CEDAR LAKE (Alcona/Iosco Counties, MI)

WATERSHED MANAGEMENT PLAN

2025 Update

(FINAL DRAFT for EGLE Review)

Submitted on behalf of the:

Cedar Lake Improvement Board
PO Box 53
Greenbush, Michigan 48738

August 26, 2025

Acknowledgements

This Watershed Management Plan (WMP) Update has been prepared for the Cedar Lake Improvement Board and the Alcona/Iosco Cedar Lake Association. It represents the progress to date following the State of Michigan and USEPA approval of the original 2011 WMP, documenting the monumental progress towards protecting and restoring Clean Water Act designated uses, as well as desired uses articulated by watershed stakeholders. Both the 2011 and this 2025 update were prepared by Kieser & Associates, LLC of Kalamazoo, Michigan working on behalf of the CLIB and Association.

The information in the original and this updated plan represents local and regional stakeholder input through a steering committee process. The steering committees were comprised of a variety of local stakeholders including township and county leaders, lake association members, property owners association, state natural resources staff, biologists, and other natural resources professionals. Their local knowledge of watershed conditions, public opinions, and general interest in improving and protecting the Cedar Lake watershed have contributed to the goals, objectives, strategies, approaches, and recommendations now collectively contained in this updated plan.

In particular, the steering committee participants and other individuals involved in this watershed management planning process would like to thank Cedar Lake property owners, the CLIB and Lake Association for investing in these efforts that began in 2008. The updated plan celebrates accomplishments and renewed strategies for natural resource protection and restoration in the Cedar Lake watershed for the next chapter of management efforts. These serve to protect and improve the lake, property values, and recreational value for generations to come.

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List of Acronyms

AICLA	Alcona-Iosco Cedar Lake Association (Lake Association)
AIS	Aquatic Invasive Species
AROS	Aquatic Resource Observation Site (formerly BOS)
BB	Briarwood Bay (water quality sampling station)
BMP	Best Management Practice
BOS	Biological Observation Site (presently AROS)
CLIB	Cedar Lake Improvement Board (Lake Board)
CLMP	MiCorps Cooperative Lakes Monitoring Program
DEQ	Michigan Department of Environmental Quality (presently EGLE)
DNR	Michigan Department of Natural Resources
EGLE	Michigan Department of Environment, Great Lakes, and Energy (formerly DEQ)
EPA	United States Environmental Protection Agency
I&E	Information and Education
K&A	Kieser & Associates, LLC
LSPOA	Lakewood Shores Property Owners Association
MCL	Maximum Contaminant Level
NOAA	National Oceanic and Atmospheric Administration
NPS	Non-Point Source Pollution
OTD	Oscoda Township Dump
SAD	Special Assessment District
SC	Steering Committee
SEAS	Superior Environmental & Aquatic Services, LLC
SP	Schmidt's Point (water quality sampling station)
TSI	Trophic State Index
UAL	Unit Area Load
WMP	Watershed Management Plan

CHAPTER 1: INTRODUCTION

A comprehensive watershed management plan (WMP) represents the framework where watershed needs and solutions are identified to preserve, protect, and restore water quality and natural resources around and within Cedar Lake. The WMP is not a regulation, ordinance or law, but rather serves as a template for justifying and developing such controls that may be needed. For many of the issues in the watershed, the WMP does not recommend regulatory action, but identifies voluntary efforts that the Cedar Lake Improvement Board (herein the Lake Board), the Alcona-Iosco Cedar Lake Association (herein the Lake Association), and other interested groups should pursue. The approved and updated 2025 WMP will continue to serve as a road map toward achieving community goals for sustaining Cedar Lake and its watershed.

The updated WMP has seven chapters:

1) **Introduction to the WMP** development and technical update processes and components
2) **Background on the Cedar Lake watershed** and its resources
3) **Designated and Desired Uses** in the watershed
4) **Pollutant source concerns, threats and impairments** identified and assessed
5) **Pollutant sources** linked to water quality
6) **Goals, Objectives and Milestones** for the watershed, and assessing progress
7) **Implementation Strategies** recommended for WMP prioritization, with detailed approaches and potential implementation projects for protection and restoration

The WMP also prioritizes the necessary approaches and improvement projects in the watershed, based on impacts, timing, feasibility and funding considerations.

The WMP describes “critical areas” within the watershed where protection and restoration actions have been and should continue to be prioritized. Managing critical areas to minimize impacts from past, present, and future development such as drainage and diversions from Cedar Lake, increased nutrient and sediment loads to the lake or emerging pollutants of concern, is vital for protecting the Cedar Lake watershed, the lake and its resources. Watershed goals in the WMP were developed through an integrated analysis of the watershed threats and concerns, watershed designated and desired uses, and critical areas for protection. Updated watershed goals build on progress achieved or not yet achieved toward originally identified implementation project priorities, objectives and goals. Goals focus on both watershed and lake management needs.

Purpose of the WMP

Development of the Cedar Lake Watershed Management Plan began in 2008. The need for a comprehensive plan was initially realized following presentation of hydrologic study results to the Lake Association. The study’s findings revealed that land development and installation of a drainage system on the southeast side of the lake was a major source of water loss from the lake during summer months. In addition, the study identified the wetlands complex in the northwest part of the watershed as the critical and predominant source of water recharge for Cedar Lake, through both groundwater and seasonal surface water inflows. Severe water level losses through the summer recreational season, particularly in low rainfall years, was the primary issue driving interests in assessing and mitigating factors impacting these lake level conditions.

Land use change, such as historic development on the southeast side of the lake and its resulting impacts through drainage, demonstrated to the Lake Board that a watershed management planning process for the Cedar Lake watershed and its recharge areas was necessary to protect the lake. In addition to the findings of the hydrologic study, several other undesirable conditions in the watershed worked as drivers to create a WMP. The Lake Board noted several water quality and resource concerns requiring management approaches for critical areas and conditions in the broader watershed.

Invasive and nuisance aquatic vegetation was exponentially increasing in the lake and residents were noticing the negative impacts on recreation and aesthetics demanding action. Fisheries and hydrology studies both indicated that flows from the tributaries and related fish-spawning habitat showed declining conditions. The flux of summer lake levels was creating problems with re-suspension of muck sediments and reducing functional aquatic habitat and recreational uses. The final issue that initially created demand for developing a WMP was the lack of a cohesive plan to address water resource and lake management needs and opportunities.

The WMP was developed through a Steering Committee-driven process that included local, regional, and state of Michigan agency representation as well as lake and watershed stakeholders. The WMP was published in 2011 following approval by Michigan Department of Environmental Quality (DEQ) and US Environmental Protection Agency (US EPA), meeting EPA 9-elements requirements for WMPs. Since then, completion of several WMP implementation projects have advanced progress toward WMP goals and objectives.

In 2021, the Cedar Lake Improvement Board approved the WMP technical update process to specifically evaluate progress toward original objectives, re-identify watershed threats, concerns, and critical protection areas, and to establish and prioritize future implementation projects. This 2025 WMP technical update effort assesses progress toward WMP goals and objectives, building on nearly a decade of improvement efforts, for the purpose of reassessing and addressing both ongoing and emerging watershed issues.

Watershed Management Plan Technical Update Process

Details of the original WMP planning and development processes, including public participation in WMP development, can be found in Attachment A, which excerpts the original WMP Chapter 1 text in full. The Cedar Lake Improvement Board and Alcona-Iosco Cedar Lake Association led the original WMP planning and development processes with Kieser & Associates, LLC (K&A) providing technical consulting, facilitation assistance, and authorship of the WMP. A WMP Steering Committee was formed to guide WMP development and included a broad set of stakeholders. Public participation was solicited on multiple fronts, as described in Attachment A.

Following more than a decade of implementation projects and efforts undertaken following the guidance of the original WMP, the Cedar Lake Improvement Board decided to initiate a WMP technical update. The purpose of this update is to assess progress toward established goals, objectives, and milestones, and to re-establish new priorities for future watershed improvement projects. The Lake Board approved the WMP technical update contracting with K&A to

facilitate the process, with 2024 Lake Association support and Steering Committee meetings beginning in Spring 2025.

The WMP technical update process began with an assessment of Cedar Lake watershed conditions and changes since 2008, including those resulting from implementation of WMP projects. The Cedar Lake WMP website was updated with technical reports and summaries to ensure these outcomes were publicly accessible.[1] The preliminary review included assessment of outcomes for all known watershed improvement implementation projects and progress toward stated WMP goals and objectives, including efforts towards each WMP objective.

During the WMP technical update process, the Lake Board renewed its Special Assessment District (SAD) in 2020 which forecast potential improvement project costs for the next ten years. These forecasted projects were integrated into the updated WMP implementation plan with accompanying details in Chapter 7. This approved project list therefore serves as the basis of many of the proposed improvement projects included in the WMP technical update. Chapter 7 also includes carry-over projects from the original WMP which have not yet been completed, or were partially completed but still recommended for implementation.

Important updates to the watershed management plan include:

- Descriptions of the watershed including hydrology, water quality and lake conditions.
- Assessments of watershed concerns, watershed pollutants, pollutant sources and causes including emerging contaminants, their current impact on Cedar Lake designated and desired uses and their priority status for WMP updated implementation
- Assessment of progress to date toward original WMP goals, objectives and milestones, as well as assessment of implementation tasks including:
    - Lake and watershed assessments, biological and hydrological monitoring, data collection efforts, implementation of several major wetland protection/hydrology improvements for fisheries habitat and lake level augmentation
- Implementation tasks, potential timelines and costs for each objective including new tasks as part of the 10-year Cedar Lake SAD planning, additional new tasks and WMP carry-over tasks that have been partially pursued or not yet pursued but remain relevant
- Information and education (I&E) tasks intended to support and promote WMP projects and watershed stakeholder awareness, interest, and engagement in improvement projects including opportunities for garnering both broad and specific public feedback
- Updated milestones for measuring progress toward new tasks for each WMP objective

To complete the process of an updated WMP, the following approach was pursued:

1) K&A shared initial Draft WMP materials with the Core Team for review, including Lake Board Chairperson Rex Vaughn, AICLA Chairperson Brian Vokal, and AICLA Chairperson Frank A Kramarz for draft review and feedback
2) K&A revised the draft with feedback, then provided updated implementation priorities to

[1] The Cedar Lake WMP website is accessible at: <www.cedarlakewmp.net>.

a WMP Core Group to prepare for Steering Committee (SC) meeting discussions around the updated WMP draft

3) The Core Group facilitated Steering Committee meetings on (a) Updated Implementation Priorities, (b) Discussions around the revised draft, and (c) an SC review of the final WMP with solicited public feedback
4) Submission of the WMP Technical Update to EGLE and U.S.EPA for review and approval

The Steering Committee for this updated WMP included:

Name	**Position/Affiliation**
Fred Strauer	Iosco County Drain Commissioner
Heather Tait	Oscoda Township Clerk
Tom Chatel	Oscoda Township Superintendent
Carolyn Brummund	Alcona County Commissioner
Jennifer Lueck	Lakewood Shores Property Owners Association
Tonia Brenk (alt)	Lakewood Shores Property Owners Association
Jim Martin (alt)	Lakewood Shores Property Owners Association
Cori Upper	District Health Department #2
Dave Schmidt (alt)	District Health Department #2
Teresa Salveta	Michigan EGLE
Jesse Campbell	Alcona County Road/Drain Commission
Mark Kieser	Kieser & Associates, LLC
Kurt Dalman	Natural Resources Conservation Service
Doug Pullman	Kieser & Associates, LLC
C. Lee Major	Greenbush Township Supervisor
Terry Dutcher	Iosco County Commissioner
Matt Klungle	Michigan DNR Fisheries
Russell Williams	Alcona County Conservation District
Rex Vaughn	Cedar Lake Improvement Board
Brian Vokal	Alcona-Iosco Cedar Lake Association
Frank Kramarz	Alcona-Iosco Cedar Lake Association

CHAPTER 2: WATERSHED DESCRIPTION

An understanding of watershed characteristics is essential for making management decisions to improve problem areas, maintain good conditions and protect critical areas. Several Cedar Lake watershed projects and studies undertaken prior to, during and since the development of the WMP in 2011 provided the original and 2025 Steering Committee with critical information for understanding important watershed features and their influence on lake conditions. Studies and projects undertaken since the 2011 WMP have achieved progress toward stated watershed priority goals and objectives. These achievements have set the stage for a new suite of potential implementation efforts based on updated goals and objectives, now re-established and re-envisioned for the next decade. This chapter provides a detailed background of the natural and geopolitical features in the Cedar Lake watershed relevant to the WMP update and implementation. It relies on 2011 WMP information with relevant updates.

Physical and Natural Features

The Cedar Lake watershed is located in the southeast corner of Alcona County and the northeast corner of Iosco County. The area draining to Cedar Lake is located in the HUC 04070003-0406 and is approximately 3,613-acres in size. This 1,075-acre, high-quality lake is situated approximately 0.5 miles west of the Lake Huron shoreline and spanning north from the Township of Oscoda (Figure 2-1). Cedar Lake is approximately 5.9 miles long, averaging approximately 0.25 miles wide, and 0.5 miles at its widest point in the center. The lake is shallow, about 5 feet deep on average with a few limited areas as deep as 14 feet. The lake is used for boating, swimming, fishing, hunting, and wildlife viewing.

Land uses in the area immediately surrounding and directly draining to the lake are generally comprised of residential, recreational, transportation, forests, grasslands and wetlands. The main source of water recharge to Cedar Lake is the large wetland complex (cedar swamp) along the northwest side of the lake. The wetland is hydraulically connected to Cedar Lake via intermittent streams and groundwater recharge. Because the lake is perched above other surface features, nearly 75% of the surrounding lands to the southwest, south and east (including shoreline areas) do not drain to the lake.[2] This condition presents a unique influence on both lake water level and water quality.

The lake is primarily groundwater-fed, with two intermittent streams, Sherman Creek and a second unnamed stream known locally as Jones Ditch, contributing seasonal surface water inflows. These begin to flow during late winter months, with flows continuing into early summer and picking up again in autumn. These streams outflow from the wetland complex in the northwest part of the watershed and inflow to Cedar Lake (Figure 2-2). Several Cedar Lake Improvement Board projects have been implemented to restore beneficial hydrology to this wetland complex and enhance surface water inflows from Sherman Creek. More recently, culvert enlargement and lowering at W. Cedar Lake Road has beneficially enhanced the surface water connection between the northern contributing wetlands and the lake via Jones Ditch.

[2] Kieser & Associates, LLC. (2005). "Phase I - Final Report for the Preliminary Hydrologic Evaluation of Cedar Lake with Reference to Lake Levels (Alcona & Iosco Counties, MI)." *Prepared for the Alcona/Iosco Lake Association, July 15, 2005*.

Figure 2-1. Site vicinity map of the Cedar Lake watershed located in northeastern Michigan in Alcona and Iosco Counties.

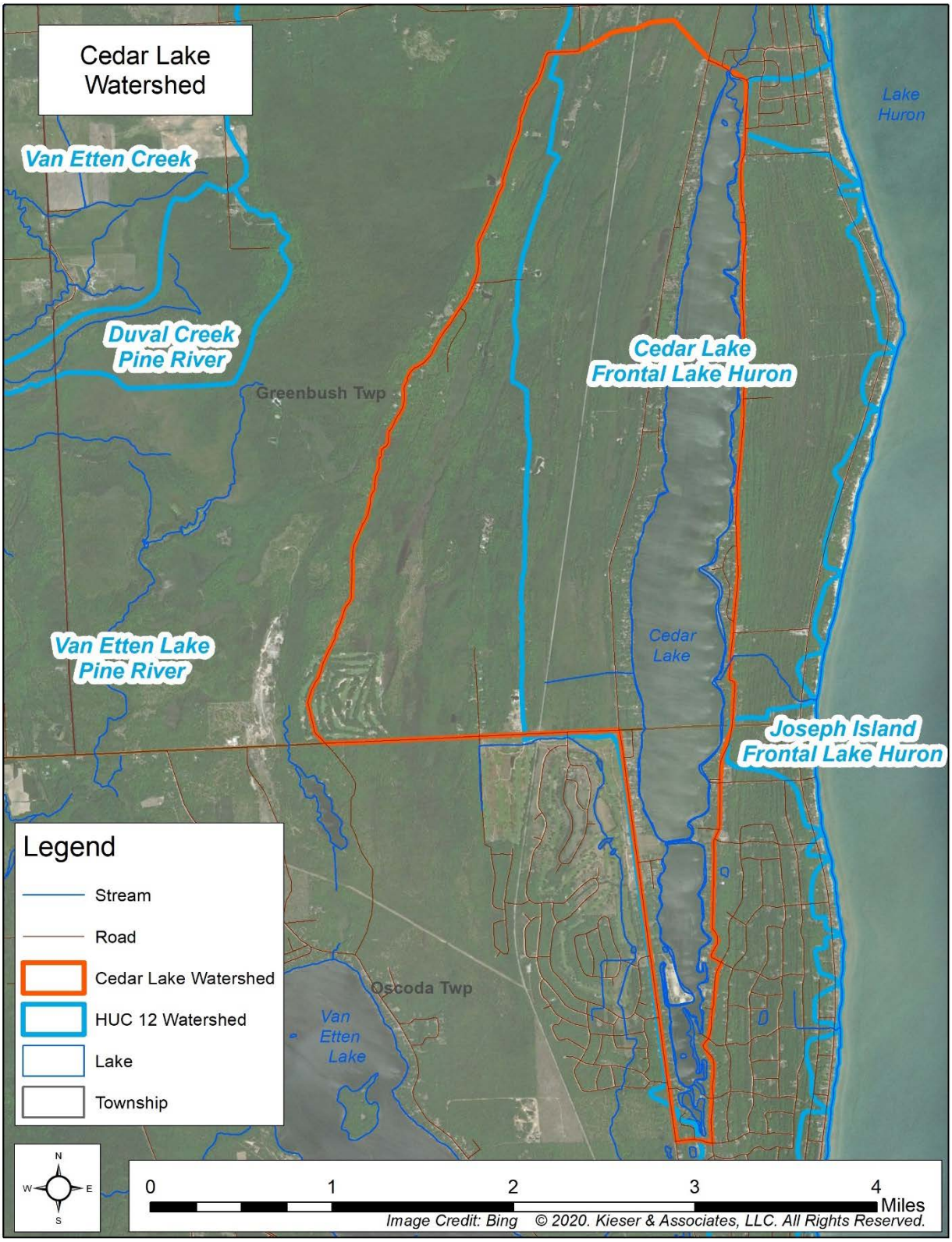

Figure 2-2. Map of the Cedar Lake watershed (in red). The watershed boundary represents the direct surface and groundwater areas contributing to the Lake.

The lake has an outflow structure at its north end to regulate the Cedar Lake water level. Originally constructed in the 1950s, the structure was replaced with a new outflow structure in the fall of 2020. Surface outflows leaving Cedar Lake through the outlet structure typically begin with late winter snowmelt and continue through late May. The Cedar Lake outflow discharges northeast to Lake Huron through an intermittent stream channel and wetlands complex.

Water levels in this shallow lake have historically dropped dramatically through summer months once lake outflow ceases. This is particularly evident during dry summer conditions with below average monthly rainfall. The issue has been a driver for several improvement projects as identified in the WMP. Because of the importance of recharge and groundwater influences on the lake, the shoreline and adjacent areas to the north, east and south that drain away from the lake but still require appropriate drainage and land use management. Surface and groundwater from these areas, as well as from the lake, eventually reach Lake Huron via the lake outlet stream, groundwater discharge, and stormwater underdrains.

The Michigan Department of Natural Resources (DNR) original mapping of the watershed boundary for Cedar Lake was published in the 1974 version of *Michigan Inland Lakes and Watersheds -- An Atlas*. This historic watershed boundary showed how the largest contributing area of surface water and groundwater is located around the cedar swamps toward the immediate northwest corner of the lake. It also illustrated that the entire lake perimeter contributed to the lake and including approximately 3,000 acres of direct surface drainage to the lake.

During early Cedar Lake hydrology studies of Cedar Lake, K&A delineated a new watershed boundary based upon surface and groundwater data from around the lake collected during 2003-2006.[3] The updated boundary, shown in Figures 2-1 and 2-2, reflects the 3,613 acres of land that contribute both groundwater and surface water to the lake from the northwest cedar swamp. One major difference is that in these northwest wetlands, the boundary extends further west to Poor Farm Road, and represents the only major drainage to the lake with very limited areas immediately surrounding the lake that are contributing. In a 2005 study, K&A found that groundwater moved away from the lake on the southwest, south and east sides of the lake beginning at the water's edge. These findings have been consistently confirmed through the K&A's subsequent annual monitoring that is reported annually. The southern and eastern watershed boundary therefore only includes the surface runoff from riparian properties immediately adjacent to the lake. All groundwater in these riparian areas otherwise drains away from the lake.

The immediate shoreline of Cedar Lake is primarily developed with residential homes, recreational and homeowner association properties and some natural areas. In addition to the developed areas immediately surrounding Cedar Lake, platted allotments with sparse housing are located just outside of the watershed in the areas immediately to the south and southeast, generally extending to the shores of Lake Huron. These areas are referred to as Lakewood Shores

[3] Kieser & Associates, LLC. (2005). "Phase I - Final Report for the Preliminary Hydrologic Evaluation of Cedar Lake with Reference to Lake Levels (Alcona & Iosco Counties, MI)." *Prepared for the Alcona/Iosco Lake Association, July 15, 2005*.

Subdivision.[4] A smaller, more recently platted housing development also exists to the immediate northeast of Cedar Lake. This area is referred to as the Timberlakes Estates Subdivision.

Although now developed for residential purposes, these areas once supported large tracts of cedar swamp. Platting, road development and housing construction in the south and southeast areas began in the 1960s, with additional subsurface drainage infrastructure constructed in the early 1980s. The latter has resulted in the substantial loss of cedar swamps. One unintentional but significant ramification of these activities was the lowering of the groundwater table adjacent to Cedar Lake that accelerates summer-month lake level losses.

Topography and Elevation

The overall change in elevation across the Cedar Lake watershed is very limited and gradual, resulting in less than 10 feet change in elevation from west to east. Beyond the eastern shoreline of the lake, topography slopes quickly to the shore of Lake Huron with a drop of 30 feet. The highest watershed elevations are found in the northwest section of the Cedar Lake drainage, which is approximately 636 feet above sea level. The point of lowest elevation in the watershed is at the lakeshore, which is approximately 608.2 feet above sea level.

The topography of the Cedar Lake watershed influences and determines the hydraulic routing of surface runoff to the lake. Figure 2-3 shows the elevation contours in the watershed, which generally slope away from the lake on the southeast and east sides, routing any surface water (and all groundwater) away from the lake towards Lake Huron.

Surface and Groundwater Resources

Cedar Lake is a shallow, mesotrophic lake approximately 1,075 acres in size. There are two main inlet creeks on the northwest side of the lake. The southerly inlet is Sherman Creek, a ditched channel located approximately 1,600 feet north of Kings Corner Road. This creek drains excess surface water from the cedar swamp on the west side of W. Cedar Lake Road into Cedar Lake. The northerly inlet is an unnamed channel (locally referred to as Jones Ditch) located approximately 1,750 feet south of the northern-most end of the lake. This channel also drains excess water into Cedar Lake from the cedar swamp on the west side of W. Cedar Lake Road.[5] These two creeks provide seasonal surface water inflows to Cedar Lake during spring following snowmelt, and flow intermittently through the summer depending on precipitation. Historically, during low rainfall years, inflows from these creeks have ceased as early as late May, remaining dry for several months. In wetter years, these creeks may flow more frequently into the early summer with recharge following rain events. Twenty years of flow monitoring, funded initially by the Lake Association and annually by CLIB, provide extensive records of these conditions.

[4] See: https://lakewoodshorespoa.com/

[5] Kieser & Associates, LLC. (2005). "Phase I - Final Report for the Preliminary Hydrologic Evaluation of Cedar Lake with Reference to Lake Levels (Alcona & Iosco Counties, MI)." *Prepared for the Alcona/Iosco Lake Association, July 15, 2005*.

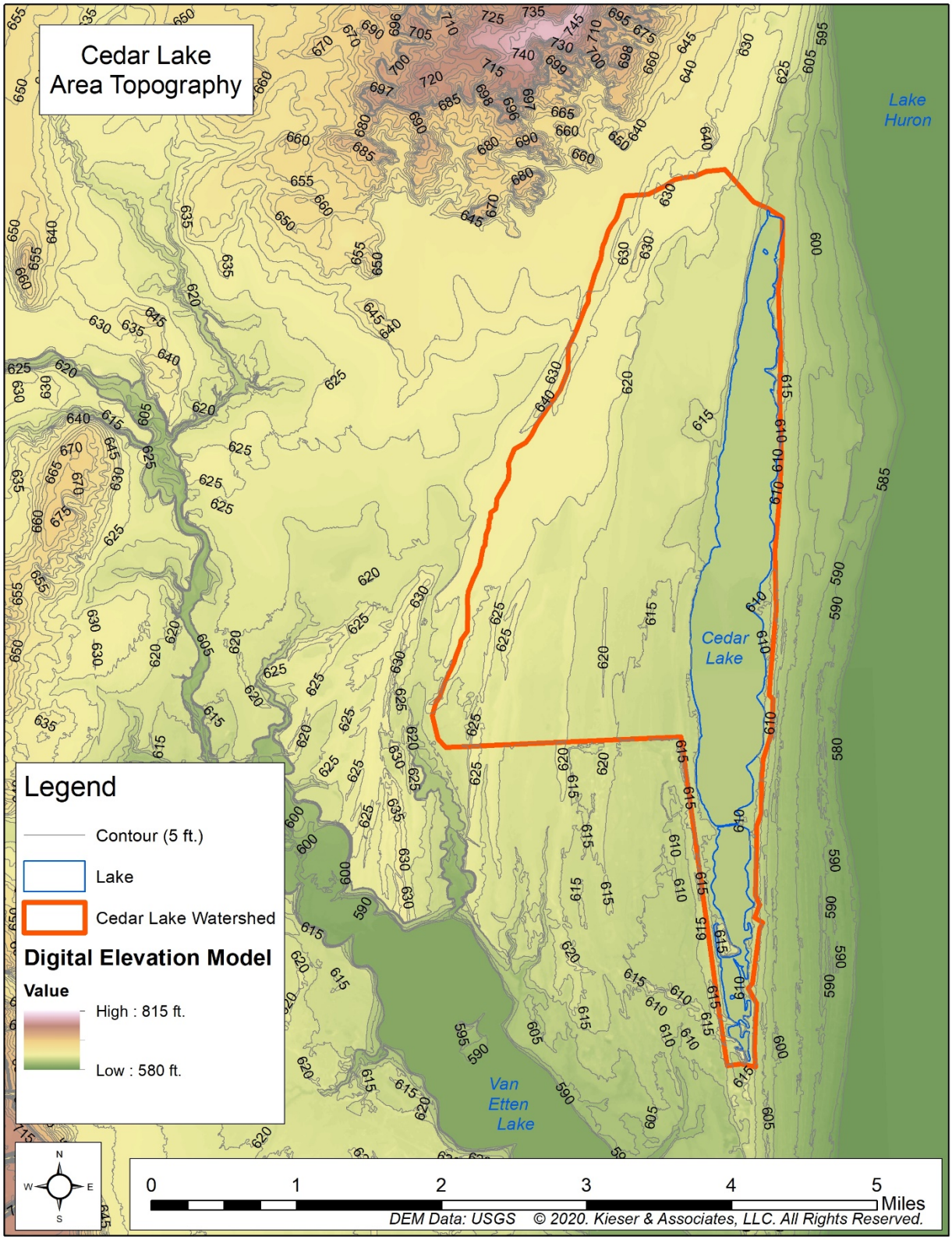

Figure 2-3. Topography of the Cedar Lake watershed from the national elevation dataset.

Cedar Lake has only one direct outlet at the northern end of the lake which impounds lake water and allows outflows above the legal lake level. A court order issued in 1954 established the legal lake level at 608.5 feet above mean sea level and states the lake level must be maintained by a suitable dam or spillway. The outlet historically consisted of two metal drop-box structures which were replaced by a single, fixed broad-weir outlet structure in 2020. Because of the court-established legal lake level, the weir structures had historically been set at an elevation to maintain the legal level. In preparation for the outlet structure replacement in August 2018, Spicer Group, Inc. resurveyed the historic structure "as constructed" on behalf of Alcona and Iosco Counties, and reported the actual structure elevation to be 608.2 feet (NAVD 88).

An October 2018 petition of the County Board of Commissioners for Alcona and Iosco Counties was therefore filed to correct the legal lake level to 608.2 feet. A Special Assessment Notice was issued in November of 2019 to notify residents of the planned reconstruction of the lake outlet structure. The Iosco and Alcona County Drain Commissioners, as the delegated authorities of the Cedar Lake Level District, held a public hearing on November 12, 2019 regarding this work. Design of the new outlet structure was managed by Spicer Group, Inc. and constructed by Team Elmers. The work was completed in October of 2020, with the new outlet spillway at the legal lake level of 608.2 feet.

Once outflow from the lake outflow passes over the outlet structure weir, it travels through a wetland area north of the lake before discharging to Lake Huron to the east. This outflow represents a direct surface water loss from Cedar Lake when water levels exceed 608.2 feet. Similar to its inlet creeks, the Cedar Lake outflow generally occurs during the spring for six to twenty weeks after snow/ice melt, depending on spring and summer rainfall amounts. Often during the summer and fall, no outflow is observed at the outlet structure due to the water levels dropping below the legal lake level.

K&A continues to monitor groundwater and lake levels; additional monitoring of outflows occurring at, and downstream of the new structure is recommended as part of the WMP Objective I (Chapter 7). Of particular importance is ensuring that the new structure will not contribute to greater losses of groundwater on the lake's north end. Figure 2-4 provides side-by-side image comparison of the old and new structures.

Figure 2-4. Historic Cedar Lake outlet structure, March 2017 (left) and newly constructed outlet structure November 2020 (right) (*Photo Source: Kieser & Associates, LLC*).

A road culvert beneath Kings Corner Road near W. Cedar Lake Road diverts watershed drainage from Cedar Lake. The culvert routes surface water from the Cedar Lake watershed south to the Van Etten/Pine River watershed via Phelan Creek. This is a diversion of surface water away from Sherman Creek and out of the Cedar Lake watershed. In 2006, the property on the north side of Kings Corner Road and west of W. Cedar Lake Road was clear-cut with the former owner's expressed intentions to convert this area to an RV park to support their golf course resort. This prompted the Cedar Lake Improvement Board's purchase of 138.6 acres of these parcels in 2014 and 2015 to avoid destruction of these wetland/upland areas. This provided the opportunity for the CLIB to install a wetland diversion berm on the newly obtained property to reduce out-of-watershed flows, redirecting these to Sherman Creek and in turn, Cedar Lake. Surface and groundwater resources found on the northwest side of the lake in the cedar swamp have implications for wildlife, fish habitat and spawning, recreational value, water quality protection, and water quantity benefits for Cedar Lake.

The groundwater resources of Cedar Lake are critically interconnected with these various surface water features. The CLIB has had an active water level monitoring program at groundwater and surface water monitoring sites around Cedar Lake since 2004. Water level monitoring has since expanded to include additional critical areas using automated water level logger equipment in lieu of intermittent volunteer measurements. Figure 2-5 shows the locations of all active groundwater and surface water level and temperature monitoring wells (piezometers) as of 2024.

Figure 2-6 illustrates the movement of groundwater in the watershed based on monitoring program data. Groundwater generally moves away from the lake on the east side, as well as the southwest side of the lake. On the east and southwest sides of the lake, surface water from the lake is being lost to the groundwater and the surrounding watersheds (Lake Huron and Van Etten/Pine River, respectively). Only the cedar swamp on the northwest side of the lake contributes groundwater to Cedar Lake (marked in green in Figure 2-6). The blue arrows on this figure indicate groundwater and lake water loss to the surrounding area.

To protect these critical watershed resources, several hydrology improvement projects have been undertaken in the northwest cedar swamp to help sustain late-spring and early summer inflow volumes from Sherman Creek. These improvements are designed to restore hydrology and improve retention and seasonal storage of critical recharge waters within the northwest cedar swamp while improving fish spawning habitat. An important aspect of these efforts was the Lake Board's purchase of critical wetland parcels within the cedar swamp contributing areas.

The Lake Board purchased critical wetland properties in 2014 (58 acres), 2015 (80.6 acres) and 2022 (10.9 acres). In 2014, the Improvement Board also convinced the Lake State Railroad operators to reduce blockages to seasonal wetland flows along their right-of-way through the northwestern Cedar Lake watershed. In Fall 2017, a major water retention effort to reduce out-of-watershed losses through the King's Corner culvert began, with construction of a wetland-enhancement berm parallel with King's Corner Road on the Lake Board property as noted previously. A groundwater monitoring station was installed at the upstream side of the berm spillway to measure its effectiveness at decreasing water losses through King's Corner culvert.

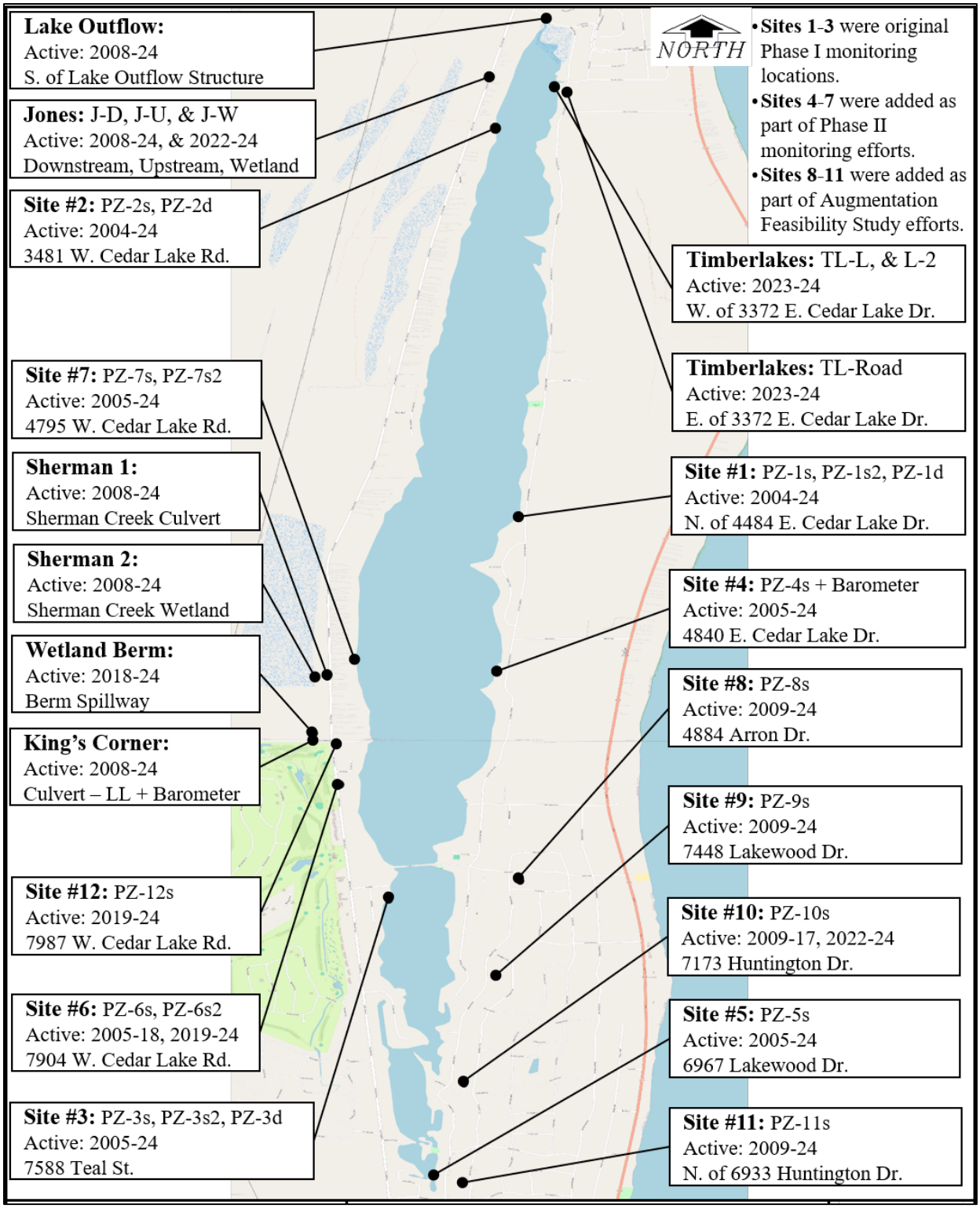

Figure 2-5. The 2024 locations of Surface and Groundwater Level Loggers for the Cedar Lake Hydrology Study, active since 2004.

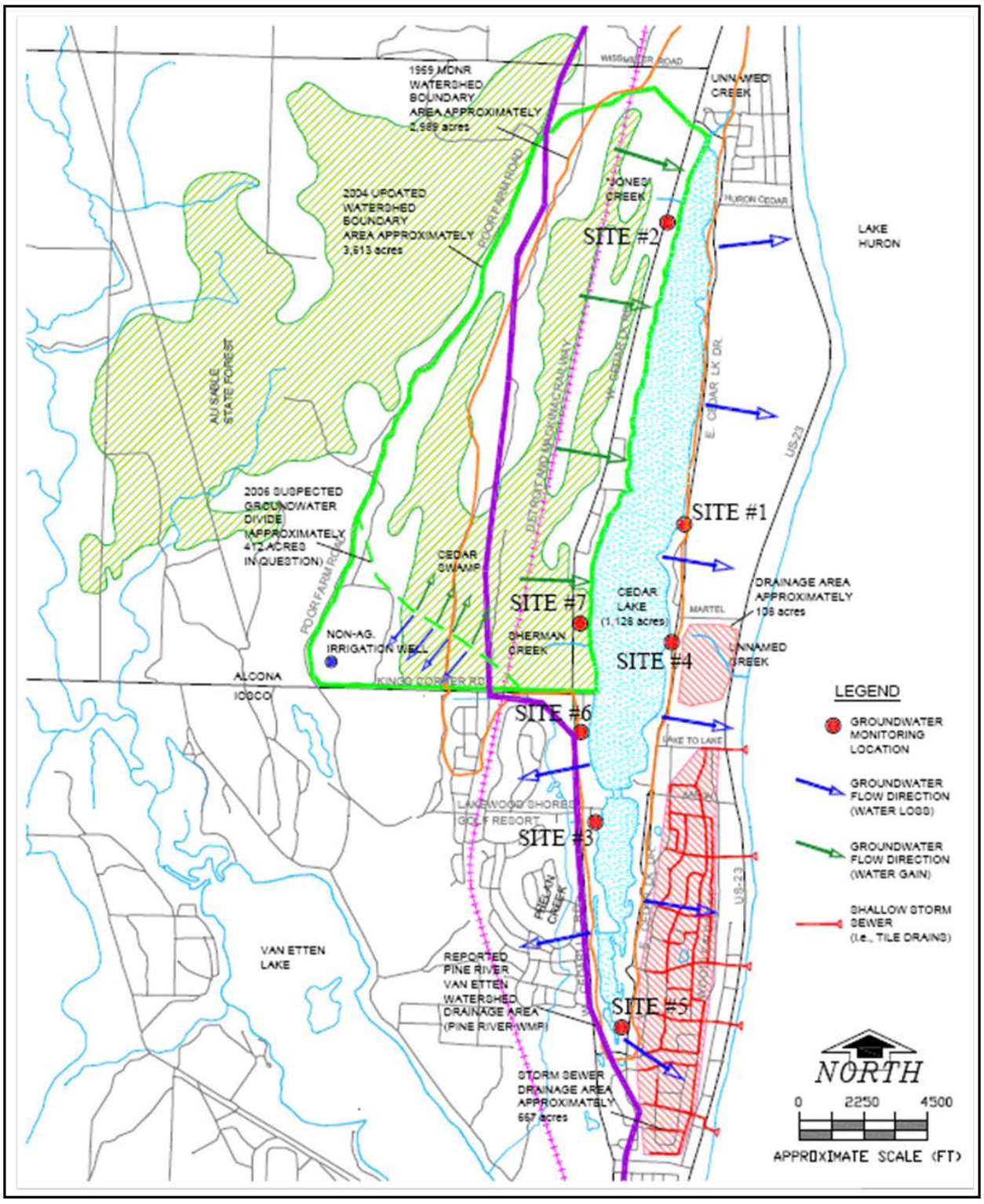

Figure 2-6. Losing and gaining areas in the Cedar Lake watershed and shoreline (*Source: K&A, 2006*)

Further improvements to water retention were undertaken in September 2019 with the permitting and implementation of Sherman Creek instream grade structures. Large stone instream grade structures were installed at approximately 50 ft, 100 ft, and 150 ft upstream of the Sherman Creek culvert at W. Cedar Lake Road. Following installation of these structures in October 2019, temporary instream stilling tubes were installed to monitor water levels at each grade structure. Monitoring of fish passage during spawning season is a recommended priority (Chapter 7).

Project objectives for these instream structures included: 1) delay Spring wetland discharges to Cedar Lake when lake levels are above the Cedar Lake outflow structure; 2) extend the timeframe of surface water inflows to Cedar Lake for a more naturalized water supply; 3) enhance groundwater recharge to extend groundwater contributions from this area to the lake, and; 4) improve pike spawning habitat in Sherman Creek and associated wetlands by extending wetted conditions in the creek and wetland during Spring flows.

Following these improvements in the Sherman Creek wetland area, hydrology monitoring on the west shore of the lake at Site 3 and Site 6, has also revealed that shallow groundwater is now moving toward Cedar Lake. From early spring to early summer, shallow groundwater gradients now tend mostly toward Cedar Lake, as groundwater is retained in the cedar swamp. Under near-average rainfall conditions in 2024 for example, groundwater flows at Site 3 and Site 6 showed strong gradients of flow toward Cedar Lake from spring to early-summer. From mid-June to November, shallow groundwater gradients still trended mostly away from Cedar Lake, toward Phelan Creek/Van Etten Lake showing groundwater loss from Cedar Lake occurring only during the late-summer months rather than year-round in this area.

