

Chub Lake

Adaptive Lake Management Plan

prepared for:

Dakota County Soil and Water Conservation District

North Cannon River Watershed Management Organization

November 2025



Chub Lake

Adaptive Lake Management Plan

prepared by:

LimnoTech

under contract to:

Dakota County Soil and Water Conservation District



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1 OVERVIEW

Chub Lake is a shallow 300 acre lake within the upper northwest reaches of the Cannon River watershed in Eureka Township, Dakota County, Minnesota. The lake experiences low water clarity and excessive algal growth, impairing recreational uses, and is listed as impaired for nutrients. A Total Maximum Daily Load (TMDL) has been completed by the Minnesota Pollution Control Agency (MPCA) for the lake. The TMDL calls for an 84% reduction in phosphorus loads to the lake. The TMDL estimates that the majority of the phosphorus load to the lake is from the sediments in the lake.

Management actions aimed at reducing phosphorus loads to Chub Lake will not only make progress towards restoring and protecting the lake, but will also contribute to progress in reducing nutrient loads downstream in Chub Creek, the Cannon River and Lake Byllesby, the Mississippi River and Lake Pepin, as well as contribute to progress for nutrient reduction goals included in the statewide Minnesota Nutrient Reduction Strategy (NRS).

In an effort to restore and protect Chub Lake, the Dakota County Soil and Water Conservation District (SWCD) contracted LimnoTech to develop this Adaptive Lake Management Plan (Plan). The development of this Plan was included as a goal in the 4th Generation North Cannon River Watershed Management Organization (NCRWMO) Watershed Management Plan (2023-2033). The purpose of this Plan is to:

- Identify and prioritize the primary goals for Chub Lake.
- Assess potential management actions contributing to the restoration and protection of Chub Lake.
- Identify and prioritize specific management actions for implementation over the next ten years, 2026-2035.

This Plan for Chub Lake accomplishes these purposes and is presented in the following sections:

- Watershed and Lake Characteristics
- Potential Management Actions
- Recommended Implementation Plan

1.1 Management Objectives

The **Primary Objective** of this Plan is to:

- Attain MPCA's Lake Eutrophication Standard that applies to shallow lakes in the North Central Hardwood Forest (NCHF) ecoregion of 60 µg/L total phosphorus by reducing phosphorus loads to the lake. The TMDL characterized existing conditions in the lake as 172.8 µg/L total phosphorus.

Secondary objectives include the following:



- Reduce phosphorus loads to downstream water bodies.
- Support the aesthetics of the lake and other recreational uses such as hunting, paddling, and birding.
- Maintain and promote shoreline protection and shoreline aesthetics.
- Control and prevent aquatic invasive species.
- Assess the potential of the lake for walleye rearing.

1.2 Stakeholders and Partners

The development of this Plan has relied on input from key public and private stakeholders and project partners who have a vested interest in the lake. Successful implementation of this Plan will also depend on close coordination across this group. Table 1 lists the key stakeholders and partners involved in the development and implementation of this Plan.

Table 1. Chub Lake stakeholders and partners

Stakeholder / Partner Group	Name
Public Entities	Eureka Township Board of Supervisors and Planning Commission
	Dakota County Soil and Water Conservation District (SWCD)
	North Cannon River Watershed Management Organization (NCRWMO)
	Minnesota Department of Natural Resources (DNR) – East Metro Fisheries
	Minnesota Pollution Control Agency (MPCA)
	Metropolitan Council Environmental Services (MCES District 16)
	Minnesota Board of Soil and Water Resources (BWSR)
Private (62 total)	20 Property Owners (w/Chub Lake shoreline)
	42 Property Owners (Chub Lake Watershed)

A meeting with stakeholders and partners was held on August 12, 2025. Key takeaways from the meeting included:

- The primary impairments to the lake appear to stem from internal sources, particularly cycling of phosphorus from the organic lake sediment.



- Common carp are likely contributing to phosphorus release from this sediment due to their feeding and spawning behavior.
- The last fish survey was conducted in 1985, and the most recent commercial carp harvest occurred in the 1960s.
- Overall, the lake suffers from a lack of current and comprehensive data.

While a variety of management options were discussed at the meeting, the discussions indicated that the most cost-effective first steps likely include:

1. Collecting additional baseline water quality data through volunteer-based monitoring; and
2. Conducting a carp population survey to inform a potential management strategy.

The outcomes from the August 2025 meeting have been used to inform this Plan.



2 WATERSHED & LAKE CHARACTERISTICS

Several studies have been completed that relate to Chub Lake over the past 10 years. The list of studies below were reviewed as part of the development of this Plan.

- Cannon River Watershed Total Maximum Daily Load (TMDL) (LimnoTech, 2016a)
- Cannon River Watershed Restoration and Protection Strategies (WRAPS) (LimnoTech, 2016b)
- Aquatic Plant Surveys for Chub Lake (Blue Water Science, 2018a)
- Aquatic Invasive Species Action Plan for Chub Lake (Blue Water Science, 2018b)
- Paleolimnological Study of Phosphorus-Impaired Lakes in the Cannon River Watershed (MPCA, 2019)
- North Cannon River Watershed 4th Generation Watershed Management Plan (ISG, 2023)

The following sub-sections summarize conditions in the watershed, conditions in Chub Lake, and discusses the primary stressors impacting phosphorus levels in the lake.

2.1 Watershed Characteristics

The Chub Lake watershed is located in Eureka Township, Dakota County along the northern boundary of the Cannon River watershed (Figure 1). An unnamed tributary flows into Chub Lake at the north end while remaining inflows are from surrounding runoff and direct precipitation. The lake forms the headwaters to Chub Creek, a tributary to Lake Byllesby. Lake Byllesby is an impoundment of the Cannon River formed by a dam on the river. The dam is owned and operated by Dakota County. The drainage area to Chub Lake is 1,487 acres and is comprised of mostly deciduous/mixed forest (39.2%), cultivated crops (22.5%), and pasture (18.8%) (Figure 2). Less than 10% of the watershed is categorized as “developed” and the remaining land cover is comprised of wetlands. There are a total of 63 property owners within the Chub Lake watershed, 20 who have lakefront property, and one property owned by the DNR at the south end of the lake.

The potential sources of phosphorus to Chub Lake from the watershed are runoff from agricultural fields, organic material, and atmospheric deposition. The MPCA and their contractors have developed watershed models to support the development of TMDLs, Watershed Restoration and Protection Strategies (WRAPS), and One Watershed One Plan (1W1P) studies and documents. The watershed model chosen by MPCA for these studies was the Hydrologic Simulation Program – Fortran (HSPF). The HSPF model for the Cannon River watershed was developed and calibrated by LimnoTech to support the TMDL in 2015-2016. The HSPF model simulates the potential sources of phosphorus in the Chub Lake watershed. Land use conditions in the Chub Lake watershed have not changed significantly since model development. The next section presents estimates of phosphorus loads to the lake from the watershed.



