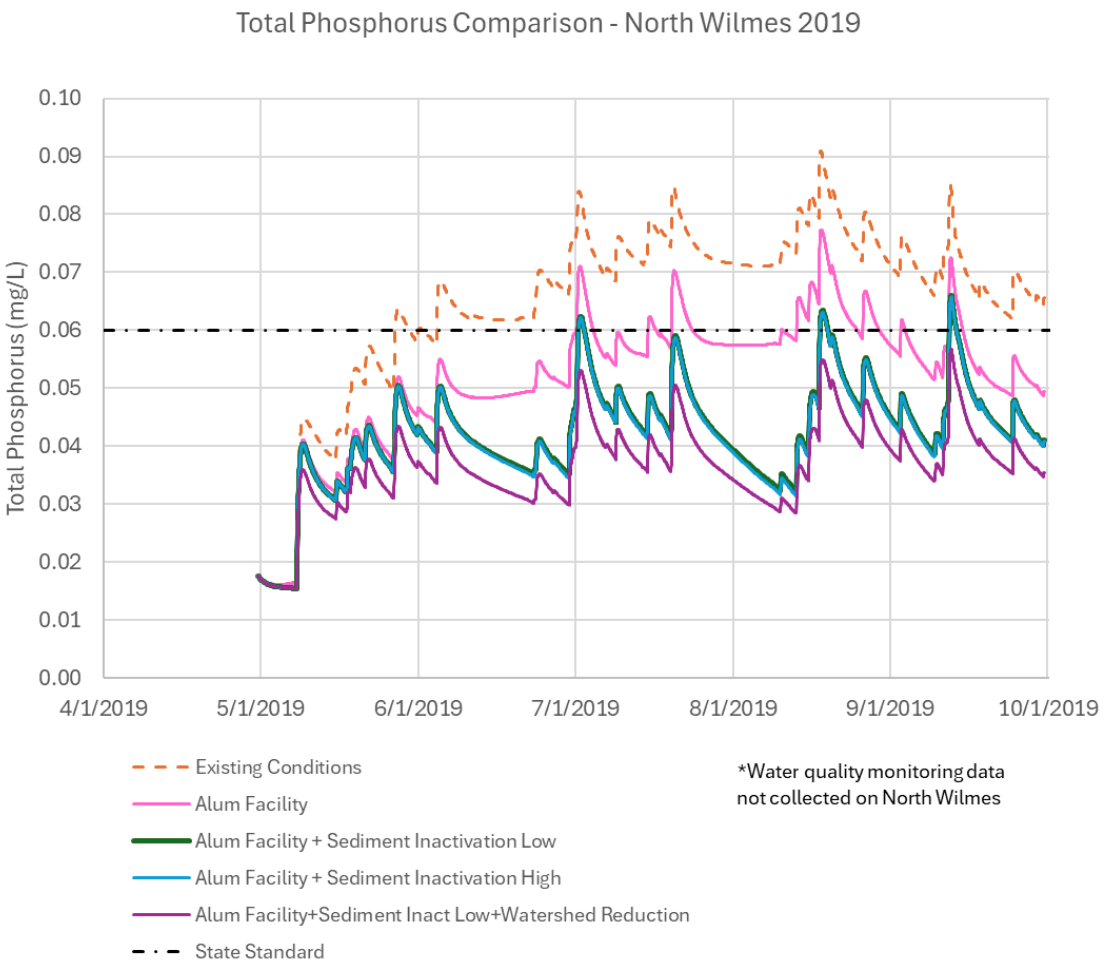


Figure 10-8 Model-predicted reductions in 2019 total phosphorus concentrations in North Wilmes Lake with the proposed management practices

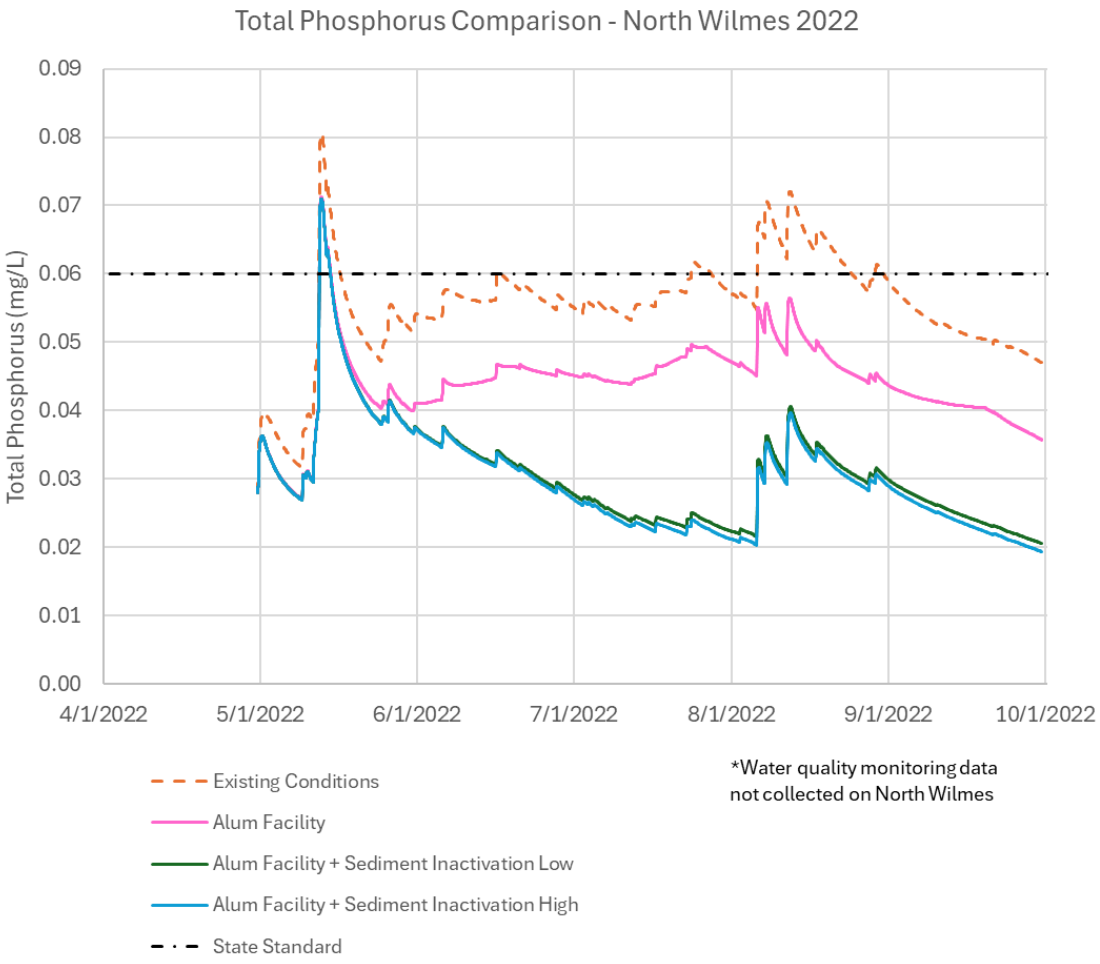


Figure 10-9 Model-predicted reductions in 2022 total phosphorus concentrations in North Wilmes Lake with the proposed management practices

Model results estimating the in-lake response to reduced phosphorus loading—both from internal treatments and the surrounding watershed—reflect the estimated impacts to in-lake conditions during the 2019 and 2022 growing seasons if those practices had been in place at that time. The modeling incorporates a range of assumed sediment-treatment efficacies to account for application variability and the fact that the specific treatment approach (alum, alum/iron, or aeration) has not yet been selected. Assumed efficacies were informed by monitoring data from comparable Barr sediment-inactivation projects one year post-implementation. Monitoring of past projects shows that sediment inactivation efficacy can vary and is expected to decline over time due to product aging, new watershed inflows, and/or burial from rough fish activity. As such, results presented in this report provide an estimate of the expected scale of treatment impacts within a given growing season, but do not account for longer-term changes within the system and how that may impact benefits over time. For more information on the sediment inactivation modeling assumptions see Section 6.4.

10.6.2 South Wilmes Lake

The calibrated in-lake models were used to estimate the impact of implementing sediment treatment projects in South Wilmes Lake. For the South Wilmes Lake scenarios, it was also assumed that all upstream lakes (except for Armstrong Lake) also had internal treatments implemented.

Table 10-4 summarizes the estimated phosphorus load reduction from two scenarios: sediment inactivation (low efficacy) and sediment inactivation (high efficacy). The sediment inactivation scenarios include assumed sediment treatments in both South Wilmes Lake and its upstream contributing waterbodies (except for Armstrong). Results from the in-lake modeling predict a reduction of 28 – 211 pounds of total phosphorus loading into South Wilmes Lake through implementation of sediment inactivation practices for a wet (2019) and dry (2022) year. This reduction in phosphorus loading translates to a reduction in the in-lake total phosphorus concentrations. Model results estimate that the 2019 summer average total phosphorus concentration of 60 µg/L would reduce to 35 - 38 µg/L with the implementation of sediment treatments; and the 2022 summer average total phosphorus concentration of 48 µg/L would reduce to 25 - 27 µg/L (Table 10-4Table 11-5). Figure 10-10 and Figure 10-11summarize the predicted reductions in in-lake total phosphorus concentrations for the 2019 and 2022 model years, respectively, for each of the proposed scenarios.

Table 10-4 Summer growing period estimated reductions in phosphorus loads and in-lake concentrations in South Wilmes Lake with the proposed management practices

Scenario	Modeled Summer Total Phosphorus Loading (lbs)					Summer Average Total Phosphorus (µg/L)[1]	Summer Average Chlorophyll-a (µg/L)[1]
	Watershed Inflow	Upstream Lakes	Internal Loading	Total	Load Reduction		
2019 Existing	35	405	55	495	-	60	28
2019 Sediment Inactivation Low	35	259	14	307	-188	38	20
2019 Sediment Inactivation High	35	239	11	284	-211	35	20
2022 Existing	7	12	32	52	-	48	28
2022 Sediment Inactivation Low	7	8	8	23	-28	27	12
2022 Sediment Inactivation High	7	7	6	21	-31	25	12

[1] Existing conditions summer average concentrations are calculated from calibrated in-lake models

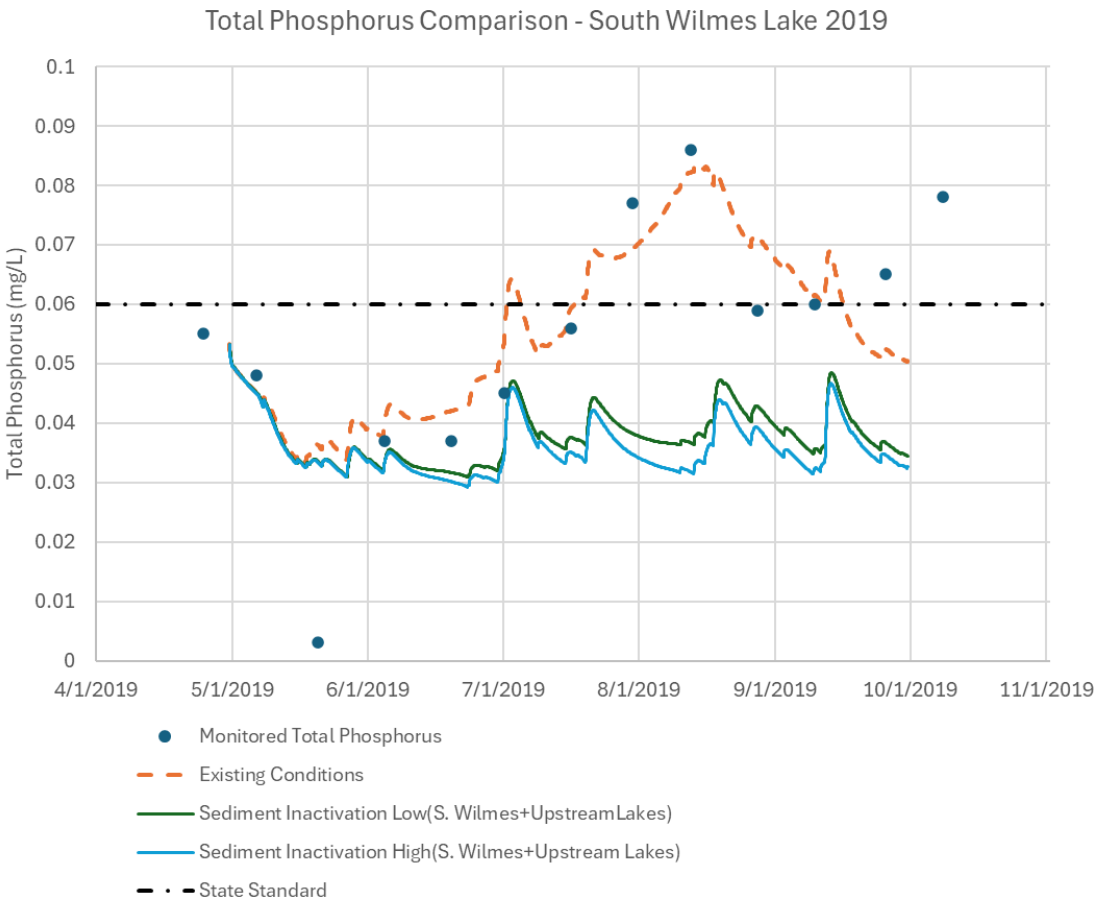


Figure 10-10 Model-predicted reductions in 2019 total phosphorus concentrations in South Wilmes Lake with the proposed management practices

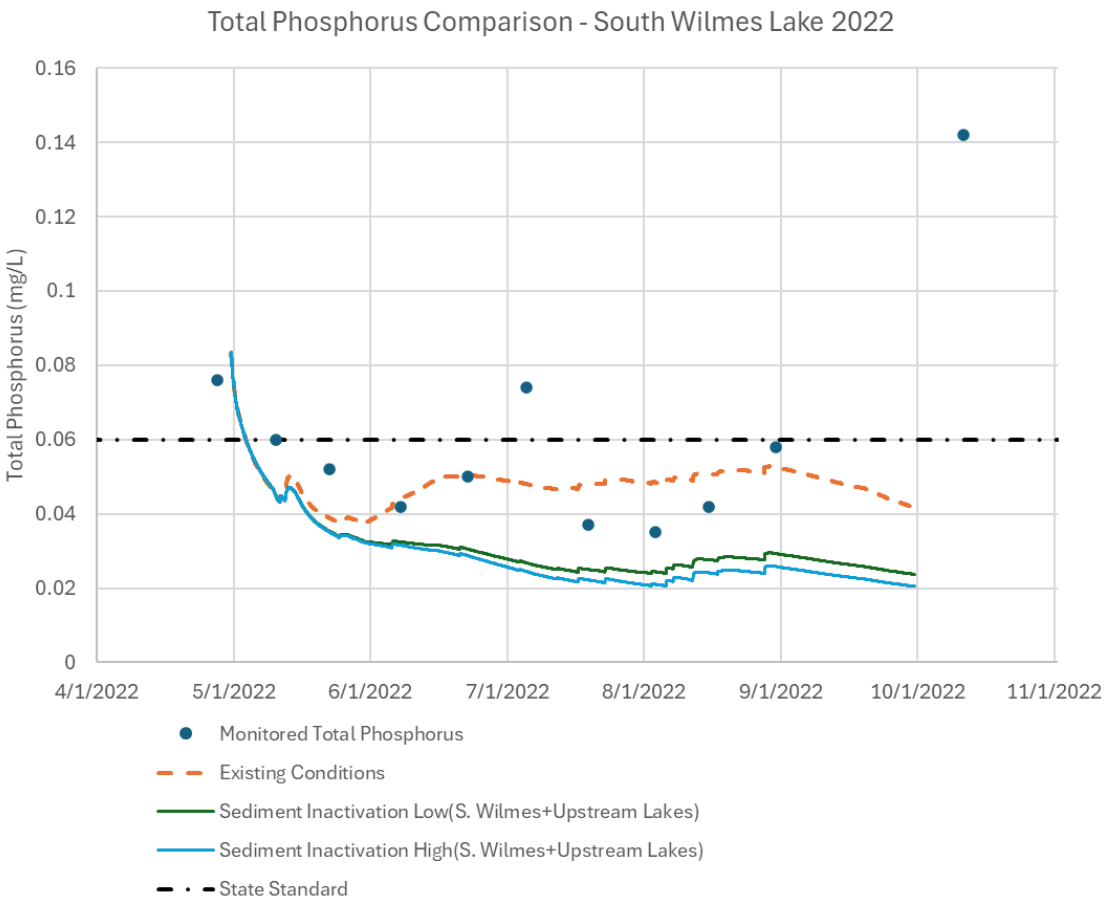


Figure 10-11 Model-predicted reductions in 2022 total phosphorus concentrations in South Wilmes Lake with the proposed management practices

Based on these results, it's predicted that implementing sediment inactivation practices in South Wilmes and its upstream lakes would be sufficient to reduce summer average in-lake concentrations for total phosphorus and chlorophyll-*a* to below the state standards. The in-lake model results represent the expected lake response to a reduction in phosphorus loading—from internal sediments in South Wilmes and its upstream lakes—during the 2019 and 2022 growing seasons if the conceptual management scenarios had been in place. The modeling incorporates a range of assumed sediment-treatment efficacies to account for application variability and the fact that the specific treatment approach (alum, alum/iron, or aeration) has not yet been selected. Assumed efficacies were informed by monitoring data from comparable Barr sediment-inactivation projects one year post-implementation.

Monitoring of past projects shows that sediment inactivation efficacy can vary and is expected to decline over time due to product aging, new watershed inflows, and/or burial from rough fish activity. As such, results presented in this report provide an estimate of the expected scale of treatment impacts within a given growing season, but do not account for longer-term changes within the system and how that may impact benefits over time. For more information on the sediment inactivation modeling assumptions see Section 6.4.

10.7 Management Recommendations

The monitoring data on South Wilmes Lake has been variable in recent years, with some years meeting state water quality standards and other years notably exceeding the standards. No historical water quality monitoring data is available for North Wilmes Lake. Both basins of Wilmes Lake have threatened native aquatic plant communities due to the notable growth of the aquatic invasive species Eurasian water milfoil and curly-leaf pondweed. Given this, future management efforts should focus on improving lake water quality and ecosystem health, monitoring for changes, and continuing water quality and ecosystem health protection measures as improvements are achieved. Table 10-5 summarizes the recommended management strategies that could be considered for Wilmes Lake to help improve water quality conditions and ecological health.

Table 10-5 Wilmes Lake management recommendations

Management/Protection Action		Basis
Address external watershed loads	Enhanced street sweeping program	Continue to work with the City of Woodbury to refine an enhanced street sweeping program to reduce pollutant loading to stormwater runoff
	Stormwater BMPs	Consider retrofitting or installing new stormwater BMPs in subwatersheds that are currently untreated or undertreated Implement site scale BMPs as opportunities arise
	Chloride	Consider applying chloride reduction strategies such as education and implementation assistance to the City of Woodbury and other stakeholders
Address internal loads	Sediment inactivation treatment	Review and consider implementing a sediment inactivation treatment to reduce lake bottom sediment phosphorus loads
Aquatic Plants	Invasive species management	Continue to monitor invasive species growth (e.g., curly-leaf pondweed, Eurasian watermilfoil) Consider continued herbicide management of Eurasian watermilfoil and curly-leaf pondweed to improve native aquatic plant health
	Promote native aquatic plant growth	Encourage native plant reestablishment during and following aquatic invasive species management
Fisheries	Fisheries monitoring	Consider collecting fish community data
Phytoplankton and Zooplankton	Phytoplankton/Zooplankton monitoring	Consider monitoring phytoplankton and zooplankton as part of routine monitoring
Water Quality	Water quality monitoring	Continue monitoring in-lake water quality and assessing for eutrophication within South Wilmes Collect in-lake water quality monitoring data for North Wilmes to assess for eutrophication and validate modeling results Continue to identify/track chloride levels from winter salt use Consider collecting water quality parameters at multiple depths to confirm lake stratification influence on internal phosphorus loading to surface waters

11 Colby Lake

11.1 Water Quality

Colby Lake is located in the City of Woodbury and is used primarily for active and passive recreation and wildlife viewing. When water levels are high enough, water discharges via gravity flow from Colby Lake through a storm sewer system, which ultimately discharges to Bailey Lake.

Colby Lake has a water surface area of approximately 73 acres, a maximum depth of 10 feet, and a mean depth of approximately 5 feet. Colby Lake is shallow enough for aquatic plants to grow over the entire waterbody and for the lake to mix many times per year (polymictic lake).

Shallow/Deep	Shallow
Location	Woodbury
Surface Area	73 acres
Average/Maximum Depth	5 feet / 10 feet
Direct Watershed Area	2,924 acres
Total Watershed Area	8,212 acres
Watershed:Lake Surface Area	112:1
Impairment Status	Impaired for nutrients since 2006
Downstream Waterbody	Bailey Lake

The State of Minnesota uses three water quality parameters to assess eutrophication standards within lakes—total phosphorus, chlorophyll-*a*, and Secchi disk transparency—to assess waterbody health and track water quality changes. These three parameters were measured in Colby Lake by the SWWD between 1994-2023 (Figure 11-1). The summer average total phosphorus concentrations exceeded the state standard for all monitored years. Summer average chlorophyll-*a* concentrations exceeded the state standard for all monitored years except 2023. In 2023, the summer average chlorophyll-*a* concentration was equal to the state standard. Summer average Secchi depths were worse than the state standard for all monitored years except 2019, 2021, and 2023. Colby Lake was added to the Minnesota impaired waters list for nutrients in 2006.

Chloride concentrations were measured by the SWWD between 2013 - 2023 (generally between April and September). In the historical record, all observed chloride concentrations were below the MPCA chronic standard of 230 mg/L. The highest observed chloride concentration was 187 mg/L in May and June 2023.

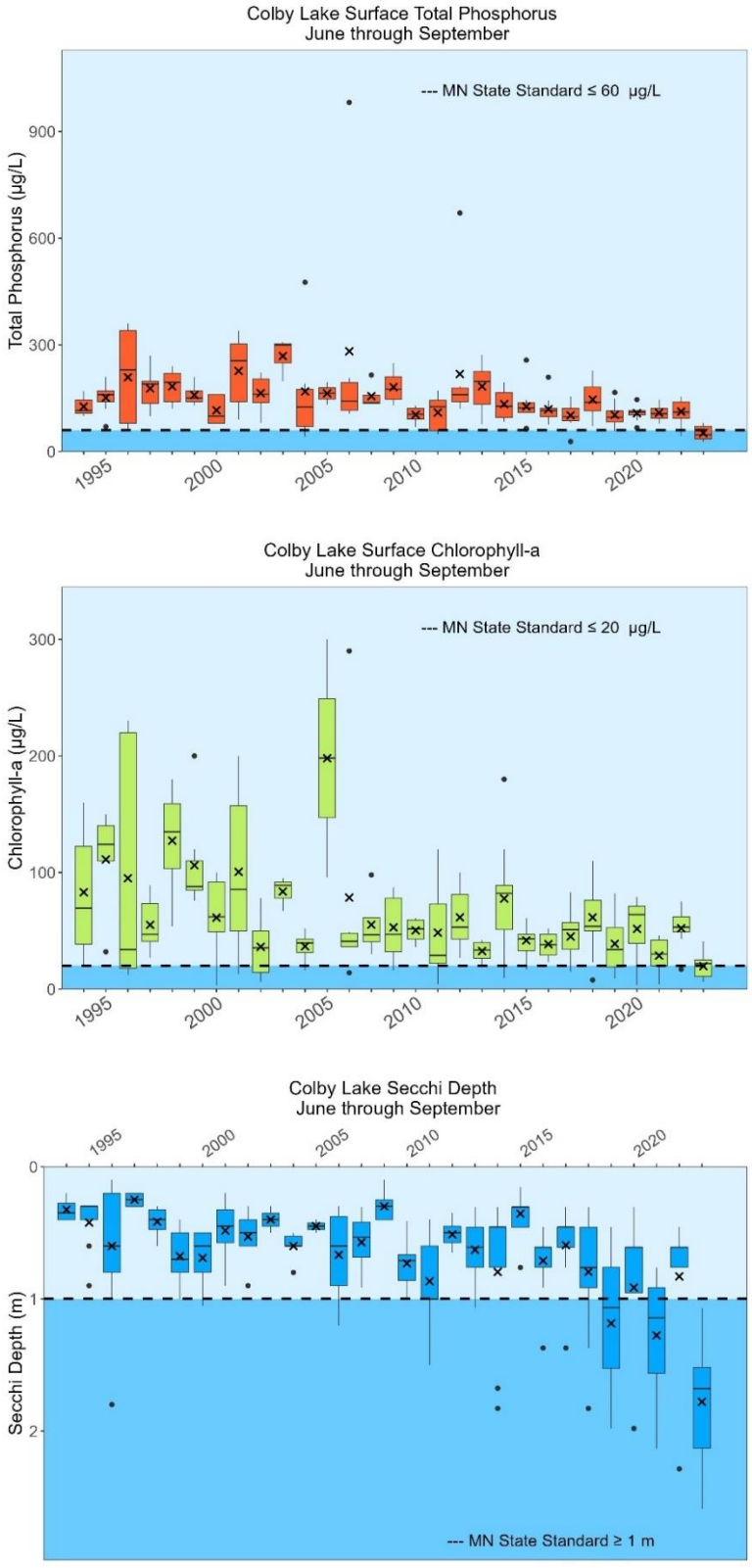


Figure 11-1 Colby Lake eutrophication monitoring data (June – September)
Summer averages are shown by x's in the box plots

11.2 Ecological Health

11.2.1 Aquatic Plants

Table 11-1 summarizes the calculated Lake Plant Eutrophication IBI values for Colby Lake based on point-intercept plant surveys completed in 2021 and 2024. Colby Lake scored below both plant IBI metrics in June and August in 2021 and 2024 indicating a degraded plant community that is likely stressed from cultural eutrophication. Table 11-1 also summarizes the percentage of the littoral area where aquatic plants were found and lists observed aquatic invasive species, their frequency of occurrence (FOO), and current management practices. Other plant health metrics can be referenced in the 2021 and 2024 Aquatic Vegetation Survey Results reports (Stantec, 2021, 2025).

Table 11-1 Colby Lake aquatic plants overview

Lake	Parameter	June 2021[1]	August 2021[1]	June 2024[2]	August 2024[2]	MnDNR Threshold	Invasive Species Management
Colby	Species Richness	10	9	9	10	>11	
	Floristic Quality Index (FQI)	15.2	13.3	11.2	12.3	>17.8	
	% Littoral with Vegetation	99%	82%	71%	91%		
	Curly-leaf Pondweed FOO	89%	P	-	-		Herbicide applications 2022 - 2025
	Eurasian Watermilfoil FOO	40%	29%	3%	2%		Herbicide applications 2022 - 2025

[1] (Stantec, 2021 Aquatic Vegetation Survey Results, 2021)
[2] (Stantec, 2025)

11.2.2 Fisheries

Colby Lake is included in the Fishing in the Neighborhood (FiN) program run by the MNDNR, which is aimed at increasing angling opportunities, public awareness, and environmental stewardship within the seven-county Twin Cities metro area. The MNDNR FiN program has actively been involved in managing the sport fish populations of Colby Lake since 2002, with the goal of providing shore fishing opportunities to the City of Woodbury. As such, the fish community is surveyed at a regular frequency. Fish stocking data from the most recent decade is also available. Table 11-2 summarizes the fish community data from the most recent survey conducted in June 2015 (MNDNR, 2015). Table 11-3 summarizes the fish stocking report from the last decade (MNDNR, 2024). Walleye have been stocked in Colby Lake most recently (i.e., in 2019 and annually between 2022 – 2024).

A winter aeration system was installed in the southeast portion of the lake, near Edgewater Park, in 2012 to provide better winter oxygen conditions and limit the risk of winter fish kills.

Table 11-2 Colby Lake fish survey report – 2015 (MNDNR, LakeFinder, 2015)

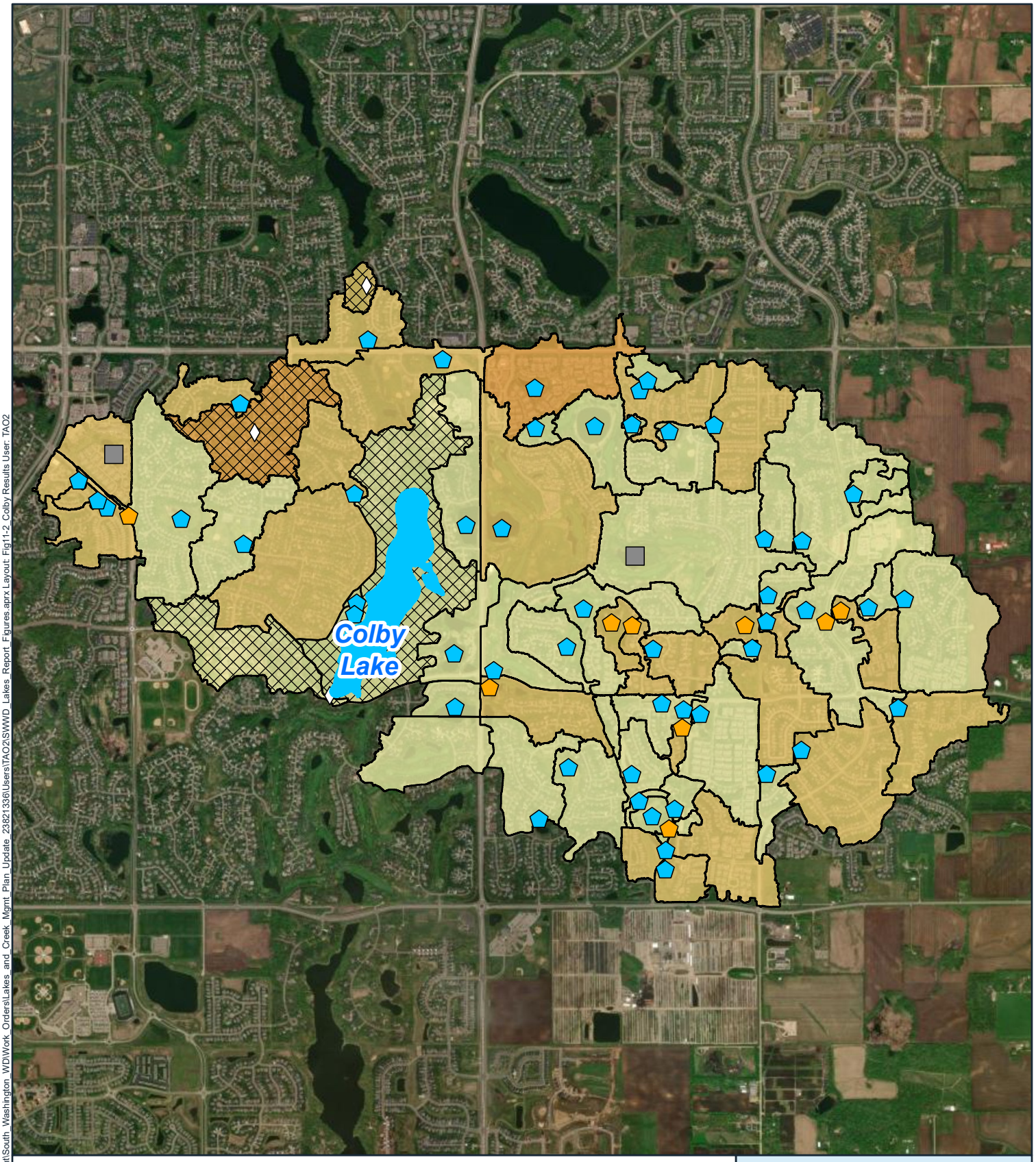
Catch Method	Fish Species	Catch per Unit Effort (CPUE)	Normal CPUE Range	Count
Standard trap nets	Black bullhead	36.3	2.5 – 70.2	254
	Black crappie	1.6	1.3 – 27.7	11
	Bluegill	12.7	2.8 – 43.3	89
	Channel catfish	0.9	N/A	6
	Golden shiner	0.1	0.4 – 3.9	1
	Green sunfish	0.1	0.4 – 3.8	1
	Hybrid sunfish	0.1	N/A	1
	Pumpkinseed	0.7	0.8 – 9.3	5
	Yellow perch	0.4	0.4 – 3.5	3
Standard gill nets	Black bullhead	43.0	8.0 – 90.0	43
	Black crappie	10.0	2.0 – 19.0	10
	Channel catfish	3.0	N/A	3
	Yellow perch	38.0	2.5 – 25.8	38

Table 11-3 Colby Lake fish stocking report – 2015-2024 (MNDNR, LakeFinder, 2024)

Year	Fish Species	Size	Number	Pounds
2024	Walleye	fry	500,000	4.5
2023	Walleye	fry	500,000	4.0
2022	Walleye	fry	400,000	3.3
2019	Walleye	fry	2,000,000	16.2
2016	Channel Catfish		10,000	52.9
	Walleye	fry	420,000	4.3
2015	Channel Catfish	yearlings	2,100	350.0

11.3 Watershed Total Phosphorus Loads

P8 modeling shows low to moderate watershed phosphorus loads to Colby Lake, with higher loads coming from denser residential developments north and east of the lake. Some areas of the drainage area are untreated (e.g., a neighborhood northwest of the lake, and the direct drainage area to the lake) before entering the storm sewer system and reaching the lake. The map in Figure 11-2 shows the effective areal phosphorus load by subwatershed, modeled BMPs, and untreated subwatersheds within the area. The effective phosphorus load represents the loading rate after pollutant removal by stormwater BMPs within the watershed and is reflective of the loading that actually makes it into the receiving waterbody from a given location. The effective phosphorus loads for the Colby Lake subwatersheds range from 0.1 pounds per acre per year to 0.7 pounds per acre per year, based on a 10-year modeling period (2012-2022).



Lake

P8 Device Type

- Dry Pond
- Wet Pond
- General Device
- Pipe

Effective TP Load (lbs/ac/yr)

- 0.0 - 0.3
- 0.3 - 0.6
- 0.6 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0
- Area Not Treated by BMP

N

0 500 1,000
Feet

Colby Lake
Effective TP Loading
Lake Management Plan
South Washington
Watershed District

FIGURE 11-2

BARR

Barr Footer: ArcGISPro, 8/7/2025 4:47 PM File: I:\Client\South_Washington_WD\Work_Orders\Lakes_and_Creek_Mgmt_Plan_Update_23821336\Users\TAO2\SWWD_Lakes_Report_Figures.aprx Layout: Fig11-2_Colby Results User: TAO2

11.4 In-lake Total Phosphorus Loads

Results of the in-lake modeling for Colby Lake showed that during the summer of 2019 (representing a wet year), high total phosphorus loads entered Colby Lake from watershed runoff (37%, 383 lbs) and from the upstream South Wilmes Lake (26%, 263 lbs). A notable internal load was also present in 2019, representing 37% (377 lbs) of the total load (Figure 11-3).

During the drier summer of 2022, the phosphorus loading to Colby Lake from watershed runoff and upstream South Wilmes Lake was notably lower, representing 28% (102 lbs) and 1% (3 lbs) of the phosphorus loading to the lake, respectively. The phosphorus loading from upstream South Wilmes Lake in 2022 was 99% less than the phosphorus load estimated in 2019. Internal loading estimates in 2022 were at a similar magnitude as 2019, representing 71% (261 lbs) of the phosphorus load.

Biweekly profiles collected on Colby Lake indicated that more water column mixing and weaker stratification occurred in late summer 2022 as compared to model year 2019. Dissolved oxygen concentrations were higher at lower depths during this period, possibly re-aerating the sediment and reducing phosphorus loading from the mobile phosphorus fraction in the sediment. Re-aeration of the sediment for a prolonged period could be a reason why there was decreased internal phosphorus load observed in the 2022 Colby Lake model. Phosphorus fractionation data gathered from sediment cores collected in 2024 indicated a high potential for internal phosphorus loading. Additional details on the sediment core data can be found in Section 4.8.

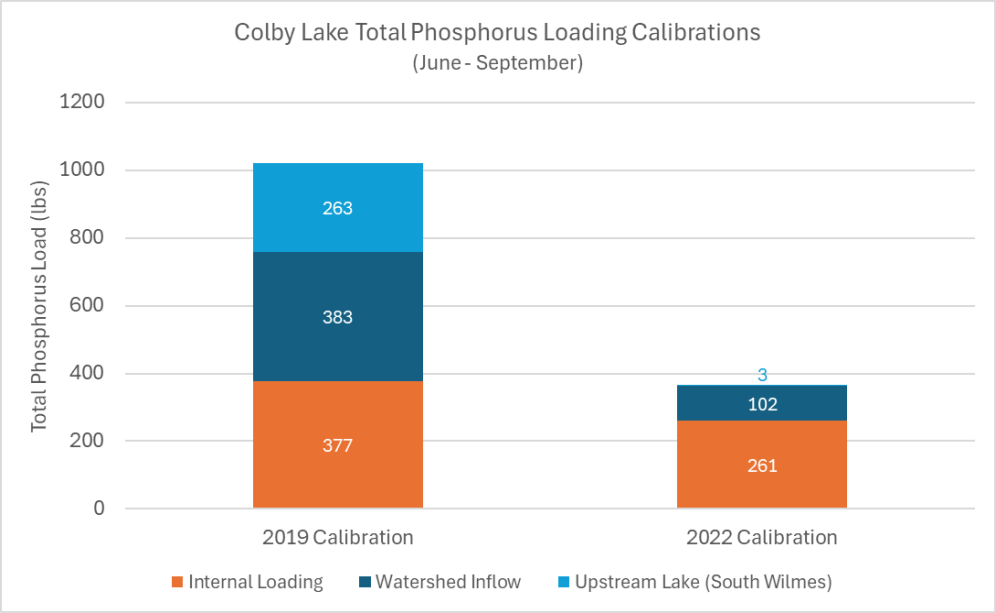


Figure 11-3 Colby Lake 2019 & 2022 estimated total phosphorus loads (June – Sept)

11.5 Nitrogen and Algal Growth

Throughout the growing season, various factors can influence the rate and volume of algae growth within a lake, such as phosphorus, nitrogen, light, and temperature. The Barr Shallow Lake Model was used for simulating water quality within Colby Lake; this model utilizes Michaelis Menten kinetics to determine which factor or combination of factors limit algae growth throughout the modeled time period. Although nitrate, nitrite, ammonia, and ammonium water quality data were not available for model calibration, the effect of nitrogen on chlorophyll-*a* growth can be deduced for Colby Lake using the model. In both the 2019 and 2022 models, accounting for nitrogen limitation as part of the model calibration improved model results with respect to simulating chlorophyll-*a*. Nitrogen limitation was estimated to be most prominent in August 2019 and July – September 2022.

Nitrogen limitation during a portion of the growing season has been seen in numerous other shallow lake modeling efforts performed by Barr. Nitrogen limitation tends to occur because the growth rate of algae can be greater than the degradation rate of nitrogen (i.e., slow decomposition from organic nitrogen forms to ammonia and/or slow nitrification rate changing ammonia to nitrite and nitrate). In other words, algae will continue to grow until they have used up bioavailable forms of nitrogen in the water column, and once depleted, algae growth will be limited. However, nitrogen limitation does not affect all algal species equally. Certain species of cyanobacteria can persist under nitrogen-limited conditions, even as other algal species decline or disappear entirely. This resilience is due to the ability of some cyanobacteria species to fix atmospheric nitrogen by converting N_2 gas into ammonia. The process is energy-intensive, though, and will be used only when necessary. This competitive advantage complicates efforts to predict how nitrogen limitation will influence overall algal growth dynamics in a waterbody. The presence of cyanobacteria with nitrogen fixing abilities could not be confirmed as part of this study, as no phytoplankton monitoring data is currently available for this lake.

The algal growth limitations identified during model calibration reflect which parameters are currently limiting growth. As management is implemented, algal growth limitations will likely change. For example, if phosphorus loading from lake bottom sediment is reduced, phosphorus limitation may become more dominant throughout the growing season. Similarly, a reduced phytoplankton population with phosphorus control could also increase nitrogen concentrations (e.g., reduced nitrogen demand) and alleviate the nitrogen limitation and also eliminate a competitive advantage of cyanobacteria. Outcomes of changes in nitrogen dynamics are more challenging to predict than phosphorus management with the information currently available.

11.6 Predicted Benefits from Implementing Management Practices

One of the study goals was to estimate the potential impact of lake sediment inactivation projects and how they could be used to improve in-lake water quality. The calibrated in-lake models were used to estimate the impact of implementing sediment treatment projects in Colby and upstream lakes (except for Armstrong Lake). For Colby Lake, watershed load reductions were also analyzed to assess joint impacts on further improving in-lake conditions to meet state standards. Specific watershed BMPs were not modeled as a part of this study. Instead, a percent reduction was applied to the calibrated watershed loading estimates across the watersheds directly tributary to Colby Lake.

Table 11-4 summarizes the estimated phosphorus load reduction from three scenarios: sediment inactivation (low and high efficacies) and sediment inactivation (low) coupled with watershed load reductions. The sediment inactivation scenarios include assumed sediment treatments in both Colby Lake and its upstream contributing waterbodies (except for Armstrong). Results from the in-lake modeling

predict a reduction of 176 – 399 pounds of total phosphorus loading into Colby Lake through implementation of sediment inactivation practices for a wet (2019) and dry (2022) year. This reduction in phosphorus loading translates to a reduction in the in-lake total phosphorus concentrations. Model results estimate that the 2019 summer average total phosphorus concentration of 101 µg/L would reduce to 52 - 60 µg/L with the implementation of sediment treatments; and the 2022 summer average total phosphorus concentration of 115 µg/L would reduce to 51 - 64 µg/L (Table 11-4).

Table 11-4 Summer growing period estimated reductions in phosphorus loads and in-lake concentrations in Colby Lake with the proposed management practices

Scenario	Modeled Summer Total Phosphorus Loading (lbs)					Summer Average Total Phosphorus (µg/L)[1]	Summer Average Chlorophyll-a (µg/L)[1]
	Watershed Inflow	Upstream Lakes	Internal Loading	Total	Load Reduction		
2019 Existing	383	263	377	1,023	-	101	37
2019 Sediment Inactivation Low	383	155	144	682	-341	60	25
2019 Sediment Inactivation High	383	147	94	624	-399	52	24
2019 Sed Inact. Low + Watershed Reduction	179	155	144	478	-545	47	20
2022 Existing	102	3	261	367	-	115	58
2022 Sediment Inactivation Low	102	2	87	190	-176	64	25
2022 Sediment Inactivation High	102	2	59	163	-204	51	22
2022 Sed Inact. Low + Watershed Reduction	60	2	87	149	-218	58	20

[1] Existing conditions summer average concentrations are calculated from calibrated in-lake models

Based on these results, it's predicted that implementing sediment inactivation practices alone would not be sufficient to reduce Colby Lake summer average concentrations for total phosphorus and chlorophyll-*a* to below the state standards. To estimate the additional total phosphorus reductions needed from watershed management practices to achieve standards for both parameters, we applied a percent reduction to the calibrated watershed loading model results in each model year. For this scenario, watershed load reductions were coupled with the sediment inactivation (low) assumptions to be conservative. During a wet year (2019), modeling predicts that an additional 204 pounds of total phosphorus would need to be reduced from the watershed to meet both total phosphorus and chlorophyll-*a* concentrations in Colby Lake. Modeling indicates that during a dry year (2022), an additional 42 pounds of total phosphorus would be required from the watershed to meet total phosphorus and chlorophyll-*a* concentrations. Figure 11-4 and Figure 11-5 summarize the predicted reductions in in-lake total phosphorus concentrations for the 2019 and 2022 model years, respectively, for each of the proposed BMP scenarios.

Model results estimating the in-lake response to reduced phosphorus loading—both from internal treatments and the surrounding watershed—reflect the estimated impacts to in-lake conditions during the

2019 and 2022 growing seasons if those practices had been in place at that time. The modeling incorporates a range of assumed sediment-treatment efficacies to account for application variability and the fact that the specific treatment approach (alum, alum/iron, or aeration) has not yet been selected. Assumed efficacies were informed by monitoring data from comparable Barr sediment-inactivation projects one year post-implementation. Monitoring of past projects shows that sediment inactivation efficacy can vary and is expected to decline over time due to product aging, new watershed inflows, and/or burial from rough fish activity. As such, results presented in this report provide an estimate of the expected scale of treatment impacts within a given growing season, but do not account for longer-term changes within the system and how that may impact benefits over time. For more information on the sediment inactivation modeling assumptions see Section 6.4.

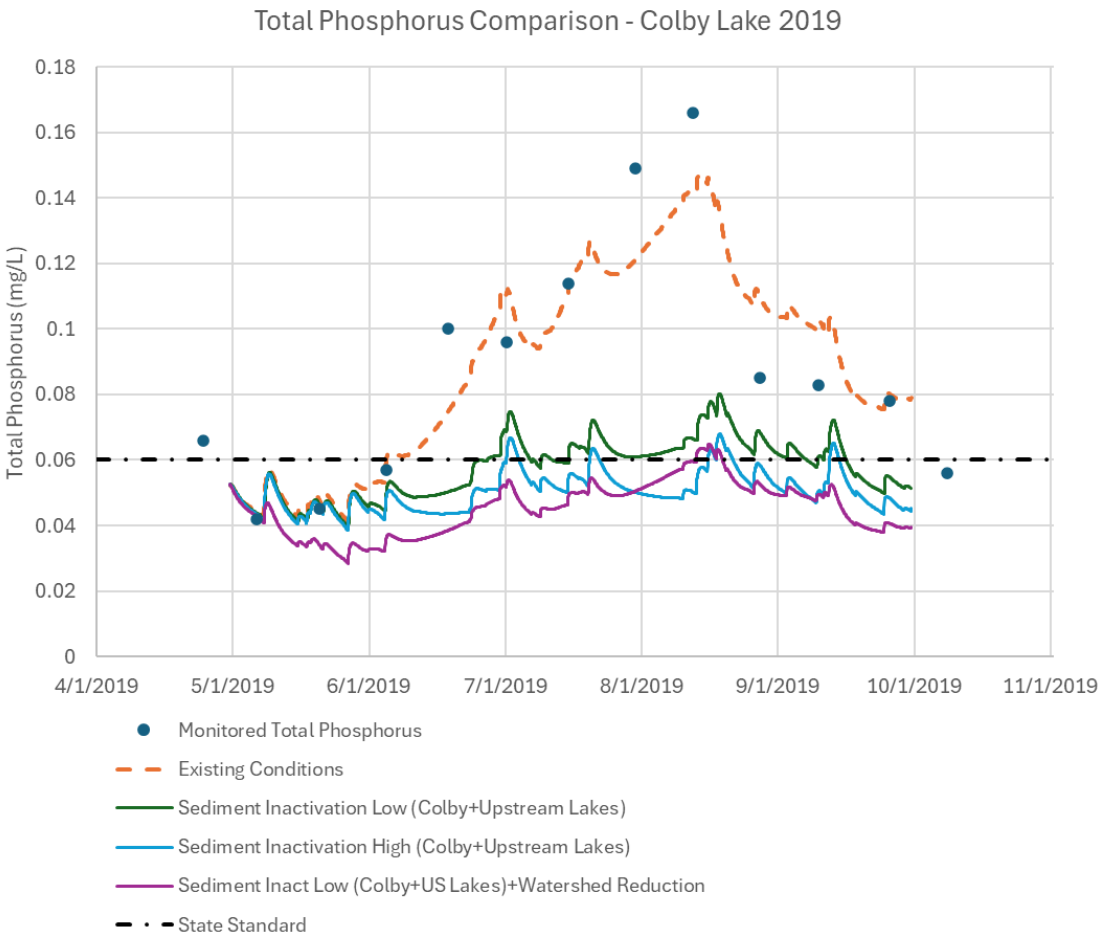


Figure 11-4 Model-predicted reductions in 2019 total phosphorus concentrations in Colby Lake with the proposed management practices

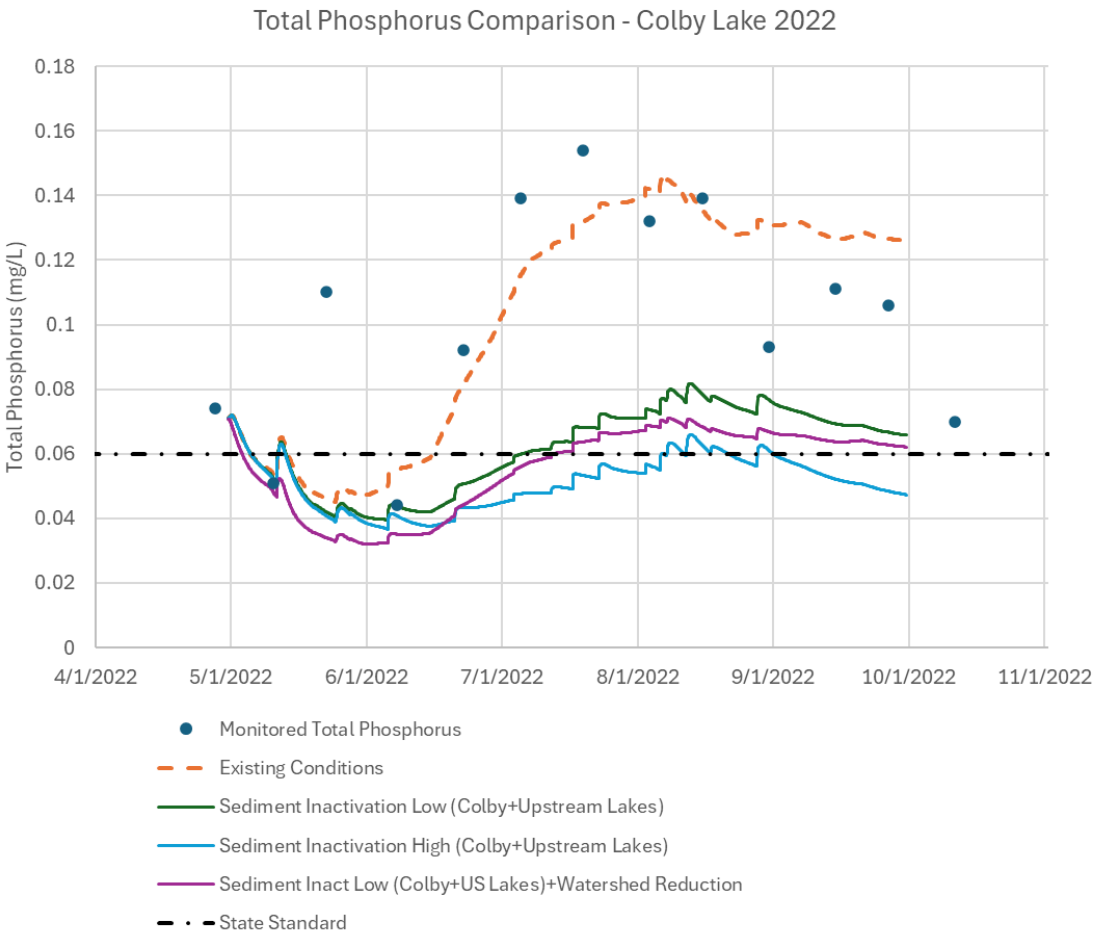


Figure 11-5 Model-predicted reductions in 2022 total phosphorus concentrations in Colby Lake with the proposed management practices

11.7 Management Recommendations

Monitoring data from within Colby Lake indicates degraded water quality and shows that the lake has largely not met water quality standards over the course of its monitored history. Colby Lake also has a threatened native aquatic plant community due to the notable growth of the aquatic invasive species Eurasian water milfoil and curly-leaf pondweed. Given this, future management efforts should focus on improving lake water quality and ecosystem health, monitoring for changes, and continuing water quality and ecosystem health protection measures as improvements are achieved. Table 11-5 summarizes the recommended management strategies that could be considered for Colby Lake to help improve water quality conditions and ecological health.

Table 11-5 Colby Lake management recommendations

Management/Protection Action		Basis
Address external watershed loads	Enhanced street sweeping program	Continue to work with the City of Woodbury to refine an enhanced street sweeping program to reduce pollutant loading to stormwater runoff
	Stormwater BMPs	Consider retrofitting or installing new stormwater BMPs in subwatersheds that are currently un-treated or undertreated Implement site scale BMPs as opportunities arise
	Chloride	Consider applying chloride reduction strategies such as education and implementation assistance to the City of Woodbury and other stakeholders
Address internal loads	Sediment inactivation treatment	Review and implement a sediment inactivation treatment to reduce lake bottom sediment phosphorus loads
Aquatic Plants	Invasive species management	Continue to monitor invasive species growth (e.g., curly-leaf pondweed, Eurasian watermilfoil) Consider continued herbicide management of Eurasian watermilfoil and curly-leaf pondweed to improve native aquatic plant health
	Promote native aquatic plant growth	Encourage native plant reestablishment during and following aquatic invasive species management
Phytoplankton and Zooplankton	Phytoplankton/Zooplankton monitoring	Consider monitoring phytoplankton and zooplankton as part of routine monitoring
Water Quality	Water quality monitoring	Continue monitoring in-lake water quality and assessing for eutrophication within Colby Lake Consider supplementing routine monitoring with additional nitrogen parameters for better assessment of phytoplankton nitrogen limitation. Continue to identify/track chloride levels from winter salt use

12 Bailey Lake

12.1 Water Quality

Bailey Lake is located in the City of Woodbury and is used primarily for active and passive recreation and wildlife viewing. When water levels are high enough, water discharges via gravity flow from Bailey Lake to a downstream stormwater pond. Water is then pumped from this pond into the Central Draw Storage Facility, which allows the water to infiltrate into the soil and recharges the groundwater.

Shallow/Deep	Shallow
Location	Woodbury
Surface Area	62 acres
Average/Maximum Depth	6 feet / 19 feet
Direct Watershed Area	6,031 acres
Total Watershed Area	14,243 acres
Watershed:Lake Surface Area	230:1
Impairment Status	Impaired for nutrients since 2024
Downstream Waterbody	Central Draw Storage Facility

Bailey Lake has a water surface area of approximately 62 acres, a maximum depth of 19 feet, and a mean depth of approximately 6 feet. Bailey Lake falls under the MNDNR classification of a “shallow lake” given that the lake’s littoral area is greater than 80% the total lake area. Bailey Lake is deep enough that prolonged periods of lake stratification occur during the growing season. Profile monitoring data collected within the lake supports this finding.

The State of Minnesota uses three water quality parameters to assess eutrophication standards within lakes—total phosphorus, chlorophyll-*a*, and Secchi disk transparency—to assess waterbody health and track water quality changes. These three parameters were measured in Bailey Lake by the SWWD between 2017-2023 (Figure 12-1). The summer average total phosphorus concentrations exceeded the state standard for all monitored years except 2023. Summer average chlorophyll-*a* concentrations exceeded the state standard for all monitored years. Summer average Secchi depths were worse than the state standard between 2017 – 2020, but were better than the state standard between 2021 - 2023. Bailey Lake was added to the Minnesota impaired waters list for nutrients in 2024.

Chloride concentrations were measured by the SWWD between 2017 - 2023 (generally between April and September). In the historical record, all observed chloride concentrations were below the MPCA chronic standard of 230 mg/L. The highest observed chloride concentration was 181 mg/L in May 2019.

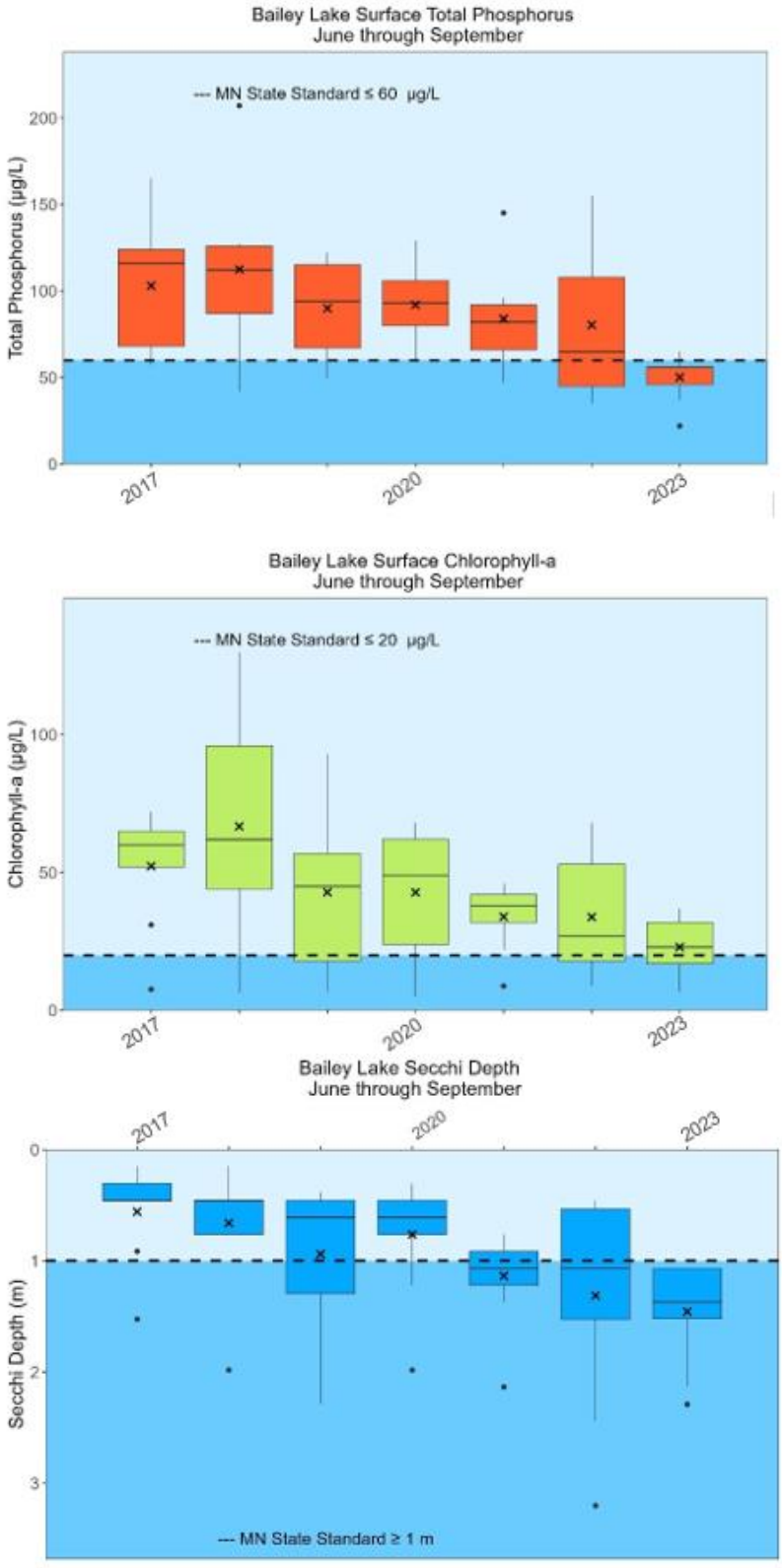


Figure 12-1 Bailey Lake eutrophication monitoring data (June – September)
Summer averages are shown by x's in the box plots

12.2 Ecological Health

12.2.1 Aquatic Plants

Table 12-1 summarizes the calculated Lake Plant Eutrophication IBI values for Bailey Lake based on point-intercept plant surveys completed in 2021 and 2024. Bailey Lake scored above the MNDNR threshold for species richness, but below the threshold for floristic quality in June and August 2021 and June 2024. In August 2024 Bailey Lake scored below both plant IBI metrics indicating a degraded plant community that is likely stressed from cultural eutrophication. Table 12-1 also summarizes the percentage of the littoral area where aquatic plants were found and lists observed aquatic invasive species, their frequency of occurrence (FOO), and current management practices, if applicable. As of this study, SWWD had not actively managed Eurasian watermilfoil, curly-leaf pondweed, or common reed on Bailey Lake. Other plant health metrics can be referenced in the 2021 and 2024 Aquatic Vegetation Survey Results reports (Stantec, 2021, 2025).