Jones Ditch, further north in the northwest cedar swamp, is also an important surface water contributor to Cedar Lake. One-third of the Cedar Lake watershed surface flows associated with Jones Ditch have been impeded by historic infrastructure changes and thus, were not providing responsive hydrological and ecological needs for the lake. A 2017 Road Commission culvert replacement under W. Cedar Lake Road on Jones Ditch revealed how dramatic hydrology improvements can be with full restoration. Wet weather drainage flows are now nearly three orders of magnitude greater than with the previous smaller, perched road culvert. Furthermore, the Lake Board's purchase of a wetland parcel including the lower portion of Jones Ditch will allow for future hydrology improvements.

The culvert replacement provided hydrologic reconnection with 525 acres of the 1,305 Jones Ditch drainage (with 473 of these reconnected acres being contiguous wetlands). It provided nothing for habitat connectivity between these upstream wetlands and the lake because of the remaining degraded condition of Jones Ditch at the Cedar Lake shoreline. This highly-incised channel creates spring-time instream channel velocities that exceed 5 ft/second, creating a physical barrier to pike passage. Moreover, two drainage culverts under and active railroad line owned by Lake State Railway Company (LSRC) remain major barriers to flow from the remaining 780 acres of the 1,305-acre Jones Ditch drainage west of these tracks. Restoring full hydrologic connectively of these 1,305 acres of Jones Ditch drainage is necessary to stabilize summer-time water levels for recreation and fish habitat.

A 2025 Lake Conservation Grant application was successfully submitted and approved by the Midwest Glacial Lakes Partnership to address multiple aspects of these ongoing hydrology issues in Jones Ditch wetlands. Proposed project benefits will include a restored downstream channel to the lake, accommodating high quality flows and targeting pike spawning access improvements, naturalization of drainage pathways, and improved wetland habitat connectivity. These will directly benefit Cedar Lake water level stabilization and ecological connectivity.

Another important indirect water loss from the lake occurs through groundwater loss to shallow aquifers on the south and southeast sides of the lake, which act as subsurface wetland dewatering drains for shallow groundwater. Because of the impact of these drainage systems in the south and southeast, the groundwater impacts in this area increase surface water losses in dry summer months. In the 2006 K&A Phase II Cedar Lake hydrologic evaluation study, results indicated that approximately 39% to 44% of the annual groundwater loss in dry years could be attributed to the under-drain system in these areas, particularly in Lakewood Shores to the southeast.[6]

The mostly-undeveloped Timberlakes residential development on the northeast side of Cedar Lake has also been identified as a priority area for preventing future drainage issues such as exists due to subdrainages installed in Lakewood Shores. Recent hydrology monitoring has identified a northeasterly groundwater gradient flowing away from the lake in the Timberlakes district. These data will help to compare northeastern groundwater losses to the southeast residential district where subterranean drains already exist, and provide a basis for pre-emptive action to prevent further losses from potential future development in this area.

Water Quality

The water quality of both Cedar Lake and its inlet tributaries, Sherman Creek and Jones Ditch, is considered good to very good based on the low levels of nutrients and suspended sediments. Water quality has been monitored each season by volunteers as part of the MiCorps Cooperative Lakes Monitoring Program (CLMP) and other AICLA efforts, as well as by K&A during the biannual aquatic vegetation surveys.[7] Water quality parameters measured by AICLA indicate the lake is mesotrophic. Additional water quality information, including the most-recent CLMP report, is in Attachment B. Figure 2-7 maps the water quality sampling station locations that have been sampled for more than two decades: Schmidt's Point (SP) and Briarwood Bay (BB).

The CLMP volunteer program at Cedar Lake, following the state-run CLMP guidance and instructions, has collected phosphorus, chlorophyll *a*, and Secchi depth data at Schmidt's Point from 2001-2024 (no Secchi depth data at SP from 2014-2017). At Briarwood Bay, the CLMP volunteers collected Secchi depth data from 2001-2018 only. Phosphorus samples are typically collected twice per year (generally April and September) at SP. Chlorophyll *a* is typically collected once per summer-month each year. These data serve as useful indicators of lake conditions related to eutrophication, which can be a problem in shallow inland lakes in

[6] Kieser & Associates, LLC. (2006). "Phase II - Final Report for Additional Hydrologic Evaluation of Cedar Lake (Alcona & Iosco Counties, MI)." *Prepared for the AICLA, September 18, 2005.*
[7] The MiCorps CLMP Database is publicly accessible online: <https://micorps.net/lake-monitoring/>.

Michigan. CLMP-sampled phosphorus and chlorophyll *a* concentration data sets from Cedar Lake are shown in Figures 2-8 and 2-9, respectively.

Total phosphorus concentrations in Cedar Lake have been in the range of 2-14 µg/l and relatively stable since 2002. One exception is a recent sample from March 9, 2024, measuring 25 µg/l. Phosphorus samples from 2009 in Cedar Lake's tributaries, Sherman and Jones Ditch, showed concentrations at or below 15 µg/l. These phosphorus concentrations are relatively low for a shallow, inland lake. In general, these concentrations indicate that eutrophication is not a concern in the lake at this point. The fish biologist Gary Crawford, formerly working with the Lake Board, indicated that low nutrient concentrations measured during some years in Cedar Lake may actually limit the fishery.[8]

Chlorophyll *a* concentrations show a slight decreasing trend from 2002-2024, with a maximum of 7.0 µg/L recorded in 2004 (Figure 2-9). On average these concentrations are within the range expected in a mesotrophic lake. The AICLA has been tracking changes in chlorophyll *a* and total phosphorus and has noted slight decreases in concentration around 2006-2007 when zebra mussels started to appear in Cedar Lake. These invasive organisms filter substantial amounts of water and remove particles, such as algae. This filtering action can result in increased water clarity and lower chlorophyll *a* levels as noted in Cedar Lake.

Cedar Lake water clarity, as measured by CLMP volunteers using Secchi disk transparency, is charted in Figures 2-10 and 2-11. Volunteers measured Secchi depth at two points in the lake (SP and BB stations) from 2001-2018. Maximum depths to the lake bottom vary depending on the lake level at the time of sampling but are approximately 10 ft at Schmidt's Point and 14 ft at Briarwood Bay. With the exception of several measurements in 2013 and 2018 at SP, Secchi disk data shows an overall increasing trend in water clarity over the two-decade period.

[8] Alcona-Iosco Cedar Lake Association (AICLA). (2011). "Cedar Lake 2010 Water Quality Report." *March 31, 2011*.

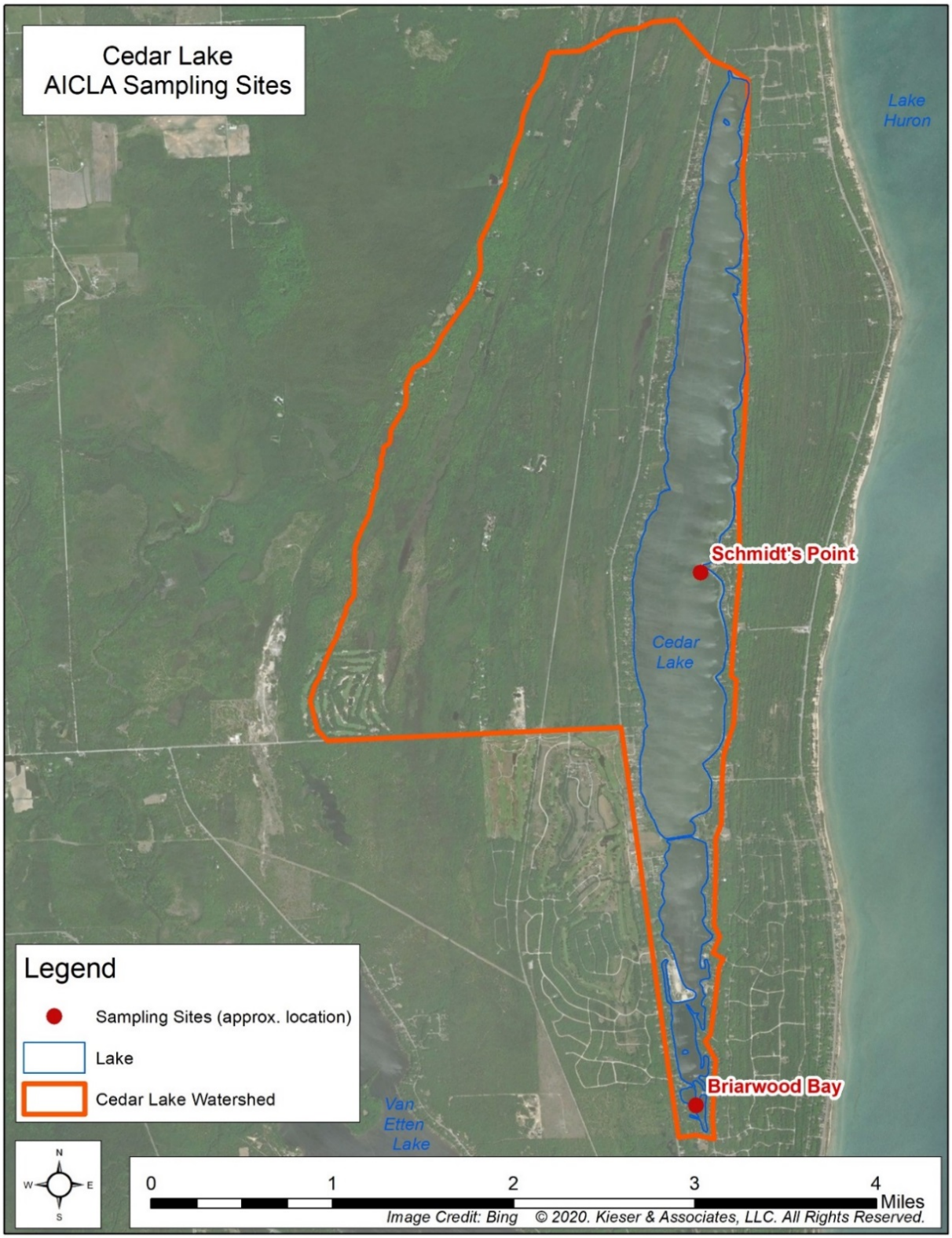

Figure 2-7. Approximate locations of Schmidt's Pointe and Briarwood Bay water quality sampling sites used by AICLA (*Source: Kieser & Associates, 2020*).

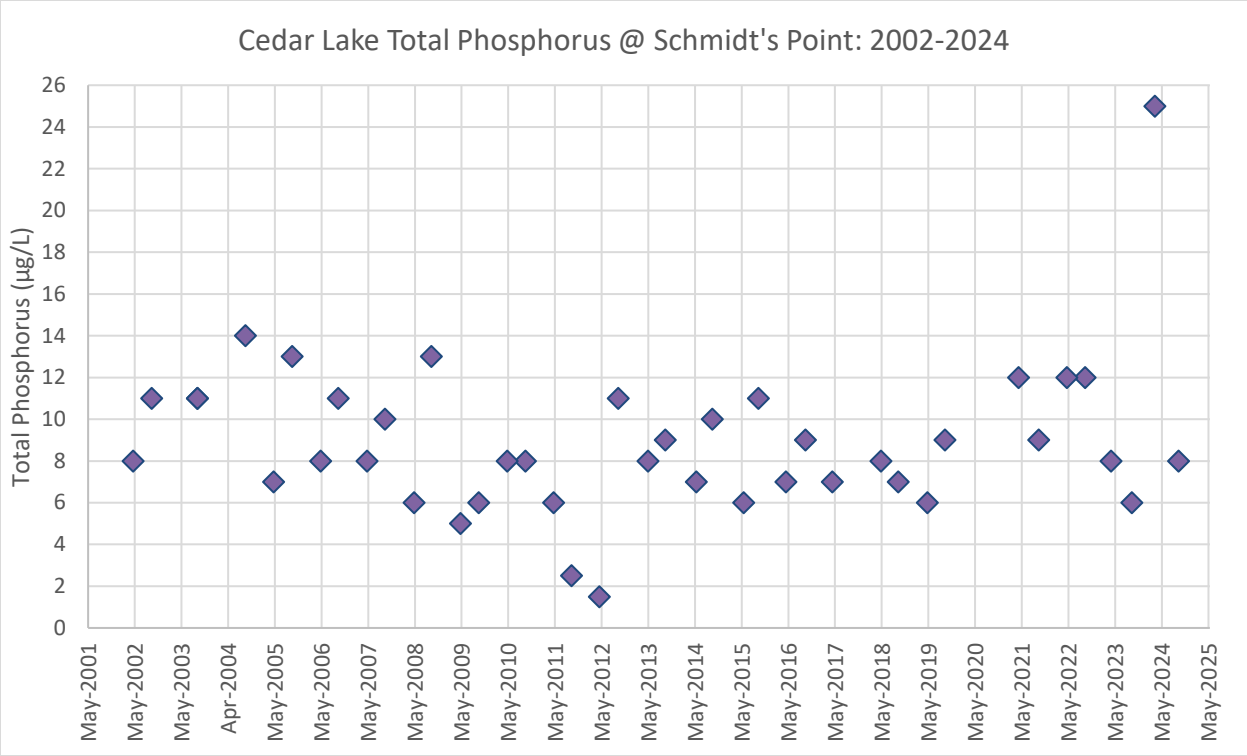

Figure 2-8. CLMP phosphorus data for Cedar Lake 2002 – 2024, collected at Schmidt's Point (Cedar Lake, Alcona County) (*Data Source: CLMP/MICORPS, 2025*).

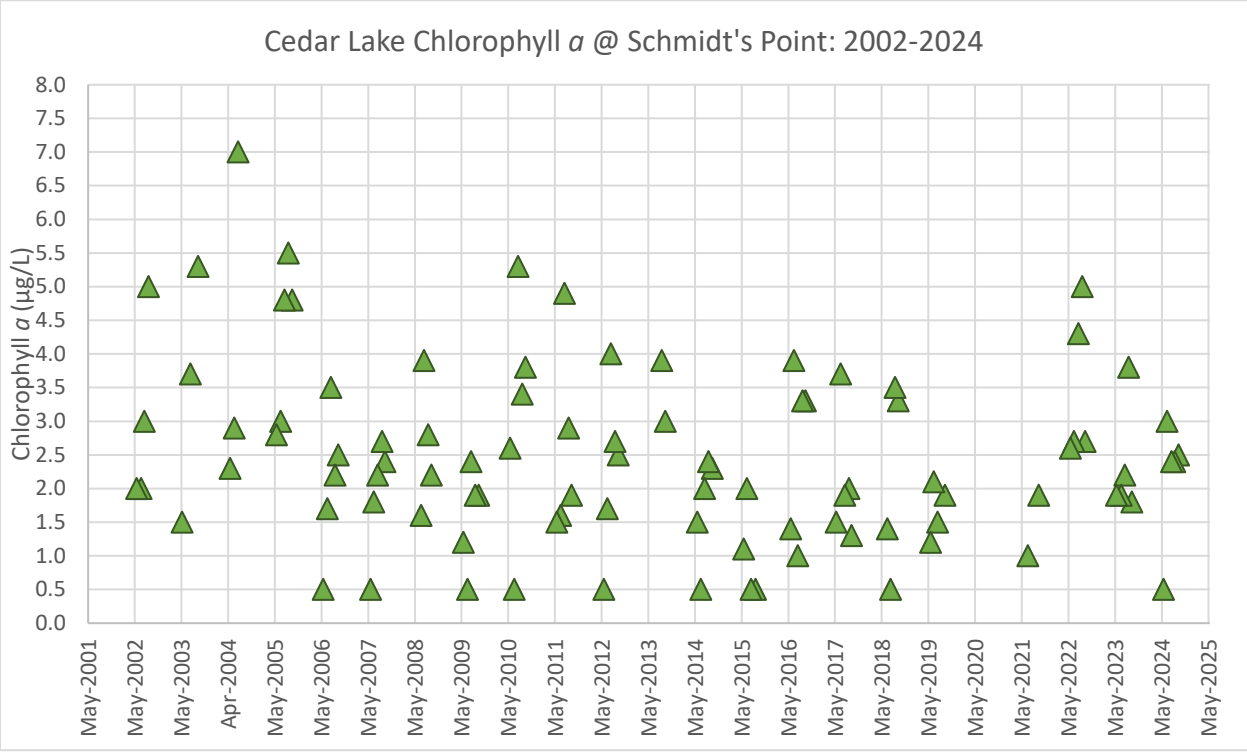

Figure 2-9. CLMP chlorophyll *a* data for Cedar Lake 2002 – 2019, collected at Schmidt's Point (Cedar Lake, Alcona County) (*Data Source: CLMP/MICORPS, 2025*).

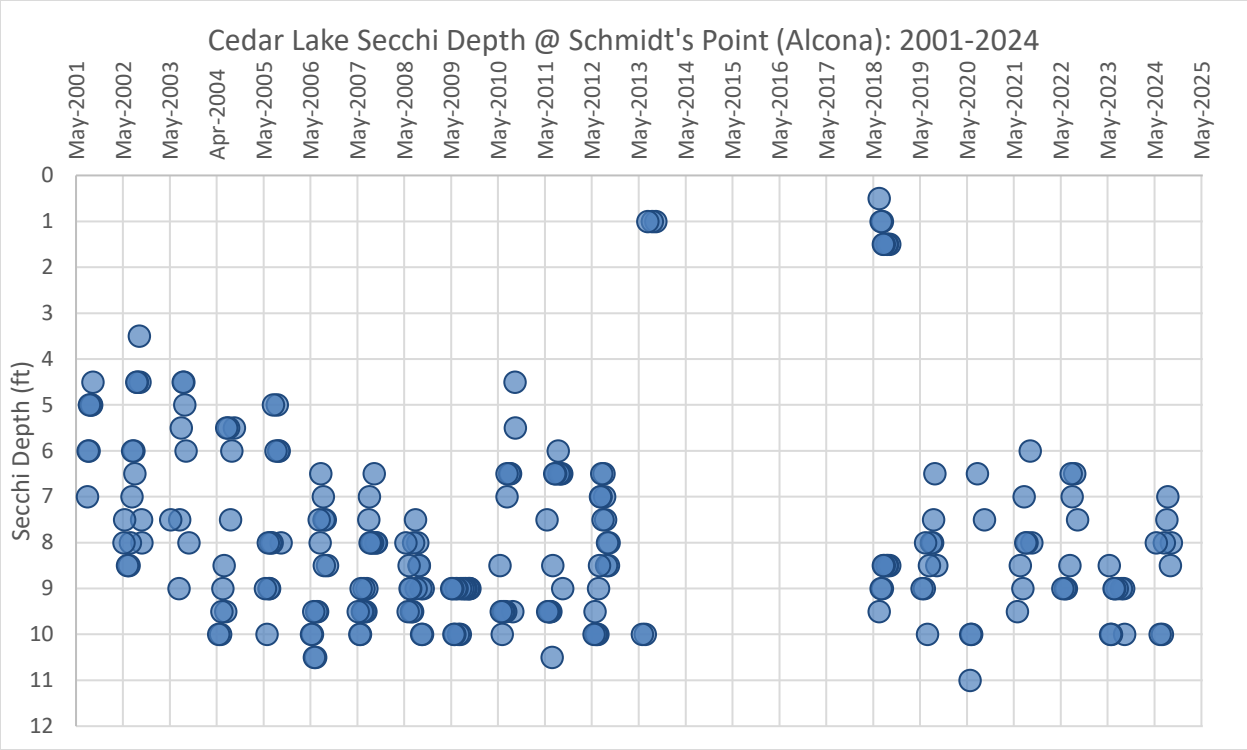

Figure 2-10. Cedar Lake CLMP data: Water clarity depth from Secchi disk measurements at Schmidt's Point, bi-weekly May-September (*Data Source: CLMP/MICORPS, 2025*).

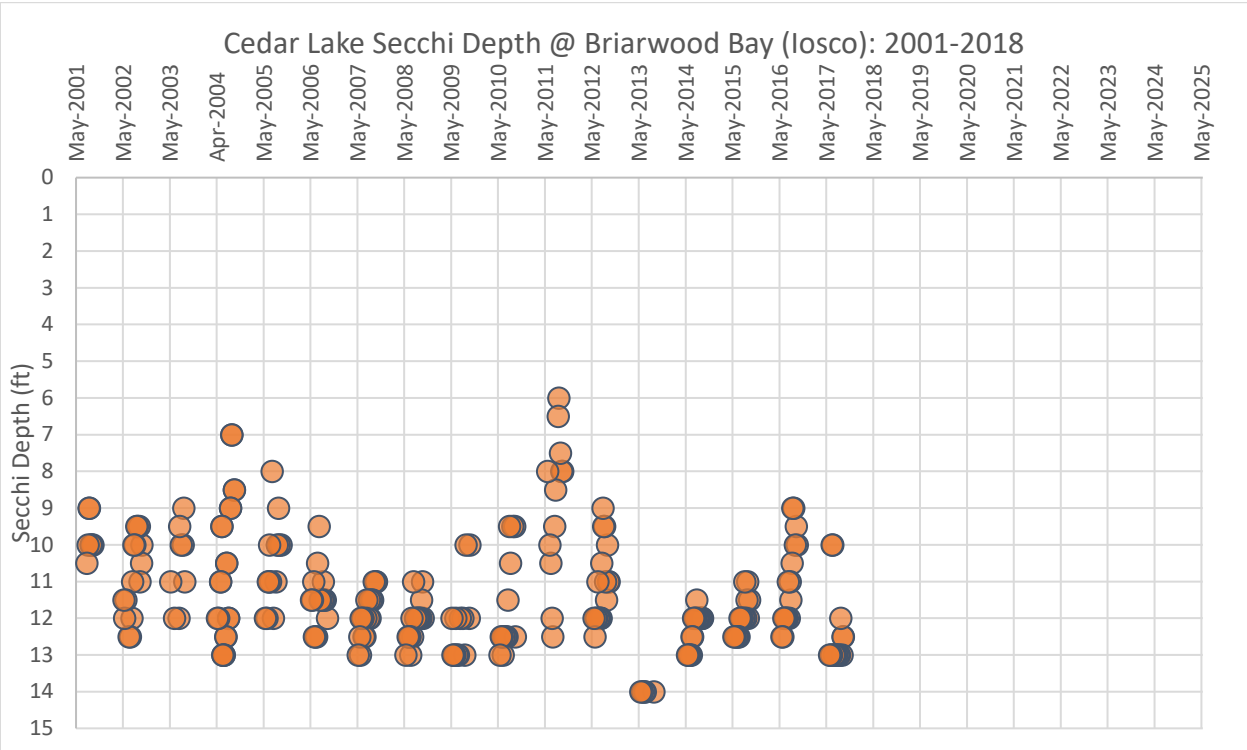

Figure 2-11. Cedar Lake CLMP data: Water clarity depth from Secchi disk measurements at Briarwood Bay, bi-weekly May-September from 2001-2018 (*Data Source: CLMP/MICORPS, 2025*).

The concentration of total suspended solids (TSS) is not directly measured in Cedar Lake. Results from limited TSS sampling that was conducted in April 2009 showed TSS concentrations in both Sherman and Jones Ditch and at the lake outlet were below the laboratory detection limit of 2 mg/l. These grab samples were collected during higher flows in the creeks and indicate that very little sediment is coming from the wetland complex on the northwest side of the Cedar Lake with very low in-lake concentrations as measured at the outlet. Turbidity was also historically measured in Cedar Lake as an indicator for monitoring solids.

Dissolved oxygen is not monitored by the AICLA because the lake does not become stratified during the summer. DO and temperature profiles are recorded by K&A, however, at each sampling station during each of the biannual aquatic vegetation surveys (typically late-June and late-August) (refer to Figure 2-12). The shallow depth of the lake and wind/wave action in the lake generally mixes the water column. Temperature and ammonia were historically monitored by the AICLA to track in-lake conditions for fish habitat and other aquatic species. Temperature and ammonia levels in Cedar Lake were found to be generally protective of fish, but temperature can become elevated at some points throughout the summer due in part to the lake's shallow average depth.

Figures 2-12 and 2-13 show the most recent five-year set of dissolved oxygen and water temperature profiles, collected by K&A from 2019-2024, for each of the sampling stations: Schmidt's Point (Cedar Lake North) and Briarwood Bay (Cedar Lake South), respectively.

From 2002-2009, water temperatures were measured by the AICLA or the Lake Board at five-foot depths at two points in Cedar Lake throughout the summer. As part of the Lake Board's hydrology monitoring program, continuous surface water temperatures have been recorded, during the summer recreation season from 2014 to the present at the lake outlet water level monitoring station. These temperature data are plotted in Figure 2-14. Comparisons of historic measured temperatures at the lake outlet show an overall increasing trend in water temperature since 2014. The highest summer-month surface water temperatures were recorded in 2021, and the largest range of water temperatures in 2024 (Figure 2-14). Cedar Lake water temperatures have not exceeded the State of Michigan standards for monthly temperature in Michigan inland lakes with one exception during an abnormally hot period in October, 2024 (see Figure 2-15).

Historic un-ionized ammonia levels for 2002-2009 were derived by AICLA from Florida Department of Environmental Protection Methods using pH, temperature and ammonia-nitrogen measured at the same points in Cedar Lake.[9] Un-ionized ammonia levels were computed and tracked by AICLA to watch for problematic levels that could harm aquatic wildlife. The levels in Cedar Lake have generally been low (below 0.02 ppm), but have been measured at higher levels (above 0.03 ppm) that are not desirable for some aquatic species.

[9] Florida Department of Environmental Protection. (2020). Division of Environmental Assessment and Restoration. Accessible online: <https://floridadep.gov/dear>.

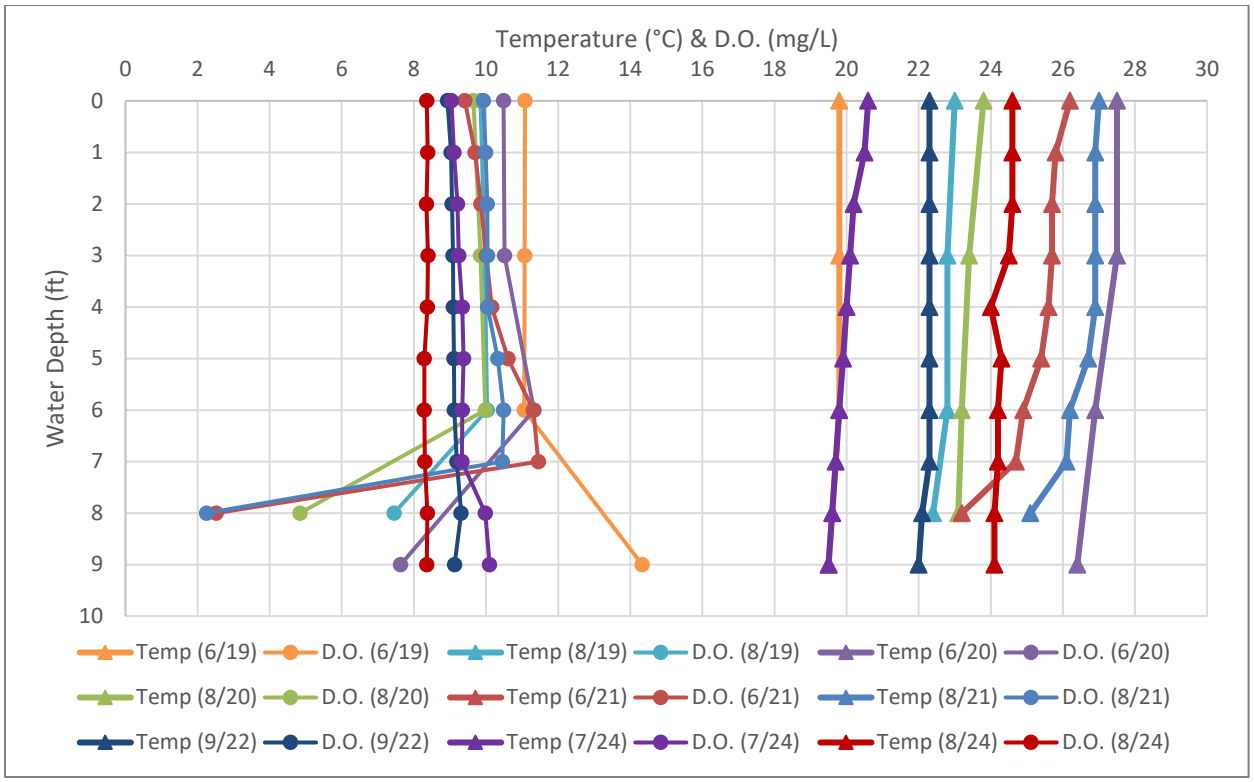

Figure 2-12. Dissolved oxygen and temperature profiles from 2019-2024 at Schmidt's Point.
***Note: Bottom measurements taken with probe in vegetation/sediment.* (*Data Source: Kieser & Associates*).**

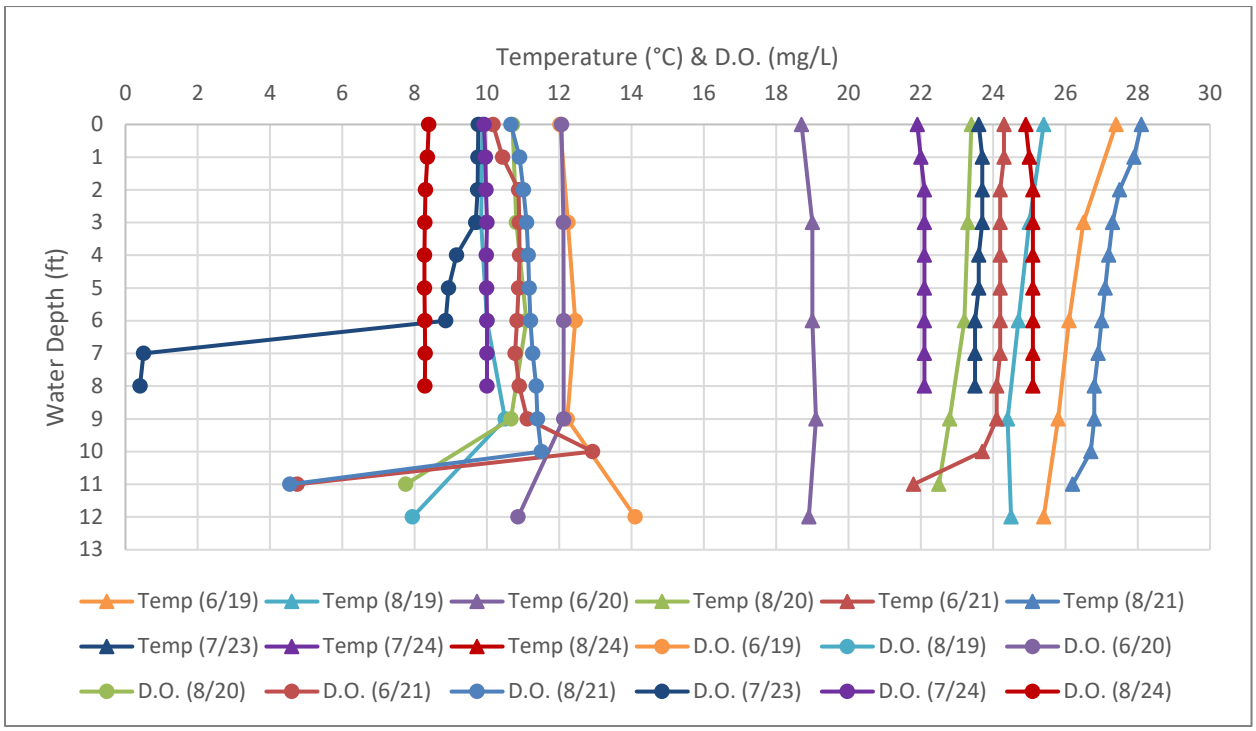

Figure 2-13. Dissolved oxygen and temperature profiles from 2019-2020 at Briarwood Bay.
***Note: Bottom measurements taken with probe in vegetation/sediment.* (*Data Source: Kieser & Associates*).**

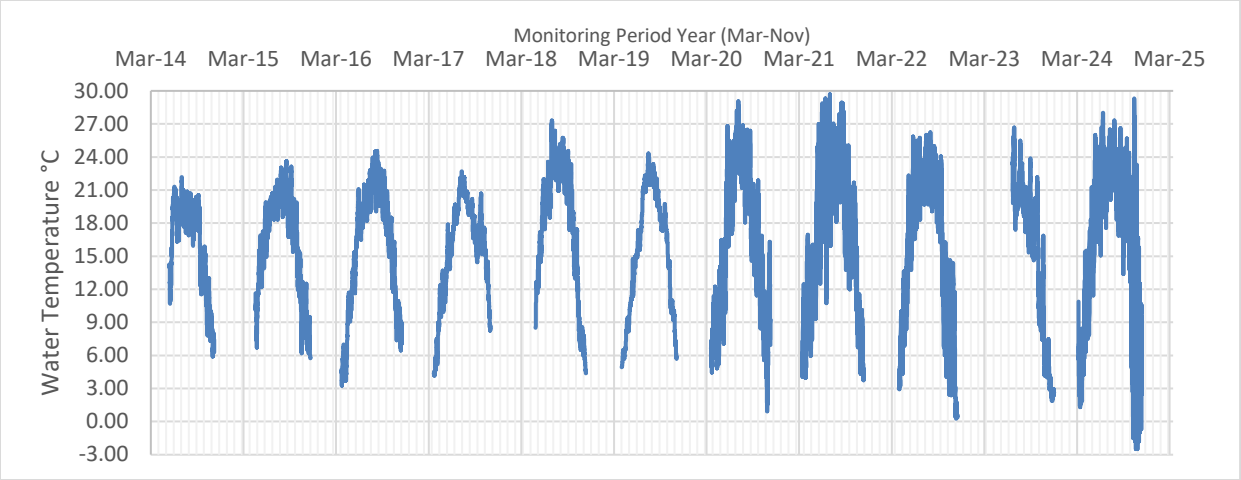

Figure 2-14. Cedar Lake Outlet water temperature during recreation seasons, 2014-2024.

E. coli sampling for Cedar Lake has been conducted by the District Health Department No. 2 since 2006. Samples are collected near the public beach at Greenbush Township Park (Lat: 44.53596, Long: -83.3266).[10] Because the program is grant funded, samples are collected based on available funds. Since 2006, samples have been collected either once per week or three times per week. Results are posted on the Michigan EGLE BeachGuard website and any advisories due to high levels of *E. coli* are posted on the District Health Department's website. Since 2006, no violations of State of Michigan water quality standards for total body contact recreation have been measured at Cedar Lake.[11] The AICLA also started to monitor *E. coli* levels in several locations in Cedar Lake in 2010. During their sampling investigation, no *E. coli* levels in exceeding water quality standards were measured.

Finally, water quality in the Cedar Lake watershed has been impacted by per- and polyfluoroalkyl substances (PFAS), a known contaminant of regional groundwater and surface water. A major nearby pollutant source, Wurtsmith Airforce Base (WAFB) has yet to be identified as a confirmed PFAS source for Cedar Lake. PFAS substances include PFOA, PFOS, and many other varieties of this man-made group of chemicals which persist in the environment and the human body, causing both water quality and public health concerns for the Cedar Lake watershed. The USEPA found evidence of adverse human health outcomes related to exposure to PFAS, particularly through ingestion leading to bio-accumulation in animals and humans alike. Studies have linked long term exposure to PFOA and PFOS to reproductive and developmental issues, adverse effects on liver and kidney and immune systems, and increased cholesterol, thyroid hormone disruption (PFOS), and cancer (PFOA).[12]

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[10] Michigan Department of Environmental Quality (DEQ). (2010). "Beach Guard." *Cedar Lake – Greenbush Township Beach.* Accessible online: <https://www.egle.state.mi.us/beach/BeachDetail.aspx?BeachID=2456>.

[11] Part 31 of the Natural Resources and Environmental Protection Act, 1997 PA 451, as amended; R 323.1062(1) states: "All waters of the state protected for total body contact recreation shall not contain more than 130 E. coli per 100 ml, as a 30-day geometric mean...[or] contain more than a maximum of 300 E. coli per 100 ml."
State of Michigan. (1994). "Natural Resources and Environmental Protection Act 451 of 1994. Accessible online: <http://www.legislature.mi.gov/documents/mcl/pdf/mcl-act-451-of-1994.pdf>.

[12] US EPA. (2021). "PFOA, PFOS, and Other PFAS." Accessible online: <https://www.epa.gov/pfas/basic-information-pfas#health>.

Water quality testing for PFAS regionally has been led by EGLE, and has shown several residential wells on the eastern side of Cedar Lake and groundwater samples on the southwestern and southern sides of Cedar Lake contained total PFAS concentrations between 10 and 500 ppt.[13] Expressions of PFAS contaminants in Cedar Lake have only occurred more recently, visibly identified through PFAS foam forming on the surface of the lake, as described in Attachment C. PFAS foams observed and confirmed on Cedar Lake were tested by EGLE in 2018 and 2020, showing increased concentrations of PFAS since 2018. Foam tested from Cedar Lake in 2020 revealed concentrations of 7,260 ppt. The 2020 PFAS foam sample did not include PFHxS, a component in fire-fighting foam, which if present, could have implicated Wurtsmith Airforce Base (WAFB) as a source of PFAS in Cedar Lake.

Between 2019 and 2021, the Lake Board contracted K&A to perform additional PFAS testing in the Cedar Lake watershed. In 2019, K&A sampled for PFAS in Sherman Creek surface water and in two shallow groundwater wells, one along Sherman Creek and one at the Jones Ditch culvert. In 2021, K&A sampled for PFAS in groundwater at 30-ft and 60-ft depths from the deep groundwater augmentation well just north of Sherman Creek. Additionally, in 2021, K&A sampled for PFAS in Cedar Lake sediments at eight distinct locations throughout the lake (see Attachment L). Lab tests for each of these events included analyses of 28 PFAS substances for each sample. All sample results from each sampling site of surface and groundwater, and sediment, were reported as non-detect by the analytical lab, Merit Laboratory of Lansing, MI.

Further investigation is needed to determine the sources of PFAS contamination to the Cedar Lake watershed; additional discussion is provided in Attachment C in these regards.[14] Potentiometric maps show that shallow groundwater flows away from Cedar Lake's south side, suggesting that the WAFB may not be a direct source of contaminants entering Cedar Lake by way of shallow groundwater exchange.[15,16,17] PFAS contaminants, however, have substantial

[13] Michigan EGLE. (2020). "Oscoda Area Conceptual Site Model." Accessible online: <https://www.michigan.gov/documents/pfasresponse/Oscoda_Area_Conceptual_Site_Model_July_21_2020_Presentation_697071_7.pdf>.
[14] Michigan EGLE. (2020). "Oscoda Area Historical Timeline." *Michigan PFAS Action Response Team*.
[15] Northeastern University. (2020). "Public SSEHRI PFAS Contamination Site Tracker." Accessible online: <https://pfasproject.com/pfas-sites-and-community-resources/>.
[16] District Health Department No. 2. (2020). "Media Release." Accessible online: <https://www.dhd2.org/wp-content/uploads/2020/06/2020-6-30-VEL-and-Cedar-Lake-foam.pdf>.
[17] Michigan DEQ. (2017). "Wurtsmith Air Force Base – Public Meeting." *Presentation by Susan Leeming (DEQ) and Michael Jury (DEQ)*. Accessible online: <https://www.michigan.gov/documents/deq/120617-presentation-MDEQ_608360_7.pdf>.

mobility and can be found in deep groundwater aquifers, as well as in atmospheric deposition of wind, rain, and snow.[18,19,20,21,22]

Climate and Precipitation

Seasonal climate and precipitation variables have a substantial impact on the Cedar Lake watershed, particularly in regard to maintaining the legal lake level. The National Oceanic and Atmospheric Administration (NOAA) climate monitoring site closest to Cedar Lake is the Harrisville 2NNE station. Figure 2-15 provides the NOAA-generated chart presenting daily temperature data for 2019 (in °F), from the Harrisville 2NNE station, graphed against the normal temperature range and historic maximum and minimum temperatures, for reference.

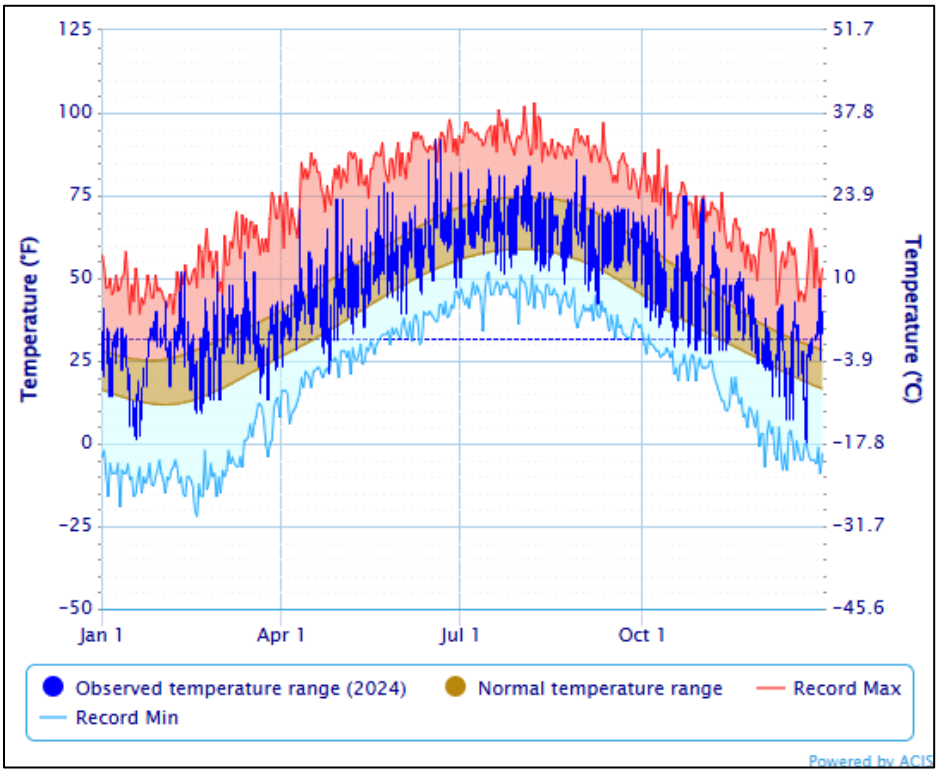

Figure 2-15. Harrisville 2NNE NOAA Weather Station: Daily temperature data from 2024 for the Cedar Lake region, with reference to the historic norm and record max and min temperatures (1971-2024). (*Graph Source: NOAA Harrisville 2NNE Weather Station, automatically generated*).[23]

[18] Dauchy, Xavier, *et al*. (2019). "Deep seepage of per- and polyfluoroalkyl substances through the soil of a firefighter training site and subsequent groundwater contamination." *Chemosphere: Vol 214, Jan 2019, 729-737.*
[19] Lieu, Yan, *et al*. (2019). "Contamination Profiles of Perfluoroalkyl Substances in Groundwater in the Alluvial-Pluvial Plain of Hutuo River, China." Accessible online: <https://www.mdpi.com/2073-4441/11/11/2316/htm>.
[20] Brusseau, Mark L., *et al*. (2019). "Comprehensive retention model for PFAS transport in subsurface systems." *Water Research: Vol 148, Jan 2019, pages 41-50.*
[21] Kim, Seung-Kyu. (2007). "Perfluorinated Acids in Air, Rain, Snow, Surface Runoff, and Lakes." *Environmental Science and Technology.*
[22] Northeast Waste Management Officials Association. (2018). "Atmospheric deposition as a source of contamination at PFAS impact sites." *Presentation by Christopher D. Zevitas, Sc.D. & Stephen Zembra, Ph.D., P.E.*
[23] National Oceanic and Atmospheric Administration (NOAA). (2020). "Harrisville 2NNE NOAA Weather Station: 44.65°N, 83.3°W (Elev. 597 ft)." Accessible online: <https://www.weather.gov/wrh/climate>.