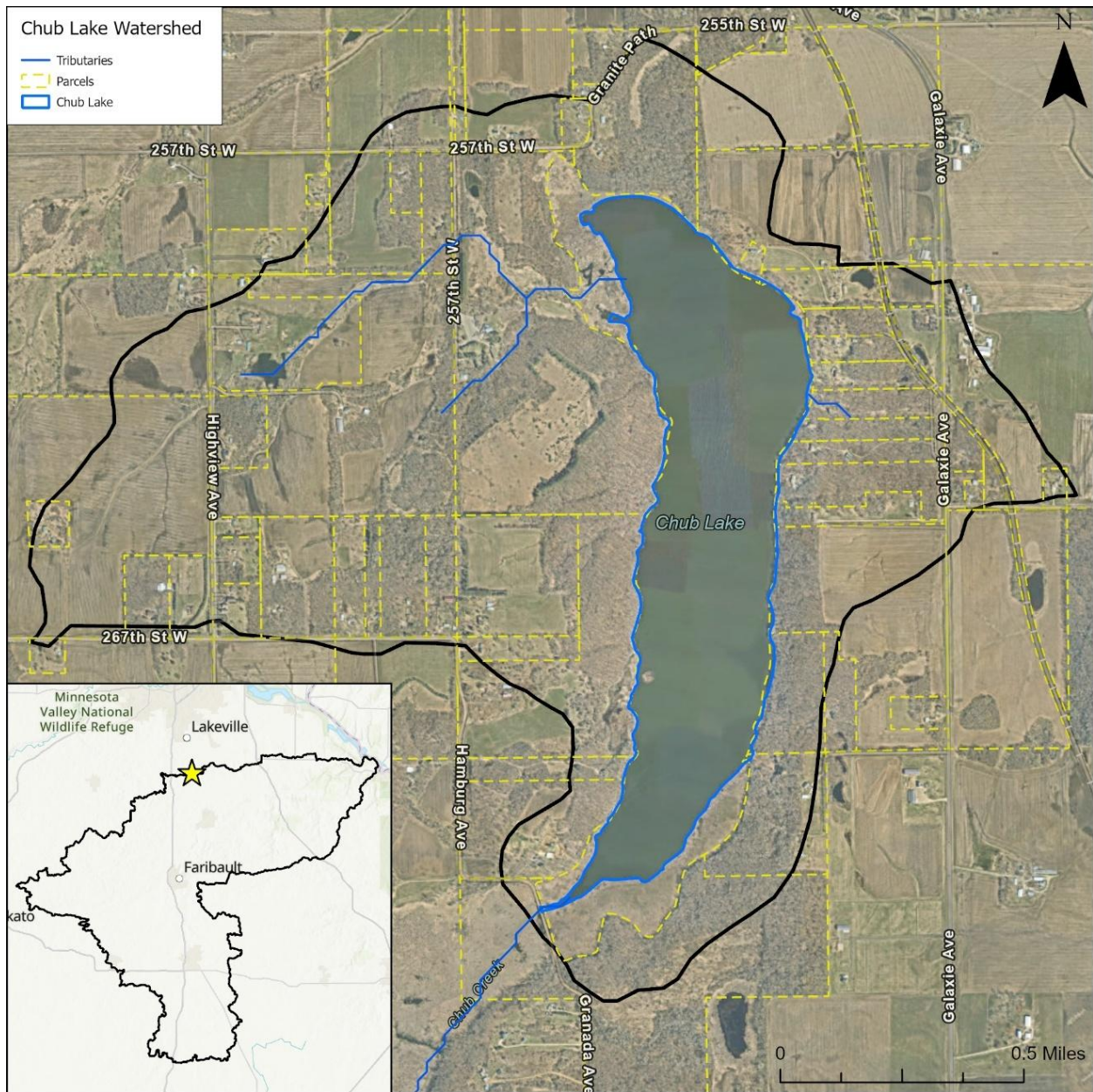


Figure 1. Site map of Chub Lake, contributing drainage area, and parcel boundaries.

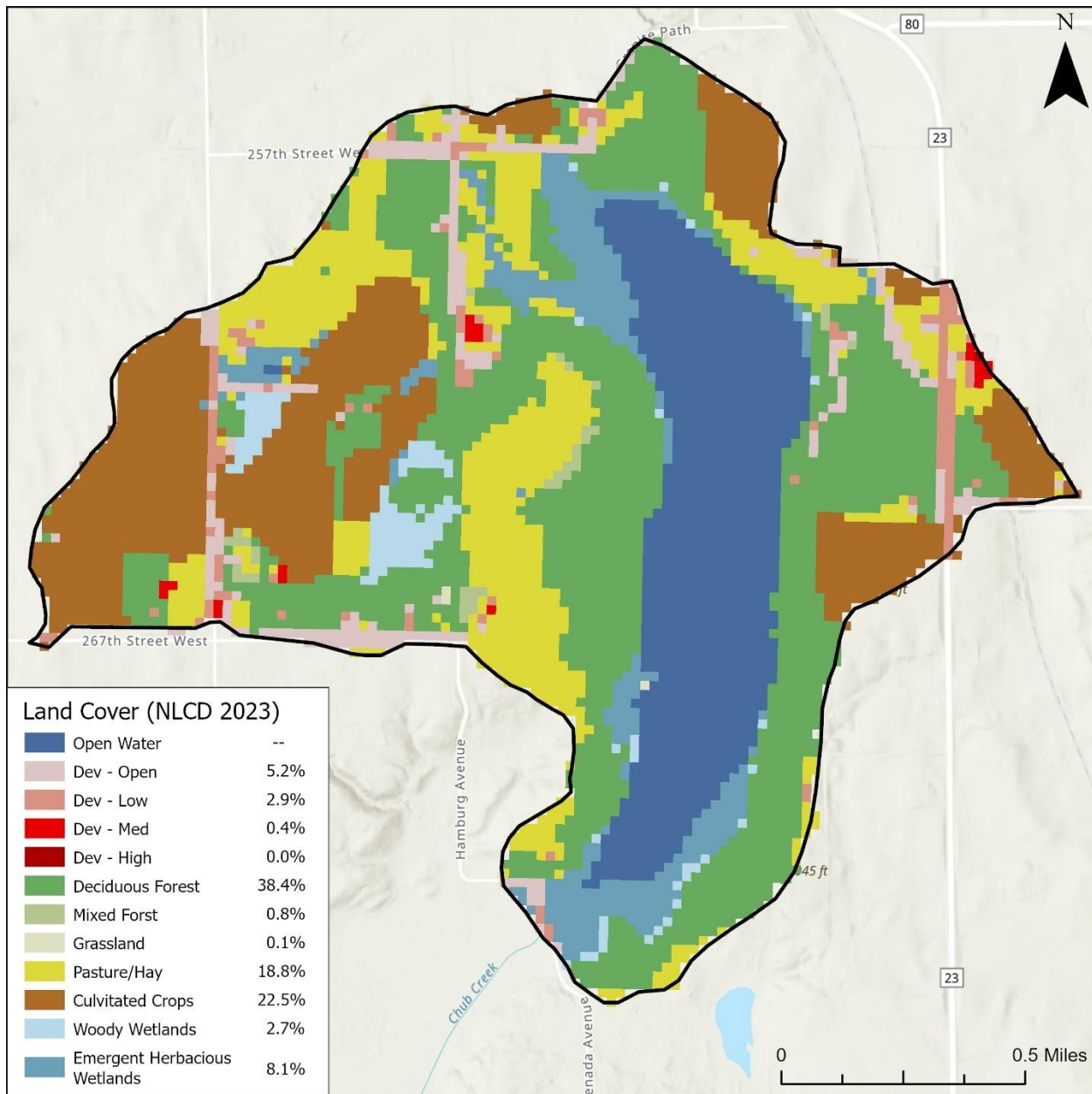


Figure 2. NLCD 2023 land use coverage in the Chub Lake Watershed.

2.2 Lake Characteristics

Chub Lake is identified by MPCA as Assessment Unit ID (AUID) 19-0020-00. MPCA assigns AUIDs to lakes and watercourses (rivers and streams) for monitoring and assessment purposes. Chub Lake is classified as a shallow lake, with an average depth of 3.28 ft and maximum depth of 9.5 ft under typical lake level conditions. It has a surface area of approximately 300 acres, with an average width of 1,500 ft and length of 4,000 ft. The predominant wind direction is out of the west-northwest direction. Because the lake has a north/south orientation, the lake is not typically subjected to large wind-driven wave action due to a shorter fetch relative to the length. Therefore, the lake is not subject to significant wave-driven shoreline erosion events or sediment resuspension events. The wind sheltering also likely limits the amount of mixing in the



water column during the open water season. This may result in longer periods of low dissolved oxygen at the sediment-water interface, resulting in conditions promoting the release of phosphorus from the sediments. The lake forms the headwaters to Chub Creek and discharges through a culvert under Grenada Ave, which also provides non-motorized public access to the lake.

2.2.1 Water Quality

Water quality data has been collected on Chub Lake since 1980 through the Met Council's (MCES) Citizen-Assisted Lake Monitoring Program. This data is publically available through the Minnesota Pollution Control Agency's Surface Water Data web tool. A review of the available data shows large gaps of several years between rounds of data collection. A suite of chemical (eg. metals, nutrients, solids) and physical (temperature, Secchi depth, dissolved oxygen) are collected, and of particular interest to Chub Lake are samples for total phosphorus, chlorophyll-a, dissolved oxygen, and Secchi depth. Results are shown in the figures below and discussed further below.

2.2.1.a Total Phosphorus

Total phosphorus concentrations generally fall between 100 µg/L – 200 µg/L, well above the 60 µg/L standard for NCHF shallow lakes (Figure 3). All samples collected over the growing season in 2022 exceeded the standard. No orthophosphate samples were analyzed in the dataset, which could provide additional insight into bioavailable nutrients for algal growth during the summer months. Collection of paired total phosphorus and orthophosphate samples may be of benefit to further inform the adaption implementation of this Plan.

2.2.1.b Chlorophyll-a

Chlorophyll-a concentrations spanning 2004 to 2018 vary greatly with a range generally between 20 µg/L – 250 µg/L, typically well above the 20 µg/L standard for NCHF shallow lakes (Figure 4).

2.2.1.c Dissolved Oxygen

Dissolved oxygen was measured on Chub Lake in 2010, 2011, and most recently in 2018. Readings were taken at multiple depths corresponding with the surface, mid, and bottom. Figure 5 shows the dissolved oxygen concentrations at each depth group compared against the 5 mg/L standard for aquatic life. The figure shows that a majority of the surface measurements are well above the standard. Chub Lake can experience low dissolved oxygen conditions near the bottom, also referred to as anoxia. Anoxic conditions are indicative of high organic content of sediments. Samples collected in 2018 are all above the standard except for two samples collected near the bottom of the lake.