Table 12-1 Bailey Lake aquatic plants overview

Lake	Parameter	June 2021[1]	August 2021[1]	June 2024[2]	August 2024[2]	MnDNR Threshold	Invasive Species Management
Bailey	Species Richness	12	12	11	10	>11	
	Floristic Quality Index (FQI)	13.3	14.4	14.3	13.0	>17.8	
	% Littoral with Vegetation	84%	68%	79%	70%		
	Curly-leaf Pondweed FOO	70%	11%	21%	-		No management to date
	Eurasian Watermilfoil FOO	7%	11%	4%	3%		No management to date
	Common Reed FOO	2%	2%	-	-		No management to date

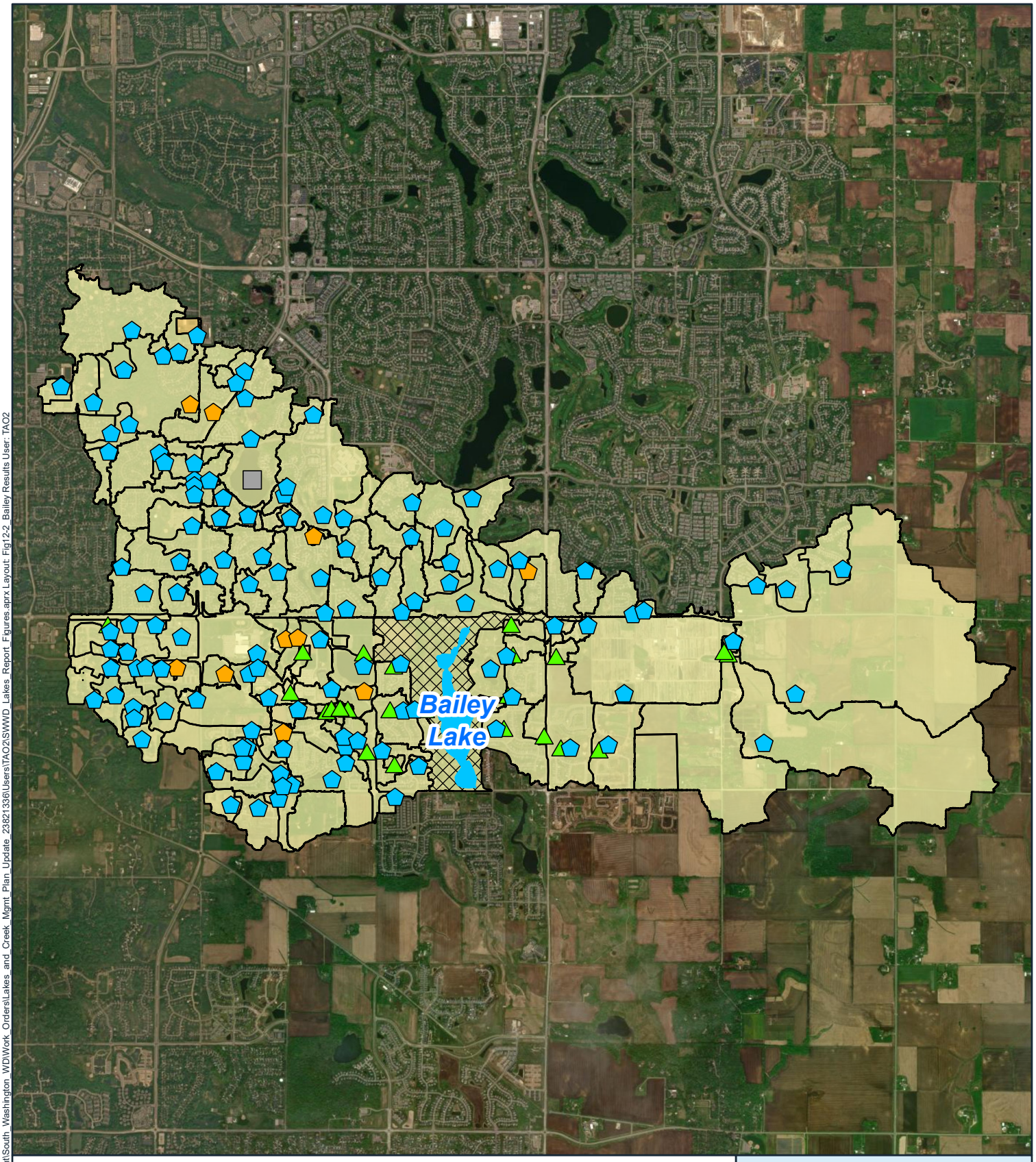
[1] (Stantec, 2021 Aquatic Vegetation Survey Results, 2021)
[2] (Stantec, 2025)

12.2.2 Fisheries

There are no MNDNR fish survey or stocking data available for Bailey Lake.

12.3 Watershed Total Phosphorus Loads

P8 modeling shows low watershed phosphorus loads to Bailey Lake, with the majority of the watershed being devoted to single-family home developments or undeveloped. Many of the developments in this watershed include large infiltration basins that capture and prevent stormwater runoff from reaching Bailey Lake for an average annual rainfall event. The direct drainage area to the lake is currently untreated. The map in Figure 12-2 shows the effective areal phosphorus load by subwatershed, modeled BMPs, and untreated subwatersheds. The effective phosphorus load represents the loading rate after pollutant removal by stormwater BMPs within the watershed and is reflective of the loading that actually makes it into the receiving waterbody from a given location. The effective phosphorus loads for the Bailey Lake subwatersheds range from 0.01 pounds per acre per year to 0.4 pounds per acre per year, based on a 10-year modeling period (2012-2022).



Lake

P8 Device Type

- Dry Pond
- General Device
- Infiltration Basin
- Pipe
- Wet Pond

Effective TP Load (lbs/ac/yr)

- 0.0 - 0.3
- 0.3 - 0.6
- 0.6 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0
- Area Not Treated by BMP

N

0 2,000 4,000

Feet

Bailey Lake
Effective TP Loading
Lake Management Plan
South Washington
Watershed District

FIGURE 12-2

BARR

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12.4 In-lake Total Phosphorus Loads

Biweekly profile monitoring data is typically collected in Bailey Lake between April and October of each year, including the collection of temperature and dissolved oxygen concentrations. Lake profile data indicates that Bailey Lake can have temperature stratification as early as late April or early May most years, and typically remains stratified until fall. As such, a stratified in-lake model approach was used for Bailey Lake, and phosphorus inputs to the fully mixed epilimnion volume (surface waters) were estimated for this study (Figure 12-3). The profile monitoring data was used to quantify the volume of the epilimnion throughout the model period. Phosphorus load estimates to the hypolimnion of the lake were not estimated as a part of this study.

Results of the in-lake modeling for Bailey Lake showed that during the summer of 2019 (representing a wet year), phosphorus loading to Bailey Lake was dominated by upstream lake inputs, representing 76% (603 lbs) of the phosphorus loading from major sources (Figure 12-3). Smaller, but still significant, total phosphorus loads were from internal loading (14%, 110 lbs) and watershed runoff (10%, 78 lbs). The reported internal load from lake bottom sediment represents the phosphorus load from shallow sediment located in the epilimnion zone as well as phosphorus that migrated to the epilimnion from the hypolimnion (deep waters) via diffusion across the thermocline or during mixing events.

During the drier summer of 2022, phosphorus loading to Bailey Lake from the upstream Colby Lake was notably lower, representing 8% (15 lbs) of the phosphorus loading to the lake. The phosphorus loading from Colby Lake in 2022 was 98% less than the phosphorus load estimated in 2019. Total phosphorus loading from watershed runoff was also notably lower in 2022, representing 10% (17 lbs) of the load to Bailey Lake. Internal loading estimates in 2022 were similar to 2019, representing 82% (146 lbs) of the phosphorus load.

Differences in annual lake stratification can influence lake mixing potential as well as the anoxic area over lake bottom sediment, which ultimately influences the potential total phosphorus load that reaches surface waters from lake bottom sediment. Given that the monitoring data demonstrates strong lake stratification during the summer, the collection of water quality parameters at multiple depths is recommended to better estimate internal loading influence on surface water conditions (e.g., collecting phosphorus near the surface, at the thermocline, and near the bottom). Understanding how lake stratification influences internal loading will be essential for developing effective sediment inactivation strategies and demonstrating benefits should the District decide to pursue this type of treatment. The collection of water quality parameters at multiple depths is especially important as sediment core phosphorus fractionation data indicate a high potential for phosphorus release from lake bottom sediment (Section 4.8).

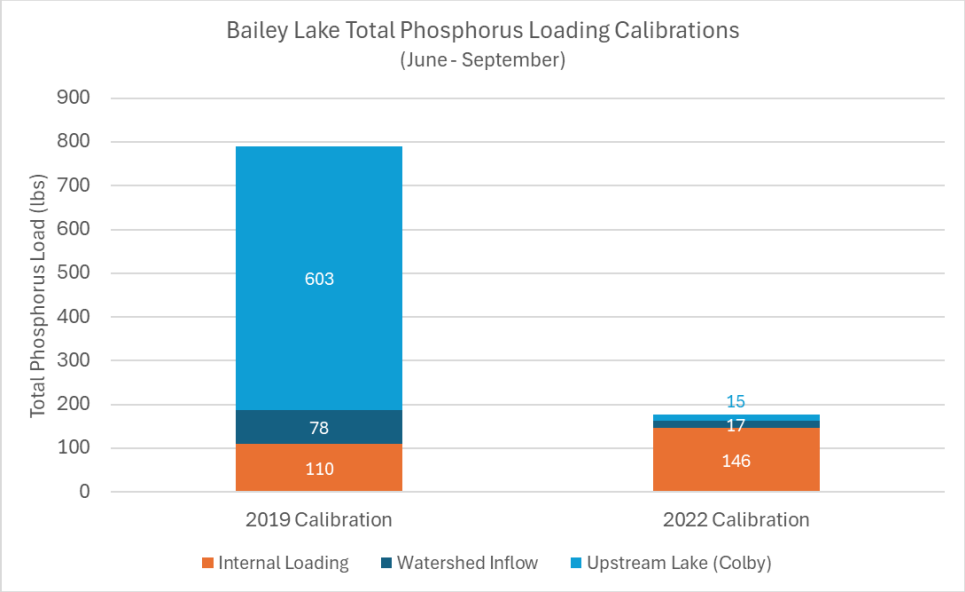


Figure 12-3 Bailey Lake total phosphorus load estimates – 2019 & 2022

12.5 Predicted Benefits from Implementing Management Practices

One of the study goals for Bailey Lake was to estimate the potential in-lake water quality benefits if upstream Colby Lake met state standards. The two Colby Lake proposed model scenarios that were used in the Bailey Lake models were:

- 2019 – Sediment inactivation (low efficacy) for all upstream lakes (except Armstrong) coupled with watershed loading reductions
- 2022 – Sediment inactivation (low efficacy) for all upstream lakes (except Armstrong) coupled with watershed loading reductions

Table 12-2 summarizes the estimated phosphorus load reduction to Bailey Lake if upstream Colby Lake met state standards for both total phosphorus and chlorophyll-a, represented by the scenarios noted above. Results from the in-lake modeling predict a reduction of 331 and 7 pounds of total phosphorus loading into Bailey Lake for a wet (2019) and dry (2022) year, respectively. This reduction in phosphorus loading translates to a reduction in the in-lake total phosphorus concentrations. Model results estimate that the 2019 summer average total phosphorus concentration in Bailey Lake of 84 µg/L would reduce to 51 µg/L with Colby Lake meeting state standards; and the 2022 summer average total phosphorus concentration of 77 µg/L would reduce to 71 µg/L (Table 12-2). Figure 12-4 and Figure 12-5 summarize the predicted reductions in in-lake total phosphorus concentrations for the 2019 and 2022 model years, respectively.

Model results estimating the in-lake response of Bailey Lake to reduced phosphorus loading reflect the estimated impacts that would have occurred during the 2019 and 2022 growing seasons given the assumptions noted above. The results presented provide an estimate of the expected scale of treatment impacts within a given growing season, but do not account for longer-term changes within the system and how that may impact benefits over time. For more information on the sediment inactivation modeling in Colby Lake see Section 11.6 and Section 6.4.

Table 12-2 Summer growing period estimated reductions in phosphorus loads and in-lake concentrations in Bailey Lake with the proposed management practices

Scenario	Modeled Summer Total Phosphorus Loading (lbs)					Summer Average Total Phosphorus (µg/L)[1]
	Watershed Inflow	Upstream Lakes	Internal Loading	Total	Load Reduction	
2019 Existing	78	603	110	791	-	84
2019 Colby Meeting State Standards	78	272	110	460	-331	51
2022 Existing	17	15	146	178	-	77
2022 Colby Meeting State Standards	17	8	146	171	-7	71

[1] Existing conditions summer average concentrations are calculated from calibrated in-lake models

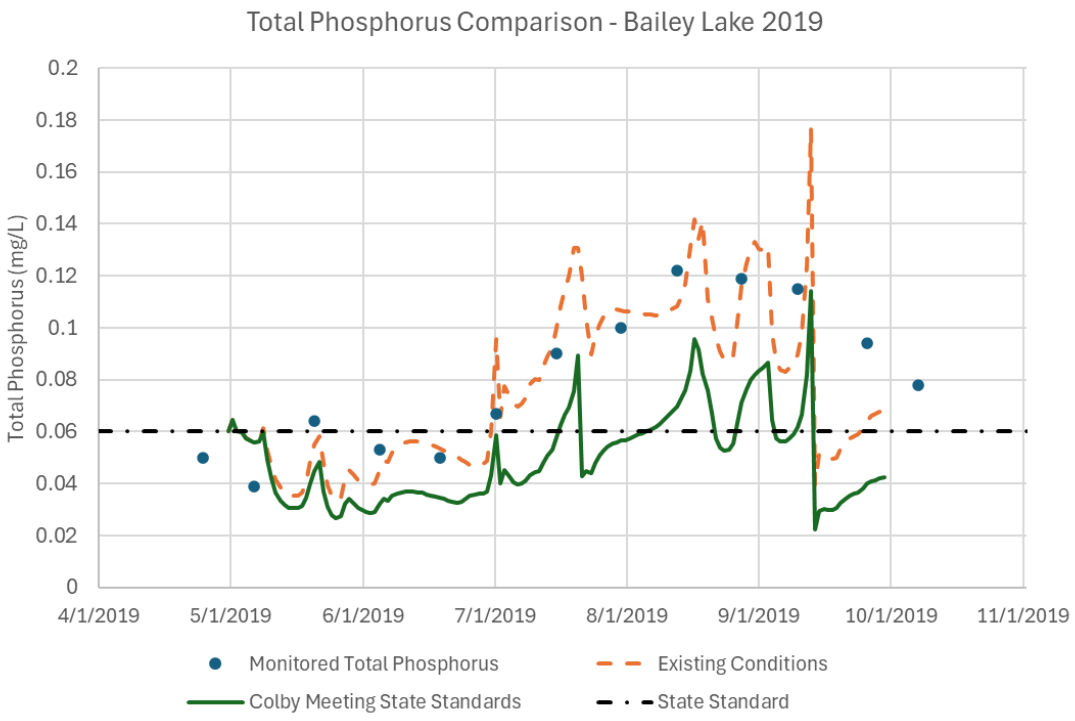


Figure 12-4 Model-predicted reductions in 2019 total phosphorus concentrations in Bailey Lake with the proposed management practices

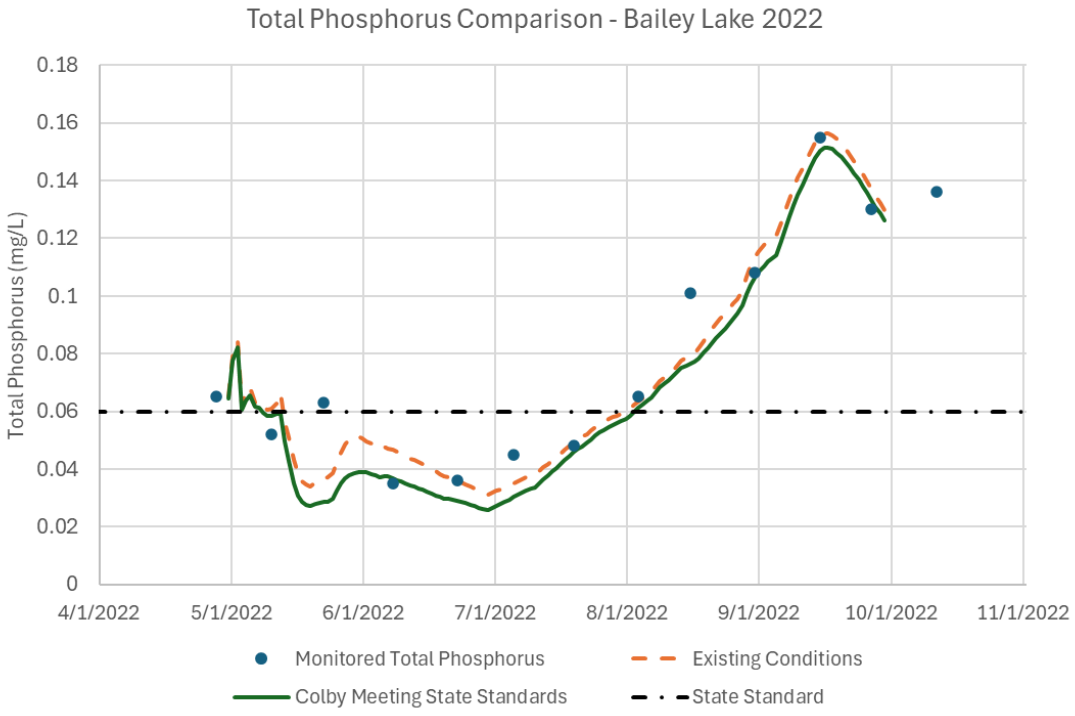


Figure 12-5 Model-predicted reductions in 2022 total phosphorus concentrations in Bailey Lake with the proposed management practices

12.6 Management Recommendations

Monitoring of Bailey Lake indicates degraded water quality and shows that throughout the historical record, the lake has largely not met water quality standards. Bailey Lake also has a threatened native aquatic plant community due to the notable growth of the aquatic invasive species Eurasian water milfoil and curly-leaf pondweed. Given this, future management efforts should focus on improving lake water quality and ecosystem health, monitoring for changes, and continuing water quality and ecosystem health protection measures as improvements are achieved. At this time, the SWWD has indicated that they would be most interested in focusing on nutrient reductions into Bailey from upstream lakes and the surrounding watershed before considering the potential for an in-lake sediment treatment. Recommendations in Table 12-3 reflect this strategy. Table 12-3 summarizes the recommended management strategies that could be considered for Bailey Lake to help improve water quality conditions and ecological health.

Table 12-3 Bailey Lake management recommendations

Management/Protection Action		Basis
Address external watershed loads	Enhanced street sweeping program	Continue to work with the City of Woodbury to refine an enhanced street sweeping program to reduce pollutant loading to stormwater runoff
	Stormwater BMPs	As the watershed develops, continue to enforce SWWD rules and consider implementing site scale BMPs as opportunities arise
	Chloride	Consider applying chloride reduction strategies such as education and implementation assistance to the City of Woodbury and other stakeholders
Address upstream lake water quality	Upstream lake water quality	Continue work to improve water quality in the lakes upstream and draining into Bailey Lake.
Aquatic Plants	Invasive species management	Continue to monitor invasive species growth (e.g., curly-leaf pondweed, Eurasian watermilfoil, common reed) Consider herbicide management of Eurasian watermilfoil and curly-leaf pondweed to improve native aquatic plant health
	Promote native aquatic plant growth	Encourage native plant reestablishment during and following aquatic invasive species management
Fisheries	Fisheries Survey	Consider collecting fish community data
Phytoplankton and Zooplankton	Phytoplankton/Zooplankton monitoring	Consider monitoring phytoplankton and zooplankton as part of routine monitoring
Water Quality	Water quality monitoring	Continue monitoring in-lake water quality and assessing for eutrophication within Bailey Lake. Continue to identify/track chloride levels from winter salt use Consider collecting water quality parameters at multiple depths to confirm lake stratification influence on internal phosphorus loading to surface waters

13 La Lake

13.1 Water Quality

La Lake is located in the City of Woodbury and is used primarily for wildlife viewing. La Lake doesn't have any upstream waterbodies, has a small watershed area, and is landlocked with no surface outlet.

Shallow/Deep	Shallow
Location	Woodbury
Surface Area	50 acres
Average/Maximum Depth	5 feet / 10 feet
Watershed Area* ****Post BMP Construction***	133 acres
Watershed:Lake Surface Area	3:1
Impairment Status	Delisted for nutrients in 2024
Downstream Waterbody	Landlocked

La Lake has a water surface area of approximately 50 acres, a maximum depth of 10 feet, and a mean depth of approximately 5 feet. La Lake is shallow enough for aquatic plants to grow over the entire waterbody and for the lake to mix many times per year (polymictic lake).

The State of Minnesota uses three water quality parameters to assess eutrophication standards within lakes—total phosphorus, chlorophyll-*a*, and Secchi disk transparency—to assess waterbody health and track water quality changes. These three parameters were measured in La Lake by the SWWD between 1994-2023 (Figure 13-1). Monitoring data collected in 2001 and between 2003 – 2004 was collected at a reduced frequency from other monitored years. Given the low number of samples, computed summer averages have a high level of uncertainty for those years. During the monitored years with adequate data, summer average total phosphorus concentrations were better than the state standard between 2015 – 2023. Prior to 2015, all other monitored years exceeded the state standard. Summer average chlorophyll-*a* concentrations were better than the state standard between 1994 – 1996, 1998, 2002, 2005, 2008, 2011, and 2015 - 2023. Summer average Secchi depths met or were better than the state standard for all monitored years between 1994 – 2023. La Lake was removed from the Minnesota impaired water lists as impaired for nutrients in 2024 due to improved water quality conditions between 2015 – 2023.

Chloride concentrations have not been monitored in La Lake.

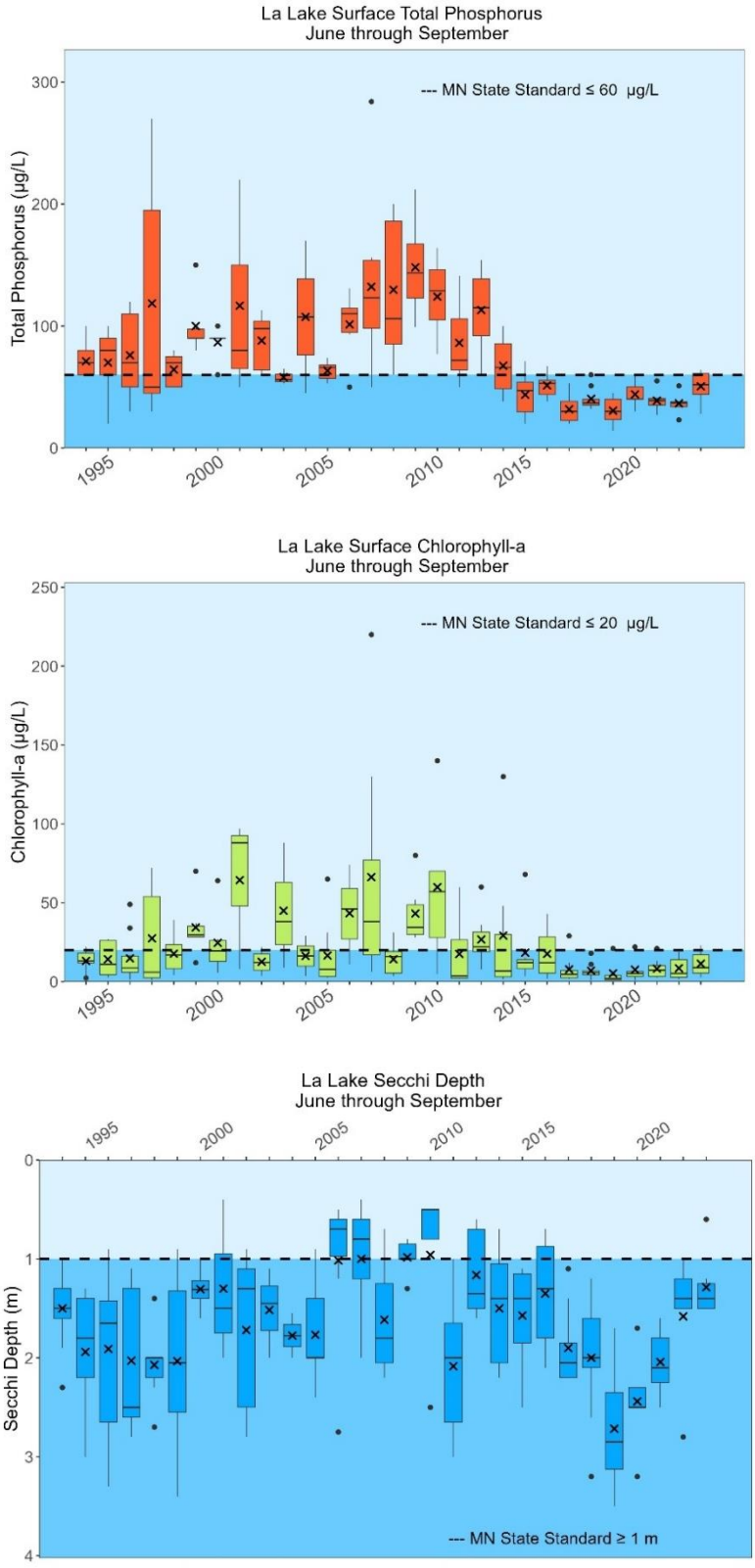


Figure 13-1 La Lake eutrophication monitoring data (June – September)
Summer averages are shown by x's in the box plots

13.2 Ecological Health

13.2.1 Aquatic Plants

Table 13-1 summarizes the calculated Lake Plant Eutrophication IBI values for La Lake based on point-intercept plant surveys completed in 2021 and 2024. La Lake scored above both plant IBI metrics in June 2021, but below both metrics in August 2021 and June and August 2024. The most recent metrics suggest a degraded plant community that is likely stressed from cultural eutrophication. Table 13-1 also summarizes the percentage of the littoral area where aquatic plants were found and lists observed aquatic invasive species, their frequency of occurrence (FOO), and current management practices. Other plant health metrics can be referenced in the 2021 and 2024 Aquatic Vegetation Survey Results reports (Stantec, 2021, 2025).

Table 13-1 La Lake aquatic plants overview

Lake	Parameter	June 2021[1]	August 2021[1]	June 2024[2]	August 2024[2]	MnDNR Threshold	Invasive Species Management
La	Species Richness	12	10	9	8	>11	
	Floristic Quality Index (FQI)	18.7	16	13.4	11.5	>17.8	
	% Littoral with Vegetation	100%	100%	76%	59%		
	Curly-leaf Pondweed FOO	29%	-	-	-		Herbicide applications 2022 - 2025
	Purple Loosestrife FOO	-	P	-	-		Managed naturally by leaf eating beetles

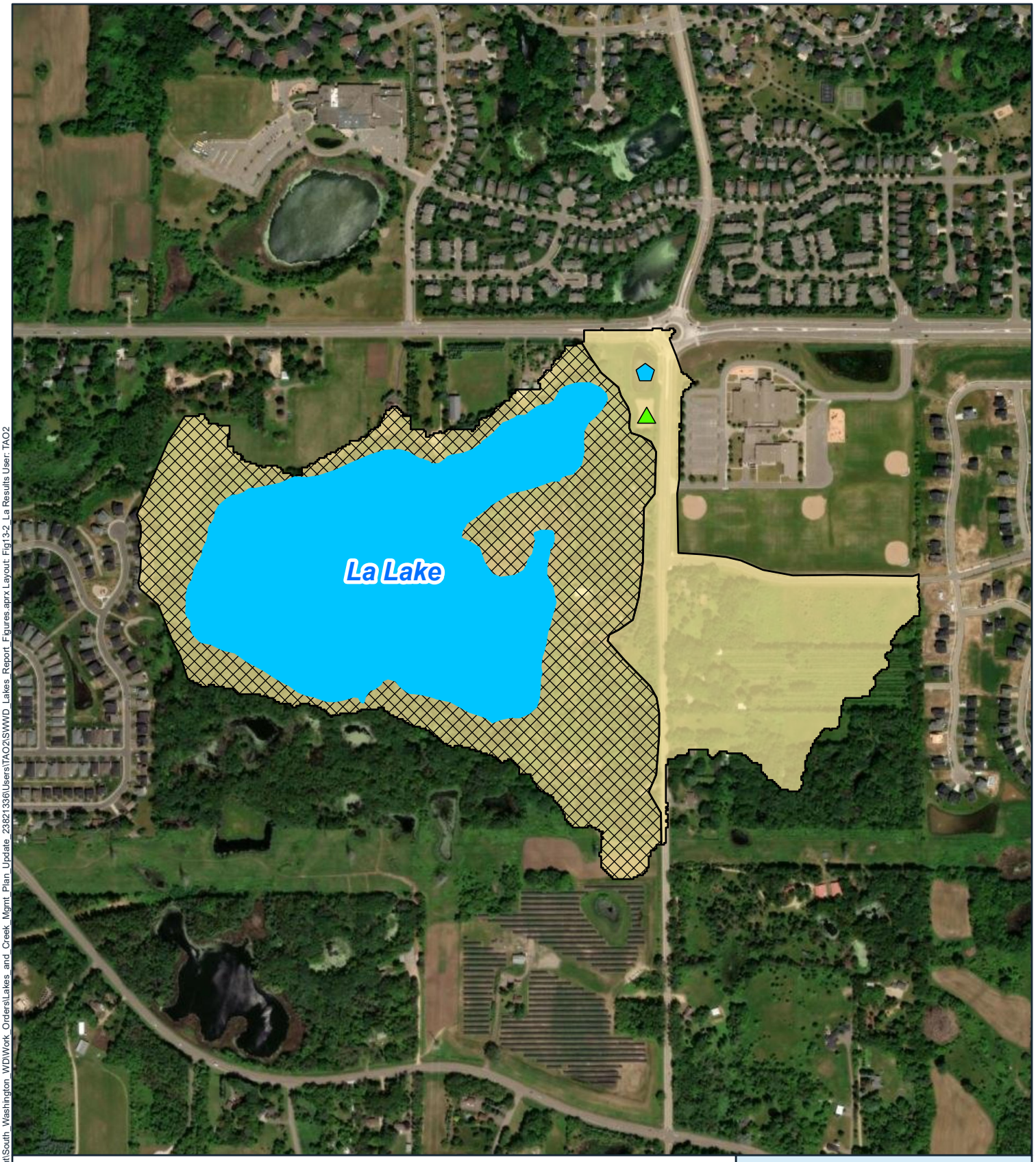
[1] (Stantec, 2021 Aquatic Vegetation Survey Results, 2021)
[2] (Stantec, 2025)

13.2.2 Fisheries

Although La Lake has historically been used as a walleye rearing waterbody, the absence of recent fish survey data prevents an assessment of current walleye abundance. There are no MNDNR fish survey or stocking data available for La Lake.

13.3 Watershed Total Phosphorus Loads

P8 modeling shows low watershed phosphorus loads to La Lake. There are only two watersheds that drain to La Lake under current conditions, totaling approximately 130 acres. The direct drainage area to La Lake is primarily wooded and undeveloped, and runoff does not receive any treatment before entering the lake. The upstream watershed to the lake drains some agricultural land as well as a portion of Woodlane Drive before discharging to a stormwater pond and filtration basin. It should be noted that these BMPs were constructed after 2019, so the modeling results for 2019 only include the direct drainage area to La Lake. The map in Figure 13-2 shows the effective areal phosphorus load by subwatershed, modeled BMPs, and untreated subwatersheds in the area. The effective phosphorus load represents the loading rate after pollutant removal by stormwater BMPs within the watershed and is reflective of the loading that actually makes it into the receiving waterbody from a given location. The effective phosphorus loads for the La Lake subwatersheds range from 0.08 pounds per acre per year to 0.2 pounds per acre per year, based on a 10-year modeling period (2012-2022).



Lake

P8 Device Type

- Infiltration Basin
- Pipe
- Wet Pond

Effective TP Load (lbs/ac/yr)*

- 0.0 - 0.3
- 0.3 - 0.6
- 0.6 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0
- Area Not Treated by BMP

*Watersheds shown represent post-BMP condition

N

0 300 600

Feet

La Lake
Effective TP Loading
Lake Management Plan
South Washington
Watershed District

FIGURE 13-2

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13.4 In-lake Total Phosphorus Loads

Results of the in-lake modeling for La Lake showed that given the small size of the tributary watershed, phosphorus loading was dominated by internal loading in both the wet summer of 2019 and the dry summer of 2022, representing 77% (34 lbs) and 90% (57 lbs) of the phosphorus loading to the lake, respectively (Figure 13-3). In 2019, smaller total phosphorus loads were estimated to be present from groundwater inflow (16%, 7 lbs) and watershed runoff (7%, 3 lbs). Similarly in 2022, smaller total phosphorus loads were present from groundwater inflow (9%, 6 lbs) and watershed runoff (1%, 0.4 lbs).

There is uncertainty associated with the internal loading estimates for La Lake due to: (1) uncertainty in estimating groundwater interactions and that groundwater inflows were estimated as a major component of the La Lake water balance; and (2) no lake profile monitoring data is available for La Lake (e.g., temperature, dissolved oxygen). Limited groundwater data is available within the vicinity of La Lake, including data on groundwater quality. For the purposes of this study, a groundwater total phosphorus concentration of 88 µg/L was assumed based on the median of the most recent 10 years of annual monitoring data available from well 798060 (National Water Quality Monitoring Council, 2025). The median was used to represent the central tendency of monitoring results for this well, instead of the 10-year average, given the large variability of results within the available monitoring data. If the assumed groundwater total phosphorus concentration was too low during the modeled periods, then the internal phosphorus load is overestimated in the lake calibrations. Conversely, if the assumed groundwater concentration was too high, then the internal phosphorus load is underestimated in the lake calibrations. Since groundwater inflow is a major component of the La Lake water balance, more detailed groundwater monitoring is recommended to confirm the extent of groundwater inflow impacts on in-lake phosphorus concentrations.

Additionally, profile monitoring data, including dissolved oxygen and temperature, has not historically been collected on La Lake. Therefore, no definitive conclusions can be drawn about the effects of lake stratification and mixing on internal loading. Understanding the role of lake stratification on internal loading would be important should the District decide to pursue developing sediment inactivation strategies. The collection of profile water quality data is especially critical since sediment core release rate experiments conducted in 2017 indicated a relatively low potential for internal phosphorus loading from lake bottom sediment (Section 4.8). However, even a low internal phosphorus loading rate can notably increase phosphorus concentrations in the lake water column, especially in shallow lakes with small water volumes per surface area of lake bottom.

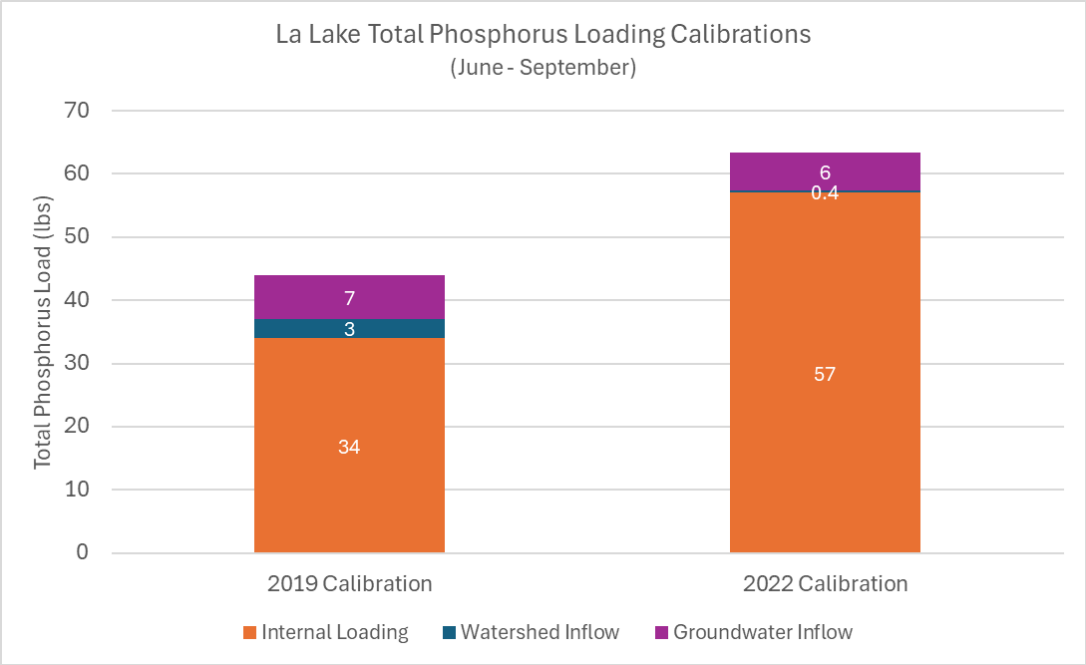


Figure 13-3 La Lake total phosphorus load estimates – 2019 & 2022

13.5 Predicted Benefits from Implementing In-lake Management Practices

One of the study goals was to estimate the potential impact of lake sediment inactivation projects and how they could be used to improve in-lake water quality. The calibrated in-lake models were used to estimate the impact of implementing sediment treatment projects in La Lake.

Table 13-2 summarizes the estimated phosphorus load reduction from two scenarios: sediment inactivation (low efficacy) and sediment inactivation (high efficacy). Results from the in-lake modeling predict a reduction of 21 – 46 pounds of total phosphorus loading into La Lake through implementation of sediment inactivation practices for a wet (2019) and dry (2022) year. This reduction in phosphorus loading translates to a reduction in the in-lake total phosphorus concentrations. Model results estimate that the 2019 summer average total phosphorus concentration of 32 µg/L would reduce to 21 - 24 µg/L with the implementation of sediment treatments; and the 2022 summer average total phosphorus concentration of 39 µg/L would reduce to 23 - 27 µg/L (Table 13-2). The existing summer average total phosphorus concentrations in La Lake already meet state standards, but implementing sediment inactivation projects would offer opportunities to further reduce phosphorus concentrations. Figure 13-4 and Figure 13-5 summarize the predicted reductions in in-lake total phosphorus concentrations for the 2019 and 2022 model years, respectively, for each of the proposed scenarios.

Table 13-2 Summer growing period estimated reductions in phosphorus loads and in-lake concentrations in La Lake with the proposed management practices

Scenario	Modeled Summer Total Phosphorus Loading (lbs)					Summer Average Total Phosphorus (µg/L)[1]
	Watershed Inflow	Groundwater Inflow	Internal Loading	Total	Load Reduction	
2019 Existing	3	7	34	44	-	32
2019 Sediment Inactivation Low	3	7	13	23	-21	24
2019 Sediment Inactivation High	3	7	7	17	-27	21
2022 Existing	0.4	6	57	63	-	39
2022 Sediment Inactivation Low	0.4	6	23	29	-34	27
2022 Sediment Inactivation High	0.4	6	11	17	-46	23

[1] Existing conditions summer average concentrations are calculated from calibrated in-lake models

Model results estimating the in-lake response to reduced internal phosphorus loading reflect the estimated impacts that would have occurred during the 2019 and 2022 growing seasons if a sediment inactivation project had been implemented that year. The modeling incorporates a range of assumed sediment-treatment efficacies to account for application variability and the fact that the specific treatment approach (alum, alum/iron, or aeration) has not yet been selected. Assumed efficacies were informed by monitoring data from comparable Barr sediment-inactivation projects one year post-implementation. Monitoring of past projects shows that sediment inactivation efficacy can vary and is expected to decline over time due to product aging, new watershed inflows, and/or burial from rough fish activity. As such, results presented in this report provide an estimate of the expected scale of treatment impacts within a given growing season, but do not account for longer-term changes within the system and how that may impact benefits over time. For more information on the sediment inactivation modeling assumptions see Section 6.4.

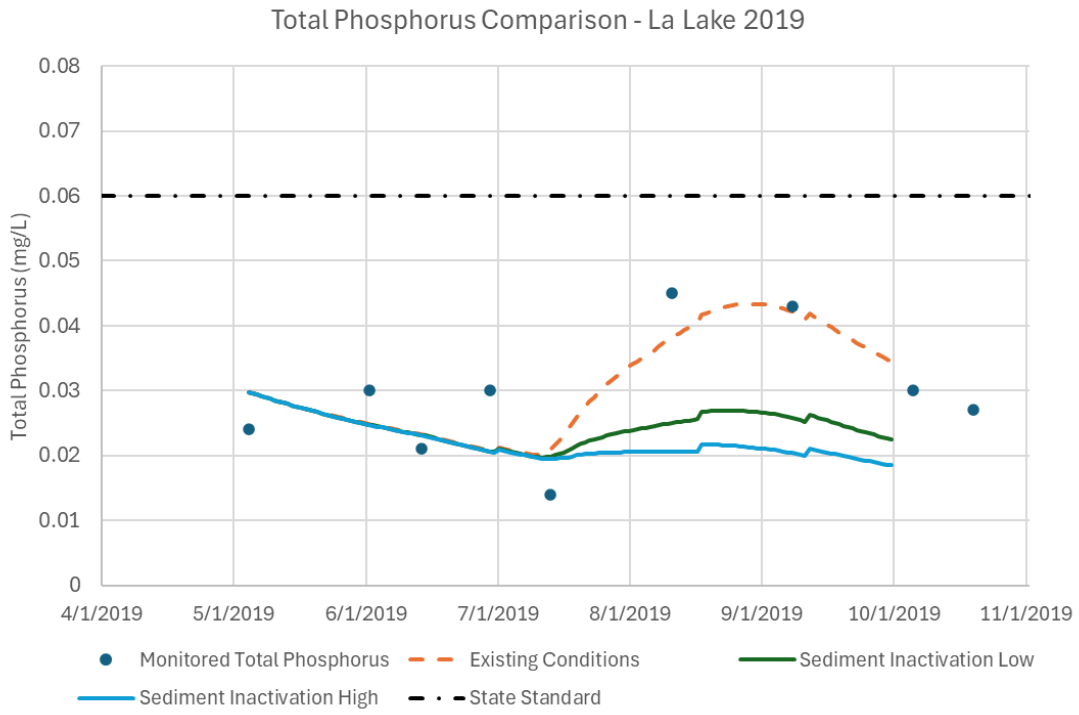


Figure 13-4 Model-predicted reductions in 2019 total phosphorus concentrations in La Lake with the proposed management practices

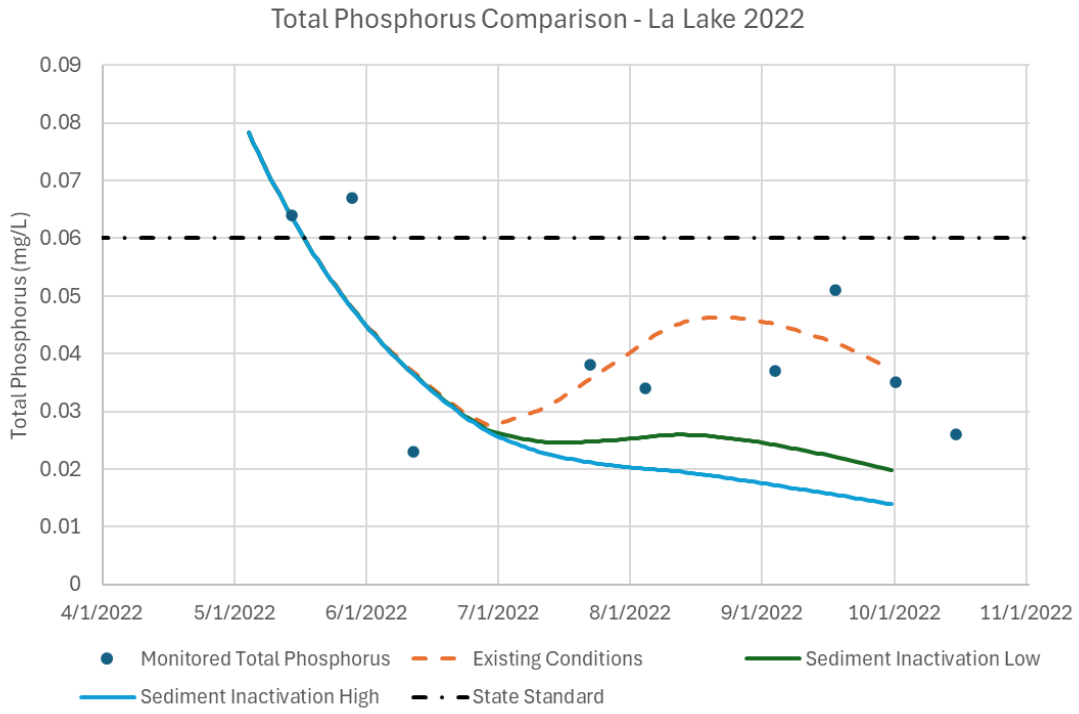


Figure 13-5 Model-predicted reductions in 2022 total phosphorus concentrations in La Lake with the proposed management practices

13.6 Management Recommendations

Monitoring of La Lake indicates improved water quality in recent years; however, the aquatic plant community is threatened by the growth of the aquatic invasive species, curly-leaf pondweed. Given this, future management efforts should focus on protecting lake water quality and improving ecosystem health, monitoring for changes, and continuing water quality and ecosystem health protection measures as improvements are achieved. Table 13-3 summarizes the recommended management strategies that could be considered for La Lake to help protect water quality conditions and improve ecological health.

Table 13-3 La Lake management recommendations

Management/Protection Action		Basis
Address external watershed loads	Enhanced street sweeping program	Continue to work with the City of Woodbury to refine an enhanced street sweeping program to reduce pollutant loading to stormwater runoff
	Stormwater BMPs	If areas of the small watershed develop, continue to enforce SWWD rules and consider implementing site scale BMPs as opportunities arise
Address internal loads	Sediment inactivation treatment	Review and consider implementing a sediment inactivation treatment to reduce lake bottom sediment phosphorus loads should in-lake conditions start to worsen
Aquatic Plants	Invasive species management	Continue to monitor invasive species growth (e.g., curly-leaf pondweed) and continue management as needed
	Promote native aquatic plant growth	Encourage native plant reestablishment during and following aquatic invasive species management
Fisheries	Fisheries Survey	Consider collecting fish community data
Phytoplankton and Zooplankton	Phytoplankton/Zooplankton monitoring	Consider monitoring phytoplankton and zooplankton as part of routine monitoring
Water Quality	Water quality monitoring	Continue monitoring in-lake water quality and assessing trends for eutrophication within La Lake Consider collecting chloride data to monitor in-lake chloride concentrations from winter salt use Consider collecting profile monitoring data (e.g., dissolved oxygen, temperature) Collect additional information on groundwater contributions into the lake (water quality, groundwater-surface water interactions) to confirm impacts

14 Ravine Lake

14.1 Water Quality

Ravine Lake is located in the City of Cottage Grove and is used primarily for active and passive recreation and wildlife viewing. When water levels are high enough, water discharges via gravity flow from Ravine Lake to a downstream creek which ultimately discharges to the Mississippi River. The total watershed area to Ravine Lake is approximately 4,341 acres; however, a large portion of the watershed only contributes flow to the lake under extreme rainfall events, causing the more typical tributary area to be approximately 1,698 acres.

Shallow/Deep	Shallow
Location	Cottage Grove
Surface Area	25 acres
Average/Maximum Depth	5 feet/16 feet
Watershed Area	1,698 acres
Watershed:Lake Surface Area	68:1
Impairment Status	Impaired for nutrients since 2006
Downstream Waterbody	Unnamed Stream/Mississippi River

Ravine Lake has a water surface area of approximately 25 acres, a maximum depth of 16 feet, and a mean depth of approximately 5 feet. Ravine Lake falls under the MNDNR classification of a "shallow lake" given that the lake's littoral area is greater than 80% the total lake area. Ravine Lake is deep enough that prolonged periods of lake stratification occur during the growing season. Profile monitoring data from within the lake supports this finding.

The State of Minnesota uses three water quality parameters to assess eutrophication standards within lakes—total phosphorus, chlorophyll-*a*, and Secchi disk transparency—to assess waterbody health and track water quality changes. These three parameters were measured in Ravine Lake by the SWWD between 1998 – 2023 (Figure 14-1). Monitoring data collected in 2017 was collected at a reduced frequency from other monitored years. Not enough measurements were collected to calculate summer averages for that year. During the monitored years with adequate data, summer average total phosphorus concentrations were better than the state standard in 2005, 2007, 2009 – 2010, 2014 – 2015, and 2019. Summer average chlorophyll-*a* concentrations were better than the state standard in 1998, 2007, and 2009. All other monitored years exceeded the state standard. Summer average Secchi depths met or were better than the state standard in 1999, 2004 – 2020, and 2022 – 2023. Ravine Lake was added to the Minnesota impaired water lists as impaired for nutrients in 2006.

Chloride concentrations were measured by the SWWD between 2005 – 2007 and 2009 – 2023 (generally between April and September). In the historical record, all observed chloride concentrations were below the MPCA chronic standard of 230 mg/L. The highest observed chloride concentration was 84 mg/L in July 2014. Most observed chloride concentrations are below 50 mg/L. While chloride concentrations within Ravine Lake remain well below the chronic water quality standard, concentrations have been on a steady rise within the lake over the past 18 years; with average annual observed concentrations increasing from 10 mg/L to 45 mg/L between 2005 and 2023.

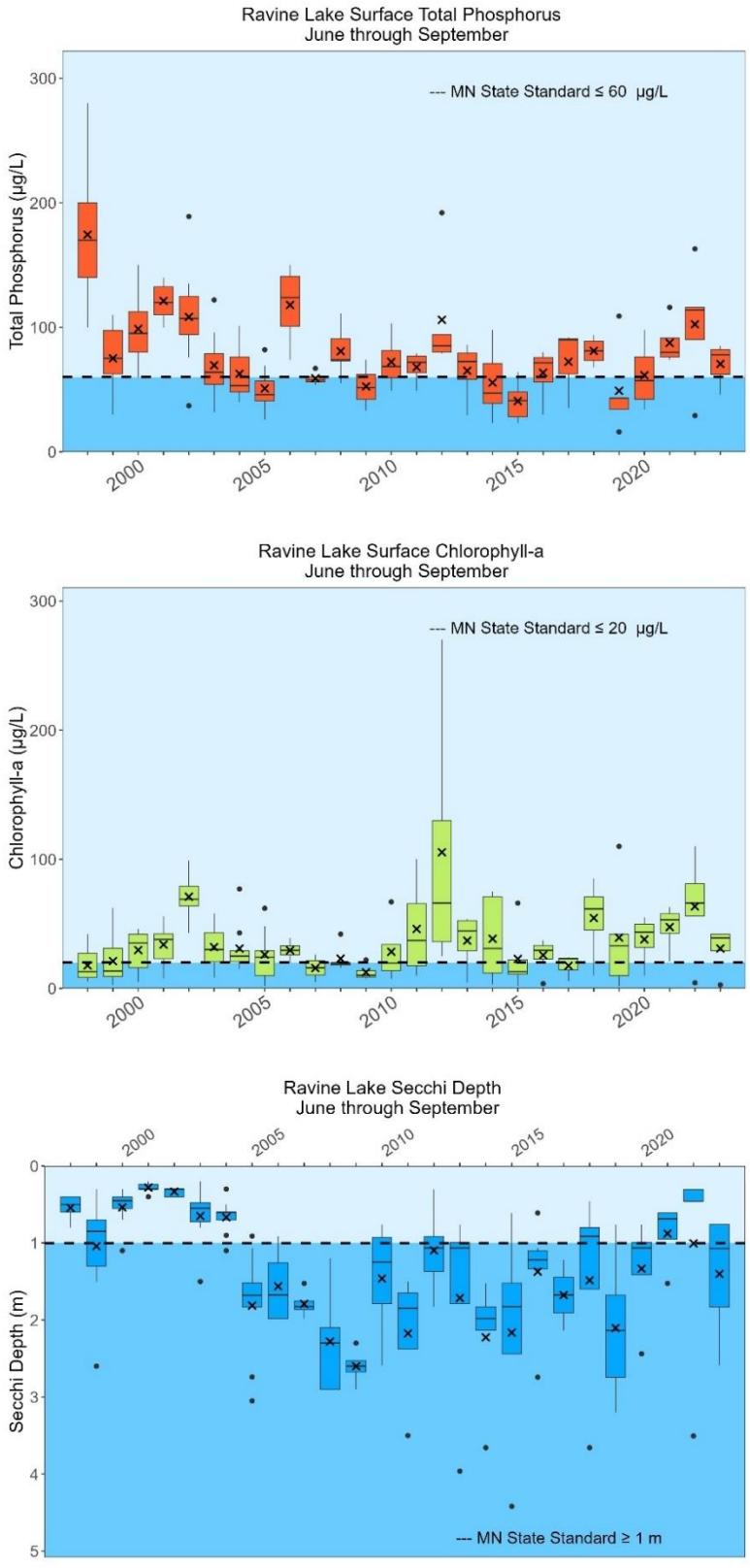


Figure 14-1 Ravine Lake eutrophication monitoring data (June – September)
Summer averages are shown by x's in the box plots

14.2 Ecological Health

14.2.1 Aquatic Plants

Table 14-1 summarizes the calculated Lake Plant Eutrophication IBI values for Ravine Lake based on point-intercept plant surveys completed in 2021 and 2024. Ravine Lake is the only lake in the District that falls in the Western Corn Belt Plains ecoregion. This ecoregion has less stringent MNDNR plant IBI metrics than the other District Lakes, which are located in the North Central Hardwood Forest ecoregion. Comparing Ravine Lake to the Western Corn Belt Plains ecoregion metrics, the lake scored above both plant IBI metrics in June and August in 2021 and 2024. Table 14-1 also summarizes the percentage of the littoral area where aquatic plants were found and lists observed aquatic invasive species, their frequency of occurrence (FOO), and current management practices. Other plant health metrics can be referenced in the 2021 and 2024 Aquatic Vegetation Survey Results reports (Stantec, 2021, 2025).

Table 14-1 Ravine Lake aquatic plants overview

Lake	Parameter	June 2021[1]	August 2021[1]	June 2024[2]	August 2024[2]	MnDNR Threshold	Invasive Species Management
Ravine[3]	Species Richness	11	9	8	7	>4	
	Floristic Quality Index (FQI)	15.5	11.7	11.8	11.7	>7.7	
	% Littoral with Vegetation	90%	88%	78%	75%		
	Curly-leaf Pondweed FOO	86%	27%	39%	-		Herbicide applications 2022 - 2025

[1] (Stantec, 2021 Aquatic Vegetation Survey Results, 2021)
[2] (Stantec, 2025)
[3] Ravine Lake is the only lake in the District that falls in the Western Corn Belt Plains ecoregion, which has different species richness and FQI thresholds than the North Central Hardwood Forest ecoregion.

14.2.2 Fisheries

Ravine Lake is included in the Fishing in the Neighborhood (FiN) program run by the MNDNR, which is aimed at increasing angling opportunities, public awareness, and environmental stewardship within the seven-county Twin Cities metro area. The MNDNR FiN program has been actively involved in managing the sport fish populations of Ravine Lake since 2001. As such, the fish community is surveyed at a regular frequency. Fish stocking data from the most recent decade is also available. Table 14-2 summarizes the fish community data from the most recent survey conducted in August 2021 (MNDNR, 2021). Table 14-3 summarizes the fish stocking report from the last decade (MNDNR, 2024). Walleye have been stocked annually in Ravine Lake since 2002.

Based on the review of aerial imagery and field observations, Ravine Lake does not always completely ice over during the course of winter due to impacts from groundwater inflows. Open water areas in winter can provide better winter oxygen conditions within the lake and limit the risk of winter fish kills.

Table 14-2 Ravine Lake fish survey report – 2021 (MNDNR, LakeFinder, 2021)

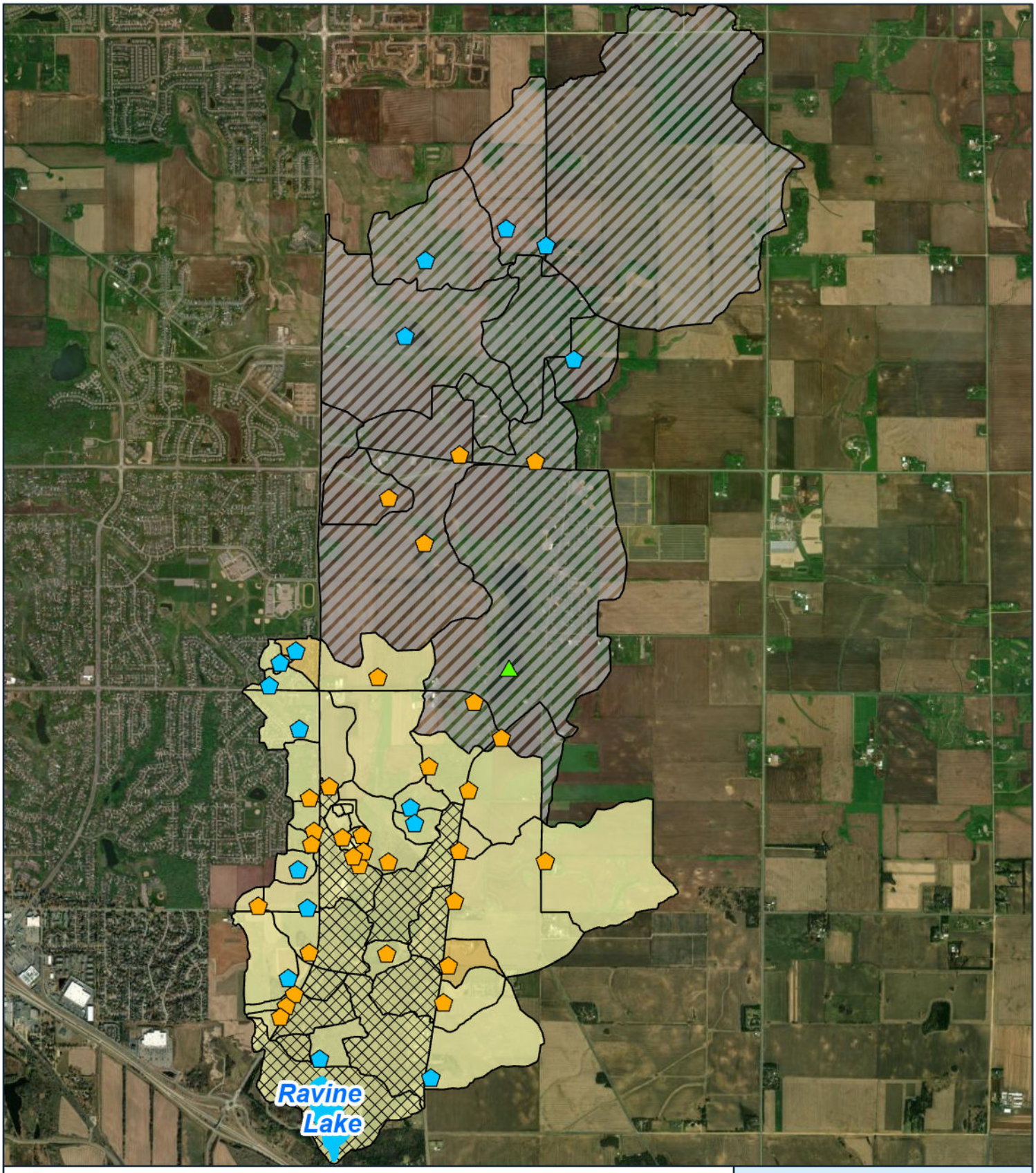
Catch Method	Fish Species	Catch per Unit Effort (CPUE)	Normal CPUE Range	Count
Standard trap nets	Black bullhead	0.2	2.5 – 70.2	1
	Black crappie	0.6	1.3 – 27.7	3
	Bluegill	50.2	2.8 – 43.3	251
	Brown bullhead	0.4	0.2 – 6.2	2
	Hybrid sunfish	1.2	N/A	6
	Pumpkinseed	0.4	0.8 – 9.3	2
	Walleye	0.6	0.3 – 1.3	3
	White sucker	0.4	0.2 – 2.2	2
Standard gill nets	Black bullhead	1.0	8.0 – 90.0	1
	Black crappie	2.0	2.0 – 19.0	2
	Bluegill	7.0	N/A	7
	Northern Pike	1.0	1.5 – 9.0	1
	Yellow Perch	5.0	2.5 – 25.8	5

Table 14-3 Ravine Lake fish stocking report – 2015-2024 (MNDNR, LakeFinder, 2024)

Year	Fish Species	Size	Number	Pounds
2024	Walleye	yearlings	411	75.0
2023	Walleye	adults	43	43.0
2022	Walleye	adults	107	100.0
2021	Walleye	adults	167	233.8
		yearlings	126	18.0
2020	Walleye	adults	60	60.0
		yearlings	252	42.0
2019	Walleye	fingerlings	627	66.0
2018	Walleye	adults	120	120.0
2017	Walleye	adults	75	75.0
2016	Walleye	adults	16	16.0
		yearlings	269	79.0
2015	Walleye	yearlings	1,990	99.5

14.3 Watershed Total Phosphorus Loads

P8 modeling shows low watershed phosphorus loads to Ravine Lake. Approximately half of the area tributary to Ravine Lake does not contribute runoff for events smaller than the 100-year storm event. This area is noted as non-contributing in Figure 14-2. The remainder of the tributary area receives some treatment from stormwater ponds or dry detention areas, but much of the contributing area is regional conveyance through undeveloped land. The map in Figure 14-2 shows the effective areal phosphorus load by subwatershed, modeled BMPs, and untreated subwatersheds within the tributary area. The effective phosphorus load represents the loading rate after pollutant removal by BMPs within the watershed and is reflective of the loading that actually makes it into the receiving waterbody from a given location. The effective phosphorus loads for the Ravine Lake subwatersheds range from 0.0 pounds per acre per year to 0.3 pounds per acre per year, based on a 10-year modeling period (2012-2022).