Ambient temperatures impact Cedar Lake level conditions through their influence on evaporation rates, and the timing of snow accumulation and snowmelt which drive early-spring inflow and outflows. Ambient air temperatures also directly influence water temperatures on Cedar Lake. Water temperature in turn directly impacts fisheries and aquatic plant management in regards to identifying the most effective time to target AIS with management, as well as water temperature regulatory limits for chemical application (Attachment D).

Over the past two decades the regional average annual precipitation, including all available monthly data, was approximately 28.44 inches. Monthly precipitation accumulation and annual precipitation totals from the Harrisville NOAA station are graphed in Figure 2-16. Supplemental daily rainfall data is collected on the east side of Cedar Lake by a Lake Board volunteer during the spring to fall monitoring period. Each fall, these data are correlated and cross-checked with nearby precipitation monitoring stations to provide a best estimate of monthly rainfall for the summer months at Cedar Lake. In regard to lake levels, K&A's 2006 hydrologic study found that years with the same amount of annual precipitation did not necessarily show the same drop in lake level. Rather, rainfall amounts from June to September each year had the greatest influence on summer-month lake level fluctuations.

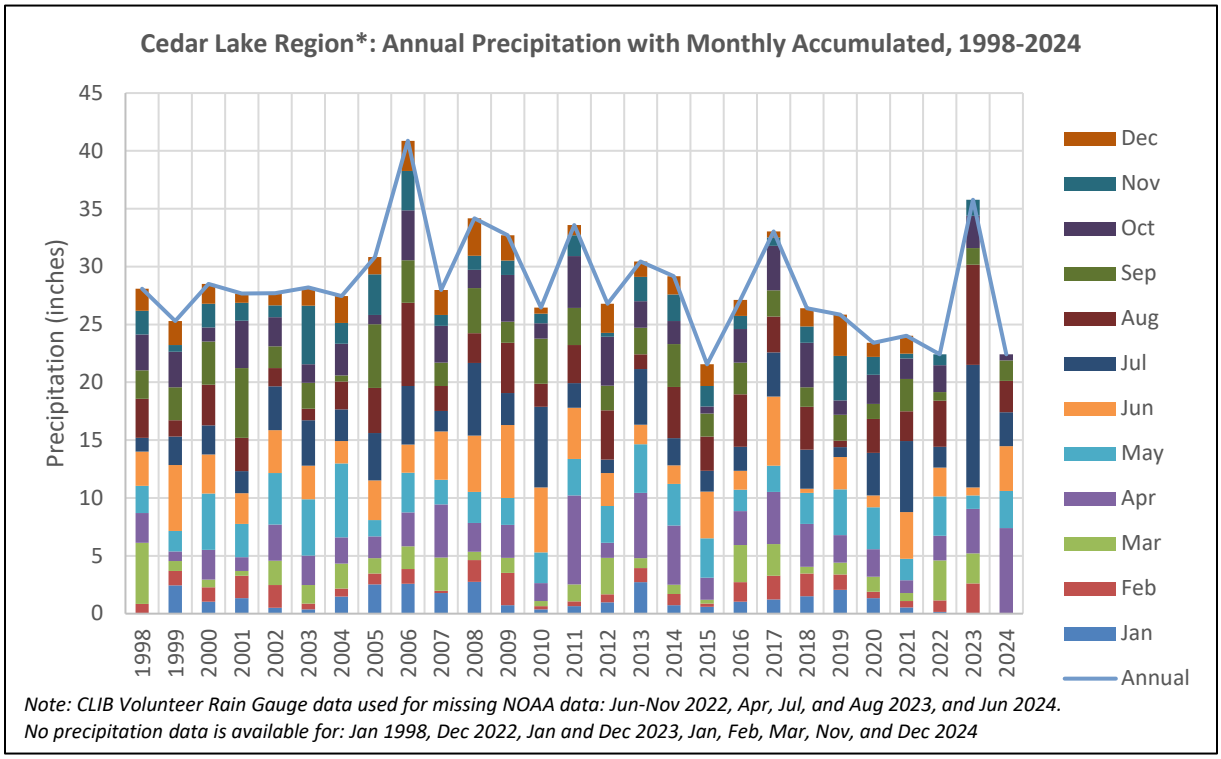

Figure 2-16. Regional annual precipitation totals and monthly accumulation for Cedar Lake from 1998-2024. (*_Harrisville 2NNE Station, Alcona County, MI, and CLIB Volunteer Rain Gauge_).[24]

[24] National Oceanic and Atmospheric Administration (NOAA). (2024). Accessible online: <https://www.weather.gov/wrh/climate>.

The 2011 Cedar Lake Augmentation Feasibility Study further investigated this assertion that lake levels substantially depend on summer precipitation amounts. It was discovered that to avoid a drop in lake levels exceeding 3 inches per month during the summer months of June to September, an average rainfall amount of 2.75 inches per month is required. Therefore, if rainfall is below 2.75 inches in any given summer month (June-September), a lake level drop of 3 inches or more is expected in that month. A summer average of 11 inches of rainfall (i.e., 2.75 inches multiplied by 4 months) is therefore used to assess the summer season as a whole in regard to desired lake level conditions. Summer month precipitation data are therefore compiled and published each year in K&A's annual hydrology reports. Summer month rainfall from June to September, which averaged 11.9 inches over the period 1998-2024, is presented in Figure 2-17.

Cedar Lake experienced less than 11 inches total of rainfall during the summer months of 1998, 2002-2004, 2007, 2012, 2013, 2015, 2019, 2020, 2022, and 2024. Summer month rainfall was below the 26-year average of 11.9 inches during each year 2017-2020, 2022, and 2024. Summer rainfall was relatively consistent, differing by less than 2-inches, during the periods 1999-2002, 2008-2011, and 2015-2019. Years with summer month rainfall more than 2-inches higher than the 26-year average of 11.9 inches included 2005, 2008-2010, 2014, and 2021.

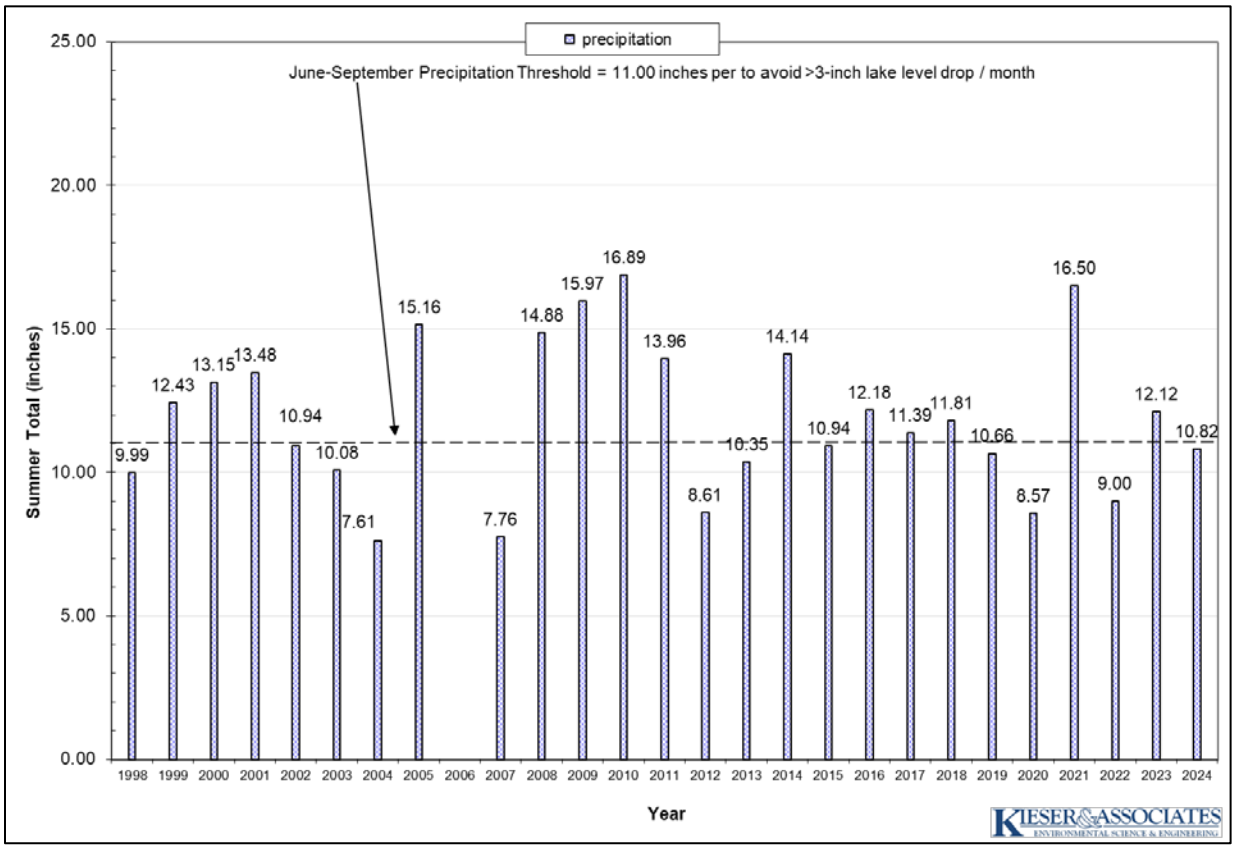

Figure 2-17. Cedar Lake summer month precipitation data, 1998-2024 (*Data Sources: Cedar Lake Improvement Board Volunteer Rain Gauge, Alcona County, MI; NOAA, Harrisville 2NNE Station, Alcona County, MI; Oscoda Wurtsmith Airport Station #14808*).[25]

[25] Kieser & Associates. (April 2025). "Cedar Lake 2024 Hydrology Report." *Prepared for the CLIB.*

Figure 2-18 illustrates the impact of summer month precipitation on Cedar Lake water level fluctuations using available data from 2004-2024. This graph shows the extent of fluctuations for each summer month period (June-September) by charting the average lake level and maximum water level above and below the legal lake level during summer of each year. Summer month precipitation totals are also graphed to illustrate lake level fluctuation responses to precipitation in the recreational season. Water levels above the legal lake level represent periods with active outflows over the lake outlet spillway, while below that level no surficial outflows occur.

Linear trendlines were applied to two datasets featured in Figure 2-18, summer month precipitation totals and the maximum water level below the spillway for consideration. The summer month precipitation trend line showed a slightly decreasing trend over the 20-year period. The trend line for maximum water level below the legal lake level showed an upward trend, suggesting that summer water level drops below the spillway became less drastic over time. Such reductions in fluctuations of lake levels are desirable for many reasons as described elsewhere in this chapter.

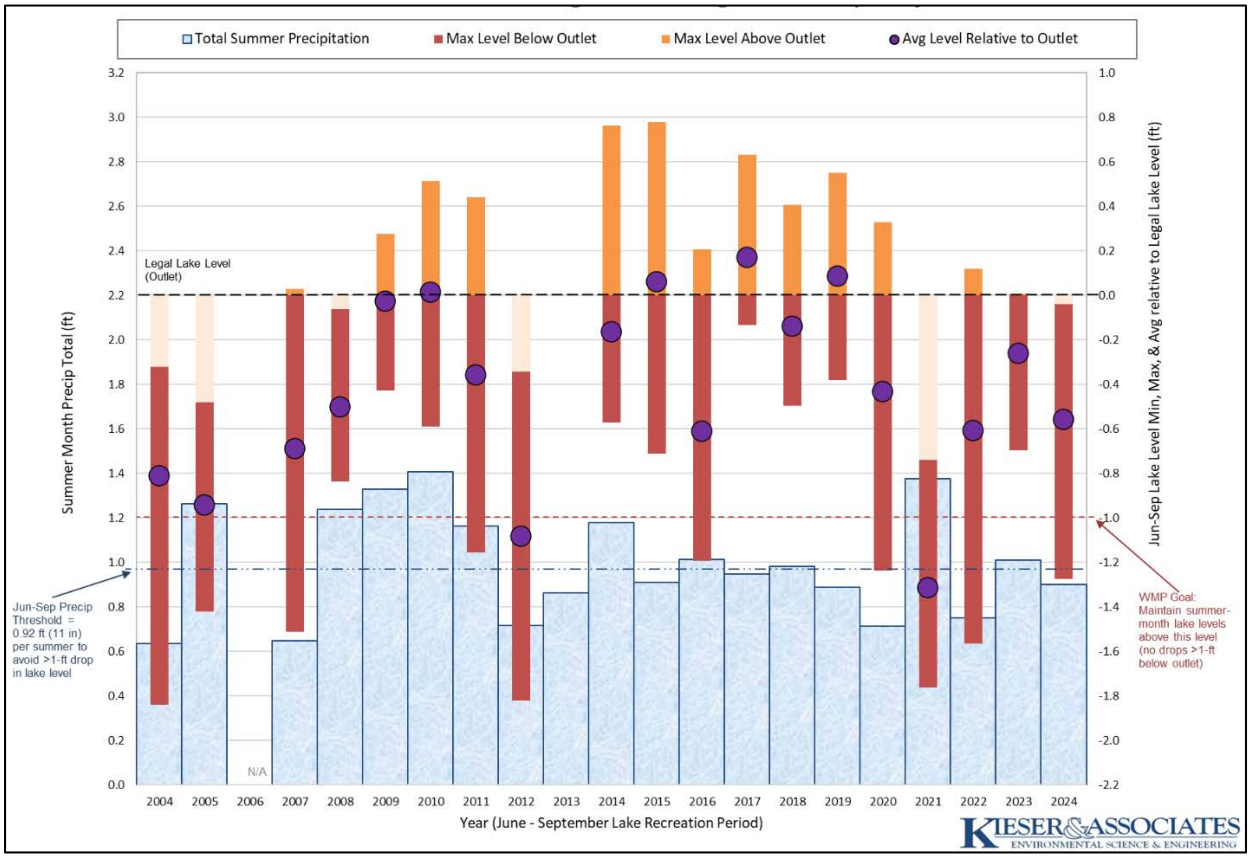

Figure 2-18. Cedar Lake summer month (Jun-Sep), 2004-2024, lake level fluctuations: Annual summer month lake level maximum, minimum, and average relative to the legal lake level (Cedar Lake outlet) and total summer month precipitation.[26]

[26] Kieser & Associates. (March 2021). "Cedar Lake 2020 Hydrology Report." *Prepared for the CLIB.*

The extent to which this improved condition results from Lake Board wetland enhancement implementation in the Sherman Creek contributing area since 2017 continues to be monitored and analyzed. In 2018-2019, average summer month water levels were near or above the legal lake level and maximum water levels below the outlet were closer to the legal lake level compared to other years with similar near-average summer month rainfall. During the very-low rainfall summer period of 2020, lake levels averaged 0.43-ft below the spillway and dropped to a maximum of 1.24-ft below the legal lake level.

The Cedar Lake outlet spillway was replaced in Fall 2020. Average lake levels at the outlet in 2021 were notably much lower than normal given above-average rainfall. This prompted concern amongst lake residents that the new spillway was "leaking" water out of the lake, however, the presence of beaver activity just upstream of the spillway may have been partially responsible for the deflated water elevations measured at the outlet. Average water levels at the outlet 2022-2024 were closer to the legal lake level despite below-average or near-average summer month rainfall. These trends should continue to be carefully monitored to track long-term change.

The maximum water level above the legal lake level also shows an increased trend in the last decade. This could relate to repairs made to the outlet structure which prevented leakage beneath the spillway. Intermittent beaver activity has also caused substantial hydrological modifications and debris build-up at the outlet from 2016-2018. Notably, the new outlet structure design is intended to prevent large fluctuations above the legal lake level; intensive monitoring is recommended to monitor how the new structure will impact lake levels going forward.

Geology and Soils

The major soil types in the Cedar Lake watershed include sands and mucks. As shown in Figure 2-19, the area along the east and west shoreline is composed of Au Gres sand. The north and south ends of the lake have Tawas and Lupton mucks, respectively. On the southwest corner of the lake, near Kings Corner Road, the area is described as Udipsamment (slope is nearly level and undulating). This soil type basically consists of unconsolidated sand deposits with very coarse-textured material (loamy sand or coarser). The area of the watershed west of the lakeshore consists of a striated pattern of Battlefield, Au Gres, and Croswell sands interspersed with Leafriver, Lupton, and Tawas mucks. Highly organic soils also appear in this area, which is generally indicative of marsh or wetland cover.

Soils are a relevant factor in determining the amount of overland runoff and erosion that occurs in the Cedar Lake watershed. Soils in many areas of the watershed are very permeable and allow for high infiltration rates of precipitation or runoff from impervious surfaces. High infiltration rates of runoff limit the amount of surface runoff that is likely to carry pollutants into Cedar Lake. Other areas of the watershed where muck soils are present along with high groundwater levels will experience slower surface water infiltration when soils are already highly saturated. Low slopes slow or reduce overland flow and create standing water after spring snow melt and rain events. Due to organic muck soils in wetlands in the watershed, these areas store infiltrated runoff as groundwater and slowly release it to the lake.

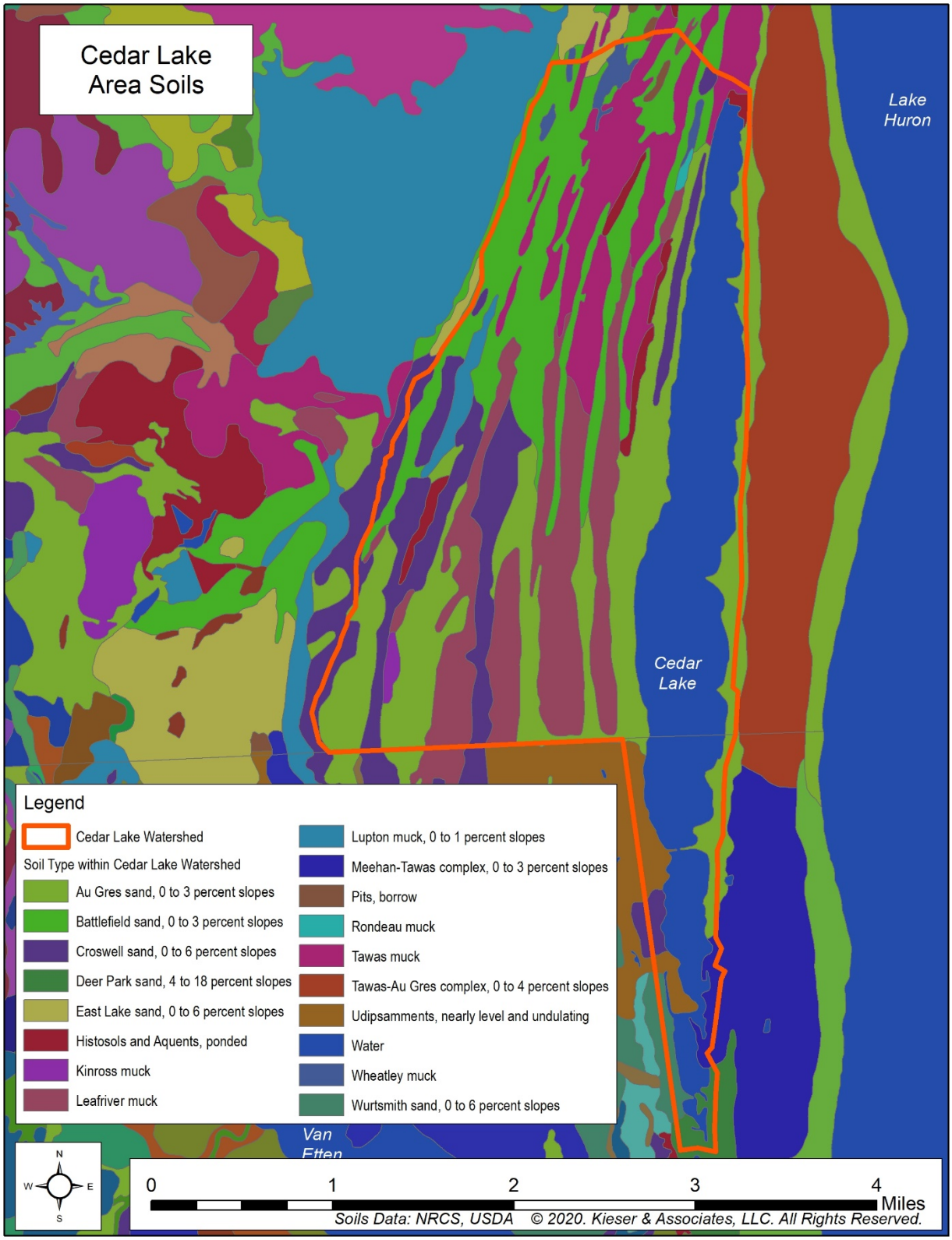

Figure 2-19. Various soil types in and around the Cedar Lake watershed.

Fishery

Cedar Lake has an extensive history of fisheries surveys, which have been conducted by the MDNR fisheries division as well as private consultants. These surveys influenced the recommendations developed for the Cedar Lake 2011 watershed management plan to enhance the fishery. Surveys conducted prior to the Cedar Lake WMP included a creel census and an evaluation of the pike spawning migration to and from Sherman Creek and the adjacent wetland.

Fish community surveys of Cedar Lake began in 1956, performed by the Department of Conservation, now the Michigan Department of Natural Resources (MDNR). Since then, MDNR has conducted five more-extensive fish community surveys on Cedar Lake. Historical sampling efforts suggest a diverse fishery in Cedar Lake, including black crappie, bluegill, pumpkinseed, largemouth bass, northern pike, rock bass, smallmouth bass, tiger muskellunge, walleye, and yellow perch. The most recent survey in 2020 found similar fish community results compared to past surveys, except for black crappie and tiger muskellunge.[27]

A creel censes was conducted in 2008 by Aquest Corp. and Superior Environmental and Aquatic Services, LLC (SEAS), under contract with the Lake Board. Results from angler surveys indicated that most fishing takes place north of the causeway, which supports better aquatic vegetative structure for the fishery. Anglers caught an average of 2.5 fish/hour, which is considered quite good for Michigan lakes. Overall, angling pressures are generally low in Cedar Lake. The report concluded that Cedar Lake is a bass/bluegill fishery, with largemouth bass and northern pike comprising nearly 75% of fish caught during the survey. Yellow perch, walleye, and smallmouth bass were the most-harvested species during the survey, but angling selectivity for fish species was generally evenly distributed. The report concluded that Cedar Lake had the potential to support a more robust sport fishery with species such as walleye and northern pike.[28]

In addition to creel census data, anecdotal information from longtime residents and local agency officials suggests that both Sherman Creek and Jones Ditch once ran year-round. Early spring spawning runs of pike were observed annually and with such abundance that fish were frequently observed in inundated roadside ditches adjacent to these streams. Drainage modifications by county road commissions in the 1980s appear to have substantially lowered the groundwater table in the drainage areas of these creeks such that flows are now limited to select times of the year. Since these modifications, there have been limited reports of the pike spawning runs that were once commonly noted. Because of these observations, in 2008 SEAS conducted an evaluation of the spawning migration to and from Sherman Creek and the adjacent wetland. The general conclusion was that Sherman Creek and the adjacent wetlands need to be protected from development in order to preserve and extend the duration of creek flow during spring and early summer months for fish spawning and migration.[29]

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[27] Cwalinski, T. (n.d.). "Cedar Lake, Alcona and Iosco counties Lake Huron watershed, last surveyed 2011". *Michigan Department of Natural Resources Status of the Fishery Resource Report.*

[28] SEAS, LLC. (2009). "Cedar Lake 2008 Creel Census, Greenbush and Oscoda Townships, Alcona & Iosco Counties, Michigan." *Prepared for Cedar Lake Improvement Board, June 29, 2009.*

[29] SEAS, LLC. (2009). "Cedar Lake 2008 Evaluation of the Spawning Migration of Northern Pike of Cedar Lake Greenbush and Oscoda Townships, Alcona & Iosco Counties, Michigan." *Prepared for Cedar Lake Improvement Board, June 10, 2009*.

Restoration of Sherman Creek and adjacent wetlands began in 2014 when the Lake Board purchased 58 acres of critical wetlands around Sherman Creek. The Lake Board pursued wetland and creek hydrology restoration projects with two implementations to improve and protect Sherman Creek and its adjacent wetlands: the wetland berm in 2017 and the instream grade structures in 2019. This resulted in a shift from springtime Sherman Creek flows for only 1-2 months and a similar timeframe for inundation of a few acres of adjacent wetlands, to stabilized streamflow from February through June with 26 acres of wetland inundation. These restoration efforts have reduced seasonal lake level fluctuations and resulted in a potential 5-fold increase of northern pike wetland spawning habitat.

Cedar Lake has also had an extensive stocking history dating back to 1980. Stocking records prior to that time are lacking. Available stocking data is recorded in Table 2-1. Numerous species have been stocked including tiger muskellunge, walleye, redear sunfish, and hybrid sunfish. Tiger muskellunge were stocked from 1980 to 1991 to promote increased predator numbers and reduce stunted panfish. This program produced limited results which is why it ceased in 1991.

Continued walleye stocking continues to this day and efforts appear to be successful. The Cedar Lake walleye population demonstrated the greatest increase for predator species in the 2011 survey compared to past surveys. During this survey, eight year-classes of walleye were collected. Cedar Lake walleye growth rates were considered average when compared to statewide walleye growth rates. However, the walleye population lacks confirmation of natural reproduction and is thought to be sustained predominantly from periodic spring fingerling stocking efforts.[30]

Redear sunfish were stocked from 2010 to 2016 by the AICLA in an effort to increase the Cedar Lake panfish population with a species desirable for anglers that would also act as a biological control against the increasing zebra mussel population.[31] Redear sunfish were stocked in hopes that this species would thrive. In 2018, the Lake Association contracted with Northpointe to conduct a survey in order to determine the success of previous redear sunfish stocking efforts. The consultants surveyed the lake with fyke nets for 18 net nights; no redear sunfish were collected in the survey effort. Unfortunately, no redear sunfish were recovered during the 2018 fisheries assessment; other species found were similar to MDNR surveys.[32] Recommendations were made to either terminate stocking efforts, or increase stocking rates. The Lake Association has not stocked redear sunfish since this effort, though future stocking using a more controlled experimental pilot approach remains a low-priority recommendation of this updated WMP.[33]

[30] Cwalinski, T. (n.d.). "Cedar Lake, Alcona and Iosco counties Lake Huron watershed, last surveyed 2011". *Michigan Department of Natural Resources Status of the Fishery Resource Report.*
[31] Sendek, S. P. (2018). "Cedar Lake Redear Sunfish Stocking Evaluation September 25-28, 2018." *Northpoint Fisheries Management, LLC.* Grayling, Michigan; and, Cwalinski, T. (n.d.).
[32] Sendek, S. P. (2018).
[33] Sendek, 2018; and, Cwalinski, T. (n.d.).

Table 2-1. Available Cedar Lake Stocking History.[34]

Source	Year	Species	Strain	Avg. Length	No. Stocked	Mark
DNR	1989	Walleye	Muskegon	1.7	30,012	--
DNR	1994	Walleye	Muskegon	1.7	31,298	--
DNR	1996	Walleye	Muskegon	1.4	78,680	--
DNR	1998	Walleye	Tittabawassee	2.0	21,632	OTC
DNR	2001	Walleye	Tittabawassee	1.8	74,487	OTC
DNR	2003	Walleye	Tittabawassee	1.2	62,255	OTC
DNR	2005	Walleye	Tittabawassee	1.7	61,000	OTC
DNR	2006	Walleye	Tittabawassee	1.9	62,880	OTC
DNR	2008	Walleye	Muskegon	2.1	59,928	--
DNR	2009	Walleye	Muskegon	1.5	80,753	--
DNR	2010	Walleye	Muskegon	2.0	50,195	--
DNR	2013	Walleye	Muskegon	2.0	53,235	--
DNR	2014	Walleye	Muskegon	1.8	70,784	--
DNR	2016	Walleye	Muskegon	1.9	53,919	--
DNR	2018	Walleye	Muskegon	1.8	50,470	--
DNR	2021	Walleye	Muskegon	1.5	58,529	--
DNR	2022	Walleye	Muskegon	1.8	50,624	--
DNR	2024	Walleye	Muskegon	1.1	9,133	--
DNR	2024	Walleye	Muskegon	1.2	41,792	--
Source	**Year**	**Species**	**Strain**	**Avg. Length**	**No. Stocked**	**Mark**
DNR	1980	Tiger Muskellunge	--	8.5	5,000	--
DNR	1982	Tiger Muskellunge	--	5.8	9,600	--
DNR	1984	Tiger Muskellunge	--	6.9	1,900	--
DNR	1986	Tiger Muskellunge	--	6.4	5,000	--
DNR	1988	Tiger Muskellunge	--	9.3	5,000	--
DNR	1990	Tiger Muskellunge	--	9.4	5,236	--
DNR	1991	Tiger Muskellunge	--	9.3	9,600	--
Source	**Year**	**Species**	**Strain**	**Avg. Length**	**No. Stocked**	**Mark**
Private	2010	Redear Sunfish	--	3.0	1,000	--
Private	2011	Redear Sunfish	--	5.0	1,000	--
Private	2012	Redear Sunfish	--	4.0	760	--
Private	2013	Hybrid Sunfish	--	3.0	920	--
Private	2014	Redear Sunfish	--	3.5	2,500	--
Private	2015	Redear Sunfish	--	3.0	2,580	--
Private	2016	Redear Sunfish	--	3.5	4,170	--

[34] DNR Fisheries stocking data for Cedar Lake available online: <https://www.dnr.state.mi.us/FishStock/?qry=1&Water=7107&StartMonth=1&StartDate=1979&EndMonth=8&EndDate=2024&STOCKDATE=true>

Invasive Species

Aquatic invasive species (AIS) are a concern in the Cedar Lake. The lake has seen establishment of invasive species such as zebra mussels since their explosion in the Great Lakes. Recreational use and the public boat launch provide an easy avenue for invasive species transmission to Cedar Lake. Human recreation activities like boating and fishing are considered vectors of AIS transmission through the distribution of viable aquatic plant fragments and reproductive structures.

A list of current AIS that technical experts have identified as present or threatening Cedar Lake over several decades, as well as potential invaders, and descriptions of common native species in Cedar Lake, is compiled in Attachment D. Attachment D also includes the most-recent 2024 Cedar Lake LakeScan™ reports (split into Cedar North and Cedar South), which provide technical details, data analyses, and year-to-year comparisons, with reference to identification and management strategies. AIS currently known to be established in Cedar Lake include:

- Eurasian watermilfoil (*Myriophyllum spicatum*),
- Eurasian watermilfoil hybrid (*M. spicatum x sibericum*),
- Starry stonewort (*nitellopsis obtusa*),
- Round goby (*Neogobius melanostromus*),
- Common carp (*Cyprinus carpio*),
- Rusty crayfish (*Orconectes rusticus*), and
- Zebra mussels (*Dreissena polymorpha*)

Each of the aquatic vegetation species has been targeted with annual chemical management interventions each year they have been observed within Cedar Lake.[35] Elsewhere in the watershed, low levels of the emergent AIS phragmites (*Phragmites australis subsp. Australis*) and purple loosestrife (*Lythrum salicaria*) have been observed. Data gaps exist, however, for upland invasive plants and other invasive wildlife species that might be present in the watershed.

Several aquatic invasive species which threaten Cedar Lake but are not currently known to be established in the watershed are listed below. These AIS are of special interest to the State of Michigan and considered potential invaders because of their proximity to Cedar Lake (i.e. found elsewhere in Lake Huron, for example). These species include:

- European frog bit (*Hydrocharis morsus-ranae*)
- Yellow floating heart (*Nymphoides peltate*)
- Carolina fanwort (*Cabomba caroliniana*)
- Tubenose goby (*Proterorhinus marmoratus*)
- White perch (*Morone americana*)

Figures 2-20 and 2-21 show the aquatic invasive species coverage trends for the five-year period from 2020-2024 based on LakeScan™ monitoring program conducted by Kieser & Associates.

[35] Up to date Cedar Lake Aquatic Vegetation Survey Reports can be found on the Cedar Lake WMP website: <www.cedarlakewmp.net>.

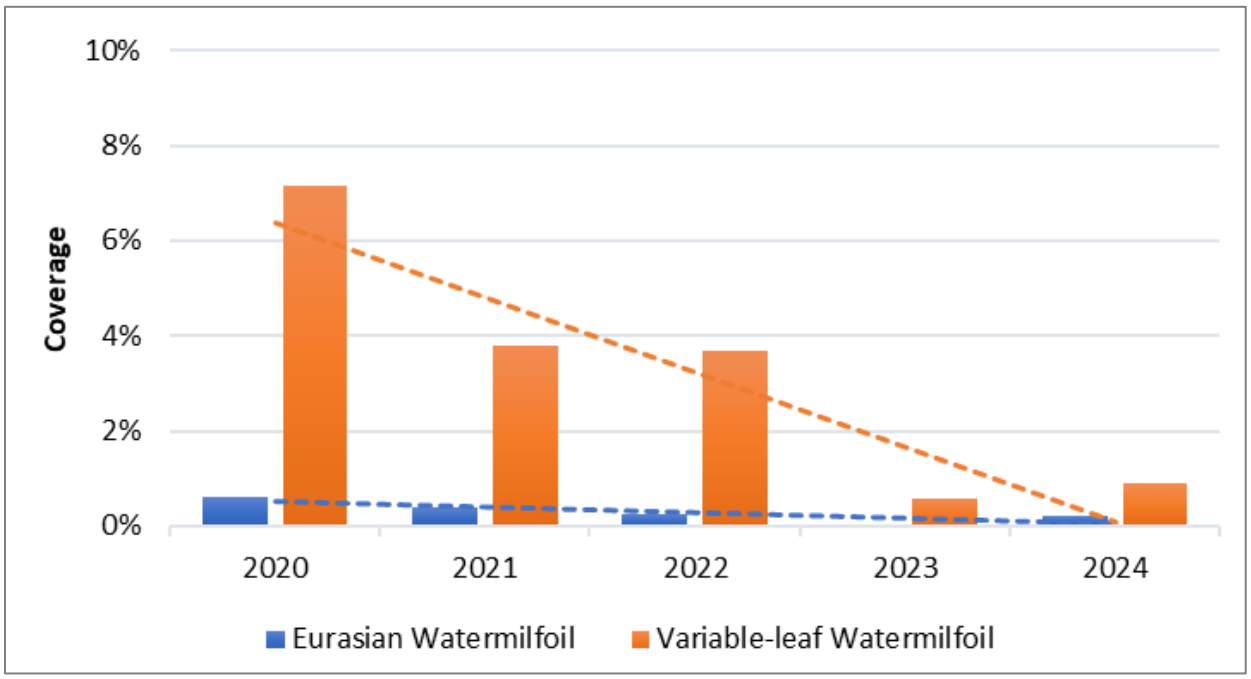

Figure 2-20. Cedar Lake North: Invasive and Nuisance Species Coverage 5-year trend, 2020-2024

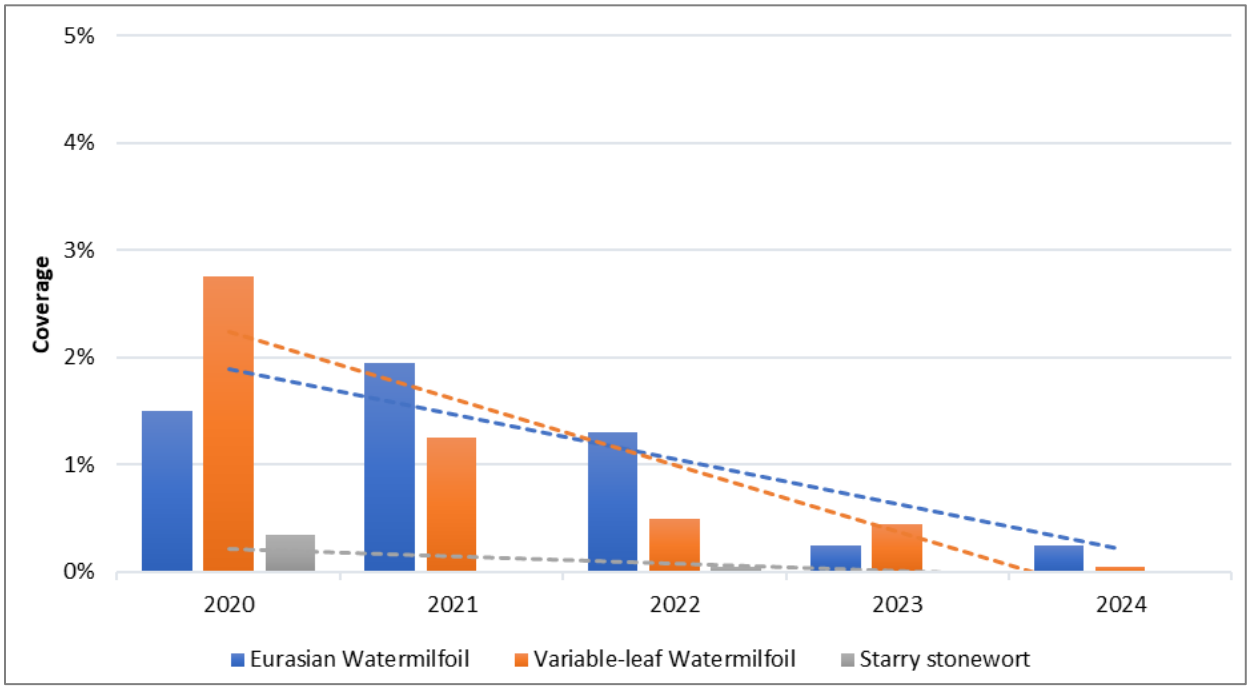

Figure 2-21. Cedar Lake South: Invasive and Nuisance Species Coverage 5-year trend, 2020-2024.

Watershed stakeholders are particularly concerned about aquatic vegetation causing nuisance issues within Cedar Lake, exacerbated during low lake level years. Increases in variable watermilfoil, a native species, have shown an increase in coverage over the last decade which

can lead to severe nuisance navigational conditions at certain times during the recreational season. This species has therefore been occasionally targeted with management intervention to reduce nuisance conditions for navigational safety. Due to its intensive growth habit on Cedar Lake, a specimen was genetically examined by Ryan Thum, Associate Professor of Plant Sciences and Plant Pathology at Montana State University, who determined it was not a genetic hybrid of the native variable milfoil species.[36]

Historical mussel surveys conducted by Michigan Natural Features Inventory indicate that a State of Michigan listed endangered species, the Eastern Pond mussel (*Sagittunio nasutus*), was found within the southern portion of Cedar Lake South in 1953. Regional surveys conducted between 1998 and 2015 found no presence of this species within Cedar Lake.[37] Most recently in summer 2022, however, the endangered Eastern Pond mussel *S. nasutus* was again found in Cedar Lake, at three study sites in the northern portion the lake, during a detailed study of unionids conducted by Central Michigan University's Department of Biology and Institute of Great Lakes Research. The objectives of this study were to determine the diversity and unionids in Cedar Lake emphasizing rare species and to determine risks of invasive mollusks on native unionids. The study found four unionid species in Cedar Lake with variable communities and abundances throughout the lake.[38]

All native mussels are protected in Michigan and cannot be handled without a Michigan Department of Natural Resources (MDNR) Cultural and Scientific Collectors Permit.[39] A State Threatened and Endangered Species permit will also be required given the presence of a State listed endangered species. The 2022 CMU study recommended careful management, standardized surveys every 5 years, community education and involvement, and further rigorous scientific study, for the conservation of unionids in Cedar Lake. Qualifications for personnel conducting future mussel surveys should be evaluated with MDNR prior to survey efforts.

Land Use and Land Cover

The Cedar Lake watershed is a mix of developed and undeveloped land uses. Over the past half century, increased residential development has occurred around the lake. The watershed is highly recreational with many seasonal residents that live on the lake part-time. Surrounding the lake are several golf courses, swimming beaches, and a boat launch area. While the lakeshore area has felt development pressure over the past few decades, much of the watershed is still undeveloped.

Based on 2016 land cover data, residential land use and transportation make up approximately less than a quarter of the land in the watershed and represent the impervious areas in the

[36] Doug Pullman. (February 2021). *Personal Communication*.
[37] Badra, P. J. (2017). Status Assessment of Unionid Mussel Species in the Huron-Manistee National Forest. *Michigan Natural Features Inventory.*
[38] Vlasak, Aaron L., Alec J. Barczewski, Ava M. Laszlo, Nicole M. Vellequette, and Daelyn A. Woolnough. (2022). Unionids of Cedar Lake, Michigan, USA: Community, Abundances, and Invasive Mollusk Risks. *Department of Biology and Institute for Great Lakes Research, Central Michigan University, Mount Pleasant, MI.*
[39] Bean, R. (2018). Michigan Survey and Relocation Protocol for Federally Listed Mussels.

watershed. The remaining land in the watershed is relatively natural or covered by surface water. The chart in Figure 2-22 shows the percent area of the watershed by land cover group.

