Cedar Lake Watershed Management Plan (2025) - Title Page Placeholder

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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
ODT	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, or 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 Board. 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

PLACEHOLDER NOTE: SHOULD THE FULL UPDATE STEERING COMMITTEE LIST BE INCLUDED HERE

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 east 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 West 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.

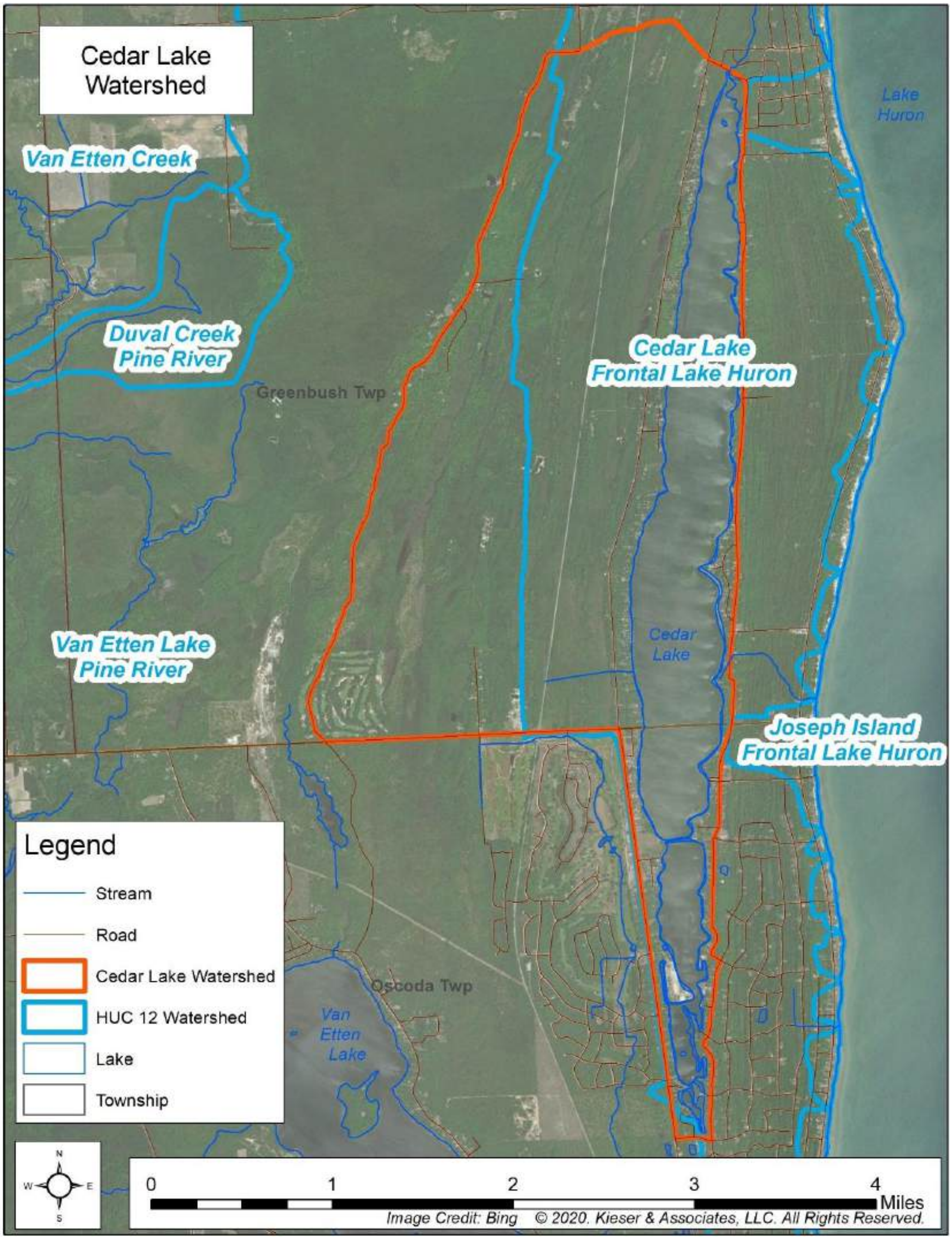

Figure 2-2. Map of the Cedar Lake watershed (in red). The watershed boundary represents the direct surface and groundwater areas contributing to the Lake.

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 in 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 man-made creek 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 West Cedar Lake Road, into Cedar Lake. The northerly inlet is a man-made unnamed creek (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 West 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 AICLA and annually by CLIB provide extensive records of these conditions.

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[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*.

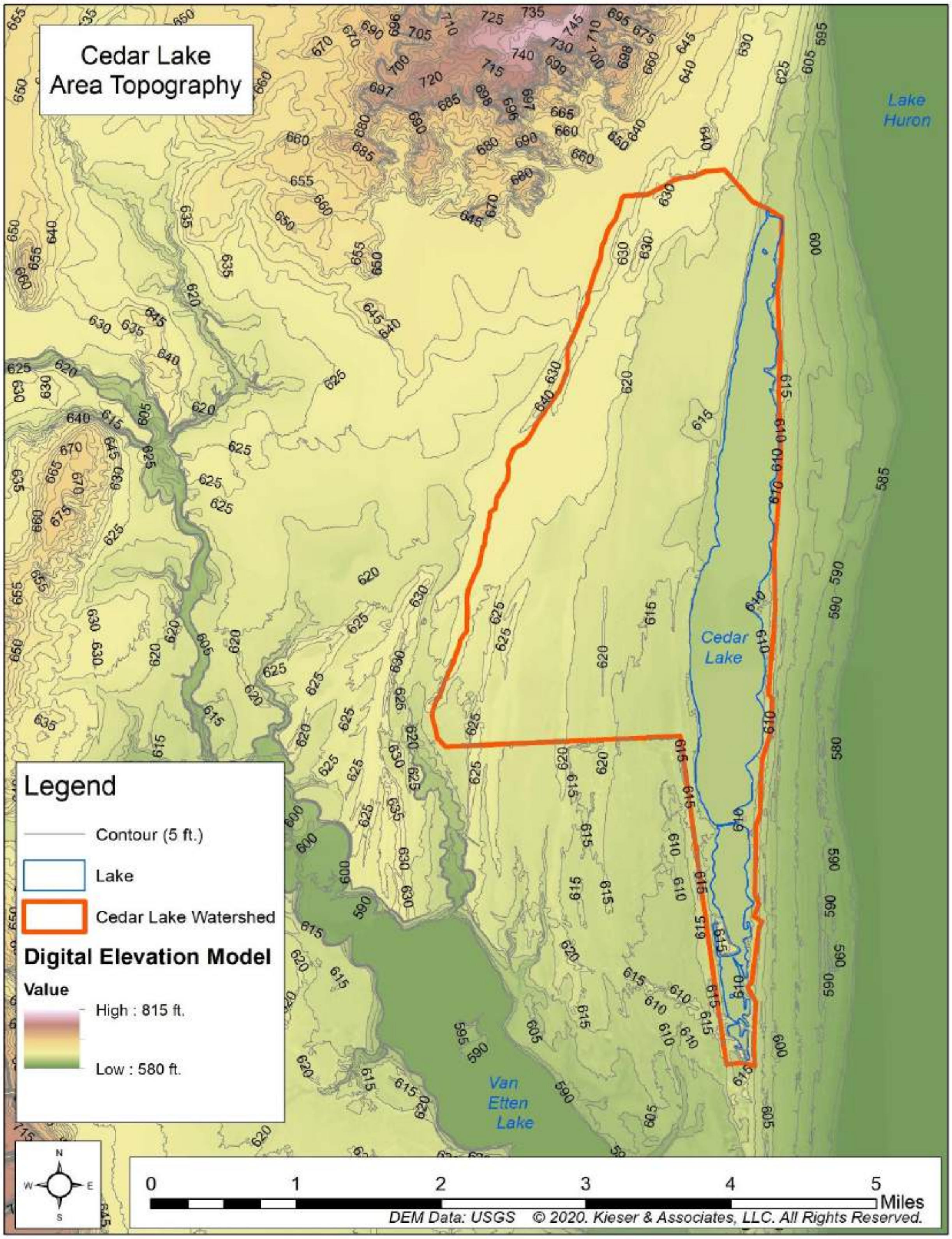

Figure 2-3. Topography of the Cedar Lake watershed from the national elevation dataset.

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 Supervisors 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 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. 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 structures 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*).