Lake

P8 Device Type

- Dry Pond
- Infiltration Basin
- Pipe
- Wet Pond

Effective TP Load (lbs/ac/yr)

- 0.0 - 0.3
- 0.3 - 0.6
- 0.6 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

Area Not Treated by BMP

Non-Contributing Subwatersheds

N

0 2,000 4,000

Feet

Ravine Lake
Effective TP Loading
Lakes and Creeks Management Plan
SWWD

FIGURE 14-2

BARR

Barr footer:

14.4 In-lake Total Phosphorus Loads

Results of the in-lake modeling for Ravine Lake showed that during the summer of 2019 (representing a wet year), phosphorus loading into Ravine Lake from the tributary watershed was greater than the contribution from internal loading or groundwater inflow. Phosphorus load from watershed runoff represented 51% (80 lbs) of the phosphorus loading during the summer of 2019 (Figure 14-3). Internal loading in summer 2019 was estimated to be 42% (67 lbs) and groundwater inflow was estimated to be 7% (12 lbs) of the phosphorus load to the lake. During the drier summer of 2022, the phosphorus loading to Ravine Lake from watershed runoff was notably lower, representing 21% (37 lbs) of the phosphorus loading to the lake. The 2022 total phosphorus load from groundwater inflow was similar to the load in 2019, representing 5% (9 lbs) of the total load. Internal phosphorus loading in 2022 was notably higher than 2019, representing 74% (127 lbs) of the phosphorus load.

As discussed in Section 6.2.1.1 Water Balance Assumptions, there is high level of uncertainty associated with Ravine Lake's water balance calibrations in 2019 and 2022. Beaver dams are frequently observed at the Ravine Lake outlet and, while field notes provided some information on beaver dam observations and occasional removal dates, there are no detailed records available for model years 2019 and 2022 on the exact durations of beaver dam impacts, approximate dimensions of the beaver dams, and/or measured impacts to outflow discharge rates. This led to a high level of uncertainty with simulating hourly outflows from the lake. Secondly, Ravine Lake is known to have sizable groundwater inflow; however, there are no detailed monitoring records available on groundwater inflow rates. Beaver dam impacts to the outlet, coupled with non-monitored groundwater inflow rates, result in two unknowns in the water balance. For the purposes of model development, Barr used the available data on water surface elevations and water quality monitoring to infer the most accurate inflow and outflow rates over the modeled time periods. For example, between mid-June through mid-September 2019 the monitored water surface elevations in Ravine Lake were approximately 0.3 feet above the outlet elevation. During this time period, the model includes an assumption that a beaver dam was installed in the outlet and changed the control elevation of the lake. Similar assumptions were needed in the 2022 model. Given the uncertainty associated with inflows and outflows in the Ravine Lake model, this inherently results in uncertainty in the total phosphorus loading estimates. Improved monitoring on Ravine Lake inflow and outflow rates could support better certainty in phosphorus loading estimates.

The higher estimated groundwater influence on Ravine Lake also contributes to uncertainty in the internal loading estimates. Limited groundwater water quality monitoring data is available from wells in the vicinity of Ravine Lake. For the purposes of this study, a groundwater total phosphorus concentration of 20 µg/L was assumed based on the 10-year average annual monitoring data available from well 778334 (National Water Quality Monitoring Council, 2025). If the assumed groundwater total phosphorus concentration was too low during the modeled periods, then the internal phosphorus load is overestimated in the lake calibrations. Conversely, if the assumed groundwater concentration was too high, then the internal phosphorus load is underestimated in the lake calibrations. Since groundwater inflow is a notable component of the Ravine Lake water balance (Section 6.2.1.1), more detailed groundwater monitoring is recommended to confirm the extent of groundwater inflow impacts on in-lake phosphorus concentrations.

Bi-weekly profile monitoring data is typically collected from Ravine Lake between April and October each year, including the collection of temperature and dissolved oxygen concentrations. The data indicates that Ravine Lake can have temperature stratification as early as late-April or early-May in most years and typically remains stratified until fall. To simulate lake stratification, model calibration parameters were adjusted to suppress the amount of internal phosphorus load reaching the surface waters during the growing season. Given that the monitoring data demonstrates strong lake stratification during the

summer, the collection of water quality parameters at multiple depths is recommended to better estimate internal loading influence on surface water conditions (e.g., collecting phosphorus near the surface, at the thermocline, and near the bottom). Understanding how lake stratification influences internal loading will be essential for developing effective sediment inactivation strategies and demonstrating benefits, should the District decide to pursue this type of treatment. The collection of water quality parameters at multiple depths is especially important as sediment core phosphorus fractionation data indicate a high potential for phosphorus release from lake bottom sediment (Section 4.8).

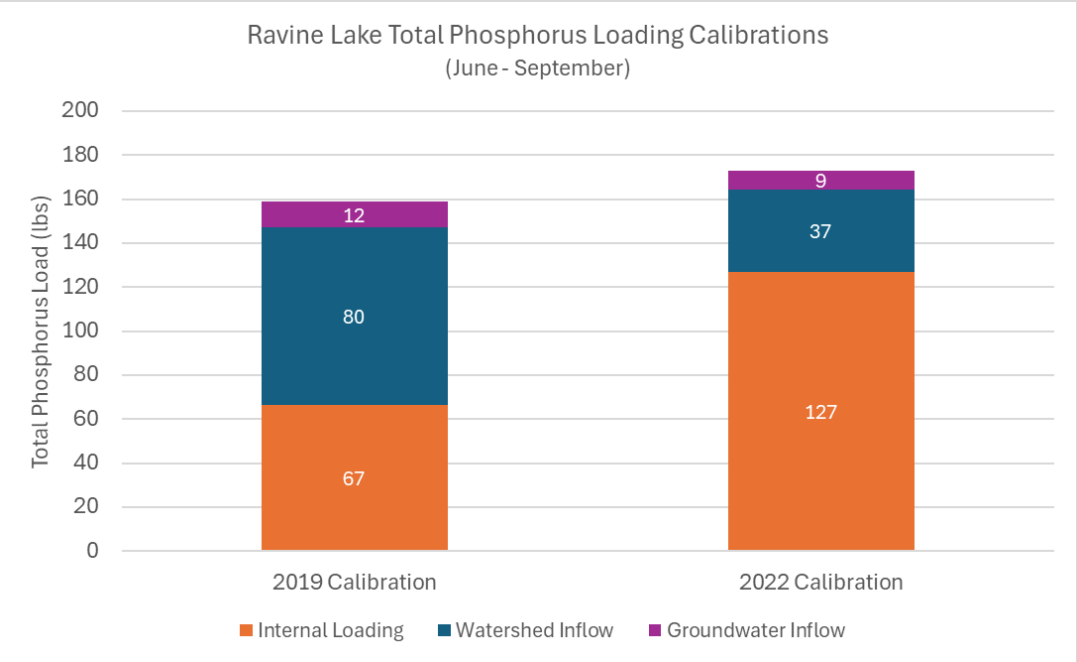


Figure 14-3 Ravine Lake total phosphorus load estimates – 2019 & 2022

14.5 Nitrogen and Algal Growth

14.5.1 Nitrogen Limitation

Throughout the growing season, various factors can influence the rate and volume of algae growth within a lake, such as phosphorus, nitrogen, light, and temperature. The Barr Shallow Lake Model was used for simulating water quality within Ravine Lake; this model utilizes Michaelis Menten kinetics to determine which factor or combination of factors limit algae growth throughout the modeled time period. Although nitrate, nitrite, ammonia, and ammonium water quality data were not available for model calibration, the effect of nitrogen on chlorophyll-*a* growth was deduced for Ravine Lake using the lake model. In both the 2019 and 2022 models, accounting for nitrogen limitation as part of the model calibration improved model results with respect to simulating chlorophyll-*a*. In the 2019 model, nitrogen limitation was initiated in early August to match the drop in chlorophyll-*a* concentrations observed in the monitoring data. In the 2022 model, nitrogen limitation was initiated in early July and sustained throughout portions of August and September to match the drop in chlorophyll-*a* concentrations observed.

Nitrogen limitation during a portion of the growing season has been seen in numerous other shallow lake modeling efforts performed by Barr. Nitrogen limitation tends to occur because the growth rate of algae can be greater than the degradation rate of nitrogen (i.e., slow decomposition from organic nitrogen forms to ammonia and/or slow nitrification rate changing ammonia to nitrite and nitrate). In other words, algae

will continue to grow until they have used up bioavailable forms of nitrogen in the water column, and once depleted, algae growth will be limited. However, nitrogen limitation does not affect all algal species equally. Certain species of cyanobacteria can persist under nitrogen-limited conditions, even as other algal species decline or disappear entirely. This resilience is due to the ability of some cyanobacteria species to fix atmospheric nitrogen by converting N_2 gas into ammonia. The process is energy-intensive though and will be used only when necessary. This competitive advantage complicates efforts to predict how nitrogen limitation will influence overall algal growth dynamics in a waterbody. The presence of cyanobacteria with nitrogen fixing abilities could not be confirmed as part of this study, as no phytoplankton monitoring data is currently available for this lake.

The algal growth limitations identified during model calibration reflect which parameters are currently limiting growth. As management is implemented, algal growth limitations will likely change. For example, if phosphorus loading from lake bottom sediment is reduced, phosphorus limitation may become more dominant throughout the growing season. Similarly, a reduced phytoplankton population with phosphorus control could also increase nitrogen concentrations (e.g., reduced nitrogen demand) and alleviate the nitrogen limitation and also eliminate a competitive advantage of cyanobacteria. Outcomes of changes in nitrogen dynamics are more challenging to predict than phosphorus management with the information currently available.

14.5.2 Ammonia Impairment

The unnamed stream downstream of Ravine Lake has been identified as impaired for ammonia (NH_3). When ammonia-based fertilizers are applied to agricultural fields, excess can be washed downstream during storm events. Animal waste from livestock also contains ammonia and can enter downstream waterbodies from runoff. Urban areas can also contribute ammonia to downstream waterbodies, especially from areas where fertilizers or animal waste are present.

Under slightly acidic or neutral pH levels (pH < 7), a large percentage of ammonia that enters a waterbody will be transformed into ammonium (NH_4^+) due to the availability of H^+ ions:

$$NH_3 + H^+ \leftrightarrow NH4^+$$

However, at higher pH levels (pH > 9) when there are less H^+ ions available, a higher percentage will be present as ammonia. This is important because high concentrations of ammonia can be toxic to aquatic organisms. Elevated pH levels in freshwater ecosystems often result from intense photosynthetic activity during algal blooms. During high algal growth conditions, carbon dioxide uptake can be rapid. When carbon dioxide is removed from the water, an equilibrium shift occurs between carbonic acid, bicarbonate, carbonate, and carbon dioxide, which removes H^+ ions, resulting in high pH conditions. pH > 9 is often observed in Ravine Lake during the late summer months (July – September). In September 2017, a pH of 11.2 was recorded. Field notes indicate that there were algal scums along the shoreline and definite algal presence at the monitoring location during this sampling event. It's possible that intense photosynthetic activity from algal growth may be sustaining elevated pH levels, which in turn increases the proportion of ammonia in the water.

14.6 Predicted Benefits from Implementing In-lake Management Practices

One of the study goals was to estimate the potential impact of lake sediment inactivation projects and how they could be used to improve in-lake water quality. The calibrated in-lake models were used to estimate the impact of implementing sediment treatment projects in Ravine Lake.

Table 14-4 summarizes the estimated phosphorus load reduction from two scenarios: sediment inactivation (low efficacy) and sediment inactivation (high efficacy). Results from the in-lake modeling predict a reduction of 53 – 104 pounds of total phosphorus loading into Ravine Lake through implementation of sediment inactivation practices for a wet (2019) and dry (2022) year. This reduction in phosphorus loading translates to a reduction in the in-lake total phosphorus concentrations. Model results estimate that the 2019 summer average total phosphorus concentration of 71 µg/L would reduce to 35 - 36 µg/L with the implementation of sediment treatments; and the 2022 summer average total phosphorus concentration of 105 µg/L would reduce to 39 - 44 µg/L (Table 14-4). Figure 14-4 and Figure 14-5 summarize the predicted reductions in in-lake total phosphorus concentrations for the 2019 and 2022 model years, respectively, for each of the proposed scenarios.

Based on the model results, it's predicted that implementing sediment inactivation practices alone in Ravine Lake would not be sufficient to reduce summer average concentrations for chlorophyll-*a* below the state standards. However, given the high level of uncertainty in the calibrated models for this lake, the addition of watershed loading reduction scenarios were not summarized for this report. For more background on the model uncertainty associated with the calibration of the Ravine Lake models and recommendations for addressing that as part of next steps, please refer back to Sections 14.4 and 14.5.

Model results estimating the in-lake response to reduced phosphorus internal loading reflect the estimated impacts that would have occurred during the 2019 and 2022 growing seasons if a sediment inactivation project was implemented in those years. The modeling incorporates a range of assumed sediment-treatment efficacies to account for application variability and the fact that the specific treatment approach (alum, alum/iron, or aeration) has not yet been selected. Assumed efficacies were informed by monitoring data from comparable Barr sediment-inactivation projects one year post-implementation. Monitoring of past projects shows that sediment inactivation efficacy can vary and is expected to decline over time due to product aging, new watershed inflows, and/or burial from rough fish activity. As such, results presented in this report provide an estimate of the expected scale of treatment impacts within a given growing season, but do not account for longer-term changes within the system and how that may impact benefits over time. For more information on the sediment inactivation modeling assumptions see Section 6.4.

Table 14-4 Summer growing period estimated reductions in phosphorus loads and in-lake concentrations in Ravine Lake with the proposed management practices

Scenario	Modeled Summer Total Phosphorus Loading (lbs)					Summer Average Total Phosphorus (µg/L)[1]	Summer Average Chlorophyll-a (µg/L)[1]
	Watershed Inflow	Groundwater Inflow	Internal Loading	Total	Load Reduction		
2019 Existing	80	12	67	159	--	71	56
2019 Sediment Inactivation Low	80	12	13	105	-53	36	30
2019 Sediment Inactivation High	80	12	11	103	-55	35	29
2022 Existing	37	9	127	173	--	105	73
2022 Sediment Inactivation Low	37	9	29	74	-98	44	25
2022 Sediment Inactivation High	37	9	23	69	-104	39	24

[1] Existing conditions summer average concentrations are calculated from calibrated in-lake models

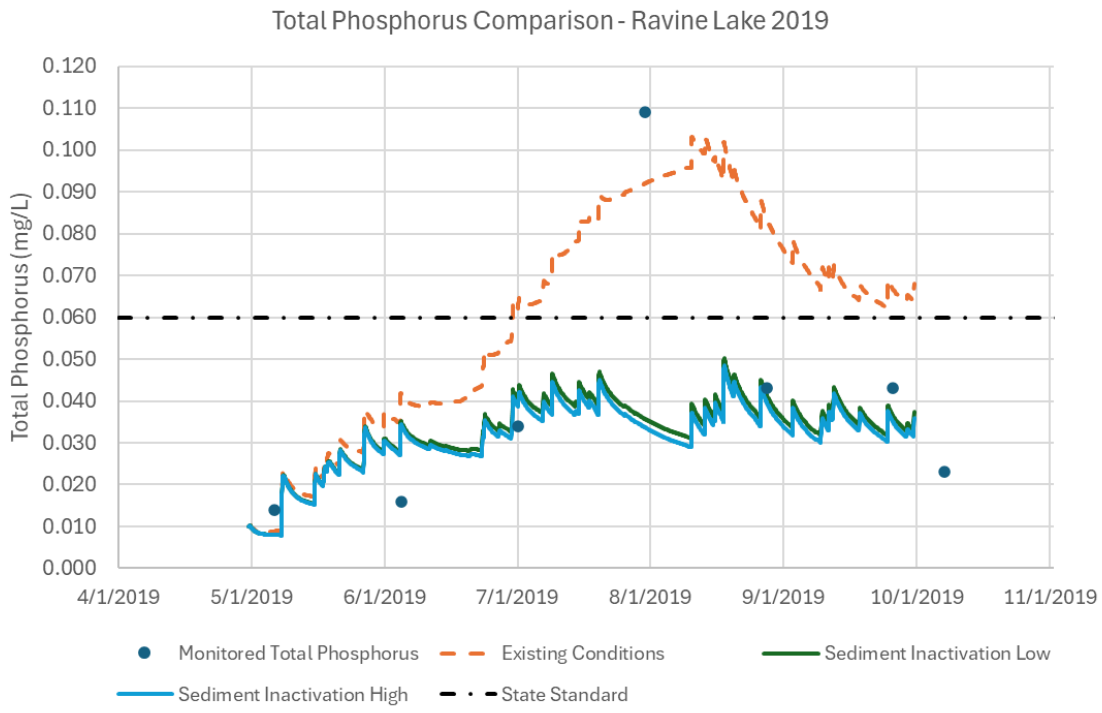


Figure 14-4 Model-predicted reductions in 2019 total phosphorus concentrations in Ravine Lake with the proposed management practices

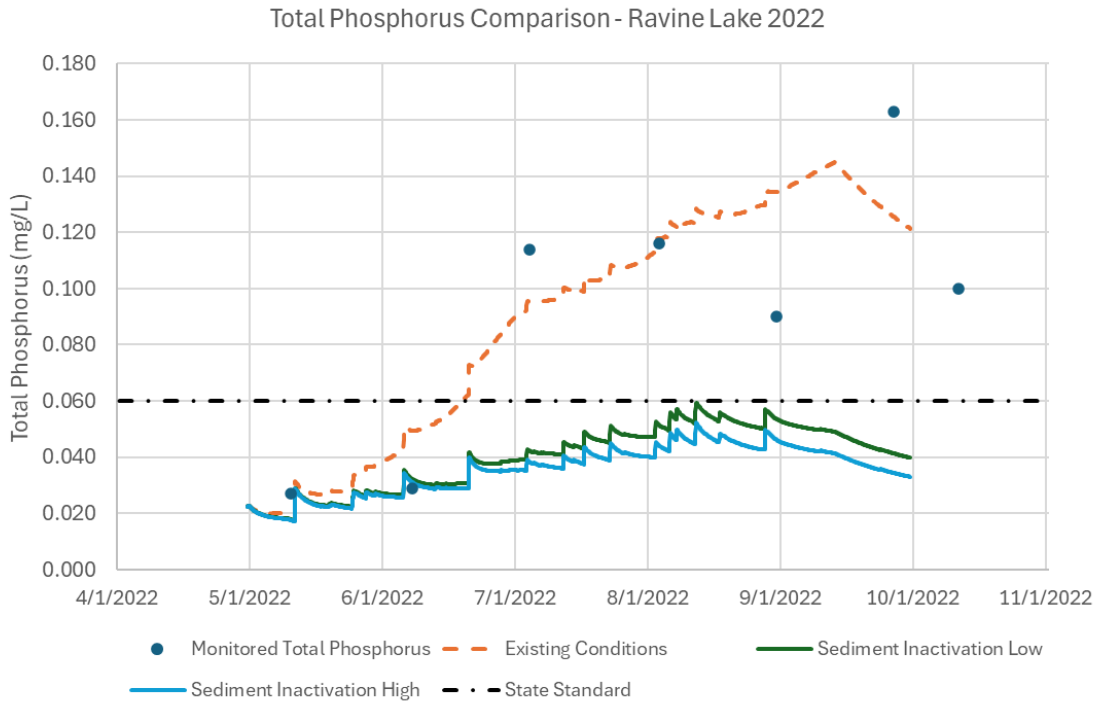


Figure 14-5 Model-predicted reductions in 2022 total phosphorus concentrations in Ravine Lake with the proposed management practices

14.7 Management Recommendations

Monitoring of Ravine Lake indicates degraded water quality in recent years and while aquatic plant monitoring indicates the lake is meeting the MNDNR Western Corn Belt Plains ecoregion plant IBI thresholds, the native aquatic plant community is threatened by the growth of the aquatic invasive species, curly-leaf pondweed. Given this, future management efforts should focus on improving lake water quality and ecosystem health, monitoring for changes, and continuing water quality and ecosystem health protection measures as improvements are achieved. Table 14-5 summarizes the recommended management strategies that could be considered for Ravine Lake to help improve water quality conditions and ecological health.

Table 14-5 Ravine Lake management recommendations

Management/Protection Action		Basis
Address external watershed loads	Enhanced street sweeping program	Consider partnering with City of Cottage Grove to implement enhanced street sweeping programs to reduce pollutant loading to stormwater runoff
	Stormwater BMPs	If areas of the watershed develop (e.g., agricultural land to impervious land use types), continue to enforce SWWD rules and consider implementing site scale BMPs as opportunities arise. Protect un-developed natural and park areas tributary to Ravine Lake
Address internal loads	Sediment inactivation treatment	Review and implement a sediment inactivation treatment to reduce lake bottom sediment phosphorus loads
Aquatic Plants	Invasive species management	Continue to monitor invasive species growth (e.g., curly-leaf pondweed) and continue management as needed
	Promote native aquatic plant growth	Encourage native plant reestablishment during and following aquatic invasive species management Monitor success of native vegetation transplant projects
Phytoplankton and Zooplankton	Phytoplankton/Zooplankton monitoring	Consider monitoring phytoplankton and zooplankton as part of routine monitoring
Water Quality	Water quality monitoring	Continue monitoring in-lake water quality and assessing trends for eutrophication within Ravine Lake Continue to identify/track chloride levels from winter salt use Consider collecting water quality parameters at multiple depths to confirm lake stratification influence on internal phosphorus loading to surface waters Consider supplementing routine monitoring with additional nitrogen parameters for better assessment of phytoplankton nitrogen limitation and ammonia impairment Collect additional information on groundwater contributions into the lake (water quality, groundwater-surface water interactions) to confirm impacts

15 Trout Brook, O'Conners Creek, and O'Conners Lake Watershed and In-lake Modeling

15.1 Water Quality

15.1.1 O'Conners Lake

O'Conners Lake is located in Denmark Township and is used primarily for wildlife viewing. O'Conners Creek flows into O'Conners Lake, which is landlocked with no surface outlet. Under typical climatic conditions water leaves O'Conners creek through groundwater discharge or evaporation only.

O'Conners Lake	
Shallow/Deep	Shallow
Location	Denmark Township
Surface Area (4-yr average)	59 acres
Average/Maximum Depth	4 feet / 13 feet
Watershed Area	6,305 acres
Watershed:Lake Surface Area	107:1
Impairment Status	Not listed on impaired waters list
Downstream Waterbody	Landlocked

Because O'Conners Lake is landlocked, the observed historical water levels have been quite variable ranging from 796.9 in May 2009 to 806.5 in October 2020. In the most recent 4 years of monitoring, O'Conners Lake has had an average water surface area of approximately 59 acres, a maximum depth of 13 feet, and a mean depth of approximately 4 feet. O'Conners Lake is typically shallow enough for aquatic plants to grow over the entire waterbody and for the lake to mix many times per year (polymictic lake).

The State of Minnesota uses three water quality parameters to assess eutrophication standards within lakes—total phosphorus, chlorophyll-*a*, and Secchi disk transparency—to assess waterbody health and track water quality changes. These three parameters were measured in O'Conners Lake by the SWWD between 2005 – 2023 (Figure 15-1). Monitoring data collected between 2011 – 2012, 2019, and 2021 were collected at a reduced frequency from other monitored years. Not enough measurements were collected to calculate summer averages for those years. During the monitored years with adequate data, summer average total phosphorus concentrations were better than the state standard between 2005 – 2008, 2013 – 2014, and 2016 – 2018. Summer average chlorophyll-*a* concentrations were better than the state standard between 2005 – 2008 and in 2014, and 2017. Summer average Secchi depths met or were better than the state standard for all monitored years between 2005 – 2023 except 2007 and 2010. At the time of this study, O'Conners Lake was not included on the Minnesota impaired water list.

Chloride concentrations were measured by the SWWD between 2011 – 2018 and 2020 – 2023 (generally between May and September). In the historical record, all observed chloride concentrations were well below the MPCA chronic standard of 230 mg/L. The highest observed chloride concentration was 40 mg/L in May 2020. Most observed chloride concentrations are below 30 mg/L.

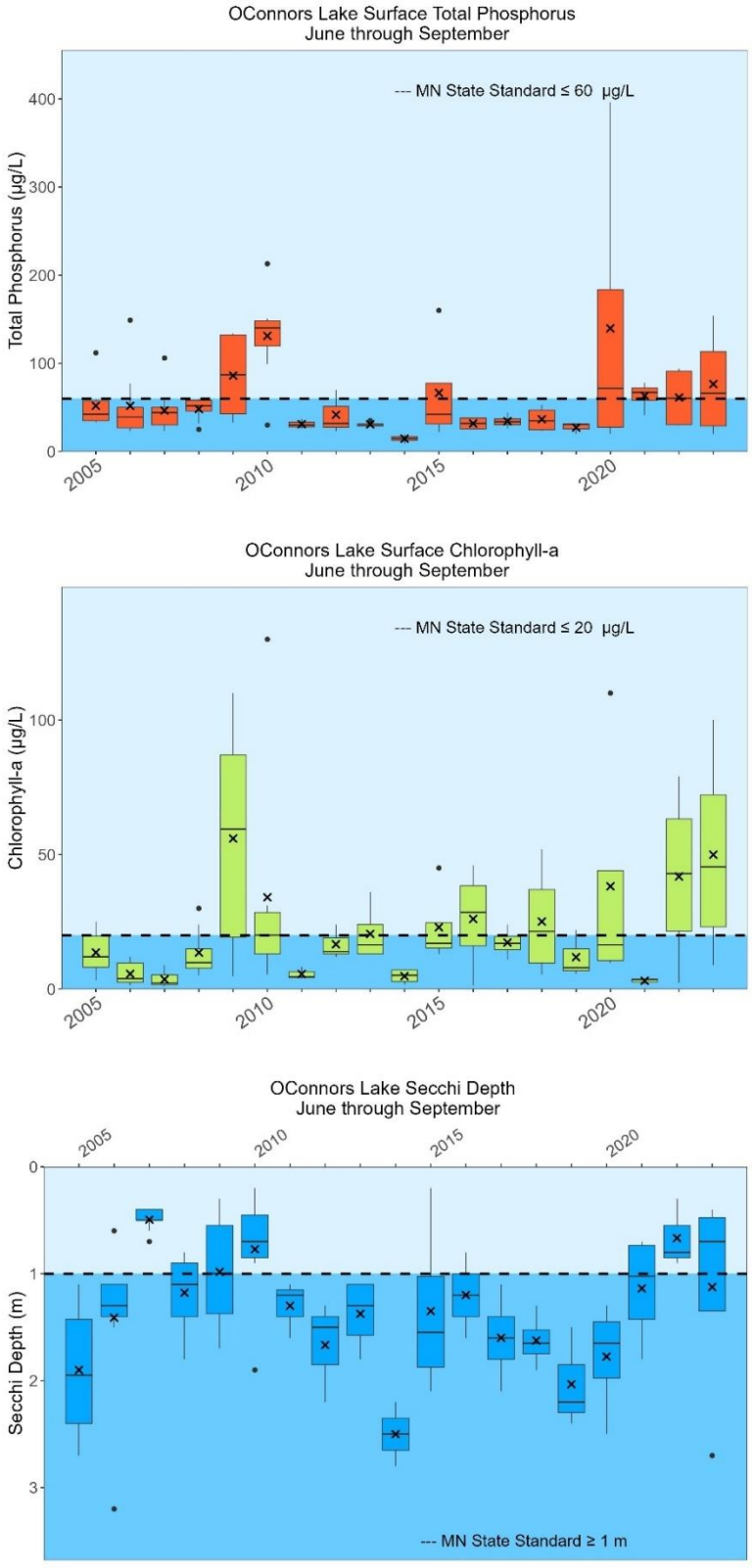


Figure 15-1 O'Conners Lake eutrophication monitoring data (June – September)
Summer averages are shown by x's in the box plots

15.2 Ecological Health

15.2.1 Aquatic Plants

There have been no aquatic plant surveys completed in the last 19 years on O'Conners Lake. Aquatic plant surveys were conducted in 2005 (Emmons & Olivier Resources (EOR), O'Conner's Stream and Lake Management Plan, 2007); however, the data may no longer reflect current lake conditions since water levels between 2020 - 2023 have been 3 – 6 feet higher than what was observed between 2004 – 2005.

15.2.2 Fisheries

There are no MNDNR fish survey or stocking data available for O'Conners Lake.

15.3 Watershed Total Phosphorus Loads

The Trout Brook and O'Conners Creek subwatersheds are located in the eastern portion of the SWWD, and are part of the larger Lower St Croix River Watershed. This portion of the SWWD is more rural in nature than other areas of the District. Primary land cover includes agriculture, forests, and grasslands.

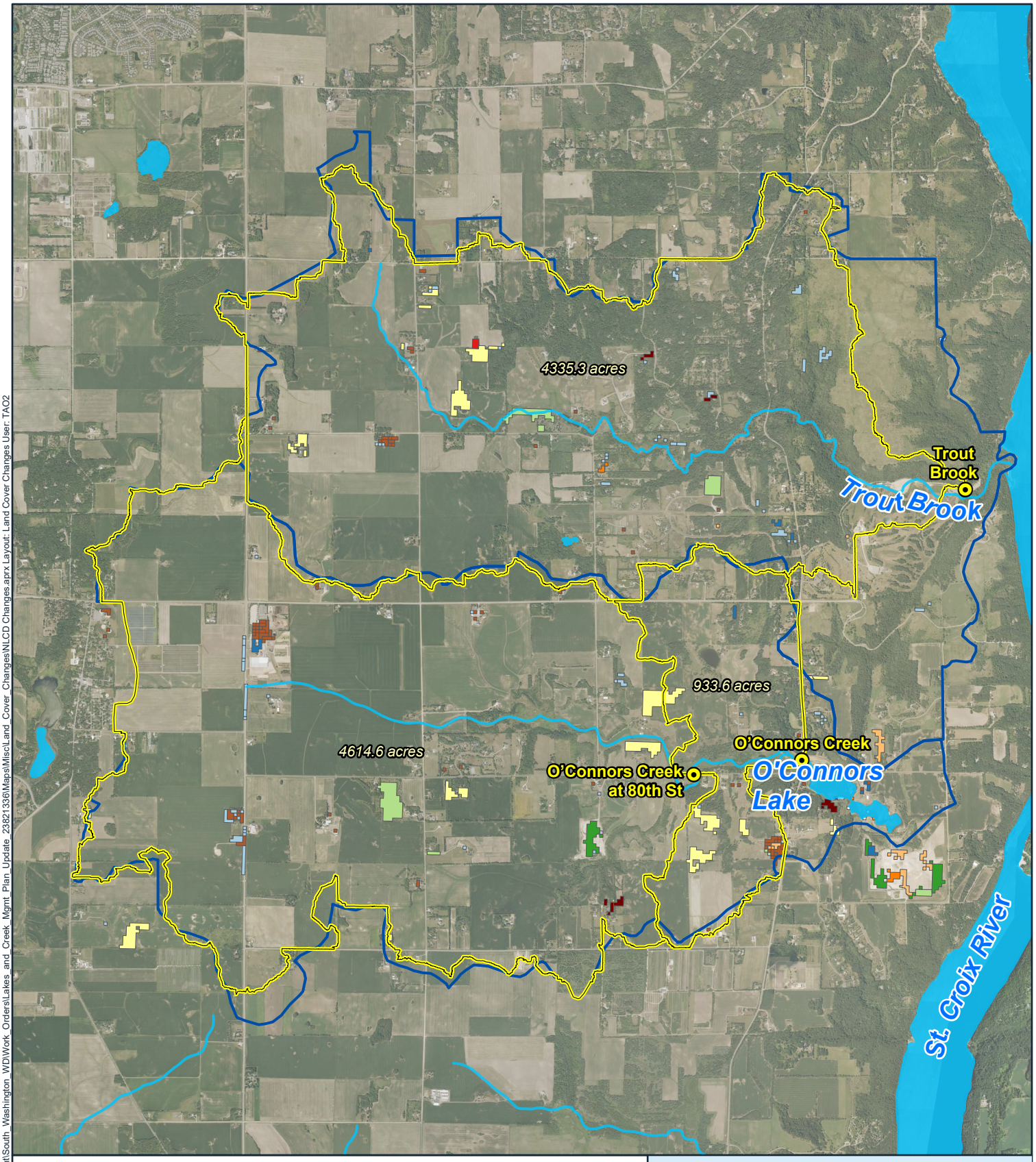
The MPCA completed a TMDL study for the Lake St Croix Watershed in 2012 which includes the Trout Brook and O'Conners Creek subwatersheds. This 2012 study included work to estimate TP areal loading rates for the subwatersheds tributary to Lake St Croix and setting load reduction goals for those areas. Results from the TMDL study indicated an estimated average annual loading of 0.35 lbs TP/acre/year from the Trout Brook and O'Conners Creek subwatersheds. These loads were estimated using information on land uses within these subwatersheds in the early 1990s. The TMDL identified a goal of reducing loads from this area to achieve an average annual loading of 0.22 lbs TP/acre/year to improve water quality conditions within Lake St Croix.

The SWWD has been collecting water quality and flow monitoring data within the Trout Brook and O'Conners Creek subwatersheds since the early 2000s. Water quality sampling for total phosphorus and total suspended solids (TSS) began in 2007, paused for a few years, and then picked up again in the early 2010s. Monitoring data collected by the SWWD was analyzed for this study in order to: 1) assess current water quality conditions within the Trout Brook and O'Conners Creek subwatersheds by estimating current TP loading rates as compared to the goals established within the 2012 TMDL; and 2) to look for trends and correlations within the data that may help to inform future management strategies for improving water quality.

15.3.1 Watershed Characteristics and Monitoring

The monitoring data analyzed for this task was downloaded from the SWWD's water quality database (wq.swwdmn.org) for the Trout Brook, O'Conners Creek, and O'Conners at 80th monitoring sites.

Figure 15-2 shows the location of these monitoring sites. The original O'Conners Creek monitoring site was located at the crossing with St. Croix Trail; this site was relocated upstream to the O'Conners at 80th location following the 2020 monitoring season, due to on-going challenges with tailwater from O'Conners lake impacting monitoring at the original location. Data collection began at the new monitoring location in 2022.



Monitoring Site
Watershed Boundary
Monitoring Site Subwatershed

2004 to 2021 NLCD Changes

- Agriculture, Developed
- Agriculture, Forest
- Agriculture, Grassland
- Agriculture, Shrubland
- Forest, Agriculture
- Forest, Developed
- Forest, Grassland
- Forest, Shrubland
- Forest, Water
- Grassland, Agriculture
- Grassland, Developed
- Grassland, Forest
- Grassland, Shrubland
- Shrubland, Forest
- Shrubland, Grassland
- Shrubland, Water
- Water, Forest

N

0 2,000 4,000
Feet

Trout Brook and O'Connors Creek Subwatersheds, Monitoring Locations, and Land Use Changes
Lake Management Plan
South Washington Watershed District
FIGURE 15-2

BARR

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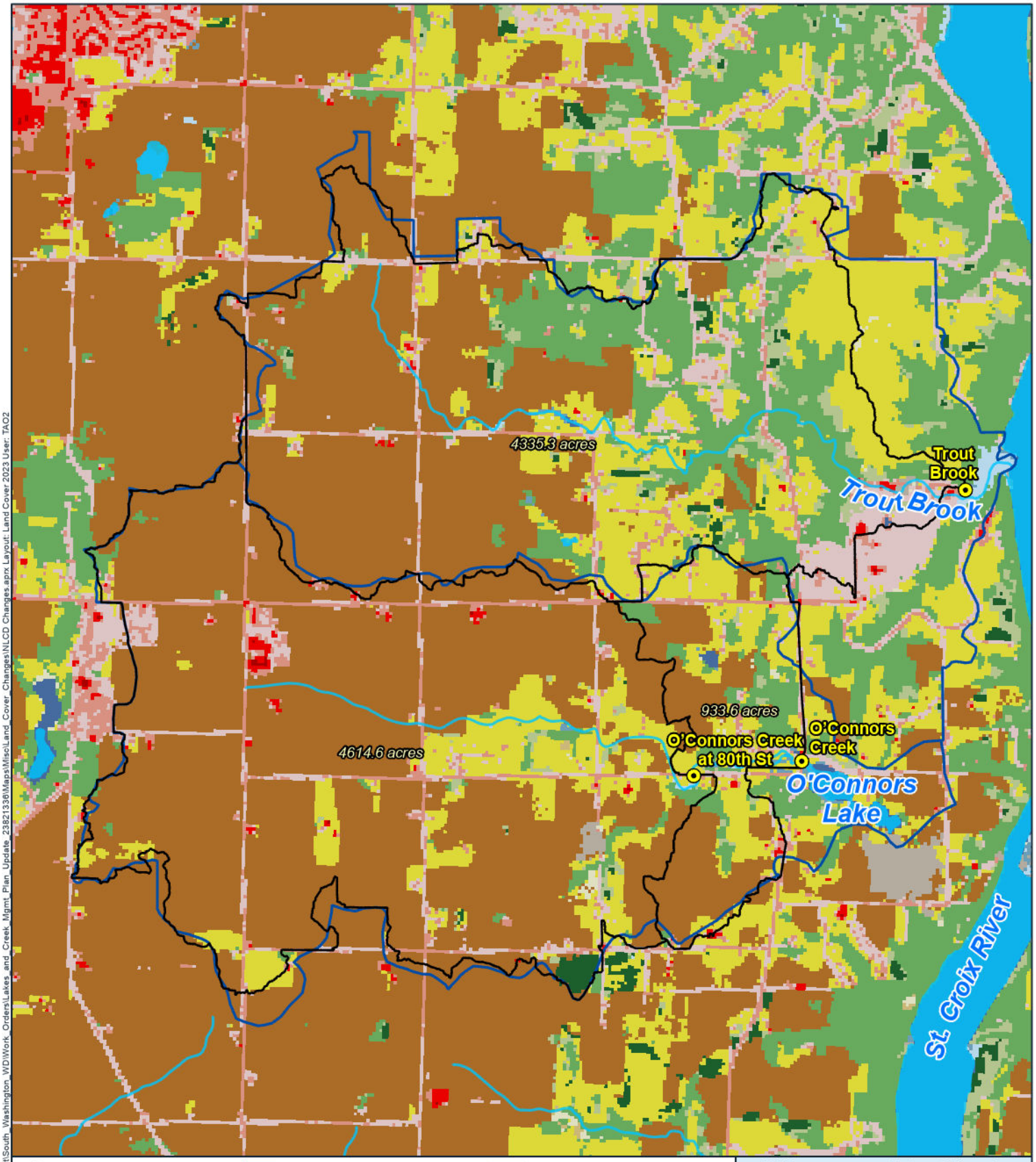
The total drainage areas for the Trout Brook and O'Conners Creek subwatersheds and contributing areas to the various monitoring locations are listed in Table 15-1. Landcover within the watersheds as of 2023 is shown in Figure 15-3; the percent landcover type in each watershed from 2023 is shown in Table 15-2. The landcover within these watersheds has been fairly stable over the period of the monitoring record. Changes within landcover type (based on the NLCD) between 2004 and 2021 are presented in Figure 15-2. Differences between landcovers between the Trout Brook and O'Conners Creek watersheds may contribute to different loading mechanisms when considering water quality conditions within the two systems. This is discussed further in review of the monitoring data.

Table 15-1 Total subwatershed area and contributing area to monitoring locations and O'Conners Lake (acres)

Trout Brook		O'Conners Creek			
Watershed	Monitoring Station	Watershed	Lake	Monitoring Station (2004-2020)	Monitoring Station at 80th (2022-present)
5,407	4,335	6,305	6,305	5,548	4,615



Monitoring Site
Watershed Boundary
Monitoring Site Subwatershed

NLCD 2023 Land Cover

- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceous Wetlands

0 2,000 4,000
Feet

O'Connors and Trout Brook Watershed Land Cover (NLCD 2023)
Lake Management Plan
South Washington Watershed District
FIGURE 15-3

BARR

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Table 15-2 Percent landcover type in Trout Brook and O'Conners Creek watersheds (2023)

Landcover Type	Trout Brook	O'Conners Creek
Agriculture	36.9%	67%
Forest	27.5%	6%
Grassland	22.4%	16%
Shrubland	0.1%	1.5%
Urban	13%	9%
Water	0.2%	1%

Raw monitoring data from the three monitoring locations along these creeks are presented in Figure 15-4. Mean values for observed data are presented in Table 15-3. Plots of yearly, monthly, and seasonal concentrations are presented in Appendix C.

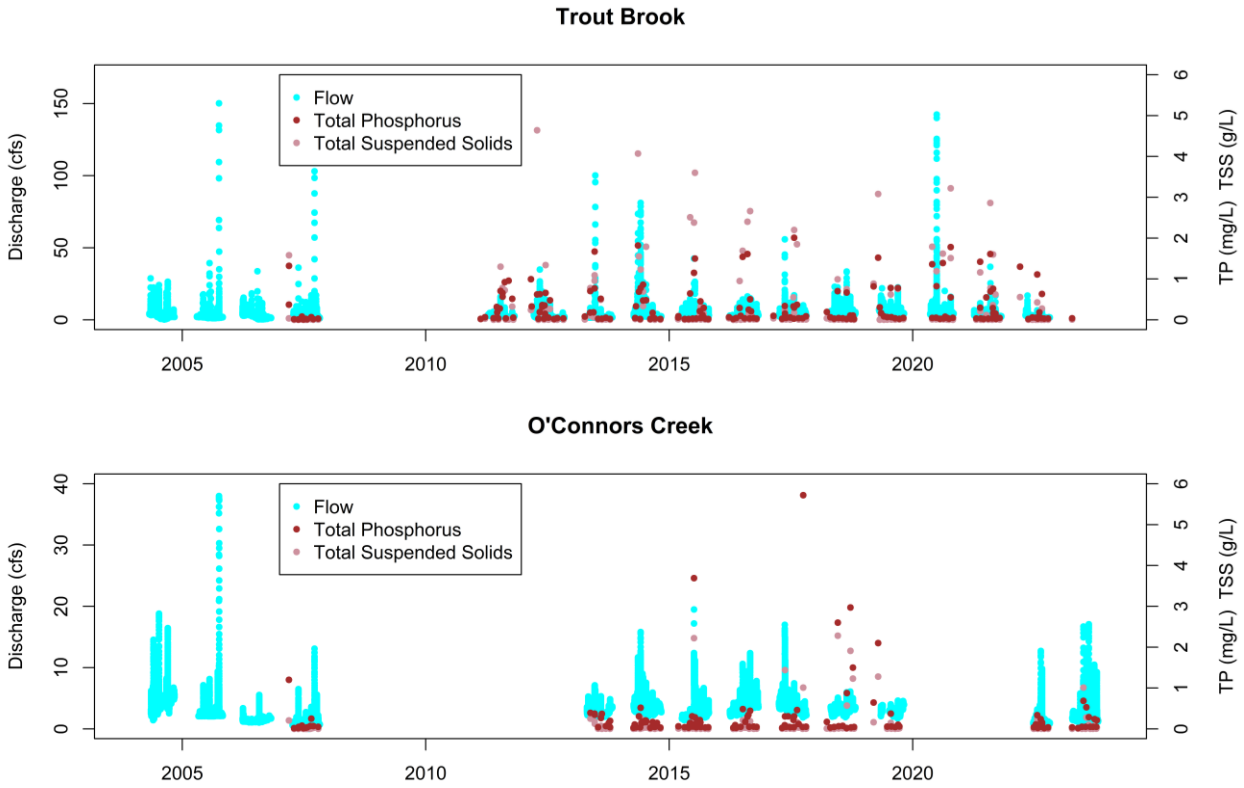


Figure 15-4 Observed flow, TP, and TSS in the Trout Brook and O'Conners Creek[1] watersheds.

*Note that the location of the O'Conners Creek monitoring station changed after the 2020 monitoring season.

Table 15-3 Mean values for observed flow, TP, and TSS for the Trout Brook and O'Conners Creek watersheds over the full historical records

Trout Brook (2005 – 2022)			O'Conners Creek (2005 – 2023)		
Observed Flow (cfs)	TP (mg/L)	TSS (mg/L)	Observed Flow (cfs)	TP (mg/L)	TSS (mg/L)
2.76	0.329	501	2.51	0.294	135

Some simple observations can be made from the information in Figure 15-4 and Table 15-3. Although the mean observed flows are similar, the range of observed flows in Trout Brook is greater than in O'Conners Creek, with peak observed flows being nearly 4 times higher in Trout Brook. Although mean TP concentrations are similar, the mean TSS concentration in Trout Brook is higher than in O'Conners Creek. As a result, the ratio of TSS to TP is higher for Trout Brook, suggesting that the source of phosphorus and the loading mechanism for Trout Brook is different from O'Conners Creek.

15.3.2 Monitoring Data Analysis

Plots of observed streamflow vs. total phosphorus and total suspended solids concentrations were created to observe any apparent correlation between observed flow and pollutant concentrations (Figure 15-5 and Figure 15-6). Based on visual observation, there does not appear to be a strong correlation between observed streamflow and pollutant concentrations over the observed record (i.e., the data are not strongly linear). However, the data show high concentrations of both TP and TSS in Trout Brook under most flow regimes, while high concentrations of both TP and TSS are primarily seen under lower flow events in O'Conners Creek.

Note that some of the concentrations reported within these plots are from averaged flows over a long sample duration (i.e., multiple hours). These datapoints are reflective of composite sample monitoring results where samples are collected and then composited for laboratory analysis. Results are presented as a single (composite, shown in red) pollutant concentration over the entire storm event, such that concentrations are presented as an average over the sampling time period. This is in contrast to grab samples (shown in green), which are reported as an instantaneous result at the time of sampling.

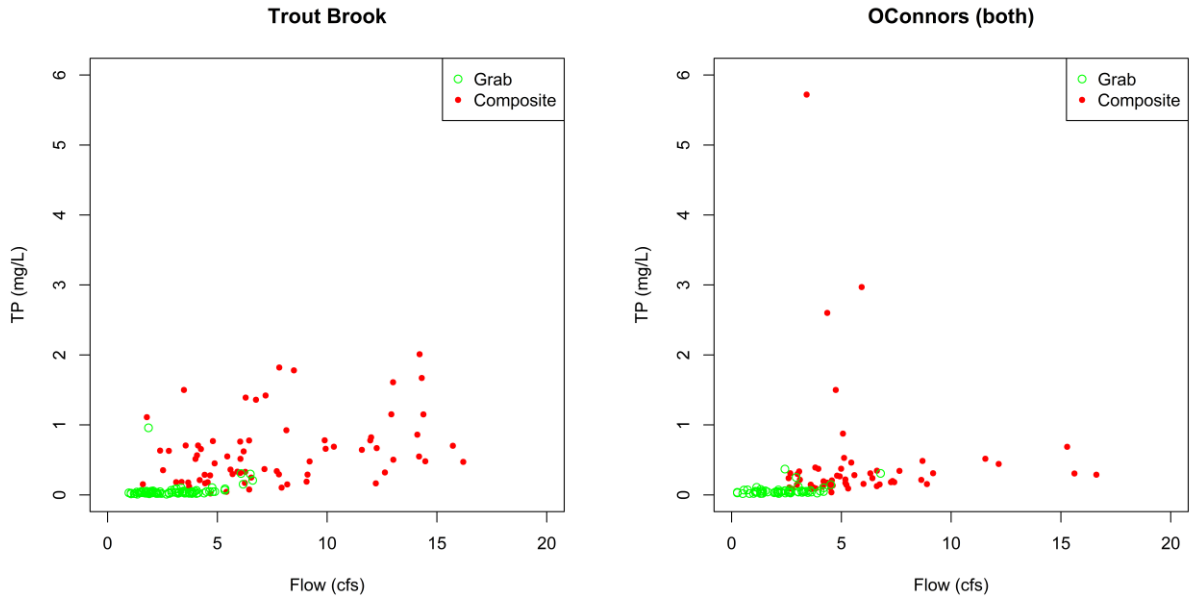


Figure 15-5 Observed flow versus total phosphorus for Trout Brook and O'Conners Creek

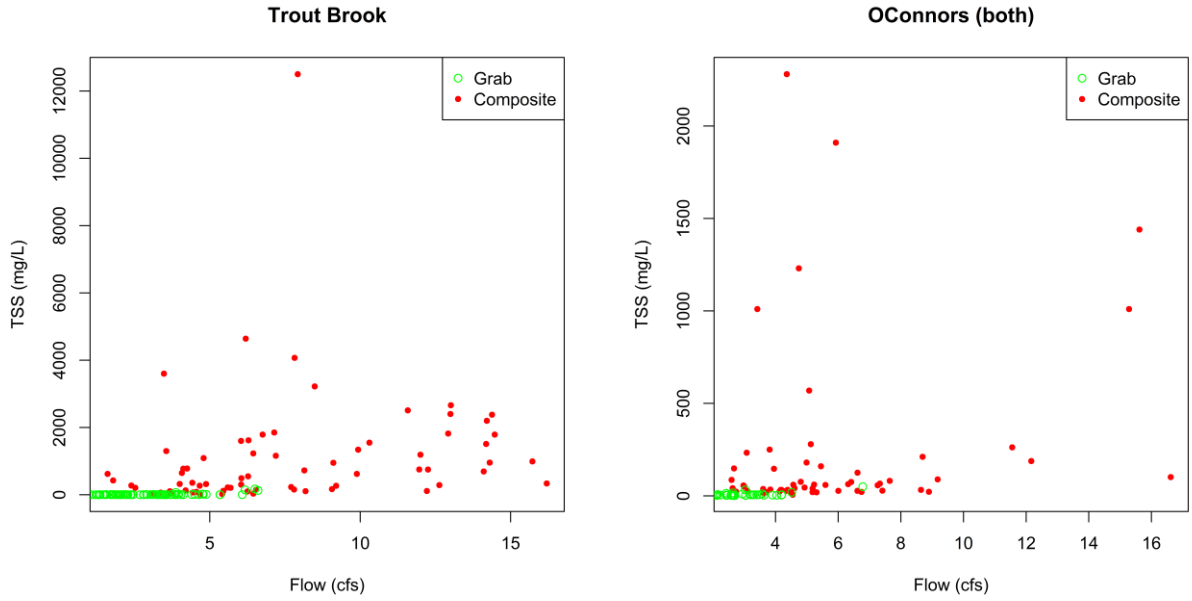


Figure 15-6 Observed Flow versus total suspended solids for Trout Brook and O'Conners Creek

15.3.2.1 Baseflow Separation

As a next step, the separation of baseflow from storm event samples was investigated to consider how the concentration of total phosphorus within the streams varied under conditions when observed flow was primarily a function of baseflow vs. during storm runoff events.

Consistent with the methods used in Janke (2015), baseflow for both Trout Brook and O'Conners Creek was estimated using the sliding interval method as described by Sloto and Crouse (1996). Using this method, storm events are then identified using breakpoints, where one event ended and the next began, which are defined as the point in time where baseflow equals observed flow (i.e., baseflow = total flow). Precipitation is included in Figure 15-7 to help visualize the timing of increased observed flow due to storm events.

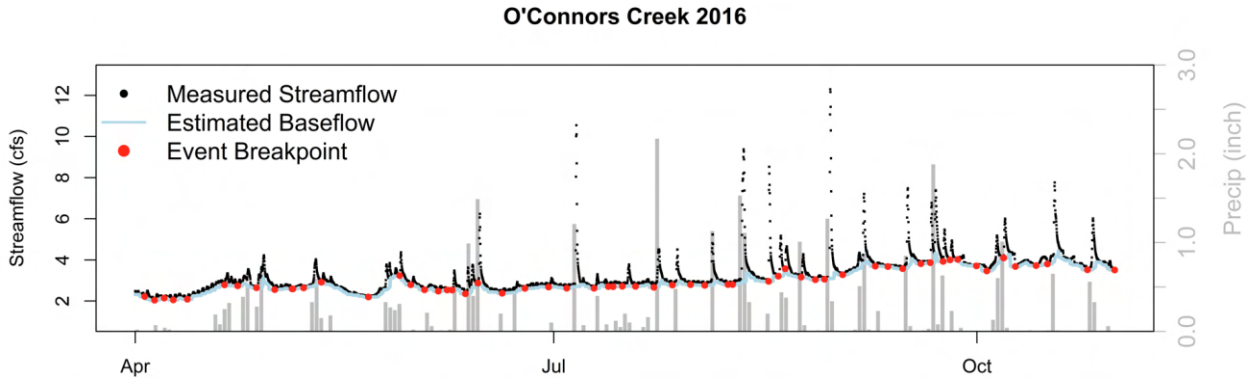
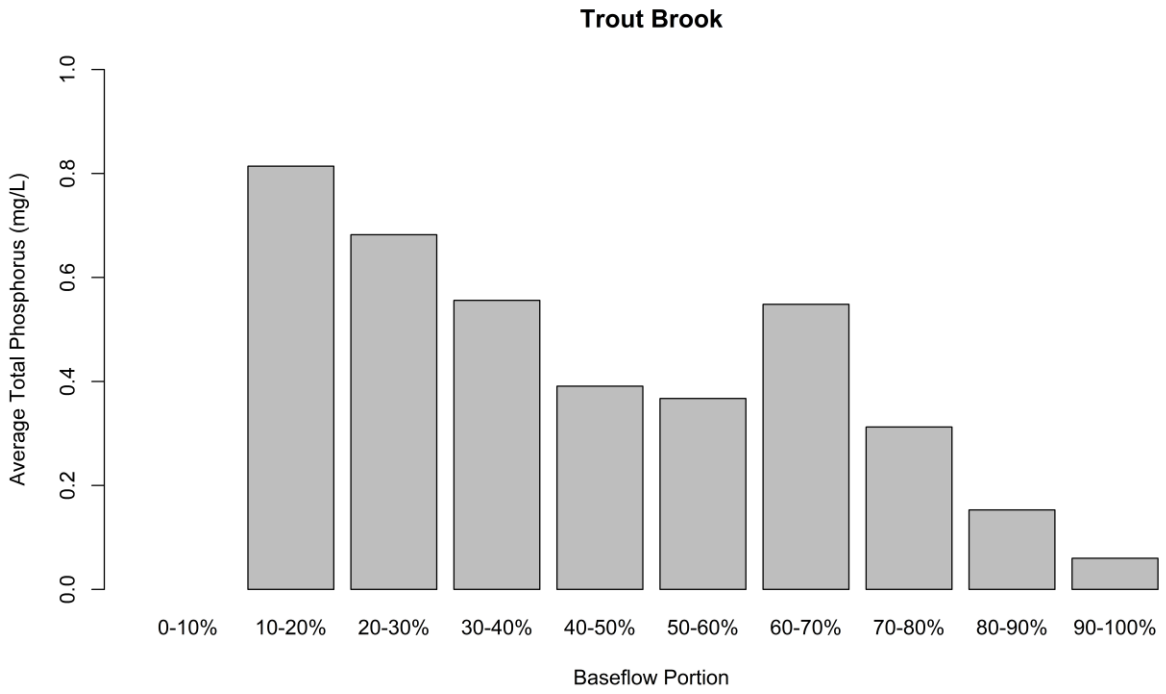


Figure 15-7 Observed flow, estimated baseflow, and precipitation in the O'Conners Creek watershed for 2016

Results from the baseflow separation analysis were then used to compare the average concentration of total phosphorus across the different ranges of percent baseflow present for the period of record for each watershed (Figure 15-8). Using this approach, we see the average total phosphorus concentration observed within the baseflow (i.e., proportions greater than 90%) is estimated to be ~0.06 mg/L for both Trout Brook and O'Conners Creek. However, it is notable that the relationship between baseflow proportion and average total phosphorus is different for Trout Brook and O'Conners Creek. For Trout Brook, lower baseflow proportions (e.g., less baseflow as a fraction of total observed flow) correspond to higher total phosphorus. This suggests, perhaps, that runoff and surface flows across the landscape that generate erosion and solids are primary drivers of loading to Trout Brook. Phosphorus concentrations are more uniform across different flow conditions for O'Conners Creek (e.g., baseflow as a fraction of total observed flow), suggesting that the source and delivery mechanism for O'Conners Creek differs from Trout Brook.