Figure 2-23 shows a map of the different land uses in the watershed and how residential and transportation land use is primarily clustered around the perimeter of the lake. The north end of the lake is less developed with some residential land use primarily on the northwestern shore and fewer on the northeastern side. The northern end of the lake contains a mix of wetlands and lowland forested wetlands.

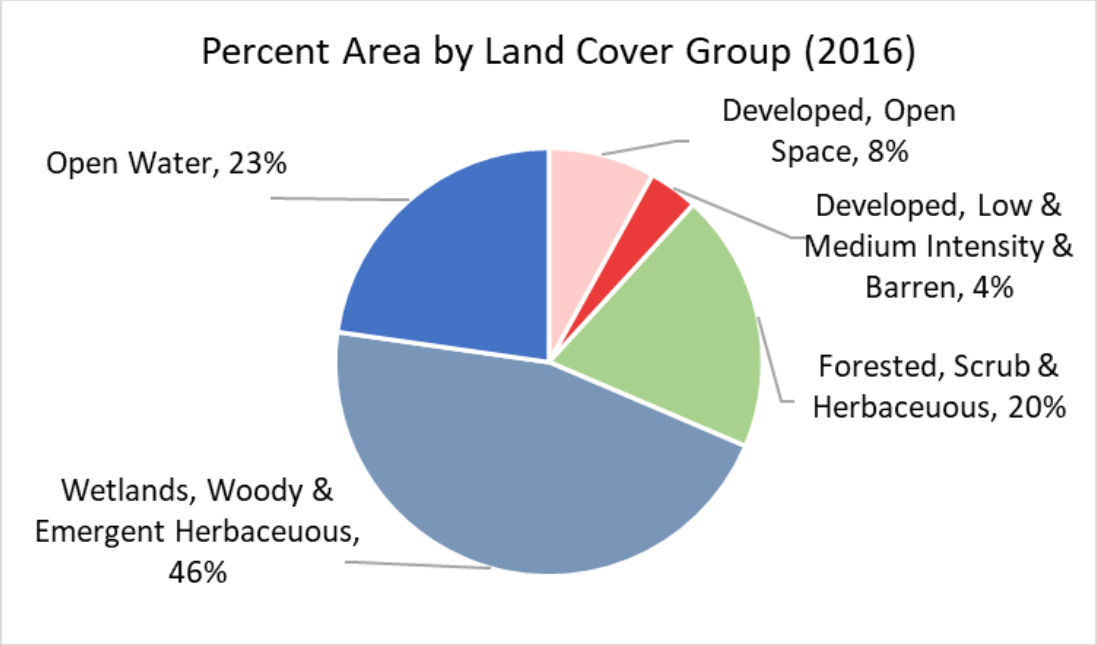

Figure 2-22. Distribution of land uses in the Cedar Lake watershed by percent cover from 2016 data.[40]

Aside from the residential development around the perimeter of the lake, most of the land draining to Cedar Lake is located on the northwest side of the lake. These lands include the shoreline and direct drainages associated with Sherman Creek and Jones Ditch. These creek drainage areas are mostly undeveloped wetlands and forests with limited residential development. Within the last decade, the Cedar Lake Improvement Board has purchased several parcels with the intention of protection and wetland enhancement surrounding the two Cedar Lake inlets, Sherman Creek and Jones Ditch. Residential homes are mostly located along the east side of W. Cedar Lake Road. One golf course is located just inside of the watershed boundary to the north of Kings Corner Road. The State of Michigan owns several hundred acres of land in the middle of the northwest wetland area. The remaining land is generally privately owned.

[40] Multi-Resolution Land Characteristics consortium (MRLC). (2020). "The 2016 National Land Cover Database." Accessible online: <www.mrlc.gov>; and
Microsoft. (2018). "US Building Footprints." *Release 1.1: 125,192,184 building footprint polygon geometries in all 50 US States in GeoJSON format.* Accessible online: <https://github.com/microsoft/usbuildingfootprints>.

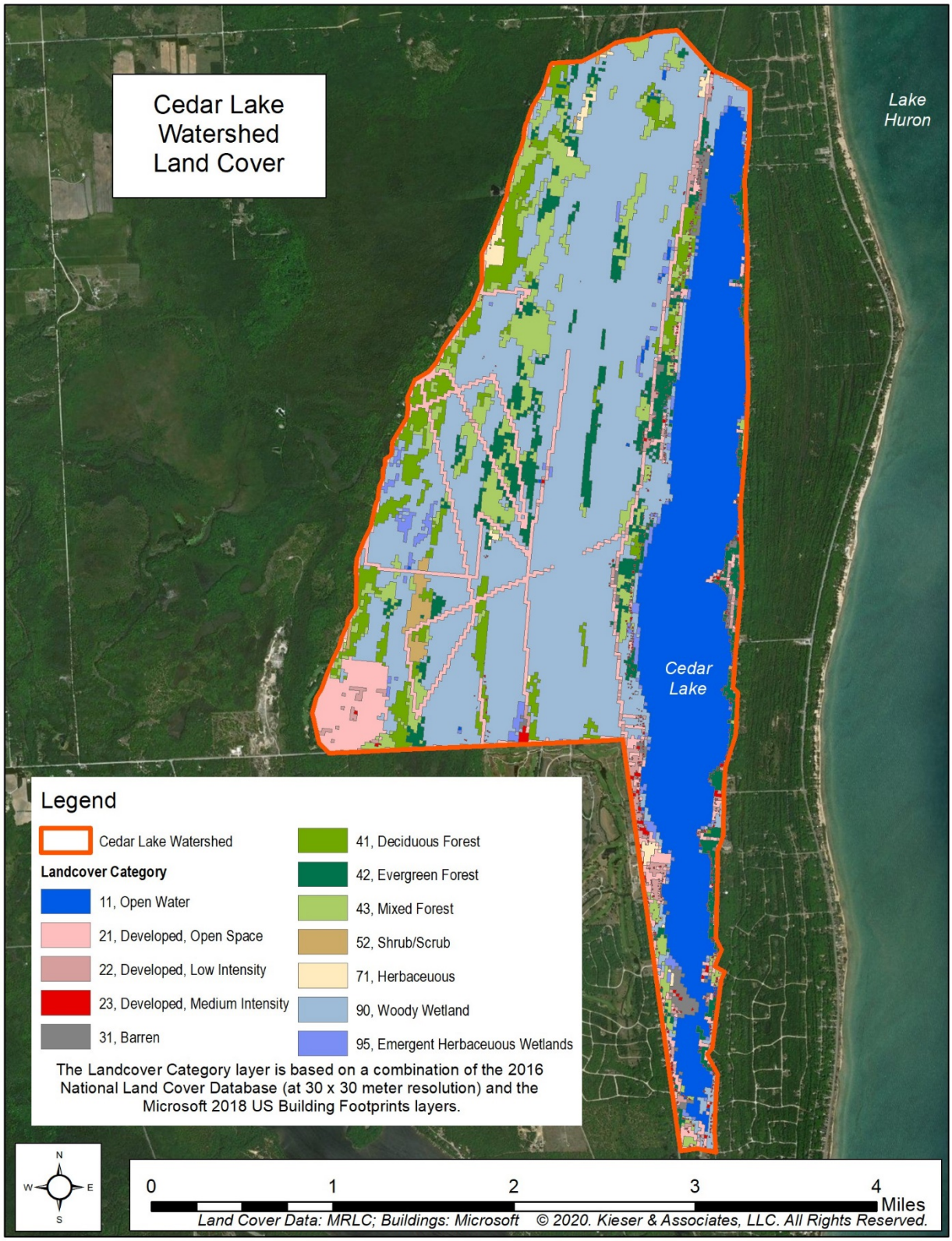

Figure 2-23. 2016 distribution of land use in the Cedar Lake watershed.

Political Characteristics

The majority of the Cedar Lake watershed is in Alcona County and the southern portion of the watershed is in Iosco County.[41] Moreover, the watershed is split between Greenbush Township on the north end and Oscoda Township on the south end. The large majority of the watershed (northwest corner) is located in Alcona County and Greenbush Township. Cedar Lake contributes a much greater percentage of the Greenbush tax base than in Oscoda Township. There are over 702 individual property owners around the lake many of which are part-time and use their property primarily for recreation. Both of these townships have zoning ordinances that affect the watershed. Several ordinance elements are relevant to the WMP efforts including:[42, 43]

- **Vegetative Buffer zoning:** Oscoda Township requires that 75 feet to the water's edge be vegetated on private property and 150 feet to the water's edge be vegetated on public property. No buffer zoning exists in Greenbush Township but Section 3.11 Waterfront Regulations does make special note of the need to protect the nature of shoreline zones.
- **Waterfront Setback zoning:** Oscoda Township requires residential structures are at least 50 feet setback from the water's edge; Greenbush Township requires a 25 feet setback.
- **Percent Impervious Cover zoning:** Oscoda Township restricts impervious cover to 35% cover for residential lots; Greenbush Township restricts coverage to a maximum of 35% coverage for lots within the shoreline protection district.

Another important political boundary in the watershed is the Lakewood Shores drainage district on the southern and eastern sides of Cedar Lake in Iosco County. The district is under the jurisdiction of the Iosco County Drain Commissioner. Subsurface dewatering drains in this area impact Cedar Lake levels through a shallow groundwater connection and many homes in the drainage district rely on the drains to keep their homes and properties dry. If the Township, or at least 5 property owners in the drainage district, petition the Drain Commissioner to expand the drain, modifications could take place that would have a negative impact on Cedar Lake levels.

An important factor in the issues surrounding Cedar Lake water level is the court-ordered lake level set in 2019.[44] The ruling set the official lake level for Cedar Lake at 608.2 feet above sea level. This order legally constrains the lake level and spillway at the north end of the lake. At no time during the year is the lake level supposed to exceed the 608.2 feet level, and the Drain Commissioner is responsible for managing the lake in such a way as to maintain the level at or below 608.2 feet. The court-ordered lake level has implications for Cedar Lake in terms of limiting the storage capacity of the lake, which during dry years can deplete quickly (as much as 2.2 feet in 2004). Several WMP implementation projects undertaken in the Cedar Lake watershed since 2011 have aimed to increase the retention and volume of groundwater and surface water in the northwest cedar swamp, the critical recharge area for Cedar Lake.

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[41] United States Census Bureau. (2010). Accessible online: <https://www.census.gov/quickfacts/>.
[42] Greenbush Township Planning Commission. (2014). "Greenbush Township Zoning Ordinance." *Accessible online:* <http://www.discovernortheastmichigan.org/downloads/greenbush_township_zoning_ordinance_2015.pdf>.
[43] Oscoda Township. (2011). "Oscoda Township Zoning Ordinance 165." *Accessible online*: <http://www.oscodatownshipmi.gov/1/322/files/oscodazoningordinance13.pdf>.
[44] Court mandated Cedar Lake level documentation: https://iosco.net/wp-content/uploads/2018/12/2018.11.02-Cedar-Lake-Notice-of-Hearing.pdf

CHAPTER 3. WATERSHED CONDITIONS

The Cedar Lake watershed to the northwest of the lake is largely undeveloped and in a naturalized condition. This is highly protective of water quality as the drainage area to surface area ratio is only 3:1. When this ratio exceeds 10:1, watershed drainage tends to influence surface water quality of the lake, particularly in developed watersheds. Several specific conditions related to hydrology in the northwest contributing drainage area continue to create concern among watershed stakeholders. Hydrology in the watershed has been degraded by decades of drainage and building in wetlands. Within Cedar Lake, invasive and nuisance aquatic plant species exponential growth in parts of the lake historically caused substantial concern for the lake's recreational and ecological functions. As part of the WMP technical update, the SC worked to update the originally-developed comprehensive list of the watershed concerns regarding desired uses in the watershed, to more fully address and influence the overall conditions of the Cedar Lake watershed.

Watershed Assessments and Concerns

Many of the concerns and conditions in the Cedar Lake watershed have been well identified over the past decade. These are outlined extensively for each WMP objective in Chapter 6. Under the direction of the Lake Board and through studies commissioned by the AICLA, several technical experts have investigated and continue to monitor and address issues in and around Cedar Lake. These studies have involved countless hours assessing conditions in Cedar Lake and the surrounding watershed. Since 2005, K&A has produced several comprehensive hydrologic reports as well as annual technical reports involving ongoing field investigations of hydrologic routing of both surface and groundwater.

Findings from these studies have been integrated into the updated WMP, including recommendations for future implementations (Chapter 7). These studies helped to define critical watershed contributing areas (northwest wetlands including Sherman Creek and Jones Ditch) and areas losing groundwater at artificially accelerated rates (e.g., Lakewood Shores drainage district representing 39-44% of losses, King's Corner Road culvert surface water diversion). In general, modifications of the hydrologic mass balance in the watershed result in negative impacts on Cedar Lake during dry years.

Aquatic plant management efforts at Cedar Lake have resulted in annual reports assessing plant community conditions of Cedar Lake. These have helped guide the adaptive management strategy for AIS and findings from these efforts have been integrated into the implementation plan for the updated WMP (Chapter 7). Recent assessment of the aquatic plant community in Cedar Lake indicates that past conditions in Cedar Lake have been good in terms of the aquatic plant community; however, invasive and recreational nuisance species have demonstrated the potential to threaten conditions in Cedar Lake for several decades.

The aquatic invasive species Eurasian watermilfoil (and hybrids) continue to be a high priority plant for eradication due to intensive colonization in certain parts of Cedar Lake. This species has shown some signs of herbicide resistance in Cedar Lake. Recreational nuisance conditions caused by the native species variable watermilfoil has also prompted occasional management intervention of this plant which has shown more aggressive growth in Cedar Lake. Starry

stonewort has also been observed in Cedar Lake at select but limited locations, and has been targeted with management intervention since 2012 with algaecides. Findings from the biannual vegetation studies continue to guide adaptive management of these AIS and nuisance species.

Fisheries management to date has focused on assessments as guided by original recommendations of the WMP. In conjunction with aquatic plant surveys, fishery management activities at Cedar Lake have also characterized watershed conditions. Habitat for bass and sunfish spawning is considered adequate although in general, the spawning habitat utilization has been characterized as below average for Michigan.[45] The updated WMP implementation section provides several recommendations for future fisheries habitat assessments and direct improvement projects (Chapter 7). Expanding habitat is essential for increasing recruitment.

Additional watershed assessments have been conducted by K&A as part of the WMP development, previous augmentation pilot study, WMP implementation, and this WMP technical update. Monitoring of existing groundwater piezometers in and along important surface water and wetland locations throughout the watershed continues to provide useful information in terms of watershed runoff and groundwater movement. These watershed investigations have indicated that WMP implementation projects to protect and enhance the northwest wetlands, for example, have increased inflows to Cedar Lake from Sherman Creek and decreased out-of-watershed losses via the Kings Corner Road culvert. These issues are detailed in Chapter 5, with tables and figures showing the surface inflow and outflow changes over time. This information was also used to inform empirical calculations used to estimate pollutant loads in Chapter 5.

Designated and Desired Uses

To inform and affirm the recommendations of the WMP technical update, the original list of specific watershed concerns for desired uses has been updated, including the SC core team ranking the original watershed concerns table on a consensus basis. Table 3-1 shows the updated list of watershed concerns regarding Cedar Lake conditions, including a compiled ranking of all watershed concerns with updated prioritization for each issue, prioritizing them as high (H), medium (M), or low (L) concerns in relation to desired uses of the watershed.

The draft concerns in the watershed that ranked high among the WMP updates include sediments (or composition of lake bottom), habitat loss (especially wetlands), aquatic plants and wildlife (or biota), hydrologic modification and future watershed development. Of medium concern are nutrient loading to the lake and improper disposal of yard waste into the lake. Pathogens and parasites were ranked as a low concern due to low frequency of reported problems from lake residents. Drainage and development in wetlands were of particular concern to watershed stakeholders' desired watershed uses, and this is represented in several categories in Table 3-1.

In addition to ranking the concerns regarding desired uses of the watershed, the SC identified and updated which concerns presented a threat to the watershed or where indicators of a degraded ecosystem. "Degraded" is an intermediate term used to describe ecosystem functions that are not yet "impaired", but are more severe than the "threatened" designation.

[45] SEAS, LLC. (2009). "Cedar Lake 2008 Creel Census, Greenbush and Oscoda Townships, Alcona & Iosco Counties, Michigan." *Prepared for Cedar Lake Improvement Board, June 29, 2009.*

Table 3-1. Watershed Concerns Ranked by Priority and Evaluated in Terms of Desired Uses in the Watershed. **Cedar Lake Watershed Desired Use Concerns**	**Rank of Importance**	Warmwater Fisheries	Fish Consumption	Ind. & Aquatic Wildlife	Partial Body Contact Recreation	Full Body Contact Recreation	Groundwater Protection	Maintain Lake Level	Habitat Protection
SEDIMENTS	**H**	D		D	D	T		D	D
Lake bottom and muck accumulation	H								
Accumulation of dying weeds in lake	H								
Minor erosion around lakeshore	L								
HABITAT LOSS	**H**	D		D	T		D	D	D
Wetland development in watershed (esp. NW side of lake)	H								
Loss of fish spawning areas (streams/wetlands)	H								
Loss of fish nursery areas (nearshore wetlands)	H								
Loss of fish and wildlife habitat (due to low lake levels)	H								
BIOTA	**H**	D		T	T	T			T
Invasive aquatic plants in the lake	H								
Native aquatic plant overgrowth in the lake	H								
Purple loosestrife/Phragmites around shoreline areas	M								
Invasive fish and mussels	M								
Nuisance waterfowl (esp. geese)	H								
Blue-green algae/other species growth in lake	M								
URBANIZATION & LAND USE	**H**	T		T	T		D	D	D
Lot development (draining lots)	H								
Road access in wetlands (esp. filling wetlands)	H								
GROUNDWATER CONTAMINATION	**H**		T	T		T	D		
Toxicants from historic land uses (PFAS)	H								
HYDROLOGIC MODIFICATION	**H**	D		D	T	T	D	D	D
Drainage of wetlands for development	H								
Surface water / stormwater drainage to lake	M								
Pumping water for irrigation	H								
Stream modification (Sherman Creek / Jones Ditch)	H								
Road ditches that drain water away from lake	H								
LOSS OF WETLANDS	**H**	D		D	T		D	D	D
Development in wetlands (esp. filling wetlands)	H								
Drainage of wetlands	H								
Loss of lake recharge capacity	H								
LITTER	**M**				T	T			T
Dumping lawn waste into water bodies	M								
NUTRIENTS	**M**				T	T			T
Runoff of lawn fertilizers to lake	M								
Leaking septic systems in NW side of the lake	M								
Stormwater runoff to lake	M								
PATHOGENS AND PARASITES	**M**				T	D			
Swimmer's itch	L								
Leaking septic systems in NW corner of the lake	M				T	T			
Runoff from waterfowl/pet waste to lake (esp. geese)	L								

(H) = High; (M) = Medium; (L) = Low; (D) = Degraded; (T) = Threatened

Specific ways that water can be used are called "designated" uses and are recognized uses of water established by federal and state water quality laws and programs.[46] Designated uses were first identified in the federal Clean Water Act (1972) and are included in the State of Michigan's Natural Resources Protection Act (R323.1100 of Part 4 of PA 451, 1994, revised 4/2/99).[47] For water bodies in Michigan, all of the designated uses must be met. State of Michigan designated uses include: agriculture, navigation, industrial water supply, public water supply at the point of water intake, warmwater or coldwater fisheries, other indigenous aquatic life and wildlife, fish consumption, partial body contact recreation, and total body contact recreation from May 1 to October 31.[48]

The State of Michigan assessed all waters of the state to determine if State Water Quality Standards are being met (see list of standards in Table 3-2). If a violation of Water Quality Standards is measured, the waterbody is listed on the 303(d) list of impaired waters. Cedar Lake and its tributaries are not listed on the 303(d) list (in the Integrated Report) except for fish consumption.[49] The State of Michigan has issued a statewide impairment for mercury contamination due to atmospheric deposition for all waterbodies. This impairment is not addressed in this WMP because it is being addressed at the state/federal level and is beyond the scope of this WMP. Since none of the other designated uses are impaired, the SC evaluated Cedar Lake in terms of whether the designated use is "threatened" or perceived to be close to "impaired" status, which is referred to as "degraded" in this WMP.

An emerging group of contaminants of concern for Cedar Lake and its tributaries, and to a much higher degree in neighboring watersheds, are per- and poly-fluorinated substances (PFAS). PFAS compounds are detrimental to human health in very small quantities, typically denoted as parts per trillion (ppt equal to ng/l). Upwards of 5,000 types of PFAS compounds exist, and the extent of detrimental impacts to human health are still being revealed. To limit PFAS exposure to humans, the State of Michigan has enacted much stricter PFAS maximum contaminant levels (MCL's) compared to federal regulations.[50]

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[46] Brown, E., A. Peterson, R. Kline-Robach, K. Smith, and L. Wolfson. (2000). "Developing a Watershed Management Plan for Water Quality: An Introductory Guide." *A guide developed by Michigan State University, MSU Extension, and the Michigan Department of Environmental Quality with funding provided by the U.S. EPA.*

[47] Michigan DEQ Water Resources Division. (2006). "Part 4 Water Quality Standards." Accessible online: <https://www.michigan.gov/documents/deq/wrd-rules-part4_521508_7.pdf>.

[48] Michigan EGLE. (2020). "Michigan Water Quality Standards." Accessible online: <https://www.michigan.gov/egle/0,9429,7-135-3313_3681_3686_3728-350340--,00.html>.

[49] Michigan EGLE. (2020). "Water Quality and Pollution Control in Michigan Sections 303(d), 305(b), and 314 Integrated Report." Accessible online: <https://www.michigan.gov/egle/0,9429,7-135-3313_3681_3686_3728-12711--,00.html>.

[50] Michigan EGLE. (2020). "Michigan Adopts Strict PFAS in Drinking Water Standards." Accessible online: <https://www.michigan.gov/egle/0,9429,7-135--534660--,00.html>.

Table 3-2. State of Michigan Water Quality Standards.[51]

Parameter	Michigan Water Quality Standards*	Affected Designated Use(s)
Chlorides	125 mg/l monthly average	Public water supply
Dissolved Oxygen	Minimum 7 mg/l for coldwater designated streams and Great Lakes/connecting waterways. Minimum 5 mg/l daily average for all other waters.	Cold water fishery Warm-water fishery
E. coli	130 *E. coli*/100 ml 30-day geometric mean (from 5 or more samples). 300 *E. coli*/100 ml (maximum per sample) 1,000 *E. coli*/100 ml (as maximum).	Total body contact recreation Partial body contact recreation
pH	6.5 - 9.0	Warm-water fishery Other indigenous aquatic life and wildlife
Phosphorus	Narrative criteria developed for nonpoint sources	All
Radioactive Substances	Pursuant to U.S. nuclear regulatory commission and EPA standards	All (except navigation)
Taste/Odor-Producing Substances	Any concentration so long as the use of the water is not impaired or the palatability of fish is not impaired.	Industrial Water Supply Public Water Supply Agricultural Water Supply Fish Consumption
Temperature	Natural daily and seasonal fluctuations shall be (monthly average for inland lakes like Cedar Lake): Jan: 45°F (7.2°C); Feb: 45°F (7.2°C); Mar: 50°F (10°C); Apr: 60°F (15.5°C); May: 70°F (21.1°C); Jun: 75°F (23.9°C); Jul: 80°F (26.7°C); Aug: 85°F (29.4°C); Sep: 80°F (26.7°C); Oct: 70°F (21.1°C); Nov: 60°F (15.5°C); Dec: 50°F (10°C)	Warm-water fishery Other indigenous aquatic life and wildlife
Total Suspended Solids	No established WQS; TSS concentration less than 20 mg/l considered to be clear	All
Toxic Substances	DDT and metabolites: 0.00011 ug/l Mercury (and methylmercury): 0.0013 ug/l PCBs: 0.00012 ug/l 2,3,7,8-TCDD: 3.1 $x10^{-9}$ ug/l PFNA: 6 ng/l; PFOA: 8 ng/l; PFHxA: 400,000 ng/L; PFOS: 16 ng/L; PFHxS: 51 ng/L; PFBS: 420 ng/l HFPO- DA (GenX): 370 ng/l	All (except navigation)

[51] Legislative Counsel, State of Michigan. (2020). "Natural Resources and Environmental Protection Act 451 of 1994 (Excerpt): 324.3103 Department of environmental quality; powers and duties generally; rules; other actions."; and "… (Excerpt): 324.3106 Establishment of pollution standards; permits; determination of volume of water and high and low water marks; rules; orders; pollution prevention." Accessible online: <http://www.legislature.mi.gov/(S(wkxxxbbfx2h4e413rbvwd1yg))/mileg.aspx?page=getobject&objectName=mcl-324-3103>; and <http://www.legislature.mi.gov/(S(fwdruagzw40kt3xv5h4cdgeo))/mileg.aspx?page=GetObject&objectname=mcl-324-3106>.

CHAPTER 4: POLLUTANT SOURCE ASSESSMENT

Identifying and categorizing known and suspected pollutants, as well as the potential causes and sources of these pollutants, is a critical step toward identifying and prioritizing potential future management strategies and implementation projects intended to address pollutant concerns. In order to address the critical watershed threats and concerns, the Steering Committee identified the known and suspected pollutants associated with those threats and concerns during the development of the WMP. Potential pollutants were identified through existing reports and study findings, anecdotal experiences from SC members, and pollutants perceived by the public as problematic (as identified by SC members who regularly interact with the public and seek their input). By identifying known and suspected pollutants, the SC was able to link them with the potential pollutant sources and ultimately the causes in the watershed that produce or result in excess pollutants. Nearly a decade after the development of the original WMP, identified pollutants and pollutant concerns were updated and reprioritized based on current threats and concerns as well as positive changes and ongoing improvements.

Importantly, during the original WMP development process, the SC identified common pollutants that are generally implicated with the threats and impairments in the watershed, as well as problematic conditions or modifications in the watershed such as modified hydrology (both surface and groundwater). Pollutants and modifications are grouped together in the WMP as just "pollutants," for simplification purposes. The pollutants identified in the WMP are generally nonpoint source (NPS) related, as no specific point sources are present in the watershed. The SC prioritized and updated the information presented in this section by consensus, which was used to develop management strategies to control the potential sources and problems in the watershed (see Chapter 7). Only PFAS compounds have been added to the list of pollutants as these were not yet discovered during the development of the original WMP.

Known or Suspected Pollutants and Concerns

The original Steering Committee compiled a list of known and suspected pollutants for the watershed from the threats and degradations in the watershed discussed during their meetings for the original WMP. As part of the watershed assessment update, Core Team knowledge was used to identify and update suspected pollutants. Other watershed assessments are used to identify, confirm, and update known pollutants. Pollutants are re-identified in this technical update through available water quality data for Cedar Lake, hydrologic reports for the watershed, and empirical modeling to determine the likely problematic pollutants in the watershed. Table 4-1 lists the pollutants of concern and distinguishes between *known* and *suspected* pollutants.

Known pollutants are those that have been measured and/or observed while suspected pollutants are those that are likely or common to a particular impairment. Investigations and inventories include: 1) public surveys on septic systems, watershed concerns, and privately-owned lakefront conditions and uses; 2) aerial imagery and GIS mapping; 3) visual field inspections by technical consultants; 4) water quality monitoring and sampling reports, and; 5) direct groundwater and lake level/quantity monitoring.

Prioritization of pollutants and pollutant sources (Table 4-1) for the watershed was developed through a collaborative Steering Committee process. Members of the SC assigned the problematic pollutants a prioritization ranking of high (H), medium (M), or low (L) priority.

Table 4-1. Known and suspected sources of pollution or concerns in the Cedar Lake watershed.

Rank	Pollutants	Sources of Pollution	Priority
1	Modified hydrology (K)	Diversion/reduced recharge (NW area/wetlands) Drainage/lowered groundwater table (SE area storm sewers)	**H**
2	Invasive, non-native species (K)	Boats (boat launch areas) carrying invasive species Birds and other wildlife transporting invasive species Bait/fishermen introducing potential invasive species	**M**
3	Sediments (K)	Lakeshore erosion Internal plant production cycles Leaf matter/human contribution Stormwater/lawn runoff Streambank erosion	**H**
4	Toxicants (K)	PFAS/PFOA pollutants in groundwater, surface water and air	**H**
5	Pathogens (S)	Wildlife fecal runoff Pet/geese waste runoff Leaking septic systems Largemouth Bass virus	**M**
6	Nutrients (S)	Leaking septic systems Residential fertilizer runoff Pet/geese waste runoff Natural plant die-off	**M**

(K)=Known
(S)=Suspected

(H)=High
(M)=Medium
(L)=Low

Each member of the original SC individually evaluated the pollutants or watershed problems based on overall importance in the context of their role or duty in the watershed. In addition to their general perspective, the SC also incorporated public opinion and ease of implementation into their priority ranking. Then as a group, the SC ranked the pollutants, sources, and causes based on consensus. Table 4.1 was updated with Core Team input in the 2025 WMP.

Past water quality monitoring data from the AICLA and CLMP program indicate that phosphorus, dissolved oxygen, and temperature are not at levels that would cause impairment or pose an immediate threat to designated or desired uses. The AICLA continues to monitoring these parameters as they are good indicators of problems. If problematic levels are detected, the Lake Board is prepared to act on these issues.

Potential Causes and Sources of Pollutants and Concerns

Modified hydrology in the watershed is considered a substantial concern in the contributing watershed and immediate surroundings of the lake. Phase I and II hydrologic studies of the watershed developed a mass balance that indicated modifications to groundwater and surface hydrology negatively impact local wetlands and lake level during drier summer periods. For this reason, modified hydrology is considered a high priority on the list of pollutants/concerns.

All of the potential pollutant causes are listed in Table 4-2. The prioritization of pollutant sources was accomplished through Steering Committee consensus during the WMP process.

Table 4-2. WMP updated potential sources and causes of pollution in the watershed ranked by priority.

Rank	Sources of Pollutants/Concerns	Priority	Potential Causes	Priority
1	Drainage (K)	**H**	Current zoning (K) Residential development (K) No wetlands protection (i.e., ordinances) (K)	**H** **H** **H**
2	Diversion (K)	**H**	No wetlands protection (K) Filling wetlands for driveways (K) Culverts (S)	**H** **H** **M**
3	Stream flow modification (K)	**H**	Upstream development (S) Dewatering of wetlands (S) Culvert maintenance & beaver activities (K)	**H** **H** **H**
4	Toxicant-contaminated groundwater/surface water (S)	**H**	Historic land uses causing contamination (S)	**H**
5	Infected waterfowl/ wildlife waste runoff/infected snails (K)	**H**	Infected waterfowl and wildlife with presence of suitable host molluscan to continue lifecycle (K)	**M**
6	Stormwater runoff (K)	**H**	Lakeshore management (K) Manicured lawns (K)	**H** **M**
7	Residential fertilizer runoff (S)	**M**	Improper or excessive fertilizer application (S) No soil testing prior to fertilizer application (S)	**M** **M**
8	Leaking septic systems (S)	**M**	Old septic systems (S) Improper maintenance (S)	**M** **M**
9	Lakeshore erosion (K)	**M**	Manicured lawns (K) Soil instability (K) Nuisance waterfowl (S)	**M** **M** **M**
10	Leaf dumping in lake (K)	**M**	Lack of education for lakefront residents and less education for non-lakefront residents (K)	**M**
11	Pet/geese waste runoff (S)	**M**	Improper disposal of pet waste (S) Nuisance geese in yards (no deterrents) (K)	**L** **M**
12	Streambank erosion (S)	**L**	Intermittent high flows/limited vegetation (S)	**L**
13	Road-stream crossings/culverts (K)	**L**	Deteriorating culverts/infrastructure (S)	**L**

(K) = Known (H) = High
(S) = Suspected (M) = Medium (L) = Low

Sources of hydraulic modification are shown in Table 4-2 and include diversion of water from the wetlands in the northwest corner of the watershed where recharge water for the lake is stored. Diversion of surface water out of the watershed through a culvert beneath Kings Corner Road (diverting water to the south) shunts water away from Cedar Lake during early spring months. The wetland berm project, completed in 2017, has substantially reduced out-of-watershed losses through King's Corner, however, this culvert still acts as a diversion during spring periods of high flow.

The other surface water contributing waterbody in the northwest wetland, Jones Ditch, has also largely been impacted by hydraulic modifications impeding flows and inhibiting responsive hydrological and ecological needs for the lake. A 2017 Road Commission culvert replacement under W. Cedar Lake Road on Jones Ditch provided a threefold increase in wet-weather surface water drainage flows to Cedar Lake. Additional future improvements for upstream wetlands in the Jones Ditch drainage are a priority for continued benefits to hydrology and ecology.

Wetland and groundwater dewatering through a shallow storm sewer system on the southeast side of the lake continues to have a known negative impact on lake levels during dry summer months.[52] This drainage area continues to be monitored to more fully understand the relationship between lake levels and groundwater as it moves away from the lake in shallow aquifers towards Lake Huron. Similar future investigations are considered warranted in areas to the immediate northeast of Cedar Lake in the Timberlakes subdivision to further understand and quantify potential hydrological influence of this area on lake levels. These will inform related future drainage modifications being contemplated by potential developers and the Road Commission.

Invasive, non-native species are a high-priority concern in the lake that impair and threaten recreation and the fishery in Cedar Lake. This known problem has been documented in the watershed through annual reports and surveys of the lake by K&A serving the CLIB as the aquatic plant manager. There are several potential sources of invasive species. First, the SC identified boats that are transferred from other waterbodies to Cedar Lake as a very likely source, especially because of Cedar Lake's proximity to several other inland lakes, rivers, and Lake Huron. Second, birds and wildlife naturally transport species between watersheds. Last, Cedar Lake is a desirable fishing lake for many visitors and lake residents, which can result in use and disposal of bait in the lake and serve as a source of invasive species transmission.

Sediment loading to Cedar Lake was classified as a known pollutant based on lakefront resident surveys conducted by the AICLA in 2007-2008. The survey results indicated slight to moderate lakeshore erosion issues for the majority of the residents. Lake level fluctuations, substantial ice scour, and hard-armoring of neighboring shorelines all contribute to localized lakeshore erosion on Cedar Lake riparian properties. In addition to public surveys, slight bank scour has been observed on Sherman and Jones Ditch streambanks downstream of culverts under W. Cedar Lake Road. Potential sources of sediments to Cedar Lake are listed in Table 4-1. The sources include confirmed sites of erosion in the watershed, common sources (such as road-stream

[52] Kieser & Associates, LLC. (2006). "Phase II - Final Report for Additional Hydrologic Evaluation of Cedar Lake with Reference to Lake Levels (Alcona & Iosco Counties, MI)." *Prepared for the Alcona/Iosco Lake Association, September 18, 2005*.

crossings), and natural biological seasonal decay processes (which generally contribute low volumes of sediment or organic materials).

Sediment loading to Cedar Lake was ranked as a high priority because the public has been vocal about the issue as it relates to in-lake bottom sediments which impact recreation and aesthetics. The problematic lake-bottom sediments are made up of mostly flocculent, organic muck material that is considered largely historical material that has remained at the bottom of the lake since centuries ago when highly productive wetlands predominated in the area. A bathymetric survey and preliminary sediment assessment took place in 2019 to determine the extent of sedimentation throughout Cedar Lake. Investigation of new sources of sediment and modeling of the watershed indicates that watershed/external sources of sediment are moderate to low. However, overall lake sediment issues are important to residents of the watershed.

Toxicants were added to the list of known sources of watershed pollutants during this WMP technical update to reflect recent expressions of PFAS contaminants occurring within the Cedar Lake watershed. Attachment C contains a discussion with several figures of findings related to ongoing MI EGLE investigations of the sources and extent of PFAS contamination in the region. Testing to date shows multiple residential wells on the eastern side of Cedar Lake contained total PFAS concentrations between 10 and 500 ppt. Groundwater samples on the western and southern sides of Cedar Lake contained similar concentrations (between 10 and 500 ppt).[53] PFAS foams, unnaturally light, bright white, and sticky foams accumulating on surface water and shorelines, have also been observed and confirmed on Cedar Lake since 2018. Concentrations of PFAS tested in these foams have increased since 2018, with foam tested in 2020 revealing concentrations of 7,260 ppt, suggesting that PFAS-contaminated surface or groundwater continues to enter Cedar Lake.

The main source of regional PFAS contamination is Wurtsmith Airforce Base (WAFB), the known contributor of much more substantive PFAS pollution impacting Van Etten Lake, Cedar Lake's southwesterly neighbor. A substantial effort is underway to remediate the ongoing contamination issues at the WAFB. Given the measured directions of shallow groundwater flow away from Cedar Lake's south end toward Van Etten Lake, it is unlikely that contaminants are entering Cedar Lake by way of shallow groundwater exchange with Van Etten Lake.[54, 55, 56] PFAS contaminants, however, have been found in aquifers as deep as 700 ft underground, so the

[53] Michigan EGLE. (2020). "Oscoda Area Conceptual Site Model." Accessible online: <https://www.michigan.gov/documents/pfasresponse/Oscoda_Area_Conceptual_Site_Model_July_21_2020_Presentation_697071_7.pdf>.
[54] Northeastern University. (2020). "Public SSEHRI PFAS Contamination Site Tracker." Accessible online: <https://docs.google.com/spreadsheets/d/10y4u1KG6gegnw3zoTUTbXxQiEqitU1ufPlGvGiETtcg/edit#gid=682068550>.
[55] District Health Department No. 2. (2020). "Media Release." Accessible online: <https://www.dhd2.org/wp-content/uploads/2020/06/2020-6-30-VEL-and-Cedar-Lake-foam.pdf>.
[56] Michigan DEQ. (2017). "Wurtsmith Air Force Base – Public Meeting." *Presentation by Susan Leeming (DEQ) and Michael Jury (DEQ)*. Accessible online: <https://www.michigan.gov/documents/deq/120617-presentation-MDEQ_608360_7.pdf>.

role of deep groundwater aquifers cannot be discounted.[57,58] Atmospheric deposition of water containing PFAS compounds, which easily become airborne and can travel by wind, rain, and snow, is another possible contributor of this toxic substance to the Cedar Lake watershed.[59,60,61] The former Oscoda Township Dump (OTD), located on King's Corner Road near Loud Drive, represents perhaps the most likely potential source of PFAS contamination to Cedar Lake. The OTD, confirmed to have PFAS contaminated groundwater on site, historically accepted waste from the WAFB. EGLE's potentiometric maps highlight the possibility of the OTD as a potential source, including identification of an ancient river delta which spanned the area between the present day former OTD and Cedar Lake.[62] Further pollutant source investigations are needed.

Although nutrients are very common non-point source (NPS) pollutants in most watersheds, Cedar Lake generally has low levels of nutrients. This is illustrated by phosphorus concentrations measured through previous monitoring efforts, including the AICLA, CLMP, and DEQ data from the MiSWIMS database.[63] For this reason, nutrients were given a medium priority ranking. Maintaining low to moderate levels of nutrient inputs was identified as an extremely important preventative measure to protecting the lake against accelerated eutrophication over time due to anthropogenic impacts.

Pathogens were originally ranked as a low priority because of the lack of violations with the *E. coli* water quality standard. The District Health Department No. 2 has measured relatively low levels of *E. coli* in Cedar Lake at the Greenbush Township beach.[64] Recent health department sampling for *E. coli* has not measured persistently high or problematic concentrations in Cedar Lake at public access locations. Other bacterial concerns are associated with concentrations of nuisance waterfowl, and lakeshore resident septic systems in the northwest area of the lake.

As a parallel, but higher pollutant concern, includes summer outbreaks of swimmer's itch (cercarial dermatitis) in Cedar Lake. These have led to a re-prioritizing of this concern as a medium priority. The lifecycle of the adult parasite (schistosome) begins in the blood of infected

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[57] Dauchy, Xavier, *et al*. (2019). "Deep seepage of per- and polyfluoroalkyl substances through the soil of a firefighter training site and subsequent groundwater contamination." *Chemosphere: Vol 214, Jan 2019, 729-737.*
[58] Lieu, Yan, *et al*. (2019). "Contamination Profiles of Perfluoroalkyl Substances in Groundwater in the Alluvial-Pluvial Plain of Hutuo River, China." Accessible online: <https://www.mdpi.com/2073-4441/11/11/2316/htm>.
[59] Brusseau, Mark L., *et al*. (2019). "Comprehensive retention model for PFAS transport in subsurface systems." *Water Research: Vol 148, Jan 2019, pages 41-50.*
[60] Kim, Seung-Kyu. (2007). "Perfluorinated Acids in Air, Rain, Snow, Surface Runoff, and Lakes." *Environmental Science and Technology*.
[61] Northeast Waste Management Officials Association. (2018). "Atmospheric deposition as a source of contamination at PFAS impact sites." *Presentation by Christopher D. Zevitas, Sc.D. and Stephen Zembra, Ph.D., P.E.* Accessible online: <http://www.newmoa.org/events/docs/344_301/2018-12-13_ZevitasZembaAtmosphericDepositionWebinar.pdf>.
[62] Michigan EGLE. Michigan PFAS Action Response Team: Former Wurtsmith Air Force Base (Oscoda, Iosco County) Accessible online: <https://www.michigan.gov/pfasresponse/investigations/sites-aoi/iosco-county/wurtsmith>.
[63] Michigan EGLE. (2020). "Michigan Surface Water Information System." Accessible online: <http://www.mcgi.state.mi.us/miswims>.
[64] Michigan DEQ. (2010). "BeachGaurd: Cedar Lake – Greenbush Township Beach." Accessible online: <https://www.egle.state.mi.us/beach/BeachDetail.aspx?BeachID=2456>.

wildlife (waterfowl and some mammals), which passes eggs through the feces of the infected animal. Once the eggs enter Cedar Lake, they hatch free-swimming microscopic larvae (miracidia), which search for a molluscan (snail) intermediate host. Once infected, the snail releases different microscopic larvae (cercariae) which seek to burrow into the skin of a suitable wildlife host to continue the lifecycle. They can also burrow into human skin and, though they cannot develop inside human skin and will soon die, this burrowing can cause an allergic reaction and rash known as swimmer's itch.[65]

A comprehensive survey of the schistosomes considered as causative agents for swimmer's itch was conducted in Cedar Lake in 2020 by Freshwater Solutions and Patrick Hanington, Ph.D., University of Alberta.[66] Included in their survey were assessments of the vertebrate waterfowl hosts, invertebrate snail hosts and the parasites. These researchers also assessed the magnitude of the problem with qPCR analysis of swimmer's itch-causing cercariae in water samples. The analysis concluded that both mallards and Canada geese harbored adult schistosomes. With 94% of the summer resident waterfowl community being these two species, it was concluded that they were the most likely contributors to the swimmer's itch on Cedar Lake. Trapping and relocating geese was not, however, considered a potentially effective means of reducing the prevalence of swimmer's itch outbreaks vs. shoreline naturalization that tends to otherwise discourage their localized presence. K&A alternatively reintroduced the idea of stocking at-scale, Redear sunfish (known as shellcrackers) that feed almost exclusively on snails and clams as possible means to reduce outbreaks by reducing the numbers of this vector. The potential benefits and limitations of this notion are discussed further in Chapters 6 and 7, with details laid out in Attachment K.