2.2.1.d Secchi Depth

Secchi depth measurements were collected spanning 1993 through 2024. Measurements were taken at multiple depths corresponding with the surface, mid, and bottom. Figure 6 presents the Secchi depth results and shows measurements below the criteria of 1 m and a trend of declining water clarity in the lake.



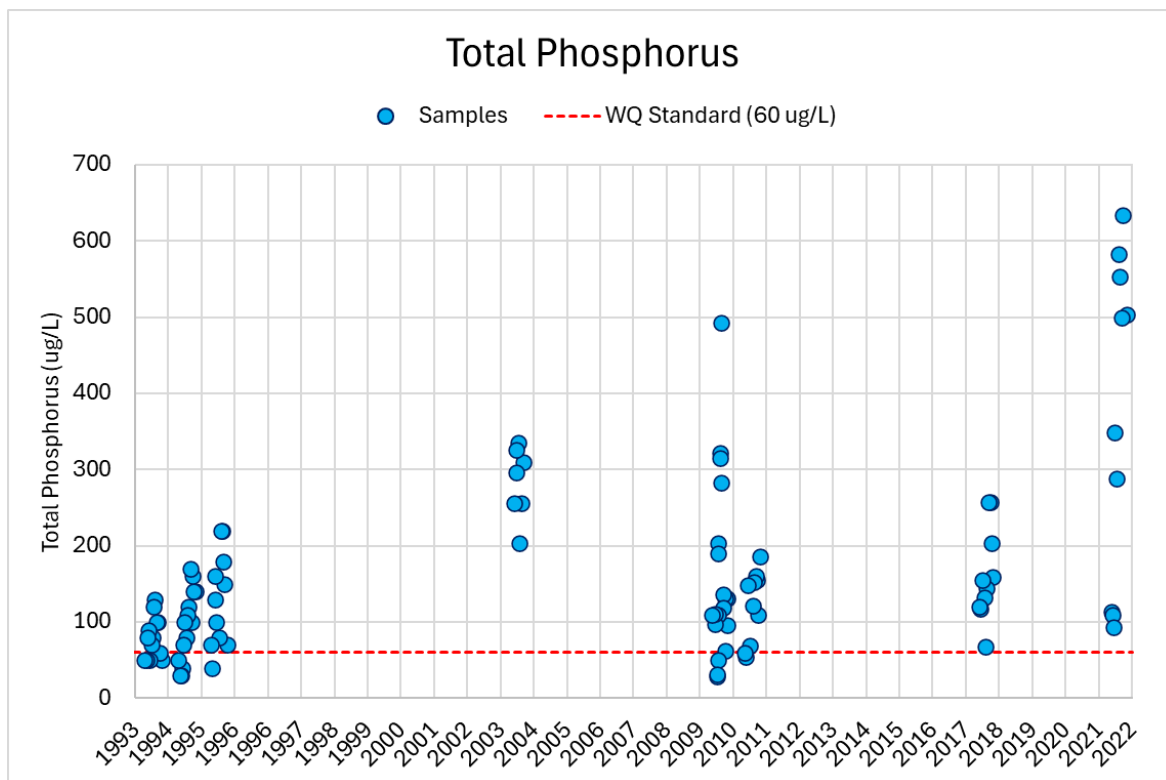


Figure 3. Total Phosphorus data in Chub Lake collected through the MCES Citizen-Assisted Lake Monitoring Program.

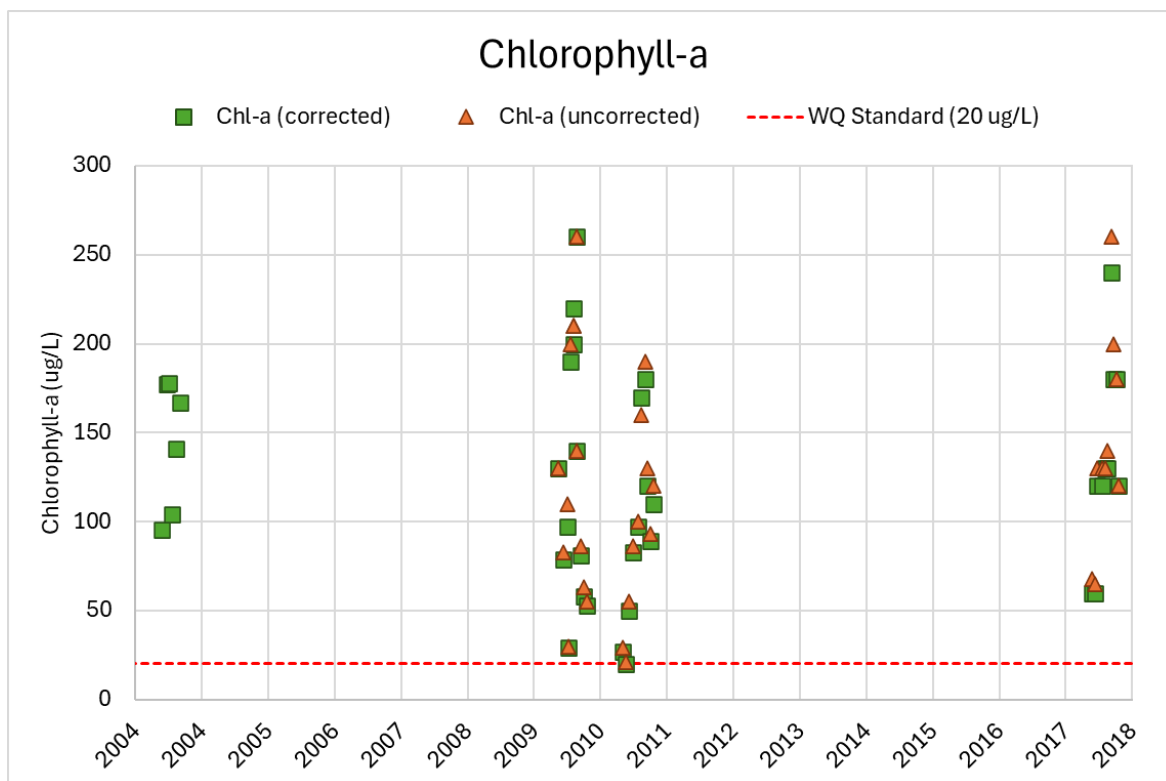


Figure 4. Chlorophyll-a data (both corrected and uncorrected for pheophytin) in Chub Lake collected through the MCES Citizen-Assisted Lake Monitoring Program.



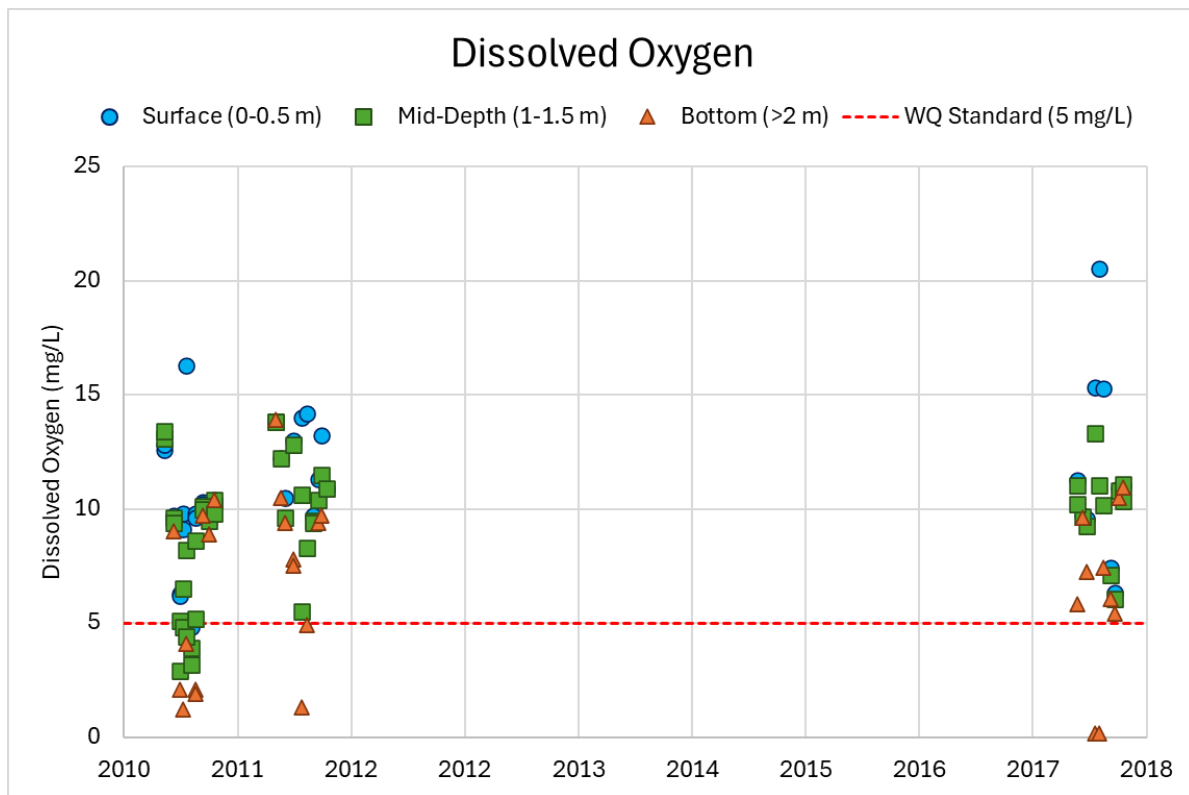


Figure 5. Dissolved oxygen samples collected through the MCES Citizen-Assisted Lake Monitoring Program.