Another man-made, out-of-the-watershed surface water diversion exists on the west side of the lake. A culvert beneath Kings Corner Road, near West Cedar Lake Road, 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 West Cedar Lake Road was clear-cut with the 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. 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 the described 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. Groundwater generally moves away from the lake on the east, south, and southwest sides of the lake. On the south side of the lake, surface water from the lake is being lost to the groundwater and the surrounding watersheds (Van Etten/Pine River and Lake Huron). Only the cedar swamp on the northwest side of the lake contributes groundwater to the lake (marked in green). The blue arrows 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 convinced the railroad operators to reduce blockages to seasonal wetland flows along their right of way through the 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. The berm is designed to retain water in the cedar swamp which contributes inflows to Cedar Lake via Sherman Creek. 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.

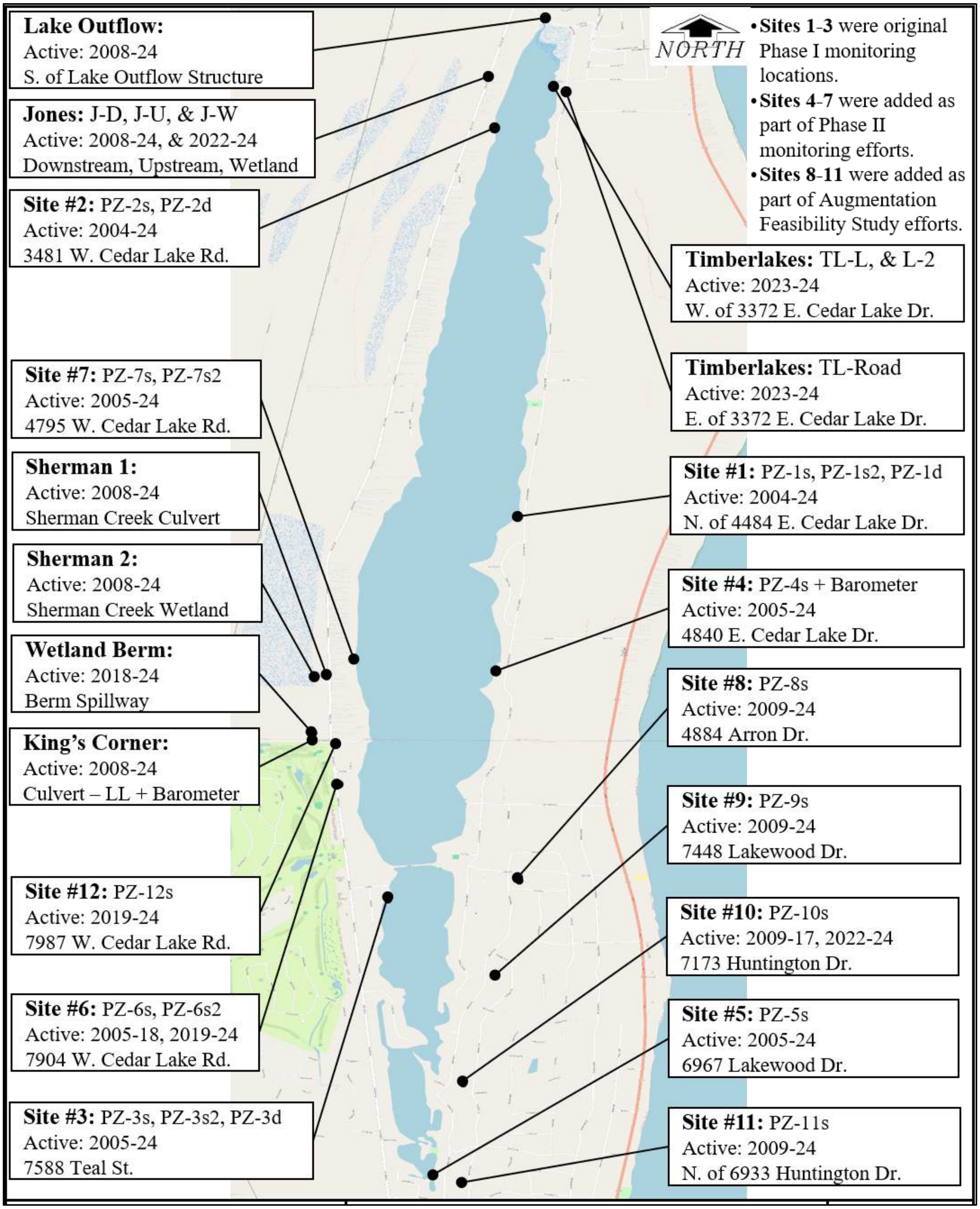

Figure 2-5. The 2024 locations of Surface and Groundwater Level Loggers for the Cedar Lake Hydrology Study, active since 2004.

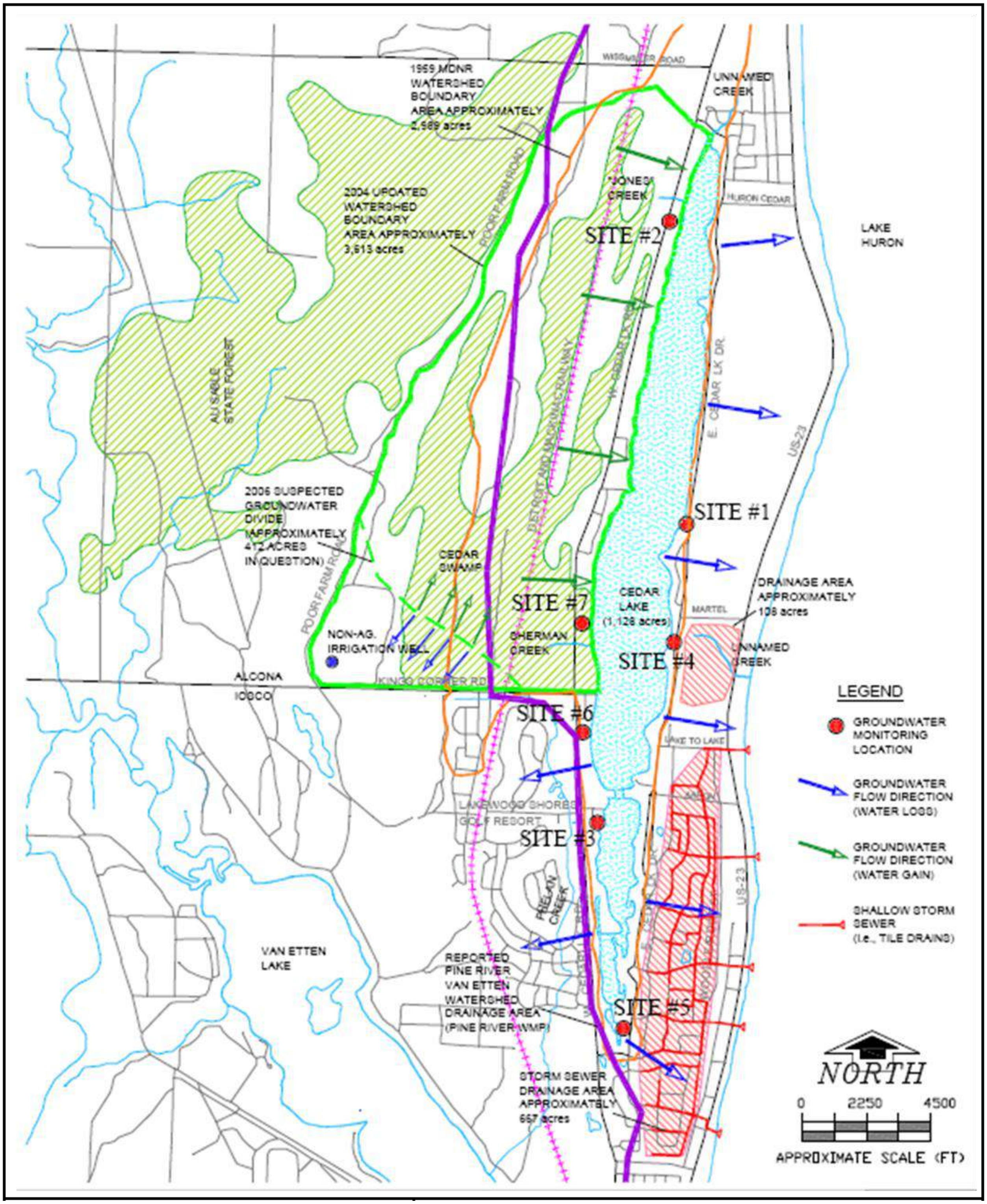

Figure 2-6. Losing and gaining areas in the Cedar Lake watershed and shoreline (*Source: K&A, 2006*)

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 West Cedar Lake Road. Following installation of these structures in October 2019, temporary instream stilling tubes monitored water levels at each grade structure. Monitoring of fish passage during spawning season is a recommended priority (Chapter 7).

Project objectives 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, and; 4) improve pike spawning habitat in Sherman Creek and associated wetlands by extending wetted conditions in the creek and wetland.