To further investigate and confirm other likely pollutants, sources, and causes in the Cedar Lake watershed, K&A quantified pollutant loads using a scientifically based empirical method as part of the original development of this WMP. With this quantification method, information specific to Cedar Lake was collected and used with state of Michigan default values. The final output was an estimation of the likely pollutant loads from several land uses in the watershed. More information about the inputs and outputs are discussed in Chapter 5. Information ranked in this chapter, along with the results from empirical loading calculations, is used to identify critical areas for protection and restoration. Identifying critical areas serves to refine the management recommendations in the WMP that will help managers work toward reaching watershed goals.

[65] Centers for Disease Control and Prevention (CDC). (2020). "Parasites – Cercarial Dermatitis (Also Known as Swimmer's Itch)." Accessible online: <https://www.cdc.gov/parasites/swimmersitch/faqs.html>.
[66] Reimink, R. and P. Hanington. (2020). "Comprehensive Lake Assessment: Alcona-Iosco Cedar Lake Association, 2020 Final Report." September 2020. Prepared for the AICLA.

CHAPTER 5: LINKING POLLUTANT LOADS TO WATER QUALITY

Estimating likely pollutant loads from different land uses in a watershed can inform Watershed Management Plan recommendations for implementation projects and approaches. Identifying areas with high total pollutant loads or high loading per unit area can provide key information for prioritizing projects. Relative pollutant loading information also can assist in quantifying the expected load reductions from implementation projects. In addition, the information is useful for many types of future planning activities including land use and zoning, regulatory or ordinance measures, and general watershed management. Notable for the Cedar Lake watershed is its northwest cedar swamp drainage that can contribute non-point source runoff via Sherman Creek and Jones Ditch, as well as immediately adjacent land surfaces in riparian areas.

Beyond estimating current pollutant loads, predicting future loads from land use changes over time is a useful tool in determining and controlling future unintended impacts to water quality. Nutrients and sediments can negatively impact aquatic ecosystems in excess, yet play an essential role in maintaining healthy and functioning water resources at balanced levels. Water quality parameters such as total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS) are commonly used as indicators of water quality along with nutrient content of sediments. This chapter describes the quantification methods used to estimate current pollutant loads (TP, TN, and TSS), surface water runoff volume, and predicted future loading and runoff in order to identify key critical areas in the watershed for protection and restoration efforts.

Land Use Change

Nonpoint source surface runoff washes nutrients and sediments from the landscape into waterbodies. The land use types in a watershed impact the quality and quantity of the runoff. In order to quantitatively estimate the nutrient and sediment loads to Cedar Lake, percent land use by type within the watershed was originally determined using the 2001 land use data layer. For the WMP technical update, the percent land use by type was updated using the most-recent 2016 land use data layer (Refer to Figures 2-18 and 2-19).

This inventory of land uses shows that forest and wetland comprise approximately 84% of the land cover in the Cedar Lake watershed (not including surface water of Cedar Lake, covering approximately 22% of the total watershed, or 1,075 acres). About 15% of the watershed is classified as developed (including open space, low and medium intensity urban, and barren land cover). The 2016 land use dataset shows an 8% decrease in forested, scrub, and herbaceous lands, but a 6% increase in wetlands, wet woody, and emergent herbaceous lands since 2001. These changes are attributed to a more refined 2016 dataset, better able to distinguish between emergent herbaceous and forested herbaceous, rather than reflective of actual land use changes. The percent of combined developed land increased by only 1%, a relatively minor change, suggesting that only minor anthropogenic developments have taken place in the watershed since 2001.

Most of the developed area in the watershed is located near the shoreline of Cedar Lake, with privately-owned residential property comprising about 71% of the shoreline land use. Because the 2001 data layer initially lumped tree covered shoreline areas into the “forest” land use

category, a 2005 USDA aerial image was used to delineate residential riparian parcels lumping them instead into the "low intensity urban" land use category. The 2016 land use dataset by contrast, distinguishes the category of development within the riparian residential parcels. Thus, riparian residential properties may include "forest" or "developed open space" as the dataset distinguishes between wooded lawns and mowed grass or open lawns. These are further distinguished from "developed low and medium intensity and barren" land uses, such as houses, buildings, driveways, and parking lots. Figure 5-1 shows the updated distribution of land use, using the 2016 dataset in the entire watershed compared to the distribution of land use in the Cedar Lake shoreline area only.

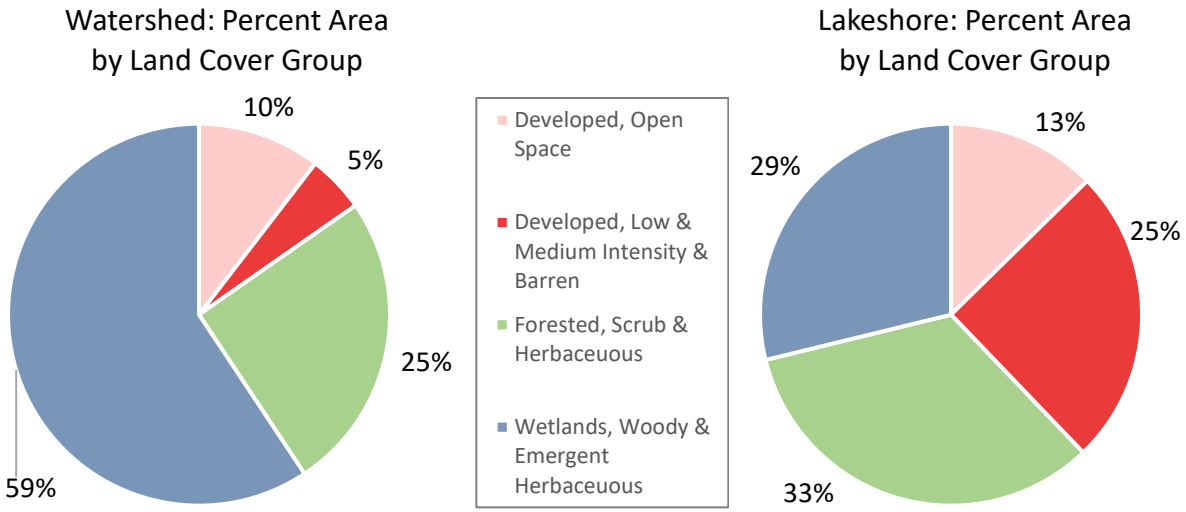

Figure 5-1. Comparison of 2016 land use distribution for the entire watershed and for the Cedar Lake shoreline only.

In order to estimate future land uses in the Cedar Lake watershed, a predicted future land use map for the watershed was developed for the original WMP from the Land Transformation Model, a GIS-based land use change model developed by researchers from Michigan State University.[67] This analysis is included as Attachment E.

Estimation of Pollutant Loads

Nutrient and sediment loading to Cedar Lake originates from four different source pathways: inflow from the northwest wetlands via Sherman Creek and Jones Ditch, stormwater runoff from shoreline properties, septic system discharges, and atmospheric deposition. Loads from each of these pathways were estimated using appropriate methods as supported by scientific literature and described as follows.

[67] Pijanowski, et al., (2000, 2002). "LTM". The LTM is currently hosted by Purdue University and available at: http://ltm.agriculture.purdue.edu/ltm.htm

Because phosphorus is commonly considered the nutrient that control aquatic plant and algal growth in freshwater systems, phosphorus loading is examined here and not nitrogen. Computations and consider sediment inputs. Load calculations consider creek loads from Jones Ditch and Sherman Creek, as well as the Cedar Lake shoreline area (as surface runoff from a narrow band of land between perimeter roads and the shoreline). Additional phosphorus sources consider atmospheric inputs directly to Cedar Lake, and septic system loading from the individual sewer systems near the shoreline. Septic system discharges are considered for only the northwest shoreline area as it is now well-documented that shallow groundwater from all other shoreline areas of the lake flows away from the lake and not to it. Thus, wherever septic system drain fields are located on developed shoreline properties in areas other than the northwest watershed areas, these are flowing away from the lake. Attachment F provides the details and results of the septic system survey conducted for the original WMP.

The Cedar Lake load quantification indicates that approximately 36% of the TP load comes from the northwest wetland area via Sherman Creek and Jones Ditch. Approximately 27% of the TP load comes from atmospheric deposition, and 20% of the TP load comes from shoreline stormwater runoff. The remaining 17% is estimated to come from septic system discharges in the northwestern shoreline area. Septic system inputs are not expected to contribute any significant TP loading to the lake along the majority of developed shoreline areas where shallow groundwater moves away from the lake. Empirically estimated loads are illustrated in Figure 5-2.

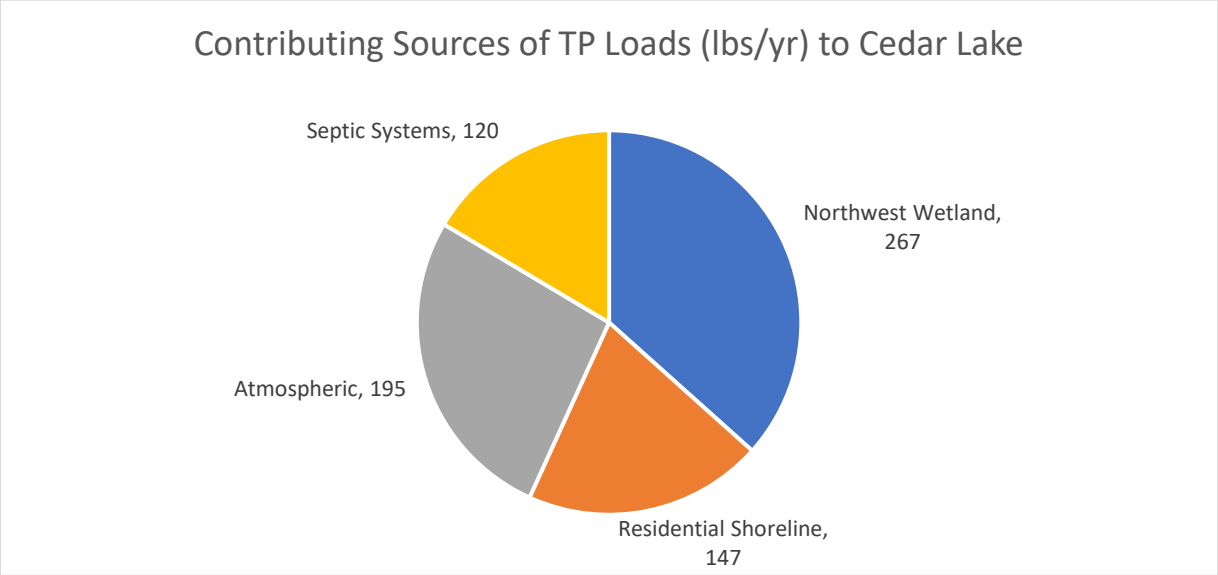

Figure 5-2. Sources and distribution of estimated TP loads to Cedar Lake.

Total phosphorus and sediment loads to Cedar Lake from the forest and wetland areas to the northwest of the lake reach the lake via Sherman Creek and Jones Ditch. These two creeks have years of flow monitoring which allows for more accurate load quantification methods than using unit area loading techniques. Loads can be calculated by applying phosphorus and sediment concentration values to flow volumes obtained from stream monitoring. Flow monitoring from

2014-2024 showed an average of approximately 800 million gallons of water flowing into Cedar Lake annually for both Sherman Creek and Jones Ditch combined.

Nutrient loading estimates could be improved with expanded water quality sampling on Sherman Creek and Jones Ditch. Limited water sampling was conducted in July 2024 in both the upstream and downstream of Jones Ditch. These showed a range of 18-20 µg/L for TP and a range of 5-7 µg/L for soluble reactive phosphorus (SRP). Published studies have observed median TP concentrations of 4 µg/L[68] and TSS concentrations of 15 mg/L[69] in small forested streams similar to these creeks. Applying these concentrations to the averaged observed flow volume results in loads of 267 lbs/yr TP and 50 tons/yr TSS. Notably, annual watershed loads will vary substantially given the high variability in stream discharges which are driven by snow melt and precipitation. Moreover, hydraulic improvement projects in these drainage areas, particularly Sherman Creek, now retain and deliver far more surface water to Cedar Lake than discussed in the original WMP. These are high quality waters from areas of the surrounding cedar swamp and represent undisturbed, naturally cleansed tributary inflow.

The northwest wetlands make up the majority of Cedar Lake's contributing watershed. Beyond the narrow band of shoreline properties, much of the area east and south of the lake actually drain surface water away from Cedar Lake towards Lake Huron or Van Etten Lake, respectively. Total phosphorus and sediment loading for these nearshore contributing areas of surface runoff can be quantified using a unit area loading method where established loading rates (lbs/ac/yr) can be applied to areas to estimate an annual load (lbs/yr).[70] The 2016 land use classification data were used for such an analysis. Developed shoreline land uses are responsible for 86% of phosphorus loading and 64% of sediment loading from these areas in these regards. Thus, even small increases in developed land uses could presumably have relatively large impacts on loading to the lake. Annual loads for these shoreline areas were calculated to be 147 lbs/yr of total phosphorus and 18 tons/yr of sediment. This shoreline loading condition points to the need for riparian stewardship that minimizes property runoff to the lake.

Particle deposition from the atmosphere can be a large source of phosphorus to lakes. Loading for this phosphorus pathway was calculated using rates summarized in literature.[71] These rates typically are given in micrograms per square meter per day. These values were converted to pounds per acre per year and applied to the surface area of Cedar Lake to calculate a load. Atmospheric deposition is predicted to contribute 195 pounds of phosphorus to the lake annually.

Septic systems can contribute phosphorus to water bodies when they discharge into shallow groundwater. This issue is more prevalent with older septic systems (e.g., >20-30 years old as a

[68] Binkley, D., Ice, G. G., Kaye, J., & Williams, C. A. (2004). Nitrogen and Phosphorus Concentrations in Forest Streams of the United States. 1. JAWRA Journal of the American Water Resources Association, 40(5), 1277-1291.
[69] Macdonald, J. S., Beaudry, P. G., MacIsaac, E. A., & H.E. Herunter. (2003). The effects of forest harvesting and best management practices on streamflow and suspended sediment concentrations during snowmelt in headwater streams in sub-boreal forests of British Columbia, Canada. Canadian Journal of Forest Research, 33(8), 1397-1407.
[70] Tomasek, M., Hora, M., Wilson, G., & H. Runke. 12. Detailed Assessment of Phosphorus Sources to Minnesota Watersheds.
[71] Tipping, E., Benham, S., Boyle, J. F., Crow, P., Davies, J., Fischer, U., ... & H. Toberman. (2014). Atmospheric deposition of phosphorus to land and freshwater. Environmental Science: Processes & Impacts, 16(7), 1608-1617.

coarse rule-of-thumb). A method for estimating the contribution of TP to lakes from shoreline septic system is outlined in Reckhow, *et al.* (1980).[72] The method estimates the inefficiency of shoreline septic systems in trapping phosphorus and preventing it from entering the lake though groundwater. The method involves calculating a soil retention coefficient and using site-specific average conditions of the septic systems and residential use to estimate a TP load. In order to gather this information, a septic system survey was distributed to riparian homeowners around Cedar Lake in 2011. Riparian homeowners were asked to provide information on: 1) the age of their septic systems, 2) distance from the lakeshore, 3) maintenance schedule, 4) number of permanent residents, 5) number of visitors, and; 6) use of a dishwasher. To estimate future TP loading from septic systems, the average age of each septic system was increased by the respective number of years since 2011. The final TP loading results for the 189 parcels on the northwest side of the lake is approximately 120 pounds of TP per year. This is likely a low estimate as the collected information represents conditions from 14 years ago.

Calculations for total phosphorus inputs (Figure 5-3) and sediment inputs (Figure 5-4) to Cedar Lake are illustrated below. The northwest wetland is the largest contributor of phosphorus and sediment to the lake, but it is also roughly 10 times the size of the shoreline band of parcels. These residential lots can have outsized phosphorus and sediment contributions to water bodies relative to their small size. Septic systems can also become significant contributors of phosphorus over time as they age.

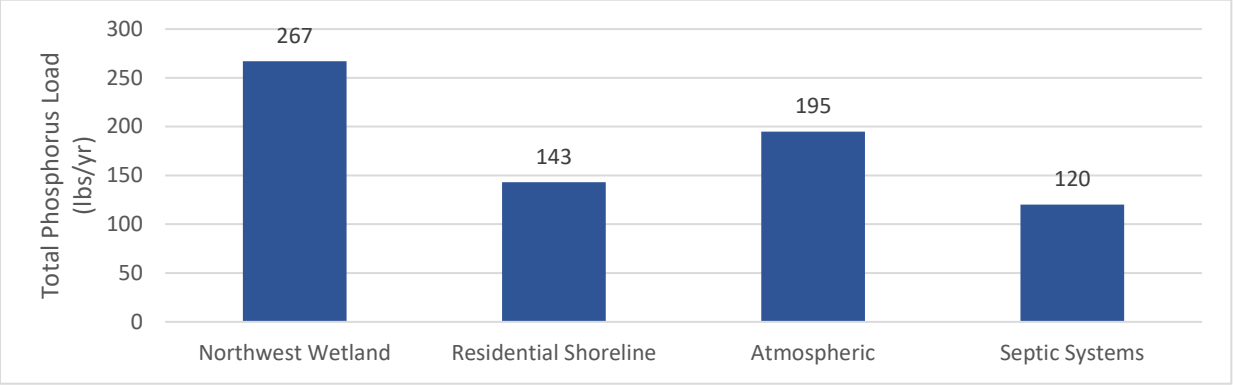

Figure 5-3. Total Phosphorus Nutrient Inputs to Cedar Lake.

[72] Reckhow, K. H., Beaulac, M. N., & Simpson, J. T. (1980). Modeling phosphorus loading and lake response under uncertainty: A manual and compilation of export coefficients.

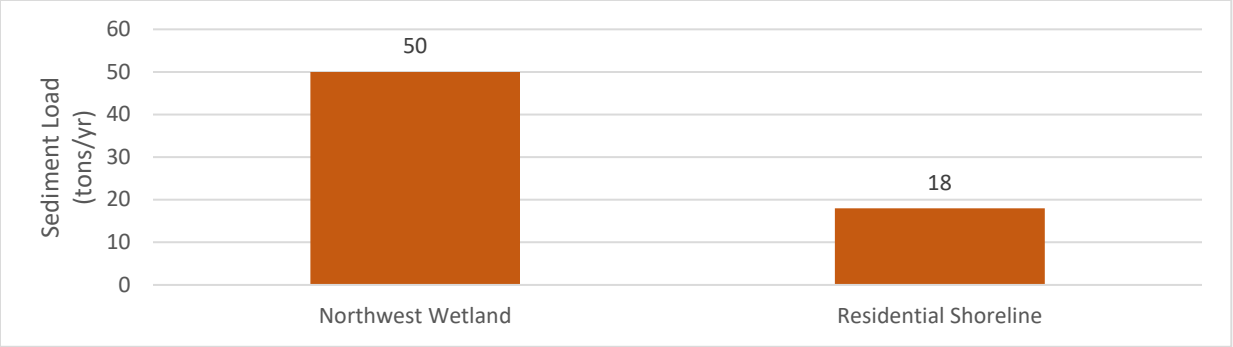

Figure 5-4. Sediment Load Inputs to Cedar Lake.

Estimation of Hydrologic Runoff

A primary goal for updating the WMP for Cedar Lake is to better manage activities in the watershed to protect recharge areas. The main sources of water to Cedar Lake are direct rainfall, surface runoff and groundwater. The hydrologic mass balance of Cedar Lake was investigated in K&A's 2005-2006 hydrology study to determine the causes of major lake level losses during dry years, and has since been confirmed with continued watershed hydrology monitoring.[73] The original hydrologic mass balance for Cedar Lake was estimated as follows:

Net gains to Cedar Lake:

- Rainfall (53%)
- Groundwater and Surface Water (northwest) (47%)

Net losses from Cedar Lake:

- Evaporation (15%)
- Groundwater (southwest to Phelan Creek through the Kings Corner Road culvert) (4%)
- Groundwater (northeast to Lake Huron in the Timberlakes subdivision) (33%)
- Storm sewers (southeast toward Lake Huron in the Lakewood Shores subdivision) (39%)
- Lawn watering (9%)

Monitoring of groundwater, precipitation, and surface flows in the northwest wetland has been performed by K&A since 2009 as part of the WMP watershed investigation in addition to data collected in 2004 and 2005 as part of the hydrologic study. Collectively, these data continue to provide useful information on the approximate volume of runoff coming from Sherman Creek and Jones Ditch. Data also help define surface water loss to the south from the culvert under Kings Corner Road that still diverts water to the Van Etten Lake/Pine River watershed via Phelan Creek, though only under high water level conditions in the surrounding cedar swamp. Importantly, recent data provide quantifiable evidence of beneficial changes resulting from the

[73] Kieser & Associates, LLC. (2006). "Phase II - Final Report for Additional Hydrologic Evaluation of Cedar Lake with Reference to Lake Levels (Alcona & Iosco Counties, MI)." *Prepared for the Alcona/Iosco Lake Association, September 18, 2005*.; and
Kieser & Associates. (March 2021). "Cedar Lake 2020 Hydrology Report." *Prepared for the CLIB.*

several improvement projects undertaken since 2014 in the northwest cedar swamp and Sherman Creek.

The approximate surface runoff volumes of Sherman Creek and Jones Ditch, as well as the water loss from the Kings Corner Road culvert from the original monitoring study in 2009 are compared to updated figures for 2014-2024 in Table 5-1. The large majority of surface runoff contributed to Cedar Lake occurs in late winter to later fall from both Sherman Creek and Jones Ditch. The culvert at Kings Corner Road typically diverted a majority of runoff in late fall through early spring. The volume of water diverted through King's Corner culvert has substantially decreased since implementation of the wetland berm.

As Table 5-1 shows, implementation projects since 2014 have supported efforts to bolster water retention and surface water contributions to Cedar Lake. Water control management efforts include railroad culvert cleanouts in 2014, the construction of a wetland enhancement berm in 2017, recent instream grade structures within Sherman Creek in 2019, and Jones Ditch culvert replacement in 2017 which improved water release from wetland storage.

Table 5-1. Comparison of approximate volume of surface runoff from the northwest wetland area for annual 2009 and May 1 to Oct 1, 2014-2024, including out-of-watershed losses from the diversion at Kings Corner Road culvert. ***(Data Source: K&A as seen at:*** *https://cedarlakewmp.net/monitoring-reports***).**

Site	Volume (MGal)										
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Sherman Creek (inflow)	136.0	191.0	198.1	449.4	328.1	446.8	359.9	195.2	147.4	524.4	501.1
Jones Ditch (inflow)	64.8	21.6	18.0	*59.8	75.7	654.7	177.3	800.0	287.8	952.7	549.8
Lake Outlet (outflow)	13.0	109.5	**0.2	**26.1	52.0	143.2	21.6	0.0	0.145	18.1	137.3
Kings Corner (outflow)	32.2	46.9	17.0	38.1	4.4	10.2	21.8	0.2	0.2	10.4	0.1

*Jones Ditch 2017 flows from 5/1/17 to 9/1/17 only.

**Affected by presence of beaver dam upstream of Cedar Lake outlet, mechanically removed in fall 2017.

Figure 5-5 illustrates these improvements by comparing 2014-2024 May to September monthly rainfall totals with monthly combined total volumes contributed to Cedar Lake via Sherman and Jones Ditch and volumes lost from the Cedar Lake watershed via King's Corner culvert.

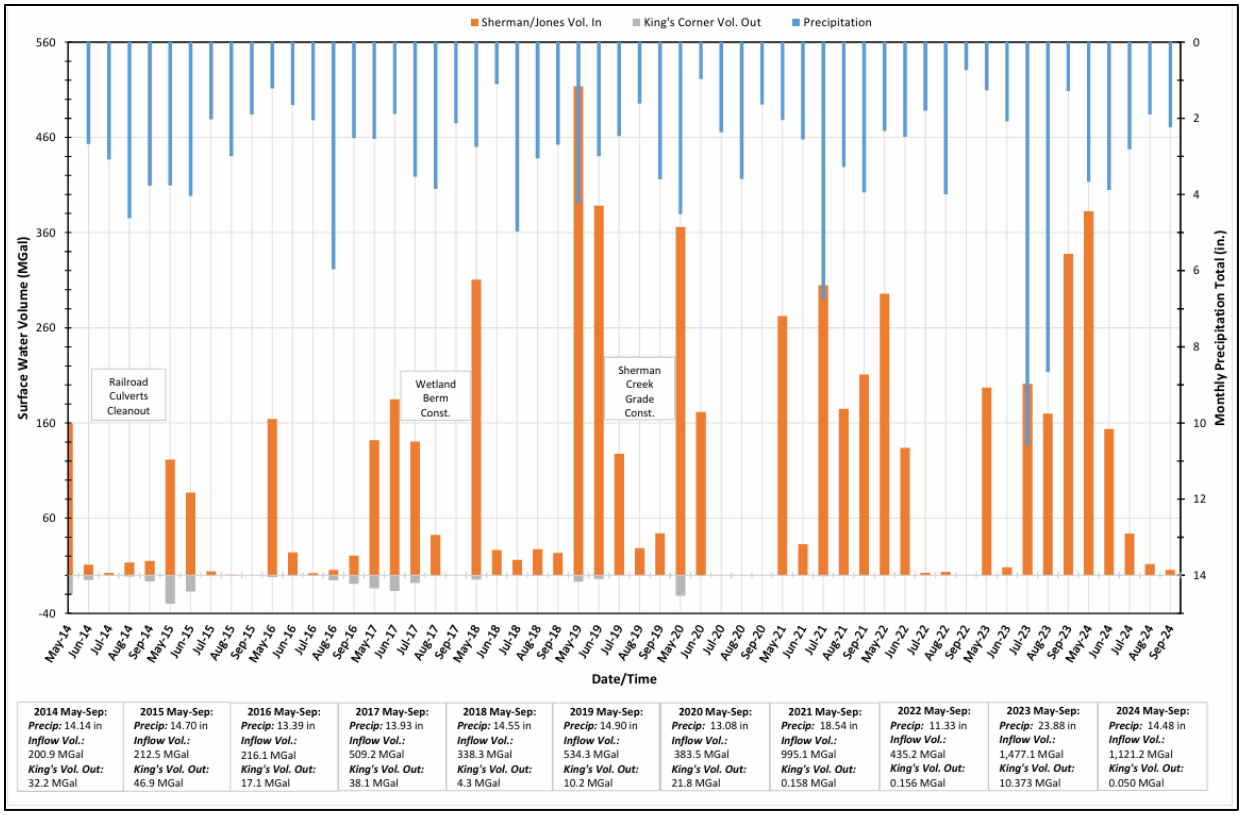

Figure 5-5. May-Sep 2014-2024: Precipitation, Sherman/Jones Ditch Combined Surface water Volume into Cedar Lake, and King's Corner Surface Water Volume Away from Cedar Lake.

The most recent 2024 K&A hydrology report demonstrates the overall decrease in water lost through the King's Corner culvert, mainly due to the wetland berm project. It also demonstrates an increase in volume entering Cedar Lake through Sherman Creek and Jones Ditch. These benefits have forestalled an imminent need to pursue deep groundwater augmentation wells such as outlined in the 2011 Augmentation Feasibility Study[74] (with subsequent refinements in a 2022 K&A Technical Memorandum).[75]

The relative sources of surface water gains and losses for Cedar Lake are important for planning and implementation efforts associated with the WMP implementation strategy. Many of the watershed goals and objectives are focused on maintaining balanced lake levels, especially during dry summer months. As these goals and objectives continue to be worked into the implementation strategy, it will be necessary to continue to determine the likely volumetric impacts of the recommended BMPs, projects and approaches. Other considerations of the impacts of the updated WMP implementation phase will be how changing runoff patterns in the watershed will affect: 1) pike spawning in Sherman Creek and Jones Ditch; 2) limited residential

[74] Kieser & Associates, LLC. (April 2025). "Cedar Lake 2024 Hydrology Report." *Prepared for the CLIB.*
[75] Kieser & Associates, LLC. (March 2022). "Findings for Stage 2 of Task 6 – Cedar Lake Phase III Augmentation Assessment. *Prepared for the CLIB.*

structures in the northwest wetlands area, and; 3) groundwater levels in the Lakewood Shores housing development.

Critical Areas and Priority Areas for Protection in the Watershed

"Critical" areas are described in the State of Michigan WMP Guidance document as a geographic portion of the watershed contributing a majority of the pollutants and having a significant impact on the waterbody.[76] "Priority" areas are high quality locales in the watershed that may need protection from potential pollutants. For the Cedar Lake WMP, the SC considered areas of the watershed that were critical for protection or restoration in terms of lake recharge and lake levels, critical fish and wildlife habitat, and water quality. To identify and differentiate critical and priority areas, the SC drew upon identified designated and desired uses; watershed concerns and issues; known and suspected pollutants, sources and causes; and, the estimated current and future pollutant loads to Cedar Lake, to pin-point specific locations where restoration or protection are most needed. Protecting and improving these particular areas will provide the most benefit to the lake and its watershed. Figure 5-6 shows the locations identified as critical and priority areas.

In general, the large tracts of wetlands in the northwest portion of the watershed have been identified as extremely important for providing the majority of the surface water to Cedar Lake, especially through two small inlets, Sherman Creek and Jones Ditch. These creeks convey surface water from spring to early summer that is collected and stored in the wetlands and then discharged to the lake. Other areas identified as priorities for protection are in-lake fish habitat and natural shorelines. While these areas are broader in scope, specific pockets of fish habitat and parcels with natural shorelines have been identified through surveys and assessments in the watershed. These specific types of land are identified for projects that will provide habitat protection, and serve as valuable examples for educating stakeholders. The remaining areas identified in Figure 5-6 have been selected because restoration or protection projects are most needed in these select areas.

[76] Brown, E., A. Peterson, R. Kline-Robach, K. Smith, and L. Wolfson. (2000). "Developing a Watershed Management Plan for Water Quality: An Introductory Guide." *A guide developed by Michigan State University, MSU Extension, and the Michigan Department of Environmental Quality with funding provided by the U.S. EPA.*

Figure 5-6. Critical areas and priority areas for protection in the Cedar Lake Watershed.

The critical areas and priority areas for protection in Figure 5-6, numbered 1 through 8 for reference, are described as follows:

1. **<u>Sherman Creek</u>: *Priority Area for Protection*:** This creek serves as one of the two main sources of surface water to Cedar Lake during the spring and early summer (note volumes in Table 5-2). The creek also provides spawning habitat for several fish species (including pike) important to the Cedar Lake fishery. Sherman Creek is one of only two major surface water connections between the wetland and the lake, and provides nursery habitat for young fish before they move into the lake via the creek. The majority of the main channel of Sherman Creek is on a single property that was purchased by the Lake Board in 2014 to permanently protect and preserve Sherman Creek, its streambanks and the connections it provides to the wetland. In September 2019, instream grade structures were implemented within Sherman Creek. These structures aim to provide improvements to water retention and pike spawning habitat. Ongoing monitoring of surface and groundwater in this area continues to provide crucial data to help guide future implementation decisions.[77]

2. **<u>Jones Ditch</u>: *Priority Area for Restoration & Protection*:** Jones Ditch also provides surface runoff from the wetland into Cedar Lake. In addition, Jones Ditch can potentially provide fish habitat if the existing channel between W. Cedar Lake Road and the lake is restored to a naturalized channel condition. Currently, these most downstream sections of the ditch are downcutting with no meanders or pool features. Creating a naturalized channel will provide, for example, pike spawning access to nearly 1,000 acres of existing wetlands in the upstream areas of ditch drainage. This corridor is one of only two surface water connections between the wetland and lake, and therefore a priority area for protection as well.

   The Jones Ditch culvert beneath W. Cedar Lake Road was replaced in 2017, which substantially changed the flow pattern of upstream Jones Ditch, increasing its surface water contribution to Cedar Lake. Sedimentation and beaver activity issues upstream of and within the culvert are addressed by the Drain Commission. The Lake Board, in 2022, purchased an approximate 12-acre shoreline and wetland property including the channel with wetland acreage just upstream of the culvert. Assessment of options for managing the volume of Jones Ditch with enhanced ecological value is recommended in Chapter 7, considered as potentially beneficial for additional wetland storage inflows to Cedar Lake.

3. **<u>Sherman Creek Wetland Drainage</u>: *Priority Area for Protection*:** The wetland draining to Sherman Creek is outlined in white in Figure 5-6. This priority protection area, with the entire wetland complex, provides critical water volume inflows to Cedar Lake during the spring and early summer. The Sherman Creek grade structures have served to increase the water storage of this wetland area. The 166-acre drainage area, with 138.6 acres owned by the Lake Board, should continue to be protected from development

[77] Kieser & Associates. (April 2025). "Cedar Lake 2024 Hydrology Report." *Prepared for the CLIB.*

(including filling and clearing) to protect the storage capacity and water supply to Cedar Lake.

4. **<u>Kings Corner Road Diversion</u>: *Critical Area*:** A culvert is located under Kings Corner Road near W. Cedar Lake Road. This culvert diverts water from the wetland on the north side of the road to the south, resulting in a diversion of water out of the Cedar Lake Watershed and into the adjacent watershed (Pine River/Van Etten Lake via Phelan Creek). A wetland retention effort began in fall 2017 with the construction of a wetland enhancement berm on the newly acquired Lake Board property, parallel to King's Corner Rd. Thus far, the berm has effectively increased the volume of water retained in the cedar swamp that is now diverted into Sherman Creek, significantly decreasing water loss through King's Corner culvert. Continuing to monitor and prevent out-of-watershed losses through the Kings Corner Road culvert diversion is critical in order to restore the wetland hydrology and conserve surface water inflows for Cedar Lake.

5. **<u>Lakewood Shores Drainage District</u>: *Critical Area*:** This critical area lies just outside of the Cedar Lake Watershed but is hydrologically linked through a groundwater connection. The lake naturally loses water to shallow groundwater aquifers at the south end of the lake. The Lakewood Shores residential development has naturally high groundwater as a former cedar swamp, so a subsurface dewatering drainage system was installed to drain water towards Lake Huron. The drain system was identified in the K&A Phase II hydrologic study as the largest water loss from Cedar Lake during summer months.[78] Restoration is not the major objective for this area since residents in this area rely on the existing dewatering drainage system to keep their houses from being inundated with water during wet months. The original SC determined that educating builders and new residents about the flooding issues around this area is likely the best approach to stave off drainage upgrades that might further exacerbate groundwater losses, and in turn, decrease lake levels. The main goal for this area is to examine potential future options with the County Drain Commissioner that could meet the WMP goals while safe-guarding built domiciles through drainage management. The Drainage District has suffered two major collapses in the last few years in portions of the aging dewatering drainage system. As the system continues to deteriorate, the potential for more failures is likely. Repairs can either serve to exacerbate shallow groundwater movement away from the lake, or integrate structural features that could benefit homeowners and the lake.

6. **<u>In-lake Fish Habitat</u>: *Priority Area for Protection*:** Pockets of fish habitat in Cedar Lake were identified by fisheries biologists in 2009. The specific habitat locations shown in a report figure were identified as critical fish habitat in the 2009 Aquatic Plant Management Program Update Report.[79] Monitoring of these habitat areas is being conducted by the Board to update the in-lake and tributary conditions assessment.

[78] Kieser & Associates, LLC. (2006). "Phase II - Final Report for Additional Hydrologic Evaluation of Cedar Lake with Reference to Lake Levels (Alcona & Iosco Counties, MI)." *Prepared for the Alcona/Iosco Lake Association, September 18, 2005*.
[79] Pullman, D. (2009). "Cedar Lake Greenbush Township, Alcona County, Oscoda Township, Iosco County, Michigan: Management Program Update."

Updating the critical fish habitat area map is a recommended implementation effort for the WMP technical update (Chapter 7).

7. **<u>Lake Outlet</u>: *Critical Area*:** The outlet to Cedar Lake is located at the far northern end of the lake. The historic dual spillway structure was replaced with a single broad weir structure in autumn of 2020. The spillway structure directs water flowing over the lake outlet weir, under W. Cedar Lake Road, into a small stream to the north that eventually discharges to Lake Huron. The structure is set at the elevation of the court-ordered lake level, 608.2 ft above sea level to prevent the lake from rising above this elevation. Lake levels will continue to be monitored at the lake outlet to monitor the functionality of the new structure and determine lake levels as new WMP implementation efforts are undertaken. Data collected since 2020 show how the new structure is more effective at maintaining a lake level closer to the legal level during spring conditions, thereby reducing peak lake water levels above the legal level when compared to the historic outlet structures. Management by the road commission will be essential to the operation of this outlet.

8. **<u>Cedar Lake Shoreline</u>: *Critical Area*:** Most of the Cedar Lake shoreline has been developed for residential use, as well as for parks and recreation. Results from a 2007-2008 shoreline survey conducted by the AICLA indicated that mowed turf grass is the most common lawn cover near the shore. The survey also asked riparian landowners to indicate if they had seawalls (steel, wood, or concrete). Figure 5-6 shows developed parcels along the shores of Cedar Lake. Those without seawalls are critical areas for protection. These residents should be targeted for education on natural shorelines to deter building of additional hard shoreline structures/seawalls. As part of these initial efforts, a pilot demonstration project was conducted by the Lake Board at the Lakewood Shores clubhouse. Though 100 lineal feet of natural shoreline was installed, severe winter ice flows and later, clubhouse marina updates eventually rendered this section of shoreline back to a manicured condition. Naturalized shorelines remain optional for private property owners but without promotion, will likely remain as a limited feature of WMP implementation.

CHAPTER 6: WATERSHED GOALS, OBJECTIVES AND PROGRESS

The 2025 WMP Steering Committee developed and updated goals for the watershed that are based on restoring and protecting the designated and desired uses of Cedar Lake. These goals outline the overall desired outcomes in the watershed. The goals are broad and flexible so they can continue to accommodate changes in watershed management over time, yet still direct managers to the outcomes which the SC initially intended.

SETTING WATERSHED GOALS PROVIDES A CLEAR DIRECTION FOR EFFORTS IN AND AROUND CEDAR LAKE. OBJECTIVES PROVIDE A MORE DETAILED DESCRIPTION OF HOW GOALS CAN BE

Watershed Goals

Comprehensive watershed goals were developed to reflect the issues surrounding each threatened use or concern in the watershed. The goals reflect the final desired outcome of the Watershed Management Plan, which is to attain and protect the designated and desired watershed uses. The goals are listed below in an order that follows the list of designated and desired uses in the watershed from Table 3-1, though do not reflect any priority ranking here.

Each goal set for the watershed should be considered "equal," as successful implementation of the WMP will require working toward achievement of all watershed goals. Goals interrelate, so one could not reasonably deem protection of the Cedar Lake fishery to be any more or less important than maintaining a balanced aquatic plant community. Ultimately, the goal of the WMP will be to identify and implement improvement opportunities to, for example, reach both goals, thereby resulting in a healthy aquatic ecosystem.

The final desired outcome of the WMP to meet all designated and desired uses will be achieved by strategically accomplishing the following Cedar Lake watershed goals:

1. Restore and protect the warm-water fishery to support healthy populations of native fish species.
2. Maintain a balanced and healthy indigenous aquatic plant and wildlife community in Cedar Lake and the watershed.
3. Maintain open and clear waterways for recreation.
4. Preserve good water quality, reduce and prevent groundwater pollution, and minimize muck sediments for full body contact recreation.
5. Protect groundwater levels for lake recharge to achieve balanced lake levels.
6. Maintain lake levels at, or as pragmatically close to the legally established level of 608.2 by protecting and enhancing recharge sources and surface water inputs while preventing further exacerbation of groundwater losses.
7. Conserve and restore wetland and aquatic habitat for ecosystem function and service.

To accomplish these watershed goals, the new WMP Steering Committee was led through a process of identifying and defining objectives for each goal. A comprehensive WMP requires objectives specific to each goal that help to develop and guide the actions used in the WMP implementation phase. Each objective points to specific issues for the purpose of identifying opportunities and approaches toward implementing improvement projects, in order to reduce

pollutants or resolve other watershed problems. These objectives serve as a critical component of the road map which allows watershed managers to determine progress toward goals and re-establish updated tasks needed to achieve those goals.

Watershed Objectives

The watershed objectives developed for each watershed goal, outline ways that the designated and desired uses for the Cedar Lake watershed will be restored or protected. To accomplish the watershed goals, each objective will propose a variety of detailed actions such as consideration of existing regulatory controls, specific implementation projects, adoption of applicable BMPs, education, and other approaches. This chapter outlines each updated watershed objective, then details the accomplishments and progress made toward each watershed objective. In Chapter 7, the updated implementation strategy provides the updated management strategies, approaches, actions and tasks for each objective.