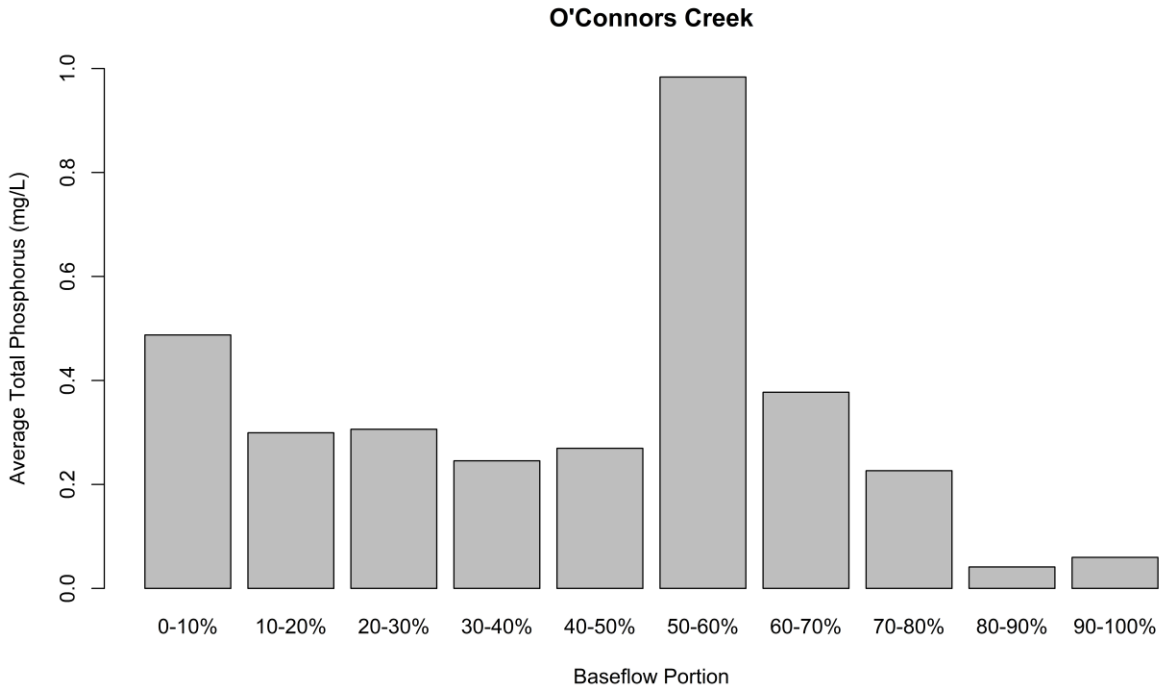


Figure 15-8 Baseflow portion of total observed flow versus average observed total phosphorus concentration

15.3.3 Estimating Phosphorus Loads

LOADEST, a US Geological Survey program for estimating constituent loads in streams and rivers, was used to estimate average annual total phosphorus and total suspended solids loading within the Trout Brook and O'Conners Creek watersheds. LOADEST uses inputs of time series of observed streamflow and point water quality data to develop regression models, which are then used to estimate pollutant loads. The program provides estimates of pollutant loading and reports on the statistical uncertainty associated with these estimates, on a monthly and seasonal basis.

LOADEST requires the time step for inputs on observed concentration and flow data to coincide. It also requires that flow data be presented as a continuous record. Raw monitoring data were pre-processed within R (a computer program for statistical computing) to translate observed flows (from the SWWD data) from a 15-minute interval to a daily average in order to create properly formatted data inputs for LOADEST. Gaps within the observed flow record were filled by using linear regression between observed data points to create a continuous calibration flow dataset. Pollutant concentrations were also averaged daily.

LOADEST was used to estimate TP and TSS loads at the Trout Brook monitoring station for the years 2011-2021. Pollutant loads were estimated at the O'Conners Creek monitoring stations for the years 2013-2019 and 2022-2023. Results from the LOADEST calculations are summarized in Table 15-4. Plots of the estimated annual TP and TSS loading at the two monitoring locations, and the reported 95 percent confidence intervals associated with the estimates are shown in Figure 15-9. As shown in Figure 15-9, the estimated TP and TSS loadings computed at the Trout Brook monitoring location have a high level of uncertainty associated with them. Results from the statistical analysis within LOADEST suggest an estimated load bias of 45% for TP and over 243% for TSS, and Nash Sutcliffe Efficiency values of -5.27 and -36.73 for TP and TSS, respectively. Errors of this magnitude suggest that the statistical relationship resulting from the LOADEST regression analysis is not a good fit for the accurate estimation of loads (i.e., the resultant loading values have a high magnitude of error). In cases such as this, it is suggested that using the mean observed concentration and flow at the monitoring location to compute an observed mean load would be a more accurate representation. For this reason, mean annual flow, concentration, and TP load were calculated for both subwatersheds; and are also included in Table 15-4.

The statistical fit of the regression equation developed from the O'Conners Creek monitoring data is much better, with an estimated bias of -24% for TP and -19% for TSS, and Nash Sutcliffe Efficiency values of 0.24 and 0.45 for TP and TSS, respectively. Results are within what would be considered a 'good fit' for the statistical relationship. Ninety-five percent confidence intervals for estimated TP and TSS loads at the O'Conners Creek monitoring stations are shown in Figure 15-9.

Table 15-4 Load results for Trout Brook and O'Conners Creek

Year	Precipitation	Trout Brook			O'Conners Creek		
		(lb/ac/yr)			(lb/ac/yr)[3]		
	(in)	TP (LOADEST[1])	TP (Mean Annual [2])	TSS (LOADEST[1])	TP (LOADEST[1])	TP (Mean Annual [2])	TSS (LOADEST[1])
2011	33	0.442	0.41	939			
2012	28	0.121	0.25	147			
2013	32	0.101	0.33	417	0.104	0.21	17
2014	40	0.332	0.58	1383	0.141	0.16	37
2015	42	0.165	0.38	308	0.087	0.26	28
2016	41	0.128	0.45	205	0.176	0.20	57
2017	36	0.189	0.46	321	0.169	0.64	76
2018	33	0.236	0.29	414	0.140	0.74	55
2019	42	0.405	0.68	729	0.141	0.45	61
2020	36	0.601	1.01	1655			
2021	32	0.165	0.49	155			
2022	27				0.026	0.06	10
2023	32				0.039	0.12	18
MEAN		**0.262**	**0.485**	**607**	**0.114**	**0.316**	**40**

[1] Results from the LOADEST calculations, using AMLE (adjusted maximum likelihood estimation) which provides an estimateof instantaneous load based on daily average flow and concentration.
[2] Mean Annual values computed as a function of mean annual concentration and mean annual flows, based on monitoring data from open water season only.
[3] Change in monitoring location from O'Conners Creek to 80th applied on 1/1/2021.

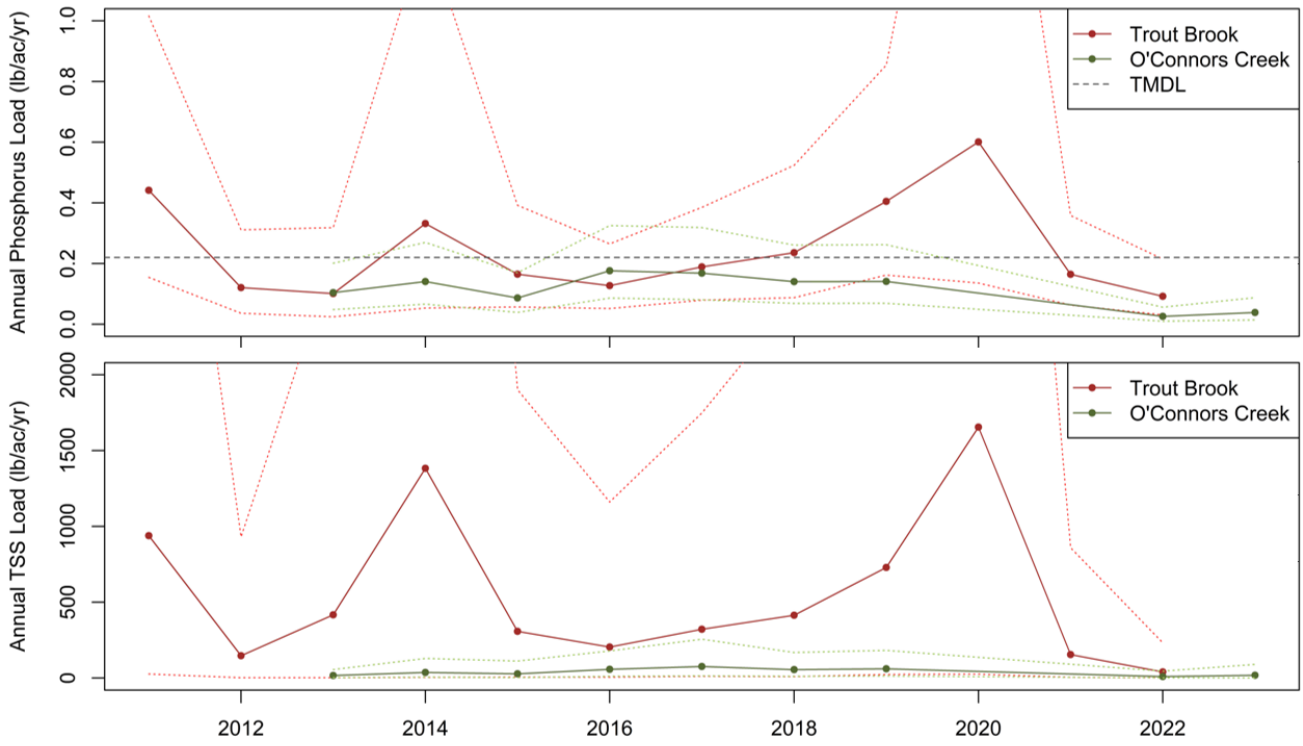


Figure 15-9 LOADEST results for annual loading of total phosphorus and suspended solids in Trout Brook and O'Conners Creek watersheds
95% confidence intervals, based on daily average flow and concentrations, shown as dashed lines. Dashed grey line in top plot is goal for TP loading set by the 2012 TMDL.

As an arithmetic check of the LOADEST results, mean annual TP loading was also calculated for these stations, using annual mean concentrations and annual mean (observed) flows. This method is oversimplified in that it uses noncontinuous data from the flow season to represent the whole year and also is based only on observed flows from the open water season, ignoring low flows during the winter months, however, it can be used to provide a reference. Results from this analysis show that results from the LOADEST TP loading estimates are within the correct range (i.e., LOADEST results are, for the most part, lower than the computed annual means, which would be expected as annual mean flow rates were based upon observed flows during the open water season and do not account for low flows during the winter months).

15.3.4 Conclusions

Both O'Conners Creek and Trout Brook are considered part of the Central Region as related to the State of MN's river eutrophication standards. Current state guidance denotes that rivers classified within Class 2A (i.e., set for a beneficial use of supporting aquatic life) in the Central Region should have an average total phosphorus concentration <100 µg/L. The long-term mean TP concentration observed within both the Trout Brook and O'Conners Creek watersheds are substantially above that standard (Table 15-3). The majority of the landcover within the Trout Brook and O'Conners Creek watersheds is designated as agricultural use, which can be a high source of phosphorus loading and could be contributing to the high TP concentrations. This is particularly true for O'Conners Creek. In addition, an increase in TP concentration can be seen during the summer season (Appendix C), leading to the assumption that prevailing TP concentrations may be due in part to agricultural activities (e.g., fertilization). TP in Trout

Brook may also be a function of erosional processes, judging from the observed relationships between flow rate, TSS, TP, and baseflow.

Based on the average observed flow, concentration, and contributing areas for the Trout Brook and O'Conners Creek watersheds, Trout Brook would be expected to produce slightly higher TP loads to O'Conners Creek and TSS loads 3-4 times that of O'Conners Creek. However, the LOADEST results show Trout Brook has TP loads over twice as high as O'Conners Creek and TSS loads over 10 times higher than O'Conners Creek. During baseflow conditions, both watersheds appear to have similar TP concentrations; observed TP concentrations in Trout Brook are about twice as high as in O'Conners Creek during high flow events.

Results from this analysis show that TP loading within the O'Conners Creek watershed is typically meeting the goals established by the 2012 Lake Saint Croix TMDL. In the Trout Brook watershed, the estimated TP loading is often exceeding the goal established in the TMDL; however, the calculation error and level of uncertainty associated with the loading estimates within the Trout Book watershed are high. Further analysis would be needed to address uncertainties within the data sets and develop a more refined estimate of loading. However, results from this analysis can be used to provide an understanding of the magnitude of nutrient loading within the watershed. High TP concentrations corresponding with observed high flows and low baseflow proportions suggest that erosion may be a contributing factor to nutrient loads within the system.

15.4 In-lake Total Phosphorus Loads

15.4.1 BATHTUB Modeling for O'Conners Lake

The O'Conners Lake response to phosphorus loading was modeled using BATHTUB. BATHTUB is a series of empirical eutrophication models that predict the response to phosphorus inputs for morphologically complex lakes and reservoirs (Walker, 1999). Several models (subroutines) are available for use within the BATHTUB model; in this case, the Canfield-Bachmann model was used to predict the lake response to total phosphorus loads.

The Canfield-Bachmann model estimates the lake phosphorus sedimentation rate, which is needed to predict the relationship between in-lake phosphorus concentrations and phosphorus load inputs (Canfield Jr. & Bachmann, 1981). The phosphorus sedimentation rate is an estimate of net phosphorus loss from the water column through sedimentation to the lake bottom and is used in concert with lake-specific characteristics, such as annual phosphorus loading, mean depth, and hydraulic flushing rate, to predict in-lake phosphorus concentrations. These model predictions are compared to measured data to evaluate how well the model describes the lake system.

To quantify groundwater interactions with O'Conners Lake, Barr developed annual water balances for the years 2023 and 2024, which represent the only years with available overlapping datasets for water surface elevations and inflow monitoring in the contributing creek. Precipitation totals for these years were 31.7 inches (2023) and 34.9 inches (2024). The finite difference spreadsheet model was used to estimate groundwater fluxes around O'Conners Lake, incorporating the observed hydrologic inputs and outputs from the lake. Because O'Conners Lake is landlocked, the only outputs are evaporation. Model results estimated a net groundwater outflow from the lake of 3.3 meters per year in 2023 and 9.7 meters per year in 2024. These values were used in the BATHTUB modeling for O'Conners Lake.

Estimated watershed, internal, and atmospheric phosphorus loads were used to predict in-lake concentrations for years with precipitation conditions similar to those in 2023 and 2024, and where in-lake water quality data were available, to ensure consistency with the variable groundwater flux data. A model representing an average year model was then developed from those results.

Given O'Conners Lake is a landlocked system, the particulate sedimentation term was the primary calibration parameter used in the Canfield-Bachmann model. Calibration was performed by comparing the average annual modeled total phosphorus concentrations to observed values. Additionally, models were calibrated across a range of internal loading scenarios, given that no sediment cores were collected for O'Conners Lake. Barr chose a low, medium, and high internal loading rate based on sediment cores that were collected in lakes with similar watershed to lake area ratios.

15.4.2 Phosphorus Loading Summaries

Model results indicate that the estimated phosphorus budget for O'Conners Lake was dominated by watershed loading across all years, except 2023, which was a dry year. Watershed loads ranged from 140 to 781 lbs, representing 31% to 94% of the phosphorus loading to the lake, depending on assumptions associated with the internal loading rate (see Figure 15-10, Figure 15-11, and Figure 15-12). For dry years with a high assumed internal loading rate, the internal phosphorus load can represent up to 67% (304 lbs).

Estimated nutrient loads for O'Conners Lake have considerable uncertainty given: (1) there is limited monitoring data available for the system; (2) no sediment cores were collected from O'Conners Lake; (3) no water quality profile data is available for the lake; and (4) uncertainty in estimating groundwater interactions within the system, particularly given the understanding that groundwater-surface water interactions are an important consideration within this portion of the watershed.

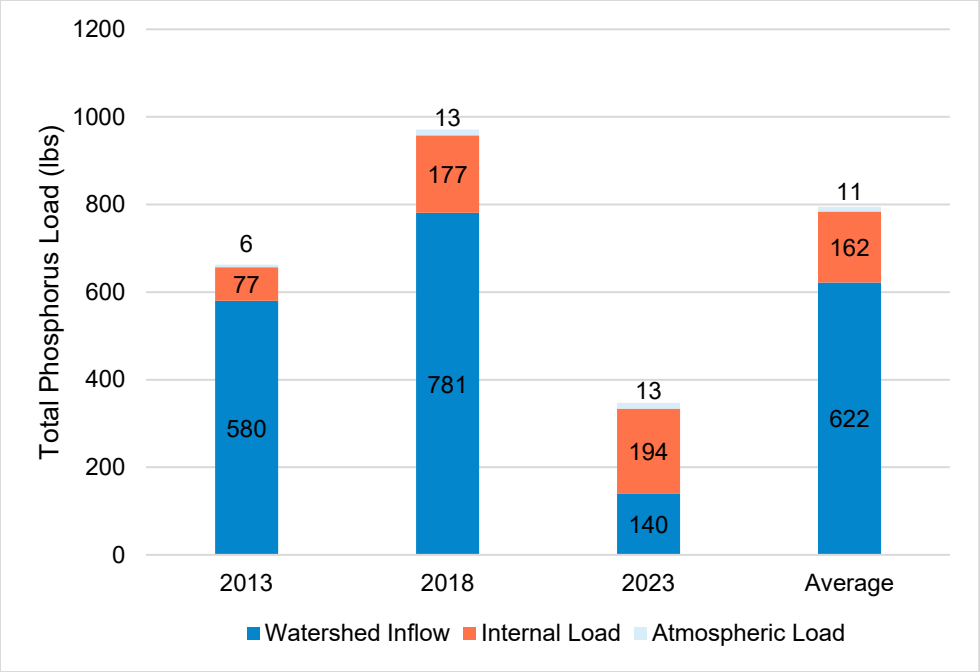


Figure 15-10 O'Conners Lake total phosphorus load estimates for average internal load (7.7 mg/m^2/d)

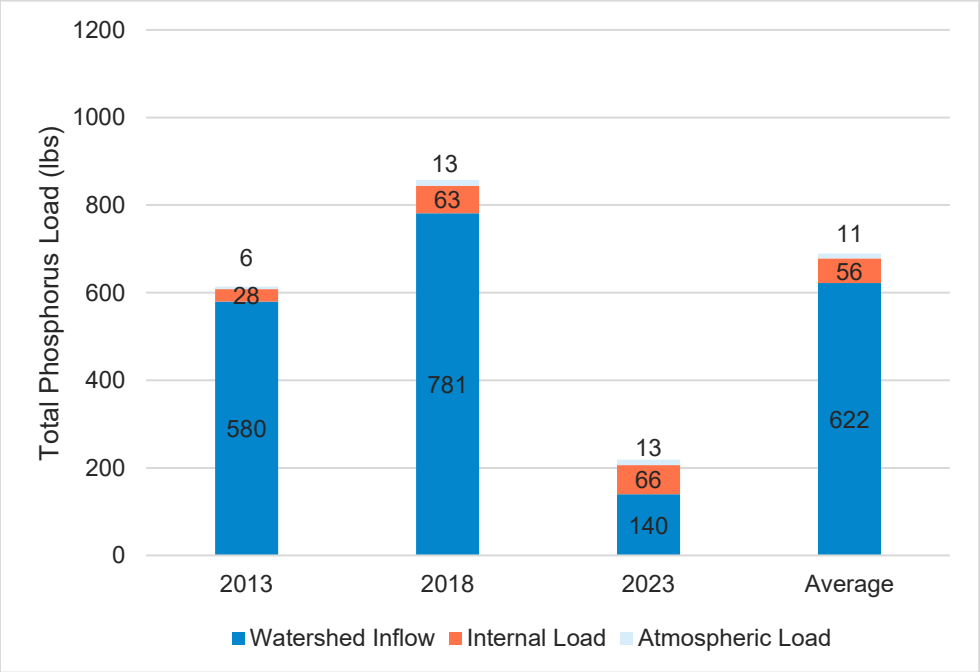


Figure 15-11 O'Conners Lake total phosphorus load estimates for low internal load (1.7 mg/m^2/d)

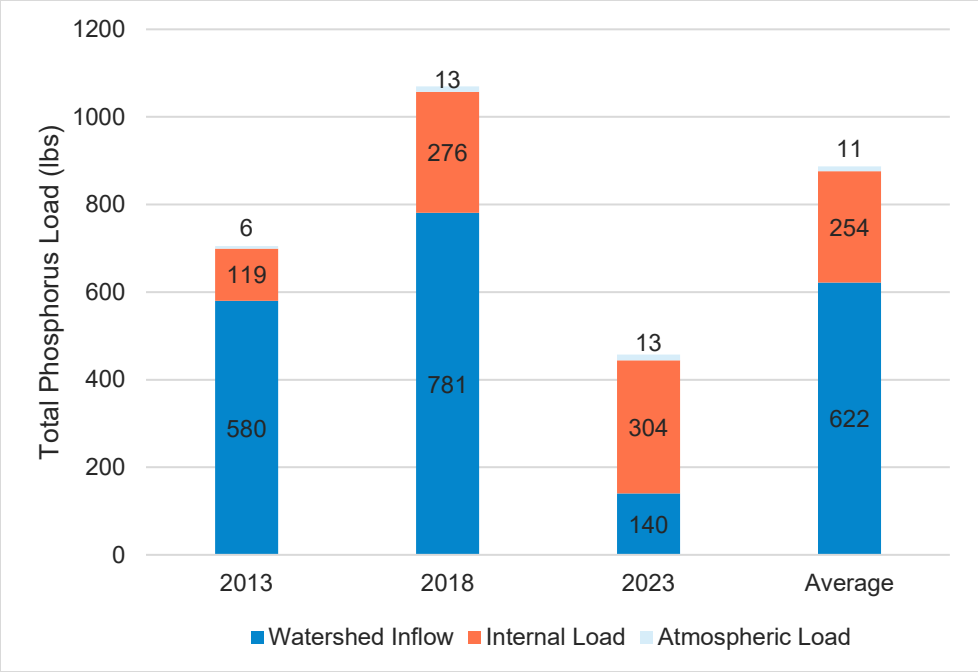


Figure 15-12 O'Conners Lake total phosphorus load estimates for high internal load (12.9 mg/m^2/d)

15.4.3 Conclusions

Results from modeling within O'Conners Lake show that watershed runoff tends to dominate nutrient loading into the lake under typical conditions. Under dry conditions, internal loading may become a larger contributor to in-lake phosphorus concentrations. It's recommended that the SWWD continue to collect water quality monitoring data within O'Conners Lake and the contributing watershed. As additional data is available, it is recommended that the O'Conners Lake model(s) be revisited and updated based on additional information.

16.1.1 Summary of Phosphorus Loadings

Results of this study show that phosphorus loading to the nine suburban lakes that were included in the study varies widely between waterbodies. For most of the lakes, watershed loading can be a significant source of phosphorus loading during wet conditions. Under dry conditions, internal loading becomes more significant. For those lakes that are located at the downstream end of the chain of interconnected lakes located within the City of Woodbury, phosphorus loading from upstream waterbodies is a dominant source of loading under wet conditions; implying that management strategies to control phosphorus loads in upstream waterbodies could also have benefits for downstream receiving waters. Results from the modeling of a subset of management strategies to reduce phosphorus loading into eight of the nine suburban lakes included in this study are summarized in Sections 8–14.

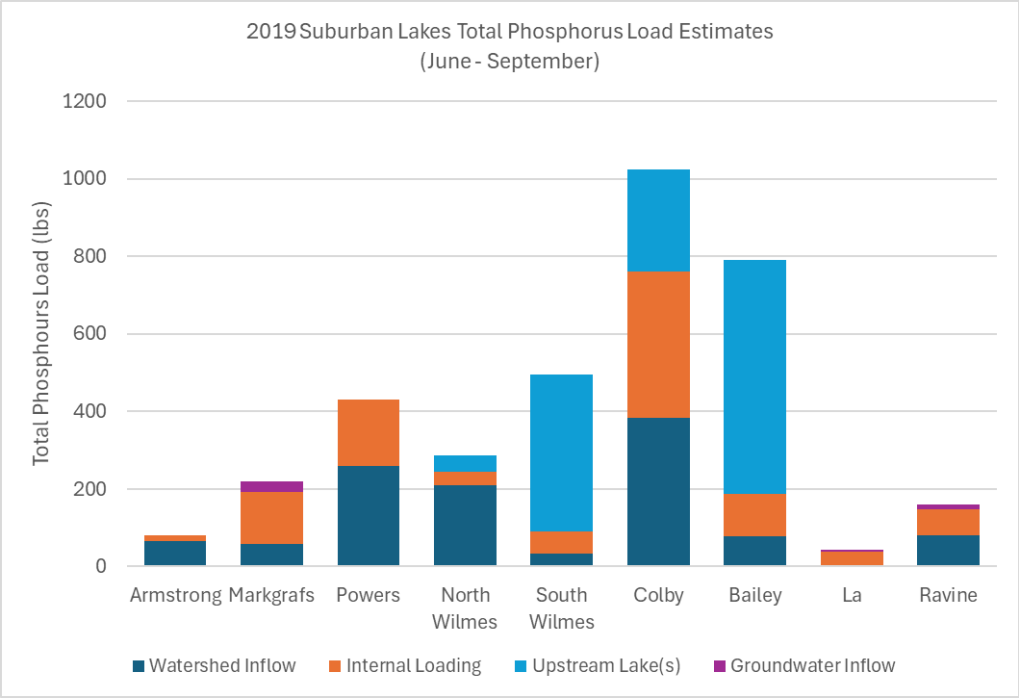


Figure 16-1 Summary of lakes total phosphorus loading for 2019 (wet year)

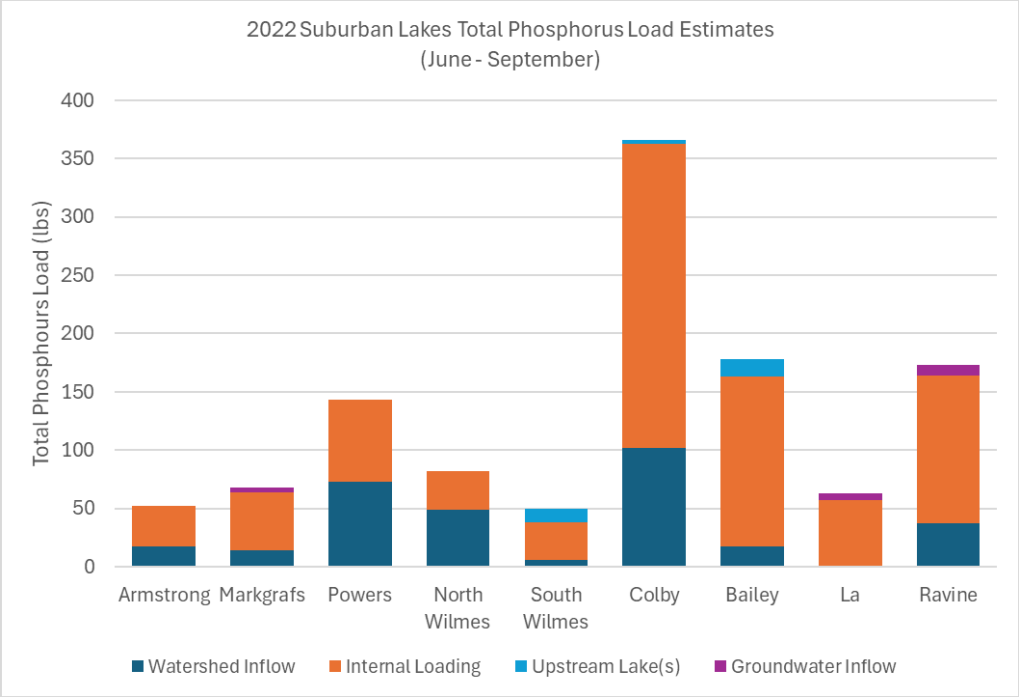


Figure 16-2 Summary of lakes total phosphorus loading for 2022 (dry year)

16.1.2 Considerations for In-lake Management

Results from the sediment coring and laboratory analysis performed in this study show that several of the lakes have high potential for internal phosphorus loading from their lake sediments. To better understand the potential impacts of performing lake sediment phosphorus inactivation projects in these lakes, Barr created planning-level management scenarios which were then applied to each of the calibrated in-lake models. These management scenarios were designed to first consider the potential impacts of performing sediment inactivation projects within the targeted lakes and then (when applicable) considering the scale of watershed load reduction also needed in order to achieve in-lake total phosphorus and chlorophyll-*a* concentrations in line with applicable state eutrophication standards.

Results of these analyses showed that for several of the lakes, sediment inactivation projects could have a considerable impact on in-lake water quality conditions, with the models predicting that in-lake treatment could reduce total phosphorus and chlorophyll-*a* concentrations to meet the state eutrophication standards within a single growing season. Results of the modeling for each of the lakes considered for in-lake treatments are summarized in Sections 8.5, 9.6, 10.6, 11.6, 12.5, 13.5, and 14.6.

The modeling developed for this study represents in-lake conditions and expected impacts from management strategies for a single growing season and does not account for longer-term water quality impacts over time. For example, once implemented, sediment inactivation efficacy is known to vary over time. Monitoring data from Twin Cities metro lakes indicate that efficacy declines in the years following initial treatment due to product aging, new watershed inflows, and burial from rough fish activity, which can again increase internal loading over time. Conversely, if water quality management projects improve water clarity, some lakes may experience a greater abundance and extent of submerged plants. Increased plant growth can reduce sediment resuspension, enhance nutrient uptake, and create increased competition with algae, leading to improved water quality. If the increased plant growth is associated with aquatic invasive species, however, this can cause additional concerns for water quality

and may warrant the consideration of additional management strategies related to vegetation management. While modeling provides useful estimates of the expected scale of impacts of water quality management strategies, post-project monitoring is essential to track changes in lake water quality and adjust management plans as needed to continue benefits over time.

16.2 Summary of Findings and Recommendations

Table 16-1 summarizes key findings and takeaways from this study for the lakes that were included. The information within the table includes key considerations related to the lakes' water quality conditions, primary sources of phosphorus loading into the waterbodies, and planning for the management of the lakes in the coming years.

Table 16-1 Summary of findings related to lakes and management planning

Lake	Water Quality Condition	Physical Characteristics	Ranking of Watershed Avg Annual TP Load Relative to Others in the Study	Summary of P Loading into Waterbody by Major Source (Watershed vs. Internal)	Estimated Impact of Loading to Waterbody from Upstream Waterbodies	Notes on Internal Loading	Notes on Watershed Loading, District Priorities, and Other Recently-Completed Projects
Armstrong	Not listed as impaired; Avg TP concentrations typically exceed state standards; chl-a typically meets standard; Secchi disc depth typically not meeting.	Watershed:SA Ratio = 57:1 Very shallow (Avg depth = 1 ft)	Moderate	Wet (2019): 82% Watershed; 18% Internal Dry (2022): 33% Watershed; 67% Internal	N/A	Sediment cores show moderate potential for internal loading depending on lake conditions.	District piloting cattail harvesting in wetland immediately upstream as potential nutrient reduction strategy.
Markgrafs	Impaired; Avg TP concentrations far exceed state standards; chl-a exceeds standard; Secchi disc depth meets some years, does not meet others.	Watershed:SA Ratio = 10:1 Very shallow (Avg depth = 3 ft)	Moderate	Wet (2019): 26% Watershed; 62% Internal Dry (2022): 21% Watershed; 74% Internal	N/A	Sediment cores show moderate potential for internal loading depending on lake conditions. Modeling estimates internal sources >50% of loading in both wet and dry year.	Pockets of higher loading areas within the watershed with opportunity for retrofits; SWWD recently completed a watershed-wide retrofit study and plans to move forward with identified projects in the next few years.
Powers	Not listed as impaired; Avg TP concentrations meet state standards; chl-a meets standards some years, exceeds others; Secchi disc depth meets standard.	Watershed:SA Ratio = 21:1 Deep lake (Avg depth = 19 ft)	High	Wet (2019): 60% Watershed; 40% Internal Dry (2022): 51% Watershed; 49% Internal	N/A	Sediment cores show high potential for internal loading depending on lake conditions.	Pockets of higher loading areas within the watershed with opportunity for retrofits. Hasenbank Park stormwater BMPs constructed (operational in 2025) to treat regional stormwater flow from the eastern portion of Powers Lake watershed. District has received more calls in recent years expressing concerns about the algae.
North Wilmes	Impaired; Avg TP concentrations typically exceed state standards; chl-a typically exceeds standard; Secchi disc depth meets some years, does not meet others.[1]	Watershed:SA Ratio = 157:1 Moderate depth (Avg depth = 7 ft)	Moderate	Wet (2019): 73% Watershed; 13% Internal; 14% Upstream Dry (2022): 60% Watershed; 40% Internal	Some impact from loading from upstream waterbodies.	Sediment cores show high potential for internal loading depending on lake conditions.	Several areas in the watershed with higher loading and/or without stormwater treatment currently and opportunity for retrofits. Kargel Park Alum Treatment Facility began operation in 2025. Facility is expected to have benefits for both North and South Wilmes.
South Wilmes		Watershed:SA Ratio = 264:1 Moderate depth (Avg depth = 8 ft)	Moderate/Low	Wet (2019): 7% Watershed; 11% Internal; 82% Upstream Dry (2022): 13% Watershed; 63% Internal; 23% Upstream	Significant impact from loading from upstream waterbodies.	Sediment cores show high potential for internal loading depending on lake conditions; but relative loading is lower in 2019 / 2022.	
Colby	Impaired; Avg TP concentrations far exceed state standards; chl-a exceeds standard; Secchi disc depth meets some years, does not meet others.	Watershed:SA Ratio = 112:1 Shallow (Avg depth = 5 ft)	Moderate	Wet (2019): 37% Watershed; 37% Internal; 26% Upstream Dry (2022): 28% Watershed; 71% Internal; 1% Upstream	Notable impact from loading from upstream waterbodies.	Sediment cores show high potential for internal loading depending on lake conditions. Modeling estimates high internal loading under both wet and dry years.	Areas of higher loading or without treatment within the watershed with opportunity for retrofits.
Bailey	Impaired; Avg TP concentrations exceed state standards; chl-a exceeds standard; Secchi disc depth meets some years, does not meet others.	Watershed:SA Ratio = 230:1 Moderate depth (Avg depth = 6 ft)	Low	Wet (2019): 10% Watershed; 14% Internal; 76% Upstream Dry (2022): 10% Watershed; 82% Internal; 8% Upstream	Significant impact; particularly in wet years.	Sediment cores show high potential for internal loading depending on lake conditions.	District only recently began collecting water quality data in this waterbody. Considered a lower priority at this time for active management compared to other waterbodies.
La	De-listed in 2024; For recent years, avg TP concentrations, chl-a, and Secchi disc depth meet state standards.	Watershed:SA Ratio = 3:1 Shallow (Avg depth = 5 ft)	Low	Wet (2019): 7% Watershed; 77% Internal Dry (2022): 1% Watershed; 90% Internal	N/A	Modeling estimates high internal load compared to external sources.	Estimated watershed load is low. Small contributing drainage area and not much room for additional treatment.
Ravine	Impaired; Avg TP concentrations typically exceed state standards; chl-a exceeds standard; Secchi disc depth meets some years, does not meet others.	Watershed:SA Ratio = 68:1 Shallow (Avg depth = 5 ft)	Moderate/Low	Wet (2019): 51% Watershed; 42% Internal Dry (2022): 21% Watershed; 74% Internal	N/A	Sediment cores show high potential for internal loading depending on lake conditions. Modeling estimates high internal loading under both wet and dry years.	Contributing watershed is primarily rural and/or undeveloped. Questions about nitrogen impacts within the system and uncertainty in groundwater contributions.

Lake	Water Quality Condition	Physical Characteristics	Ranking of Watershed Avg Annual TP Load Relative to Others in the Study	Summary of P Loading into Waterbody by Major Source (Watershed vs. Internal)	Estimated Impact of Loading to Waterbody from Upstream Waterbodies	Notes on Internal Loading	Notes on Watershed Loading, District Priorities, and Other Recently-Completed Projects
O'Conners	Not listed as impaired: Avg TP concentrations and chl-a below state standards some years and exceed in others; Secchi disc depth typically meets standard.	Watershed:SA Ratio = 107:1 Shallow (Avg depth = 4 ft)	High	Avg: 78% Watershed; 20% Internal	N/A	No sediment cores taken. Modeling estimates internal sediment loading less of a concern than watershed loads.	District has limited data for this waterbody compared to others. Considered a lower priority at this time for active management comparatively.

[1] Water quality data is not currently available for North Wilmes Lake. Summary of water quality conditions is based on data collected in South Wilmes.

The following recommendations are made for next steps for the District to consider to further existing and develop additional management strategies to protect and improve water quality and ecological conditions within the lakes included as a part of this study.

Planning for implementation

- Study results show that phosphorus loading into most of the lakes within this study is heavily influenced by internal loading. Sediment coring and laboratory analysis confirm that a significant portion of this internal loading is expected to come from sediment loading. In particular, Markgrafs, Colby, Bailey, Ravine, and La are strongly influenced by internal loading under both wet and dry conditions.

- As part of next steps, we'd recommend the District to consider moving forward with the planning and implementation of in-lake sediment phosphorus inactivation projects for a selection of these high priority waterbodies. Based on results from this study and understanding of District priorities, we'd recommend Markgrafs, Colby, and Ravine as the first lakes to be considered for sediment inactivation projects. As monitoring continues, the District may then also want to consider treatments in additional waterbodies.

- This would entail performing feasibility studies to consider the different types of sediment phosphorus inactivation strategies that could be utilized and to identify the preferred option for each individual waterbody.

- As part of the effort, we would also recommend collecting additional data, as needed, to inform the feasibility study; and also developing a monitoring plan for assessing and ensuring the long-term success of any implemented treatments.

- A critical component of any long-term lake management strategy includes addressing external watershed loads. We recommend that the District continue their work to find opportunities to reduce and control watershed pollutant loading into their receiving waterbodies.

Monitoring

- Continue existing baseline monitoring and trend analysis for priority waterbodies and pollutants of concern for waterbody health.

- Continue monitoring to track and assess for the presence of aquatic invasive species and the health of the aquatic plant community and to inform management actions that may be needed to improve water quality and protect native aquatic plant health.

- As part of the District's work to develop an updated monitoring plan, consider recommendations noted within each of the individual lake summary sections as related to noted data gaps and/or additional information that would be useful to reduce uncertainty in the lake modeling and assessment of waterbody health and to inform management recommendations.

    - For those waterbodies known, or estimated within this study, to be most impacted by groundwater inflows (i.e., Ravine, O'Conners, Markgrafs, and La), collect additional information to help verify groundwater-surface water interactions and additional groundwater quality data to better estimate loading.

- Study results indicate that South Wilmes, Bailey, and Ravine Lakes would all benefit from additional water quality samples being collected in advance or as part of undertaking a feasibility study to further inform and refine the estimated internal loading influence on the lakes' surface water quality.
- Consider including North Wilmes within the District's baseline monitoring program.
- Consider including phytoplankton and zooplankton monitoring as part of the District's lake monitoring program.

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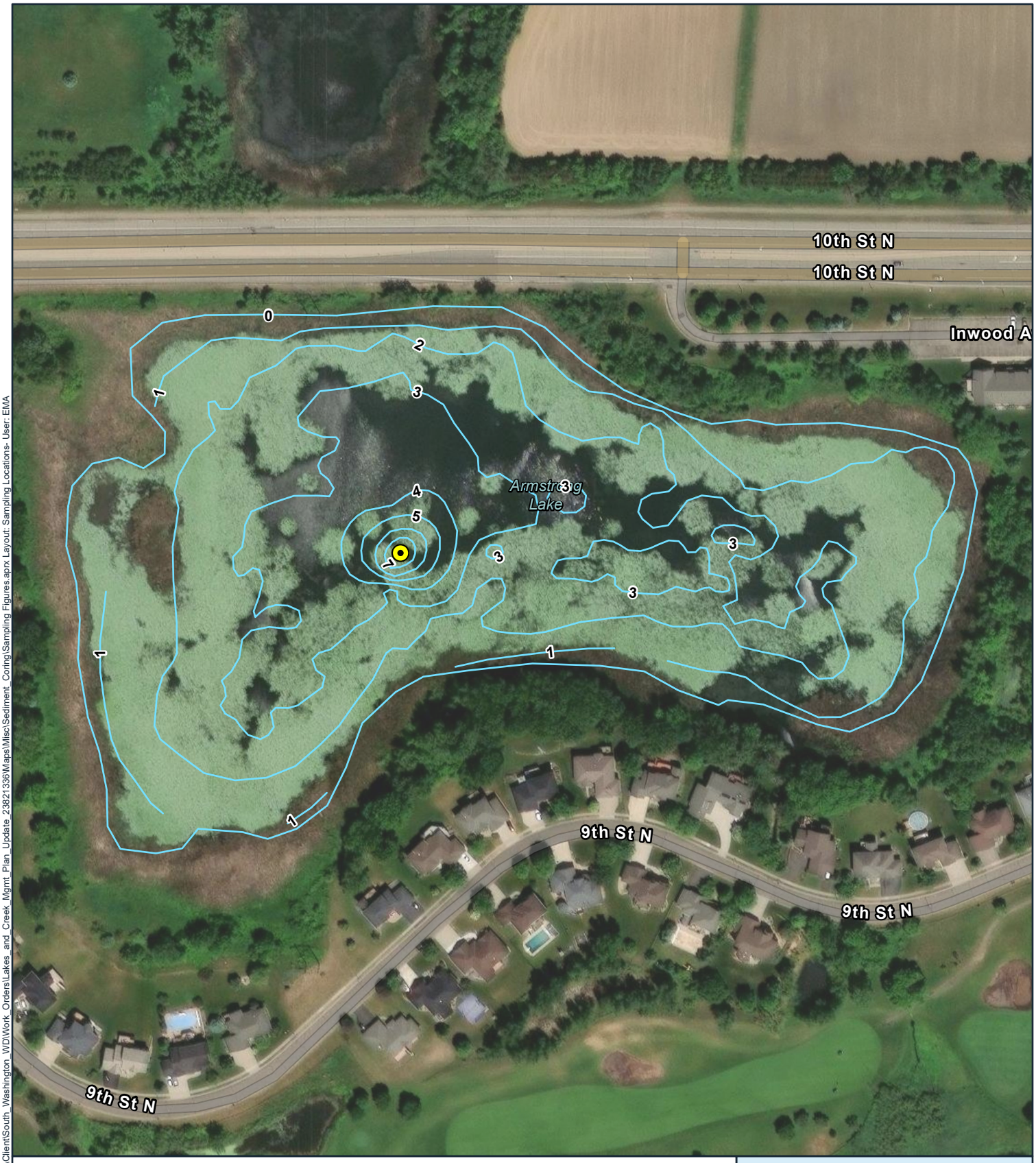
Appendices

Appendix A

Sediment Coring Locations



Coring Location

Bathymetric Contours

N

0 100 200

Feet

Armstrong
Sediment Coring Locations

SWWD Lakes and Creek Management Plan

BARR

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Coring Location

Bathymetric Contours

N

0 250 500

Feet

Bailey
Sediment Coring Locations

SWWD Lakes and Creek Management Plan

BARR

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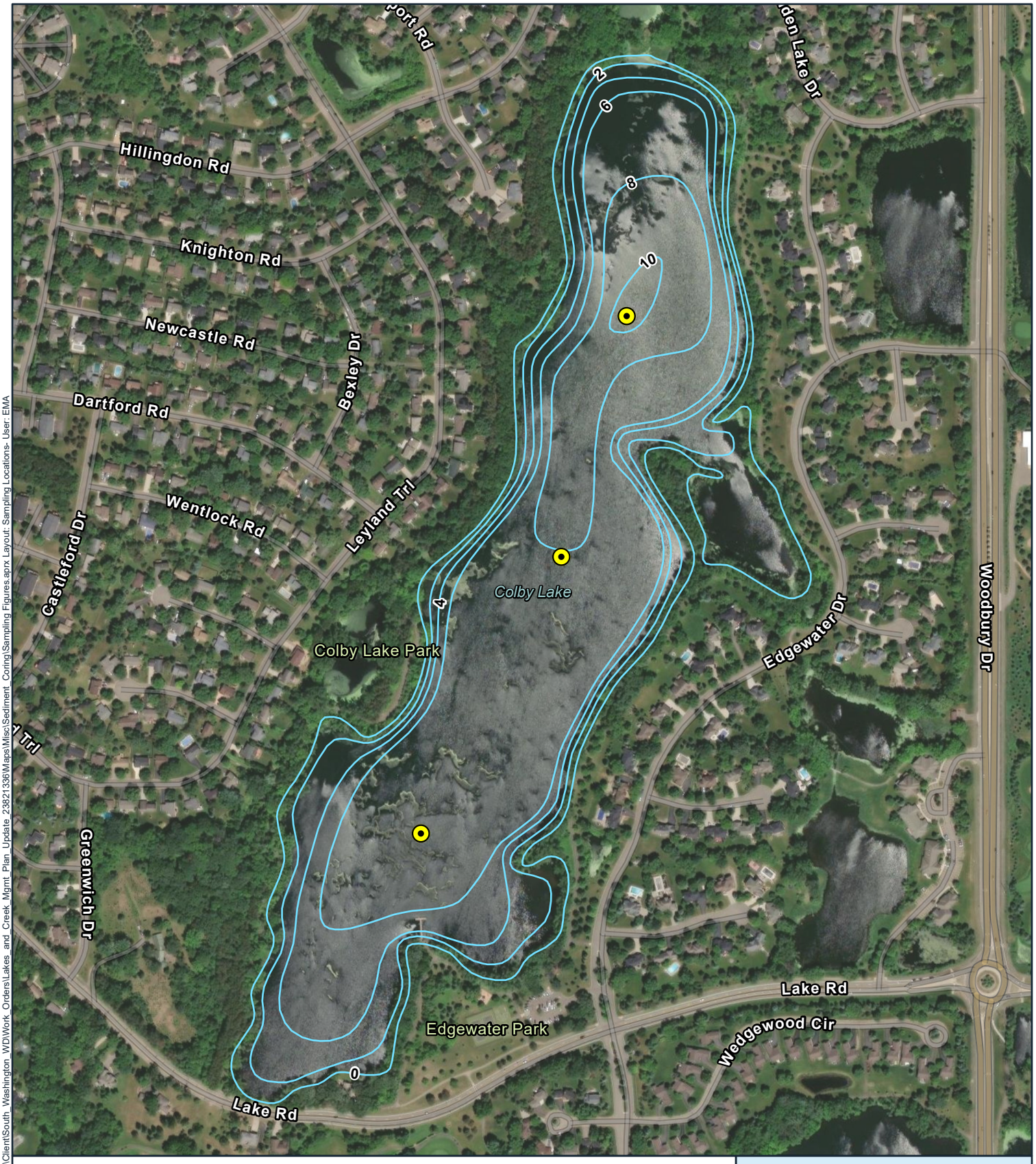

Coring Location

Bathymetric Contours

N

0 250 500

Feet

Colby
Sediment Coring Locations

SWWD Lakes and Creek Management Plan

BARR

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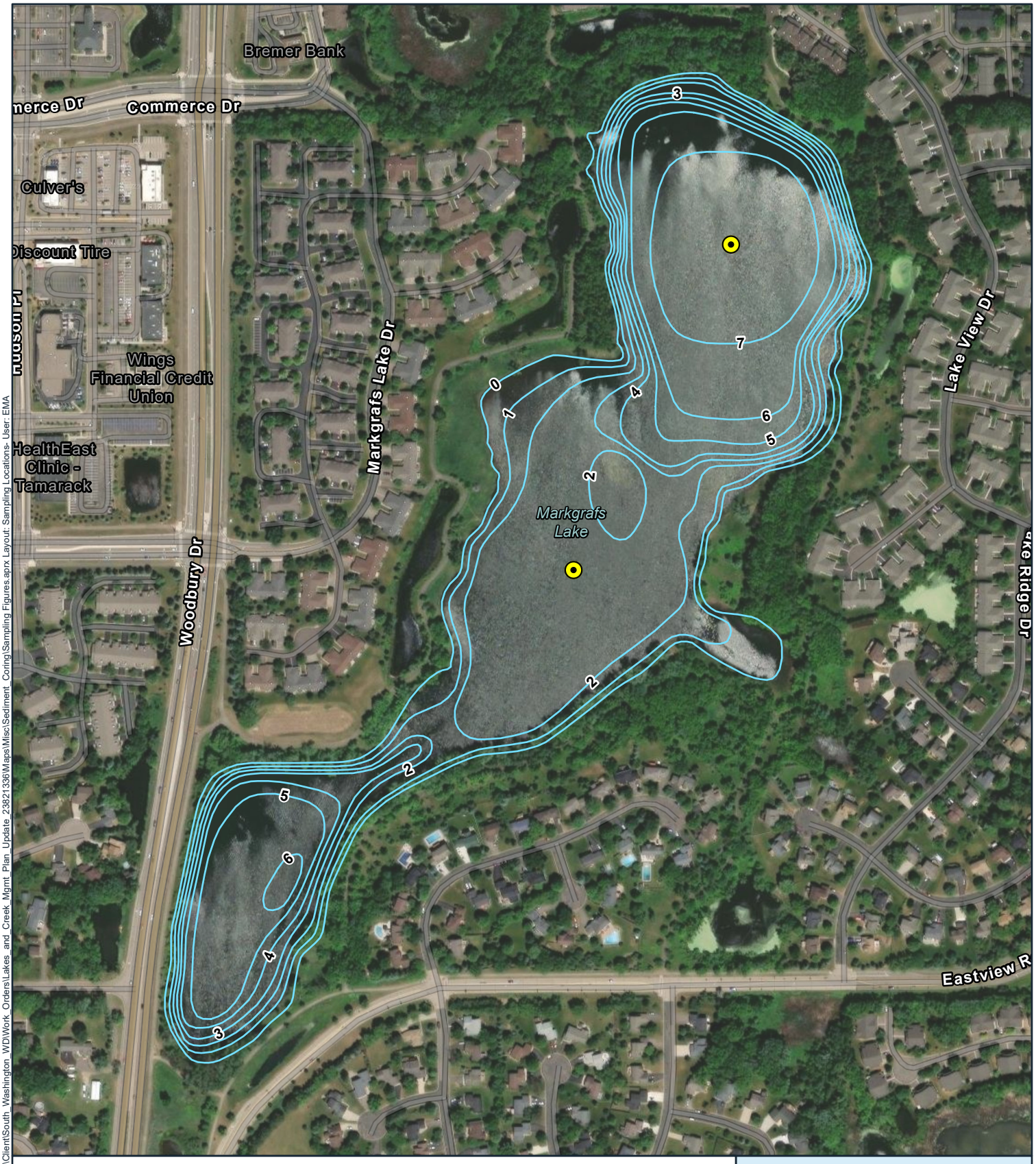

Coring Location

Bathymetric Contours

N

0 200 400

Feet

Markgrafs Sediment Coring Locations

SWWD Lakes and Creek Management Plan

BARR

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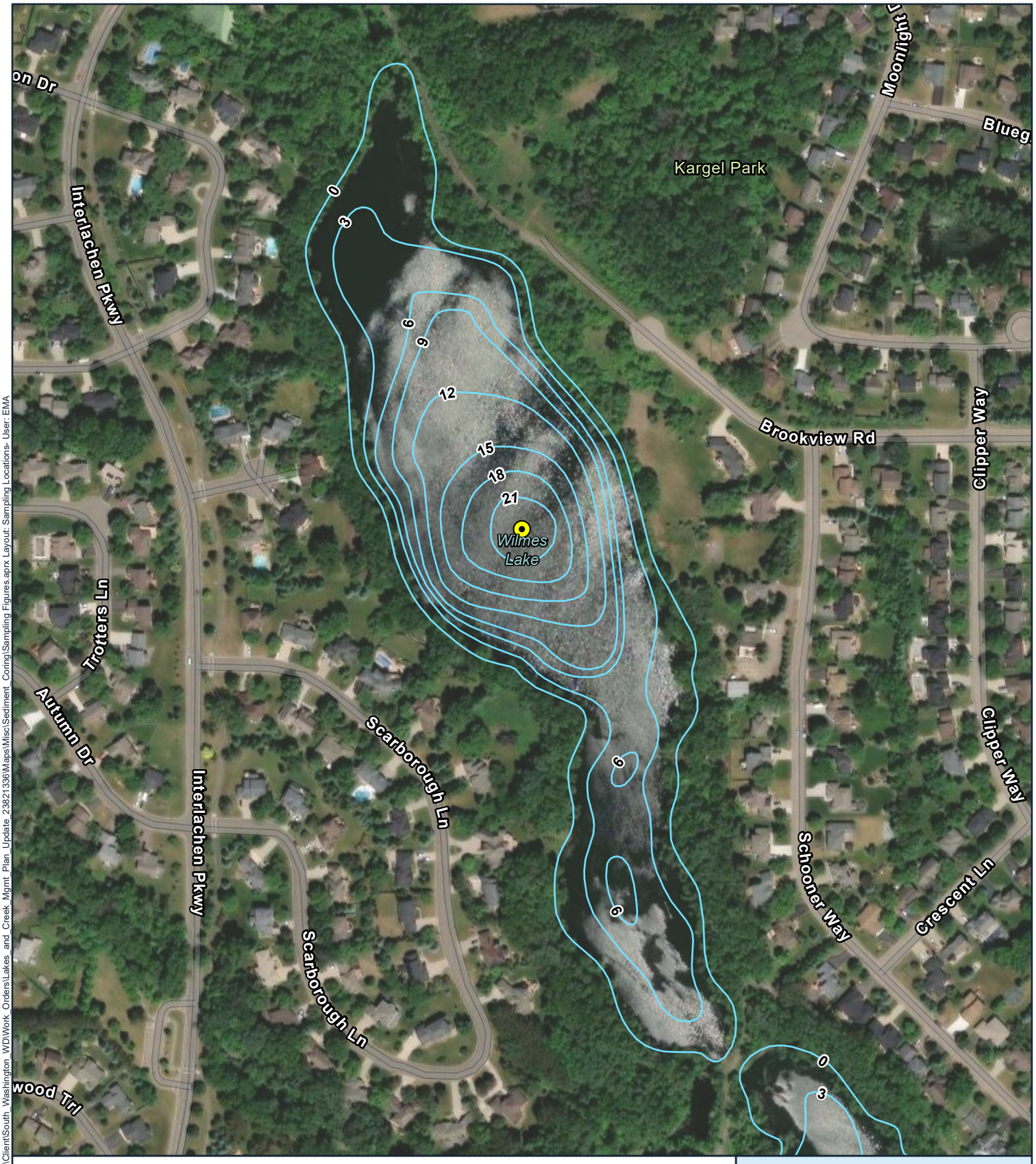

Coring Location

Bathymetric Contours

N

0 150 300

Feet

North Wilmes Sediment Coring Locations

SWWD Lakes and Creek Management Plan

BARR

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Coring Location

Bathymetric Contours

N

0 200 400

Feet

Powers
Sediment Coring Locations

SWWD Lakes and Creek Management Plan

BARR

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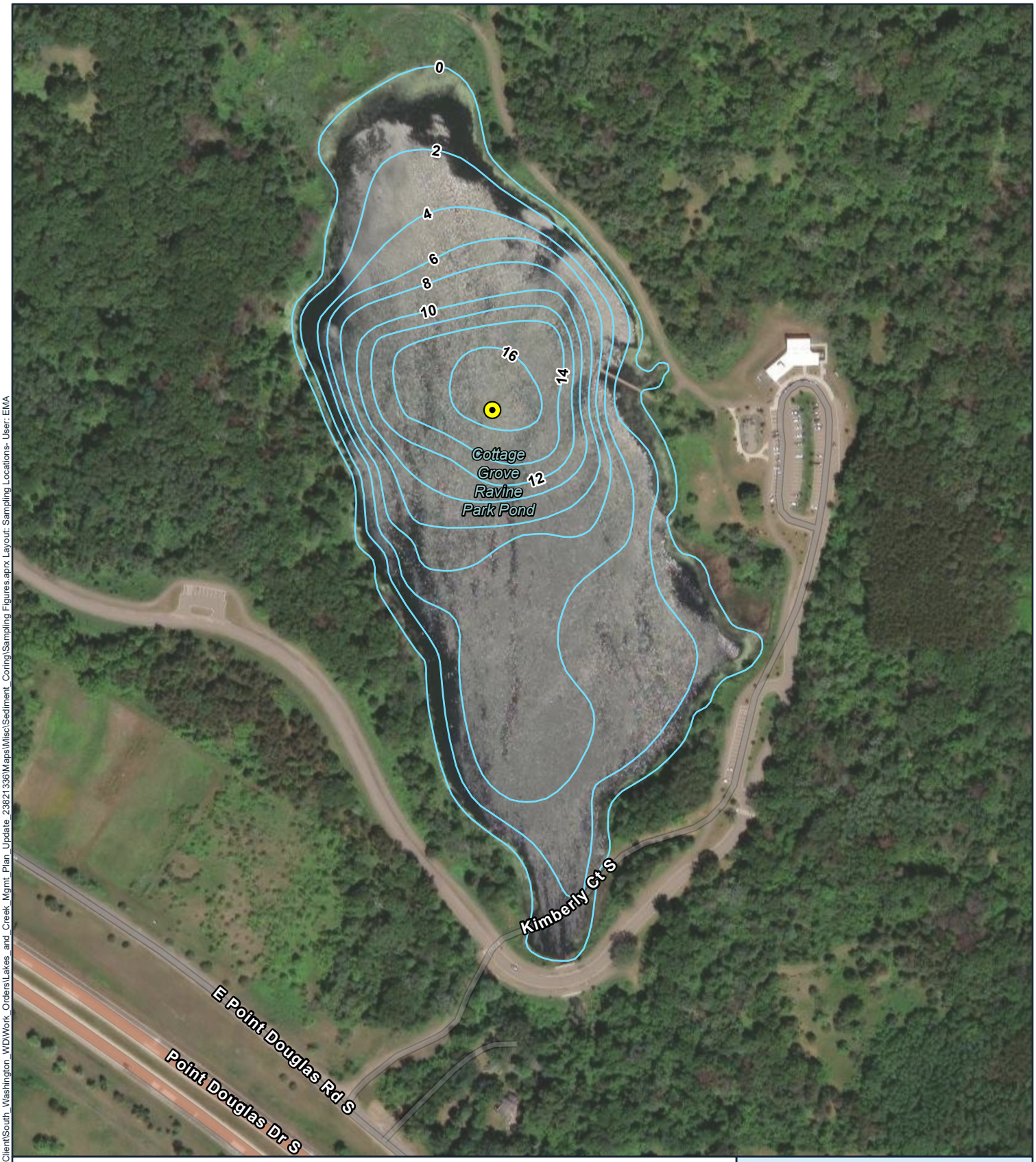

Coring Location

Bathymetric Contours

N

0 150 300

Feet

Ravine
Sediment Coring Locations

SWWD Lakes and Creek Management Plan

BARR

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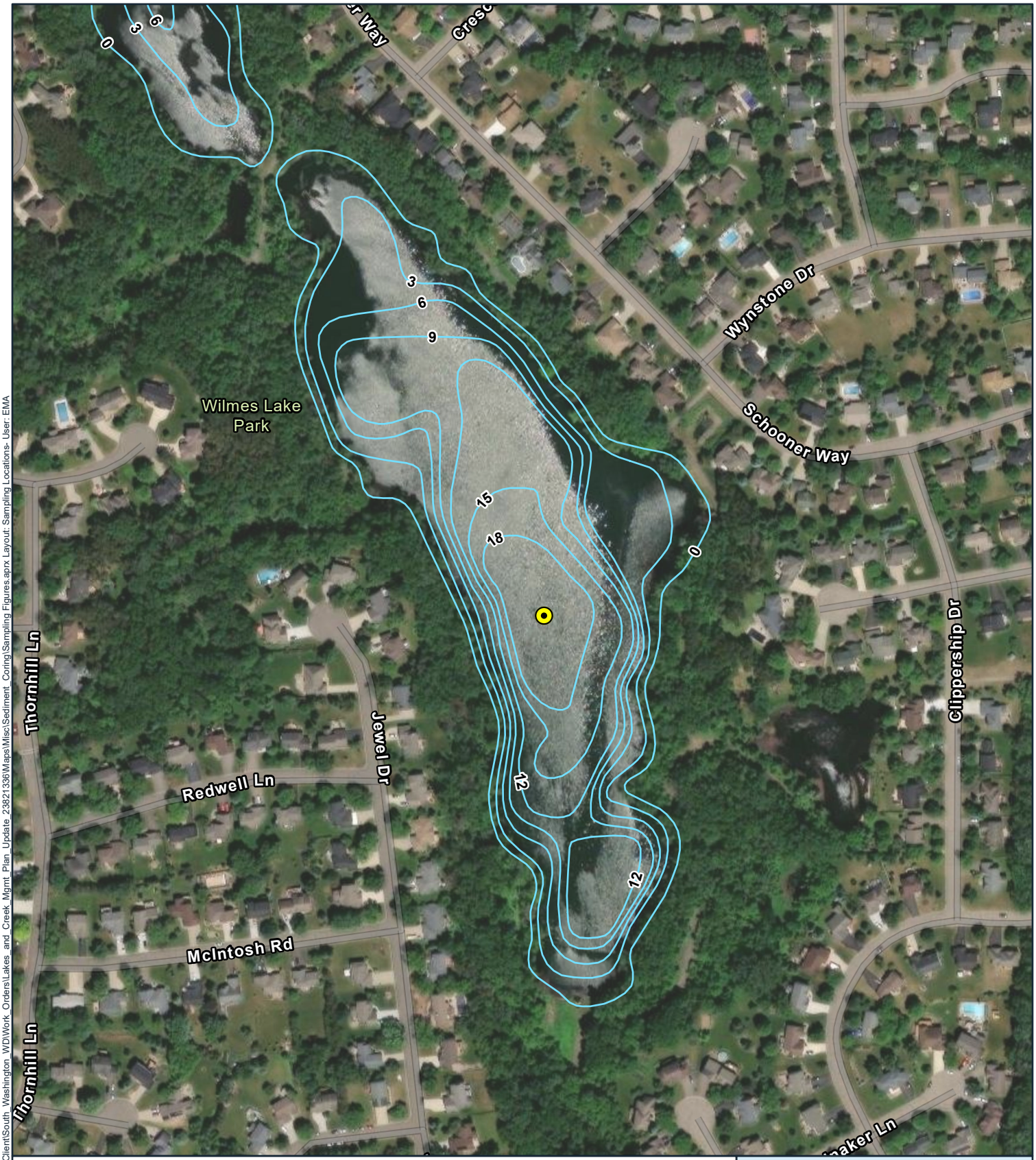