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 more 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 tended 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 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, do not provide 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 Jones Ditch will allow for future hydrology benefits.

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 Creek at the Cedar Lake shoreline. This highly-incised channel causes spring-time channel velocities to 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 submitted with the Midwest Glacial Lakes Partnership to address multiple aspects of these ongoing hydrology issues in Jones Ditch wetland. Proposed project benefits will include restored channel accommodating 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]

Additionally, the mostly-undeveloped Timberlakes residential development on the northeast side of Cedar Lake has 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 natural 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 preemptive 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 Michigan. CLMP-sampled phosphorus and chlorophyll *a* concentration data sets from Cedar Lake are shown in Figures 2-8 and 2-9 respectively.

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[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/>.

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, has 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*.

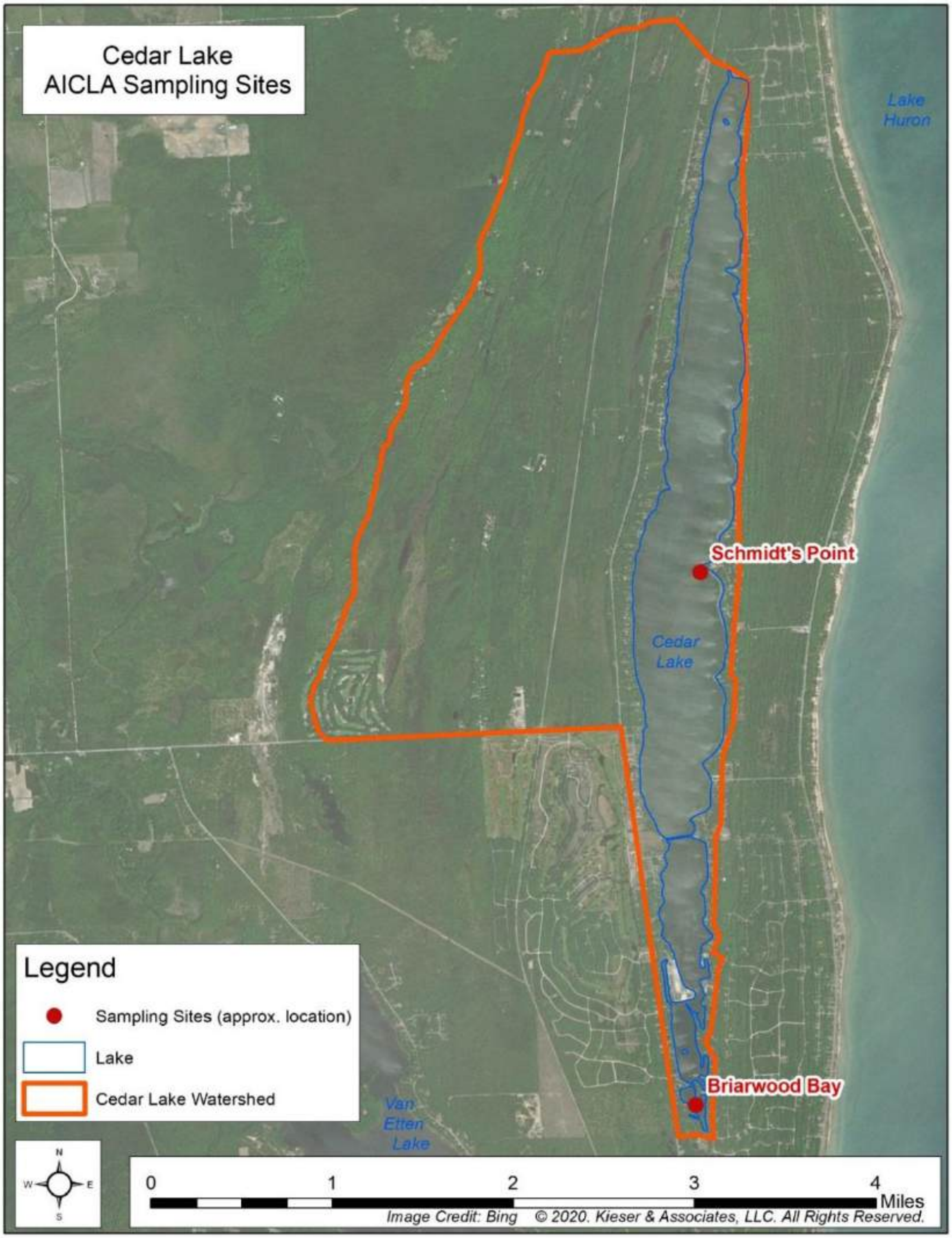

Figure 2-7. Approximate locations of Schmidt's Pointe and Briarwood Bay water quality sampling sites used by AICLA (*Source: Kieser & Associates, 2020*).

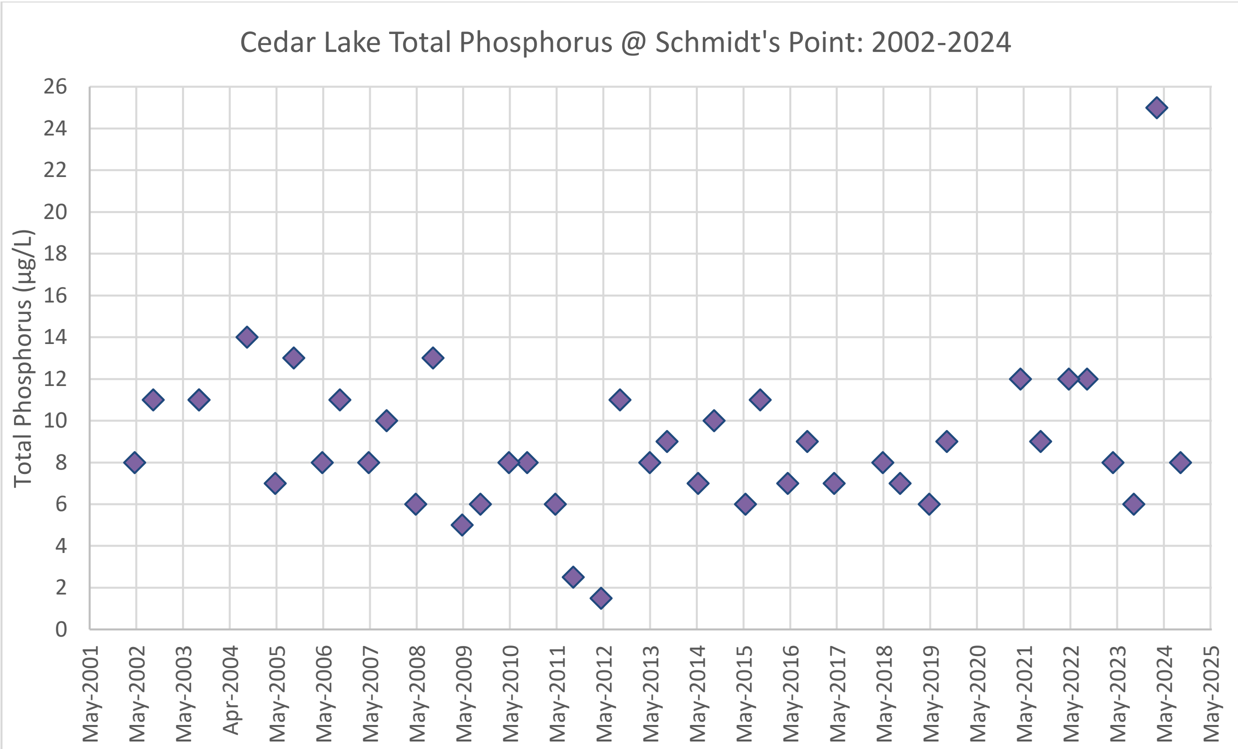

Figure 2-8. CLMP phosphorus data for Cedar Lake 2002 – 2024, collected at Schmidt's Point (Cedar Lake, Alcona County) (*Data Source: CLMP/MICORPS, 2025*).