The following is a complete list of updated watershed objectives, referencing related watershed goals, followed by a list of updated objectives which will be detailed in Chapter 7. The original WMP objectives can be found in Attachment G which shows side-by-side comparisons of the original and updated Objectives as discussed by the WMP Update Steering Committee in 2025.

Updated (2025) Cedar Lake Watershed Objectives:

- **Objective I: Cedar Lake Water Level [*Goals 1, 5, and 7*] –** Maintain the Cedar Lake legal lake level by pursuing feasible lake water level augmentation projects including enhancing wetland hydrology in the northwest cedar swamp and preventing drainage or diversion (and loss of wetland function)
- **Objective II: Groundwater Loss (Lakewood Shores) [*Goals 5 and 6*] –** Adopt strategies to prevent additional groundwater loss from the lake on the southeast side due to storm sewer infrastructure
- **Objective III: Groundwater Loss (Timberlakes) [*Goal 5*] –** Pursue strategies to prevent drainage loss through groundwater due to potential future developments in the Timberlakes area (northeast side of lake).
- **Objective IV: Fisheries [*Goal 1*]–** Improve the sport fishery in Cedar Lake through enhanced lake levels, creek flows, habitat, stocking and wetlands protection
- **Objective V: Aquatic Invasive Species [*Goals 2 and 3*] –** Work to stop the spread of invasive, non-native species to the Cedar Lake watershed and control existing nuisances
- **Objective VI: Lake Sediments [*Goal 4*] –** Clarify realistic considerations of at-scale management options while seeking innovations to improve composition of lake bottom sediments (based on scientifically supportable findings through refined feasibility studies)
- **Objective VII: Natural Shorelines [*Goals 2, 3, and 7*] –** Educate lakeshore residents about natural shoreline methods, green buffers, and other BMPs that can be used to benefit the lake
- **Objective VIII: Water Quality [*Goals 3 and 4*] –** Expand water quality monitoring on the lake including pathogens, nutrients, PFAS, and other emerging contaminants to protect good water quality and recreational value of Cedar Lake

- **<u>Objective IX</u>: Public Boat Launch [*Goals 3*] –** Pursue improvements to the DNR public boat launch to ensure safe recreational user access to the lake

Objectives I through III relate to protection and/or enhancement of groundwater and surface waters that recharge the lake, as well as prevention of groundwater losses away from the lake, supporting Goals 5 and 6. These objectives point out specific areas and resources in the watershed that require protection and management to reach watershed goals.

Objective IV relates to Goal 1 by specifically identifying improvements in the watershed that would protect and benefit the fishery. In general, adequate lake level, enhanced creek flows, improvement in available spawning habitat, and wetlands protection in the northwest part of the watershed are all specific items that must be addressed to meet the fishery goal for Cedar Lake.

Objective V points management efforts toward protection of waterways (Goal 2 and 3) by identifying the need to combat the threat of invasive species and control existing nuisance aquatic species already found in Cedar Lake. These efforts will maintain and increase the recreational and aesthetic value of Cedar Lake.

Objectives VI through VIII address in-lake conditions supporting partial and full body contact recreation as they relate to Goal 4. Existing organic muck sediments impact aesthetics of the lake. Outcomes of recent studies have determined removal of sediments to be infeasible or cost-prohibitive. Therefore, alternative strategies are discussed in this WMP update. Water quality issues related to excessive nutrients are not currently a lake-wide issue in Cedar Lake, however, localized nutrients and bacteria are a concern where there are septic systems discharging to the lake. Issues such as Swimmer's Itch and PFAS contamination will need to be studied and controlled as these conditions affect the recreational value of Cedar Lake (Goal 4).

Goal 4 emphasizes the need to take measures to preserve and protect the existing water quality conditions in Cedar Lake. Objective VII highlights the need for educating lakefront residents, in particular regarding practices they can implement on their properties to protect lake quality and prevent degradation of water quality over time. Objective VIII points to monitoring efforts as an important tool to track pollutant concentrations and changing conditions.

Objective IX provides a specific project area of the DNR Public Boat Launch on Cedar Lake related to Goal 3. The objective calls for very specific improvements needed for the Boat Launch to increase accessibility and recreational opportunities in all lake water level conditions.

<u>Progress Toward Original (2011) Implementation Goals and Objectives</u>

This section of Chapter 6 explores progress made since the 2011 WMP, as well as remaining gaps toward achieving the original WMP implementation objectives (Objectives I - IX). These depictions include relevant milestones and benchmarks for each objective. Attachment G shows a side-by-side comparison of the original and updated Objectives, as well as illustrations of progress toward original objectives with photographs and charts as discussed by the WMP Update Steering Committee in 2025.

For each of the original objectives, this section summarizes the actions and tasks undertaken and the relevant milestones and benchmarks associated with each objective. The purpose of this section is to: 1) highlight improvement project achievements to date toward achieving objectives, and; 2) acknowledge what has not yet been accomplished to better forecast updated tasks and actions currently needed to continue making progress toward each objective introduced in Chapter 7.

<u>Objective I (2011)</u>: Protect critical wetlands in the Cedar Lake watershed to the northwest of the lake from drainage, filling and diversion (and resulting loss of wetland function)
Progress toward the 2011 Objective I tasks includes:

1. Completed implementation projects undertaken to restore hydrology and retain/transmit critical stores of groundwater in the northwest wetlands to the lake:
    a. Beginning in 2014, regular inspections and clean-outs of culverts by the Lake State Railway company whose north-south line splits the northwest watershed;
    b. A wetland flow diversion berm project completed in 2017 on CLIB Sherman Creek property designed to reduce out-of-watershed losses via King's Corner Road culvert, and;
    c. Three Sherman Creek in-stream grade structures placed in 2019 to improve wetland water retention for critical spawning habitat of northern pike as well as extended creek flows into the early summer and increased groundwater recharge in the area benefitting Cedar Lake.
2. Lake Board purchase of 138.6-acres of a Sherman Creek wetlands parcels in 2014 and 2015 facilitating the wetland berm and instream grade structure projects above.
3. A 2022 purchase of a 12-acre parcel surrounding the Jones Ditch outlet to the lake with an upstream portion of the property extending into wetlands west of W. Cedar Lake Road. This purchase, along with land surrounding Sherman Creek puts portions of critical areas of the watershed under the purview of Lake Board protection. The Jones Ditch parcel ownership will facilitate proposed channel connection improvements with the lake (see Chapter 7).

Progress toward original milestones proposed for tracking Objective I efforts includes:

1. The 2014, 2015, and 2022 Lake Board wetlands parcel purchases which now protect hundreds of acres of critical contributing wetland around Sherman Creek and Jones Ditch.

<u>Objective II (2011)</u>: Prevent additional lake water loss to groundwater on the east and southeast sides of Cedar Lake
Proposed actions for the original Objective II focused on helping homeowners reduce or avoid flooding problems in homes with the understanding that fewer homeowners experiencing flooding could quell demand for storm sewer expansion. There is no specific WMP progress toward the tasks originally proposed for achieving Objective II beyond tracking Drain Commissioner efforts to periodically repair aging infrastructure. With no definable milestone achievements for this category, relevant tasks for this Objective are carried over into the updated Objectives in Chapter 7.

<u>Objective III (2011)</u>: Pursue augmentation suite of lake level management options for implementation based on Augmentation Feasibility study

Actions and tasks originally proposed to achieve this watershed management objective focused on funding a lake level augmentation feasibility study to assess priority measures implementable through the Lake Board or other agencies. The augmentation study was completed in 2011.[80] The identification of options was designed to gain public support for actions to restore natural hydrology that enhanced water movement from the northwest wetlands to the lake. The goal of these efforts was reducing occurrences of substantial lake level losses during dry years. Feasible measures are updated with detail for future implementation in Chapter 7.

Of the nine original augmentation measures identified, Measures 2, 3, and 10, have been pursued with implementation projects. Details of these measures and progress toward Objective III include:

1. **Measure 2: Kings Corner Culvert Modifications**
    a. Construction of the wetland berm in 2017 parallel to King's Corner Rd, designed to retain water in the cedar swamp and reduce out-of-watershed losses through King's Corner culvert, now retains water at just less than spring peak wetland water levels (to prevent flooding of adjacent parcel). Originally suggested use of a culvert stop-board structure adjacent to the roadway was deemed unacceptable to the Road Commission due to potential impacts on road grade stability. While the historic construction of King's Corner Road most likely bisected the northwest cedar swamp, subsequent road drainage improvements (such as the targeted culvert) artificially diverted water away from Cedar Lake. The accepted alternative was the wetland berm project implemented on purchased Lake Board property. The previously discussed property ownership issue with targeted development of the now protected wetlands was additionally resolved with Lake Board purchase of the relevant wetland parcel in 2015.

2. **Measure 3: Sherman Creek Modifications**
    a. Implementation of instream grade structures in Sherman Creek in 2019, with structures inset at 50', 100', and 150' upstream of Sherman Creek culvert under W. Cedar Lake Road were designed to enhance pike spawning habitat during spring/early summer and help retain surface water in the wetlands to improve summer month lake water levels.

3. **Measure 10: Replacing the Lake Outlet Spillway**
    a. The Cedar Lake outlet replacement project was completed in 2020. Details for the replacement, designed and implemented by the Drain Commissioners and Spicer Group, LLC, include:
        i. A structure consisting of one concrete inlet and one concrete box culvert designed to better manage the legal lake level, require less maintenance, provide increased flood protection, and provide safer working conditions

[80] Kieser & Associates, LLC. (2011). "Cedar Lake Augmentation Feasibility Study." *Prepared for the Cedar Lake Improvement Board, August 25, 2011.*

when maintenance is required.

ii. Structure design is increased outlet weir length, inlet discharge capacity and waterway area (compared to the historic concrete drop structures) providing increased hydraulic capacity.

iii. Outlet replacement efforts included removing deadfall and debris from the channel downstream of new structure, north of Cedar Lake Drive to Indian Creek Drive, and replacement of the undersized culvert that was set at an inadequate grade beneath Indian Creek Drive.

Progress toward milestones and benchmarks identified for this Objective include:

1. *Milestone*: Augmentation feasibility study completed and various options vetted with required permitting and relevant public notices/hearings.
2. *Benchmark*: Ongoing monitoring shows that from 2017-2019, the period in which augmentation Measure 2 and 3 implementation projects were implemented, lake level did not drop more than 8 inches below the legal lake level of 608.2 feet. Monitoring data from 2020-2022, however, showed a drop in lake level greater than the 8-inch benchmark during these below average rainfall summer months. In 2023 and 2024, the benchmark was achieved with a less than 8-inch drop during the recreational period of May-September. These more recent summer lake level changes are now much less dramatic than those measured prior to 2014 WMP implementation actions.

Objective IV (2011): Improve sport fishery in Cedar Lake through enhanced lake levels, creek levels, and wetland/habitat protection measures

Progress toward tasks originally proposed toward achieving Objective IV includes:

1. **Fish Assessments:**
    a. *MDNR fish community survey* (June 2011): A Michigan DNR sampling effort was spread out across the entire lake and directed at general fish community collections. Sampling was done under the DNR Fisheries Division Status and Trends sampling protocol where the effort is a product of lake size. Gear types used for total survey efforts consisted of 18 fyke-net nights (small and large mesh), 4 trap net nights, 7 experimental gill-net lifts, 6 shoreline seine hauls, and 30 minutes of nighttime electrofishing.
    b. *MDNR fisheries growth index* (2011): Concluded below average rates for bluegill, yellow perch and northern pike. Average/slightly below average rates were noted for walleye, smallmouth bass and black crappie. Above average rates were reported for pumpkinseed sunfish.
    c. *Northpointe Fisheries Management, LLC assessment* (2018): Used 6 fyke nets over a span of three nights for a total of 18 net nights in September. Species captured in the effort were common to species caught in previous surveys.

    Survey findings characterized the Cedar Lake fishery as follows:

    - **Panfish populations** (bluegill, rockbass, pumpkinseed sunfish, yellow perch, black crappie) considered diverse and abundant but slow growing. Efforts to increase panfish growth through predator stocking appear to

have done little to advance this objective.

- **Predator populations** consist of smallmouth and largemouth bass, northern pike and DNR-stocked walleye.
- **Smallmouth** and **largemouth bass** are both found in Cedar Lake but in relatively low abundances. Bass may be in lower abundance in recent years due to a documented virus affecting the bass fishery in Cedar Lake.
- **Northern pike** are sustained through natural reproduction, both in the wetland complex adjacent to the lake, from in-lake spawning areas. Recently enhanced access to the Sherman Creek wetlands is now also believed to contribute to northern pike success in Cedar Lake.
- **Walleye** are sustained predominantly from periodic spring stocking efforts. Walleye and pike are relatively common and can reach large sizes.

2. **Fish Habitat Assessment:** Aquest/SEAS completed a critical fish habitat assessment in 2008. Annual assessments have not been conducted but are either underway or planned as future Tasks via Lake Board expenditures. Recent data from 2024-2025 were not yet formally available at the time of this WMP update.

3. **Habitat Enhancement** for walleye and channel catfish has not been undertaken, however, other habitat improvements include:
    a. Sherman Creek pike spawning habitat improvement project undertaken from 2017-2019. Expected outcomes of the project include: improved Sherman Creek/wetland fish spawning habitat with critical fish passage, and decreased Cedar Lake water level fluctuations during summer months (with prolonged inflows and restored hydrology by reconnecting the natural watershed).

4. **Assessing benefits of stocking Redear Sunfish** was partially completed:
    a. Stocking occurred from 2010 to 2016.
    b. Northpointe Fisheries Management LLC surveyed the lake in 2018 to determine success of redear sunfish stocking. No redear sunfish were collected during the survey effort. Recommendations were made to either terminate stocking efforts, or increase stocking rates. Since this effort, redear sunfish have not been stocked.
5. **Walleye stocking efforts** were partially completed and ongoing, with spring fingerlings successful at creating a population and fishery in Cedar Lake. Communication between DNR and Lake Board are ongoing, and spring fingerling Walleye continue to be stocked at Cedar Lake by DNR every second or third year at rates of 50/acre.

Progress toward milestones and benchmarks for Objective IV include:

1. Fish population assessment and age/growth analysis completed in year five:
    a. The MDNR and Northpointe Fisheries Management, LLC conducted fisheries assessments in 2011 and 2018, respectively. The MDNR included growth index results in their 2011 report.
2. Continued commitment of walleye stocking on an as-needed/as-available basis:
    a. Contact with the MDNR has continued and walleye have been stocked, at minimum, every two years (exception for 2020).

3. Report on fish stocking progress and present findings to Lake Board by year two and assess habitat improvements and additional stocking needs by year three following the kick-off of any additional pilot stocking effort:
    a. The 2011 MDNR report and the 2018 Northpointe Fisheries Management report provide information related to stocking progress and limitations, but are limited on habitat descriptions.

<u>Objective V (2011)</u>: Control existing invasive species and excessive aquatic plants and prevent new invasive species from entering Cedar Lake and the watershed

Actions and tasks originally proposed to achieve this watershed management objective focused on education and raising awareness. The goal of awareness raising was for residents to become aware of potential invasive species and how these could threaten the lake and watershed, what organizations they should report sightings to, and practices that can reduce the risk of transmission of invasive species.

Progress toward actions or tasks originally proposed for achieving Objective V include:

1. **Lake resident education efforts** completed and ongoing:
    a. AICLA ongoing meetings and annual reporting of findings based on lake surveys occurring twice during the aquatic plant growing season on Cedar Lake with reporting on invasive species threats, prevention and treatment.
    b. Ongoing monitoring and treatment, with the Lake Manager performing three lake visits/year (one pre-season observational visit for potential AIS treatment needs, and two comprehensive aquatic vegetation surveys), as well as chemical treatments occurring 1-2 times/year.
    c. Strategic signage efforts partially completed, with signage now prominently displayed at the DNR boat launch and EA2 (an unimproved road end launch site).
2. **AIS awareness** raising efforts partially completed and ongoing:
    a. Newsletters continue to be published, with occasional AIS updates.
    b. AICLA meetings occur three times per summer with updates regarding aquatic plants, invasive species threats, prevention and treatment by the Lake Manager when requested.
3. **Technical consulting** contracts updated in 2011:
    a. Aquest Corp was chosen as the lake manager for aquatic plant management with K&A support. The Lake Manager role moved to K&A circa 2017. K&A has served as the Watershed Consultant to the Lake Association, and subsequently the Lake Board since 2005.
4. **Boat Cleaning Station** and **AIS Signage**:
    a. Partially completed with installation of AIS signage at the DNR boat launch, however, the boat wash station task has not been completed.
5. **An adaptive management strategy** continues to be utilized for aquatic plant management and control of nuisance species.

Progress toward relevant milestones and benchmarks for the original Objective V include:

1. *Milestone:* Educational materials on threatening invasive species distributed by newsletter or special mailing to watershed residents.
2. *Milestone:* Lake Manager or similar contract in place each year that actively works on aquatic plant management, treatment, and other issues as needed to improve and protect recreational value in Cedar Lake.
3. *Benchmarks:* Reduce AIS and improve aquatic plant ecology in Cedar Lake:
    a. Mean plant community "C" value greater than or equal to 5.
    b. Mean "weediness" factor for all areas equal to or less than 5.
    c. Total plant biodiversity value of 40 or greater.

Aquatic plant community metrics have been updated to reflect metrics more widely used throughout the ecological community today. Benchmark information has been updated given the following: Community "C" and Weediness Index are now included within Floristic Quality Index, and; Biodiversity is now Shannon Biodiversity Index. Updated Aquatic Plant Community Benchmarks and the 2024 average results for Cedar Lake North and South are listed in Tables 6-4 and 6-5, respectively, as "Management Goals":

Table 6-4. Current LakeScan™ Metrics and Cedar Lake North 2024 Average Results.[81]

LakeScan™ Metric	2024 Average	Management Goal
Species Richness	20	n/a
Shannon Biodiversity Index	10.2	> 8.8
Shannon Morphology Index	9.0	> 6.3
Floristic Quality Index	26.7	> 20
Recreational Nuisance Presence	7%	< 10%
Algal Bloom Risk	Low	Low

Table 6-5. Current LakeScan™ Metrics and Cedar Lake South 2024 Average Results.[82]

LakeScan™ Metric	2024 Average	Management Goal
Species Richness	23	n/a
Shannon Biodiversity Index	10.7	> 8.8
Shannon Morphology Index	8.6	> 6.3
Floristic Quality Index	29.1	> 20
Recreational Nuisance Presence	9%	< 10%
Algal Bloom Risk	Low	Low

Objective VI (2011): Improve composition of lake bottom sediments and determine feasibility of muck reduction

Progress toward originally proposed tasks for achieving Objective VI include:

1. Affiliated Researchers conducted a study in 2001 on the potential of dredging lake

[81] Kieser & Associates, LLC. (2024). "Cedar Lake North LakeScan™ Final Report."
[82] Kieser & Associates, LLC. (2024). "Cedar Lake South LakeScan™ Final Report."

bottom sediments at Cedar Lake which resulted in limited information on sediment composition, sediment thickness or water depth in Cedar Lake.

2. Tangential progress has been made toward stopping riparian dumping, with 2012-13 workshops and demonstrations of natural shoreline plantings, but no other direct action is known to have been taken at this time.
3. In 2019, the Lake Board commissioned updated studies on sediment thickness mapping and lake bathymetry to initially characterize sediments throughout Cedar Lake, and provide a preliminary whole-lake sediment volume estimation. Findings included feasibility and cost estimates for various dredging scenarios and recommended a more-detailed Phase II study.
4. A Phase II sediment dredging feasibility was pursued in 2022.
    a. The study included sampling of surficial lake bottom sediments in select locations in Cedar Lake. Laboratory analysis of samples included Michigan-10 metals, polynuclear aromatic hydrocarbons (PAHs), and PFAS compounds. Additional field assessments expanded findings of the 2019 study to more-shoreward areas.
    b. Results found several sediment samples to be at or above EGLE's Aquatic Life and Wildlife Screening Guidelines for lead.
        i. This suggests that 25% of sediment that might be targeted for a lake-wide dredging effort could require special handling and disposal restrictions.
        ii. For Cedar Lake, with the presence of lead in a portion of sediment that could be dredged and the resultant costs for a large-scale, lake-wide operation, projected costs suggested that such a dredging effort was cost infeasible for Cedar Lake. Selective access dredging of shoreline areas that do not exceed state guidelines may be possible if initiated by private riparian land owners, however, substantial sediment sampling would be necessary to assess the feasibility of this option with the burden of due diligence and permitting falling to land owners.

Progress toward relevant milestones for tracking progress toward Objective IV includes:

1. Sediment assessments, bathymetric mapping and dredging feasibility have been completed, while any ecological impact studies were not undertaken given the cost infeasibility of a lake-wide dredging effort.

<u>Objective VII (2011)</u>: Educate watershed residents about natural shoreline methods, native buffers, and other best practices for residents and the potential benefits

Progress toward the originally proposed tasks for achieving Objective VII includes:

1. **A natural shoreline demonstration project** was completed with installation of 100ft of natural shoreline at Lakewood Shores POA north beach at the base for the southern lake causeway. This converted an area of turf grass along the shoreline to native forbs and grasses, with over 1,000 plugs installed. The Lake Board paid for planning, permitting and plantings as outlined in #2a-c. Remaining actions toward this task included signage and other outreach methods to highlight the demonstration project. Subsequent program development for a Lake Board-led effort to incentivize other shoreline projects over a select time-frame through Board funding were abandoned given design challenges with

only simple (versus hardened) shoreline restorative methods under winter high water, severe ice conditions that impacted the Lakewood Shores project. A lack of maintenance and desire for natural shoreline retention at the pilot site has since resulted in the abandonment of the pilot effort by the landowner and conversion of the site to new private marina slips.

2. **Resident education on benefits** and implementation methods has been partially completed, with efforts in 2012 including a K&A presentation on options for natural shorelines, benefits and implementation strategies for lakeshore owners. Progress on further outreach efforts beyond the demonstration project in 2013 ceased as noted above.

Progress toward relevant milestones for Objective VII included: Implementation of the native buffer demonstration project (2014) at the highly visible LSPOA causeway site.

<u>Objective VIII (2011)</u>: Continue monitoring water quality parameters and *E. coli* levels to protect water quality, human health and recreational value of Cedar Lake

Progress toward actions and tasks for the originally proposed Objective VIII include:

1. Ongoing *E. coli* sampling by health departments
2. Ongoing water quality monitoring and analyses by the Lake Association through Michigan's CLMP, as well as initial state of Michigan sampling on emerging toxicants (i.e., PFAS foam).
3. Ongoing progress through annual LakeScan™ surveys and fish habitat evaluations by the Lake Manager.

Progress toward relevant milestones and benchmarks for Objective VIII include:

1. No violations of *E. coli* standards to date
2. Completion of the *E. coli* monitoring protocol
3. Ongoing sampling conducted through the MI Cooperative Lakes Monitoring program
4. All water quality benchmarks have been achieved to date based on available data
5. Health Department issuances of health advisories related to identification of PFAS-contaminated foam on the lake.

<u>Objective IX (2011)</u>: Utilize conservation options with local land conservancy groups as a habitat protection tool [Goals 1 and 7]

Progress toward originally proposed tasks for achieving Objective IX include:

1. The 2014 and 2015 Lake Board purchase of 138.6-acres of wetlands including a portion of Sherman Creek in the northwest cedar swamp portion of the watershed.
2. 2022 Lake Board purchase of Jones Ditch shoreline parcel and westward wetland parcel.

CHAPTER 7: IMPLEMENTATION STRATEGY

This chapter of the Watershed Management Plan describes the updated implementation strategy that will serve as the new road map for meeting watershed goals. It outlines the technical and financial resources necessary to implement the updated WMP and provides an estimate of the expected outcomes of many of the BMPs, projects and approaches recommended in the implementation phase. In addition, key organizations whose participation is necessary to successfully accomplish the recommendations are included for each of the objectives. This chapter also provides updated milestones and methods of evaluating success in the watershed and will serve as a stand-alone document for the Lake Board, Lake Association and watershed stakeholders to use in the implementation phase of the updated WMP.

THE WATERSHED IMPLEMENTATION PLAN OFFERS TURN-BY-TURN DIRECTIONS ON HOW TO MEET THE FINAL WATERSHED GOALS AND OBJECTIVES.

THE IMPLEMENTATION PLAN PROVIDES INFORMATION ABOUT PROJECT COSTS, TIMING, KEY STAKEHOLDERS, AND POTENTIAL FUNDING SOURCES.

Current Management Strategies and Recommendations

Before the creation of the 2011 WMP, activities in the Cedar Lake watershed were pursued primarily when specific concerns or desires surfaced among the AICLA members or other citizen groups. The original WMP provided a more-guided approach to documenting and pursuing improvements to address known or suspected watershed problems through sound science and engineering-based decisions. The AICLA has pursued and implemented several projects and studies over the past several decades, including fishery and wildlife projects, investigations into hydrology and lake level issues, sediment composition and water quality, as well as a variety of educational efforts.

The Cedar Lake Improvement Board, developed under the Part 309 Inland Lake Improvement Statute (Natural Resources and Environmental Protection Act 451 of 1994), consists of representatives from various levels of government including township, county and state agency representatives and a member representing the local Lake Association. The Board originally was formed in the 1990s for the purposes of aquatic weed control through contracts with chemical applicators to treat nuisance aquatic plants. This approach was upgraded in the mid-2000s to a comprehensive aquatic plant management approach. Using this approach, technical consultants now implement aquatic plant management and fisheries management strategies through weed control via chemical treatment.

In the mid-2000s, Alcona County and Iosco County, by resolutions, expanded the role of the Lake Board to more than just weed treatments. Funded by a Special Assessment, the Lake Board now directs an all-encompassing lake management program. An appropriately credentialed Lake Manager will continue to be contracted by the Lake Board to advise and guide all phases of all aquatic plant management matters handled by the Board, while a Watershed Consultant will continue to manage the Lake Board-directed implementation of this updated WMP. Ongoing aquatic plant and fisheries management strategies will be incorporated into this expanded approach. These positions are further described in the sections below and included in Attachment H.

Implementation Strategy

Many of the implementation projects and approaches originally developed and prioritized by the Steering Committee to meet watershed goals and objectives, have been implemented since the publication of the 2011 WMP. An updated, detailed implementation table is included as Attachment I and includes prioritization details for the original efforts. The SC prioritized projects using rankings based on four factors: 1) degree to which the approach is needed in the watershed; 2) level of implementation required; 3) cost-effectiveness of the project or approach, and; 4) feasibility of funding. The approaches were also given implementation rankings to determine the implementation timeline, additionally found in Attachment I. The 2025 updated implementation approaches are summarized below in Table 7-1. WMP Implementation Tasks are organized by objective.

Table 7-1. Summary Table: 2025 Implementation Strategy – WMP Tasks per Objective.

Objective	WMP Updated Implementation Task
I	**Lake Level Augmentation (Maintain Lake Water Level)**
	1. Implement lake level management projects to augment summer lake levels.
	2. Summarize feasibility study findings on passive vs. active Lake Augmentation options for the CLIB and the Drain Commissioners.
	3. Compile and provide a summary of existing state, county and township existing ordinances, policies and/or recommendations that serve to protect the NW wetlands.
	4. Re-engineer hydrology of NW wetlands:
	4.1. Assess hydrology of Jones wetland and determine feasibility of water storage measures.
	4.2. Improve NW Wetlands Railroad Culvert flows: Coordinate with RR reconstruction project.
	4.3. Explore future project benefits for Sherman Creek improvements: water supply and habitat.
	4.4. Assess storage and flow improvements in NW wetland and continue ongoing water level monitoring to track hydrology changes and improvements over time.
	5. Acquisition of property in NW for wetland restoration/enhancements where beneficial:
	5.1. Direct purchase - Explore purchasing and managing additional parcels of land in the NW area.
	5.2. Donation of conservation easements - Engage with land conservancies to provide technical resources and information to obtain conservation easements from private property owners.
II	**Lakewood Shores Drainage Issues**
	1. Work with the Iosco Drain Commissioner on storage and return issues/options.
	2. Identify tax reverted lands that could support storage and return options.
	3. Wetlands banking options on un-built parcels (for investment in return flow options).
	4. Wetland delineations for unbuilt parcels (desktop analysis or more).
III	**Timberlakes Drainage Prevention**
	1. Work with the Drain Commissioner to find solutions to potential future development issues/stormwater drainage needs.
	2. Identify and pursue opportunities to prevent future stormwater dewatering drainage issues similar to Lakewood Shores issues.

Objective	WMP Updated Implementation Task
IV	**Fisheries Improvements**
	1. Re-engineer hydrology of NW wetlands to support fisheries by improving spawning habitat and connectivity to upstream wetlands.
	2. Follow Recommendations from Fisheries Management Reports:
	2.1. Conduct a fish population assessment, including a sportfishing Creel Census.
	2.2. Conduct critical fish habitat assessments.
	2.2.a. Assess pike spawning improvements in Sherman Creek and fisheries spawning habitat in Jones Ditch using habitat surveys to determine restoration needs.
	2.2.b. Conduct an in-lake critical fish habitat assessment update.
	2.3. Provide fisheries habitat enhancements.
	2.3.a. MDNR decadal fisheries assessment and walleye fingerling stocking "as needed".
	3. Re-assess angling benefits and potential for stocking Redear sunfish to establish an increased fishery/increase bluegill spawning habitat based on pilot testing results.
V	**Invasive Species Management**
	1. Education on best practices to reduce transmission of invasive species.
	2. Ensure adequate educational signage informing lake users about invasive species risks and best practices to reduce the risk of spread.
	3. Lake Manager contract through the Lake Board to continue adaptive management strategy for lake and recommended future actions/implement WMP strategies.
	4. Continue lake treatments for noxious weeds and algae growth.
VI	**Muck Sediment Issues**
	1. Summarize lake bottom dredging feasibility study findings for the CLIB and WMP Steering Committee to clarify feasibility issues and restrictions to removing existing sediments/muck from Cedar Lake.
	1.1. Public Education: Present the findings of the Dredging Feasibility Study (levels & chemical analyses).
	1.2. Public Education: Distribute information to residents regarding best lawn care practices and how this relates to muck accumulation including state agency permitting requirements and options.
	1.3. Promoting lakeshore/water quality stewardship in relation to reducing muck.
	2. Create a Cedar Lake Property Owners Guide including muck sediment issues.
	3. Perform appropriate pilot/feasibility scale studies to determine costs, benefits and possibilities prior to any at-scale project commitments.
VII	**Natural Shorelines**
	1. Educate residents on natural shoreline benefits and techniques and provide technical support to lakefront property owners who implement native vegetation or shoreline buffers.
	2. Create a Cedar Lake Property Owners Guide with natural shoreline benefits and techniques.
VIII	**Water Quality Assessments**
	1. Continue involvement with Michigan Lakes & Streams Association to maintain knowledge on lake management strategies/practices.

Objective	WMP Updated Implementation Task
	1.1. Expanded testing.
	1.2 NW shoreline septic systems – assessing contributions to the Lake.
	1.3. Expand *E. coli* testing to western shoreline.
	2. Educate residents on proper septic system maintenance, clean-out and repair.
	3. Document and track persistent water quality problems and pursue site-specific water quality sampling.
	4. PFAS: Public Education –state of the issue and changes since the WMP was written in 2011.
	4.1. PFAS: Request and support additional state testing.
IX	**DNR Boat Launch Improvements**
	1. Structural issue due to prop-washing especially during low lake levels; users getting their boat trailers stuck.
	1.1. Redesign and implement Launch that can accommodate boats in all lake level conditions.

The remainder of Chapter 7 includes detailed background information for each updated Objective and tasks in the summary table, as well as other relevant information, SC concerns, recommendations and key implementation steps and organizations supporting tasks where applicable.

OBJECTIVE I: Cedar Lake Water Level – Maintain the Cedar Lake legal lake level by pursuing feasible lake water level augmentation projects

The watershed of Cedar Lake is comprised primarily of wetlands and wooded wetlands with some drier upland areas in northwest corner of the lake. This approximate 3,000-acre complex of wetlands northwest of Cedar Lake provides a majority of the recharge and source water to Cedar Lake. Decades of flood management, particularly in developed areas immediately southeast of the lake, have caused an imbalance in lake hydrology so that during dry years the lake level could drop by more than two feet prior to implementation of 2011 WMP restoration efforts.

Maintaining adequate surface water levels in Cedar Lake continues to be an important issue for lake users and a driver of WMP implementation. Summer lake level fluctuations have historically created issues with resuspension of muck sediments from boating, reduction of functional aquatic shoreline habitat, increasing nutrient concentrations with sediment resuspension and challenging safety conditions for recreational boating use. The major concerns for association members and lake stakeholders in general are the impacts that low lake levels have on recreation, fisheries, property values and aesthetics of Cedar Lake.

In 2006, the Lake Association commissioned K&A to undertake technical studies to address the lake level issues experienced during dry summer months (Phase I study in 2006, Phase II in

2009). The 2011 WMP and the final augmentation study in 2011 were funded by the Lake Board through special assessments. The Board continues to work with K&A as their watershed consultant on management and augmentation strategies to test feasible ways to increase water going into the lake during dry periods. K&A continues to provide lake level and wetlands hydrology monitoring and design considerations to inform such recommendations.

The lake level augmentation feasibility studies identified several areas that influence lake level drops experienced during dry summer months including: 1) Lakewood Shores dewatering underdrain system on the south and southeast side of the lake; 2) King's Corner culvert which diverts surface water from the critical contributing northwest cedar swamp area; 3) Sherman Creek and Jones Ditch historic hydrological modifications which diminished groundwater and surface water storage in the northwest cedar swamp during dry summer months, and; 4) the court-ordered legal lake level controlled by the lake outlet structure which now manages levels at the established level.

Feasibility studies included tasks to address legal issues and impacts on natural resources and/or other water users. In addition, studies included installation of aquifer testing wells to evaluate potential groundwater yield and interference to surrounding resources (as directed by the Lake Board). The Lake Board continues to monitor groundwater and surface water levels around the lake including areas in Lakewood Shores that have experienced high groundwater levels (and subsequent flooding problems) during wet periods. This information, reported annually, will continue to be used to design and implement potential lake level solutions, including all feasible considerations for lake level augmentation. Notably, there is a bifurcation in project roles between the Lake Board and governmental entities such as Road Commissions and Drain Commissioners. The latter entities are responsible for public infrastructure while the Lake Board can address improvements in the natural environment that will benefit the lake. The Board may at their discretion, examine various project opportunities in the context of lake and watershed benefits that could bring value to this setting. Such opportunities can then be shared with relevant agencies to depict relevance to WMP-related goals and objectives.

Since the publication of the 2011 augmentation study, ongoing hydrology data and monitoring of implementation projects have helped to guide and direct lake level management strategies. The Lake Board continues to be responsible for selecting lake level management projects under their purview, and solicits public feedback and support. The Lake Board will continue to contract for final engineering, permitting, potential construction bidding, and installation/construction of the select projects in these regards.

Table 7-7 outlines the originally-identified, potentially feasible lake level management projects or scenarios. The table is split into two parts: feasible management approaches that have been pursued to date, and; potentially feasible management approaches that have not yet been pursued as part of the augmentation options. The table includes discussions of intended/potential benefits, as well as potential issues.

Table 7-7. Augmentation Feasibility Study update: Lake level management strategies implemented and not yet implemented to date.

Potential Management Approach	Intended/Potential Benefits	Potential Issues
Feasible Measures Implemented To-Date		
Sherman Creek Modifications	Sherman Creek Grade Structures, 2019: ▪ Grade structure slow release of springtime surface water from wetlands ▪ Enhance spawning habitat during spring/early summer ▪ Control water level to just less than spring peak levels	▪ Potential for prolonged flooding ▪ Minor adjustments based on future monitoring of grade-structures may be necessary to ensure fish passage
Kings Corner Modifications	Wetland Berm, 2017: ▪ Berm reduces out-of-watershed losses via King's Corner culvert.	▪ Potential for prolonged flooding ▪ Culvert modifications not feasible
Cedar Lake Outlet Spillway Replacement	Lake outlet structure replaced, 2020: ▪ Preventing lake water loss below the top of the structure (historic structure was found to be leaking below the top of the structure on multiple occasions)	▪ Potential downstream hydrological impacts of new structure ▪ The new passive structure does not provide for active lake level management, including potential for drawdown ▪ Active maintenance is required to address debris build-up and beaver activities
Potentially Feasible Measures Not Yet Implemented		
Jones Ditch Modifications	▪ Enhance water level to just less than spring peak levels	▪ Potential for prolonged flooding ▪ Road right-of-way or private property access/permission issues
Groundwater Augmentation Well: Feeding Surface Water into Wetlands	▪ Enhanced habitat and fish spawning ▪ Use creeks to convey pumped water to the lake instead of direct piping ▪ Control water levels to just less than spring peak levels ▪ More control over water volume additions	▪ Will be controlled by the Drain Commissioner (separate feasibility study and assessment) ▪ Potential property flood impacts ▪ Creek flow rates must accommodate fishery (determine velocity limits) ▪ Potential groundwater contamination issues
Lakewood Shores Drainage (Re-Circulation)	▪ More flexibility in location of augmentation well(s) ▪ More control of the volume of water ▪ Potential relief of flooding conditions	▪ Will be controlled by the Drain Commissioner (separate feasibility study and assessment) ▪ Property issues and agreements for pumping houses ▪ Potential groundwater contamination issues

Of note regarding Cedar Lake water levels, the legally mandated lake level is passively regulated by the spillway structures at the north end of the lake. The spillway was replaced in September 2020. Early spring water level data trends suggest that the new spillway is more-effective than the old structure at maintaining traditional high-water periods at the legal lake elevation. This reduces fluctuations of water level maximums while eliminating storage that would otherwise periodically occur with the original structures. Monitoring lake water levels upstream of the new

spillway should continue as part of the hydrology program to better understand any long-term hydrologic changes resultant from the structure replacement and future implementation projects.

The wetlands in the northwest watershed were historically compromised by a large diversion near Kings Corner Road and W. Cedar Lake Road. The culvert drains water from the wetland to the south side of Kings Corner Road where it travels to Phelan Creek and eventually to the Van Etten Lake/Pine River watershed. This effectively removed water from the wetland that would otherwise drain to Cedar Lake.[83] Historic filling of wetlands has also occurred along W. Cedar Lake Road and along the lakeshore to allow for building of homes and driveways. This slow development over time changed the flow of water in the watershed, contributed to lower lake levels and would further impact water quantities if left unchecked. Wetlands also serve to filter sediments and pollutants, thereby improving or protecting water quality conditions in downstream waters.

For these reasons, wetlands in the northwest corner of the watershed are identified as "critical" areas for protection in the watershed. In addition to recharging the lake, the wetlands serve as important habitat for fish and other wildlife. Pike have been observed migrating up Sherman Creek to spawn during spring months. The Jones Ditch channel from W. Cedar Lake Road to the lakeshore impedes spawning access with straitened, down-cutting channel with spring velocities exceeding those acceptable for pike migration. Reduced lake water levels in the wetlands historically decreased the flow from Sherman Creek, interrupting or stopping pike from using the wetlands for vital spawning purposes.

Several strategies were originally developed by the SC to restore and protect the wetlands on the northwest side of Cedar Lake. Several projects have already been undertaken toward fulfilling this objective (see Chapter 6). As identified as a priority in the original WMP, the Lake Board purchased wetland parcels including the majority of Sherman Creek (2014 and 2015) drainage east of the Lake State RR company line. The lakeshore property surrounding the Jones Ditch confluence with the lake, (purchased in 2022 with select upstream contributing wetlands), will facilitate future channel enhancement opportunities for more naturalized release of wetland storage as well as habitat connections between the lake and upstream wetlands.

Updated priorities for achieving this objective intend to further support the goal of protecting the watershed's critical wetlands. Table 7-2 describes the updated prioritized implementation approaches and tasks for further protection of watershed areas that provide source water to the lake and ecological connections. These will ultimately help stabilize lake levels during summer months to the benefits of recreational uses and aquatic habitat.

[83] Kieser & Associates, LLC. (2005). "Phase I - Final Report for the Preliminary Hydrologic Evaluation of Cedar Lake with Reference to Lake Levels (Alcona & Iosco Counties, MI)." *Prepared for the Alcona/Iosco Lake Association, July 15, 2005*.

Table 7-2. Implementation Task Descriptions for Objective I.

Objective	WMP Implementation Task
I	**Lake Level Augmentation (Maintain Lake Water Level)**
	1. Implement lake level management projects to augment summer lake levels.
	2. Summarize feasibility study findings on passive vs. active Lake Augmentation options for the CLIB, clearly defining agency vs. Lake Board responsibilities.
	3. Compile and provide a summary of existing state, county and township existing ordinances, policies and/or recommendations that serve to protect the NW wetlands.
	4. Re-engineer hydrology of NW wetlands:
	4.1. Assess hydrology of Jones Ditch wetland and determine feasibility of additional water storage measures.
	4.2. Improve NW Wetlands Railroad Culvert flows: coordinate with RR for potential culvert replaced of old, potentially failing culvert infrastructure.
	4.3. Augment water levels by groundwater pumping into wetland if other measures prove insufficient to maintain late levels are recreationally acceptable water levels.
	4.4. Assess storage and flow improvements in NW wetland and continue ongoing water level monitoring to track hydrology changes and improvements over time.
	5. Future acquisition of properties in NW wetlands for possible restoration/protection:
	5.1. Direct purchase - Explore purchasing and managing additional parcels of land in the NW area.
	5.2. Donation of conservation easements – Engage with land conservancies to provide technical resources information to obtain conservation easements with interested private property owners.

In addition to stopping further degradation of the wetlands, the WMP prioritizes action items outlined in Table 7-2 to continue restoring the hydrology of the wetlands and lake level conditions. These fall under the umbrella of implementing lake level management projects to provide water quality protection and access to designated recreation uses. Nearly 20 years after the initial lake level management feasibility studies began, actions under Task 2 will clarify roles for watershed stakeholders moving forward. Task 3 will update efforts undertaken during the original WMP to understand the role of conservation easements or other wetland protection methods based on current ordinances and policies. Task 4 continues to consider relevance, value, and potential need for additional water delivery through assessment and implementation of physical wetland hydrology improvements. The final Objective I Task 5 regards acquisition of additional properties in the cedar swamp if deemed appropriate for furthering this objective.