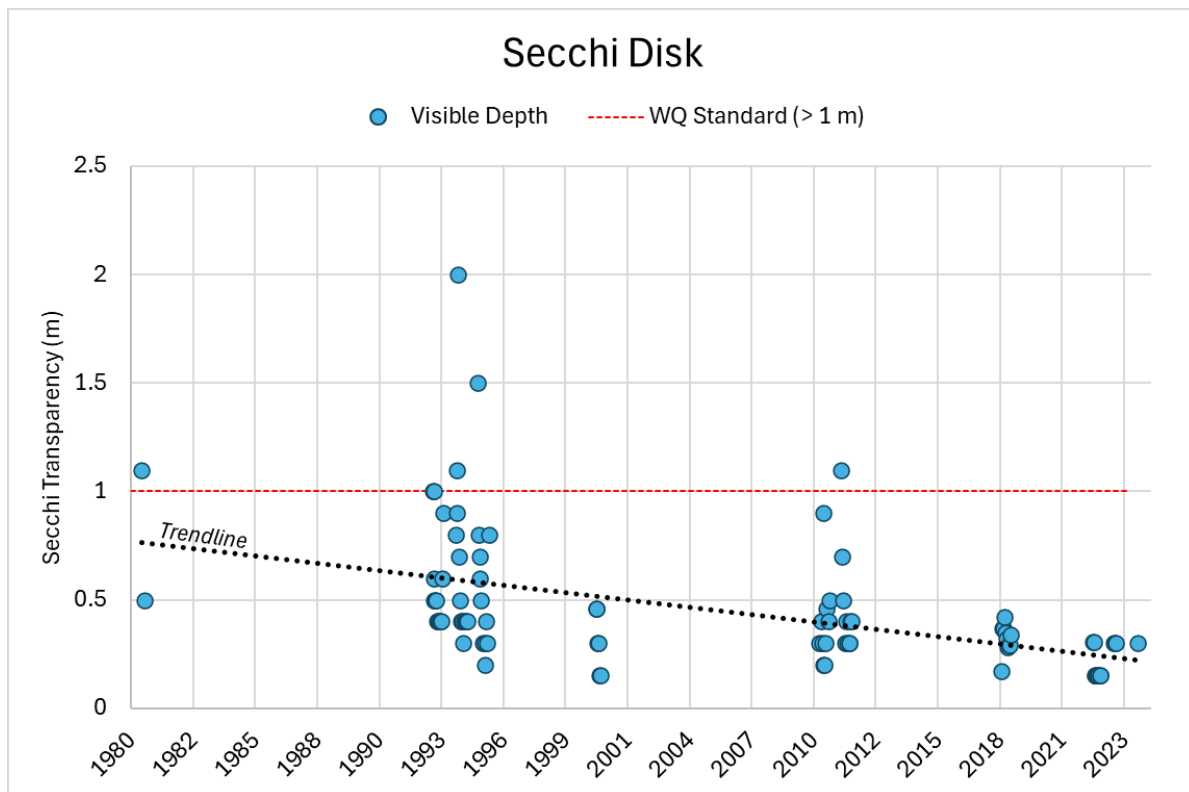


Figure 6. Secchi depth measurements collected through the MCES Citizen-Assisted Lake Monitoring Program.



The water quality data is used by MPCA to develop the Trophic State Index score for Chub Lake. This metric normalizes water quality parameters introduced above into a single score that quantifies the eutrophication level for a given lake. Chub Lake is classified as between eutrophic and hypereutrophic, indicating poor water quality conditions (Figure 7).

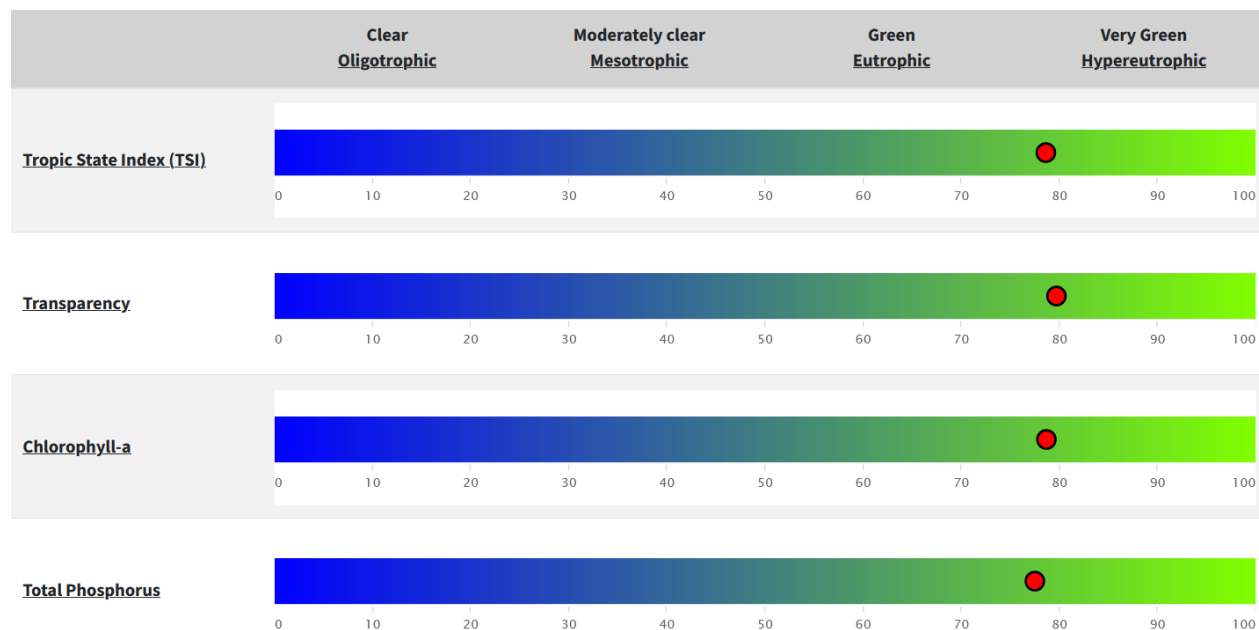


Figure 7. Trophic State Index summary for Chub Lake.

2.2.2 Aquatic Species Assessment

Dakota County commissioned a 2017 Aquatic Invasive Species Action Plan for Chub Lake. The study completed lake surveys looking for presence of 14 species. Only two invasive species were found in Chub Lake, Curlyleaf pondweed and Common carp. Several species, while not present during the 2017 study, were identified for potential growth in Chub Lake due to site conditions. Figure 8 summarizes the findings from that study, along with recommended management action plans.

Species	Lake Status	Potential for Growth in Chub Lake	Management Action	
			Short Term	Long Term
Species of Interest				
1. Cylindro (blue-green algae)	Not tested for cylindro	Moderate	Phytoplankton Monitoring	Maintain low phosphorus loading
2. Curlyleaf pondweed	Present in Chub Lake	Low to moderate	Annual delineations or surveys to check curlyleaf growth	Selective treatment for heavy growth conditions
3. Eurasian watermilfoil	Not present in Chub Lake	Low to moderate	Annual surveys or delineations if detected	Selective treatment for heavy growth conditions
4. Zebra mussels	Not present in Chub, but present in Lake Marion Dakota County	Low to moderate	Mussel monitoring devices for early detection	Small-scale removal techniques if needed
5. Common carp	Present in Chub	Moderate to high	Determine where carp are spawning if they are found	Carp management if testing shows high numbers
Species to Watch				
Flowering rush	Not present, but found in Dakota County	Moderate	Annual observations or surveys	Selective treatment
Purple loosestrife	Not present, but found in Dakota County	Fair	Annual surveys or observations	Spot control and use of beetles for large area control
Hydrilla	Not present in Chub	Low to moderate	MnDNR sponsored treatments	Ongoing control
Rusty crayfish	Not present in Chub	Fair to moderate	Crayfish traps for early detection	Use fish to control rusty crayfish
Chinese and Banded Mystery snail	Unknown	Fair	Inform and educate	Small-scale removal techniques, if needed
Spiny waterflea	Not present in Chub	Low to moderate	Inform and educate	Natural fish predation after fish learn to prey on them
Faucet snail	Not present in Chub	Moderate to high	Inform and educate	
Asian carp	Not present in Chub	Low	Inform and educate	Removal if practical
Snakehead	Not present in Chub	Moderate	Inform and educate	

Figure 8. Summary findings from the 2017 Aquatic Invasive Species Action Plan for Chub Lake.