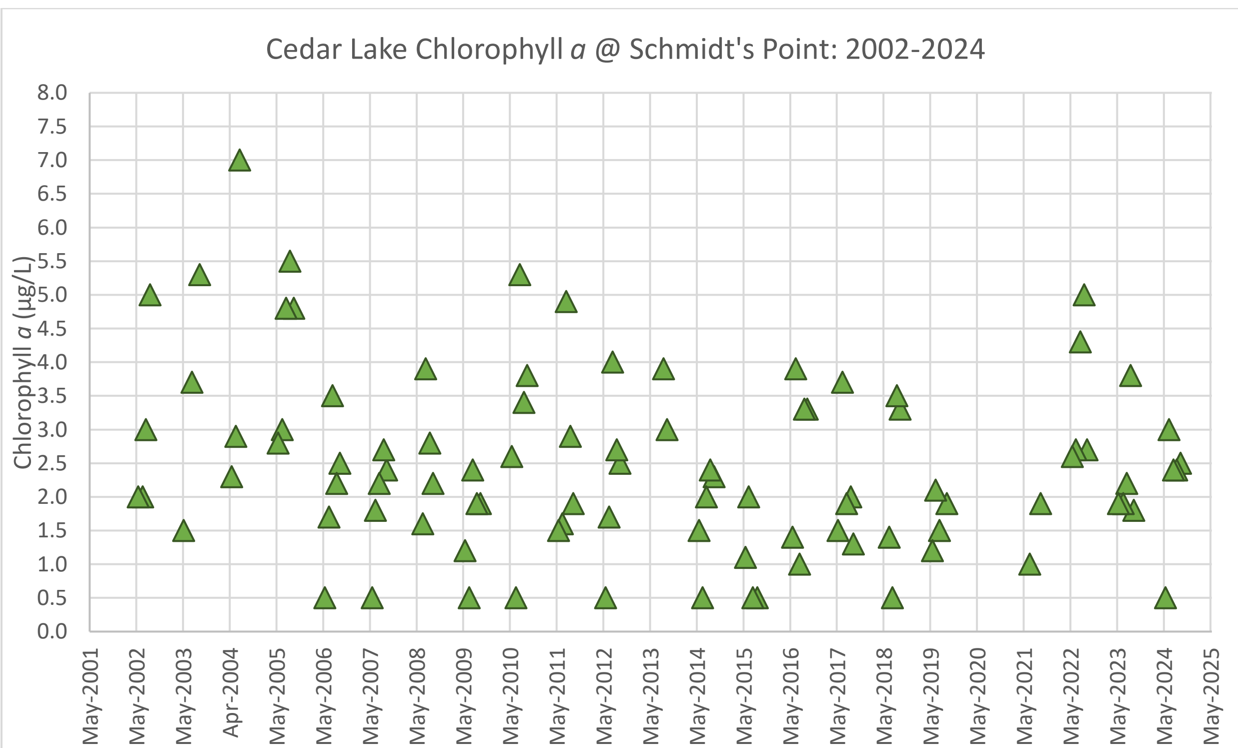

Figure 2-9. CLMP chlorophyll *a* data for Cedar Lake 2002 – 2019, collected at Schmidt's Point (Cedar Lake, Alcona County) (*Data Source: CLMP/MICORPS, 2025*).

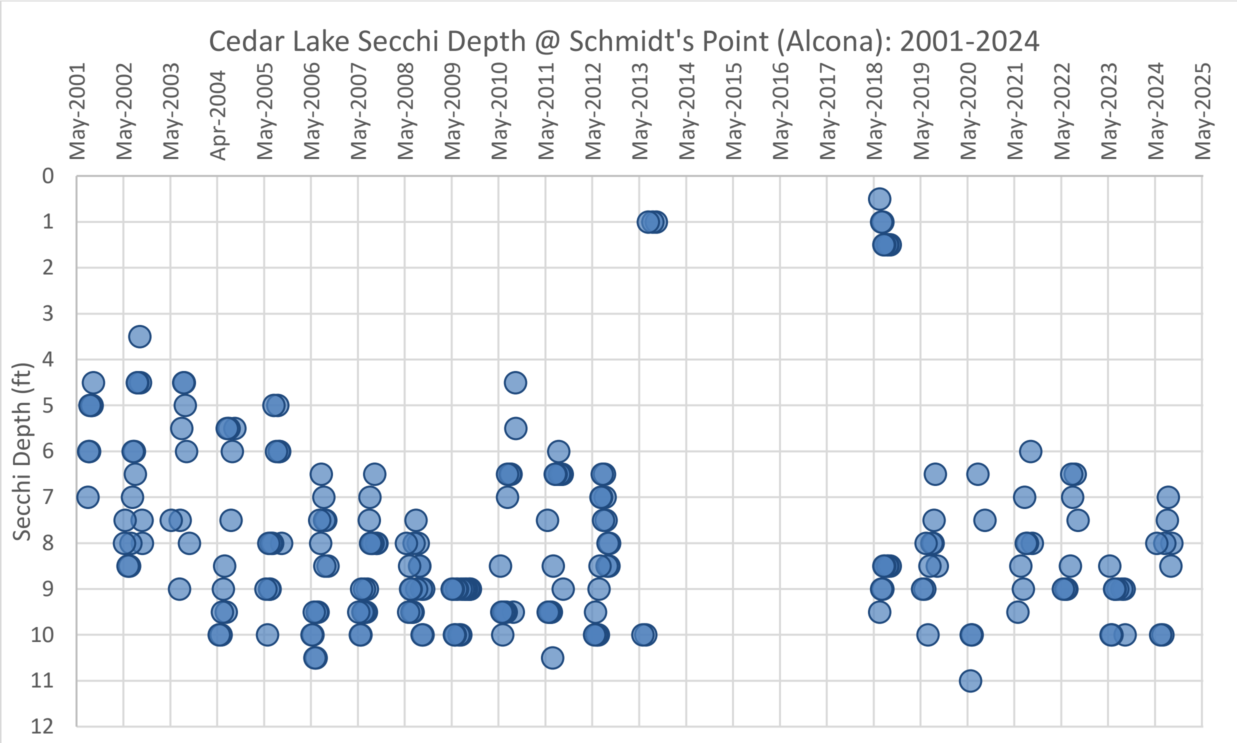

Figure 2-10. Cedar Lake CLMP data: Water clarity depth from Secchi disk measurements at Schmidt's Point, bi-weekly May-September (*Data Source: CLMP/MICORPS, 2025*).

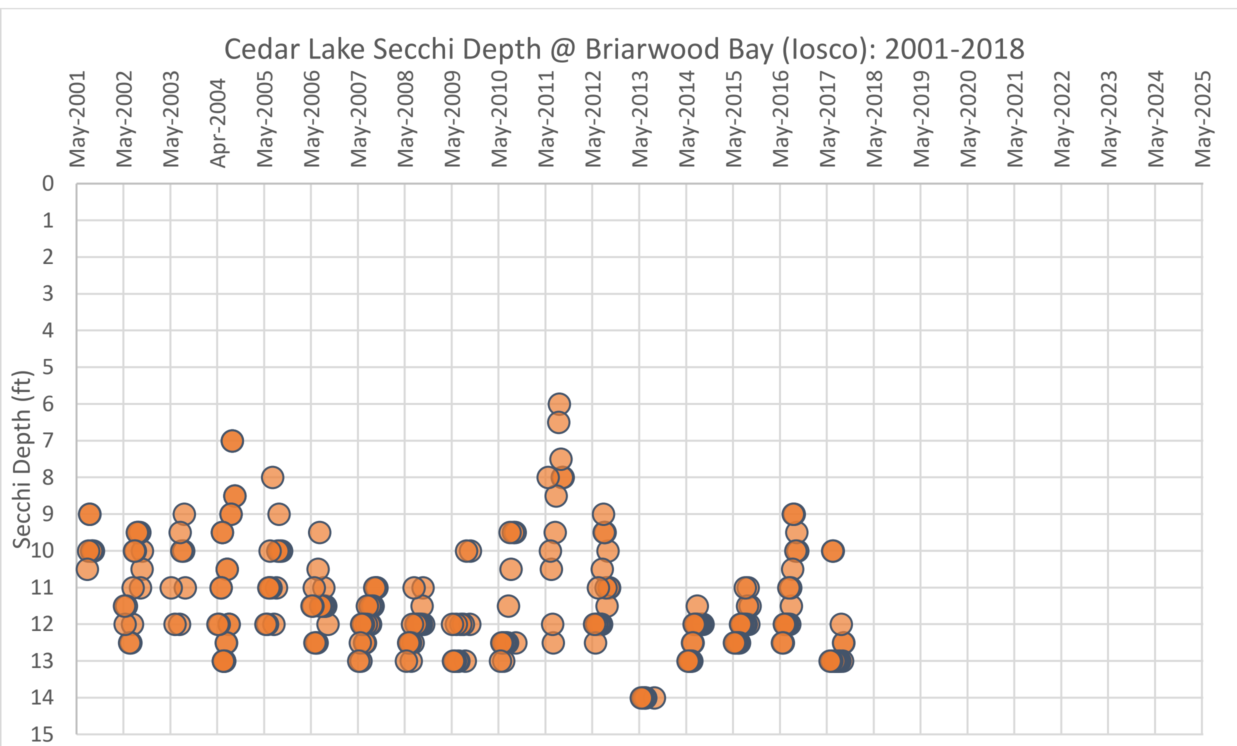

Figure 2-11. Cedar Lake CLMP data: Water clarity depth from Secchi disk measurements at Briarwood Bay, bi-weekly May-September from 2001-2018 (*Data Source: CLMP/MICORPS, 2025*).