Coring Location

Bathymetric Contours

N

0 150 300

Feet

South Wilmes Sediment Coring Locations

SWWD Lakes and Creek Management Plan

BARR

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Appendix B

In-lake Model Calibration Plots

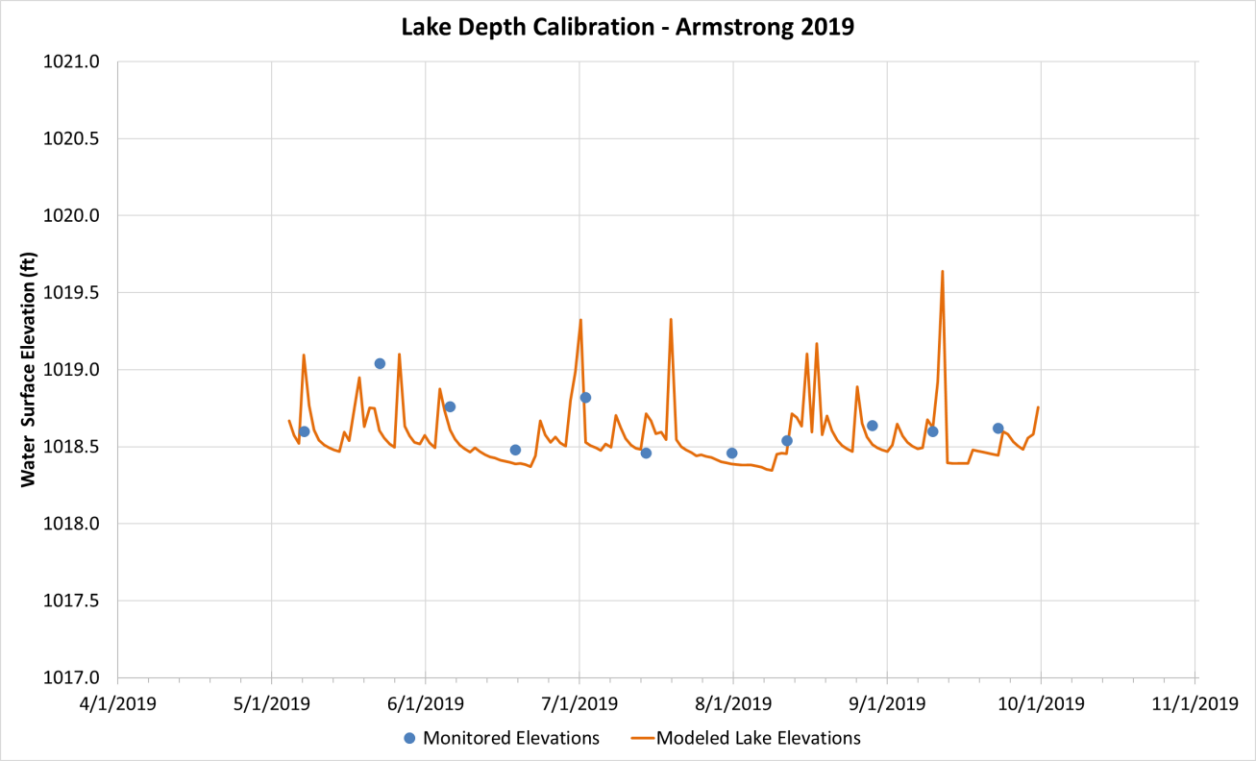


Figure B 1 Armstrong Lake water balance calibration – 2019

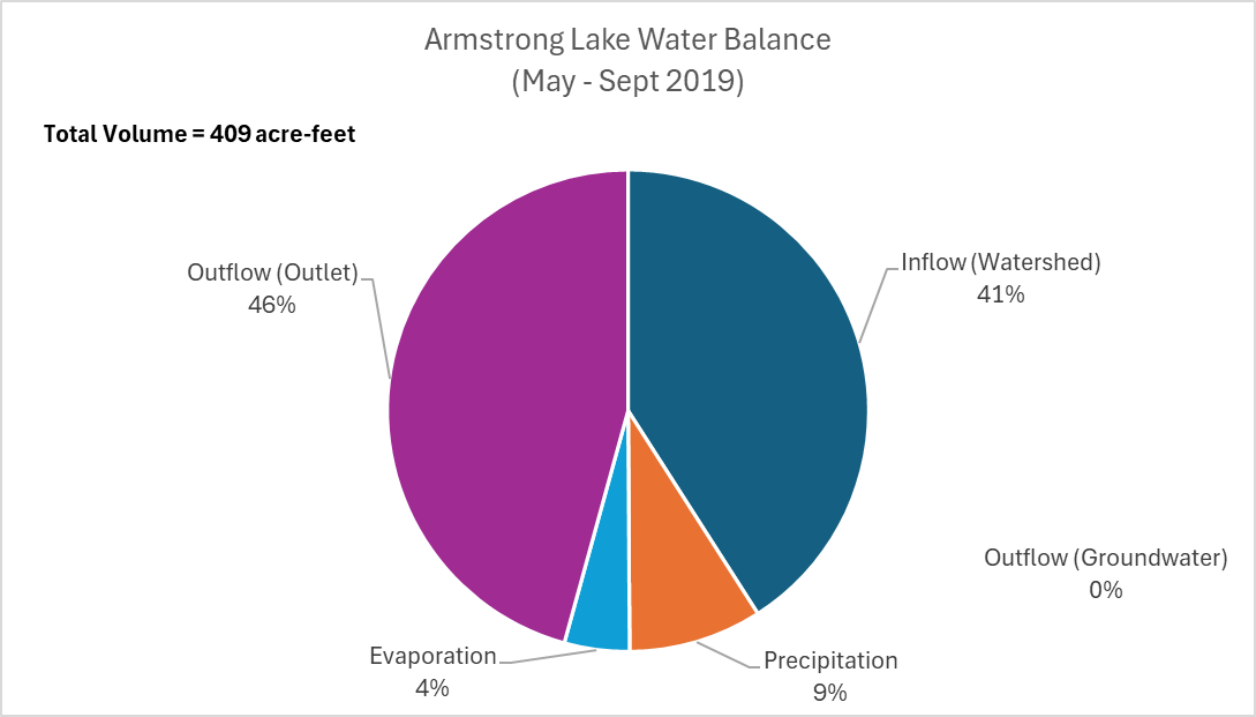


Figure B 2 Armstrong Lake water balance pie chart - 2019

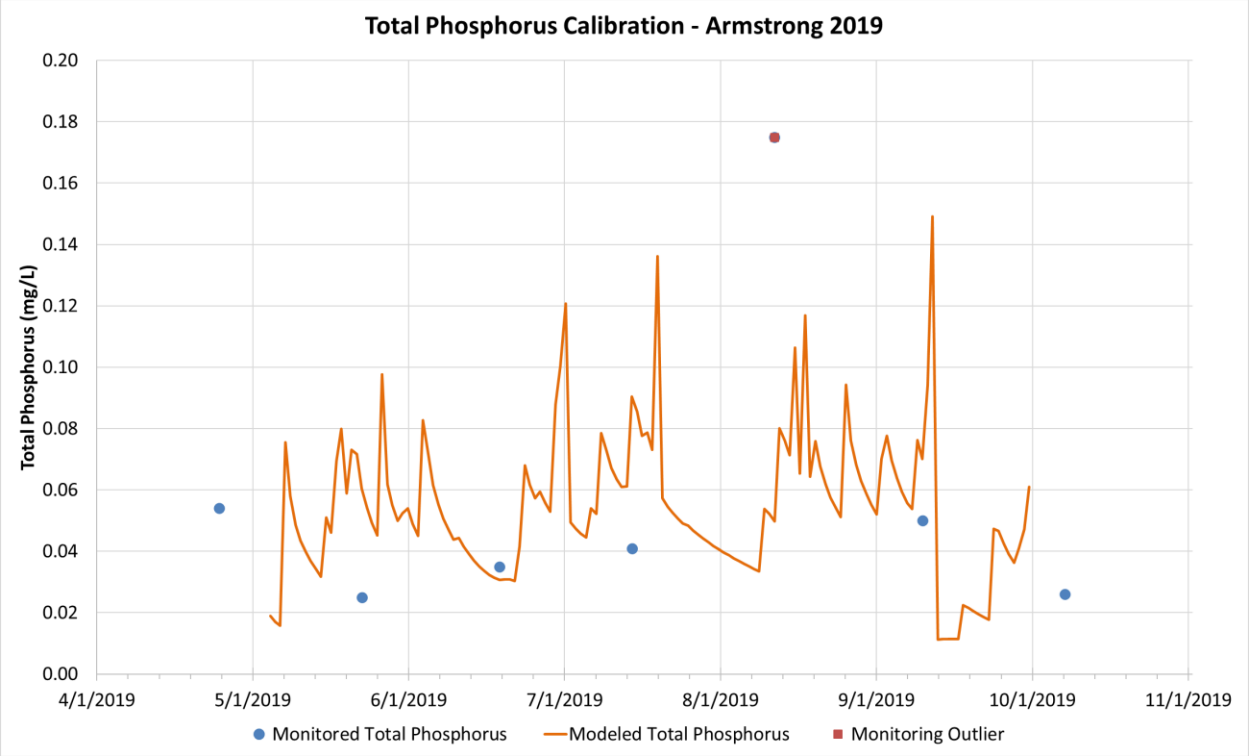


Figure B 3 Armstrong Lake total phosphorus calibration - 2019

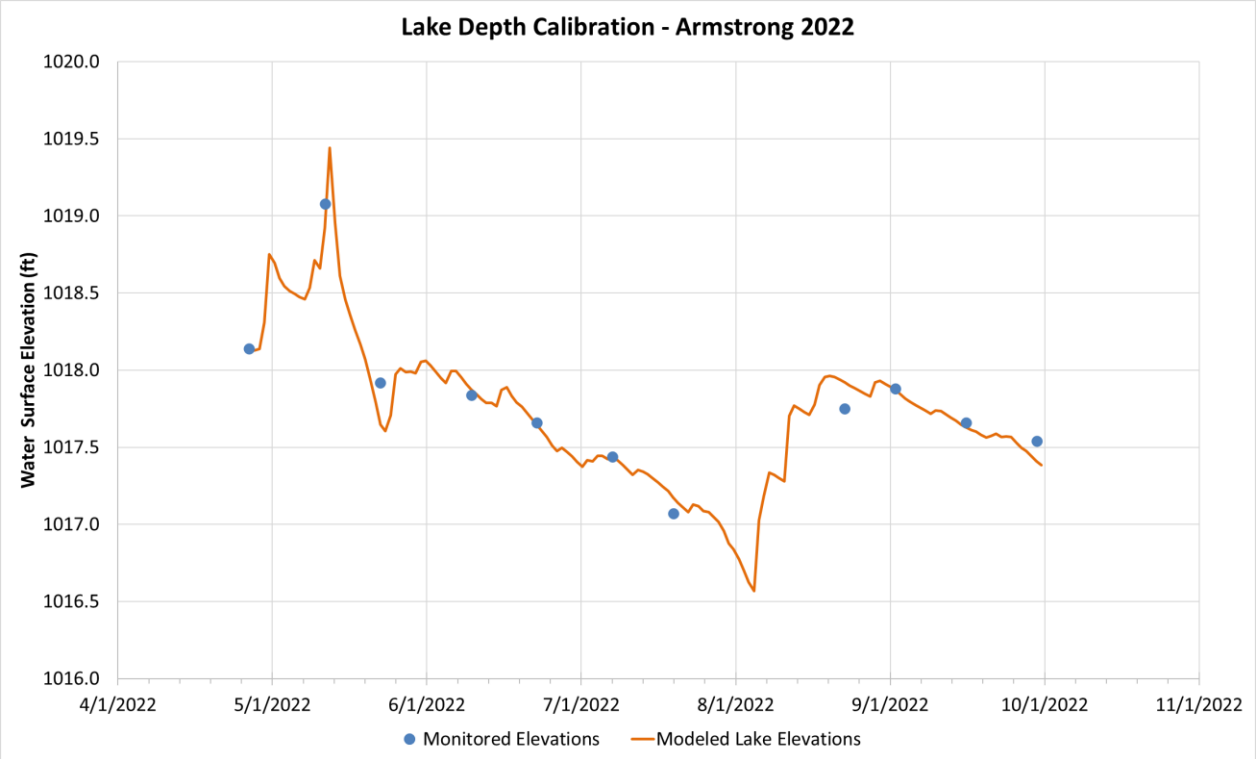


Figure B 4 Armstrong Lake water balance calibration – 2022

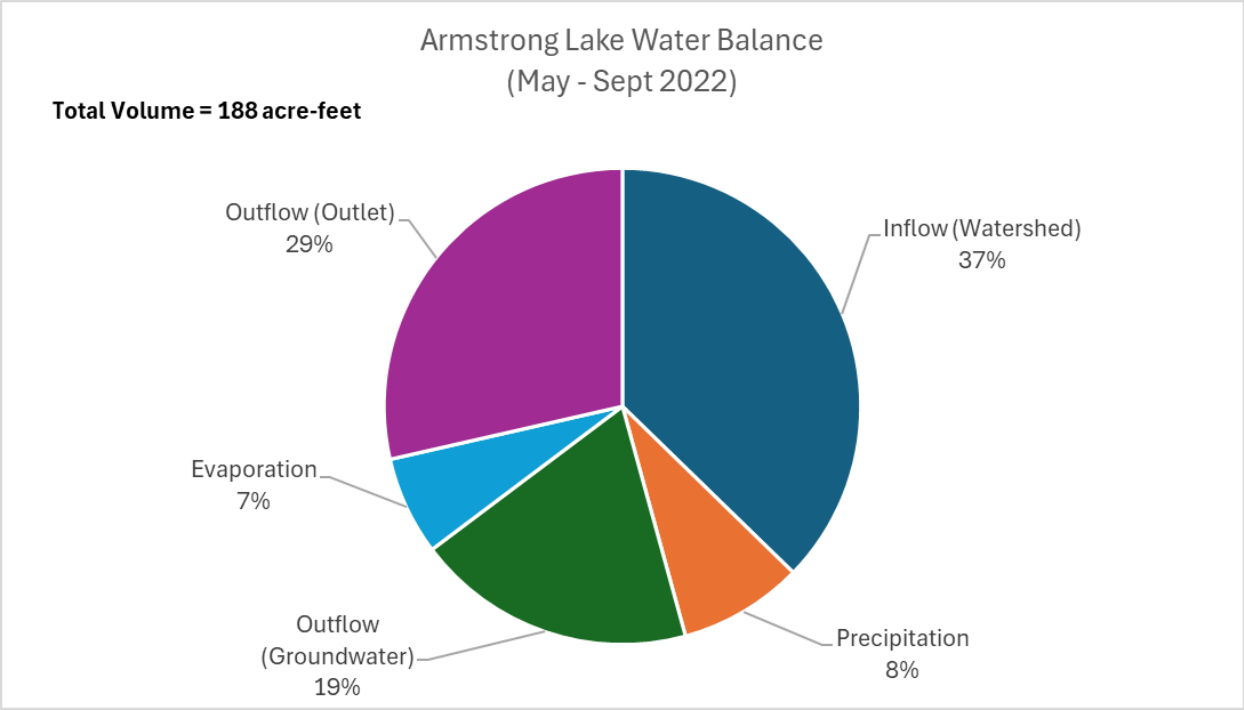
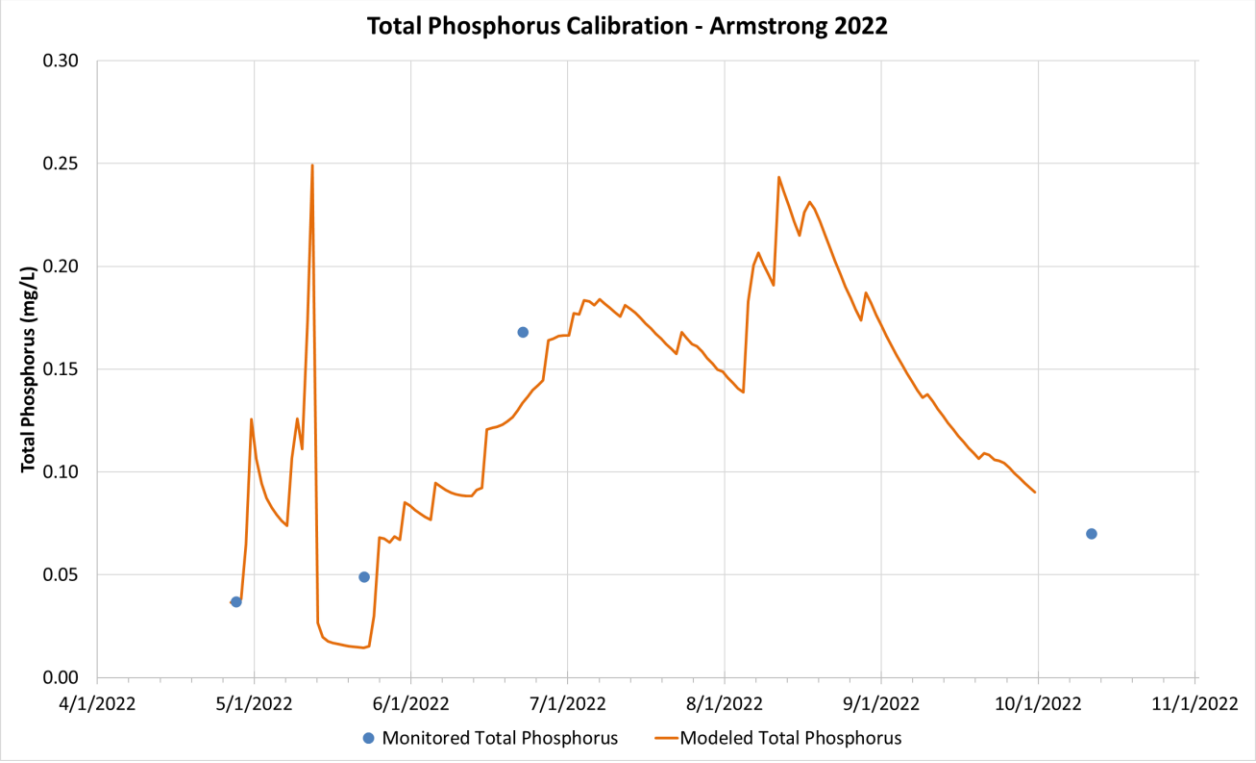


Figure B 5 **Armstrong Lake water balance pie chart - 2022**



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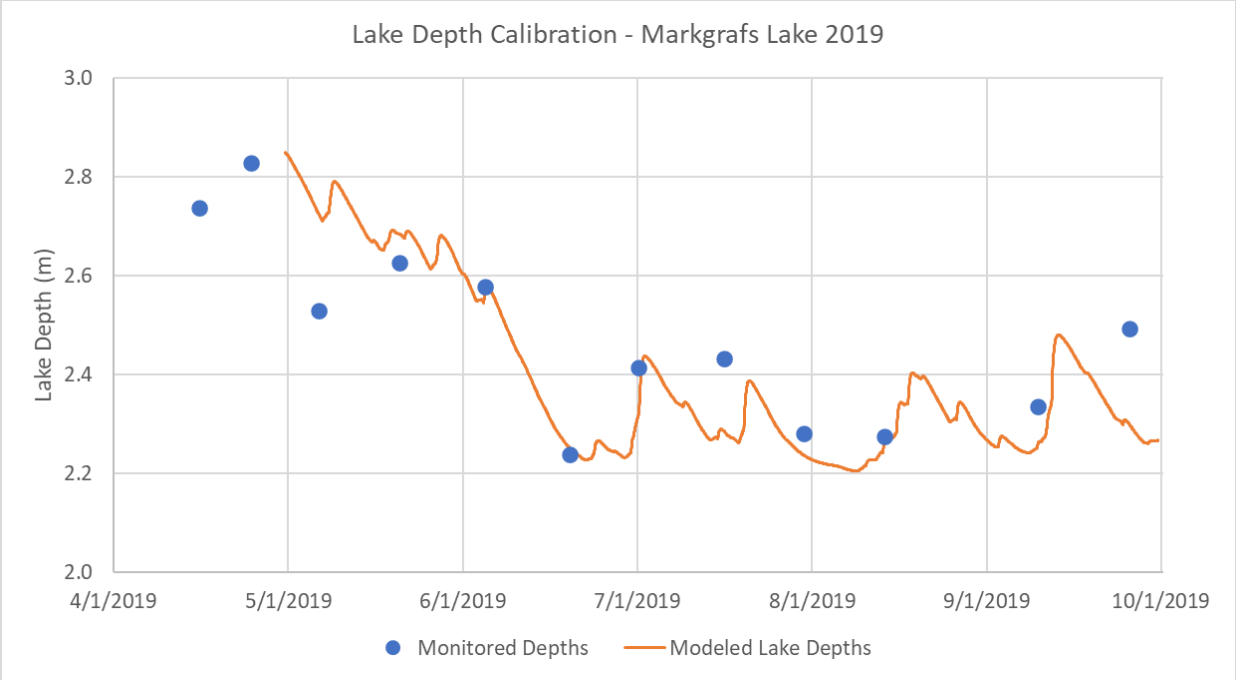
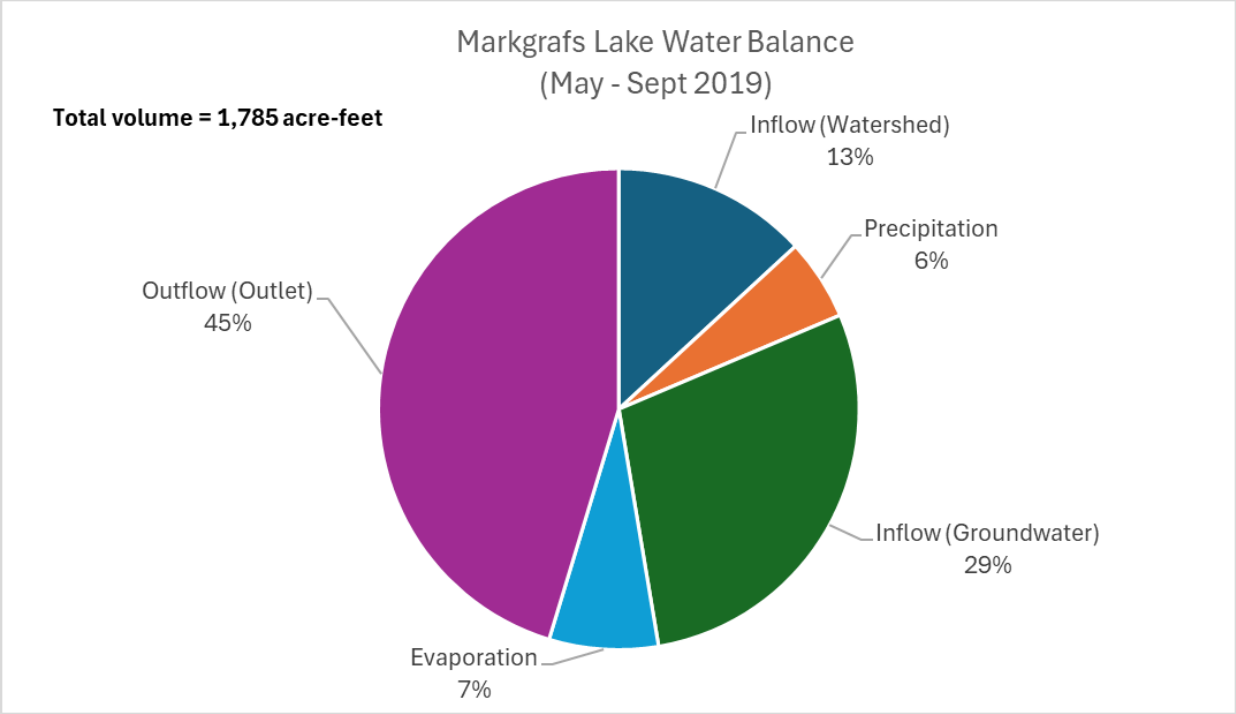


Figure B 7 Markgrafs Lake water balance calibration – 2019



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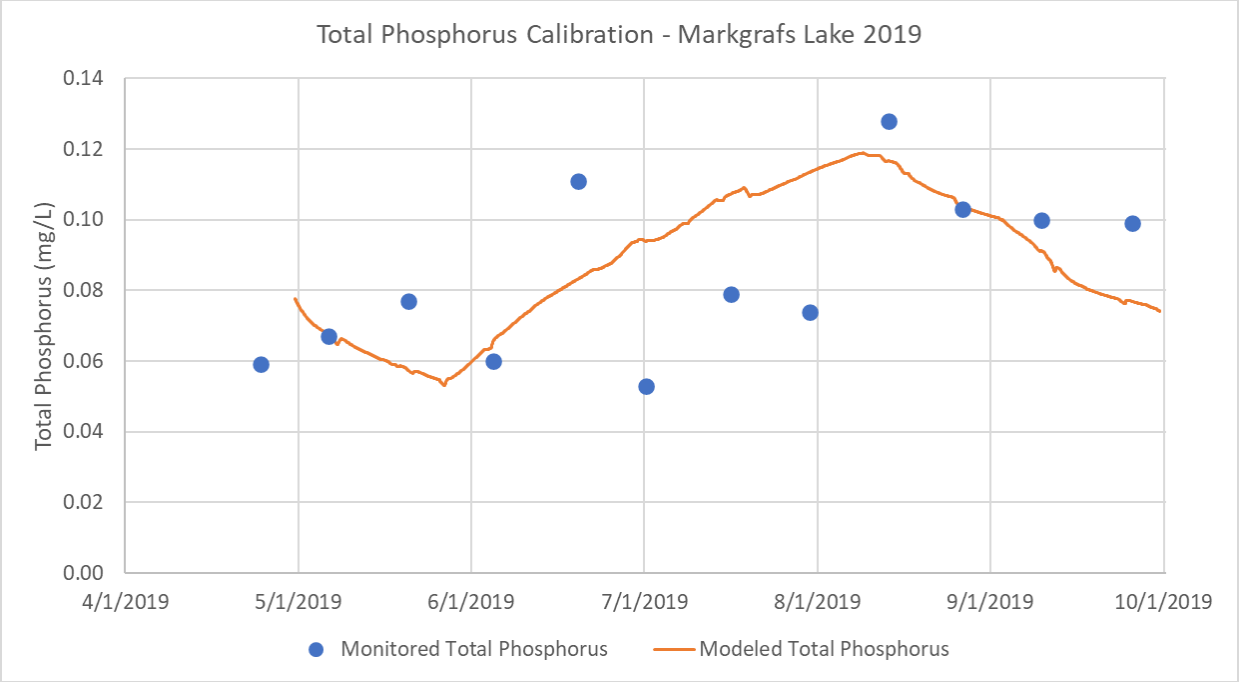


Figure B 9 Markgrafs Lake total phosphorus calibration – 2019

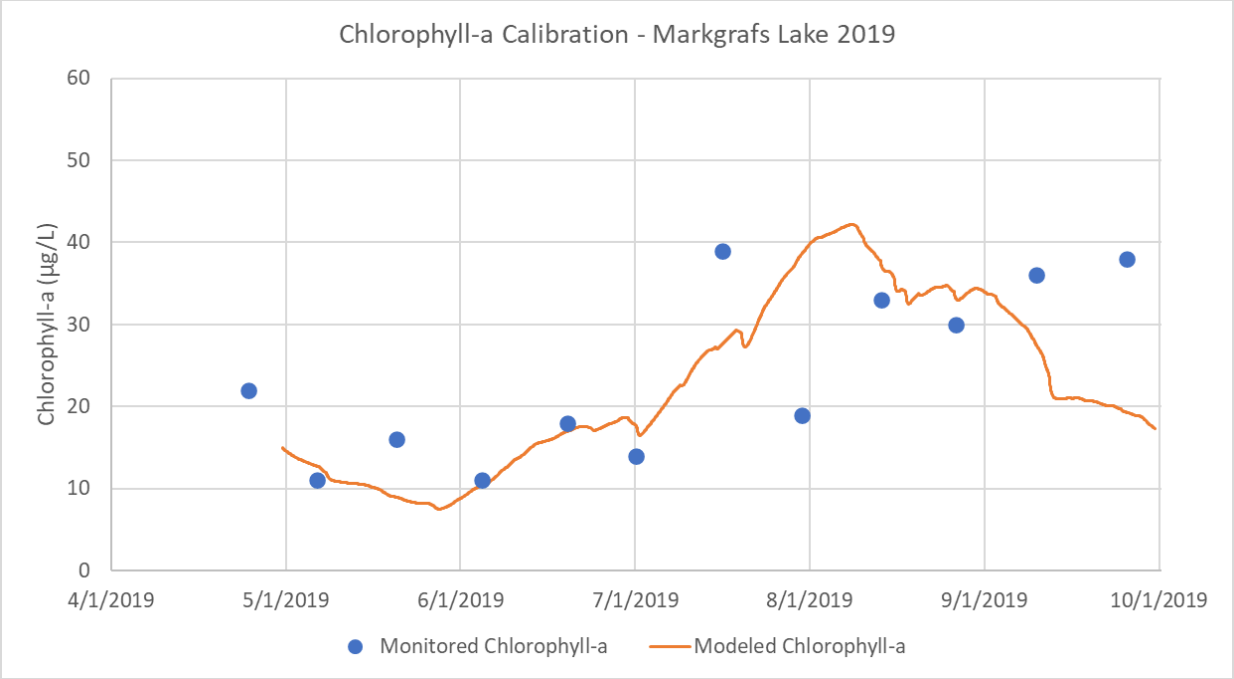


Figure B 10 Markgrafs Lake chlorophyll-a calibration – 2019

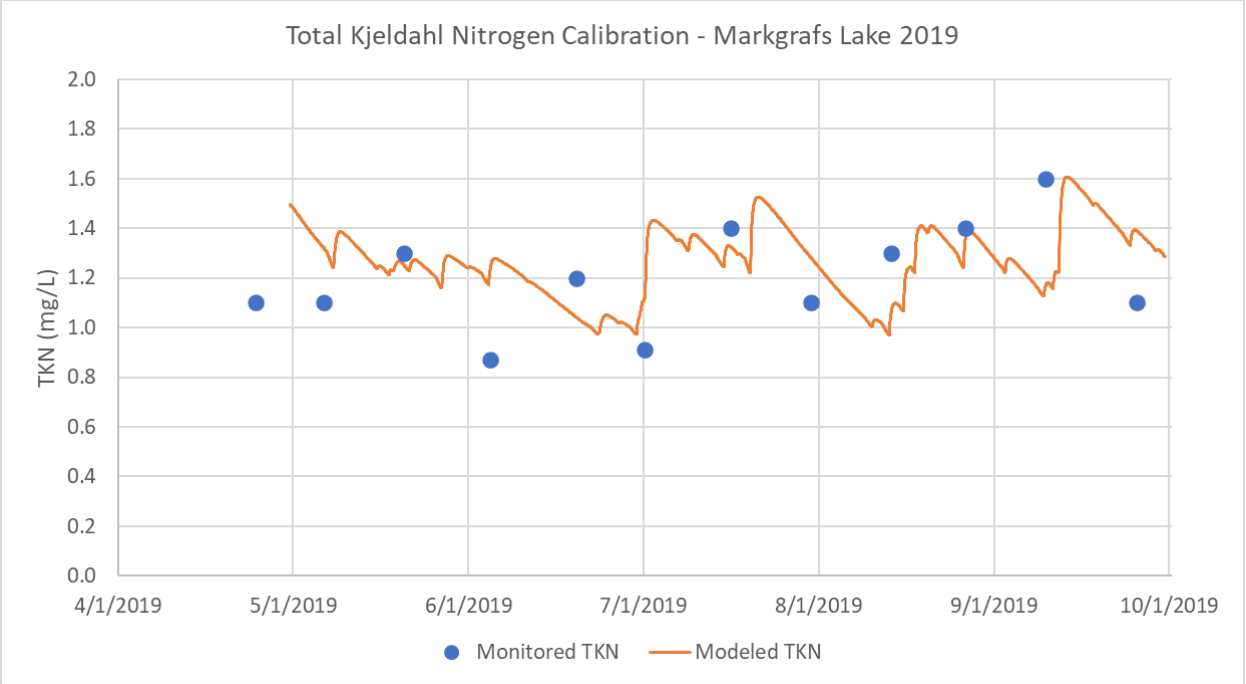
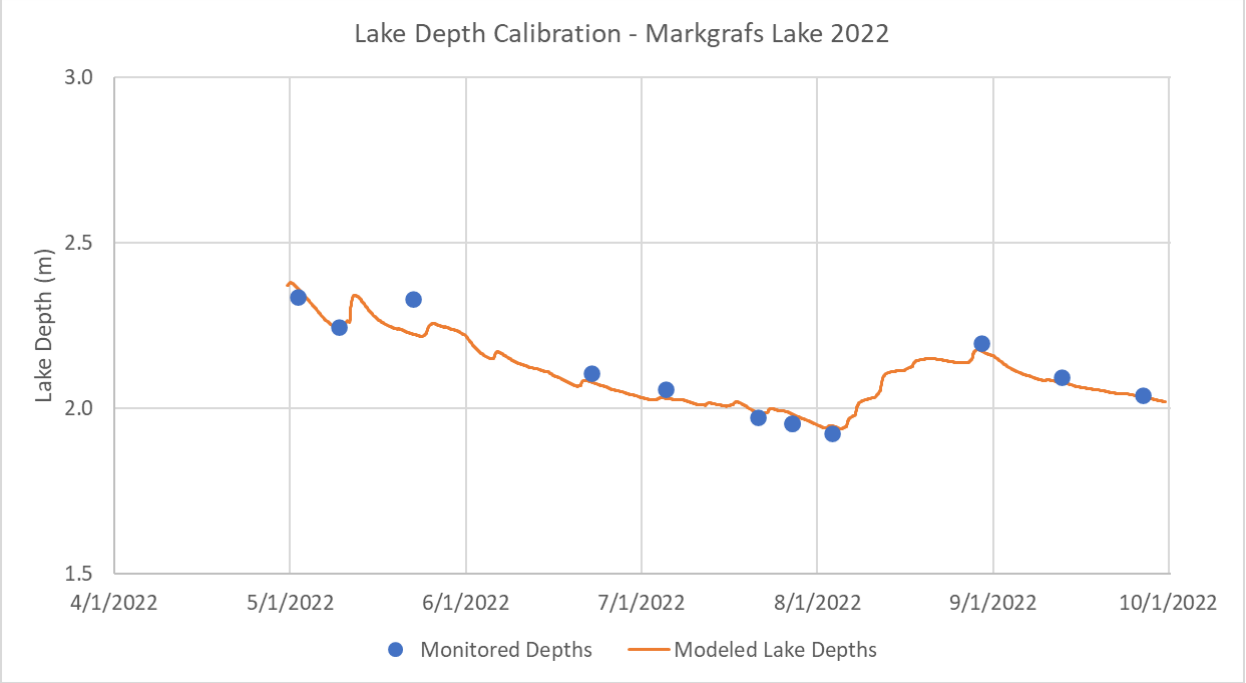


Figure B 11 Markgrafs Lake total Kjeldahl nitrogen calibration – 2019



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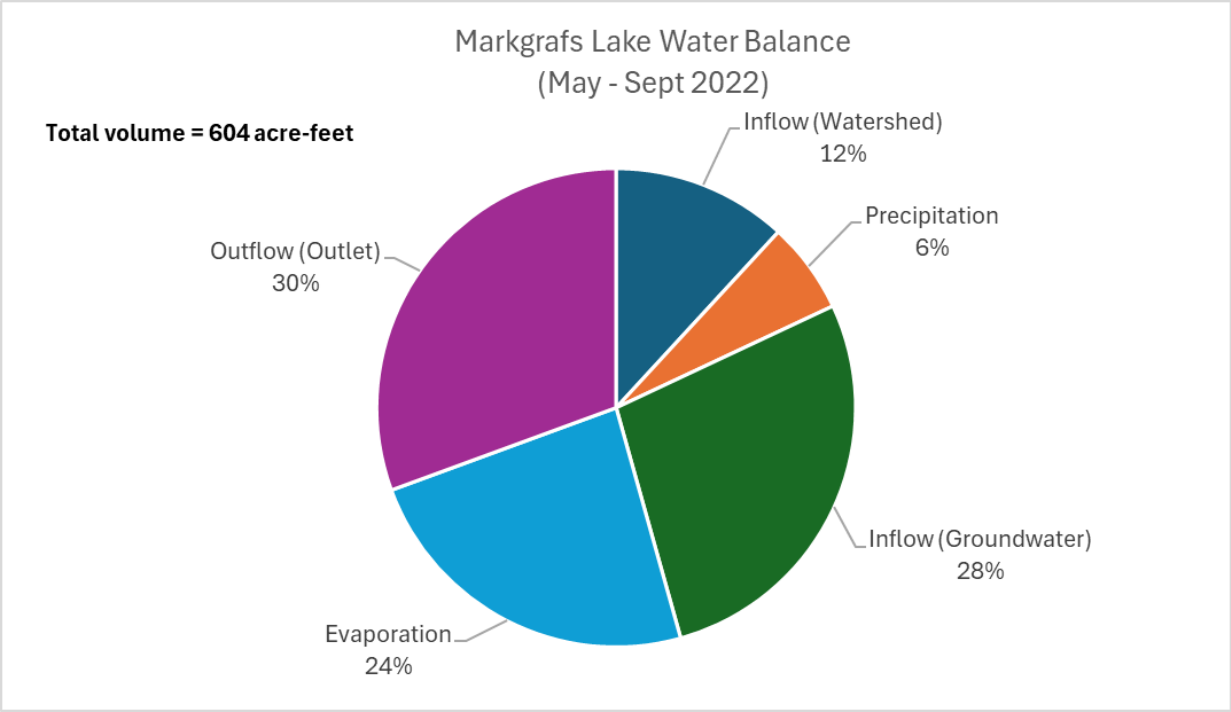

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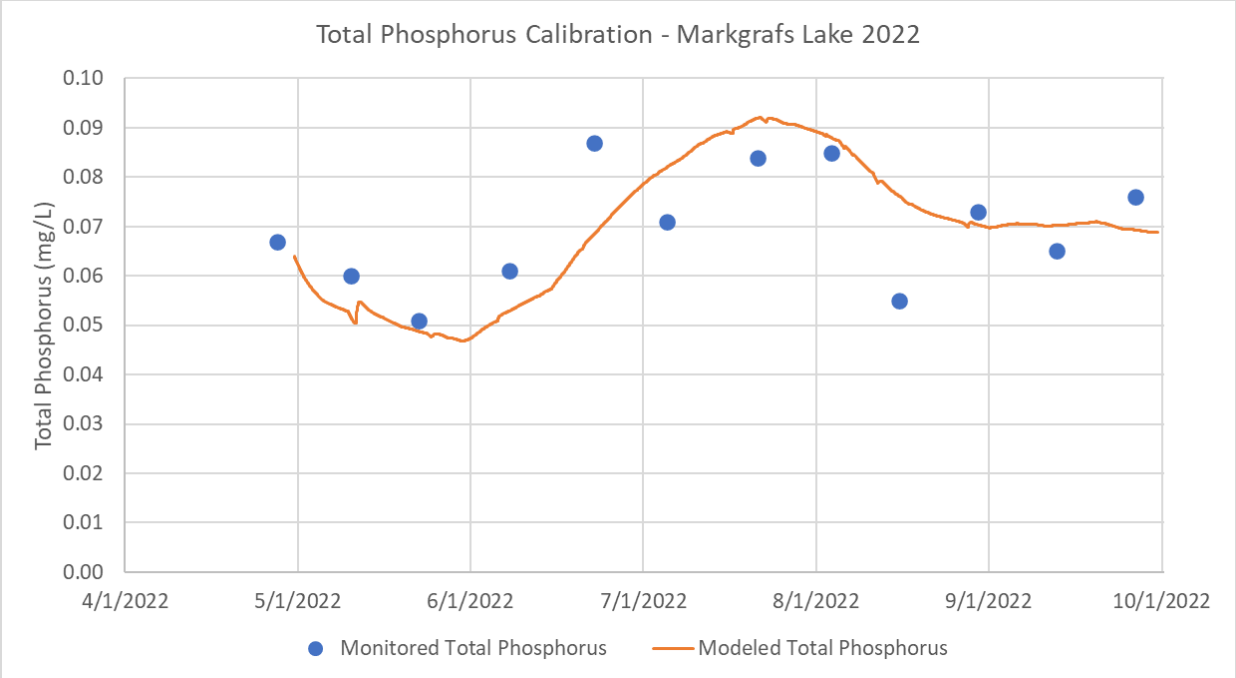

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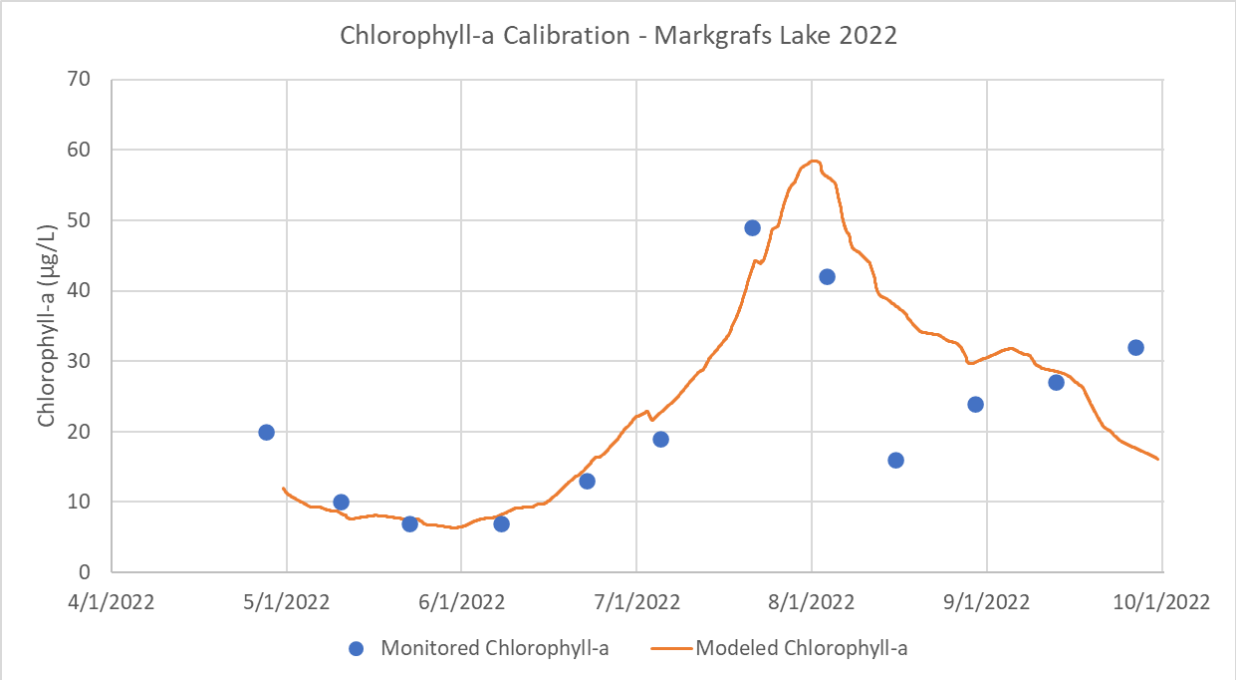

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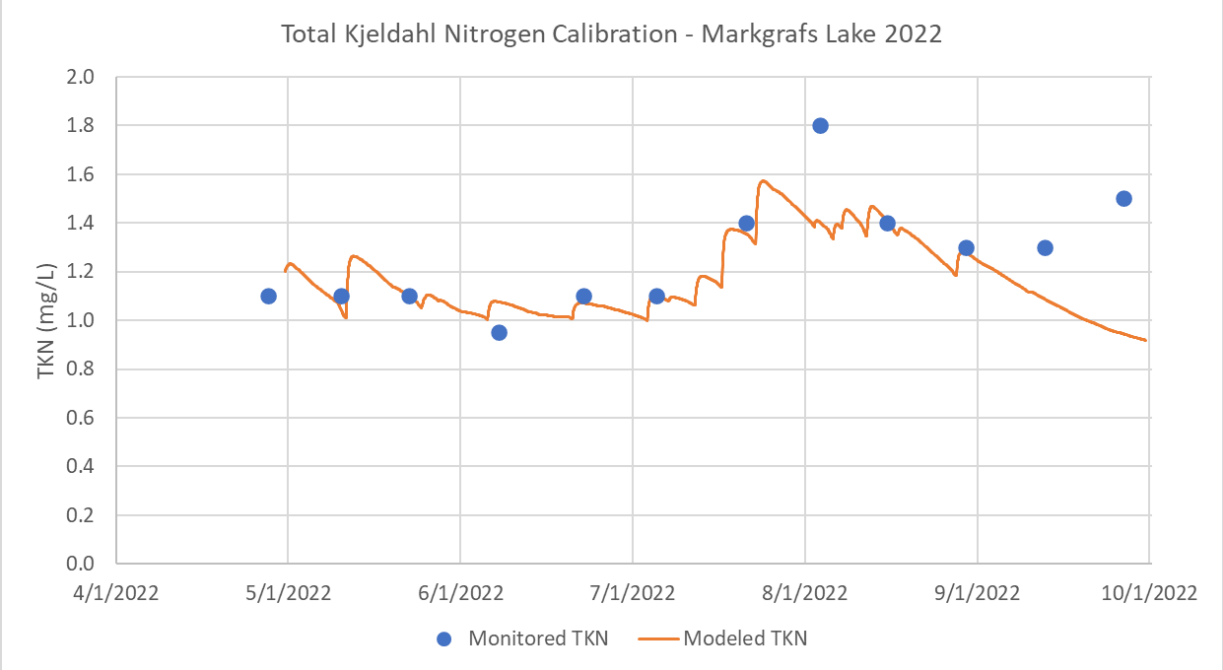

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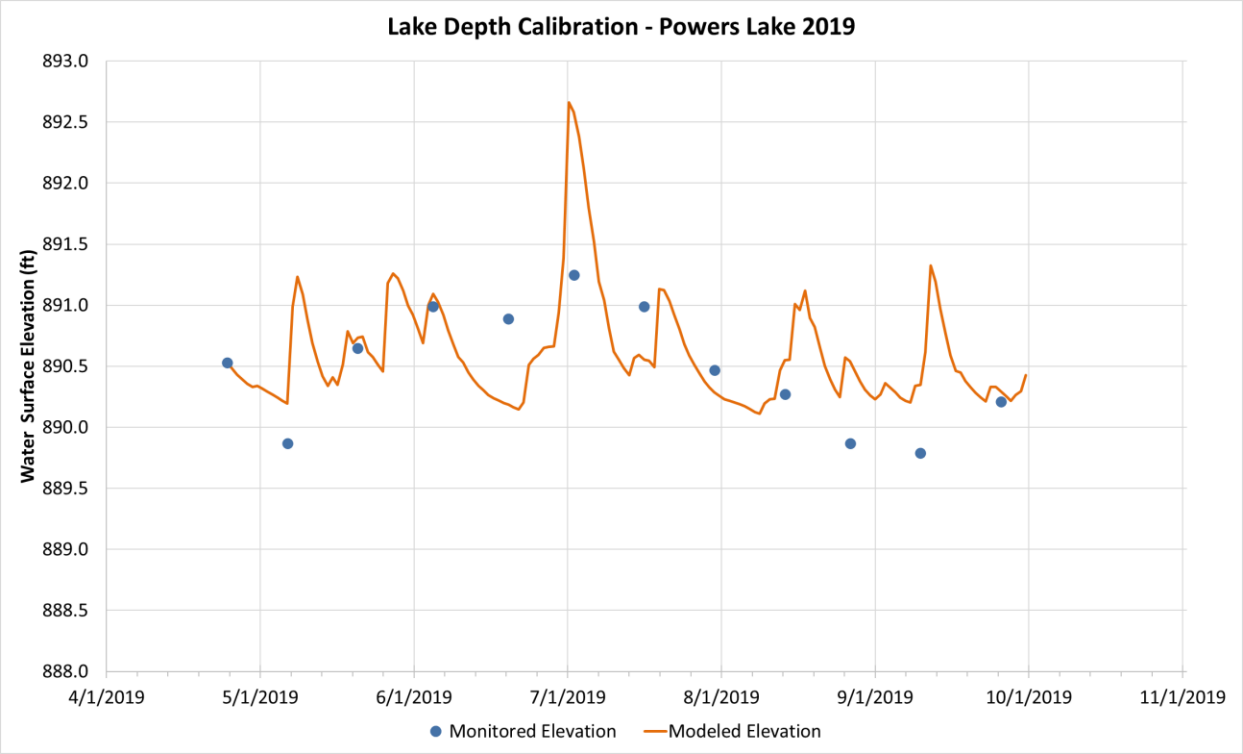
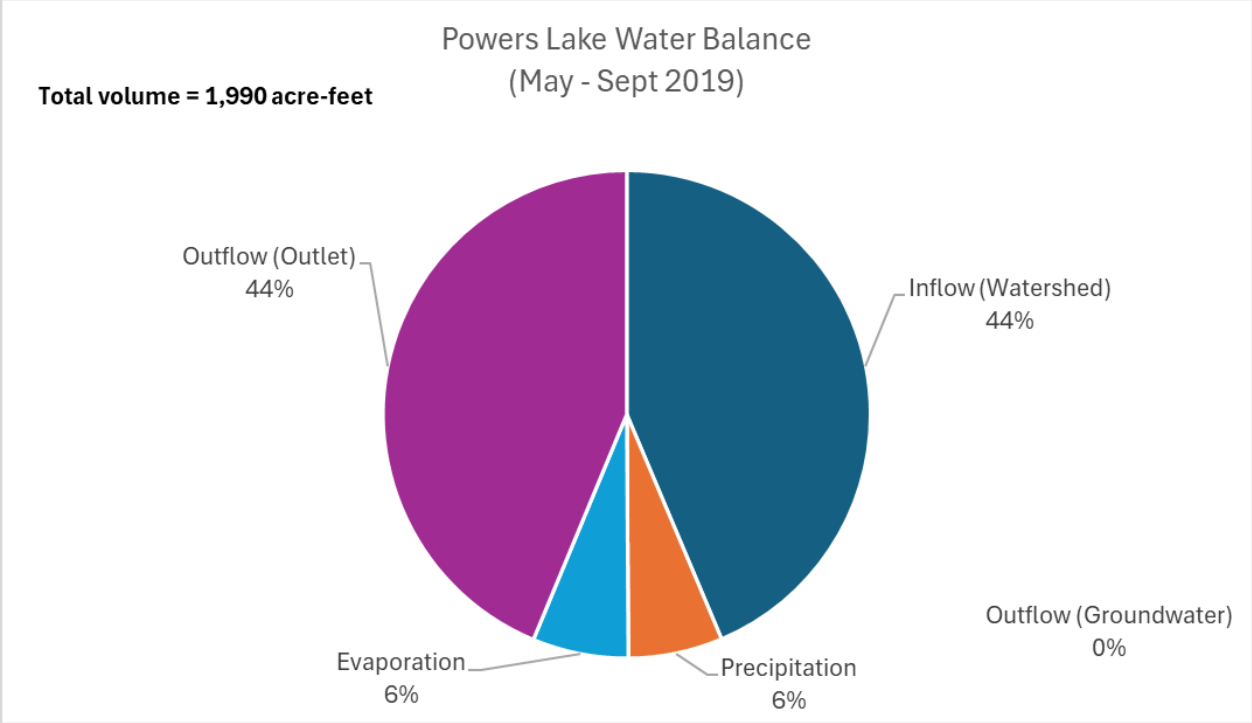


Figure B 17 Powers Lake water balance calibration – 2019



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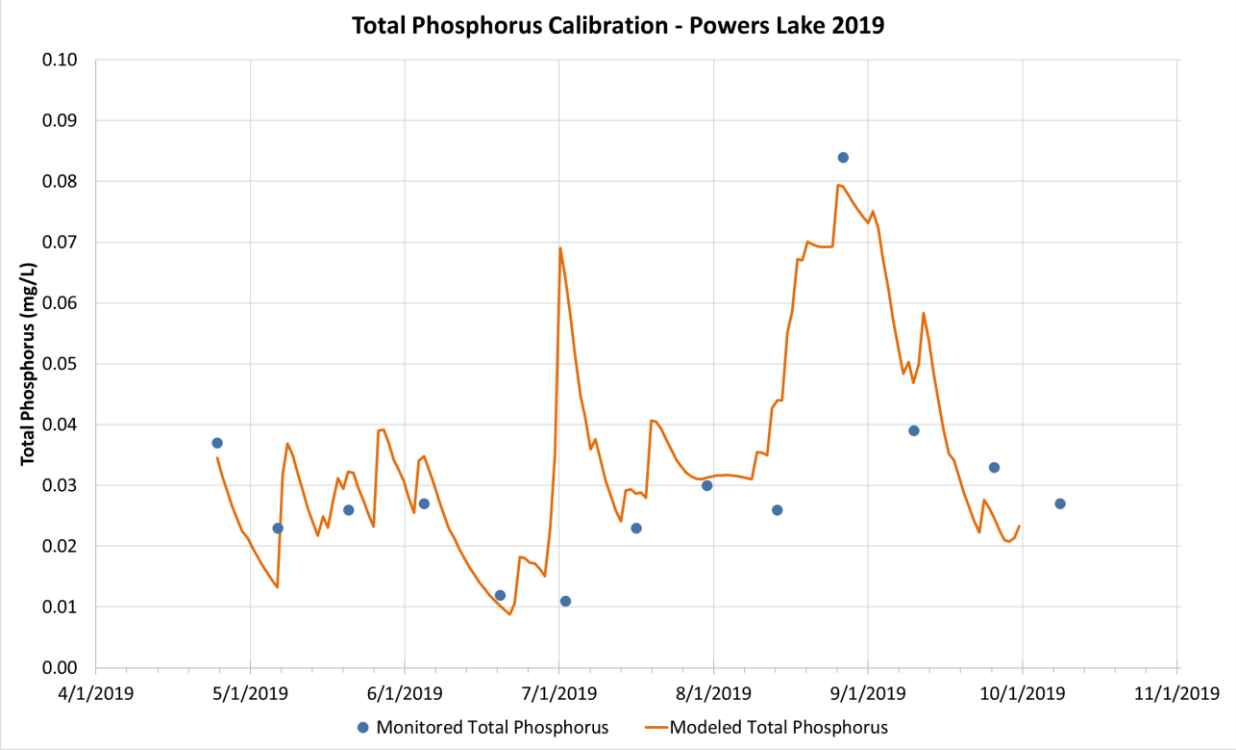

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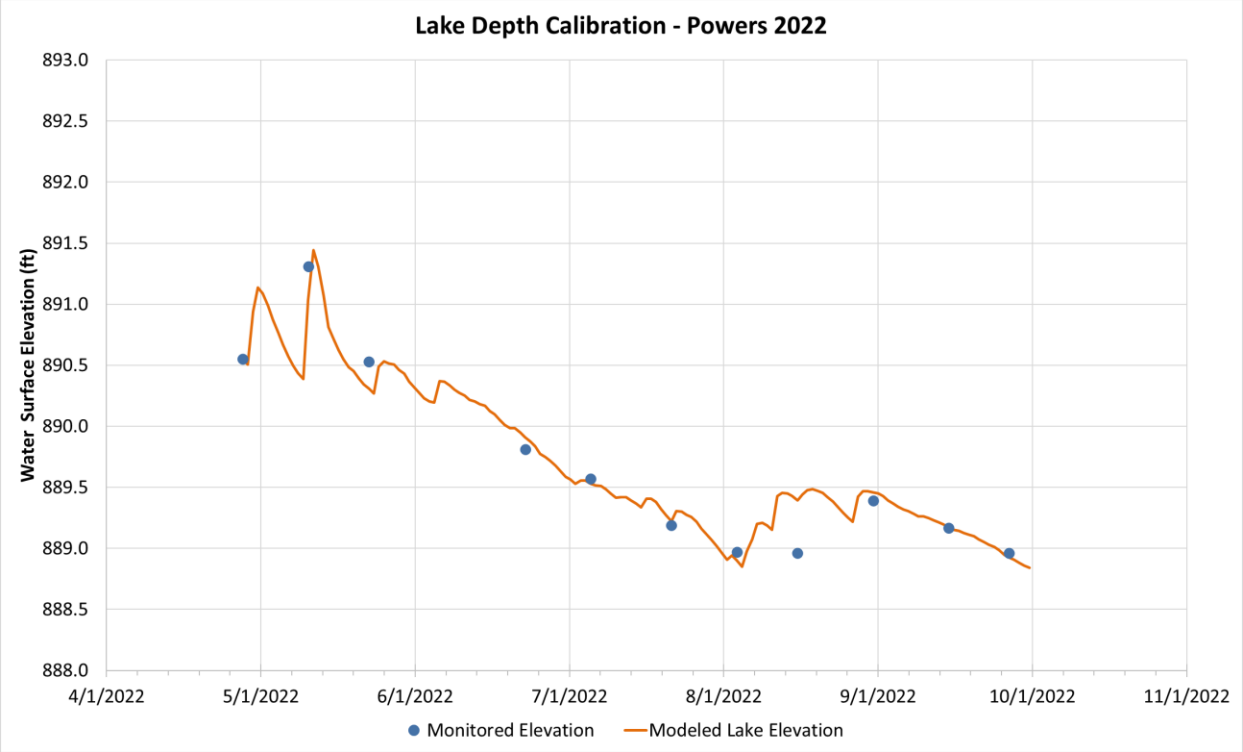