In addition to finding Common carp during the 2017 study, historical records provided by Minnesota DNR confirm past surveys from the 1960s and 1980s where common carp were found. In 1964, approximately 1,200 lbs of carp were removed from Chub Lake. Carp are bottom feeders and through the act of feeding perturb bottom sediments, resuspending nutrient rich sediments in the water column and contributing to phosphorus impairments.

2.2.3 2025 Data Collection

LimnoTech completed a site visit on May 23, 2025 to collect the following data on Chub Lake:

- bathymetry survey,
- physical water characteristics,
- soft sediment thickness and composition, and
- document shoreline conditions

Physical water characteristics were measured using a multiparameter YSI sonde for temperature, dissolved oxygen, turbidity, conductivity, and pH. Soft sediment thickness and composition was evaluated by pulling sediment cores at three locations and performing a visual texture analysis. A map presenting the resulting



bathymetry results and sampling locations is presented in Figure 9. Figure 10 shows an example of a sediment core collected. Table 2 presents results from the survey.

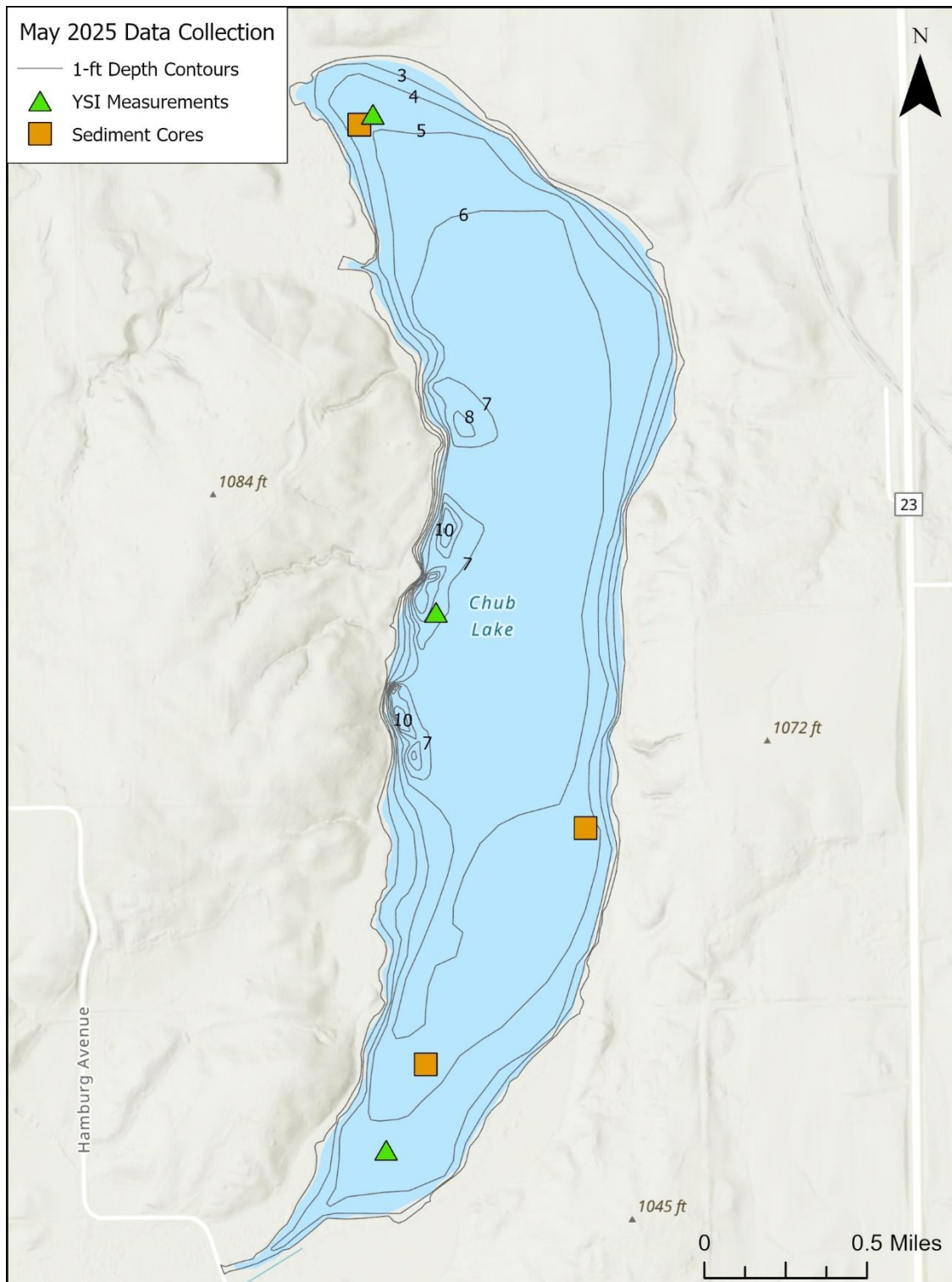


Figure 9. Map of 2025 data collection locations.



Figure 1010. Example sediment cores collected on Chub Lake by LimnoTech in May 2025.

Table 2. Physical parameters measured by LimnoTech in May 2025.

Location	DateTime	Layer	Depth (ft)	DO (mg/L)	pH (su)	Temp (deg C)	Conductivity (us/cm)	ORP (mV)
North End	5/23/2025 12:02	Surface	0.5	8.94	7.84	15.85	300	-215
North End	5/23/2025 12:02	Bottom	4	8.5	7.26	13.98	309	-185
Deep Hole	5/23/2025 13:04	Surface	0.5	9.22	7.83	16.7	297	92.5
Deep Hole	5/23/2025 13:04	Bottom	8	7.7	7.57	14.6	297	43
Outlet	5/23/2025 13:40	Surface	0.5	10.2	7.96	18	295	160

2.3 Priority Lake Stressors

Chub Lake is currently listed on the state's 303(d) Impaired Waters list for phosphorus. A TMDL was developed for the lake by LimnoTech using the BATHTUB model software and model output from the calibrated HSPF watershed model to inform inflows and phosphorus loads to the lake. The BATHTUB model was calibrated using observed data for total phosphorus, Secchi depth, and chlorophyll-a. Results of this calibration are shown in Table 3.

Table 3. Chub Lake BATHTUB calibration results.

Parameter	Observed	Predicted
Total Phosphorus (µg/L)	172.8	172.8
Secchi Depth (m)	0.4	0.4
Chlorophyll- <i>a</i> (µg/L)	119.5	118.7

LimnoTech's work concluded a load reduction of 83.8% is required to meet in-lake water quality standards. This work also concluded the primary driver of phosphorus impairment is internal loading. Internal loading is the release of phosphorus from sediments on the lake bottom. One example of internal loading is dissolved phosphorus released from the lake bed under anoxic or low dissolved oxygen conditions. Another example of internal loading can be the disturbance of bottom sediments and resuspension into the water column caused by carp activity. Both of these internal loading processes are at play in Chub Lake. A management strategy to improve water quality and meet the TMDL target will need to address the internal loading. The TMDL developed for Chub Lake is provided as Table 4.

Table 4. TMDL for Chub Lake, as documented in the Cannon River Watershed TMDL report.

Chub Lake 19-0020-00 TMDL Summary		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		kg/yr	kg/day	kg/yr	kg/day	kg/yr	%
Phosphorus Loading Capacity (TMDL)		764.27	2.09	123.50	0.34	640.77	83.84
Wasteload Allocation (WLA) Components	Permitted Municipal and Industrial WWTFs*	NA	NA	NA	NA	NA	NA
	Permitted Industrial Stormwater Facilities**	NA	NA	NA	NA	NA	NA
	Construction and Industrial Stormwater	0.25	0.00	0.25	0.00	0.00	0.00
	MS4***	NA	NA	NA	NA	NA	NA
	Total WLA	0.25	0.00	0.25	0.00	0.00	NA
Total LA		764.03	2.09	123.26	0.34	640.77	83.87
10% Margin of Safety^		NA	NA	NA	NA	NA	NA

* No permitted wastewater facilities within lake drainage area

** No permitted individual stormwater facilities in the CRW

*** No current MS4 communities within reach drainage area

^ 10% MOS was taken off of WQ target concentration and is implicit in the TMDL loading capacity



3 POTENTIAL MANAGEMENT ACTIONS

LimnoTech identified and assessed a range of potential management actions. These potential management actions were all targeted to make progress towards the primary objective of reducing phosphorus levels in the lake. Benefits to secondary objectives were also considered. This section presents a summary of the potential management actions, shown in Figure 11, their benefits, costs and other considerations.