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 indicates that very little sediment is coming from the wetland complex on the northwest side of the Cedar Lake or existing the lake 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>.

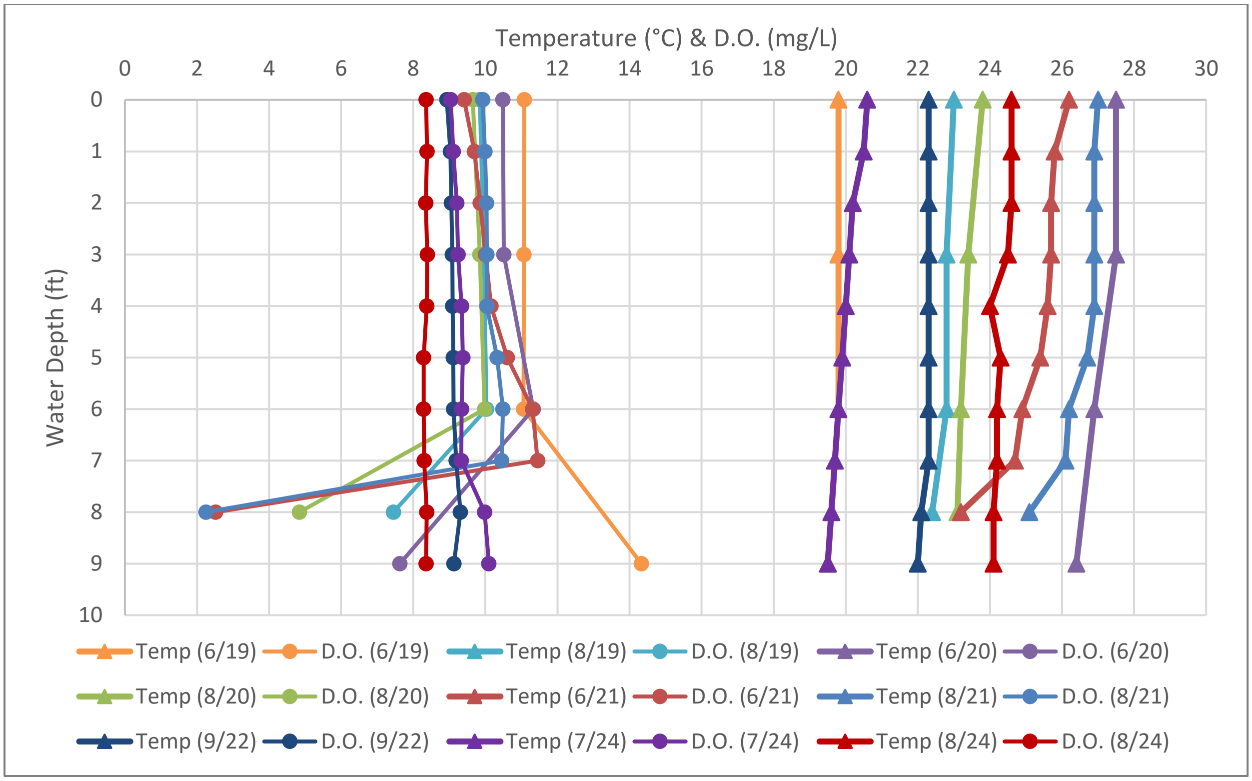

Figure 2-12. Dissolved oxygen and temperature profiles from 2019-2024 at Schmidt's Point.
***Note: Bottom measurements taken with probe in vegetation/sediment.* (*Data Source: Kieser & Associates*).**

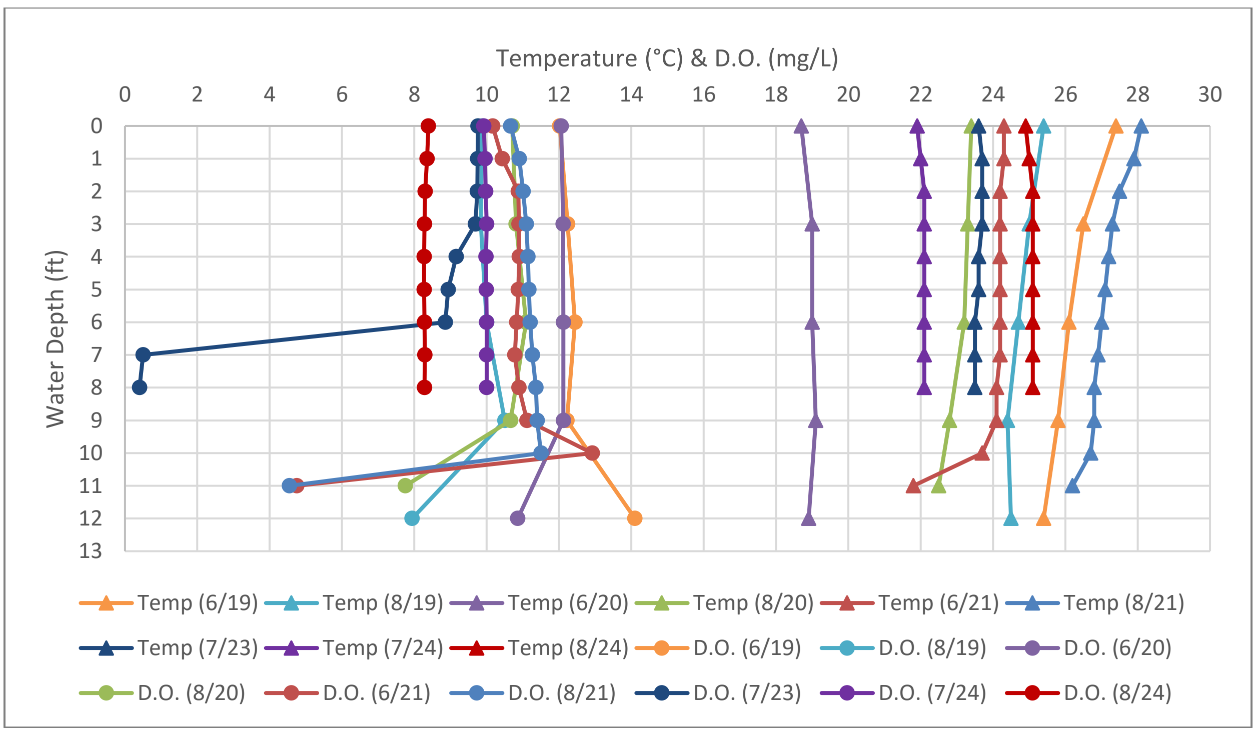

Figure 2-13. Dissolved oxygen and temperature profiles from 2019-2020 at Briarwood Bay.
***Note: Bottom measurements taken with probe in vegetation/sediment.* (*Data Source: Kieser & Associates*).**

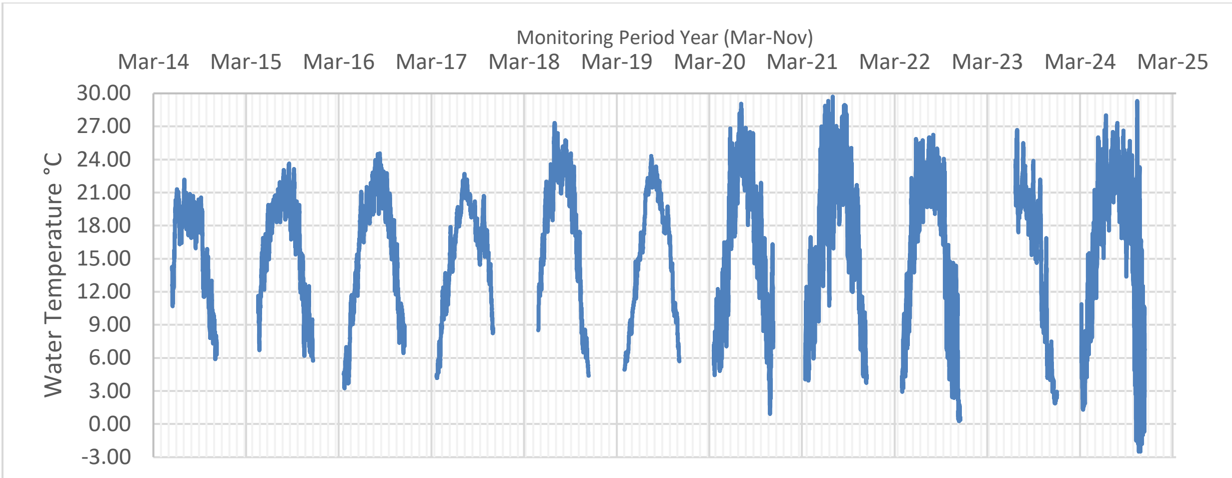

Figure 2-14. Cedar Lake Outlet water temperature during recreation seasons, 2014-2024.