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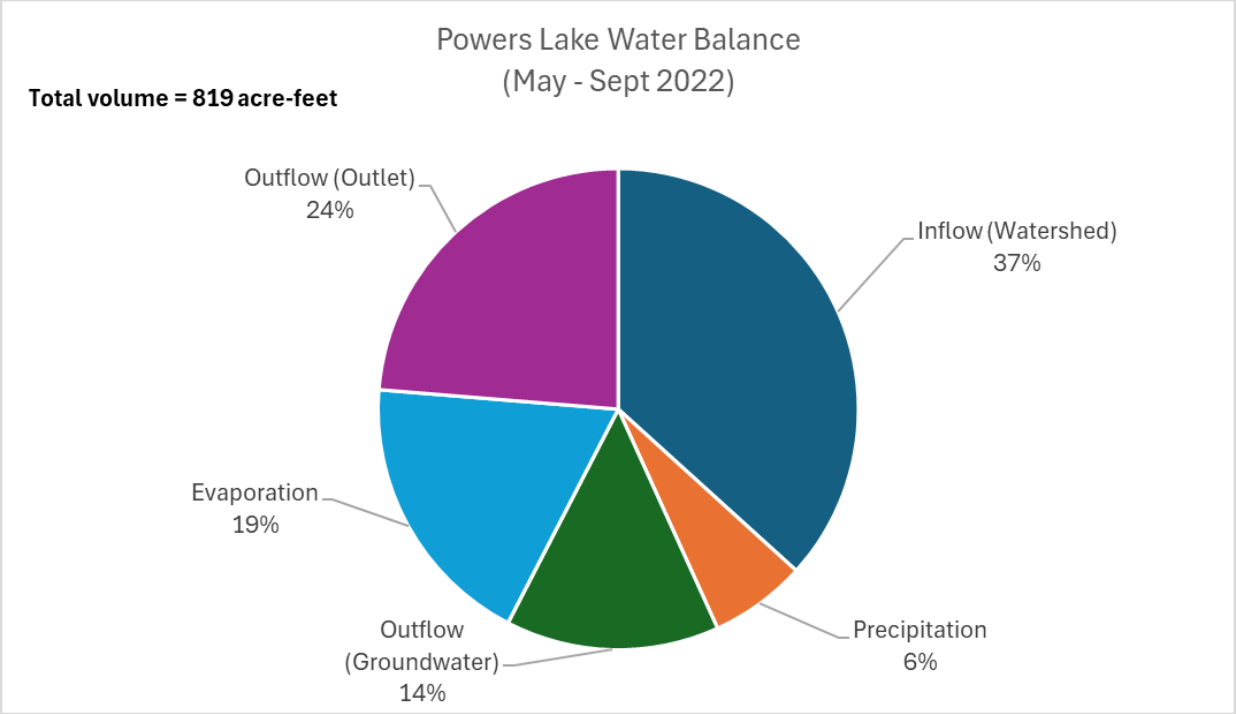

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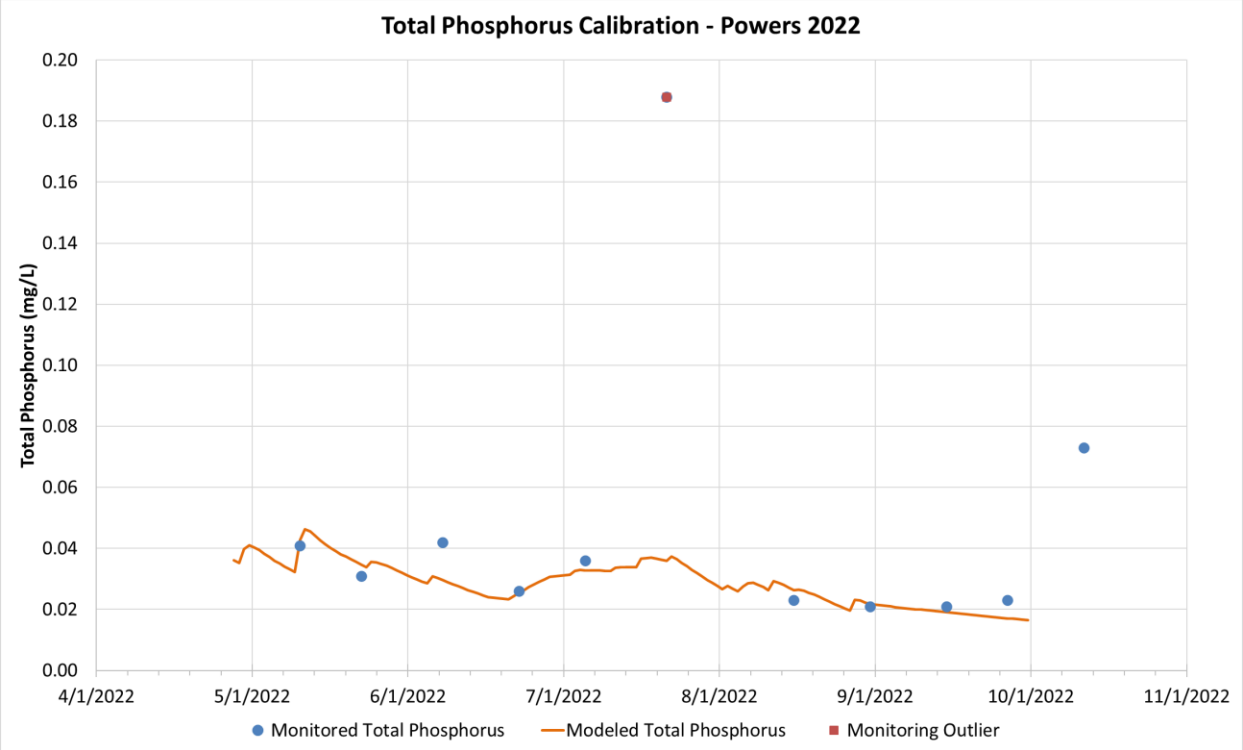

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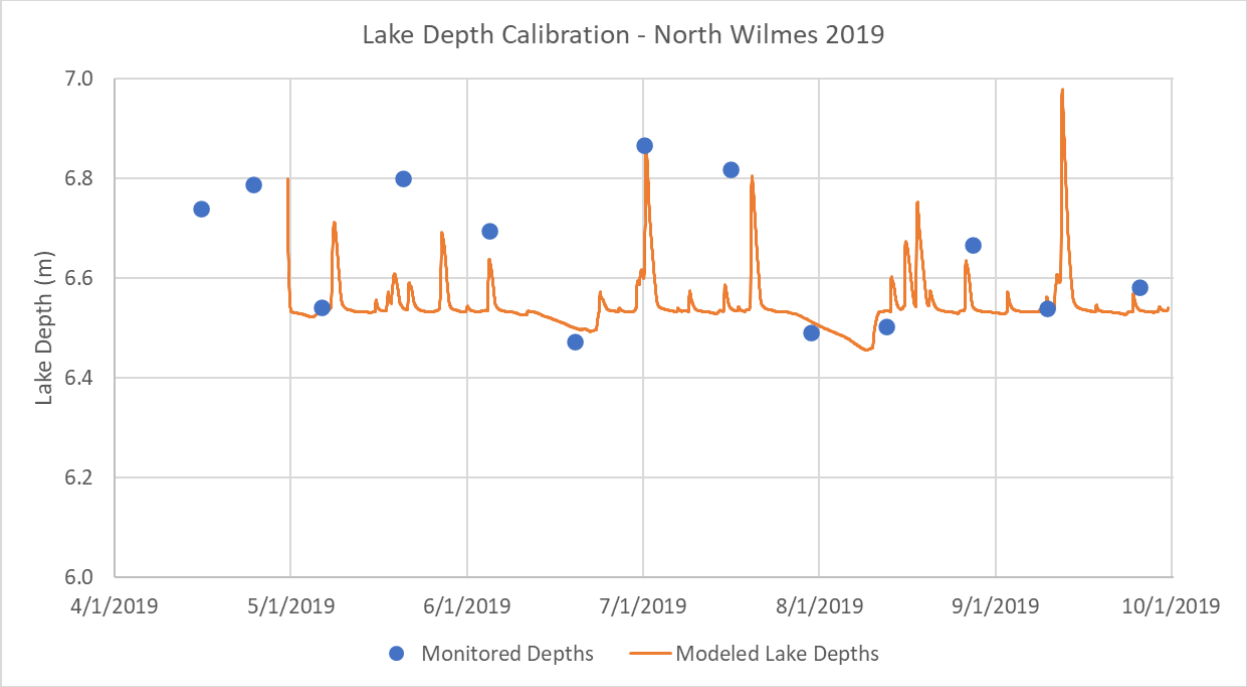
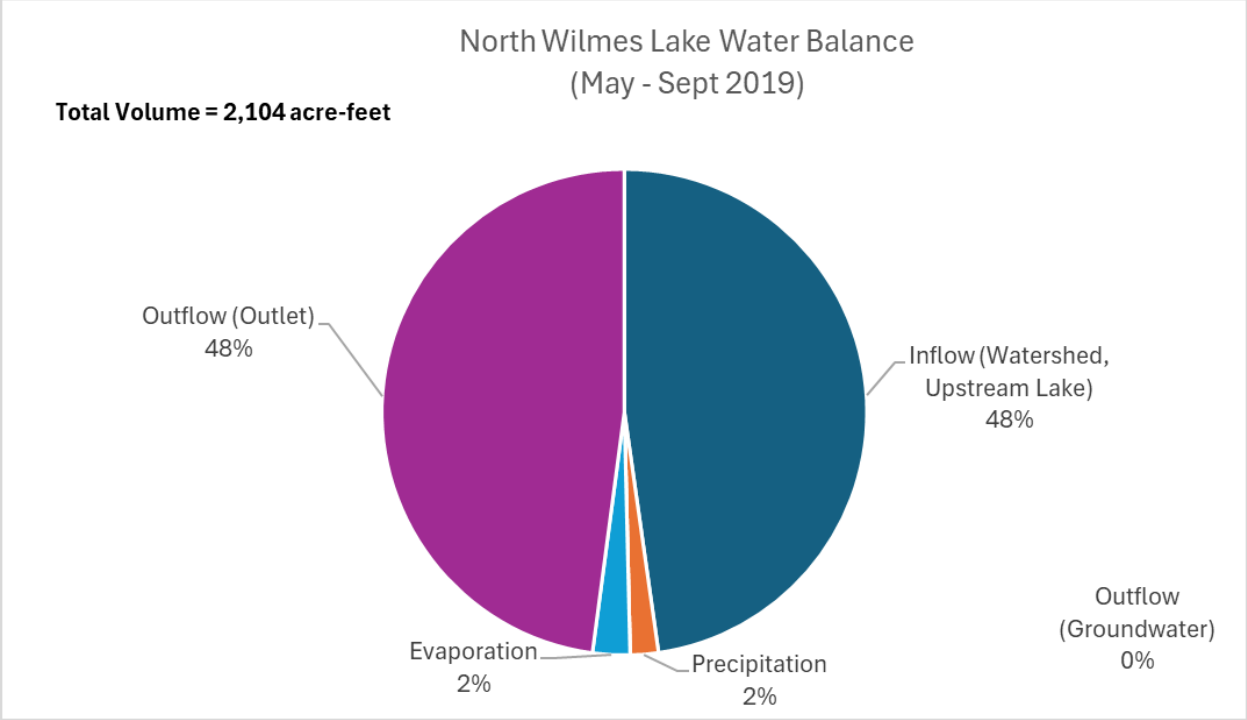


Figure B 23 North Wilmes Lake water balance calibration – 2019



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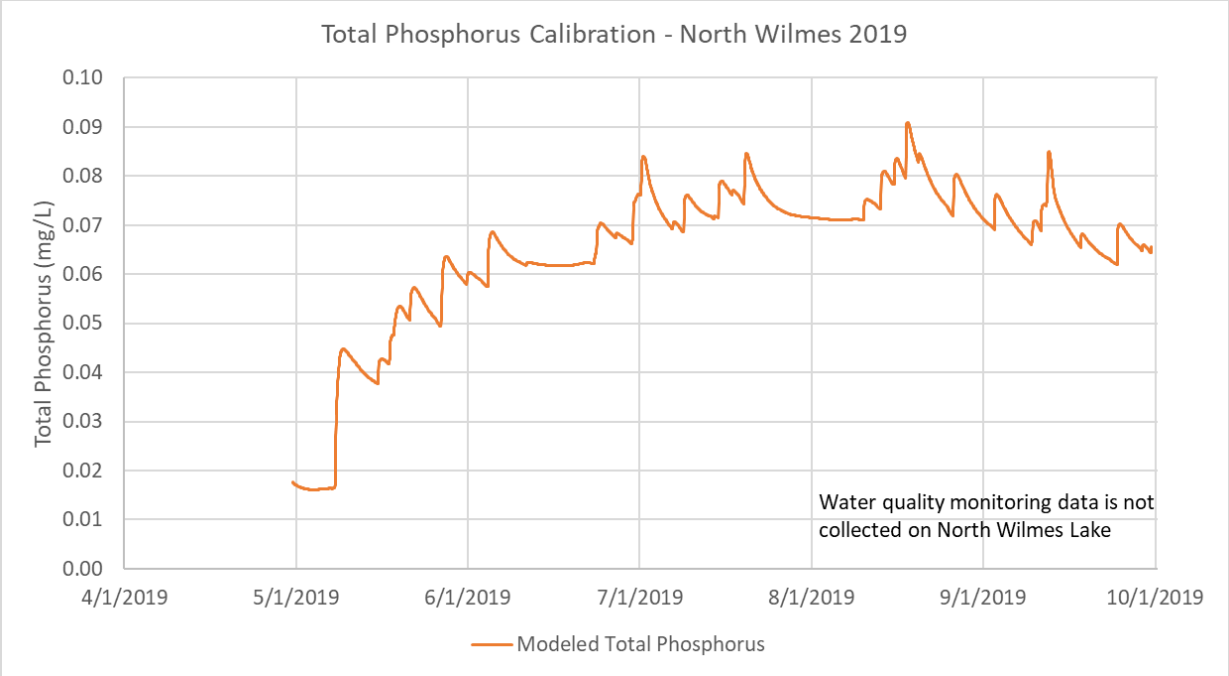
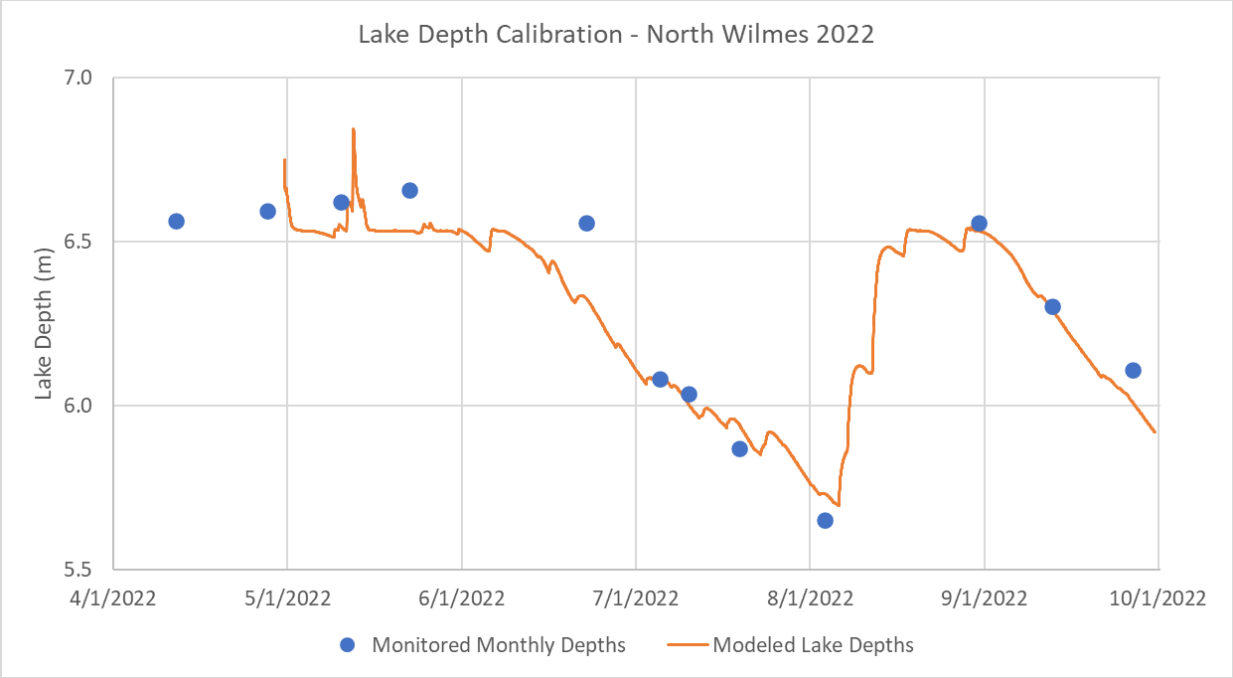


Figure B 25 North Wilmes Lake modeled total phosphorus – 2019



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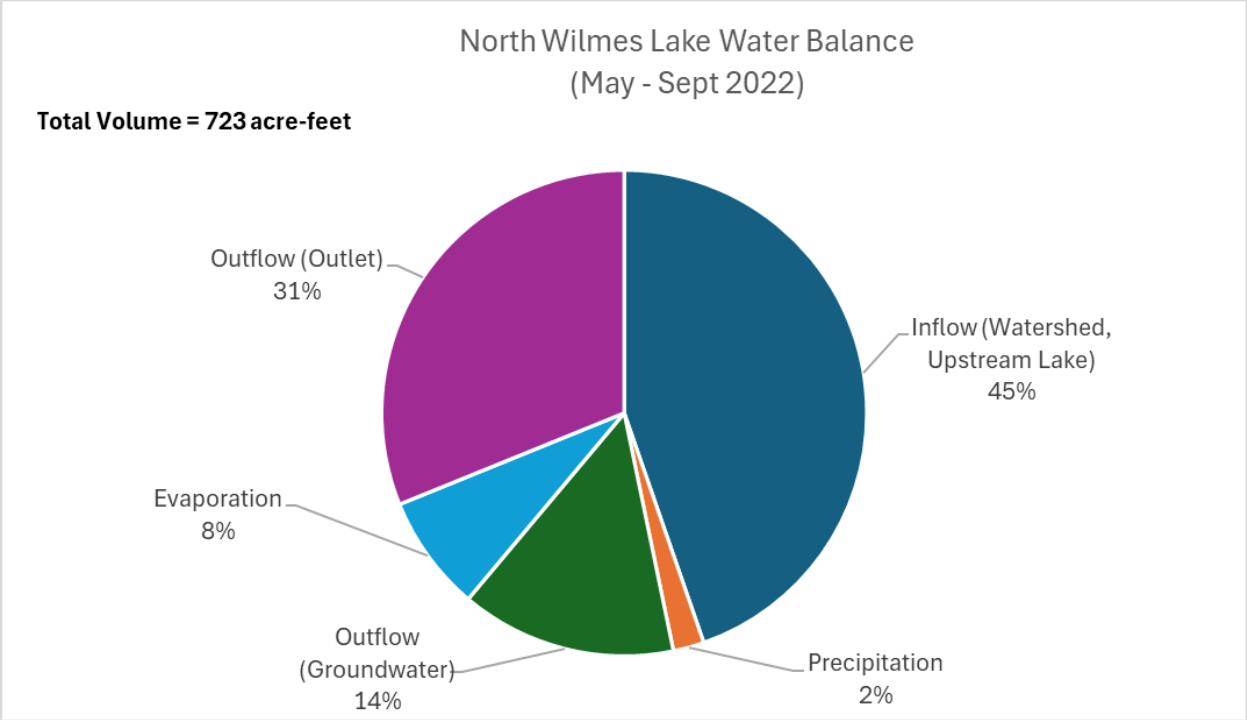

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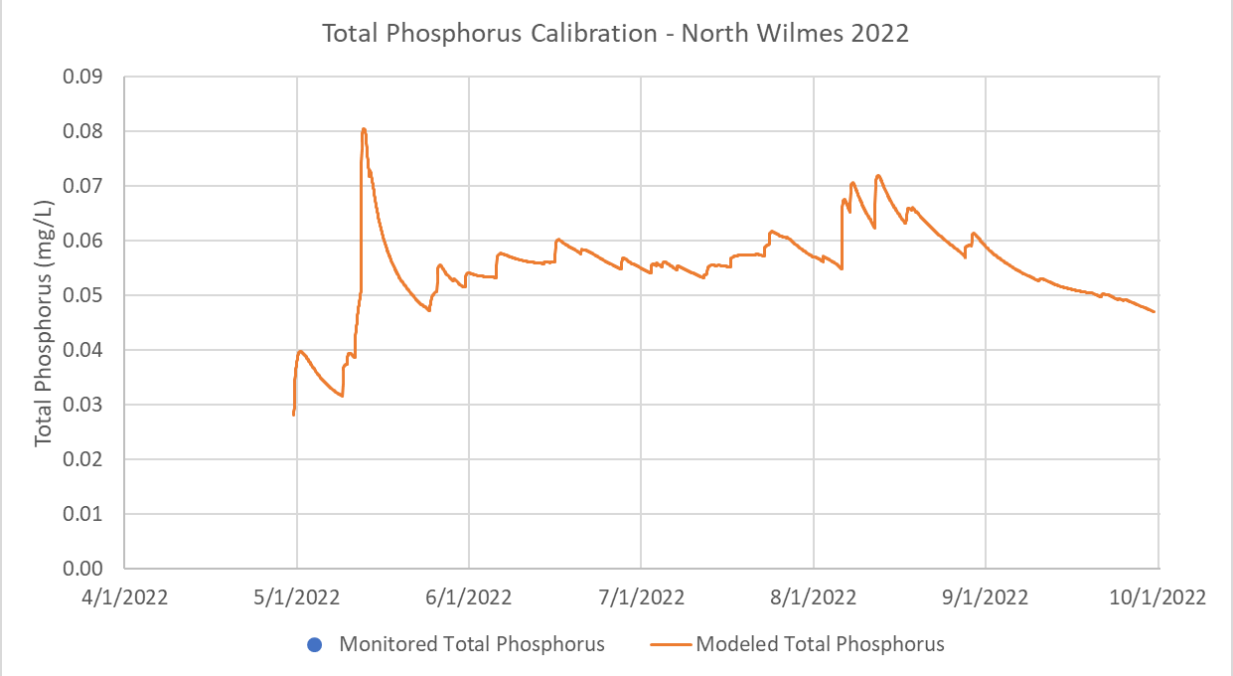


Figure B 28 North Wilmes Lake modeled total phosphorus – 2022

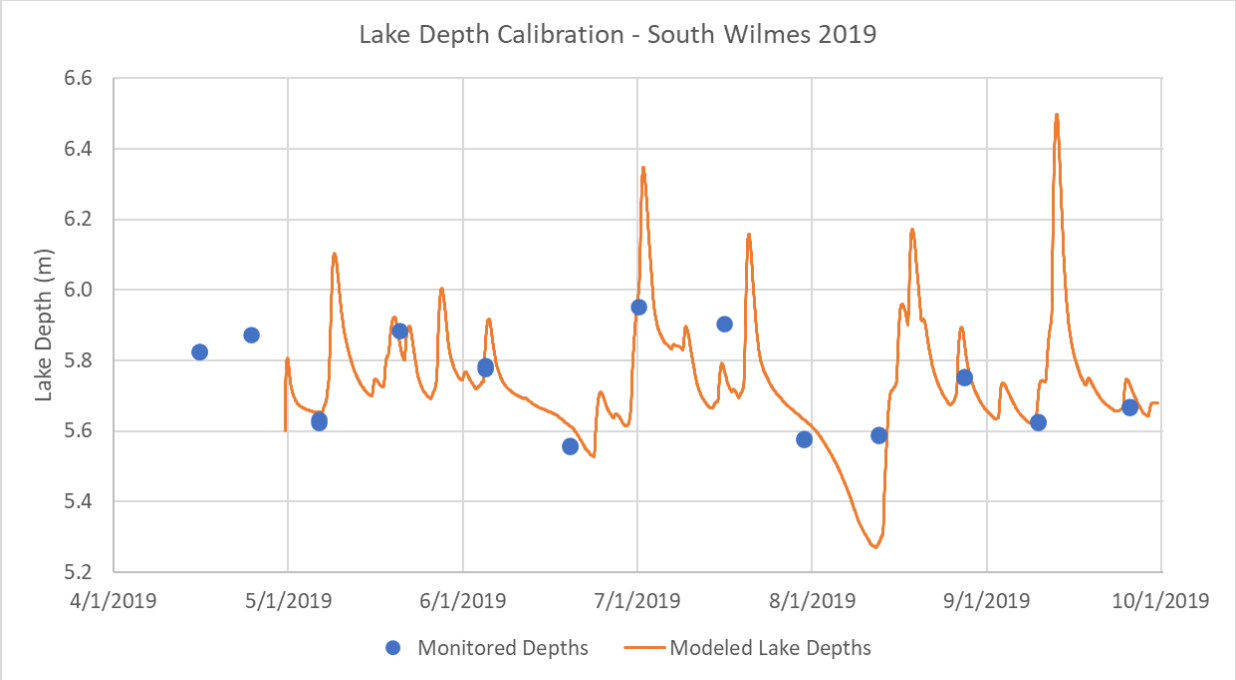
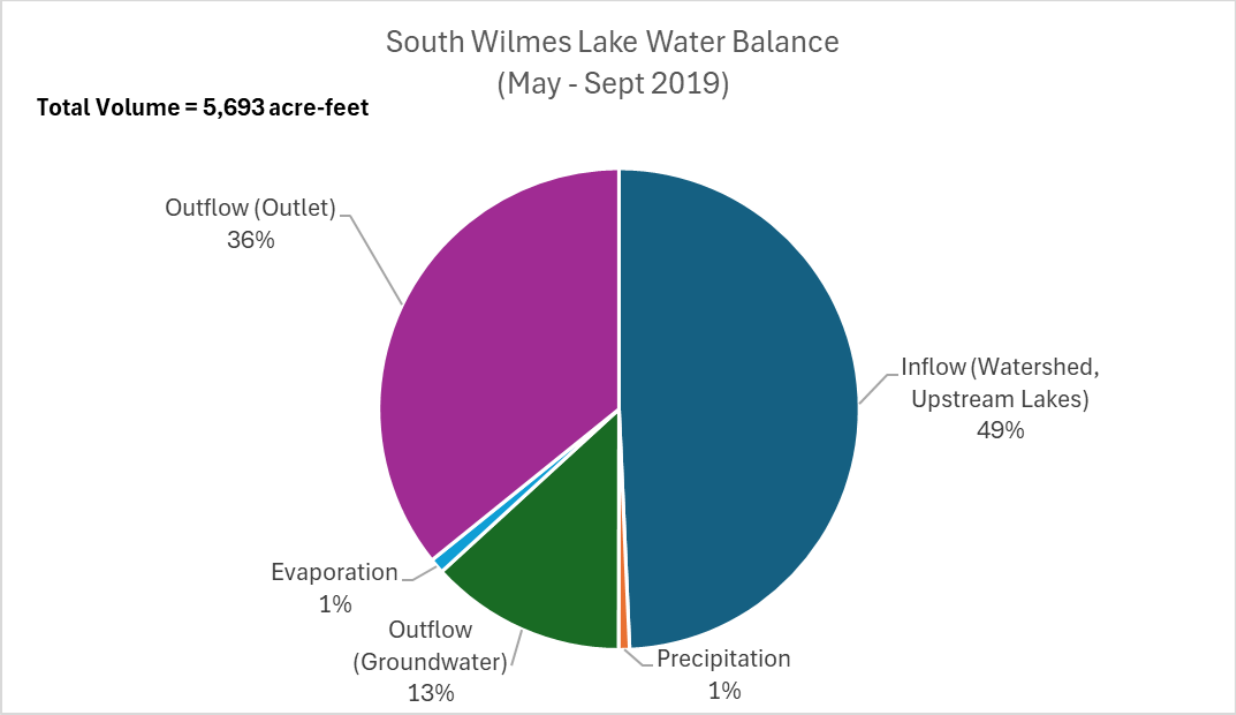


Figure B 29 South Wilmes Lake water balance calibration – 2019



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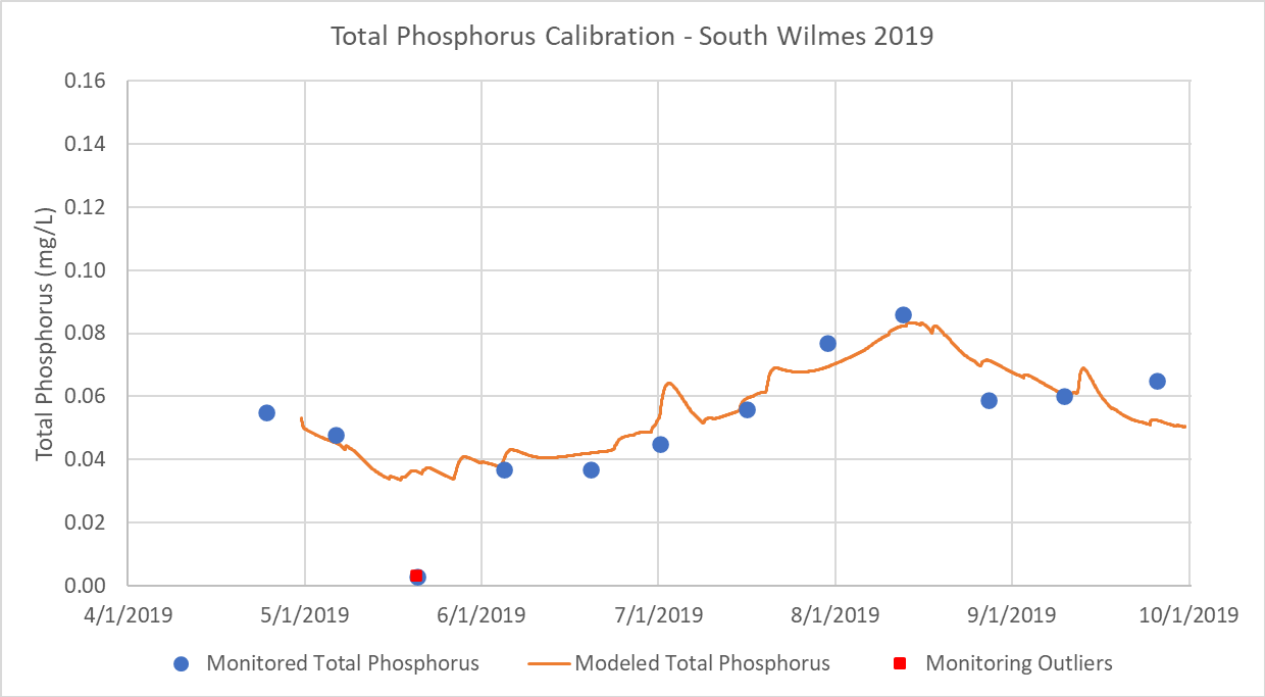


Figure B 31 South Wilmes Lake total phosphorus calibration – 2019

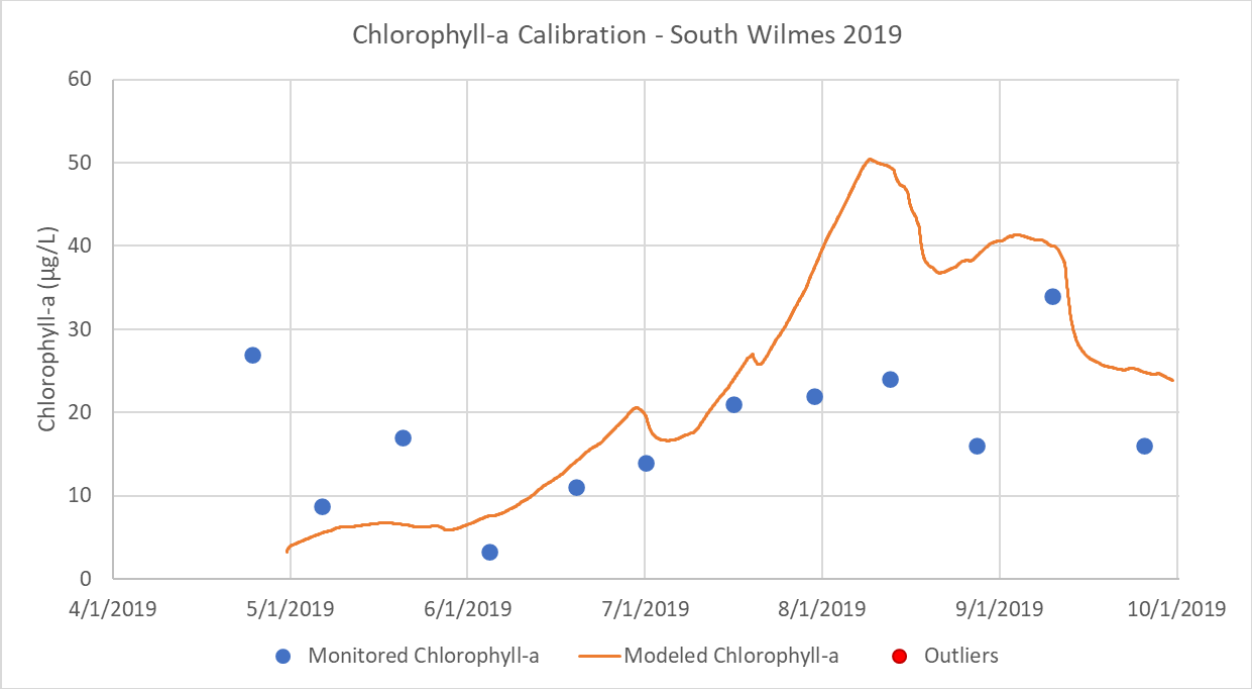


Figure B 32 South Wilmes Lake chlorophyll-a calibration – 2019

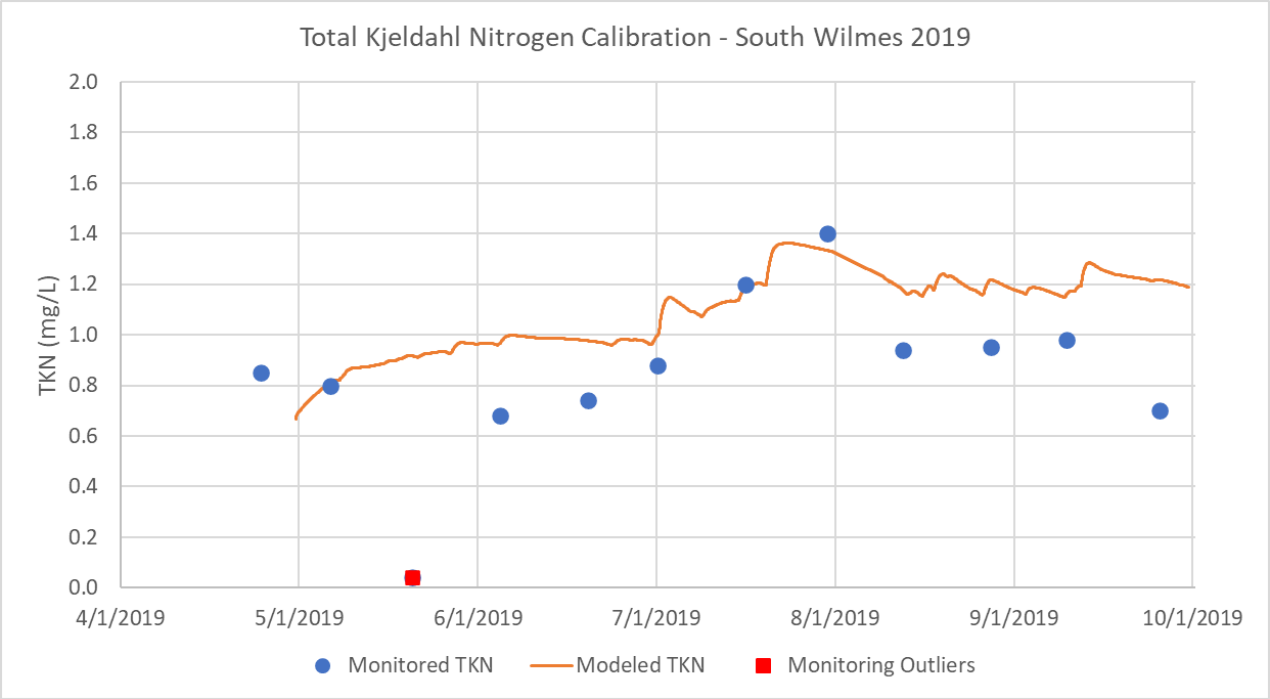


Figure B 33 South Wilmes Lake total Kjeldahl nitrogen calibration – 2019

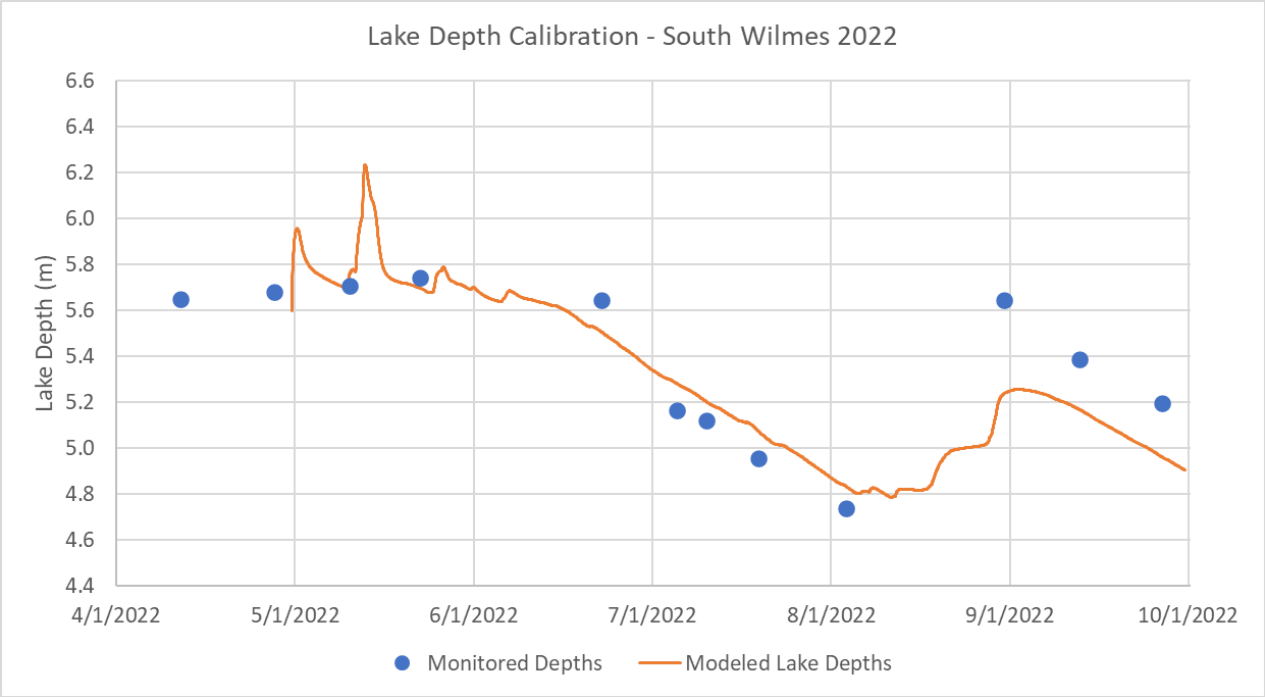


Figure B 34 South Wilmes Lake water balance calibration – 2022

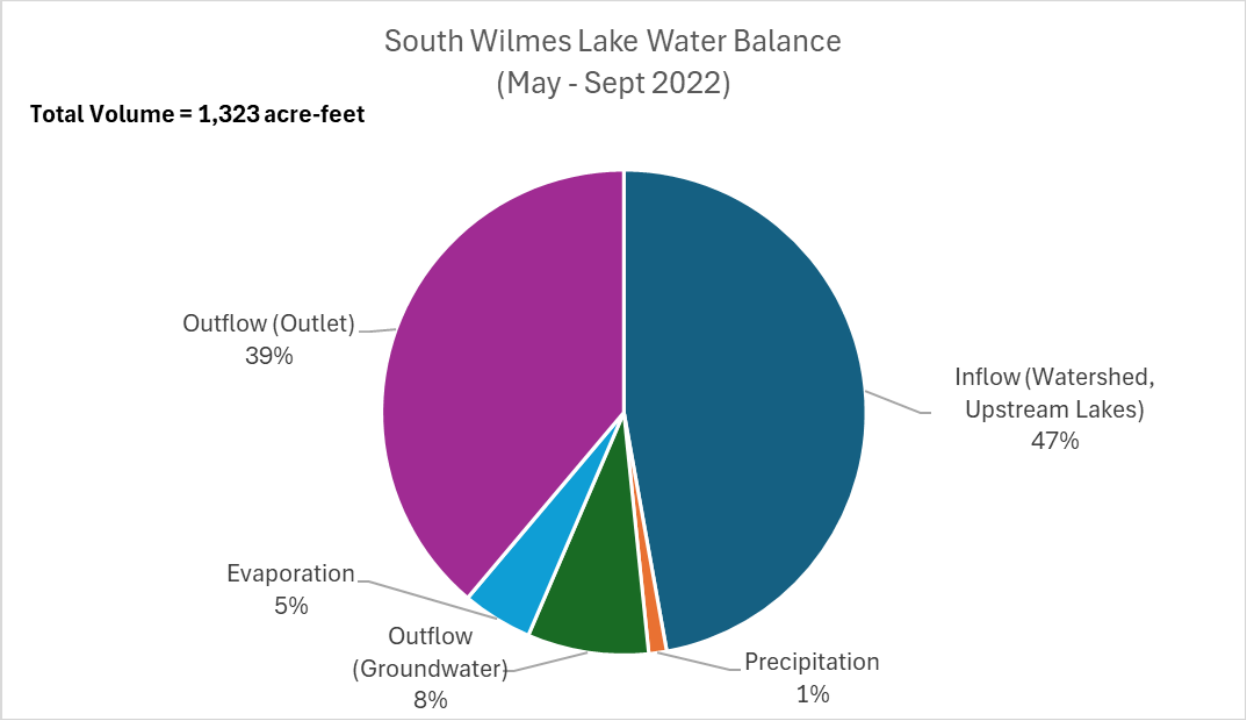


Figure B 35 South Wilmes Lake water balance pie chart – 2022

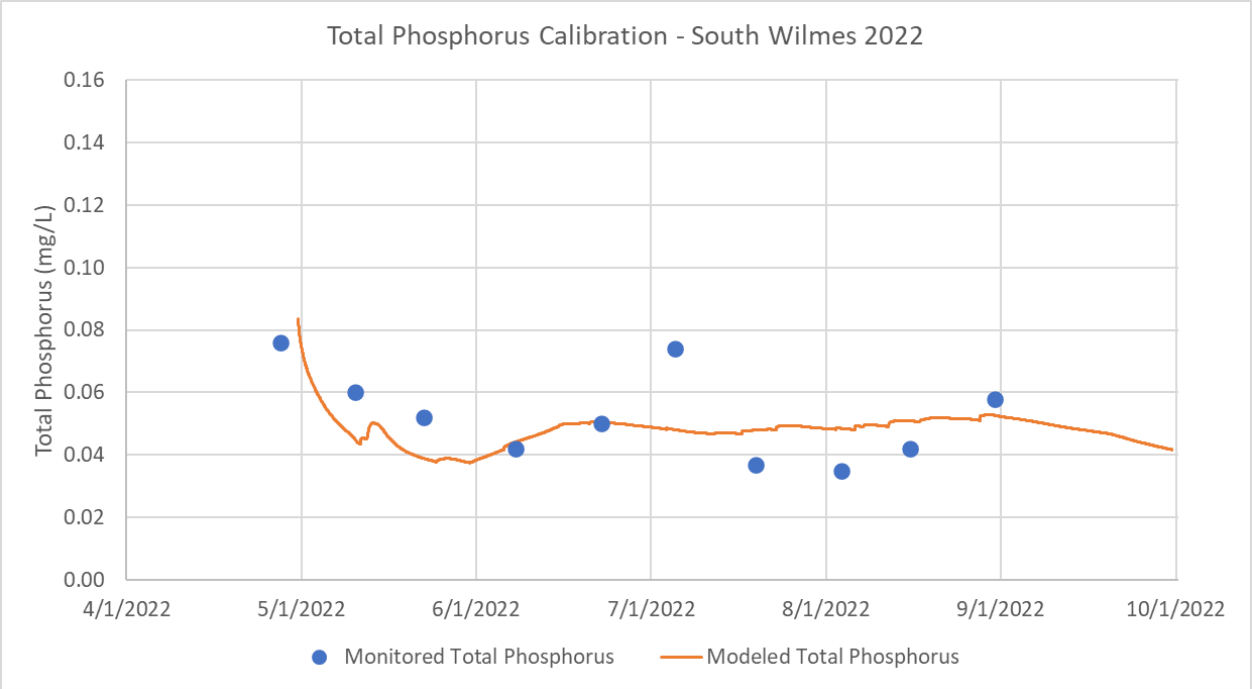
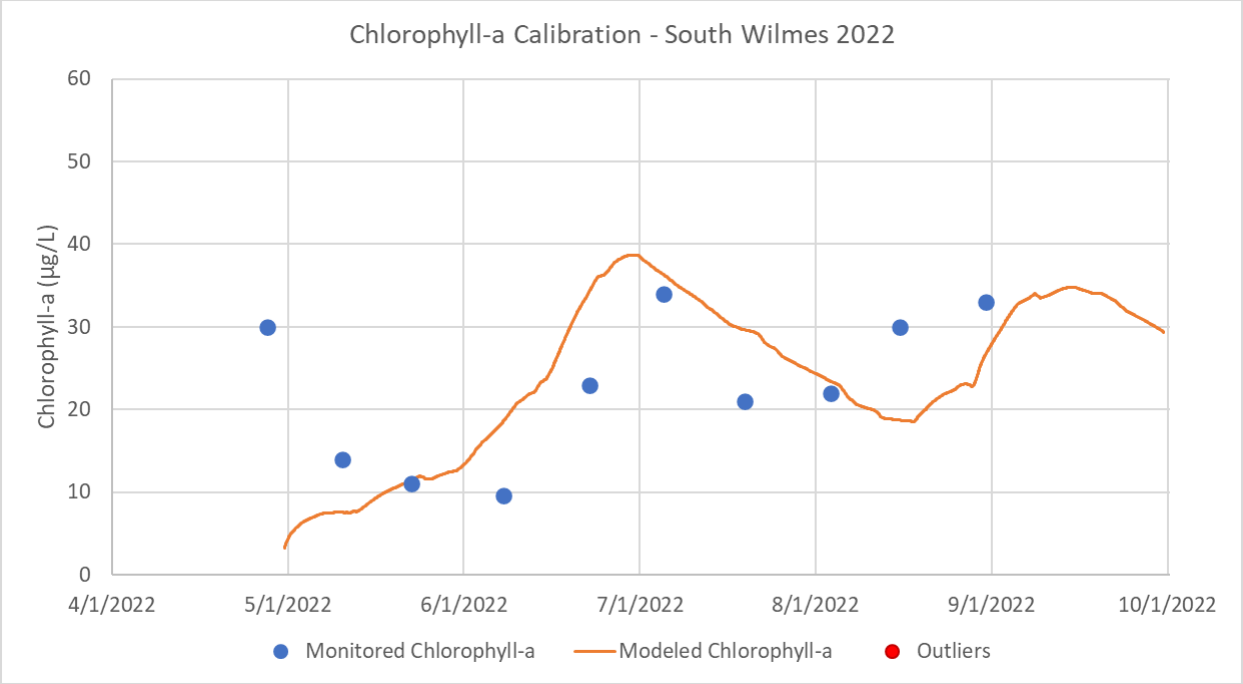


Figure B 36 South Wilmes Lake total phosphorus calibration – 2022



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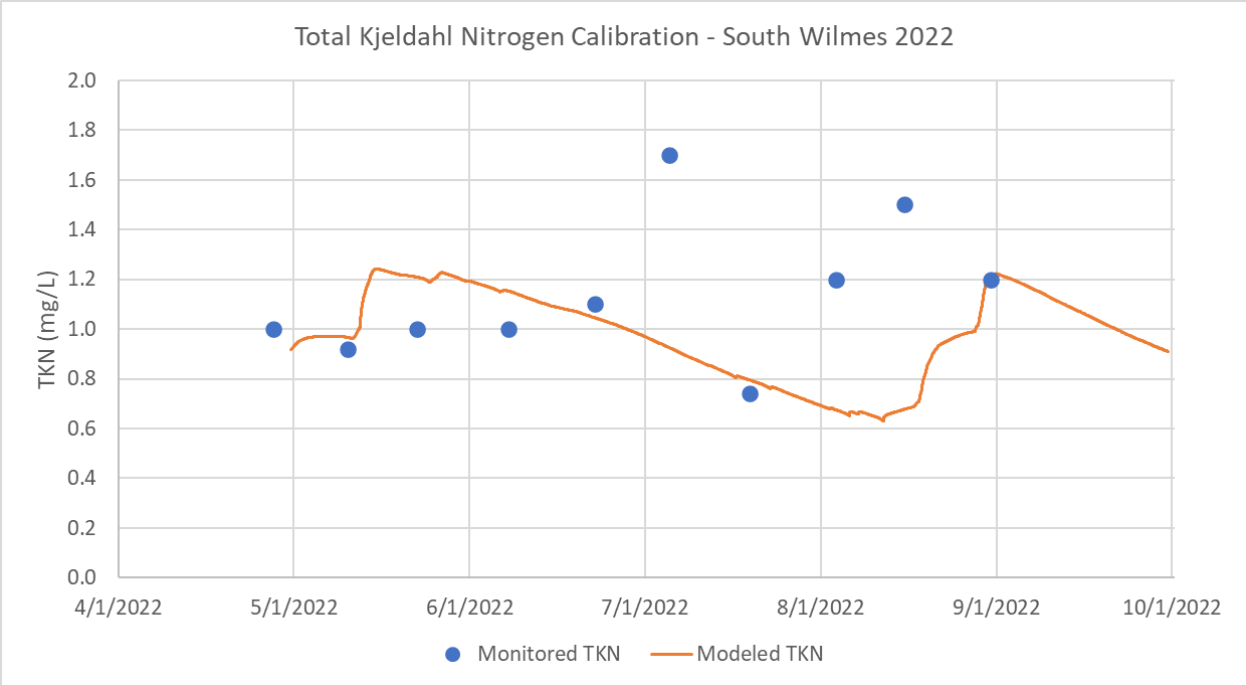


Figure B 38 South Wilmes Lake total Kjeldahl nitrogen calibration – 2022

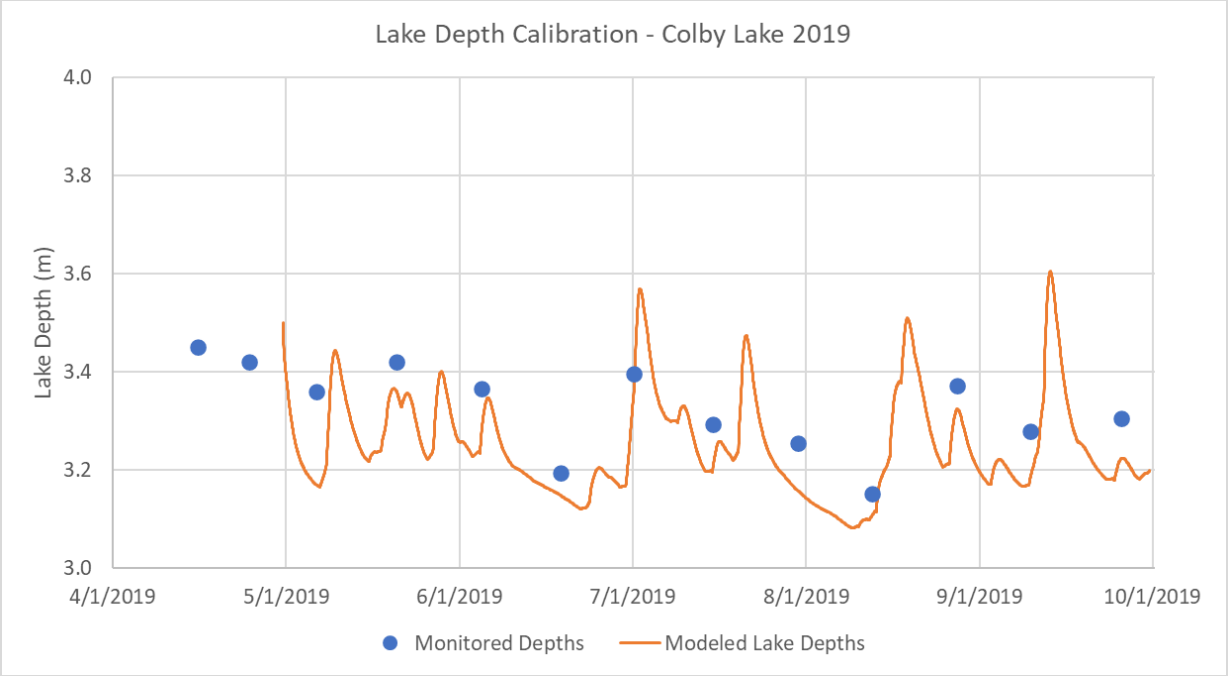


Figure B 39 Colby Lake water balance calibration – 2019

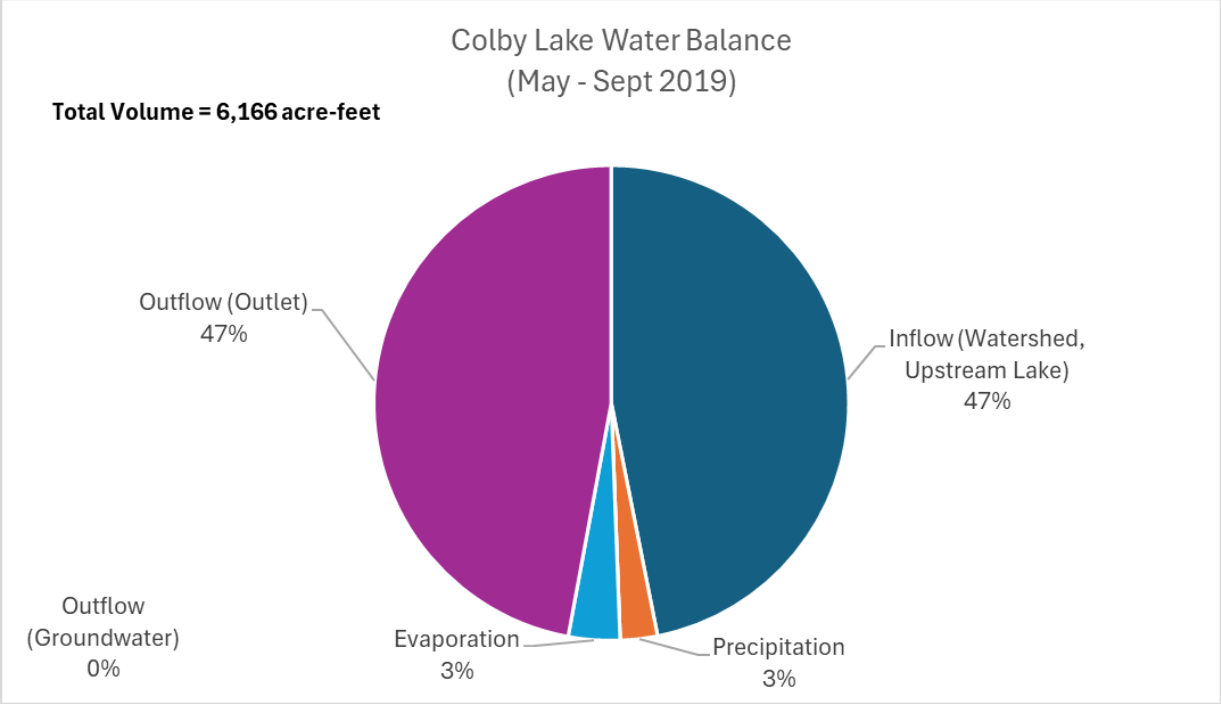
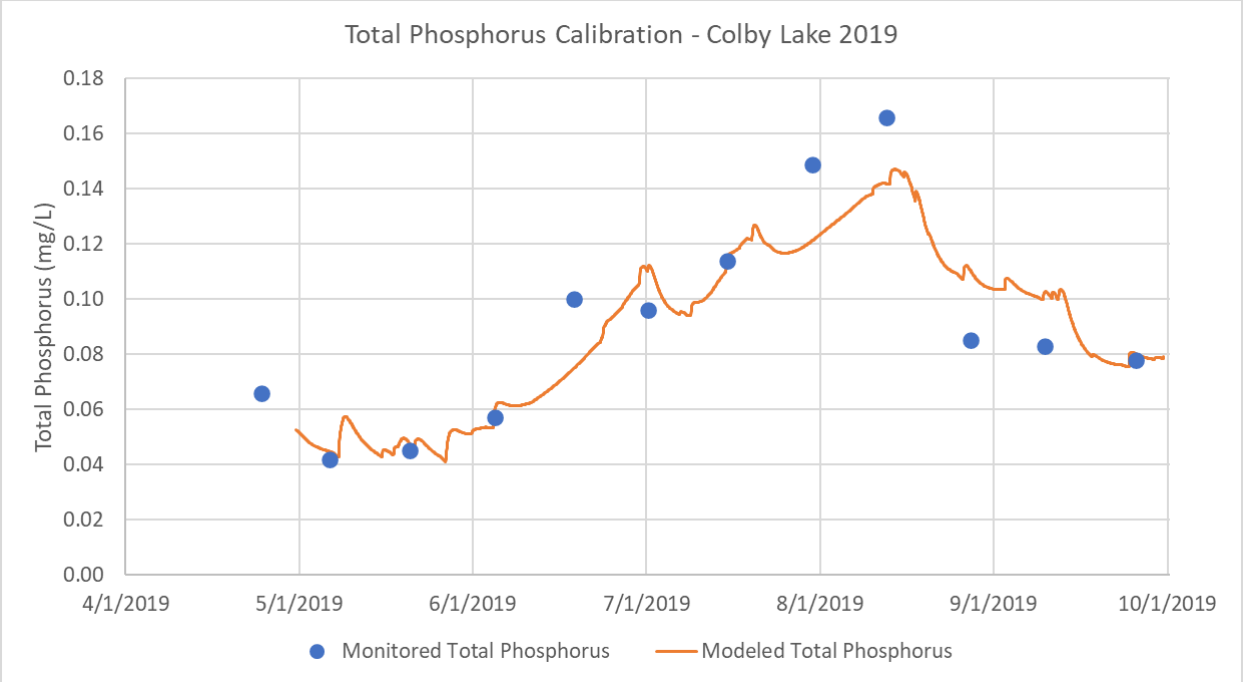


Figure B 40 Colby Lake water balance pie chart – 2019



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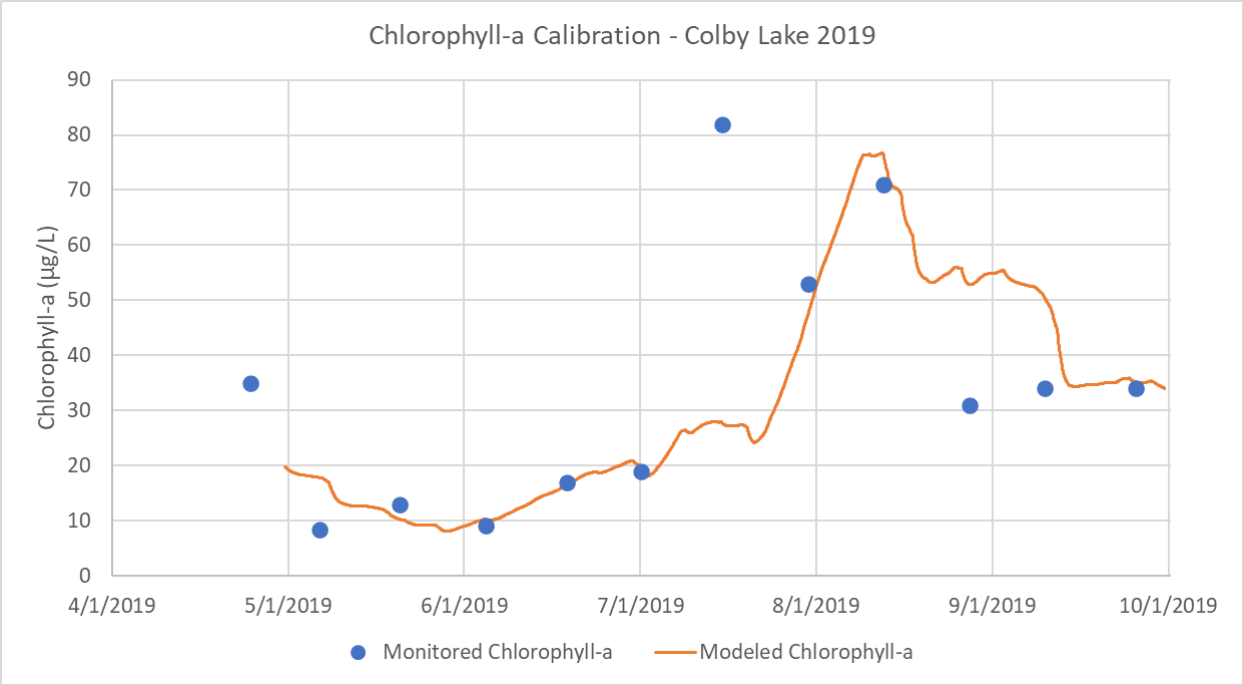