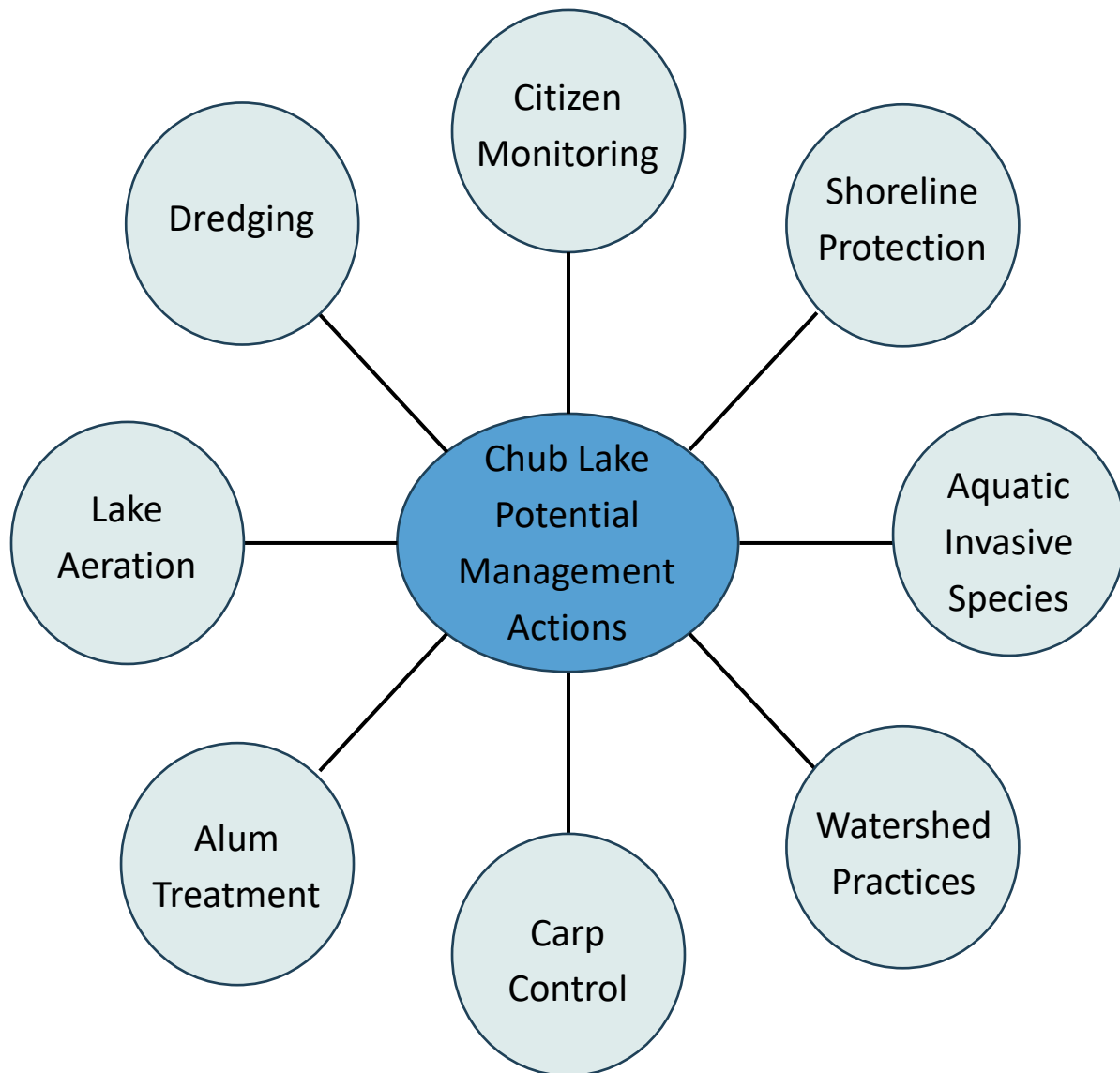


Figure 11. Potential Management Actions.

3.1 Citizen Monitoring

Description: Volunteer led water quality data collection and monitoring that typically includes measurement of physical parameters (dissolved oxygen, temperature, pH, and Secchi depth). Citizen monitoring can be expanded to include collection of grab samples and shipment to a laboratory for analysis of chemical parameters, such as total phosphorus, may also be included. Volunteers receive training and are provided with the necessary equipment. Monitoring is typically conducted at one location in the lake, often close to the deepest area of the lake. The frequency of monitoring is often monthly during the ice-out season but can be increased to bi-weekly or weekly, and may include monitoring during the winter, depending on the availability of volunteers and the data needs.



Benefits to Chub Lake: Citizen monitoring provides a low-cost solution for gathering additional data documenting the condition of the lake. These data can be used to assess compliance with water quality standards, evaluate trends over time, and assess progress towards the goals for the lake that is being made as a result of the implementation of management actions designed to reduce phosphorus loads. These data assessments play a critical role in the decision-making and implementation of an adaptive management plan.

Estimated Costs: The costs to support a citizen monitoring program may include:

- Purchase of monitoring equipment, including a sensor probe and meter for dissolved oxygen, temperature, and pH, and a Secchi disk: **\$1,750**
 - A variety of reputable brands are available including the YSI ProQuatro or Pro1020 and the Hanna Instruments Model HI 98196
- Sample kit (bi-weekly): **\$760 per year**



Additional Considerations:

- Volunteers would participate in a training course with Metropolitan Council Environmental Services (MCES) and commit to biweekly or monthly samples, April – October
- Collection of samples for dissolved phosphorus or orthophosphate during the growing season along with total phosphorus can be helpful in understanding nutrient cycling and bioavailability of phosphorus within Chub Lake. Additional support from MCES may be needed for collection and analysis of these samples.
- If walleye rearing is pursued as a potential use of the lake, extending the monitoring to year-round may be desired



3.2 Shoreline Protection

Description: Shoreline protection as a management action for Chub Lake primarily consists of maintaining a native vegetated shoreline condition along the water's edge that serves as a buffer between the lake and any type of developed land use or land disturbance on the property adjacent to the lake.

Chapter 120, Erosion Control and Stormwater

Management, of the Town of Eureka code includes requirements related



shoreline buffers and land disturbance activities for the North Cannon River watershed that apply to Chub Lake properties. Dakota County Ordinance 50 (Shoreland and Floodplain Management) applies to Eureka Township as well. Key requirements of Ordinance 50 that apply to shoreland areas, defined as anything 1,000 feet from a lake and shown on the map on the next page, are listed below:

- The removal of vegetation in shoreland areas requires a permit. Removal of vegetation is prohibited within the shore and bluff impact zones and on steep slopes/challenging soils.
- The pruning and trimming of branches are the preferred methods of obtaining views.
- Clear-cutting and intensive vegetation clearing within the shore and bluff impact zones and on steep slopes are not allowed. Intensive vegetation clearing for forest land conversion to another use outside of these areas requires a conditional use permit.
- In shore and bluff impact zones and on steep slopes, limited clearing of trees and shrubs and pruning and trimming of trees is allowed to provide a view to the water from the principal dwelling site and to accommodate the placement of stairways and landings, picnic areas, access paths, beach and watercraft areas and permitted water-oriented accessory structures of facilities, provided that:
 - Clear cutting is not allowed where soil, slope or other watershed conditions are determined by the zoning administrator to be fragile and subject to severe erosion and/or sedimentation.
 - All clear cuts must be conducted between September 15 and May 15.



Benefits to Chub Lake: The benefits of shoreline protection include reducing erosion, slowing and filtering sediment and nutrients running off into the lake, and maintenance of desirable terrestrial and nearshore aquatic habitat. Property values along the lake also benefit from maintaining a natural aesthetic.