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 identified as the 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.

In 2019, the Lake Board contracted K&A to perform PFAS testing in Sherman Creek surface water and in two shallow groundwater wells, one along Sherman Creek and one at the Jones Ditch culvert. Additionally, in 2021, the Lake Board hired K&A to test for PFAS in groundwater at 30-ft and 60-ft depths from the deep groundwater augmentation well just north of Sherman Creek. Each of these tests included analyses of 28 PFAS substances for each sample. All sample results from each of the sampling sites of both surface and groundwater were reported as non-detect by the analytical laboratory, 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 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]

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[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>.

[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.*

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.

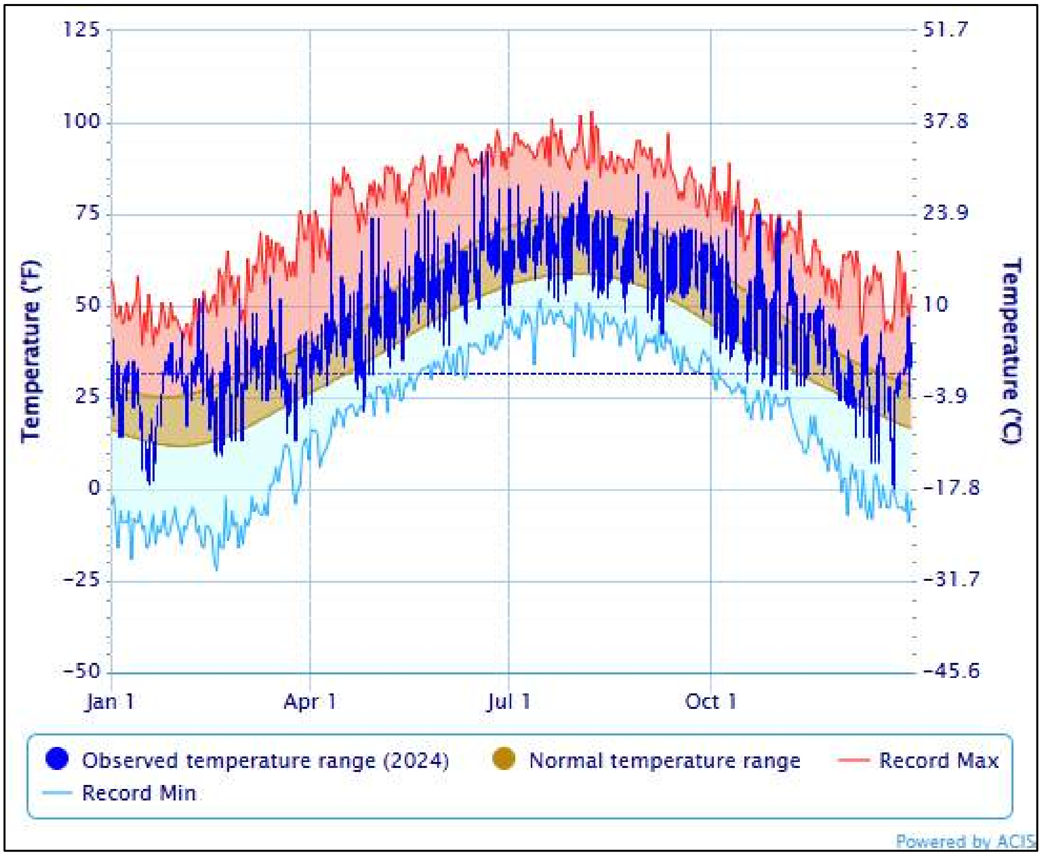

Figure 2-15. Harrisville 2NNE NOAA Weather Station: Daily temperature data from 2024 for the Cedar Lake region, with reference to the historic norm and record max and min temperatures (1971-2024). (*Graph Source: NOAA Harrisville 2NNE Weather Station, automatically generated*).[23]

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 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).

[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>.

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.

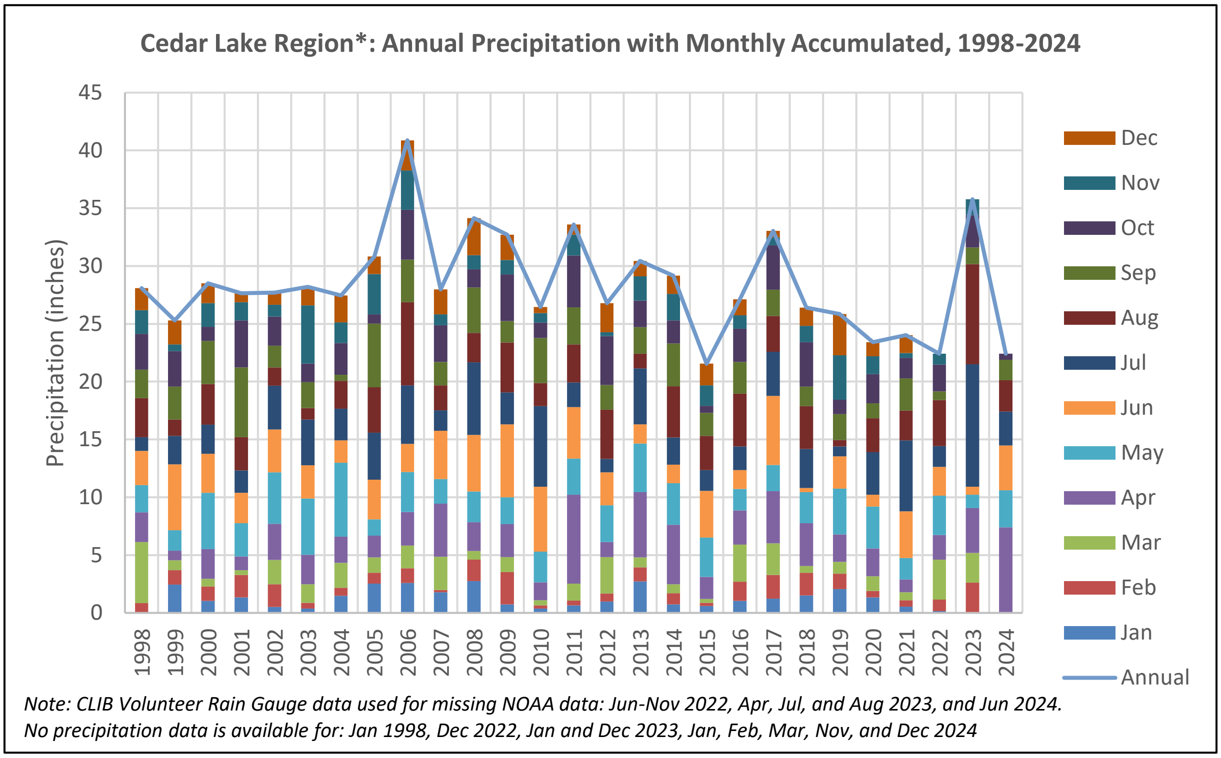

Figure 2-16. Regional annual precipitation totals and monthly accumulation for Cedar Lake from 1998-2024. (*Harrisville 2NNE Station, Alcona County, MI, and CLIB Volunteer Rain Gauge*).[24]

The 2011 Cedar Lake Augmentation Feasibility Study further investigated this assertion that lake levels substantially depend on summer precipitation amounts. Moreover, it was discovered that to avoid a drop in lake levels exceeding 3 inches per month during the summer months 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

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

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.