Monitoring of groundwater and surface water hydrology and water quality of the Cedar Lake watershed has been ongoing using the seasonal array of continuous water level/temperature sensors, reported annually. Continuing to directly monitor the hydrology impacts of implemented improvement projects is recommended to continue to ensure project efficacy, with reporting to inform future projects. Water level data collected for Cedar Lake continue to be vital for assessing, understanding, and cost-effectively pursuing appropriate water level control options in a phased manner. These are particularly relevant given recent watershed improvement projects and their impacts to water levels in relation to year-to-year variations in precipitation that largely drive summer lake levels. Feasibility assessment for use of a deep-aquifer augmentation well

near Sherman Creek was determined by water quality sampling of the deep aquifer relating to concerns of potential deep groundwater contamination due to historic uses and disposal of the common fire-retardant chemical PFAS in the region. Non-detect sampling results suggest contaminant concerns may be limited. The 2022 preliminary feasibility study further identified the potential need for multiple augmentation wells operating simultaneously under dry summer conditions. Potential costs for installation and operation exceeded $2M.

A wetlands protection ordinance was discussed in depth during the original WMP development meetings and SC members generally agreed that an ordinance would be the most effective means of protection. An ordinance could also be an effective protection against development of critical wetlands that would drain or divert water out of the contributing wetlands, negatively impacting an important water source to Cedar Lake. The major purpose of any wetlands protection ordinance is to provide an additional layer of oversight on development in wetlands to protect against destruction and loss of function. Neither Alcona or Iosco Counties (Greenbush or Oscoda Townships) have adopted or developed wetlands protection ordinances to date.[84] Though an ordinance could be a low-cost option, current SC sentiments suggest a compilation of applicable protection mechanisms from the local, state and federal prevailing requirements could provide a deterrence to wetland loss, rather than the 2011 WMP recommendation for a specific ordinance.

During the WMP development, several parcels in the northwest were explored as potential candidates for conservation easements. The approach was to explore the option of purchasing additional parcels of land near the Sherman Creek and critical areas in the northwest part of the watershed. Those parcels adjacent to streams or other surface water bodies are high priority for permanent protection. One of the new implementation tasks of the updated WMP is for the Lake Board and watershed stakeholders to evaluate the potential for additional land purchases or related use of conservation easements in the northwest wetlands area (see Attachment J).

The Headwaters Land Conservancy previously presented to the Lake Board (as part of the original WMP) providing more insight into conservation tools available for land protection. The land conservancy or other organization might be able to serve as a liaison with property owners to commit to protection measures on their properties. Information on the potential benefits of conservation easements and other land protection tools is provided in Attachment N. Its inclusion in the 2025 WMP update intends to leave open the option of easements where landowners may wish to maintain ownership but are willing to conserve their lands for conservation purposes.

KEY ORGANIZATIONS:
Cedar Lake Improvement Board
Drain Commissioners
County Road Commissions
Lake State Railroad
Michigan EGLE and Michigan DNR
Midwest Glacial Lakes Partnership (related to a 2025 grant award)

[84] Michigan DEQ. (2010). "Communities with Wetland Ordinances." Accessible online: <https://www.michigan.gov/documents/deq/wrd-wetlands-local-ordinances_558383_7.pdf>.

<u>OBJECTIVE II</u>: Prevent Groundwater Loss (Lakewood Shores) – Adopt strategies to prevent additional groundwater loss from the due to storm sewer infrastructure on the east and southeast sides of Cedar Lake

During dry summers, lake level losses can have a dramatic impact on Cedar Lake, affecting recreation, aesthetics, and habitat around the lake with severe drops in water levels. A hydrologic study of Cedar Lake performed by Kieser & Associates, LLC in 2006 concluded that dewatering storm sewers located in the Lakewood Shores drainage district have resulted in unintentional and accelerated drainage of lake water to the groundwater table away from the lake. Ongoing K&A hydrology studies continue to confirm this pattern. These dewatering storm sewers act as tile drains that shunt water from Cedar Lake to Lake Huron, and are the major source of water level loss during summer months.

Since the dewatering drainage system that services the Lakewood Shores community was established prior to state wetlands protection laws, civil litigation was discussed by the original WMP Steering Committee as a potential recourse to address the adverse effects of the existing drainage system. However, this notion was quickly dismissed as it would be divisive to the community, costly and would create no-win situations for the opposing interests in this matter. A community-based solution is preferred over litigation, where impacted parties compromise on a solution that would serve to mitigate the adverse effects of the drain, while minimizing adverse effects on the Lakewood Shores community.

Therefore, a major objective of the Watershed Management Plan (WMP) continues to be the prevention of additional lake water loss to groundwater on the east and southeast sides of the lake beyond what the current dewatering storm-sewers already drain off each year. To address this objective and effectively stop additional lake water loss to groundwater from the Lakewood Shores dewatering storm sewer system, the WMP continues to recommend a set of actions to prevent the need for expansion or further improvements to the existing dewatering storm sewer system.

The SC explored the issue of lake water loss to the groundwater table on the east and southeast sides of Cedar Lake (in the Lakewood Shores drainage district). Though these approaches have yet to be pursued, they remain as priority implementation projects as laid out in Table 7-4.

Table 7-4. Implementation Task Descriptions for Objective II.

Objective	WMP Implementation Task
II	**Lakewood Shores Drainage Issues**
	1. Work with the Iosco Drain Commissioner on storage and water return issues/options.
	2. Identify tax reverted lands that could support storage and return options.
	3. Wetlands mitigation banking (permanent re-establishment of wetlands with the potential investment for return flows).
	4. Wetland delineations for unbuilt parcels (desktop analysis or more) to elucidate the challenging area conditions for home construction.

The updated action tasks recommended for Objective II in the WMP aim to prevent the need for additional dewatering storm sewer expansion in the Lakewood Shores drainage district. A driving force behind storm sewer expansion is the flooding of homes in the Lakewood Shores housing development. Homes built in low-lying wetlands are prone to wet conditions especially in spring. Original WMP discussions identified the complication of builders buying parcels and building homes during drier months and then selling the property before wet conditions become apparent to the new owners. The WMP discussed ways to prohibit and discourage building in low-lying wetland areas, protect homeowners from additional flooding, and educate the public on ways to improve their properties without requiring development-wide expansion of the storm sewer system. Since the 2011 WMP, there has been limited new development but a more frequent need for drainage system repairs for aging infrastructure failures.

The updated Objective II Task 1 promotes collaboration between the Lake Board and Drain Commissioner to preliminarily assess potential benefits of alternative infrastructure suitable to reduce the rate of water loss through the existing stormwater underdrain system. Under current law, if the Drain Commissioner is officially petitioned by five or more property-owning citizens of the drainage district, the commissioner is required to install more subsurface dewatering drainage to address the problem of flooding or high groundwater table during wet months. This would be preceded by and expensive and comprehensive engineering feasibility study. Therefore, direct Lake Board coordination with the Drain Commissioner through the WMP is considered vital to assess infrastructure alternatives suitable to achieve drainage needs and not exacerbate (rather potentially reduce) groundwater losses impacting lake levels.

Task 2 would identify tax reverted parcels and determine whether a direct purchase of some of these parcels would eliminate the need for an expanded underdrain. This goes in line with the original WMP objective of enacting conservation easements on such parcels to prevent their development and therefore the need to expand the dewatering underdrain system. Similarly, Tasks 3 and 4 explore other alternative mechanisms for identifying and assessing the benefits of protecting vacant wetland parcels within the Lakewood Shores residential development. These include performing “desktop” wetland delineations for unbuilt parcels and exploring wetland mitigation banking options across multiple reverted parcels. The latter could present options for land purchase investment that could result in restore groundwater conditions by reducing or eliminated underdrainage. This could also result in potential return flows if underdrains remaining but otherwise collect water. Potential investment considerations for a wetland banker or private wetland bank would purport to invest strategically for the purpose of ecological benefits in protecting and restoring wetlands to the benefit of lake level management by reducing groundwater losses.

These approaches are suggested as alternatives to traditional conservation easements which were explored during the original WMP. Such easements have limited application in platted areas with small parcels per the Headwaters Land Conservancy who met with the SC during WMP development in 2009. The Conservancy outlined their organization’s requirements to oversee and receive conservation easements, which require that a parcel be adjacent to water and/or large in size (greater than 40 acres). The platted parcels in Lakewood Shores would not qualify for

consideration by the Conservancy and landowners would have to cover legal expenses if they wanted to put a conservation easement on a smaller parcel of land.

Enacting a wetlands ordinance was also discussed, which could require builders or residents to have a wetlands delineation performed at their property and obtain a special use permit if wetlands were identified on-site such that flooding problems in homes could be avoided. Fewer homeowners experiencing seasonal dampness and flooding should reduce demand for dewatering storm sewer expansion. Members of the original SC expressed concern over legal and economic issues of a wetland ordinance. Objective I Task 3 would otherwise explore existing policies or regulations to prevent construction in wetlands.

Finally, the original WMP pushed for consideration for updating the existing building codes enforced in the Lakewood Shores area so that builders might use better methods to protect homes against flooding. This included the local Architectural Standards of the Lakewood Shores Property Owners Association (LSPOA) being modified to add additional building requirements if the local county building inspector is unable to require these as part of the existing Michigan Residential Building Code. Standards on building appearance, setbacks, and size are already in place through the LSPOA. The Lake Board could work with the LSPOA to modify or add to the existing Architectural Standards to ensure builders protect future homeowners from flooding during wet periods.

Educating residents about flooding issues and educating the public and builders about building in or near wetlands is critical for Objective II. Almost all wetlands experience seasonal surface water or saturated soils. Filling in wetlands to build can worsen flooding during rainy periods on a local or regional scale. Storm sewer dewatering systems can be overwhelmed and water can back up into homes. Residents should be made aware of the risks of building in wetlands, what retrofit options they can use to reduce the risk of flooding in their home, and professional contractors they can contact for assistance.

KEY ORGANIZATIONS:
Drain Commissioners
Cedar Lake Improvement Board
Lakewood Shores POA
Oscoda Township
Greenbush Township
Iosco County Building Department/Inspector

<u>OBJECTIVE III</u>: Prevent Groundwater Loss (Timber Lakes Development) – Adopt strategies to prevent groundwater loss from future development of storm sewer infrastructure on the northeast side of Cedar Lake

The Lake Board has also expressed concerns about potential groundwater losses occurring near the Timberlakes development on the lake's northeastern-most section. Surface water flooding and related ditch and stream discharges in the Timberlakes subdivision just beyond the northern extent of the Cedar Lake watershed and just downstream of the new outlet structure were also brought to the attention of the CLIB in 2020. This led to a limited assessment of hydrology in this area with investigations beginning in 2022.

Several groundwater monitoring stations were installed in 2022 as part of the ongoing whole-lake hydrology study for the purpose of studying groundwater movement in this area. The goal for monitoring at these stations was to better understand northeasterly groundwater losses occurring near the Timberlakes residential development. Comparing these elevations and gradients to stations in the southeast allows for a comparison of the Timberlakes area to the Lakewood Shores residential district where subterranean dewatering-drains already exist.

Like the other eastern-lake stations, TL Road showed a four-five foot loss in elevation compared to TL-2 which was within a ½-foot of the lake level throughout the year. This shows that a natural northeasterly groundwater gradient flow away from the lake already exists towards the Timberlakes district. The purpose of Objective III is therefore to work with Drain Commissioners to prevent potential issues which could result from future development in Timberlakes. If a subdrainage system was expanded to reduce flooding in future developments, it could exacerbate the groundwater-losing nature of this yet-to-be developed area as seen in the Lakewood Shores development (Objective II).

Table 7-6 outlines four initial updated next-step recommendations toward Objective III for roughly the next 10 years for Cedar Lake augmentation implementation tasks.

Table 7-6. Implementation Task Descriptions for Objective III.

Objective	WMP Implementation Task
III	**Timberlakes Drainage Prevention**
	1. Work with the Drain Commissioner to find solutions to potential future development issues/stormwater drainage needs.
	2. Identify and pursue opportunities to prevent future stormwater dewatering drainage issues similar to Lakewood Shores issues.

KEY ORGANIZATIONS: ***Cedar Lake Level Management***

Cedar Lake Improvement Board
Kieser & Associates, LLC (watershed manager currently under contract)
Oscoda Township and Greenbush Township
Timberlakes Home Owners Association

OBJECTIVE IV: Improve sport fishery in Cedar Lake through enhanced lake levels, creek levels, and wetland/habitat protection measures

In developing the original WMP the Lake Board prioritized pursuing assessments to inform strategies for enhancing the sport fishery at Cedar Lake. The Lake Board contracted with Aquest Corp., who subcontracted with SEAS, LLC to develop a fishery management plan. Assessments, surveys, and studies of the sport fishery in Cedar Lake completed to date in this regard include:

- 2004-2008: Annual fishery assessment of the lake; an extensive evaluation of the spawning migration of northern pike in and around Sherman Creek; annual spawning and habitat improvement survey; recreational season-long creel survey (SEAS)
- 2008: Fish habitat study (SEAS/Aquest)
- 2011: Fish population assessment (MDNR)
- 2010 – 2016: Red ear sunfish stocking (AICLA)
- 2018: Fish population assessment related to red ear stocking, reassessing angling benefits (Northpointe Fisheries Management)
- 2019: Sherman Creek in-stream grade structure implementation related to pike spawning habitat improvement (K&A)
- 2024-205: K&A Fisheries Habitat Study (underway)

The 2008 adaptive management strategy used by the fisheries consultant is an effective and useful watershed management tool. For this reason, the recommendations from these studies and reports were integrated into the original WMP. Here, updated general recommendations for this objective, several of which are cited as part of the implementation strategy tables for other objectives, build on the still-relevant original WMP recommendations.

Table 7-7 describes the specific WMP recommendations for this objective based on fishery assessment efforts and reports as cited in the list above. Wetland protections to protect critical spawning habitat in the watershed continue to be a recommendation of the WMP, described more fully under Objective I. Objective I discussed the implementation projects undertaken to restore groundwater storage and flows from the wetlands adjacent to Sherman Creek as it relates to the augmentation pilot study. In addition to these approaches, Steve Sendek, formally with Michigan DNR Fisheries Division who served on the original SC, recommended continued stocking of walleye fingerlings and the control of aquatic invasive plant species to ensure conditions in the lake that will encourage panfish growth. The SC included these recommendations in the WMP and agreed they were high priority approaches for a healthy and balanced fish population. SEAS 2008 recommendations also have been prioritized and updated for inclusion in WMP approaches.

Chapter 6 described the originally proposed fisheries improvement implementation actions and tasks aimed at achieving these recommendations and highlighted those actions which have been implemented and those which remain to be implemented. Table 7-7 and the rest of this section provides updated implementation tasks and strategies for continuing to fulfill the recommended sport fisheries improvement strategy for Cedar Lake.

Table 7-7. Implementation Task Descriptions for Objective IV.

Objective	WMP Implementation Task
IV	**Fisheries Improvements**
	1. Re-engineer hydrology of NW wetlands to support fisheries by improving spawning habitat with channel connectivity.
	2. Follow Recommendations from Fisheries Management Reports:
	2.1. Conduct a fish population assessment, including a sportfishing Creel Census.
	2.2. Conduct critical fish habitat assessments.
	2.2.a. Assess pike spawning improvements in Sherman Creek and fisheries spawning habitat in Jones Ditch, using habitat surveys to determine restoration needs.
	2.2.b. Conduct an in-lake critical fish habitat assessment update.
	2.3. Provide fisheries habitat enhancements.
	2.3.a. MDNR decadal fisheries assessment and walleye fingerling stocking "as scheduled".
	3. Re-assess angling benefits and potential value for stocking Redear sunfish to establish an increased fishery/increased bluegill spawning habitat via pilot testing.

Overall, the WMP recommends that the Lake Board and AICLA continue contracting a fishery management consultant to regularly assess the fishery, implement projects necessary to maintain and enhance the fishery, and provide information related to future management needs. Detailed fish habitat assessments should be conducted, minimally every 5 years using a repeatable approach. Ideally, the fisheries management consultant will either be the same as or work closely with the Lake Manager as these two issues are intricately linked with management of one directly impacting the other.

Fisheries managers use many tools to gather information about fisheries within a system. One of those tools are creel surveys or angler surveys. A creel survey is an estimation of catches provided by recreational anglers that helps fisheries managers assess the health of game fish population. When the data are analyzed this information can help fisheries managers gain a better understanding of fishing quality and angler pressure within a given water body. Using this information, restoration and regulations for the fishery may be determined. The last creel survey conducted on Cedar Lake was in 2008 by SEAS, LLC.[85] In an effort to understand and enhance the overall fishery within Cedar Lake a new creel survey should be completed.

Creel surveys typically are done in person over the course of a season (summer, winter, etc.), which can be very laborious and time-consuming. Conducting creel surveys during fishing tournaments could lower the amount of effort required to collect data. Alternatively, an electronic creel survey could be created to reduce the amount of time needed for data collection. A survey link would be posted at boat launches for anglers to access and on the CLIB website.

[85] SEAS, LLC. (2009). "Cedar Lake 2008 Creel Census, Greenbush and Oscoda Townships, Alcona & Iosco Counties, Michigan." *Prepared for Cedar Lake Improvement Board, June 29, 2009.*

However, this method requires anglers to voluntarily participate which may reduce the amount of data received and truthfulness. Adding an incentives program for participation to the online creel survey may attract increase the number of users.

Beyond studying the fishery directly, several methods have been developed to protect essential fish habitat and spawning areas. One area originally identified by SEAS is the wetland complex on the northwest side of the lake. This wetland is connected to Cedar Lake through Jones Ditch and Sherman Creek. Sherman Creek was monitored in 2008 for northern pike spawning and migration. The report concluded that the wetlands contain ideal spawning habitat for the northern pike due to the good water clarity, flow, vegetation, and stable bottom substrate. Updated monitoring should be conducted following implementation projects in Sherman Creek. Targeted Jones Ditch channel improvements under Objective IV should also include similar monitoring for spawning conditions.

One original recommendation of the WMP, permanently protecting the wetlands which provide spawning habitat adjacent to Sherman Creek was advanced with the 2014 CLIB purchase of the relevant wetland parcel. In 2019, the CLIB funded a spawning habitat improvement project, installing in-stream grade structures within Sherman Creek. Hydraulic conditions continue to be monitored by K&A.

Attachment K provides extensive details on Key Steps for implementation for the first and third recommendations: High-priority Sherman Creek and Jones Ditch pike spawning improvement assessments, and low-priority redear sunfish and swimmer's itch experimental pilot assessments. Assessment of pike spawning improvements in Sherman Creek and Jones Ditch is a high-priority recommendation. This could include development of channel monitoring plans for both waterways and establishing technical and voluntary monitoring programs for assessing spring pike runs. Reassessment of stocking redear sunfish is considered a low-priority and would need to be approached carefully in the context of introducing another panfish species which risks compounding competition for limited food and habitat.

OBJECTIVE V: Control existing invasive species and excessive aquatic plants and prevent new invasive species from entering the Cedar Lake watershed

During development of the WMP, the Steering Committee identified a need to control and prevent invasive species, particularly aquatic invasive species (AIS) in and around Cedar Lake. Excessive growth of native aquatic plants in Cedar Lake can also become a perceived nuisance for people recreating in an overly-weedy lake. Of particular concern to stakeholders are milfoil species in Cedar Lake which can grow to problematic levels quickly and obstruct navigation. To address ecologically problematic invasive species as well as weedy aquatic vegetation in a balanced manner, the Lake Board has conducted the annual comprehensive AIS surveys through their Lake Manager.

The primary management goal of the aquatic plant management plan is to "modify conditions within the lake to enhance species and habitat diversity and thereby stabilize the ecosystem by promoting the production of conservative species and inhibiting the production of those plants

that are weedy or more opportunistic."[86] Recent lake-management efforts and specific updated short-term management goals include:

1. Mitigation against cultural and natural disturbances by modifying the quality of lake flora through the prescriptive use of selective plant management agents and strategies and adapting those strategies based on monitored and reported outcomes;
2. Improve opportunities for recreation, increase aesthetic values, and provide improvements in the structure of the flora for critical fish habitat;
3. Target management activities to suppress/control problematic species (such as Eurasian watermilfoil that is currently present in the lake and has been a controlled nuisance for approximately thirty years) and AIS that have colonized within the lake more recently (such as starry stonewort);
4. Survey and monitor the lake's aquatic plant population and algae species as an indicator of general water quality and the effect on the lake's fishery.

Invasive species in particular can out-compete native species for the resources they need to survive. While new methods to control invasive species are developed over time, the best way to control invasive species is to prevent their introduction to a lake or watershed.[87] For this reason, the WMP continues to direct focus on preventing the introduction of new invasive species to the watershed and lake in addition to controlling current nuisance species. As part of the implementation of the WMP the Lake Board should continue to pursue efforts: to educate watershed residents on what they can do to prevent the spread of invasive species; continue monitoring and treatment of invasive and nuisance aquatic plants on an annual basis, and; continue to strategically place new and updated signage and boat cleaning resources near the lake to prevent new invasive species from entering the lake.

The original SC identified several actions to help prevent the spread of invasive species and control current invasive species and native nuisance aquatic plant species already in the lake and watershed. Invasive and nuisance native aquatic plants are treated and controlled through the aquatic plant management plan. This plan uses an adaptive management strategy to monitor and treat the lake each year in response to changes in the plant community in Cedar Lake. Since this strategy has been effective at controlling potentially problematic species, the WMP recommends continuing the support and funding of this strategy. In addition, the Cedar Lake fishery is monitored both by the Michigan DNR, and more frequently by a fish biologist funded by the Lake Board and AICLA. This level of monitoring should continue to detect problems caused by invasive species early on and develop a treatment strategy as needed to protect the fishery.

In general, the lake surveys are completed using predetermined Aquatic Resource Assessment Sites (AROS) and observations are recorded on electronic maps and spreadsheets. The lake is also delineated into Tiers. Aquatic vegetation is evaluated by several indices, including location relative to AROS and Tier, plant species presence, coverage (a combination of density and

[86] Pullman, D. (2008). "Cedar Lake Greenbush Township, Alcona County, Oscoda Township, Iosco County, Michigan: Management Program Update."
[87] Freshwater Society. (2004). "Guide to Lake Protection and Management, 2nd Edition." *Published in cooperation with the Minnesota Pollution Control Agency*.

distribution relative to AROS), phenotype, perceived nuisance level based on an extensive survey system of visual observations, rake throws and sonar imaging. In-field observations are processed through the LakeScan™ metrics to track progress toward milestones as laid out in Chapter 6, and change over time. This allows for appropriate adaptive management strategies for targeting AIS while protecting water quality and fisheries. The fisheries habitat assessments include direct observations of nearshore and riparian habitat and woody habitat structure.

Table 7-8 outlines the general WMP implementation task and specific descriptions of recommended actions for this objective.

Table 7-8. Implementation Task Descriptions for Objective V.

Objective	WMP Implementation Task
V	**Invasive Species Management**
	1. Education on best practices to reduce transmission of invasive species.
	2. Ensure adequate educational signage informing lake users about invasive species risks and best practices to reduce the risk of spread.
	3. Continue Lake Manager contract through the Lake Board for ongoing adaptive management strategy for lake and recommended future actions/implement WMP strategies.
	4. Continue lake treatments for noxious weeds and algae growth.

The management of the aquatic plant environment is accomplished through two contracts initiated and managed by the Lake Board. The first is a Lake Manager contract for professional services to conduct regular analyses of the aquatic plant environment to inform the formal aquatic plant adaptive management plan that is updated annually, and develop the treatment plan for each recreational season. This contracting has evolved over the years to include watershed management. The latter is established to coordinate broadly with the WMP and specifically with the fishery habitat management plan. A separate Lake Board contract is with an aquatic herbicide applicator for the treatment or control of pre-determined aquatic plant problems.

The Lake Board is tasked with addressing all lake management matters for Cedar Lake. The first task the Lake Board initiated was the development of this WMP in 2011. There is a strong need for the Lake Board to have a reliable source of updated technical guidance available to it on a regular and as-needed basis as evidenced by the findings of this WMP update and the list of critical. Costly and highly technical tasks will be an inevitable outgrowth of this, as well as other lake management matters that will arise. The Lake Board does not possess within its membership the needed technical expertise to deal with the complex issues of lake management apparent in Cedar Lake's future. The Lake Manager and Watershed Consultant contracts therefore provide technically competent resources that also have overall and detailed knowledge of the specifics and intersectional issues affecting the Cedar Lake environment.

It is therefore recommended that the Lake Board continue to examine professional services contracts to ensure overall lake management function for the aquatic community including both

plant and fishery management functions of the current contract. The Lake Board will continue to clearly define contracted responsibilities. Lake Board consulting roles and responsibilities for these positions are in Attachment H as derived from the latest round of requested 5-year services.

One area that continues to present a high risk of introducing AIS into Cedar Lake is the boat launch and other access points. Lake users bringing their boats from other lakes can easily transport potentially harmful invasive species to Cedar Lake, such as nuisance aquatic plant, fish and wildlife viruses, opportunistic algae, invasive fish larvae or eggs and many other potentially harmful invaders. Additionally, signage should be posted at road ends where boaters might be accessing the lake to remind them of the risk of invasive species and how to inspect and clean their boat before and after they use the lake. The original SC also recognized the desire to create a boat cleaning station at the DNR launch to encourage boat cleaning each time lake users put in or take out at the lake. Although not yet implemented, reconsideration of this implementation project remains in the WMP update as a lower-priority project for longer-term consideration.

Another recommended action for this objective relates to the continued education of lake residents and users about invasive species. Residents should be aware of potential invasive species and how they could threaten the lake and watershed, what organizations they should report sightings to, and practices that can reduce the risk of transmission of invasive species. The AICLA continues to hold a meeting during the summer recreational season to educate and raise awareness on these issues of invasive species at Cedar Lake. The AICLA brings experts in aquatic plant management and treatment, fisheries experts and local conservationists together to present to the group each year. The meeting provides a discussion and question/answer forum that is open to all watershed stakeholders.

These meetings should be used each year because they have proven to be the most successful way to educate and outreach to the public. Another recommendation is continued updates in the AICLA newsletter or a new brochure or homeowner's guide that will disseminate important information on current invasive species in the lake or watershed and invasives in the state that could threaten Cedar Lake. These efforts will serve to continue and accelerate active engagement of lake residents.

KEY STEPS: ***AIS Prevention, Education, and Outreach***

1. Hold regular meetings with the Lake Manager and Watershed Consultant to provide the Lake Board with updates, recommendations and progress on WMP implementation priorities (directed by Lake Board following WMP directives).
2. Use existing information about AIS at Cedar Lake and potential invaders from updated Attachment D in a homeowner's guide or newsletter to provide information including:
    a. List of invasive species identified in the lake and surrounding watershed and how problematic species are currently being controlled;
    b. Pictures of potential invasive species, how transmission can be avoided, and to whom homeowners should report sightings;
    c. How boat cleaning, proper disposal of bait, and careful inspection of other fishing and recreation equipment should be done to avoid invasive species "hitch hikers."

3. Continue to use local newsletter resources to educate residents about invasive species. Use other outreach avenues, such as a watershed brochure, local newspapers, or workshops to broaden message to the entire watershed. Transfer this information to the AICLA website and update regularly.
4. Convene a subcommittee to raise funding and support for educational signage at informal boat launch areas and a potential boat cleaning station near the boat launch:
    a. Small signs produced by the DNR can be obtained from the Michigan Office of the Great Lakes (517-335-4056) that raise awareness about aquatic invasive species and how to properly inspect a boat; placing these at road ends where users access the lake is recommended
    b. Determine if a larger area near the boat launch could be dedicated to a more pronounced sign with disinfectant cleaners, buckets, and brushes for cleaning boats, in addition to wastewater and plant/debris disposal containers
    c. Reconsider plans for a boat cleaning station that would provide air or water sprayers and wastewater and debris disposal for more efficient cleaning of boats

KEY ORGANIZATIONS
Cedar Lake Improvement Board
Alcona-Iosco Cedar Lake Association
Lake Manager
Michigan DNR

OBJECTIVE VI: Improve composition of lake bottom sediments and determine feasibility of muck reduction

A major issue for lake riparians is the organic lake bottom sediment found across most locations in Cedar Lake. These organic sediments, often described as "muck," are derived from a complex blend of organic matter that accumulates on the lake bottom and begins to decay over time. The muck found in certain lake bottom areas of Cedar Lake is very flocculent and can impede recreation activities such as swimming and other water contact sports. Lake residents generally desire a sandier lake bottom. It was important for the CLIB to understand the potential source of this muck so they could determine if the WMP should or could address options to address accumulations.

Research on sediment accretion rates in a lake in Canada found that on average the sediment accumulation rate was approximately 1.2 mm/yr (average between areas with and without macrophyte beds).[88] The report indicated that this rate is similar to other accretion rates measured throughout North America. An average annual sediment accretion rate was calculated for Cedar Lake. Assuming approximately 350 acres of Cedar Lake contains macrophyte beds, it would take approximately 28 years to accumulate an additional 1 inch of sediment. It is important to note that sediment accumulates unevenly throughout any lake depending on lake morphology, wave action, location of macrophyte beds and internal energy.

[88] Rooney, N. and J. Kalff. (2003). "The role of submerged macrophyte beds in phosphorus and sediment accumulation in Lake Memphremagog, Quebec, Canada." *Limnol. Oceanogr. 48(5).*

The original WMP SC initially prioritized the issue of lake bottom muck sediments as very high. The original SC wanted to have some indication of which practices would be feasible and have lasting effects on preventing and removing muck. The SC reviewed and discussed different approaches and practices that could prevent further muck sediment accumulation and to remove existing muck. Three approaches were previously introduced: riparian practices to prevent muck sediment accumulation, aeration and bioaugmentation as a muck-reduction strategy and dredging to physically remove muck sediment from the lake.

Muck Prevention: Educational workshops to modify and improve riparian lawn practices (that would also complement other tasks to prevent increased nutrient inputs to the lake) are lower-cost and longer-term approaches that would potentially reduce muck accumulation over time. This is therefore considered an implementation effort through encouragement for better lawn care practices. This would include stopping riparian practices of dumping lawn grass clippings and leaves into the lake. Disposing of yard waste into water in Michigan is a civil infraction for which local enforcement may issue fines; Michigan EGLE provides detailed information regarding this topic.[89]

Education is the main tool recommended, with a Cedar Lake Property Owner's Guide and workshops to educate riparians on good lawn care practices. Coordinating speakers to give presentations at the summer lake association meeting(s) to educate residents about how riparian practices lead to muck accumulation. Also educating riparians about proper lawn care and leaf disposal (keeping excess materials out of the lake) that is beneficial for the lake in several ways, including preventing the potential for additional muck accumulation and keeping additional phosphorus from entering the lake (complementing other WMP tasks and goals). This could include recognizing or creating incentives for riparians to adopt BMPs, and convening a sub-committee of the lake association to educate and incentivize good lake stewardship practices.

Aeration & Bioaugmentation: Although aeration is not recommended as an implementation priority, a discussion is included here that was part of original WMP SC conversations to develop the WMP. In Michigan, there has been a general level of persistent interest in this approach as an alternative to dredging. One outcome of aeration is increased dissolved oxygen in stratified lakes. This can also be used to prevent fish kills during winter ice-cover in shallow lakes (that do not stratify or deeper ones that do).[90] Cedar Lake is too shallow to stratify and historic dissolved oxygen measurements in the deepest locations on the lake have never revealed depleted oxygen conditions. Thus, this approach offers no value for dissolved oxygen conditions in the lake.

Substantial reduction of sediments is not highly recognized as a benefit of lake aeration in most natural lakes. Limno-Tech, Inc. of Ann Arbor, Michigan conducted a controlled study on Austin Lake, located in Portage, Michigan to evaluate the effectiveness of aeration and bioaugmentation

[89] MI EGLE. (2025). "Leaf litter and yard waste." Available Online: https://www.michigan.gov/egle/about/organization/materials-management/composting/residential/leaf-litter

[90] The Freshwater Society. (2004). "Guide to Lake Protection and Management." *Published by the Freshwater Society in cooperation with the Minnesota Pollution Control Agency, 2nd Edition*.

at decreasing sediment thickness.[91] Field studies were conducted in Austin Lake in the summer and fall of 2005. Two aeration units were installed (one as a control and the other for treatment). The study also explored bioaugmentation to determine if adding bacteria would decrease the sediment thickness at a greater rate than aeration alone. The study concluded that aeration and aeration with bioaugmentation did not reduce sediment thickness. It also concluded that no significant sediment removal (nor even measurable changes) that could be achieved using in-situ aeration and bioaugmentation as it was applied in the study. The use of a propriety bacterial mix, along with aeration did not provide a greater rate of sediment removal than aeration alone. In addition, researchers found that the background sites (untreated sites measured over the same period for comparison) had the same reported loss rate of 3 inches over the 3-month period as the aeration sites. The findings suggested that annual cycling of sediments was occurring.

At East Twin Lake in Lewiston, Michigan, a decrease of several inches of sediment was reported at one end of the lake that was attributed to the aeration project implemented near the same end of the lake.[92] These results were based on repeated measurements taken at four sites in the lake. While it was reported that some riparians noted sandy lake bottom in some places on the lake, insufficient monitoring made for indeterminant conditions as to whether sediments were being completely decomposed or whether displacement of sediments could be taking place. One major concern previously discussed was that aeration of lakes has a moderate to high cost and limited consistency of beneficial results. To date, there appear to be no peer-reviewed scientific publications that have identified how and if sediment thickness decreases with aeration. The State of Michigan has since established rigorous permitting requirements for these types of projects. K&A has more recently assessed results of aeration and bioaugmentation in select lakes of Michigan, concluding that limited to no benefits were scientifically discernable.

Sediment Dredging: Physical removal of muck is the most effective way to improve the lake bottom sediment conditions. During the original SC meetings, members discussed examples of past dredging in Cedar Lake. Members recalled that a lakefront property owner did localized dredging in a small section on the south end of the lake that still seemed to have sandy sediments several years later. Dredging was also discussed in the context of immediate results at the highest cost.

Initial research on the potential of dredging lake bottom sediments was conducted at Cedar Lake by Affiliated Researchers in 2001. They measured sediment depth at 15 sites around the lake, though resulted in limited information on sediment composition, thickness and water depth. They also measured the organic content of sediment samples and found more than 50% organic content at the north end of the lake and 23% organic content at the south end of the lake.

Additional investigations were deemed necessary by the CLIB to fully characterize the lake bottom sediments and water depths to address dredging feasibility. In order to estimate costs for dredging, the WMP originally assumed that one foot of sediment would be targeted for hydraulic dredging from the entire lake bottom footprint (approximately 1,128 acres). The SC intended to

[91] Limno-Tech, Inc. (1995). "Final Project Report: Evaluation of Aeration and Bioaugmentation for Decreasing Sediment Thickness in Austin Lake, 1995." *Ann Arbor, Michigan*.
[92] East Twin Lake Aeration Association. (n.d.). "Aeration Project Report."

use future mapping efforts to select areas to dredge and coordinate disposal of sediments (paying for disposal if not contaminated). The WMP estimated dredging costs would range from $3.6-9 million if land application was possible as a disposal method; an additional $47 million was estimated for landfill disposal if sediments were found to be contaminated.

K&A conducted an updated sediment thickness study in 2019 with bathymetric mapping to approximate dredging costs, feasibility and recommend next steps.[93] Sediment mapping was used to determine thickness in select areas and to preliminary determine the volume of muck sediments and nature of cost prohibitions. The technical memorandum for this study is included as Attachment L.

Findings from the 2019 study suggest that accumulated muck sediments appear to be relatively evenly distributed across much of Cedar Lake, given observed water depths and sediment thicknesses to an underlying hard pan layer. This characteristic constrains physical muck sediment removal potential in any area of the lake. A dredging operation would need to continuously move mechanical equipment to remove only accumulated muck from dredging depths of less than approximately 12 feet below the water surface to avoid disturbance of the glacial till layers beneath observed muck build-up. Such active mechanical removal constraints add costs to dredging operations.

The next step necessitated a detailed assessment of sediment chemical composition and contaminant status to be conducted in areas selected as most feasible or most desirable for dredging. Based on sediment testing results, two sediment samples contained lead at or above EGLE's Aquatic Life and Wildlife Screening Guidelines. This suggested that 25% of sediment that might be targeted for a lake-wide dredging effort could require special handling and disposal restrictions. For Cedar Lake, dredge quantities to deepen the lake by approximately 5 feet would yield an estimated 6.5 million cubic yards of dredge spoils. At best-case costs, such a project could range from $3.25-6.5M. Costs to otherwise specially handle 25% of lead-contaminated dredge spoils could range from $30-60/cubic yard. This could increase potential costs to well over $50M as noted in Attachment L.

Table 7-9 lists updated WMP recommendations for muck prevention or removal, as well as next-step actions. The focus of these recommendations is mainly on education of lake residents to clarify for all stakeholders the limitations to feasibility for muck reduction strategies at-scale, and to promote riparian practices for reduction of muck accumulation. For individual lake residents interested in small-scale beach sanding for their shoreline, selective dredging or dock blower systems that move lighter sediments away from swimming areas, MI EGLE provides details on limitations and permit requirements in their Minor Project Categories document.[94]

[93] Kieser & Associates, LLC. (2019). "Bathymetric Mapping and Sediment Assessment Survey: Technical Report." *Prepared for the Cedar Lake Improvement Board, August 22, 2019.*

[94] MI EGLE. (21 August 2021). "Minor Project Categories in the State of Michigan." *(Section #20 & 21).* Available online: <https://www.michigan.gov/-/media/Project/Websites/egle/Documents/Programs/WRD/Wetlands/Minor-Project-Categories.pdf?rev=c0e17657e1484b20afe47010a67a6999>

Table 7-9. Implementation Task Descriptions for Objective VI.

Objective	WMP Implementation Task
VI	**Muck Sediment Issues**
	1. Summarize lake bottom dredging feasibility study findings for the CLIB and WMP Steering Committee, to clarify feasibility issues and restrictions to removing existing sediments/muck from Cedar Lake.
	1.1. Public Education: Present the findings of the Dredging Feasibility Study (levels & chemical analyses).
	1.2. Public Education: Distribute information to residents regarding best lawn care practices and how this relates to Muck accumulation.
	1.3. Promoting lakeshore/water quality stewardship in relation to reducing Muck.
	2. Create a Cedar Lake Property Owners Guide including muck sediment issues.
	3. Inform private property owners of permitting needs and constraints if they wished to pursue self-funded selective dredging efforts adjacent to their shoreline property.

KEY ORGANIZATIONS
Cedar Lake Improvement Board
Alcona Iosco-Cedar Lake Association
EGLE

OBJECTIVE VII: Educate watershed residents about natural shoreline methods, native buffers, and other best practices for residents and the potential benefits

Throughout the original watershed management planning process, the SC discussed various educational needs for lakeshore residents to promote BMPs that will reduce runoff from lawns, control erosion and provide natural habitat for wildlife (e.g., native birds and pollinators). Encouraging lakefront residents to change their normal lawncare practices will require education to make residents aware of the benefits and enable them to change behaviors and practices. Table 7-10 highlights tasks for each proposed implementation task.

Table 7-10. Implementation Task Descriptions for Objective VII.

Objective	WMP Implementation Task
VII	**Natural Shorelines**
	1. Educate residents on natural shoreline benefits and techniques to provide technical support to lakefront property owners who implement native vegetation buffers.
	2. Create a Cedar Lake Property Owners Guide with natural shoreline benefits and techniques.

The Lake Board and AICLA should engage with the MI Natural Shoreline Partnership's Shoreland Stewards Program, including program requirements and incentives and promoting

annual stewardship events.[95] Education and outreach efforts took place in 2012 with a K&A presentation on options for natural shorelines, benefits, and implementation strategies for lakeshore owners.

Installation of a natural shoreline demonstration project took place in 2013 at the Lakewood Shores POA with a native buffer strip on a portion of the causeway revealed the challenges for natural shorelines on lakes with fluctuating water levels. As discussed earlier, the limited success and eventual failure of non-hardened natural shoreline designs deflected interests of the Lake Board from more formal project funding.

The proposed Cedar Lake Property Owners Guide could include information specific to shoreline design features necessary for successful shoreline restoration on Cedar Lake. The guide could walk individuals through easy-to-follow steps for assessing the health of their shoreline, including native natural shoreline with riparian buffers, no-mow and/or no-fertilize buffer near the lakeshore (or no fertilizers at all), regular septic system maintenance and clean-out and erosion control practices. Where there might be interest for convert hardened seawall structures to a more natural shoreline, specific design features derived from the Lakewood Shores pilot would prove invaluable.

The Guide could involve a public meeting or "lake day" that could involve activities such as a tour of native buffers/natural shoreline sites (and potentially other BMPs), promoting a native plant sale or exchange and other educational opportunities (and/or promotion of lake association membership/benefits). This could build on the efforts of the AICLA which offers many of these opportunities to their members and the watershed community in general. Partnership with the Michigan State University Extension Office could provide resources for successful engagement without Lake Association or Lake Board expenditures to advance information exchanges.

Additional educational strategies in the WMP include an educational program that continues to include a series of workshops or presentations given at the current AICLA meetings. These meetings could include guest speakers discussing practices that lakeshore residents can enact to help protect the lake. The WMP has identified several educational topics that should be covered Potential speakers and local organizations are identified in Objective V.

Another part of this task is continuing to provide educational programs for lakeshore residents to learn about BMPs they can implement to protect the lake. A preliminary list of Educational Program topics is included in Attachment M.

KEY ORGANIZATIONS
Cedar Lake Improvement Board
Alcona-Iosco Cedar Lake Association

[95] Information available online: <https://www.mishorelinepartnership.org/shoreland-stewards.html>.

OBJECTIVE VIII: Continue monitoring water quality and expand monitoring parameters to protect lake water quality, human health, and recreational value

Cedar Lake water quality has been monitored by several groups, individuals, and organizations for a variety of indicators over many years. Nutrients are generally low in Cedar Lake and other water quality parameters indicate that Cedar Lake is in good condition and in a stable mesotrophic state. CLMP protocols are followed for volunteer monitoring (when applicable).