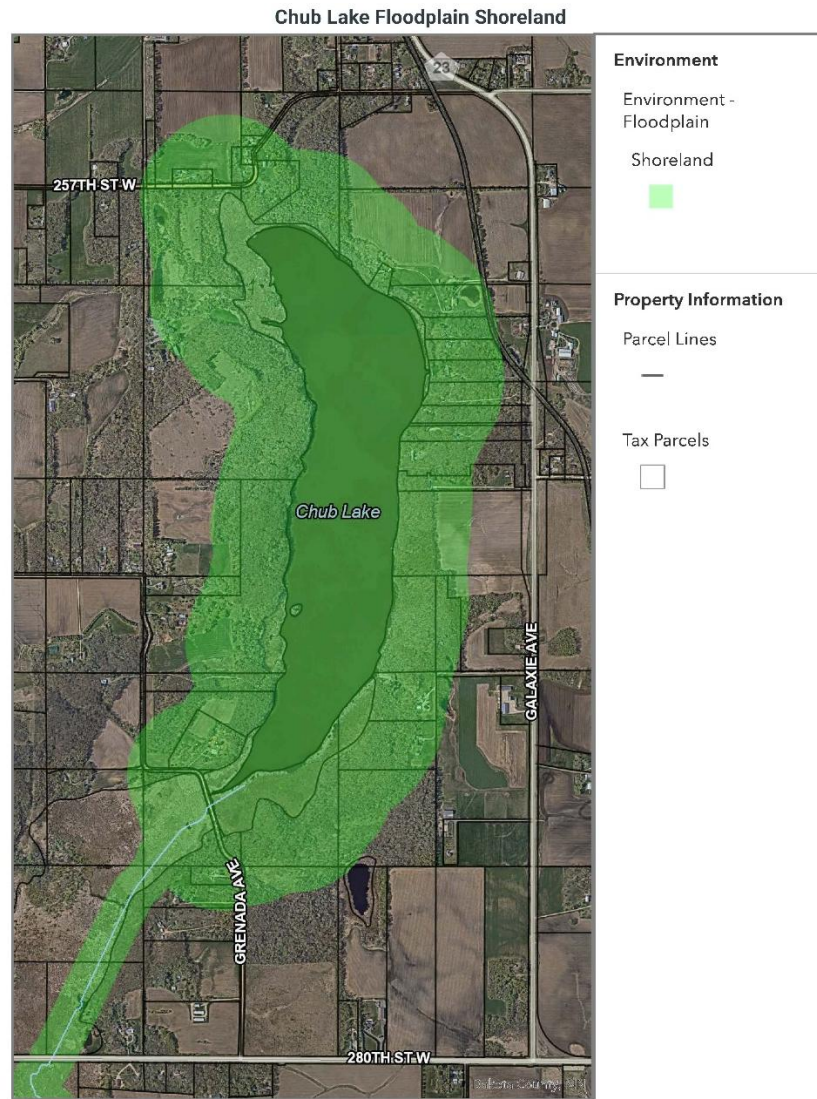




Estimated Costs: The shoreline along Chub Lake is currently maintained, to a large extent, in a natural vegetated condition. Minimal segments of shoreline have been altered on private properties. Therefore, maintaining the existing condition requires no additional cost for implementation, **\$0**. Continued monitoring of the shoreline to comply with Township code is recommended.

Additional Considerations: While the slopes and soils adjacent to Chub Lake are susceptible to erosion, the minimally disturbed condition and heavy vegetation protect the banks and shorelines

from erosion.



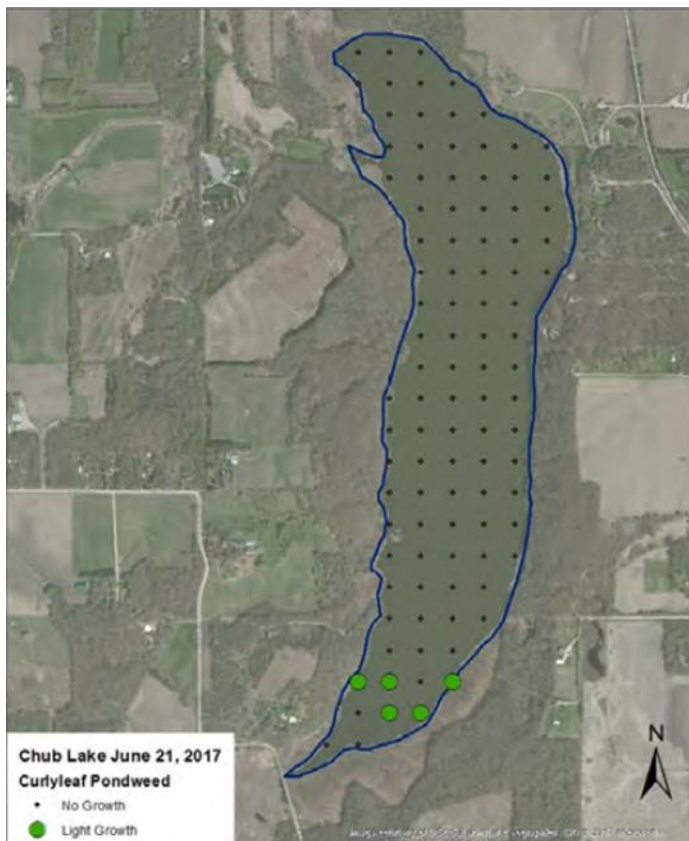
Dakota Disclaimer: Map and parcel data are believed to be accurate, but accuracy is not guaranteed. This is not a legal document and should not be substituted for a title search, appraisal, survey, or for zoning verification. Map Scale: 1 inch = 1600 feet 11/21/2025

Map of shoreline covered under Dakota County Ordinance 50



3.3 Aquatic Vegetation and Invasive Species Management

Description: Maintenance of a healthy community of native aquatic plants requires conducting surveys of aquatic vegetation conditions and identification of aquatic species, especially those considered as invasive species. When unhealthy aquatic vegetation is identified, or a growing presence of invasive species, additional management actions, such as herbicide applications, can be taken to control the spread of invasive species and restore a healthy aquatic vegetation community. The most recent aquatic vegetation survey of Chub Lake was conducted in 2017. Overall, the condition of the aquatic vegetation community is considered healthy. Curlyleaf pondweed, an invasive species that can contribute to phosphorus releases that stimulate algal blooms in mid-summer, is present but to a limited extent, roughly 5% of the lake area based on the survey results. Continuing surveys will inform adaptive management actions, such as treatments for curlyleaf pondweed.



Benefits to Chub Lake: Continuing surveys will inform adaptive management actions, such as treatments for curlyleaf pondweed.

Maintaining control of aquatic invasive species (AIS) proactively will help prevent an expansion of curlyleaf pondweed that may increase phosphorus releases in mid-summer. Control of curlyleaf pondweed is typically accomplished by herbicide treatments or mechanical/manual harvesting.



Curlyleaf pondweed

Estimated Costs: Aquatic vegetation surveys are recommended to be conducted every 5 to 10 years. The most recent survey was conducted in 2017, nearly nine years ago. A survey in the near future is recommended. The cost of a survey and associated reporting and recommendations is estimated to cost **\$10,000**.

3.4 Watershed Practices

Description: Watershed practices consist of best management practices (BMPs) on agricultural and developed land uses. For agricultural lands, BMPs can be focused on reducing phosphorus from leaving the landscape and entering Chub Lake. These types of agricultural BMPs commonly include nutrient management plans, tillage practices, cover crops, and buffer strips. On developed land, BMPs may include rain gardens, buffer strips, and reducing impervious surfaces.



Buffer strip from the BWSR website

Benefits to Chub Lake: The implementation of watershed BMPs, whether on agricultural land or developed land, has the potential to reduce phosphorus loads to Chub Lake. However, the watershed load of phosphorus to Chub Lake has been estimated to be a small percentage of the overall phosphorus load to Chub Lake. This is because:

- The ratio of the watershed area to lake area is small;
- A relatively high amount of forested land in the watershed (39.2%);
- The one tributary stream discharging into Chub Lake has substantial buffers in place and flows through a wetland providing filtering before entering Chub Lake; and
- The shoreline of Chub Lake is largely vegetated, providing filtering of direct runoff to the lake.

Therefore, while implementation of BMPs by all landowners within the watershed is highly encouraged, implementing BMPs by themselves will not reduce phosphorus levels in Chub Lake sufficiently to attain the goals.



*Rain garden from the MPCA
Stormwater Manual*

Estimated Costs: Estimated costs to support BMPs in the watershed are provided below.

- Agricultural land uses:
 - Nutrient Management Plan: \$10/acre
 - No-till: \$15/acre
 - Cover crops: \$70/acre
 - Edge-of-field buffer: \$150/acre
 - Maximum total cost for agricultural land uses: ~\$64,000
- Developed land uses: Less than 10% of the watershed area is characterized as developed. Even so, implementing BMPs is never a bad idea and provides an opportunity for landowners to contribute to good stewardship in the watershed they live in.
 - Rain gardens: \$1,000 - \$10,000+, depending on the impervious area contributing runoff and whether a do-it-yourself (DIY) approach (\$3-\$5 per square foot) or professional installation is pursued.