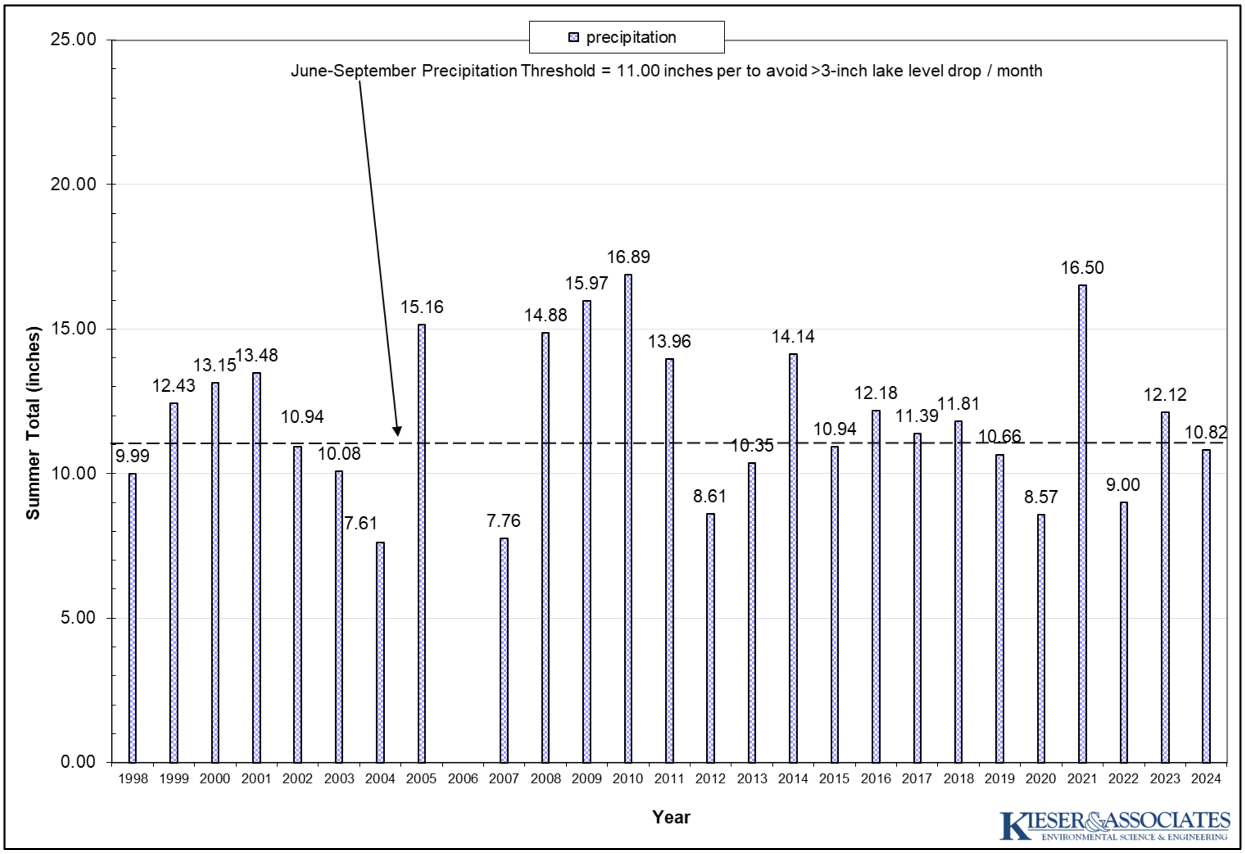

Figure 2-17. Cedar Lake summer month precipitation data, 1998-2024 (*Data Sources: Cedar Lake Improvement Board Volunteer Rain Gauge, Alcona County, MI; NOAA, Harrisville 2NNE Station, Alcona County, MI; Oscoda Wurtsmith Airport Station #14808*).[25]

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

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

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.

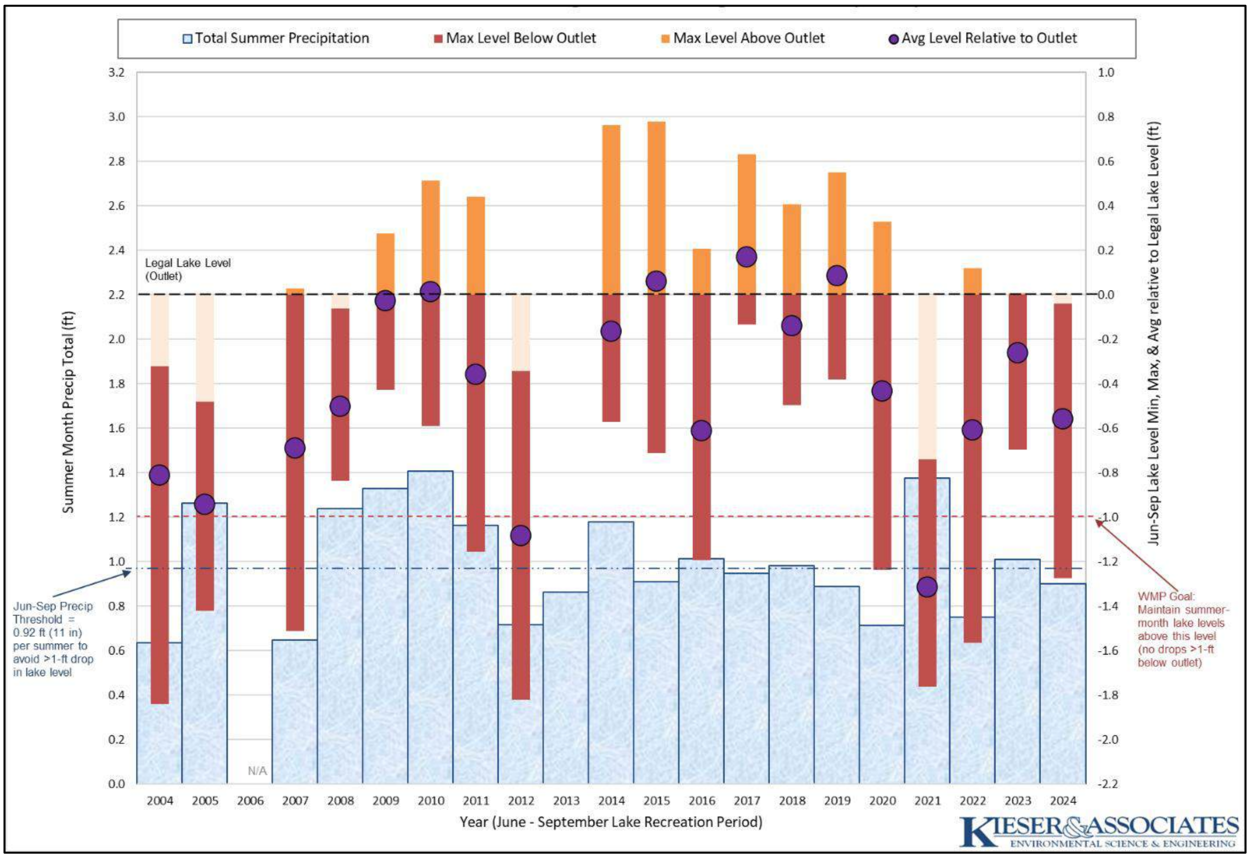

Figure 2-18. Cedar Lake summer month (Jun-Sep), 2004-2024, lake level fluctuations: Annual summer month lake level maximum, minimum, and average relative to the legal lake level (Cedar Lake outlet) and total summer month precipitation.[26]

The extent to which this improved condition results from Lake Board wetland enhancement implementations 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

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

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.