A recommended action in the WMP for this objective is to continue participation with the CLMP volunteer monitoring program and other ongoing water quality sampling in order to continue monitoring water quality in Cedar Lake. This will provide important information on lake management. Additionally, water quality measurements should continue to be conducted as part of ongoing vegetation and fisheries monitoring. The WMP relies on limited sampling data for Sherman Creek and Jones Ditch; updating nutrient and sediment loading estimates from Sherman and Jones Ditch through direct water quality sampling is therefore a recommendation of the WMP update. Similarly, sampling nutrients from nearshore groundwater in the septic-system contributing area (northwest shoreline properties) is recommended to confirm assumptions from septic system loading estimates utilized in this WMP and update this information moving forward, particularly where concerns may arise.

A description of recommended water quality parameters, methods, locations, and sampling frequency for implementation is summarized in Table 7-11 below. Table 7-12 outlines each action recommended for this objective and provides the details of the specific recommended implementation tasks for Objective VIII.

Table 7-11. Recommended water quality implementations for Cedar Lake

Water Quality Parameter	Sampling Frequency	Responsible Party (Sampler)	Sampling Location(s)
Secchi disk depth	Weekly, May-Sep	AICLA/CLMP	BB, SP
Chlorophyll *a*	1x month, May-Sep	AICLA/CLMP	SP
Nutrients (TP)	2x summer, May-Sep	AICLA/CLMP	SP
Trophic State Index[96]	Calculation	CLMP	--
E. coli	Weekly, Jun-Sep	AICLA/Health Dept.	Beaches
Dissolved Oxygen	Bi-annual	K&A	BB, SP
Temperature	Continuous / Bi-annual	K&A	Outlet / BB, SP
PFAS/PFOAs	As-required by EGLE	EGLE / K&A	Locations TBD

[96] North American Lake Management Society. (2020). "Trophic State Equations." Accessible Online: <https://www.nalms.org/secchidipin/monitoring-methods/trophic-state-equations/>.

Table 7-12. Implementation Task Descriptions for Objective VIII.

Objective	WMP Implementation Task
VIII	**Water Quality Assessments**
	1. Continue involvement with Michigan Lake & Stream Association and CLMP monitoring program to maintain data collection for knowledge on lake management strategies/practices.
	1.1. Expanded Testing: NW Shoreline septic systems – assessing contributions to the Lake.
	1.2. Expanded Testing: *E. coli* testing to western shoreline.
	2. Educate residents on proper septic system maintenance, clean out and repair.
	3. Document and track persistent water quality problems and pursue site-specific water quality sampling.
	4. PFAS: Public Education – state of the issue and changes since the WMP was written in 2011.
	4.1. PFAS: Support and encourage additional state testing.

The CLMP provides annual water quality reports to the AICLA and the Lake Board, reporting important water quality indicators including historic data comparisons to assess Trophic State Index (TSI). TSI is determined using Secchi depth, Chlorophyll *a*, and Total Phosphorus concentration measurements. Continuing this monitoring regime is recommended for tracking long-term water quality trends in Cedar Lake.

Additionally, the Lake Manager conducts bi-annual profiles of DO and temperature, as well as Secchi disk depths, at two on-lake sampling stations during each of the semi-annual aquatic vegetation surveys. Data are considered part of lake management activities and are reported annually with the aquatic vegetation/AIS final report. This WMP update recommends that additional water quality take place to more-closely assess pollutant contributions from septic system discharges from along the NW shoreline of the lake. The Lake Manager should coordinate this sampling with the Lake Board and AICLA to ensure willing participation from property owners in the targeted sampling areas.

The SC also discussed ways to prevent *E. coli* from becoming a problem in the future and whether additional sampling is necessary. *E. coli* sampling for Cedar Lake has been conducted under grant funding by the District Health Department No. 2 since 2006. Samples are collected near the public beach at Greenbush Township Park.[97] Samples are collected either once per week or three times per week in summer. Since 2006, no violations of Michigan water quality standards for total body contact recreation have been measured at Cedar Lake.[98] The AICLA also

[97] Michigan Department of Environmental Quality (DEQ). (2010). "Beach Guard." *Cedar Lake – Greenbush Township Beach.* Accessible online: <https://www.egle.state.mi.us/beach/BeachDetail.aspx?BeachID=2456>.
[98] Part 31 of the Natural Resources and Environmental Protection Act, 1997 PA 451, as amended; R 323.1062(1) states: "All waters of the state protected for total body contact recreation shall not contain more than 130 E. coli per 100 ml, as a 30-day geometric mean...[or] contain more than a maximum of 300 E. coli per 100 ml."
State of Michigan. (1994). "Natural Resources and Environmental Protection Act 451 of 1994. Accessible online: <http://www.legislature.mi.gov/documents/mcl/pdf/mcl-act-451-of-1994.pdf>.

started to monitor *E. coli* levels in several locations in Cedar Lake in 2010. During their sampling investigation, no *E. coli* levels in exceeding water quality standards were measured.

The WMP has focused on preventative measures such as education about septic system maintenance and clean-out and stress that picking up after pets and deterring excessive waterfowl will help prevent future problems. The WMP update recommends expanding AICLA monitoring efforts to include the lake's western shoreline. Overall, the education and monitoring programs will serve as a lake-wide education effort, encouraging lake riparians to improve lawn and septic system maintenance to curb nutrient runoff and reduce potential *E. coli* issues.

Regarding the emerging contaminant issue of PFAS-family contamination, which has been an ongoing regional issue related to historic uses at the Wurtsmith Airforce Base in Oscoda. Chapter 4 discussed potential pollutant sources and causes, as well as Attachment C. While EGLE is expected to be largely responsible for sampling PFAS and PFAS foams, inclusion of contaminant assessments is included in the WMP technical update to ensure that any Cedar Lake watershed-specific additional investigations which may be needed or desired are fully addressed.

These include efforts to understand the extent and sources of contamination impacting Cedar Lake and identify opportunities to mitigate or limit inputs from those sources. Additionally, the WMP strategy includes efforts to ensure EGLE engages in adequate sampling and reporting to protect and inform watershed stakeholders; where adequate sampling is not being undertaken and cannot be petitioned to be undertaken by EGLE, additional sampling using technical support may be necessary. Providing I&E outreach and making updated information publicly available to ensure public health, especially in drinking water but also in full and partial-body contact recreation and public engagement opportunities is also a priority.

KEY ORGANIZATIONS
Cedar Lake Improvement Board
Alcona-Iosco Cedar Lake Association
Michigan EGLE
Watershed Consultant
District Health Department No. 2

OBJECTIVE IX: Improve the Public-Access DNR Boat Launch

The WMP technical update Steering Committee added this final Objective to address physical issues at the DNR public boat launch for Cedar Lake. Residents have noticed that the concrete pads of the boat launch have shifted over time, creating a difficult and dangerous situation for individuals attempting to launch their boats especially during periods of low lake levels. Boats power-loading (despite signage prohibiting this practice) at the launch have likely exacerbated this issue, a practice which is especially common during low water level periods on the lake. The purpose of this Objective is to take steps toward improving the public launch so that it can handle all appropriate sizes of vessels launched during all lake level conditions.

Table 7-12 provides the recommended future implementation tasks for Objective IX.

Table 7-12. Implementation Task Descriptions for Objective IX.

Objective	WMP Implementation Task
IX	**DNR Boat Launch Improvements**
	1. Address structural issue with DNR due to prop washing especially during low lake levels; users getting their boat trailers stuck.
	1.1. Redesign and implement launch upgrades that can handle the size of boats during all lake level conditions.

KEY ORGANIZATIONS

Cedar Lake Improvement Board
Alcona-Iosco Cedar Lake Association
Michigan Department of Natural Resources

Public Information and Education

A large portion of the implementation strategy involves continual dissemination of updated information to the public and education (I&E). This is particularly relevant as residential land use constitutes the largest source of pollution to the lake that can be reasonably reduced. Effectively educating the public on how to adopt behaviors and practices that protect the lake, such as restoring natural shorelines and nearshore habitat, will necessitate a variety of resources and adaptive approaches. The original Steering Committee recognized that educating watershed stakeholders will be necessary for preventing future degradation of Cedar Lake's shared natural resources by mitigating pollutant and sediment loading to the lake, protecting habitat and recognizing invasive species. The AICLA annual summer meetings play an important role in these efforts. These principles carry over to this WMP update.

The public I&E strategies, tools and tasks outlined in the various watershed objectives are summarized below. A major task of the AICLA has been public education. Although the Lake Association welcomes and encourages the general public to attend their events, there is a need to continue outreach to riparian homeowners who are not members of the AICLA and non-riparian landowners in the watershed. Currently there are several I&E mechanisms in the watershed that should continue, and others that should be developed.

First, the AICLA has a strong presence with the lake community and regularly distributes information to all riparian homeowners via their newsletter. They also hold regular meetings during the summer for the public. These efforts are consistent and successful; they should continue into the future with I&E efforts on particular topics of interest as listed in updated Attachment M to this WMP. Attachment M includes a timeline of when the I&E efforts should be implemented (distributed across years 1-3, 4-5, and 6-10 after the WMP is approved).

In addition to the efforts of the AICLA, the Lake Board regularly engages with the public, though not in a consistent education-based manner that the AICLA has done for years. The Lake Board provides information at public hearings and meetings before deciding on projects and/or assessment issues related to aquatic vegetation, lake and watershed management under their purview. As the Lake Board works to implement the WMP, partner organizations in the watershed will be targeted to effectively meet WMP I&E goals and objectives.

WMP objectives involve an I&E component and comprise the public involvement portion of the updated plan. These are listed below with estimated costs representing a potential range of non-itemized expenditures for public notifications, technical support for information preparation, mailing costs, etc. (These do not, however, reflect actual engineering, planning or implementation costs for implementation efforts.)

Objective I – I&E:

- Hold public educational meetings to present updated findings of studies and recommendations for implementation of future projects [Approximate Annual Cost: $1,000; or $10,000 over 10 years]

Objective II – I&E:

- Hold workshops to educate homeowners and builders on practices or measures that will reduce

the risk of flooding in homes in the Lakewood Shores subdivision [Approximate Cost: $2,500]

Objective III – I&E:

- Hold workshops to educate potential builders on practices or measures to prevent shallow groundwater losses with new construction in the Timberlakes subdivision [Approximate Cost Range: $3,000]

Objective IV – I&E:

- Fisheries online survey to garner feedback on perceptions of fisheries issues, on and for recommended future fisheries improvement projects [Approximate Cost: $2,000]
- Design and implement online creel survey [Approximate Cost: $2,000]
- Educate the public on fisheries-related management efforts such as habitat protection areas in the lake to avoid when fishing, related project implementation efforts and engagement/training of volunteers in alignment with regular Lake Association education and outreach [Approximate Annual Cost: $1,000; or $10,000 over 10 years]

Objective V – I&E:

- Create and distribute a homeowner's guide to Cedar Lake to educate watershed residents about aquatic invasive species and potential threats [Approximate Cost: $2,000]
- Install additional signage in high-traffic and high-use areas [Approximate Cost: $1,000]
- Regularly post important information regarding invasive species and nuisance aquatic plants in local newsletters and WMP website [Approximate Annual Cost: $500; or $5,000 over 10 years]

Objective VI – I&E:

- Summarize lake bottom dredging feasibility study findings for the Lake Board and Lake Association to clarify feasibility issues and restrictions to removing existing sediments/muck from Cedar Lake while promoting stewardship to reduce sediment inputs [Approximate Cost: $3,500]

Objective VII – I&E:

- Implement a Cedar Lake Homeowners Guide to educate the public on good residential practices, benefits of native buffers and natural shorelines; promote workshops to educate the public on priority shoreline topics [Approximate Cost Range: $2,500-5,000]
- Lake resident online survey to garner feedback on perceptions of natural shorelines including positive and negative perceptions, design options, benefits, risks, limitations and desires for shoreline improvements on Cedar Lake [Approximate Cost Range: $1,500-2,500]

Objective VIII – I&E:

- Update WMP website to include information on PFAS groundwater contamination sampling and links to status updates for Cedar Lake [Approximate Cost: $1,000]
- Educate the public on proper pet waste disposal, how to deter waterfowl from yards and public areas, and proper septic system maintenance and clean-out schedule [Approximate Cost: $3,000]

Objective IX – I&E:

- Provide informational outreach materials for meetings with the MDNR regarding specific interests for boat launch improvements [Approximate Cost: $1,500]

Total I&E costs for a 10-year implementation period are estimated to range from $50,500-54,000.

Estimated Pollutant Load Reductions

A primary focus of the Cedar Lake WMP is on projects and approaches necessary to protect and improve quality of the watershed and lake. This section considers water quality improvements expected as outcomes with implementation of select projects. Many of the projects and approaches listed in the implementation table of Attachment I involve preventative and protective measures. As such, no changes in nutrient or sediment load are necessarily expected, and thus are not estimated. Some of the recommended projects may offset a potential future load if protective actions are taken. Other implementation efforts in Attachment I allude to expected benefits to the lake or watershed for ecological and/or habitat improvements as opposed to quantifiable water quality benefits in terms of nutrient or sediment reduction.

For implementation projects that have been developed for mitigation purposes in Table 7-13, predicted reductions or changes in nutrient and sediment load reduction have been quantified, as appropriate for the WMP. Some educational efforts, such as promoting native buffers in residential shoreline areas likely will eventually lead to lake water quality benefits in terms of reducing TSS and TP loading to the lake. To quantify these potential improvements, it was assumed that at a 25% implementation rate, the native shoreline buffers would be 75% efficient at filtering TP and 65% efficient at filtering TSS. The resulting load reductions are shown in Table 7-13. With septic system education, the goal is to improve residential clean-out practices. To quantify an associated TP load reduction to Cedar Lake, septic system clean-out frequency was shortened to once every five years resulting in a reduction of 5 pounds per year to the lake.

Table 7-13. Estimated TP and TSS load reductions and impacts on hydrology from proposed restoration projects.

Project	Application	TSS Load Reduction (lbs/year)	TP Load Reduction (lbs/year)
Native Shoreline Buffer Strips[(1)]	Low Intensity Residential (25% of residential shoreline implementation)	296.7	14.9
Improved Septic System Clean Out Frequency (once every 5 years)	Northwest Drainage Area Residential Septic Systems (100%)	N/A	5

[(1)] (MDEQ, 1999).

It is important to note that changes in watershed hydrology such as the wetland berm project (which redirects flows at Kings Corner Road in the northwest part of the watershed to the lake), will likely produce increased sediment and phosphorus loading as described in Chapter 5 due to increased inflows. The concentrations of nutrients and sediments in tributary inflows in this respect, however, are extremely low. Thus, the potential trade-off in these scenarios are large increases in the flow of water to Cedar Lake with minimal increases in mass loading of nutrients and sediments. These tradeoffs are balanced with improving summer lake levels for maintaining more desirable recreational conditions and ecological habitat.

Projected WMP Technical Assistance Needs

Professional assistance needs and estimated ranges of costs for efforts associated with each WMP objective are presented in this section. These follow implementation efforts summarized in Attachment I. Elements of these objectives that require third-party technical assistance include:

- **Augmentation Implementation & Hydrology Monitoring**: Technical services from a qualified environmental engineering firm will continue to be necessary for planning, designing and implementing recommendations. The Lake Board has the established mechanism to engage these professional services for CLIB-led implementation projects and ongoing monitoring. For infrastructure projects noted in the WMP that otherwise fall under the purview of county agencies, the solicitation process for professional assistance will be the responsibility of these entities under county and/or state requirements.
- **Wetland Protection Options**: A compilation of existing local, state and federal ordinances and regulations will be addressed by the Lake Board watershed consultant. Legal assistance for drafting potential wetlands ordinance language would be required through a qualified attorney working with township or county legal counsel.
- **Conservation Easements and Land Protection Tools**: Technical services from both legal counsel and other organizations familiar with conservation easements will be necessary if easements and other land protection tools are utilized in the watershed.
- **Home Flooding Education**: A home building expert experienced with flooding issues and methods to reduce flooding and/or control of water at homesteads in traditionally wet areas should be consulted when preparing education materials for Lakewood Shores residents.
- **Fisheries Management**: The Lake Board will continue to use as-needed services of a fisheries management professional working in conjunction with the Watershed Manager to implement the tasks outlined in the Cedar Lake fisheries objective.
- **Aquatic Invasive Species Management:** The Lake Board will continue to use the services of the Lake Manager and an AIS management service applicator to implement the tasks outlined in the Cedar Lake aquatic plant management objective.
- **Homeowner's Guide:** The Watershed Manager, working with MSU Extension and other non-profit organizations with relevant experience would be utilized to develop materials for the homeowner's guide to Cedar Lake.
- **Native Buffer/Shoreline Naturalization**: Technical services of the Watershed Consultant, MSU Extension and the Michigan Natural Shoreline Partnership could collectively be used to develop materials for the Cedar Lake setting to promote these opportunities.
- **Information & Education Program**: Technical assistance from active AICLA and Lake Board engagement will be the first line of information development relevant to WMP I&E. Other organizations can be solicited by either of these lake entities as needed.

It is important to note all potential funding sources included in the Attachment I implementation table. Much of the work done in the watershed to date has been funded through special

assessments and AICLA funds collected voluntarily. Ongoing management efforts in the watershed including aquatic plant and fisheries management, will involve annual assessments on riparian properties. Assessments will primarily control the rate of WMP implementation unless outside funding is pursued. Outside funding sources included in the table often require grant proposals.

The Lake Board and Lake Association should consider grant or other funding source solicitation. This is illustrated by current Watershed Consultant support to the Lake Board in acquiring a Midwest Glacial Lakes Partnership Grant to reconstruct the Jones Ditch channel to the lake. This pending grant (as of this writing) will also examine opportunities for public-private partnership arrangements to tackle issues such as Lake State Railroad Company maintenance and/or replacement of culverts in the northwest wetlands. Other state and/or federal grants are also applicable to WMP interests. Current special assessment district funds, as well as potential AICLA investments can serve to provide match funding often required with grants.

Projected WMP Implementation Costs

This section of Chapter 7 presents 10-year cost estimates, in 2025 dollar-values, for actions identified under each updated WMP objective targeted for completion. These costs are presented in Table 7-14 to allow for a high-level cost / benefit comparison of the nine objectives. I&A cost estimates presented earlier in this chapter are included as line items for each WMP objective in this table where applicable.

For the various implementation efforts associated with plan objectives, overlap in terms of timing, funding and outcomes from multiple projects should be sought where useful for potential cost savings. Actual costs will ultimately be based on the final strategies or designs implemented, as well as prevailing costs for professional and contracted services. Notably, feasibility analyses should be conducted for any constructed actions. Where there are construction services expected for implementing WMP-directed projects, associated engineering design, permitting, construction oversight and monitoring fees are included assuming these will be approximately 20% of construction costs. Competitive bidding processes should be employed for construction services. Not included in these projections are potential infrastructure costs that would be directed by county agencies on projects such as augmentation wells, Lakewood Shores underdrain reconfiguration and/or Timberlakes drainage that otherwise fall under their purview.

Table 7-14. Estimated cost ranges for implementing updated 2025 WMP objectives over a 10-year timeframe assuming these are third-party service provider charges (consultants, contractors, etc.) other than for portions of I&E costs to local entities (TBD = "to be determined based" based on associated technical assessments and the projected merits of implementation).

Objective	WMP Task / Cost Category	10-Year Total Estimated 2025 Line-Item Cost ($)
I	1. Implement TBD lake level management projects through Lake Board action	$250,000 - $500,000
	2. Summarize groundwater well augmentation feasibility study findings for the CLIB dissemination	$5,000
	3. Compile existing options in prevailing guidance, ordinances, policies and regulations that currently protect NW wetlands	$5,000
	4. Re-engineer hydrology of NW wetlands to improve wetland function	
	4.1. Assess hydrology of Jones wetland and feasibility of additional water storage measures	$25,000
	4.2. Coordinate with Lake State RR Company for them to improve NW wetlands railroad culvert flows	$15,000
	4.3. Explore future project benefits for upstream Sherman Creek channel flow improvements	$15,000
	4.4. Continued groundwater and flow assessment/monitoring	$200,000
	5. Acquire property in the NW wetland for restoration/enhancements	
	5.1. Explore purchasing and managing additional parcels of land (excludes TBD land purchase costs)	$25,000
	5.2. Donation of conservation easements - Engagement with land conservancies and private property owners	$5,000
	Estimated I&E Costs	*$10,000*
	Objective I – Total:	***$555,000-805,000***
II	1. Work with the Iosco Drain Commissioner on Lakewood Shores storage and return options that directly benefit lake levels	$60,000
	2. Identify tax reverted lands that could support storage and return options	(TBD)
	3. Wetlands banking (investment for return flow options)	(Private Funding)
	4. Wetland delineations for unbuilt parcels (desktop analysis)	$12,000
	Estimated I&E Costs	*$2,500*
	Objective II – Total:	***$74,500***
III	1. Work with the Drain Commissioner to find solutions to potential future development issues/stormwater drainage needs	$25,000
	2. Identify and pursue opportunities to prevent future stormwater dewatering drainage issues similar to Lakewood Shores issues	(TBD)
	Estimated I&E Costs	*$3,000*
	Objective III – Total:	***$28,000***
IV	1. Re-engineer hydrology connection of NW wetlands to support fisheries with Jones Ditch channel improvements	$100,000

Objective	WMP Task / Cost Category	10-Year Total Estimated 2025 Line-Item Cost ($)
	2. Follow Recommendations from Fisheries Management Reports:	
	2.1. Conduct a fish population assessment, including a sportfishing Creel Census	$5,000
	2.2. Conduct critical fish habitat assessments	
	2.2.a. Assess pike spawning in Sherman Creek and fisheries habitat in Jones Ditch	$20,000
	2.2.b. Conduct an in-lake critical fish habitat assessment update	$5,000
	2.3. Provide fisheries habitat enhancements	
	2.3.a. MDNR decadal fisheries assessment and walleye fingerling stocking	(State Cost)
	2.3.b. Implement in-lake habitat improvements (substrate, coarse woody habitat, etc.)	(TBD)
	3. Re-assess benefits and sustainability of potential stocking Redear sunfish at-scale via pilot testing	(Potential Grant)
	Estimated I&E Costs	*$14,000*
	Objective IV – Total:	***$144,000***
V	1. Education on best practices to reduce transmission of invasive species	*(I&E cost)*
	2. Ensure adequate educational signage informing lake users about AIS	*(I&E cost)*
	3. Lake Manager contract to continue adaptive management strategy for AIS and aquatic plant community	$150,000
	4. Continue lake treatments for noxious weeds and algae growth	$300,000
	Estimated I&E Costs	*$8,000*
	Objective V – Total:	***$458,000***
VI	1. Summarize lake bottom dredging feasibility study for CLIB and SC	
	1.1. Public Education: Present findings of the Dredging Feasibility Study	*(I&E cost)*
	1.2. Public Education: Distribute info on lawn care practices relating to muck	*(I&E cost)*
	1.3. Promoting lakeshore/water quality stewardship to reduce Muck	*(I&E cost)*
	2. Cedar Lake Property Owners Guide including muck issues	$2,500
	Estimated I&E Costs	*$3,500*
	Objective VI – Total:	***$6,000***
VII	1. Educate & partner with residents on natural shoreline benefits and techniques	*(I&E cost)*
	2. Cedar Lake Property Owners Guide including benefits of natural shorelines	*(I&E cost)*
	Estimated I&E Costs	*$4,000-7,500*
	Objective VII – Total:	***$4,000-7,500***
VIII	1. Continue with MLSA to maintain knowledge on WQ lake management	
	1.1. Expanded Testing: NW Shoreline septic systems	$10,000
	1.2. Expanded Testing: *E. coli* testing of western shoreline	(County cost)

Objective	WMP Task / Cost Category	10-Year Total Estimated 2025 Line-Item Cost ($)
	2. Educate residents on septic system maintenance, clean out, and repair	*(I&E cost)*
	3. Document and track persistent WQ problems and pursue sampling	$8,000
	4. PFAS: Public Education – state of the issue and changes since 2011	
	4.1. PFAS: Additional state testing	(State cost)
	Estimated I&E Costs	*$4,000*
	Objective VIII – Total:	***$22,000***
IX	1. Address current design challenges affecting safe boat launching	
	1.1. Redesign and implement launch improvements that can handle all lake level conditions	(State cost)
	Estimated I&E Costs	*$1,500*
	Objective IX – Total:	***$1,500***
	TOTAL	**$1,293,000-1,547,000**

Updated 10-year WMP implementation costs in Table 7-14 reflect refinements gleaned from the range of efforts completed or examined under the original 2011 plan. The earlier cost projections for plan implementation were close to $2.5M compared to the 2025 updated $1.3-1.55M projections. Many of the original estimates did not have the benefit of detailed cost discovery which has helped to refine 2025 WMP projections.

Objective I has the largest range of potential costs based what may still be considered possible for improving water storage and transmission to the lake with more northwest wetland hydrology improvements that would fall under Lake Board opportunities. Objective I tasks would ultimately identify such projects. Subtask 4.4 under this objective reflects the sustained groundwater and surface water level monitoring regimen now established with sophisticated instrumentation and analysis. Such data underpin the legitimacy and efficacy of watershed projects.

Objective II expressly does not include potential costs for a Drain Commissioner-directed project that would require a special assessment for drainage improvements or modifications. Projected funding will support acquisition of Lake Board technical input on Drain Commission project options that would specifically protect and benefit Cedar Lake levels. Objective III funding has a similar purpose with the possibility that passive groundwater management activities benefitting the lake could be implemented with Drain Commissioner approval. Such opportunities remain speculative as of this reporting and are therefore denoted as to-be-determined (TBD).

The Objective IV budget is also substantial as related to Cedar Lake fisheries enhancement opportunities. Task 1 under this objective will provide significant uplift to the fishery by providing a more naturalized connection between the lake and over 1,000 acres of upstream wetlands. The re-engineering lower section of the ditch will specifically accommodate pike

spawning access. This will also enhance the hydraulic connection between these two areas. This effort is intended to be funded through a pending Midwest Glacial Lakes Partnership grant introduced in Chapter 2. Continued interest in enhancing the redear sunfish population of the lake would include additional assessment of its benefits and sustainability prior to actual at-scale purchase of fish stock. Task 3 under this objective reflects both studies and stocking with the expectation that funding for studies under this task would be from sources other than the AICLA or CLIB, and most likely a grant. If studies identified the benefits and sustainability of Redear in the lake, the source of funds for stocking of this fish would be revisited. Reassessment of stocking redear sunfish is considered a low-priority and would need to be approached carefully in the context of introducing another panfish species which risks compounding competition for limited food and habitat.

Objective V costs represent a continuation of the ongoing aquatic invasive species and vegetation management of Cedar Lake. These are reflective of almost two decades of annually incurred costs that have been and should remain part of the special assessment district under the Lake Board.

Remaining Objectives VI-IX reflect a balance of education and outreach efforts that would include current technical support and outside agencies to bring refined information to lake residents. Potentially large ticket-item costs under these objectives would most likely fall to others and not necessarily to assessments on watershed residents.

Implementation Priorities and Schedule

A detailed schedule for implementation priorities is presented in Table 7-15. This is derived from Attachment I priority listings ranked as low, medium or high (L, M, H) for each WMP implementation phase. The original WMP priorities were developed with Steering Committee input. These have been updated for 2025 WMP objectives with input from the current WMP update committees. The priority rankings of updated projects and tasks may change over time as the Lake Board continues to track watershed milestones, as opportunistic funding options arise and as new issues or concerns emerge. For now, these priorities are translated into the Table 7-15 implementation schedule.

The schedule has been established using: a) information from the Lake Board's approval of the proposed 10-year schedule for their updated 2020 Special Assessment District re-assessment; b) priority ranking with WMP technical update meeting feedback, and; c) an implementation schedule developed by K&A to guide the Lake Board and other watershed stakeholders in selecting an optimal sequence of projects. The schedule takes into consideration the ranking of watershed concerns, pollutant sources, and overall watershed goals. In addition, sequential timing of projects, amount of time necessary to complete projects, amount of expected public engagement and acceptance, and the availability of funding were all considered when developing the schedule. Table 7-15 more definitively defines the implementation schedule for the next five years, whereas lower priority efforts and/or those expected to continue beyond this period have implementation denoted in the 2030+ timeframe.

Table 7-15. Implementation schedule for the Cedar Lake WMP projects and approaches by objective with approximate start date (by year) and duration to complete the activities (I&E efforts would run contiguous with the implementation schedule and/or extend beyond specific implementation actions).

WMP Objective YEAR:	2026	2027	2028	2029	2030	2031+
Objective I						
1. Implement lake level management projects to augment lake levels						
2. Summarize feasibility study findings for the CLIB						
3. Compile ordinances, policies, recommendations to protect NW wetlands						
4. Re-engineer hydrology of NW wetlands to improve wetland function						
4.1. Assess hydrology of Jones wetland and feasibility of additional water storage measures						
4.2. Coordinate with Lake State RR Company for them to improve NW wetlands railroad culvert flows						
4.3. Explore future project benefits for upstream Sherman Creek channel flow improvements						
4.4. Continued groundwater and flow assessment/monitoring						
5. Acquire property in the NW wetland for restoration/enhancements						
5.1. Explore purchasing and managing additional parcels of land						
5.2. Donation of conservation easements - Engagement with land conservancies and private property owners						
Objective II	**2026**	**2027**	**2028**	**2029**	**2030**	**2031+**
1. Work with the Drain Commissioner on Lakewood Shores storage and return options that directly benefit lake levels						
2. Identify tax reverted lands that could support storage and return options						
3. Wetlands banking (investment for return flow options)						
4. Wetland delineations for unbuilt parcels (desktop analysis)						
Objective III	**2026**	**2027**	**2028**	**2029**	**2030**	**2031+**
1. Work with the Drain Commissioner on options to help prevent future Timberlakes stormwater drainage impacts on lake levels						
2. Identify and pursue Lake Board opportunities to prevent future stormwater dewatering drainage issues						
Objective IV	**2026**	**2027**	**2028**	**2029**	**2030**	**2031+**
1. Re-engineer hydrology connection of NW wetlands to support fisheries with Jones Ditch channel improvements						
2. Follow Recommendations from Fisheries Management Reports:						
2.1. Conduct a fish population assessment, including a creel census						
2.2. Conduct critical fish habitat assessments						
2.2.a. Assess pike spawning in Sherman Creek and fisheries habitat in Jones Ditch						
2.2.b. Conduct an in-lake critical fish habitat assessment update						
2.3. Provide fisheries habitat enhancements						
2.3.a. MDNR decadal fisheries assessment and walleye fingerling stocking						

2.3.b. Implement in-lake habitat improvements (substrate, coarse woody habitat, etc.)						
3. Re-assess benefits and sustainability of potential stocking Redear sunfish at-scale						
Objective V	**2026**	**2027**	**2028**	**2029**	**2030**	**2031+**
1. Education on best practices to reduce transmission of invasive species						
2. Ensure adequate educational signage informing lake users about AIS						
3. Lake Manager contract to continue adaptive management strategy for AIS and aquatic plant community						
4. Continue lake treatments for noxious weeds and algae growth						
Objective VI	**2026**	**2027**	**2028**	**2029**	**2030**	**2031+**
1. Summarize lake bottom dredging feasibility study for CLIB and SC						
1.1. Public Education: Present findings of the Dredging Feasibility Study						
1.2. Public Education: Distribute info on lawn care practices relating to muck						
1.3. Promoting lakeshore/water quality stewardship to reduce muck						
2. Cedar Lake Property Owners Guide including muck issues						
Objective VII	**2026**	**2027**	**2028**	**2029**	**2030**	**2031+**
1. Educate & partner with residents on natural shoreline benefits and techniques						
2. Cedar Lake Property Owners Guide including benefits of natural shorelines						
Objective VIII	**2026**	**2027**	**2028**	**2029**	**2030**	**2031+**
1. Continue with MLSA to maintain knowledge on WQ lake management						
1.1. Expanded Testing: NW Shoreline septic systems						
1.2. Expanded Testing: *E. coli* testing of western shoreline						
2. Educate residents on septic system maintenance, clean out, and repair						
3. Document and track persistent WQ problems and pursue sampling						
4. PFAS: Public Education – state of the issue and changes since 2011						
4.1. PFAS: Additional state testing						
Objective IX	**2026**	**2027**	**2028**	**2029**	**2030**	**2031+**
1. Address current design challenges affecting safe boat launching						
1.1. Redesign and implement launch improvements that can handle all lake level conditions						

Milestones to Measure Progress

Interim milestones were originally developed to monitor the progress of WMP implementation and distributed to the SC for feedback. The early SC was asked to give input on whether the list of milestones would serve the Lake Board and other organizations involved in tracking annual watershed progress toward WMP tasks and meeting the overall goals. These original elements are carried over to the 2025 WMP update.

Progress toward these milestones was identified in Chapter 6 of this WMP technical update. Below, this section will identify the updated WMP milestones based on progress toward original milestones and new recommendations set forth in the updated WMP. This updated final list of WMP milestones is generally organized by watershed goal in chronological order. In this format, it will serve as an annual "checklist" for the Lake Board to review and monitor the progress of implementing the WMP. The checklist provides criteria that the Lake Board can quickly and

easily answer in a “yes/no” manner. Items that are not accomplished will become priorities or they will be adapted to fit current concerns, short-term goals, or grouped with other opportunities presented to the Lake Board.

The Lake Board will regularly review the milestones, add new milestones as projects evolve and remove items that have already been completed. Where appropriate, methods of measuring and monitoring progress are included in parenthesis to assist in determining progress in the watershed. Sampling and monitoring of lake conditions has been on-going through AICLA and Lake Board contracts with technical consultants (including aquatic vegetation management and treatment, fisheries management and hydrology). The Lake Board should continue to use data and results from established monitoring programs to track and gauge progress toward WMP goals and objectives. Citation of “Year” within the checklist assumes year 1 begins in 2026.

Lake Level

- Continuous annual monitoring of groundwater/surface water array reported annually
- Augmentation Feasibility findings broadly disseminated in Year 2
- Greater than 50% public support of selected augmentation measures prior to implementation.

Groundwater Protection

- Hold one groundwater/flood mitigation workshop within Year 2
- Prevailing wetlands guidance/regulations summarized by Year 2

Habitat and Natural Area Conservation

- 5 acres of additional wetlands properties permanently protected in the northwest wetland critical area before Year 5

Cedar Lake Fishery

- Sherman Creek spawning monitoring in Sherman Creek by Year 2 and recommendations for further improvements or modifications by Year 3, with critical improvements made in Year 4
- Assess fisheries habitat using LakeScan™ metrics in Year 1 and pursue habitat improvements based on Year 1 findings with the goal of improving habitat metrics by Year 4
- Final experimental assessment of Redear sunfish stocking as a biological control with recommendations for future implementation by Year 4
- MDNR fish population assessment updated by Year 3; recommendations for fisheries improvements provided by Lake Manager and approved by the Lake Board by Year 5
- Continued commitment of walleye stocking by MDNR on an as-needed basis (consistent contact with MDNR to determine if Cedar Lake will be receiving fingerlings each year)
- Walleye spawning habitat assessment complete, and habitat improvement measures identified within Year 3; spawning habitat improvements completed by Year 4, and assessment of their use documented by Year 5

- Reporting on fish stocking progress presented to Lake Board by Year 2 and habitat improvements and additional stocking needs assessed by Year 3
- Fish population assessment and analysis of fish age/growth completed in Year 2

Aquatic Plants and Wildlife

- MI Shoreland Stewards Program engagement within Year 2
- Updated educational materials on threatening invasive species and prevention distributed by newsletter or special mailing to watershed residents by Year 1
- Invasive species signage posted around lake access points (road ends) by Year 3
- Ten new native buffer shoreline buffers established on the lake by Year 5

Partial Body Contact/Recreation

- Water quality sampling through Michigan Cooperative Lakes Monitoring Program completed and summarized by AICLA each year for tracking results

Full Body Contact/Recreation

- Swimmer's itch case reporting methods improved within two years of identified outbreaks and swimmer's itch cases reduced within five years
- PFAS contaminant information with active updates on WMP website by every two years
- No violations of *E. coli* water quality standard measured by the District Health Department No. 2 at Cedar Lake beaches
- Partner with organization like District Health Department to get septic system educational materials to public (through newsletter, local newspaper, or AICLA meeting) by Year 2
- Remain engaged with EGLE regarding groundwater protection and remediation from PFAS-contaminants

Evaluation Framework

As with many management efforts, a lead watershed organization is necessary for sustaining the WMP and related implementation efforts and accomplishing the goals and objectives set through this process. In the Cedar Lake watershed, the Lake Board has taken on this leadership role since the early 2000s expansion of the enabling local government resolutions that formed the Lake Board. This ensured a long-term commitment to the WMP. The consistent, dedicated implementation of the WMP by the Lake Board will ensure goals established through this planning process will be achieved. Because the Lake Board is comprised of a variety of watershed stakeholders, including township and county agency representatives, along with local lake association members, the Lake Board will continue to serve as the primary lead for WMP implementation.

In addition to overseeing the implementation of the WMP, the Lake Board will also be responsible for evaluating environmental response to WMP implementation efforts to ensure conditions do not degrade over time. The organization meets several times each year to perform administration duties, discuss watershed and lake issues and make decisions on contractual

services. Their existing responsibility is to the benefit of the lake and for this reason, adding the responsibility of implementing tasks of the WMP will continue to work well in the existing statutorily-derived framework.

The general evaluation framework for the Lake Board is constructed from their current operating process whereby the group meets regularly to discuss lake issues, perform administrative duties and make progress toward select priorities. The following framework will be used to specifically address the WMP:

- Lake Board meets approximately every other month (as necessary) from April to December each year and will incorporate regular evaluation of the WMP progress into these meetings.

- Once per year the Lake Board will review the WMP milestones and make modifications, check-off those that have been completed and use current and future milestones and management activities selected by the Lake Manager to set lake protection/restoration priorities and tasks for the coming year.

- The Lake Board will ensure that the Watershed Consultant annual reports WMP to the Lake Association at a scheduled AICLA meeting.

- The Lake Board will review the progress and annual reports from the lake manager at regular meetings and solicit input from technical consultants on whether major water quality indicators (such as nutrients, *E. coli*, etc. -- see benchmark discussion below) show good conditions in the lake or any growing concerns. The Lake Board will use any available data or conclusions from technical consultants to adapt priorities or add additional tasks to the WMP to continue progress toward overall watershed goals.

The Lake Board will use quantitative and qualitative benchmarks to evaluate the effectiveness of the WMP in terms of protecting and restoring natural resources. The benchmarks come from technical services contracted by the Lake Board, Michigan water quality standards, CLMP water quality data and existing watershed information. They will allow the Lake Board to check annual environmental monitoring results against criteria specific to the Cedar Lake watershed. When annual monitoring results are outside of the set benchmarks, this will trigger the Lake Board to examine the results and determine whether a potential problem exists. In some cases, the benchmarks will be revised as new data are available. In other cases, the Lake Board will work with the Lake Manager to develop a strategy to address the environmental concern.

As detailed in the WMP, the Lake Manager will provide periodic updates, recommendations and annual reports to the Lake Board. The data reported from the Lake Manager, such as composition of the aquatic plant community and lake hydrology updates, will be indicators to the Lake Board to determine if the WMP should be adapted, priorities changed or additional strategies added. The Lake Board will use the benchmarks in Table 7-16 to evaluate conditions in the watershed and adapt priorities and strategies accordingly.

Table 7-16. Benchmarks for evaluating WMP effectiveness in protecting and restoring natural resources of the watershed.

Evaluation	Benchmark
Aquatic Plant Community	• Shannon Biodiversity Index >8.8 • Shannon Morphology Index greater than 6.3 • Floristic Quality Index greater than 20 • Recreational Nuisance Presence less than 10%. • Algal Bloom Risk rating of "low."

Fishery	• No statistically significant decreases in the percentage of fish habitat found in AROSs within both north and south end of Cedar Lake:
	  • North = 57% active spawning habitat, 17% nursery habitat, 10% deep water habitat, 13% submerged woody structure
	  • South = 58% active spawning habitat, 38% nursery habitat, 13% deep water habitat, 19% submerged woody structure

Water Quality	• Dissolved oxygen: not less than 5 mg/L daily average • pH: monthly average pH measurements between 6.5-9.0 • Phosphorus: no annual average total phosphorus concentrations greater than 40 ug/L • Chlorophyll *a*: no annual average concentrations greater than 45 ug/L • Temperature: no average monthly temperatures above the following limits (°F): May (70), June (75), July (80), August (85), September (80) • Secchi depth: monthly average depth measurements greater than 6 ft (at Schmidt's Pointe & Briarwood Bay) • *E. coli*: not more than 130 counts/100 mL monthly average or not more than 300 counts/100 ml maximum per each sample
Lake Level	• No summer-month lake level losses greater than 8-inches below the legal lake level, after augmentation measures are installed

AROS = Aquatic Resource Observation Sites

Monitoring Program

The Lake Board will continue to use monitoring of the watershed to assess environmental conditions against the benchmarks in Table 7-16. Results of monitoring will be compared to the water quality benchmarks.

The Lake Board will continue contracting with a qualified lake manager or aquatic limnologist to conduct annual aquatic vegetation surveys (which often involve surveying plants several times throughout the growing season). K&A is currently under contract with the Lake Board to conduct these surveys using the LakeScan™ methodology and provide aquatic plant management and lake management services in partnership with Aquest. Fisheries studies will also continue under the same contract with subcontracts as needed. Both aquatic vegetation and fishery surveys will be conducted using the LakeScan™ methodology with established AROS as used in the past (see past reports for more information).

Lake levels and groundwater hydrology have historically been, and continue to be monitored by K&A through a separate contract with the Lake Board. The monitoring involves an extensive

array of ground water monitoring wells (with continuous level loggers) and level loggers placed directly in the lake (lake outlet) and its tributaries (Sherman Creek and Jones Ditch) that track changes in water level. Additional groundwater and surface water monitoring stations may be added to further investigate hydrology impacts and potential lake level augmentation solutions. This contract will continue to be modified as needed to ensure adequate monitoring of lake level and groundwater will continue to be conducted using the existing level loggers and monitoring wells.