3.5 Carp Control

Description: Common carp are an invasive aquatic species. The presence of carp in a shallow lake can enhance the cycling of phosphorus present in lake sediment through two primary processes: 1) carp are bottom feeders, consuming organic matter containing particulate phosphorus, and then excreting dissolved phosphorus which is available for uptake by algae; and 2) carp foraging and spawning activities disturb lake sediments containing phosphorus, mixing surface sediments with deeper sediments, and reintroducing them into the water column. Carp control consists of the removal of existing populations and preventing future migration of carp into a water body. Removal can occur through harvesting, pesticide treatments or oral toxicants, or biological control such as stocking bluegill to prey on carp eggs, larvae and fry. Prevention can be accomplished using fish passage barriers and electric deterrence systems. Carp are known to be present in Chub Lake and have been the target of past removal efforts in the 1950s and 1960s. However, in the most recent fish survey in 1985 low numbers of carp were found. A fish survey targeted at understanding current carp populations is needed.



Benefits to Chub Lake: The removal and control of carp can result in reduced internal cycling of phosphorus from lake sediments, contributing to the primary objective for Chub Lake of reducing phosphorus levels. Carp control may also contribute to secondary benefits, such as improved water clarity and aesthetics, as well as an improved sport fishery.

Estimated Costs and Resources Needed: The initial step related to carp control is for DNR to schedule and conduct a fish survey to understand current populations and inform potential steps for control.

Following assessment of the results of a fish survey, future steps to control may include installation of a fish barrier at the Grenada Ave. culvert outlets at the south end of Chub Lake or a location further downstream on Chub Creek. The cost for installation of a fish barrier is estimated to range between \$5,000 for barriers at the culvert to \$65,000 for a barrier across a downstream location.





Carp removal on Lake Stieger, Victoria, MN

Once a fish barrier is installed, removal of the existing carp population in Chub Lake will be needed. A feasibility study will be required to assess the various approaches to removing the existing population and decide on an approach that works best for Chub Lake.

Additional Considerations: If installation of fish barrier is considered, consultation with DNR and a permit issued by DNR are required. Fish barriers not only prevent passage of carp but other fish and aquatic animals as well. Also, fish barriers require ongoing maintenance including cleaning on a routine basis, especially during and following periods of higher flows. If biological control of carp is considered in the future as part of implementation of this adaptive Plan, installation of aeration systems will need to be considered to prevent winter-kill of the predator fish, such as bluegill.



Carp barrier on Johanna Creek, Rice Creek Watershed District

3.6 Alum Treatment

Description: Treatment of lakes with aluminum sulfate has been shown to be an effective management action to strip phosphorus from the water column and bind phosphorus in lake sediments. This results in reduced phosphorus releases from sediments, reducing the internal load.

Benefits to Chub Lake: An alum treatment has the potential to reduce the internal load of phosphorus to Chub Lake, directly contributing to the primary objective of reducing phosphorus loads from the primary source of phosphorus to the lake.

Estimated Costs: An initial cost estimate for alum was calculated using the available data and assuming treatment of the top 5 cm of sediment. The cost for a single whole-lake alum treatment is estimated to be \$1,500,000 to \$2,500,000.

Additional Considerations: In addition to the cost of an alum treatment likely making it an infeasible management action for Chub Lake, an alum treatment may have limited benefit if a carp population persists in the lake. Carp activity will continue to disturb sediments and mix surface sediment with deeper sediment. Therefore, frequent recurring treatments may be needed to maintain the reduced internal load resulting from an initial treatment.

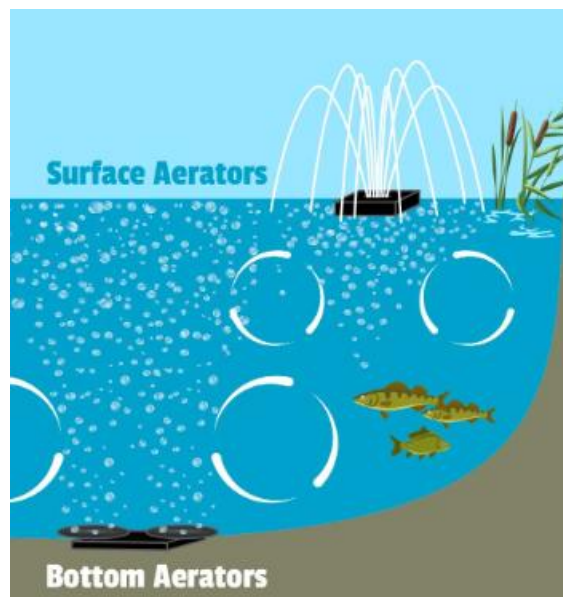


Alum treatment of Como Lake, St. Paul, MN

3.7 Aeration

Description: Aeration enhances mixing of the lake water column and improves dissolved oxygen levels. Aeration can be accomplished by a variety of approaches, commonly including pumping compressed air to the bottom of a lake. Mechanical systems such as bubblers, diffusers, or fountains are also commonly used aeration systems.

Benefits to Chub Lake: Aeration improves dissolved oxygen concentrations in a lake. Because phosphorus releases from lake sediments is typically triggered by low dissolved oxygen levels at the sediment-water interface, higher dissolved oxygen at the bottom of a lake will reduce the amount of phosphorus released from lake sediments. This result contributes to the primary goal for Chub Lake of reducing phosphorus loads to the lake. Aeration also helps to prevent winter fishkills. This can be important if a biological control, such as bluegills, is used to reduce carp populations.



Estimated Costs: The costs for an individual aeration system may run from **\$5,000 to \$15,000**.

Additional Considerations: The DNR has considered Chub Lake as a potential location for the rearing of walleye fry in the summers. This process begins in April, when DNR workers net spawning walleyes, strip the eggs and milt (sperm), and mix the two together. The fertilized eggs are then taken to the hatcheries, incubated, and hatched.

About two-thirds of the tiny fry (mosquito-sized walleyes) are stocked a few days after hatching. The rest are reared over the summer to fingerling size (4-6 inches) in more than 200 rearing ponds (winterkill wetlands and lakes). In fall they are netted and taken to lakes for



Lake aeration in Minnesota from the DNR aeration webpage

stocking. Because Chub Lake commonly experiences winterkill, it is a candidate to serve as a rearing location. Aeration, preventing winterkill, would conflict with a rearing program.



3.8 Dredging

Description: Dredging is the removal of sediments from the bottom of the lake. Dredging can be accomplished using mechanical dredging equipment resembling excavators. Dredging can also be accomplished with hydraulic dredging equipment that uses a cutter-head to loosen the sediments and a high-powered pump and pipeline to convey the sediments from the bottom of the lake to a dewatering basin.



Benefits to Chub Lake:

Dredging would remove the soft sediments from the bottom of Chub Lake, also removing the phosphorus contained in those sediments. This would reduce the amount of internal phosphorus load to the lake. Dredging would also deepen the lake, potentially improving habitat conditions. However, dredging greatly disturbs the existing habitat and vegetation conditions.

Estimated Costs: The cost to dredge Chub Lake is estimated to be between \$2,000,000 and \$20,000,000. This range accounts for a number of uncertainties, such as dredge depth, total area dredged, and disposal methods. This cost likely makes dredging an infeasible option for Chub Lake.



4 IMPLEMENTATION PLAN

Prioritization of management actions as part of an adaptive Plan for Chub Lake is critical due to the limited staff and financial resources. MPCA's adaptive water quality framework is presented in Figure 12 and this Plan generally follows this approach. The highest priority management projects for this adaptive Plan are listed in



Table 5. The actions generally fall into three categories: 1) conduct additional monitoring and assessments to fill data gaps, inform future direction, and track progress; 2) manage aquatic plant growth within the lake; and 3) reduce loads of phosphorus to the lake. This adaptive Plan should be reviewed on an annual basis using the information and knowledge developed from the previous year's implementation activities to inform priorities for the coming years.



Figure 12. MPCA's adaptive water quality framework.

Table 5. Implementation Plan for Chub Lake.

Action	Cost Estimate	Timeline and Frequency	Responsible Parties
Establish a Citizen Monitoring Program	\$1,750 for initial equipment purchase \$760 per year for sample kits	Solicit and identify volunteers in 2026 Train volunteers in 2026 Begin monitoring in 2026 or 2027 and continue annually	Partnership across MCES, NCRWMO, and citizen volunteers
Develop and Implement a Water Quality Monitoring Program	Will depend on the scale of the monitoring program	Develop a monitoring program in 2026 and begin implementation in 2027, conduct once every 3 years following	Partnership across NCRWMO, MCES, and DNR
Aquatic Vegetation Survey and Assessment	\$10,000	2026 and once every 5 to 10 years after	Contractor hired by NCRWMO
Fish Survey	Will depend on the scale of the survey	Once in in 2026 or 2027	DNR
Shoreline Protection	Continue to implement and enforce applicable ordinances, no additional costs	Continuously	Eureka Township and Dakota County
Watershed BMPs	\$5,000 to \$10,000 per year	Opportunisticly	Dakota County SWCD and NCRWMO
Review new information and data and revise Plan	\$5,000	Annually, beginning in the winter of 2026/27	NCRWMO



5 REFERENCES

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