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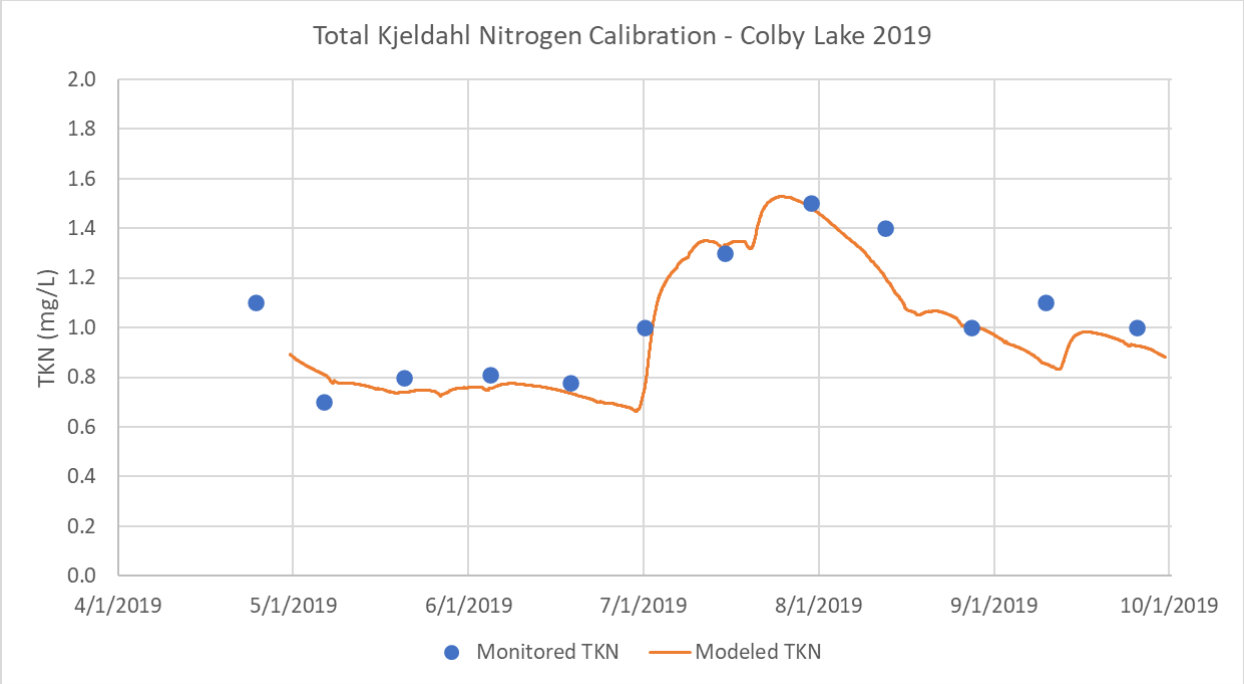

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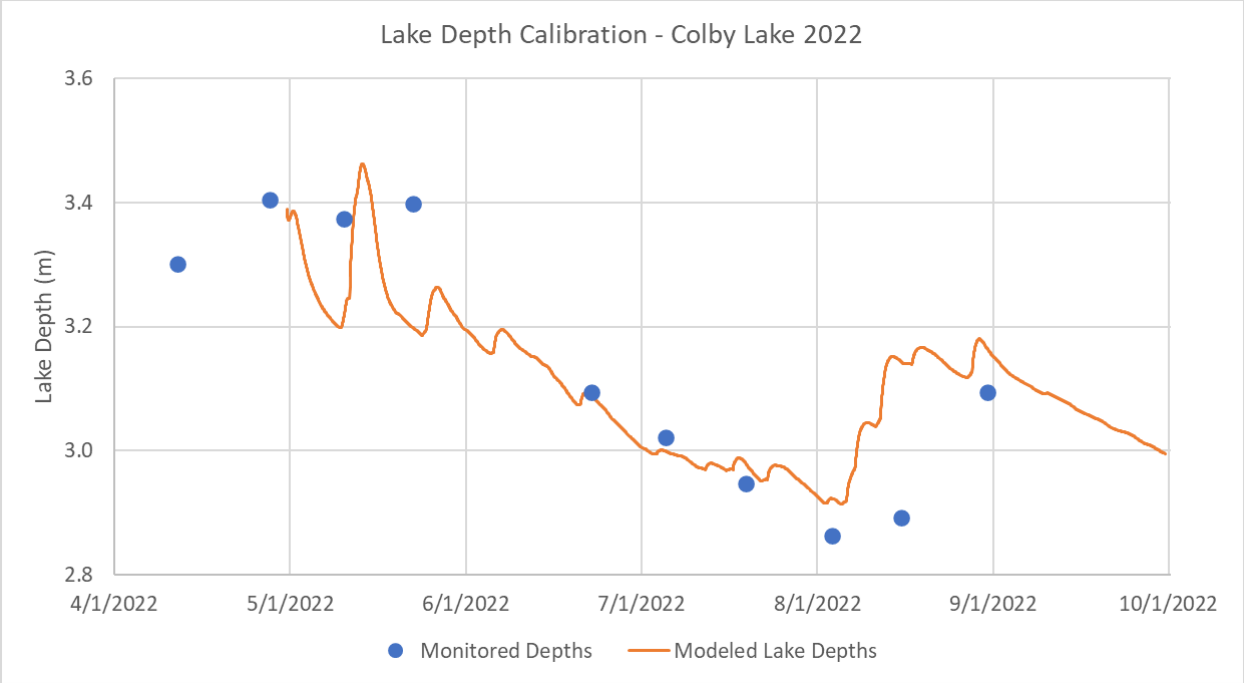

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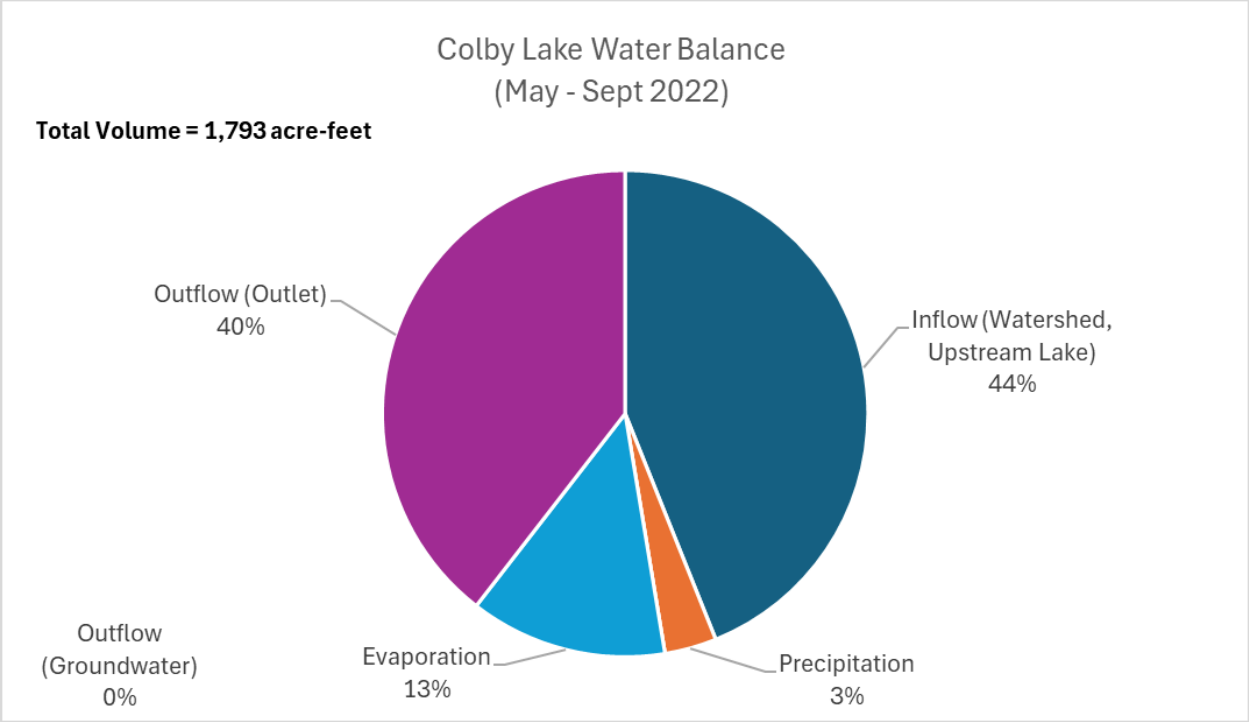

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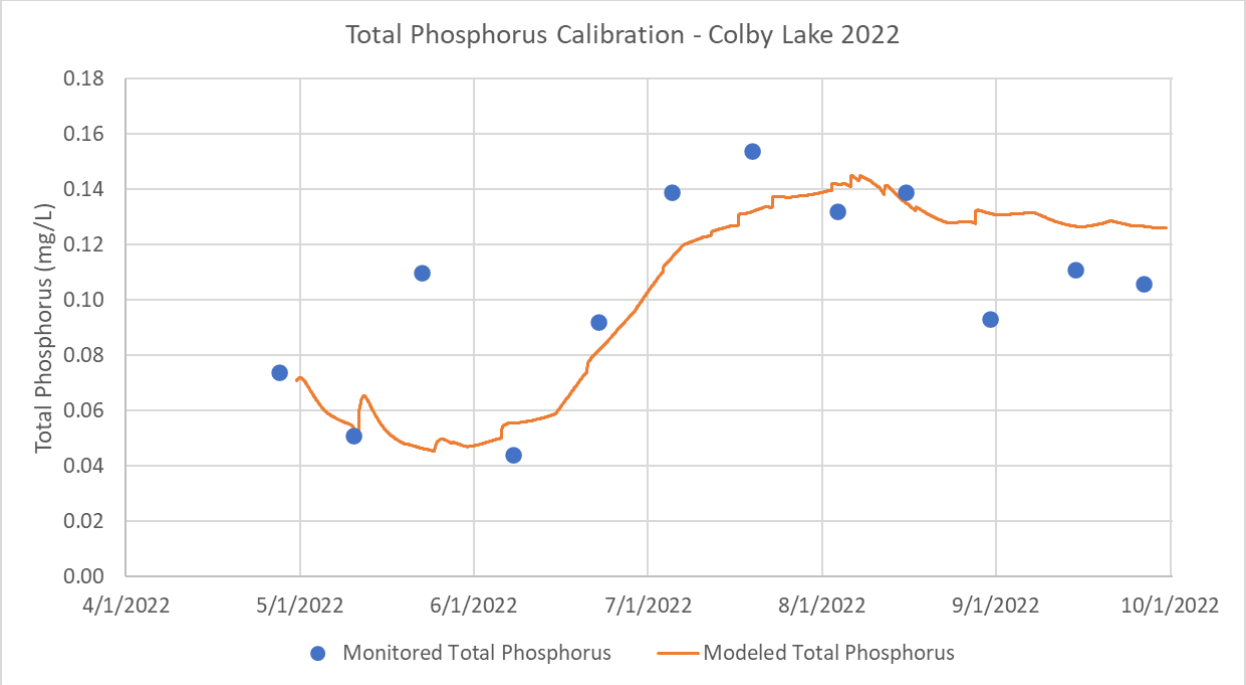

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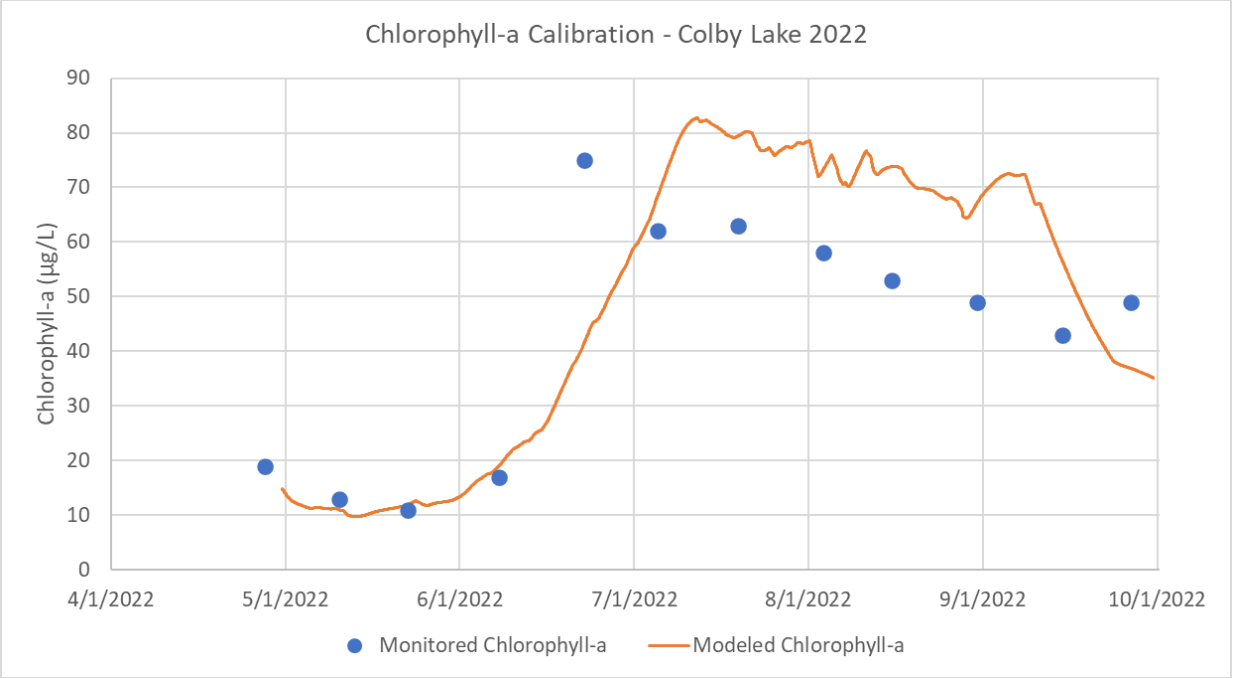

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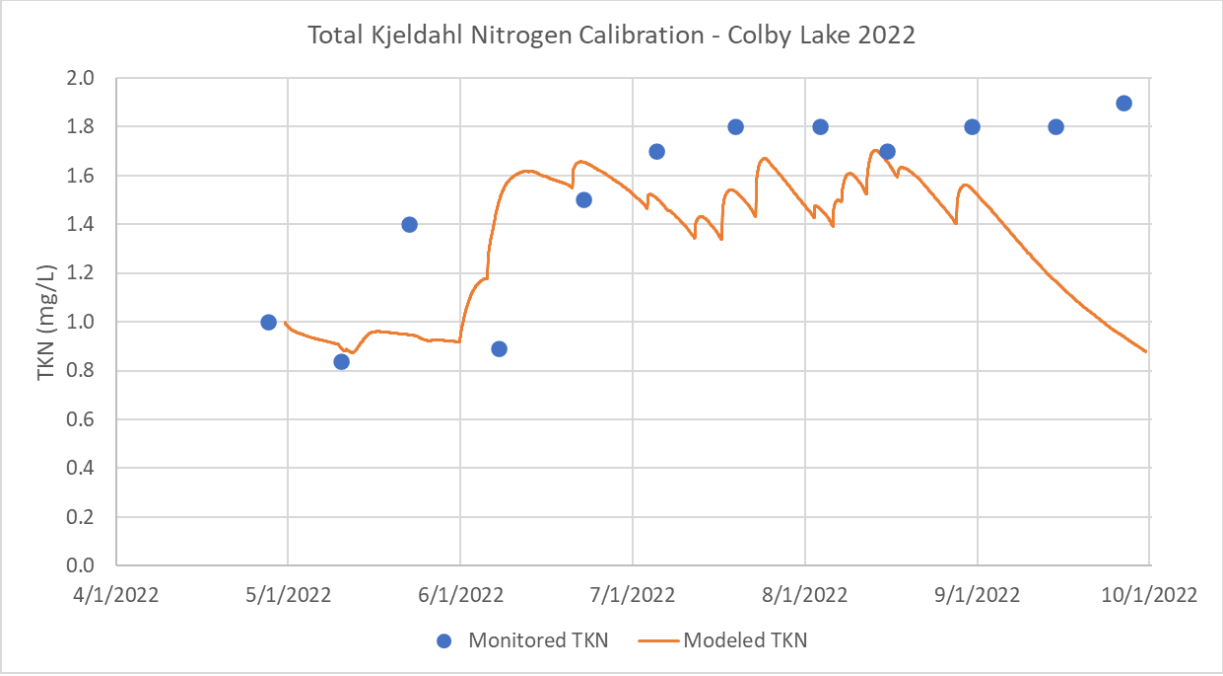

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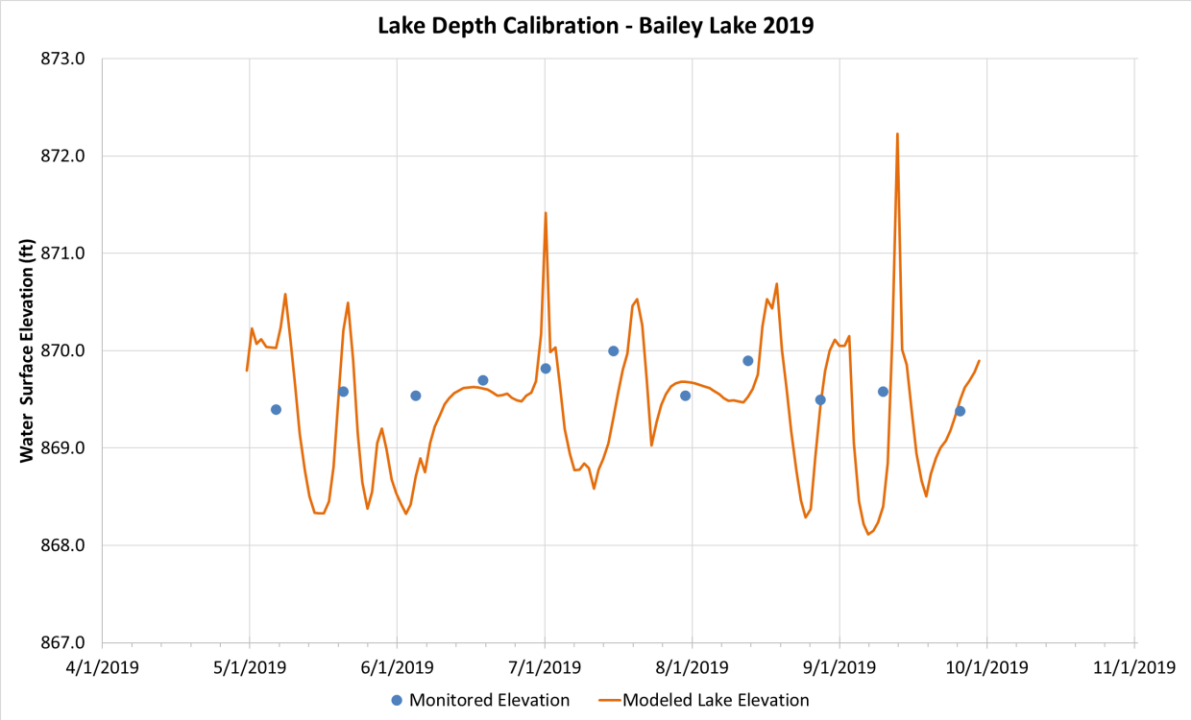

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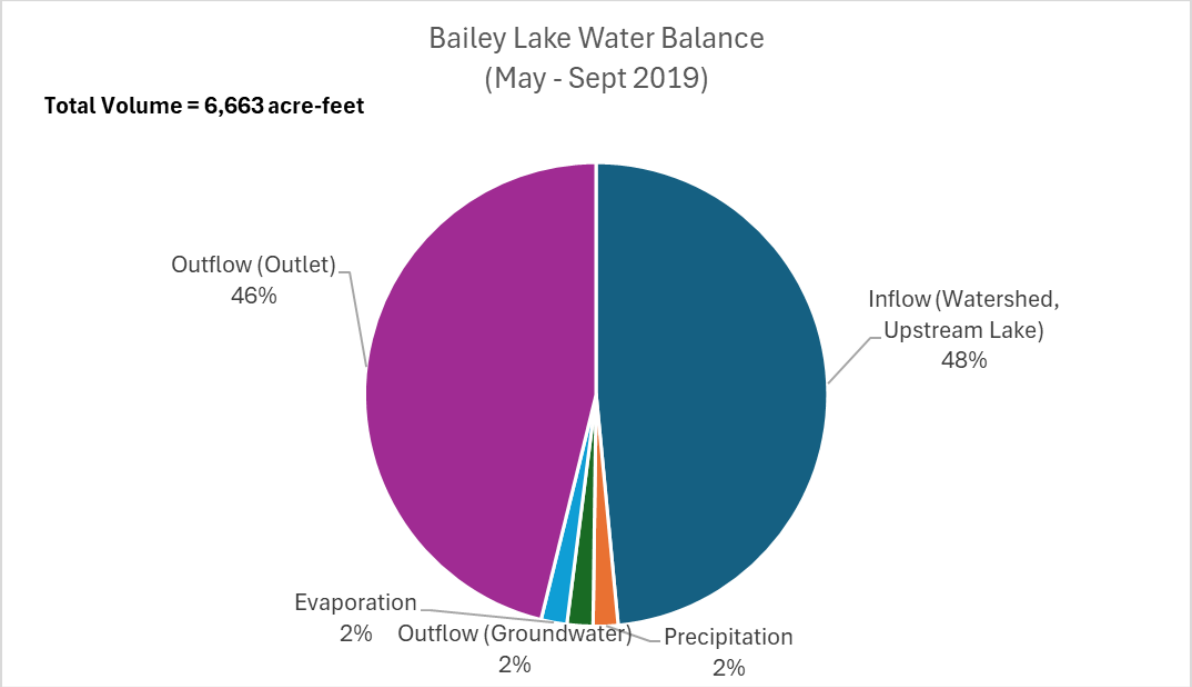

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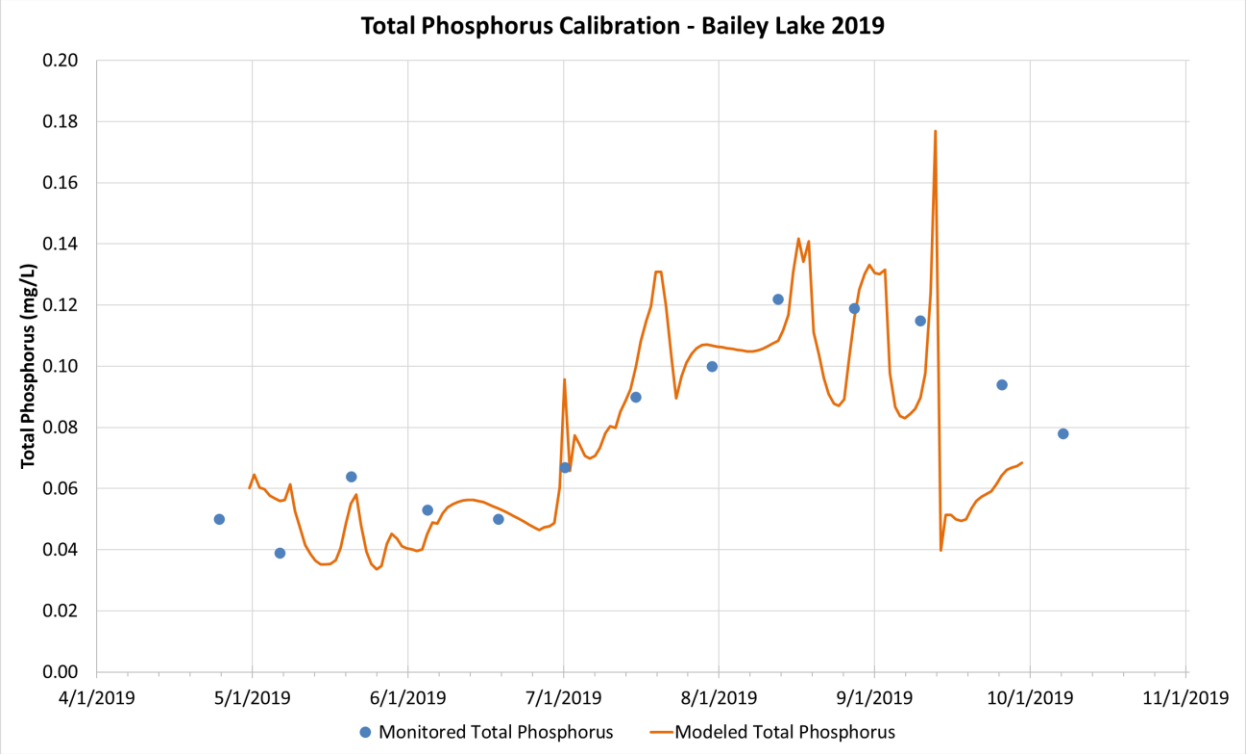

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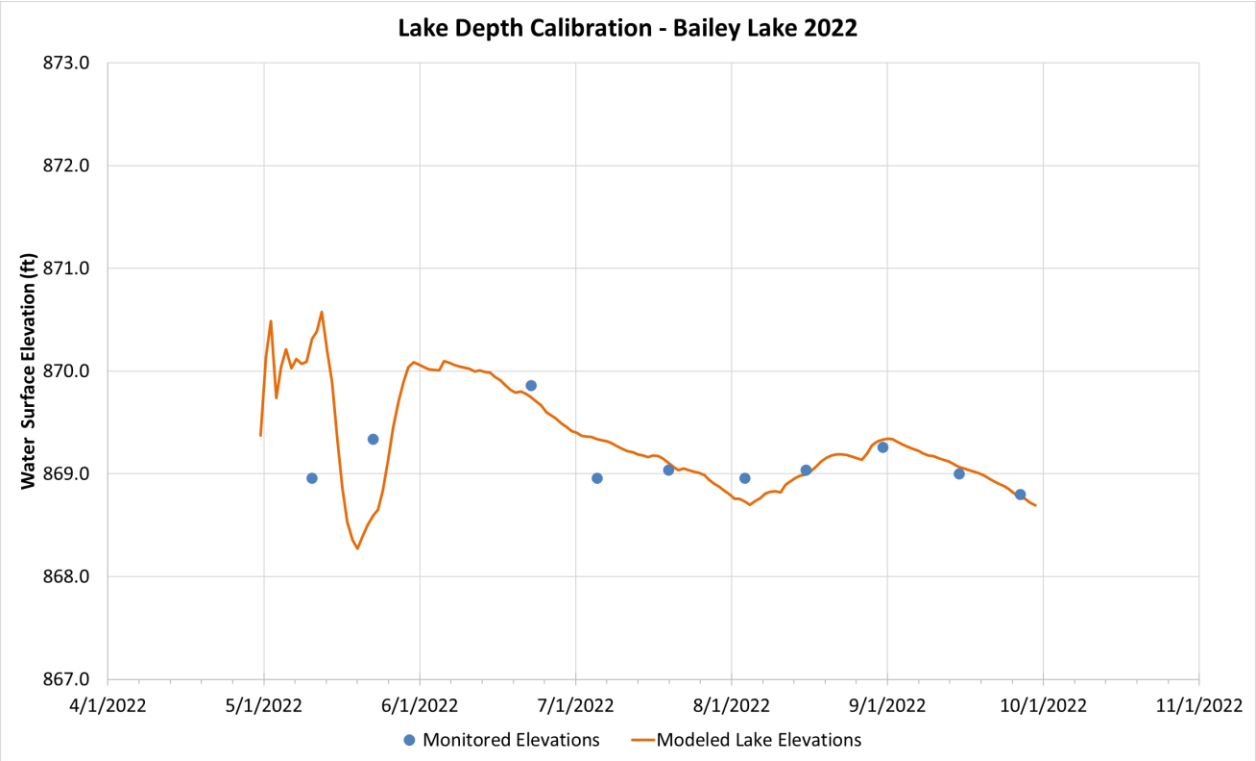

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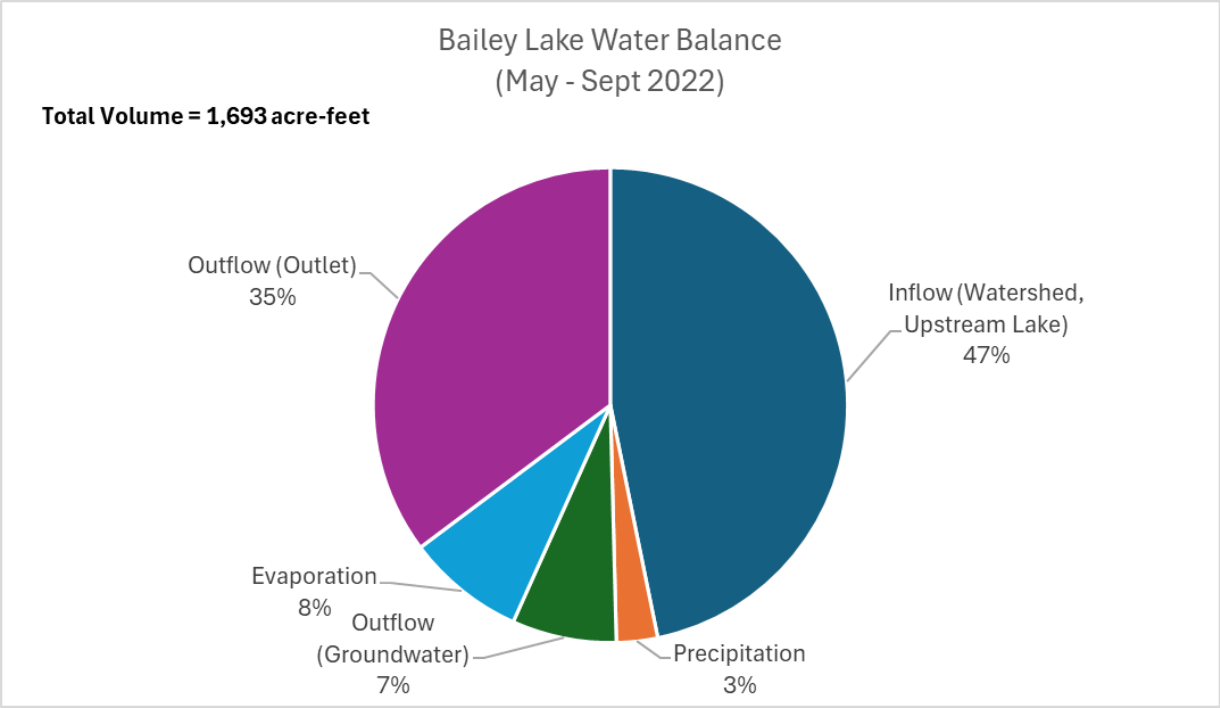

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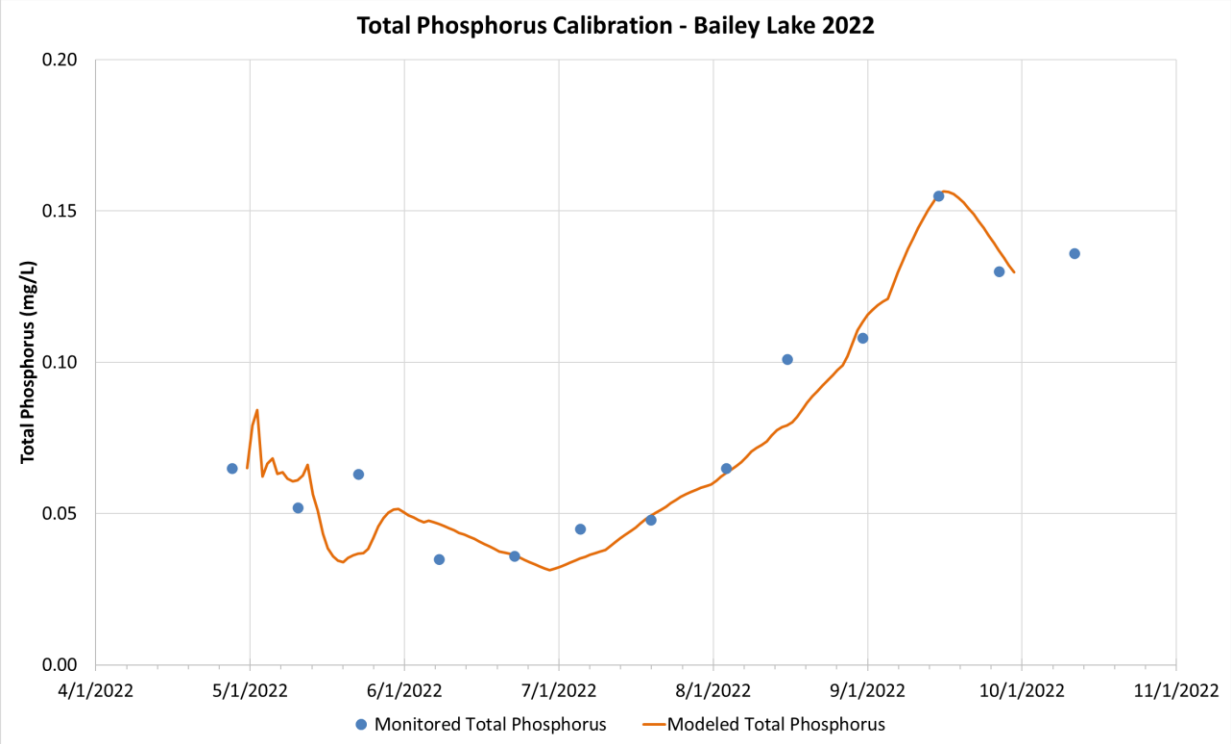

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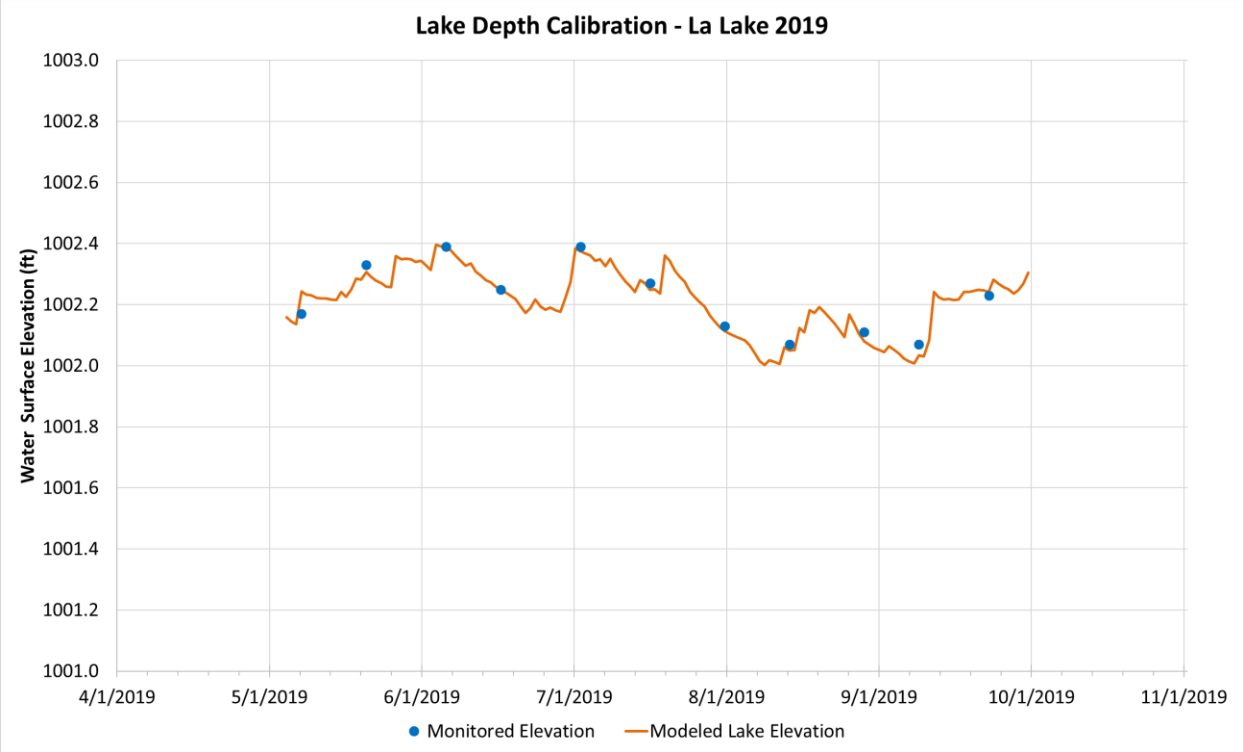

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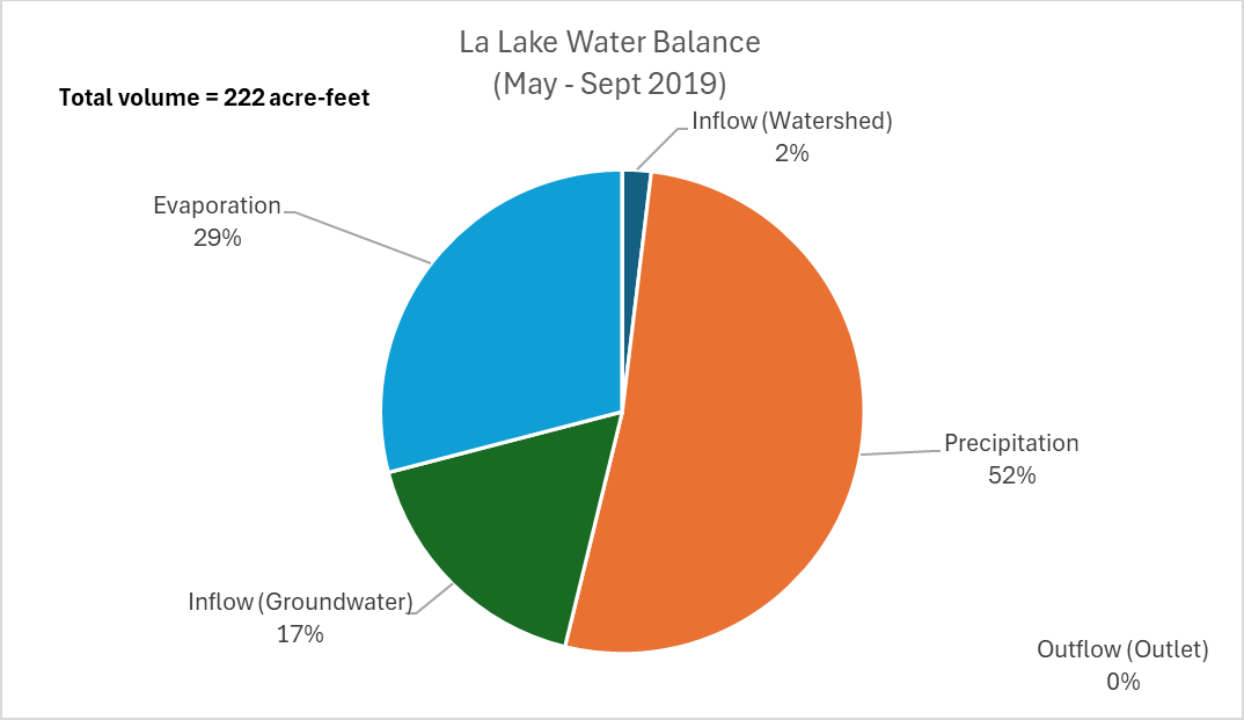

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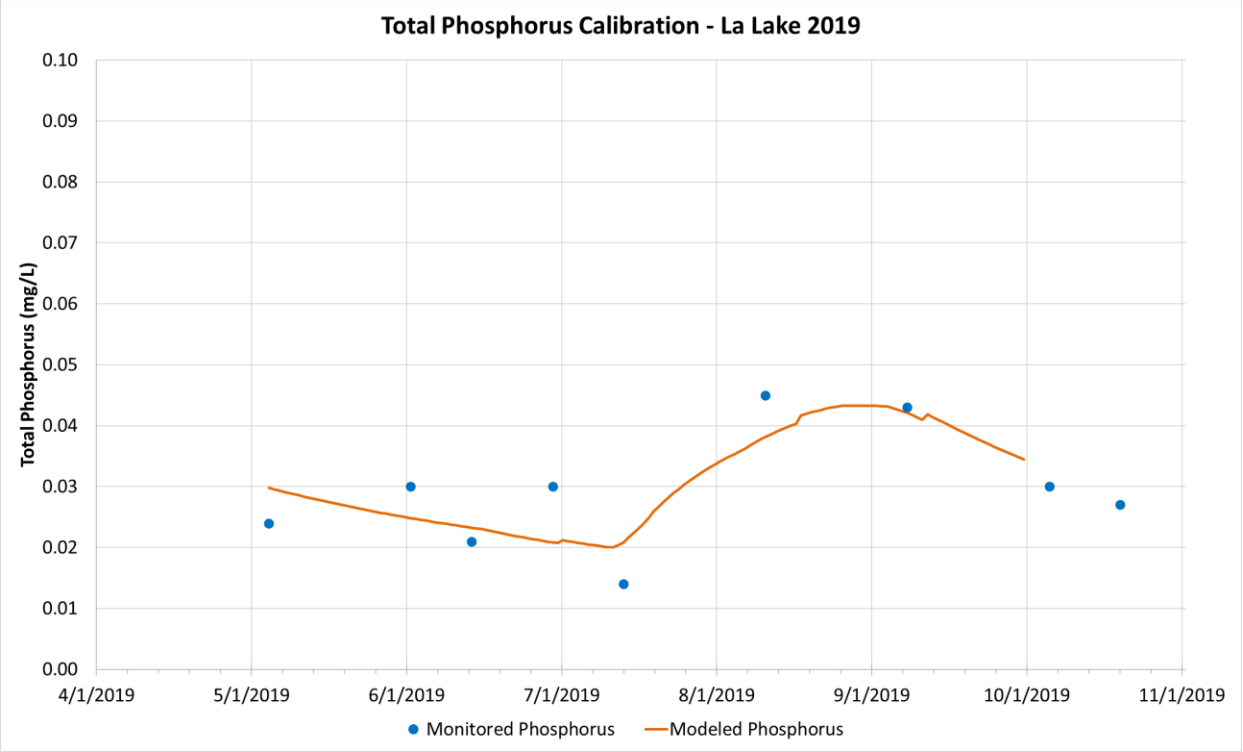

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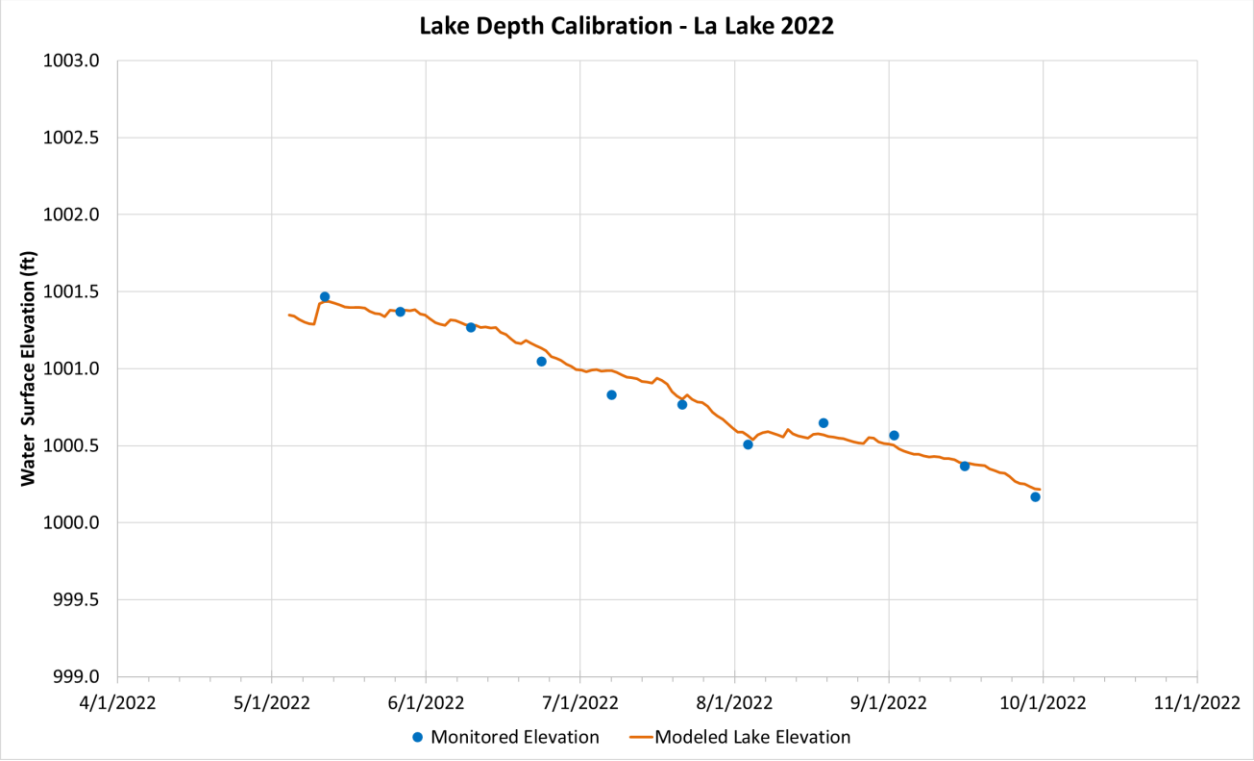

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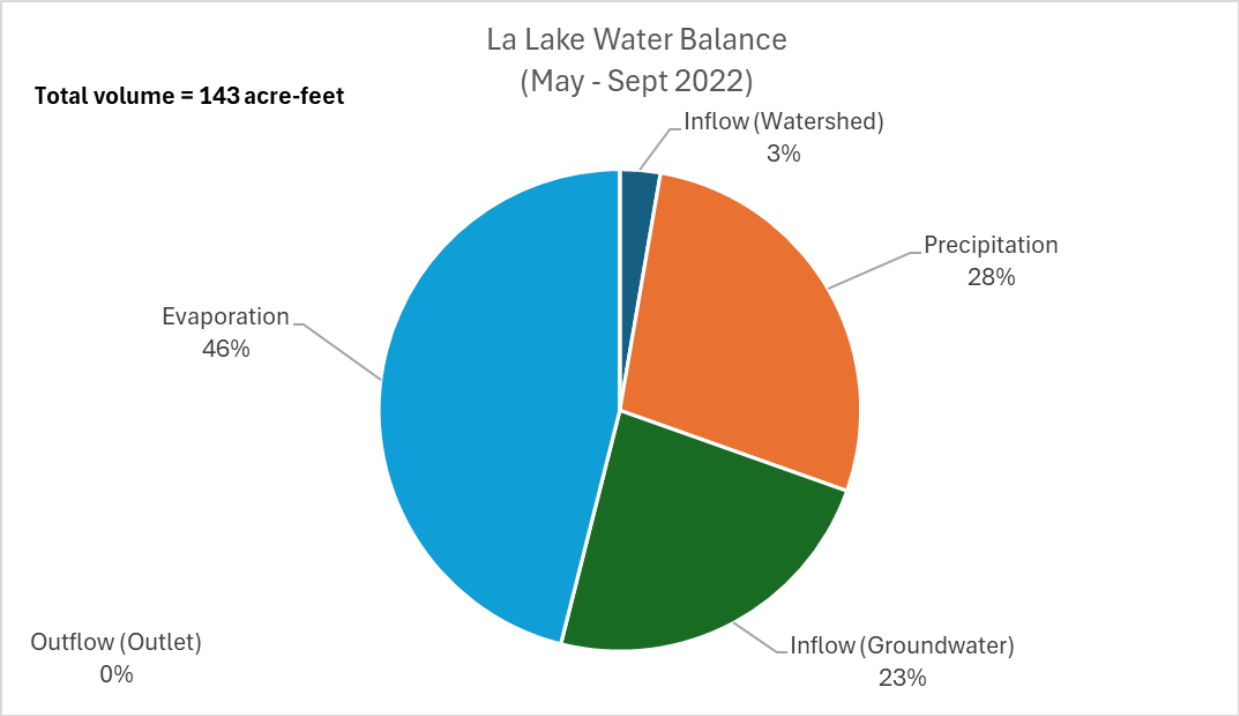

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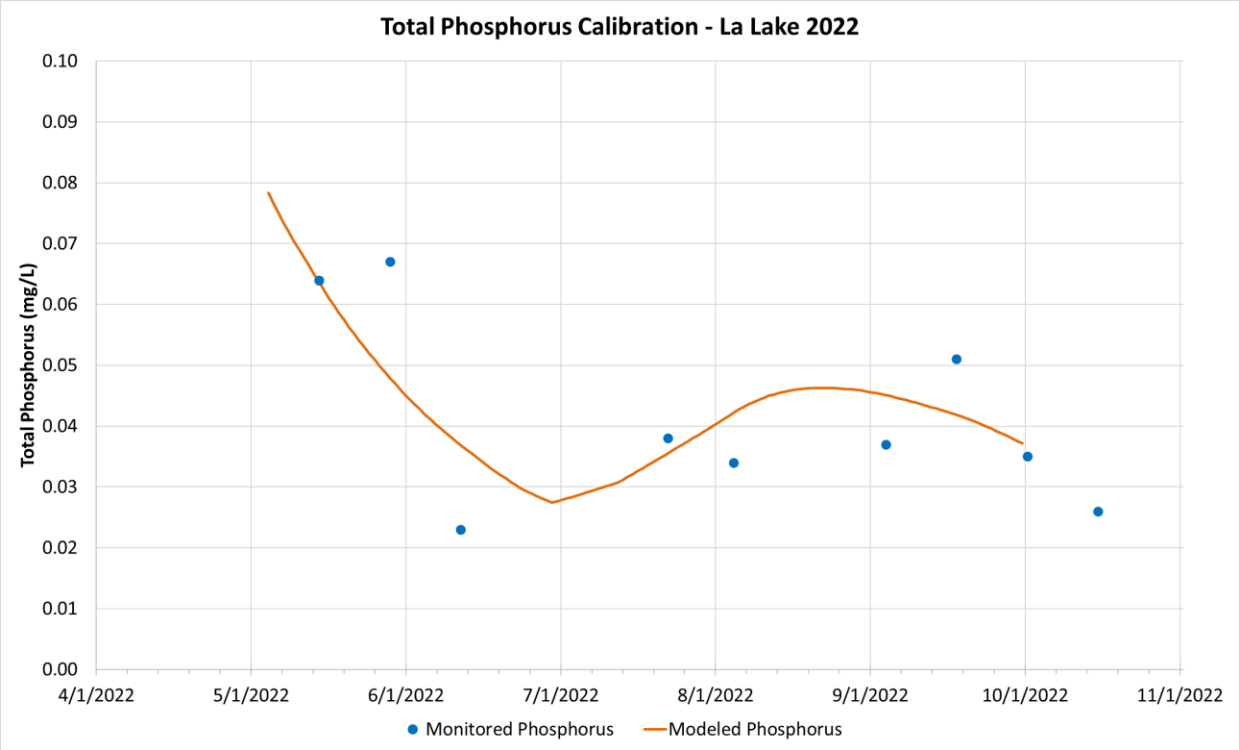

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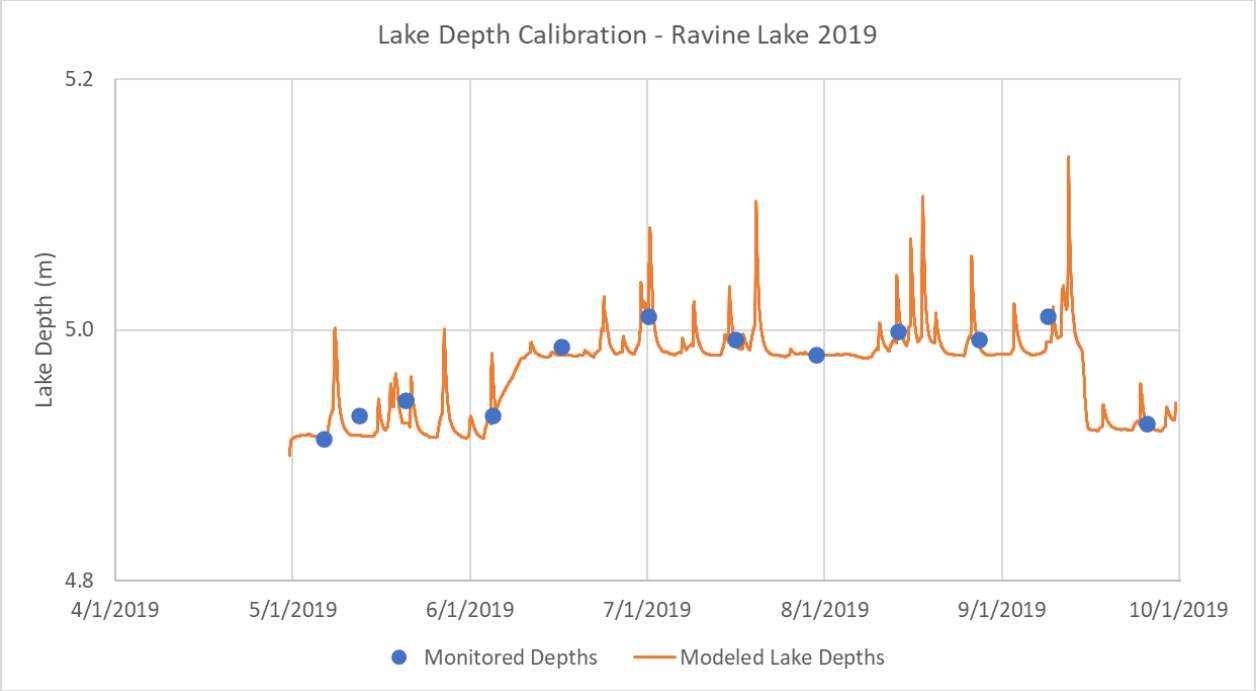
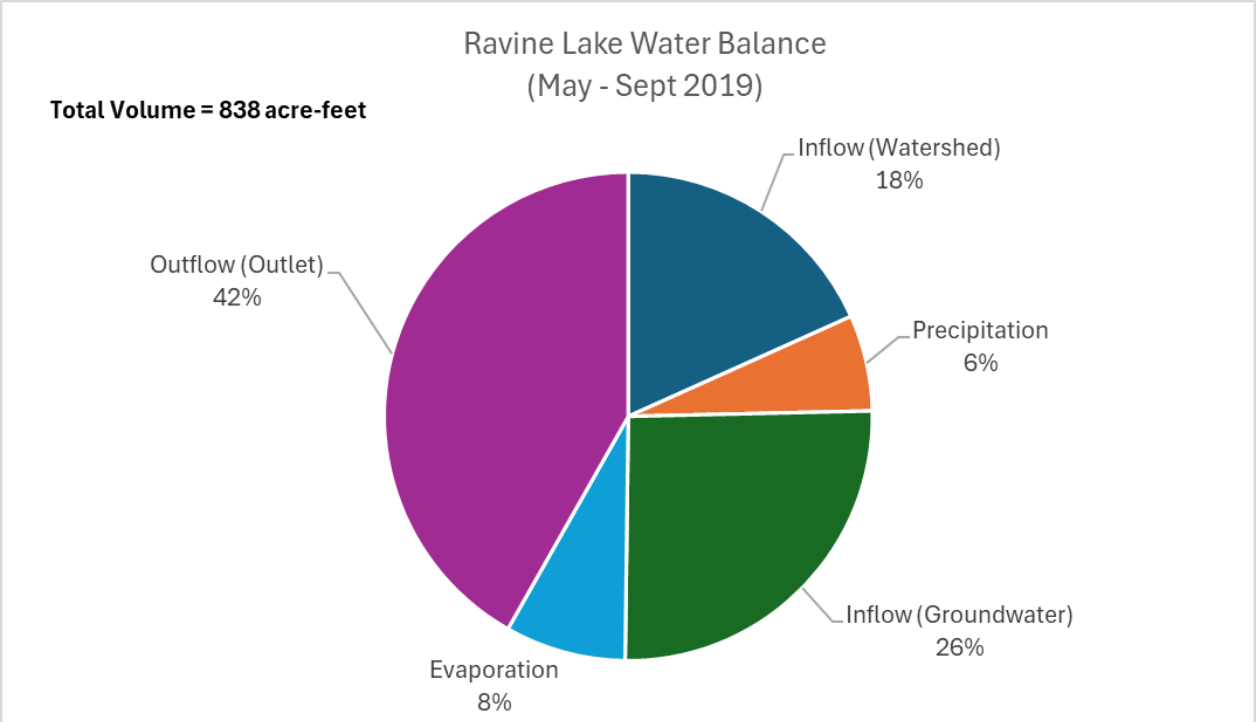


Figure B 61 Ravine Lake water balance calibration – 2019



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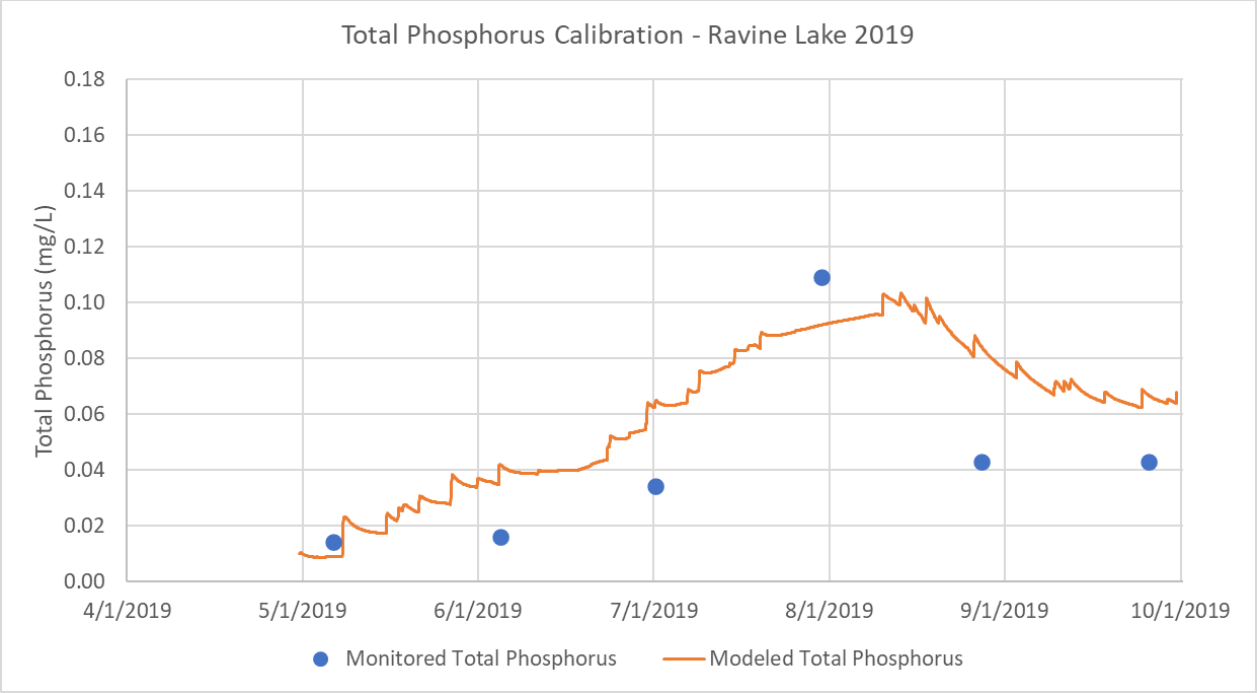

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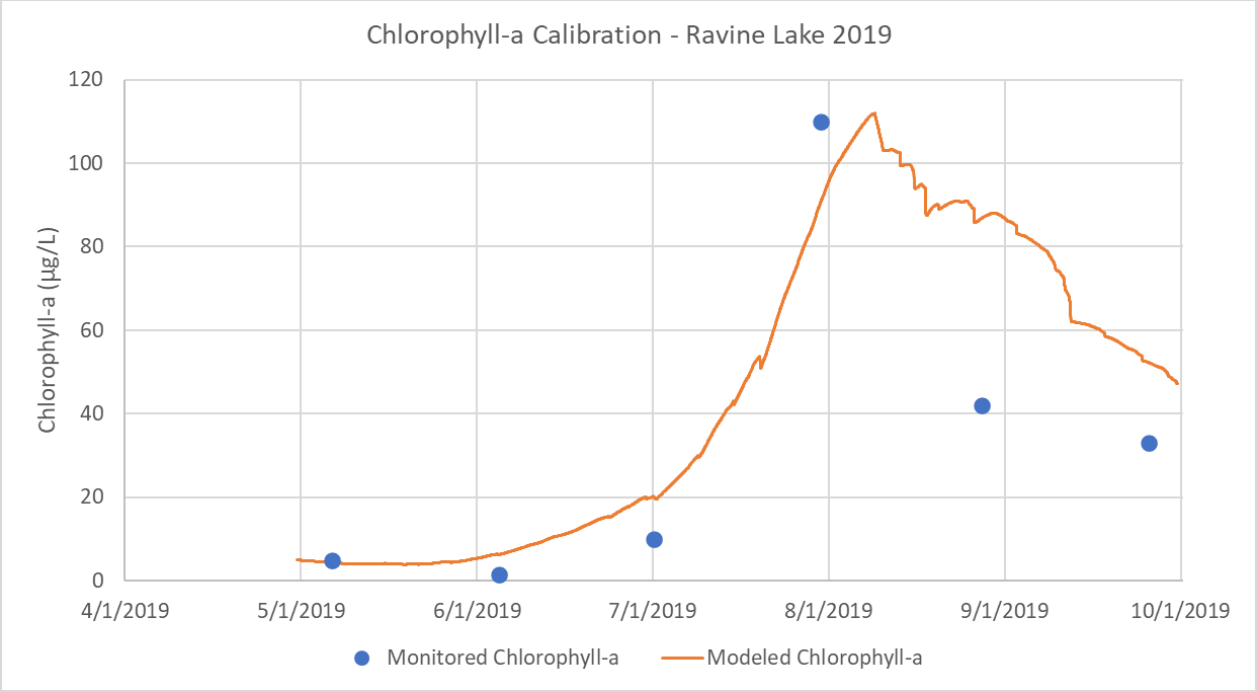


Figure B 64 Ravine Lake chlorophyll-a calibration – 2019

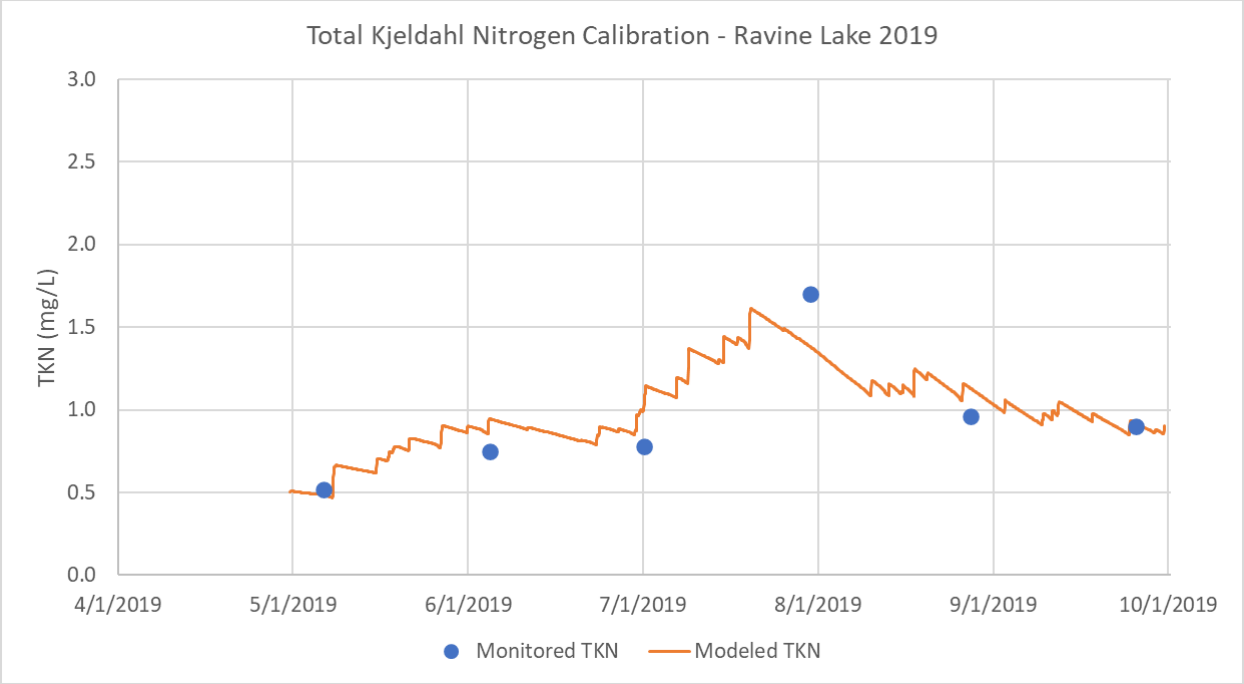
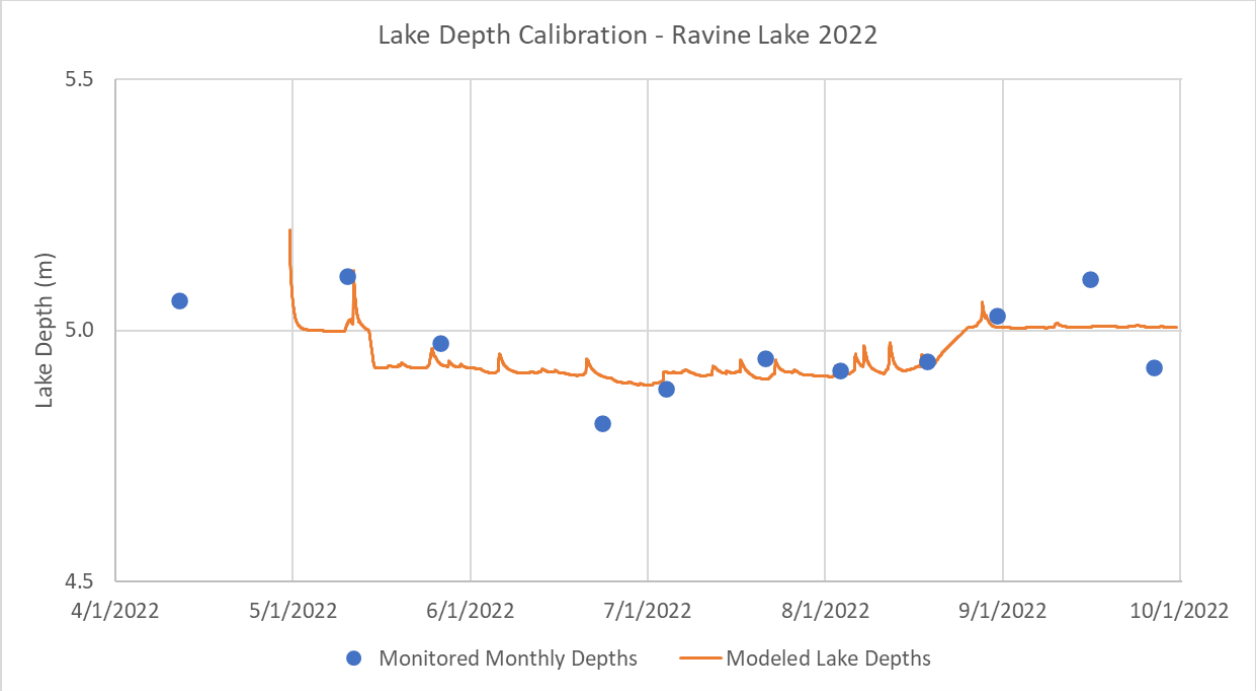


Figure B 65 Ravine Lake total Kjeldahl nitrogen calibration – 2019



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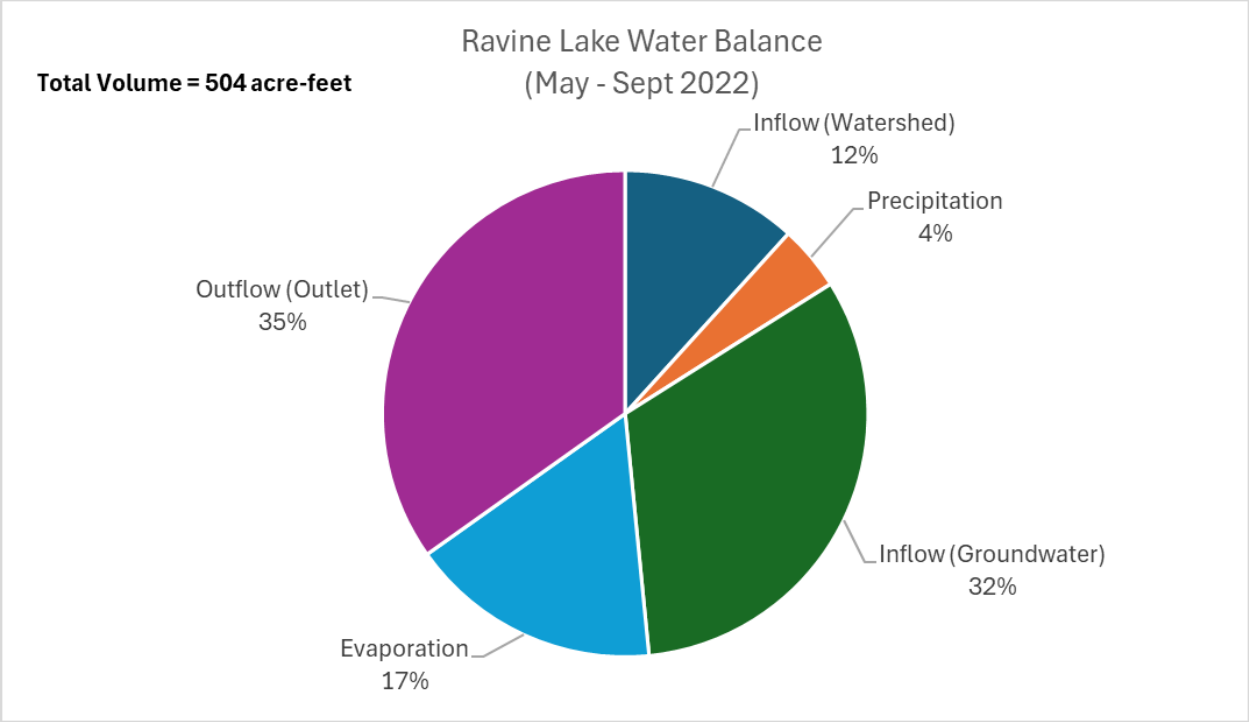

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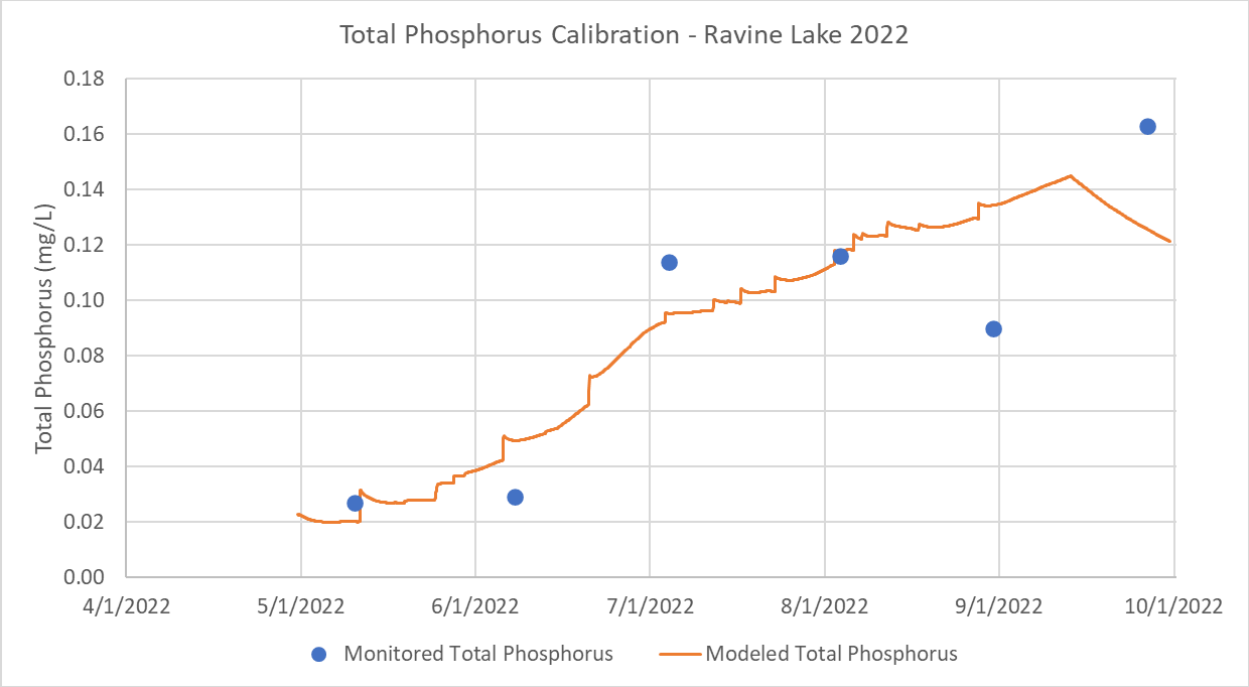

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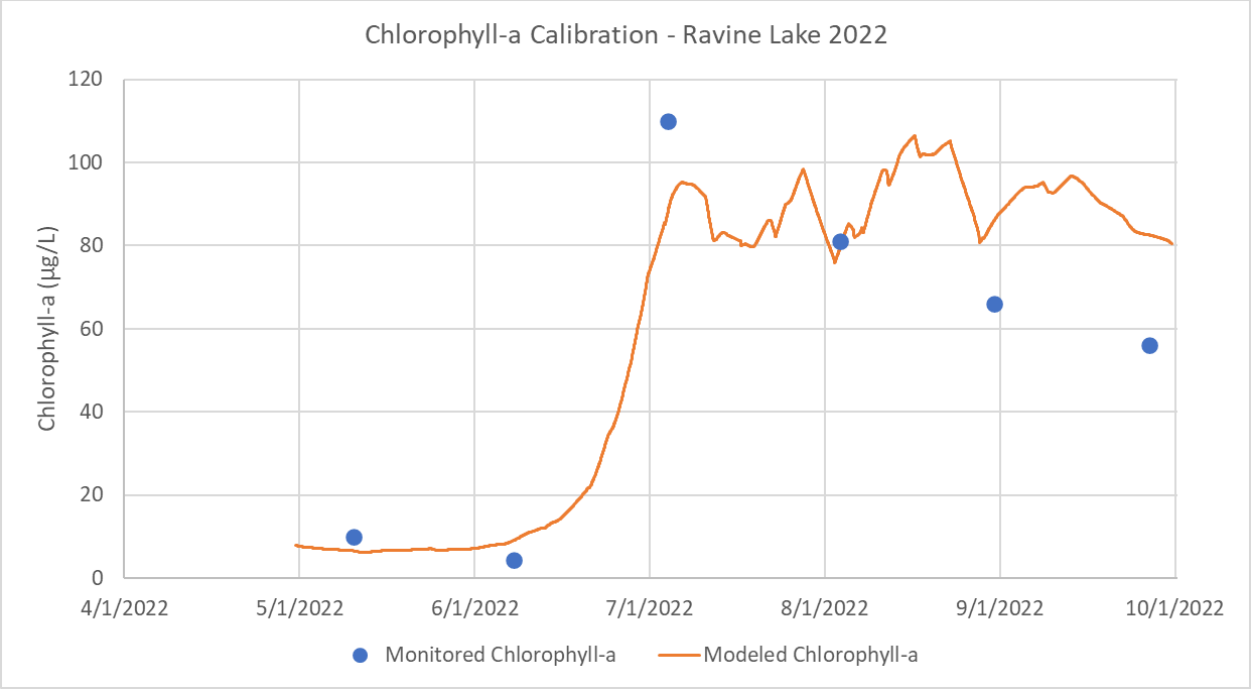

Figure B 69 Ravine Lake chlorophyll-a calibration – 2022

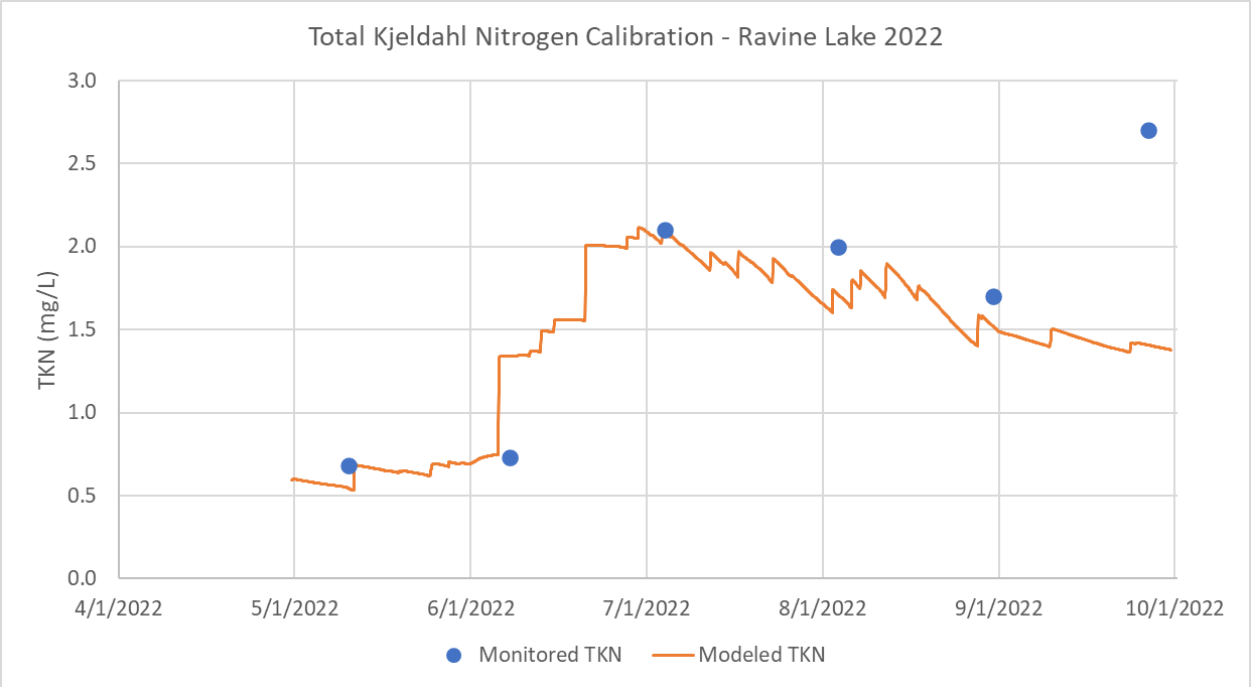

Figure B 70 Ravine Lake total Kjeldahl nitrogen calibration – 2022

Appendix C

Trout Brook and O'Conners Creek WQ Plots

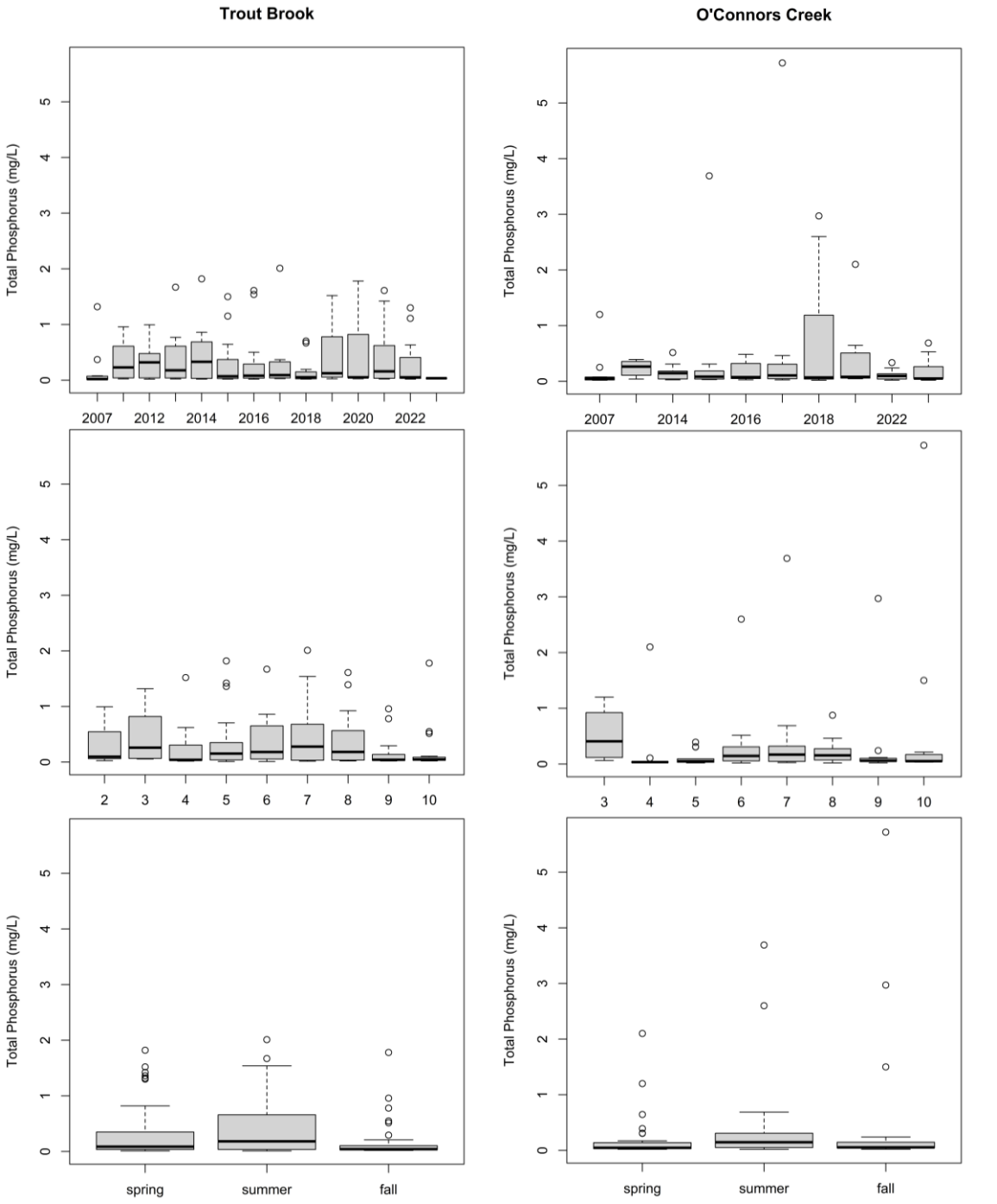

Figure C 1 Yearly, monthly, and seasonal total phosphorus concentrations in the Trout Brook and O'Conners Creek watersheds

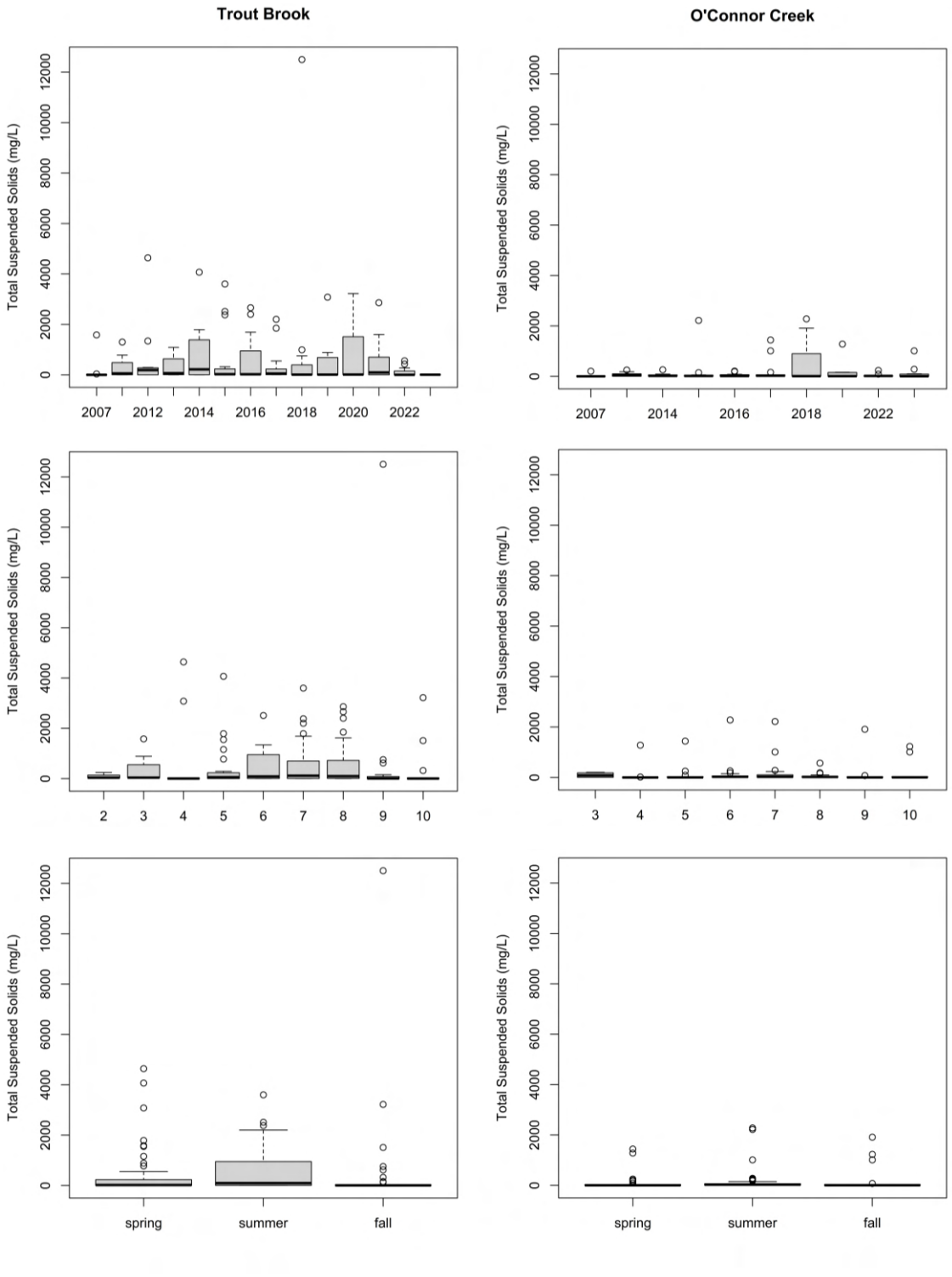

Figure C 2 Yearly, monthly, and seasonal total suspended solids concentrations in the Trout Brook and O'Conners Creek watersheds

APPENDIX B

SWWD Monitoring Plan

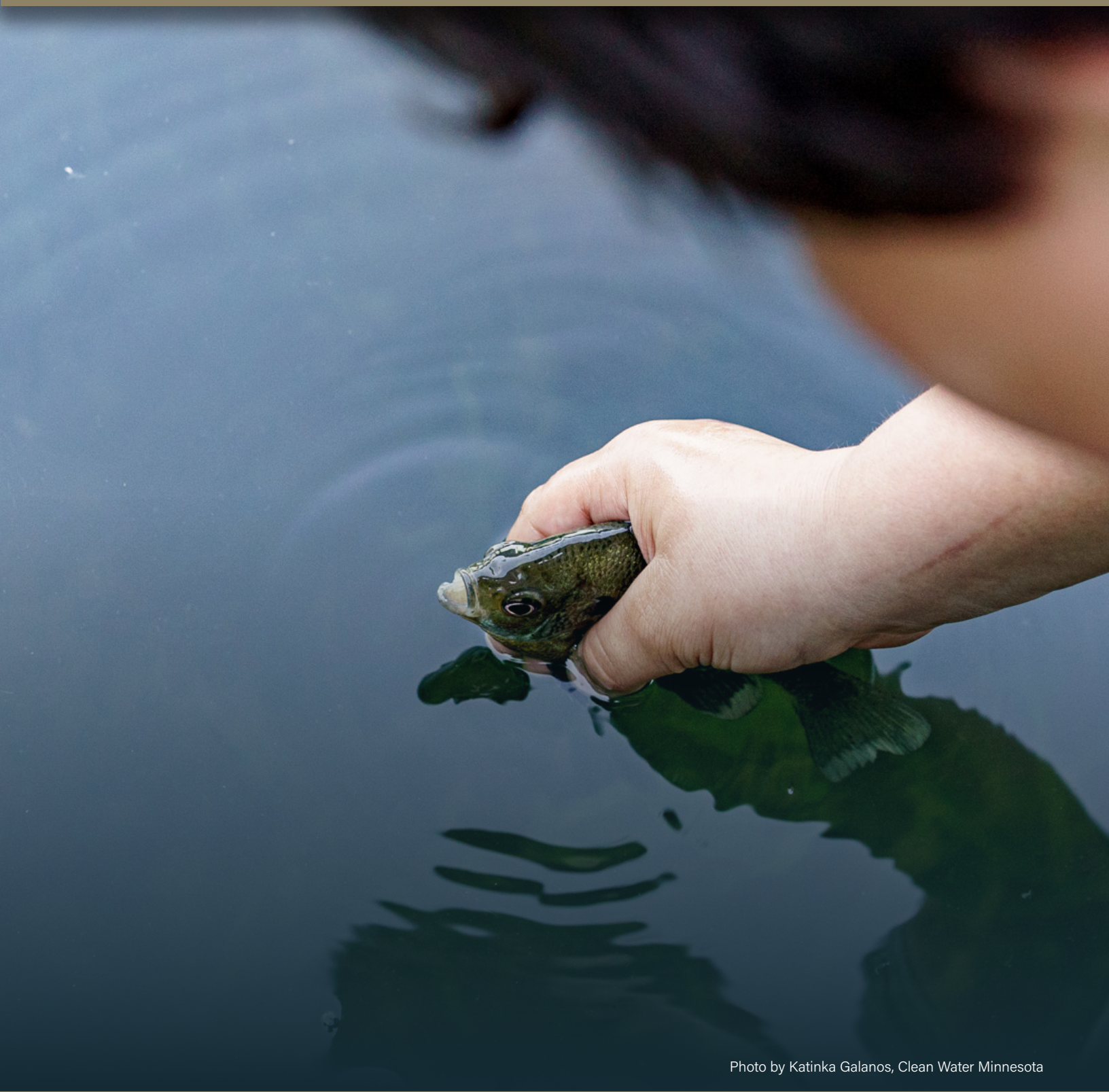

Photo by Katinka Galanos, Clean Water Minnesota

South Washington Watershed District Monitoring Plan

Prepared for

South Washington Watershed District

June 2026

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South Washington Watershed District Monitoring Plan

June 2026

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Abbreviations

API	Application Programming Interface
BMP	Best Management Practice
CAMP	Community-Assisted Lake Monitoring Program
CoCoRaHS	Community Collaborative Rain, Hail and Snow Network
CSV	Comma-Separated Values
DO	Dissolved Oxygen
EQuIS	Environmental Quality Information System
GIS	Geographic Information System
HAB	Harmful Algal Bloom
MCES	Metropolitan Council Environmental Services
MDH	Minnesota Department of Health
MnDNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer System
Obwell	Observation Well
QAQC	Quality Assurance / Quality Control
SWWD	South Washington Watershed District
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
USGS	United States Geological Survey
WCD	Washington Conservation District

1 Introduction

The South Washington Watershed District (SWWD or District) has undertaken the monitoring of its water resources throughout the District since 1996. The primary goal of the SWWD's monitoring program is to create a baseline of understanding of water quality, hydrologic, and ecological conditions across the watershed, to evaluate the effectiveness of ongoing management, and to inform future District implementation efforts. Monitoring data collected through the District's program supports the adaptive management of water resources, informs regulatory compliance, and supports strategic planning, ensuring that the SWWD can respond effectively to changing conditions and emerging challenges.

Since 2000, SWWD has partnered with the Washington Conservation District (WCD) to implement its monitoring programs. These efforts have included the monitoring of long-term regional assessment sites, lake level monitoring, water quality sampling, and groundwater observations. Over time, monitoring priorities have evolved in response to land use changes, climate variability, and regulatory requirements. The District's current approach utilizes the data collected for analysis and reporting, leveraging dashboards and modeling tools to inform projects and policies.

The SWWD's monitoring activities support compliance with state and federal programs, including providing information for their partners' use related to Municipal Separate Storm Sewer System (MS4) permit responsibilities and Total Maximum Daily Load (TMDL) requirements. SWWD collaborates with agencies such as the Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources (MnDNR), and United States Geological Survey (USGS), as well as municipalities and neighboring watershed districts in sharing their data for these purposes. Monitoring data also informs planning for capital improvement projects, project prioritization, and adaptive management strategies. Data is also regularly shared with research organizations focused on water resource management and is used to support public education and transparency through reporting tools and online dashboards.

This Monitoring Plan was developed in support of the SWWD's 2026-2035 Watershed Management Plan and establishes a framework for the collection, management, and application of monitoring data for the protection and improvement of water resources within the District. This plan defines the monitoring goals, describes program components, and structure related to the implementation of monitoring activities by the SWWD. Monitoring and data analysis related to surface water quality, regional flow locations, key infiltration areas, groundwater, lake levels, and precipitation are included as potential components of the District's overall monitoring program. The Monitoring Plan is intended for SWWD staff, technical partners, and agencies, and serves as a reference for annual planning and long-term decision making related to the program. A comprehensive list of currently active monitoring locations within the SWWD, including information on sampling frequency and parameterization, is available by contacting SWWD staff.

2 Monitoring Goals

The SWWD's monitoring program is designed to provide reliable, actionable data that supports adaptive watershed management and long-term resource protection. These goals reflect priorities identified in the District's Watershed Management Plan and recent planning initiatives, including climate resiliency and regional collaboration. The primary goals of the SWWD's monitoring program include:

- **Track Long-Term Trends –** Monitor water quality, quantity, and hydrology across the District to identify changes over time and evaluate progress toward resource protection objectives.
- **Protect Priority Waterbodies –** Maintain and improve conditions in high-value lakes and streams, particularly those that are not impaired or have been recently delisted, to prevent degradation and sustain ecological health.
- **Support Adaptive Management –** Provide data that informs annual planning, project prioritization, and updates to management strategies.
- **Evaluate Effectiveness of Management Actions –** Assess the performance of best management practices (BMPs), regulatory controls, capital projects, and other management actions in reducing pollutant loads, mitigating hydrologic impacts, and improving ecological health.
- **Ensure Compliance** – Monitoring at key locations to track and ensure compliance with regional flood mitigation and management agreements related to maximum allowable discharges.
- **Monitor Climate Impacts –** Detect changes in water quality and quantity, and stormwater runoff associated with climate variability.
- **Monitor Land Use Change Impacts –** Detect changes in stormwater runoff, water quality, and quantity associated with land use changes (e.g., development).
- **Inform Modeling and Planning –** Supply data for the calibration and validation of hydrologic, hydraulic, and water quality models used in project design and watershed planning.
- **Protect Groundwater Resources –** Understand groundwater-surface water interactions, recharge dynamics, and potential contamination risks.
- **Enhance Public Communication and Education –** Make monitoring results accessible through water resource summaries, dashboards, and other channels to promote transparency and stakeholder engagement.
- **Facilitate Interagency Coordination –** Share data with partners such as MnDNR, MPCA, USGS, research institutions, municipalities, and neighboring watershed districts to support regional water resources management.

To achieve these goals, the SWWD's monitoring program is organized into distinct categories that address different scales, data needs, and resource types. The following section describes these categories, along with their purposes, methods, and how they support the District's overall management strategy. Consistent with District policies to limit the duplication of effort between government agencies, while the District will remain adaptable to considering additions to its monitoring program over the lifespan of this plan, it may not independently monitor for specific pollutants (e.g., PFAS), instead relying on the expertise, data, and guidance of state and federal agencies to inform watershed management needs.

3 Monitoring Categories

3.1 Regional Assessment

Regional assessment monitoring provides a consistent and robust dataset as part of SWWD's long-term programming. These sites are strategically located at critical crossings and outlets to characterize watershed-scale hydrology and water quality trends. Data from these monitoring sites support trend analysis, model calibration, flood management compliance, assessing compliance with state standards, and evaluation of land use (development) and climate change impacts. This approach ensures that SWWD can identify emerging issues early and adapt management strategies accordingly.

These locations are subcategorized into long-term assessment locations and rotating subwatershed assessment locations, as described below.

3.1.1 Long-Term Assessment Locations

One of the objectives of the SWWD is to establish a framework for characterizing and managing water resources at a regional level rather than solely at a site-specific level. Long-term regional assessment monitoring stations are maintained to achieve this objective, provide continuity in monitoring from year-to-year, and to track long-term trends in flow and water quality. These sites represent major drainage areas and are selected to capture conditions entering and leaving key watershed regions, including waterbody outlets. Monitoring at these locations allows SWWD to evaluate the effects of development, cumulative BMP implementation, and climate variability on watershed health. Data from these stations is used to calibrate and validate regional hydrologic/hydraulic and water quality models, set benchmarks for regional water quality, assess compliance with state water quality standards, evaluate the effectiveness of local controls in managing pollutant loading and compliance with flood management standards, and to predict and evaluate the performance of management actions (i.e., capital improvements, natural resource conservation efforts, etc.).

The SWWD's network of long-term regional assessment locations is designed with an intent to be part of the District's permanent monitoring program and for individual stations to be operated until deemed unnecessary by the analysis of monitoring results, modeling, and/or changes in land use, regulations, and/or climatic considerations. Any additions to or retirement of stations from the District's network of regional assessment locations will be evaluated by SWWD staff, ensuring that changes support the District's long-term goals without compromising historical datasets (see Section 5).

Regional assessment monitoring stations are automated to the greatest extent feasible. Continuous measurements of stage, velocity, and discharge are collected throughout the monitoring season, typically April through November. Rainfall measurements may also be collected at these locations to complement hydrologic monitoring, when feasible. Water quality sampling includes flow-weighted storm event composites, storm event and snowmelt grab samples, and baseflow composites and grab samples. Water quality samples collected at these stations are analyzed at the Metropolitan Council Environmental Services Laboratory, and field measurements and rating curves are used to fill data gaps when sensors are compromised. Additional information about specific methods or equipment can be obtained by contacting staff at SWWD or WCD.

Table 3-1 lists the SWWD's long-term regional assessment locations and provides a general description of the station's location, the focus of monitoring at each location, and the type of data being collected. Additional details on each of the stations, including the types and frequency of data collection at each

location can be obtained by contacting SWWD staff. A map showing the current, active monitoring locations within the District is available on the District's website: South Washington Watershed District Data Viewer.

Table 3-1 Long-Term Regional Assessment Locations

Station	Station Description
MS-1	*Established in 1996 to monitor intercommunity flows from Lake Elmo and Oakdale into Woodbury. Data provides a baseline understanding of initial surface water quality and quantity at the headwaters of the watershed. Includes continuous flow data (April – November) and select water quality parameters.*
Wilmes Lake Outlet	*Established in 2009 to monitor water quality and quantity leaving the northern watershed and flowing toward Colby Lake. Includes continuous flow data (April – November) and select water quality parameters.*
Colby Lake Outlet	*Established in 2011 to monitor water quality and quantity leaving the northern watershed and flowing toward Bailey Lake. Includes continuous flow data (April – November) and select water quality parameters.*
MS-2	*Established in 1996 to monitor a large portion of Woodbury, including outflow from Colby Lake, before flowing into Bailey Lake. Monitoring data used to develop models that evaluate effects of proposed development, BMP, and conservation projects. Includes continuous flow data and select water quality parameters.*
Newport	*Established in 2006 to develop baseline of water quality and quantity data for runoff flowing into the Mississippi River from the tributary area including stormwater flows from the Cities of Newport and Woodbury, and to characterize stormwater runoff from an urban area following treatment in a stormwater pond. Includes continuous flow data and select water quality parameters.*
St. Paul Park	*Established in 2006 to establish a baseline of water quality and quantity data for runoff flowing into the Mississippi River and characterize stormwater flows from a tributary area in the City of St. Paul Park. Includes continuous flow data and select water quality parameters.*
Central Ravine	*Established in 2009 to give a better understanding of the quantity and quality of water leaving the Central Draw watershed and draining to the Mississippi River. The 100th Street location formerly served as the regional assessment location for the Central Draw watershed, but was eventually superseded by the Central Ravine station. Includes continuous flow data and select water quality parameters.*
Ravine Lake Outlet	*Established in 2015 to monitor water quality and quantity leaving Ravine Lake to a receiving stream which outlets to the Mississippi River. Includes continuous flow data (April – November) and select water quality parameters.*
Trout Brook	*Established in 2007 to monitor water quality and quantity within the Trout Brook watershed and evaluate watershed discharges to the St Croix River. Includes continuous flow data (April – November) and select water quality parameters.*
O'Connors Creek	*Established in 2010 to monitor water quality and quantity within the O'Connor's Creek watershed, which is landlocked. O'Connors Creek monitoring station was relocated to O'Connors at 80th St in 2021 to address tailwater concerns at original location. Includes continuous flow data (April – November) and select water quality parameters.*

3.1.2 Rotating Subwatershed Assessment Locations

To enhance and supplement the SWWD regional assessment framework, the District operates additional assessment sites on a rotating basis, at the subwatershed-scale (i.e., subwatershed assessment locations). Subwatershed assessment locations are established to further define hydrology and/or manage water resources within the major regions of the watershed, by providing data at the smaller, subwatershed-scale. Data collected at these locations is used to identify priority subwatersheds within the larger watershed regions of the District as well as to help calibrate regional models, assess benchmarks for regional water quality, and evaluate the effectiveness of more localized controls in managing water resources. Subwatershed assessment sites, once established, are typically operated for a temporary period (e.g., 3-10 years) depending on District goals and the value of the data being collected. In many cases, the District collects monitoring data at subwatershed assessment locations for a predetermined period of time, rotates away from the station for a few years, and then returns to the site to continue building a long-term data set of monitoring at this smaller spatial-scale, but at locations that do not require a year-after-year continuous data record in order to meet the district's monitoring and assessment goals at that given location.

Monitoring methods at subwatershed assessment locations vary depending on the SWWD's objectives for each location. Rotating subwatershed assessment monitoring stations are and will continue to be automated to the greatest extent feasible and operated by the WCD. Currently, all subwatershed assessment sites are monitored for flow using a self-powered water level logger. Stage measurements are taken every 15 minutes. Field stage measurements are taken at all sites and stage to discharge rating curves are developed, if possible. Rating curves are used to calculate discharge at the rotating assessment locations. If necessary, subwatershed assessment locations can be equipped with sampling equipment to assess nutrient and pollution loading on a subwatershed level. Additional information about specific methods or equipment can be obtained by contacting staff at SWWD or WCD.

Table 3-2 summarizes the SWWD's currently active subwatershed assessment locations, provides a general description of the station's location, the focus of monitoring at each location, and the type of data being collected. Additional details on each of the stations, including the types and frequency of data collection at each location can be obtained by contacting SWWD staff.

Table 3-2 Subwatershed Assessment Locations

Station[1]	Station Description
Powers East	*Subwatershed assessment tributary to Powers Lake. Established to monitor a residential subwatershed east of the lake and maintain or update model calibration. Includes inlet flow monitoring and select water quality parameters.* *This station is being monitored on a rotating basis.*
Colby Lake – West Inlet	*Subwatershed assessment tributary to Colby Lake. Established to monitor a residential subwatershed west of the lake. Includes continuous flow monitoring and select water quality parameters.* *This station is being monitored on a rotating basis.*

1 Stations listed in this table are those that are considered 'active' at the time of the writing of this plan, being monitored on a regular rotating basis. For information on historic, now inactive subwatershed assessment locations, contact SWWD staff.

3.2 Waterbody Assessment

Monitoring lakes and other waterbodies within the District provides essential information for protecting aquatic resources and assessing compliance with state lake water quality standards. Historically, SWWD's waterbody assessment efforts have included the long-term screening of lakes in the form of lake level monitoring and participation in the Metropolitan Council Community-Assisted Lake Monitoring Program (CAMP). To ensure data consistency and accuracy across all monitored waterbodies, in the future the District may consider moving away from CAMP, which utilizes volunteers to collect water quality samples, to having one consistent entity conducting all waterbody monitoring. By collecting this long-term baseline data, the District can assess and identify trends in water quality and quantify over time (both positive and negative), assess compliance with state water quality standards, and identify lakes that would benefit from additional analysis and more in-depth study (see Section 3.3.2 under Project Assessment).

The District conducts annual lake monitoring on all major lakes. Lake water quality monitoring includes biweekly sampling from April through November at the deepest point of each lake. Field measurements of surface temperature, dissolved oxygen, and transparency (Secchi depth) are collected alongside water samples analyzed for total phosphorus, nitrogen, and chlorophyll-a. Where appropriate, hypolimnetic samples are obtained to evaluate nutrient dynamics. Additionally, macrophyte point-intercept surveys are conducted in the District's priority waterbodies every three years.

Lake level monitoring is conducted biweekly on twelve lakes using staff gauges installed and read by WCD. These measurements document seasonal fluctuations and help identify abnormal changes that may signal hydrologic or ecological stressors.

When data from waterbody assessment locations indicate impairment or nutrient loading in excess of SWWD or state standards, the District may initiate a more in-depth assessment of targeted waterbodies. A description of in-depth assessments is included in Section 3.3.2 of this plan.

The waterbody assessment locations are intended to be adaptive. Lakes may be monitored more or less frequently depending on trends and watershed needs, allowing resources to be directed toward priority waterbodies.

Table 3-3 summarizes the SWWD's waterbody monitoring locations, provides a general description of the station's location, and the data collected at each location. A map showing the current, active monitoring locations within the District is available on the District's website: South Washington Watershed District Data Viewer. Additional details on each of the monitoring stations can be obtained by contacting SWWD staff.

Table 3-3 Waterbody Assessment Locations

Station	Station Description
Armstrong Lake	*Waterbody assessment location on SWWD priority lake. Includes bi-weekly lake level monitoring, field and physical parameters, and select water quality parameters.*
Wilmes Lake - South	*Waterbody assessment location on SWWD priority lake. Includes bi-weekly lake level monitoring, field and physical parameters, and select water quality parameters.*
Markgrafs Lake	*Waterbody assessment location on SWWD priority lake. Includes bi-weekly lake level monitoring, field and physical parameters, and select water quality parameters.*
Powers Lake	*Waterbody assessment location on SWWD priority lake. Includes bi-weekly lake level monitoring, field and physical parameters, and select water quality parameters.*
Fish Lake	*Waterbody assessment location on SWWD priority lake. Includes bi-weekly lake level monitoring, field and physical parameters, and select water quality parameters.*
Colby Lake	*Waterbody assessment location on SWWD priority lake. Includes bi-weekly lake level monitoring, field and physical parameters, and select water quality parameters.*
Ravine Lake	*Waterbody assessment location on SWWD priority lake. Includes bi-weekly lake level monitoring, field and physical parameters, and select water quality parameters.*
Bailey Wetland	*Waterbody assessment location on SWWD priority lake. Includes bi-weekly lake level monitoring, field and physical parameters, and select water quality parameters.*
O'Connors Lake	*Waterbody assessment location on SWWD priority lake. Includes bi-weekly lake level monitoring, field and physical parameters, and select water quality parameters.*
La Lake	*Waterbody assessment location on SWWD priority lake. Includes bi-weekly lake level monitoring, field and physical parameters, and select water quality parameters.*

3.3 Project Assessment

Project-specific monitoring provides SWWD with the flexibility to address unique data needs associated with the more detailed planning, design, and assessment of capital projects, BMP implementation, and in-lake management. These efforts are intended to be short-term and highly focused. Project assessment monitoring is designed to complement data collected through long-term monitoring efforts by targeting the collection of data related to more specific questions associated with the anticipated effectiveness, ecological response, and/or similar design performance metrics. Upon identification of a project's need for monitoring data, the SWWD will develop a plan summarizing the purpose of the monitoring, the type and frequency of data collection that is needed, and how long the assessment effort will last. The following subsections describe various types of project assessment monitoring and types of monitoring methods that may be used.

3.3.1 Stormwater

SWWD may conduct monitoring to support both pre-project planning and post-project evaluation for capital projects and stormwater BMPs. More localized, catchment-scale monitoring may be conducted to characterize drainage areas upstream of major outfalls or other critical locations to identify pollutant sources that are impacting downstream waterbodies. These assessments will typically be conducted in the early stages of project planning – for example, as part of a subwatershed retrofit feasibility study – or in support of gathering additional data to inform a project design. Before or following construction of a project, the SWWD may also conduct project-scale monitoring to gather additional needed information or evaluate the performance of BMPs to verify conformance with original design goals and help to inform future projects.

Monitoring at these sites may include stage and flow measurements, storm event sampling for pollutants, inflow/outflow monitoring from BMPs. Chloride sampling during winter months and spring thaw may be used to assess chloride management projects. Stormwater project assessments will generally be conducted for a relatively short time period (e.g., 2-3 years), providing sufficient data to inform design and evaluate implementation effectiveness.

3.3.2 In-Lake

When routine lake monitoring (described in Section 3.2) and assessment indicates the need for additional data to inform the development of in-lake management strategies, SWWD may initiate in-depth lake assessments to diagnose causes and guide restoration strategies. Additional data collected to perform in-lake project assessments may include:

- Sediment coring to evaluate internal loading
- Intensive water quality profiles data collection
- Additional water quality data (e.g., surface samples plus samples at-depth; soluble and bioavailable nutrients; and/or expanded nitrogen speciation)
- Macrophyte surveys (point intercept, biomass, turion, etc.)
- Phytoplankton and zooplankton sampling
- Cyanobacteria identification/speciation
- Toxicity testing of confirmed Harmful Algal Blooms (HABs)
- Fisheries assessments

In advance of in-lake management (e.g., sediment treatment) and/or updates to lake water quality models, SWWD may implement a period of more intensive monitoring to reduce uncertainty in lake response, confirm water balance assumptions, and establish a stronger pre-treatment baseline for evaluating project effectiveness. These in-lake assessments would be time-limited and targeted to specific decision needs (e.g., confirming internal loading, documenting seasonal nutrient dynamics, and collecting inputs needed for model calibration or re-calibration).

Following sediment treatment (e.g., alum application) or other in-lake management actions, SWWD may continue enhanced monitoring on an intermittent basis (e.g., every other year for a term of five years) to assess longevity of treatment benefits and identify when additional management may be warranted.

3.3.3 Geomorphic

SWWD recognizes the importance of maintaining stable channels and ravines to protect the water quality and ecological benefits of natural resources within the District. Geomorphic assessments may be utilized by SWWD to understand changes in critical watercourses such as the Mississippi River's Gray Cloud Channel, Trout Brook, O'Connor's Creek, and other ravines within the District. This monitoring may include the evaluation of channel geometry, sediment transport, and erosion risk. Data collected through geomorphic assessments will be used to inform stabilization and restoration projects, habitat improvements, and other long-term strategies for managing these systems. Monitoring may also be used to assess the effectiveness of stabilization and restoration projects post-implementation.

Table 3-4 summarizes the current project assessment locations within the SWWD, including the project assessment type and a summary of goals for monitoring at these locations. Additional details are available by contacting SWWD staff. With project assessment activities being targeted at collecting data for a relatively short time period and a more focused purpose, it is expected that these locations will rotate

frequently over time. A map showing the current, active monitoring locations within the District is available on the District's website: South Washington Watershed District Data Viewer.

Table 3-4 Current Project Assessment Locations

Stations	Station Type[1]	Station Description
Seasons Park (Inlet and Outlet)	Stormwater	*Monitoring at the inlet and outlet of the Seasons Park Filtration BMP to assess performance of the BMP in reducing nutrient loading.*
Armstrong Wetland (9th Street, 10th Street, Outlet)	Stormwater	*Monitoring at 2 main inflow points and the outlet of Armstrong Wetland to inform and assess effectiveness of cattail harvesting for nutrient load reductions.*
Kargel Park	Stormwater	*Monitoring west of Kargel Park to inform design of the Kargel Park Alum Treatment Facility.*
Armstrong Lake, Wilmes Lake, Markgrafs Lake, Powers Lake, Colby Lake, Ravine Lake, Bailey Wetland, La Lake	In-Lake	*Activities may include sediment coring to evaluate internal loading, intensive water-quality profile data collection, non-routine macrophyte surveys (point-intercept, biomass, turion, etc.), phytoplankton and zooplankton sampling, and fisheries assessments.*

1 No geomorphic monitoring stations are currently established

3.4 Groundwater Assessment

Groundwater is a vital water resource within the SWWD. Municipalities within the SWWD rely on groundwater to provide potable water, satisfy water demand for commercial and industrial users, and for irrigation. Many surface water features in the District also interact directly with groundwater, making its protection essential for maintaining healthy lakes, streams, and wetlands. The purpose of groundwater monitoring by the SWWD is to understand how surface water and groundwater interact for the purposes of managing surface water quality and quantity, to evaluate the influence of stormwater infiltration on groundwater quality and quantity, and to provide data to refine regional groundwater models. Monitoring will help to identify trends, assess contamination risks, direct management strategies, and guide coordination with partnering agencies (e.g., Washington County or the Minnesota Department of Health).

Key areas of interest for the SWWD include: tracking groundwater levels and quality, understanding recharge dynamics, and evaluating seasonal variability such as spring recharge and summer drawdown. Assessments will also focus on potential contamination risks from chlorides and other pollutants, particularly near infiltration basins and areas with vulnerable geology.

In many areas of the District, infiltrating water remains in the shallow soil profile. However, in other areas, sinkholes and karst features allow a large portion of infiltrated water to recharge into deep groundwater aquifers. These features are of particular concern in areas adjacent to the District's regional infiltration basins (CD-P85 and CD-P86) and Central Draw Overflow, which provides drainage for overflow from the regional infiltration basins to the Mississippi River. SWWD currently operates four groundwater observation wells (obwells) in the area of their Central Draw regional infiltration basins. Groundwater water level readings are collected by WCD 12 times per year using the manual tape down method. Water quality samples are collected and analyzed at the obwells three times per year.

Future monitoring efforts may leverage the District's existing observation wells as needed and leverage partnerships with agencies such as Washington County, the Minnesota Department of Health (MDH), United States Geological Survey (USGS), and MnDNR. Monitoring needs will be informed by data

collected and assessments performed by the SWWD and ongoing groundwater planning efforts being led by Washington County. Activities may include manual and automated water level measurements, targeted water quality sampling for chloride, nitrate, phosphorus, and bacteria, and integration of groundwater data with surface water monitoring to better understand interactions. Data collected will support the development of adaptive management strategies and improve groundwater modeling tools. These efforts will be implemented strategically on an as needed basis, focusing on areas where groundwater concerns intersect with SWWD projects or regional surface water priorities.

Table 3-5 summarizes the current groundwater monitoring locations within the SWWD. Additional details are available by contacting SWWD staff. A map showing the current, active monitoring locations within the District is available on the District's website: South Washington Watershed District Data Viewer.

Table 3-5 Current Groundwater Monitoring Locations

Stations	Station Type	Station Description
#616497	Obwell	*Monitoring station to assess groundwater levels and impacts of the SWWD's Central Draw system.*
#545603	Obwell	*Monitoring station to assess groundwater levels and impacts of the SWWD's Central Draw system.*
#545604	Obwell	*Monitoring station to assess groundwater levels and impacts of the SWWD's Central Draw system.*
#545602	Obwell	*Monitoring station to assess groundwater levels and impacts of the SWWD's Central Draw system.*

4 Data Management and Reporting

SWWD's monitoring data will be centrally housed and managed through a modernized database system developed in partnership with Barr Engineering Co. (Barr). This system will integrate historic and current datasets (including lake and stream water quality, lake levels, groundwater observations, and continuous flow data) into a structured database environment. Currently, after samples are collected, WCD sends them to the Metropolitan Council Environmental Services (MCES) Laboratory to be analyzed. Analytical data is then sent back to WCD for QAQC. All data will then be submitted to Barr for incorporation into the database. Water quality data will be stored in EQuIS and flow data will be stored in comma separated value (csv) format files. The monitoring data will be organized for consistency and accessibility, supporting long-term tracking and analysis across monitoring categories.

Monitoring results will be visualized through a Power BI-based reporting interface, which provides interactive dashboards, time-series graphs, and summary tables. These tools will allow staff and stakeholders to explore trends, filter data by location or parameter, and export results for further analysis. The interface will be embedded within SWWD's website, making monitoring data publicly accessible and supporting transparency in watershed management.

To enhance the utility of results from the monitoring program, SWWD's data platform will incorporate real-time data feeds from external sources. Automated web services will retrieve precipitation, groundwater, and lake level data from public APIs (e.g., MnDNR, CoCoRaHS), allowing for timely updates and expanded context. These datasets will be aligned with monitoring results from SWWD's program and refreshed on a recurring schedule.

Annual updates to the SWWD's monitoring database will be coordinated with WCD, with new data typically received in February following the monitoring season. This process will ensure that the most recent observations are incorporated into the reporting tools and available for planning, communication, and decision-making.

5 Monitoring Planning and Adaptation

SWWD's monitoring program is designed to be adaptive, ensuring that District resources are directed toward the highest priorities while maintaining continuity in long-term datasets. Each year, SWWD staff will review its planned monitoring locations for the next season and determine any sites, parameters, and methods that may need adjustments in order to meet District goals outlined within this Monitoring Plan and the 2026-2035 Watershed Management Plan.

This planning process will occur early in the winter preceding the upcoming monitoring season. The planning will begin with an evaluation of existing data, a review of data needs coming up for the District within the next several years, and if the District's monitoring goals are being met with the current monitoring setup. Staff will review and confirm that existing monitoring locations continue to provide value, whether additional monitoring sites might be needed to address emerging needs, and identify any stations that should be considered for retirement and/or for rotating out of the monitoring cycle for the upcoming year. Considerations for the addition or removal of monitoring sites may include: upcoming land use changes or development activity, impaired waters listings / delistings, trends in lake, stream, or wetland water quality, and upcoming management activities or capital projects. For example, monitoring may be expanded in areas slated for retrofit studies or reduced in subwatersheds where conditions in the receiving waterbody have met SWWD's water quality goals. The planning process will also include parameter selection for each site. While core parameters such as flow and nutrients will remain standard, additional parameters may be added to address specific concerns (e.g., chloride). Similarly, biological monitoring may be scheduled for lakes where more in-depth study is needed. The District will also evaluate opportunities to incorporate new technologies or methods that improve efficiency and data quality. These decisions will be made in coordination with partners such as WCD to identify potential capabilities gaps that would need to be addressed through subcontractors.

Any changes to the SWWD's monitoring activities for the upcoming year will be documented in a way that outlines updated site locations, sampling frequency, and parameterization. By reviewing and confirming needs for the upcoming monitoring season each year, the SWWD will ensure that its program remains relevant, cost-effective, and aligned with both the District's long-term goals and also adaptive to changing conditions.