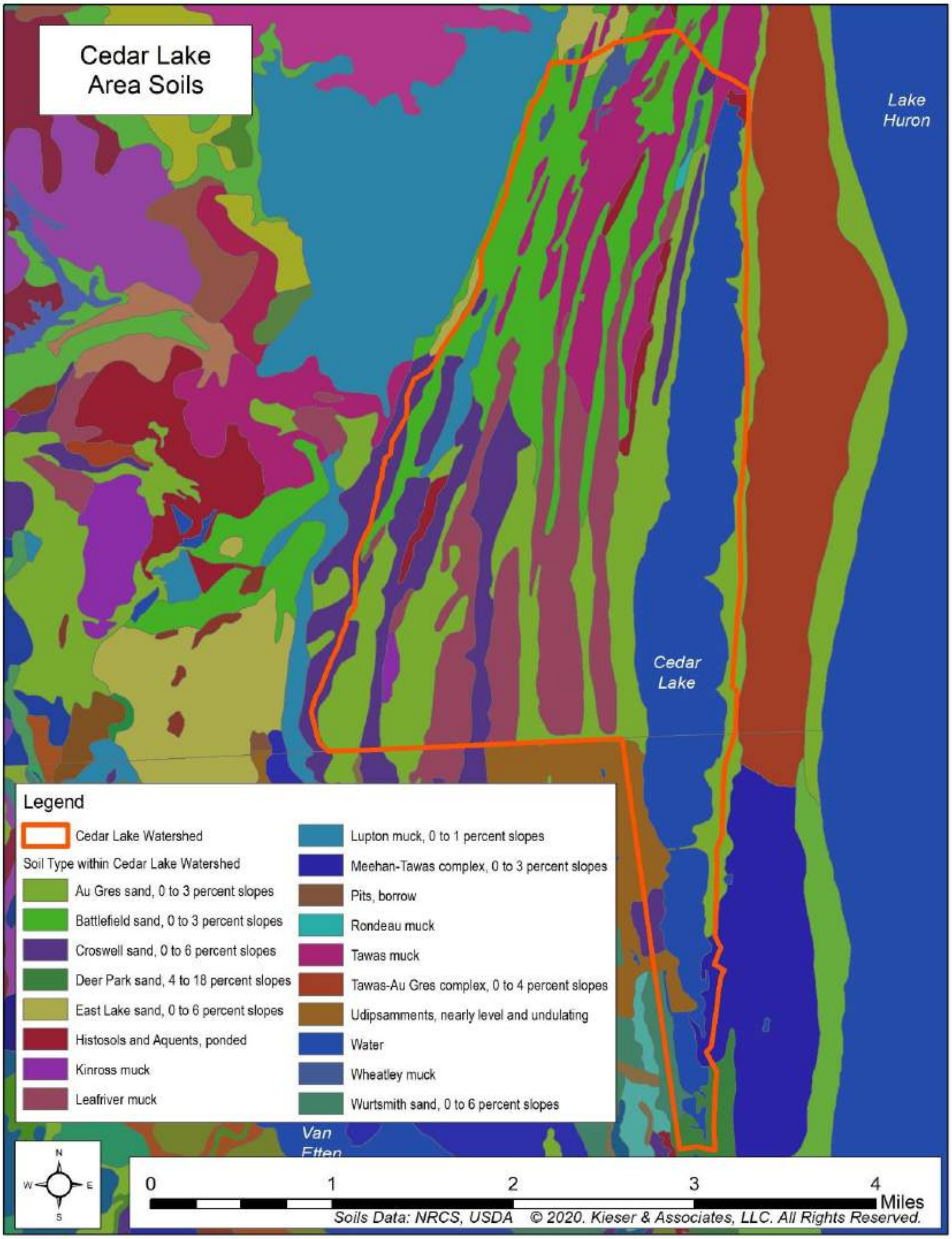

Figure 2-19. Various soil types in and around the Cedar Lake watershed.

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 Board prompted 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 approach is a recommendation of the 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.

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

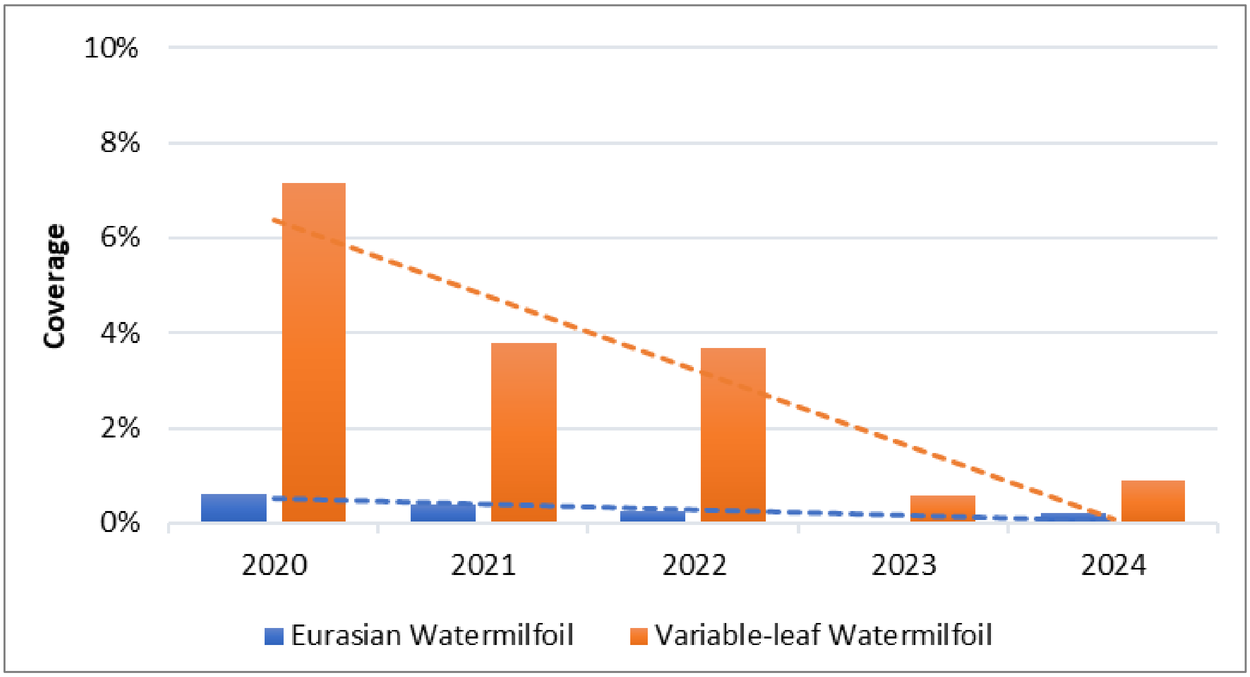

Figure 2-20. Cedar Lake North: Invasive and Nuisance Species Coverage 5-year trend, 2020-2024

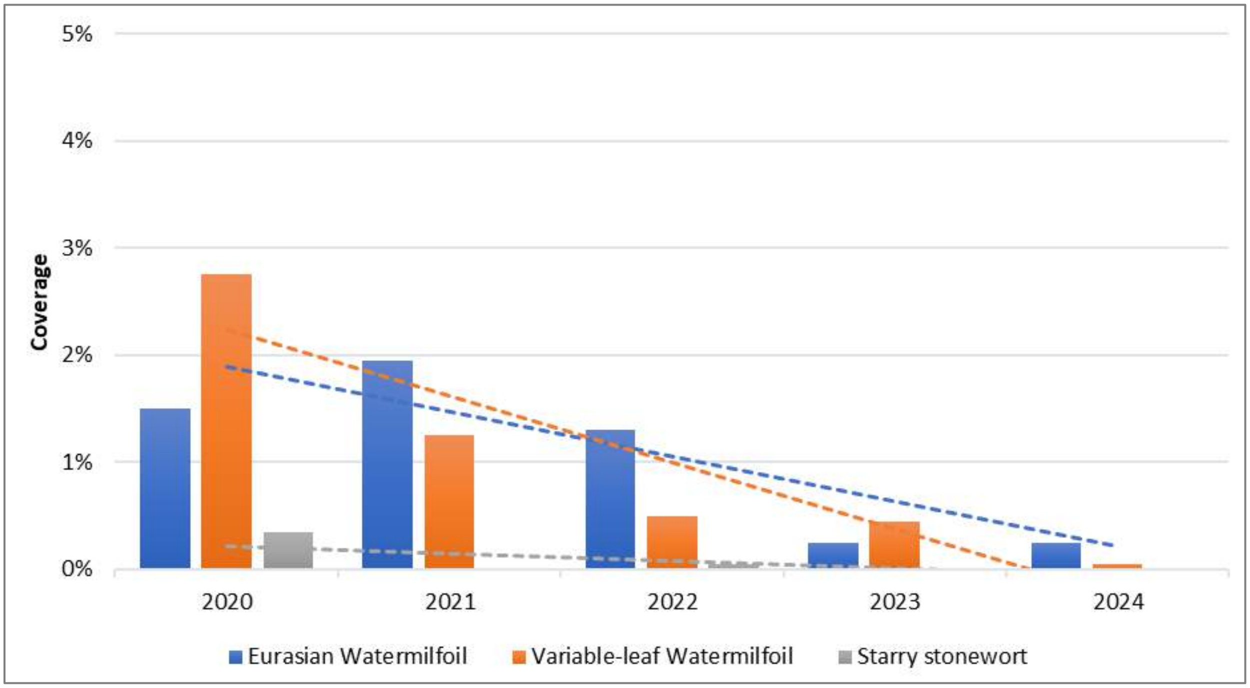

Figure 2-21. Cedar Lake South: Invasive and Nuisance Species Coverage 5-year trend, 2020-2024.

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 for 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 (*Ligumia nastua*), was found within the southern portion of Cedar Lake South in 1953. Recent regional surveys conducted between 1998 and 2015 found no presence of this species within Cedar Lake.[37] Since presence of the Eastern Pond mussel was not indicated within the most recent survey efforts, it is recommended that mussel surveys specific to Cedar Lake be conducted to discern presence of this species or other threatened or endangered mussel species.

All native mussels are protected in Michigan and cannot be handled without a Michigan Department of Natural Resources (MDNR) Cultural and Scientific Collectors Permit.[38] A State Threatened and Endangered Species permit will also be required given the historical presence of a State listed endangered species. Because endangered mussels have not been recently observed on Cedar Lake, coordination with MDNR will be required in advance of the mussel surveys. Certain qualifications may also be required for personnel conducting the mussel surveys and this 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 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.

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[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] Bean, R. (2018). Michigan Survey and Relocation Protocol for Federally Listed Mussels.

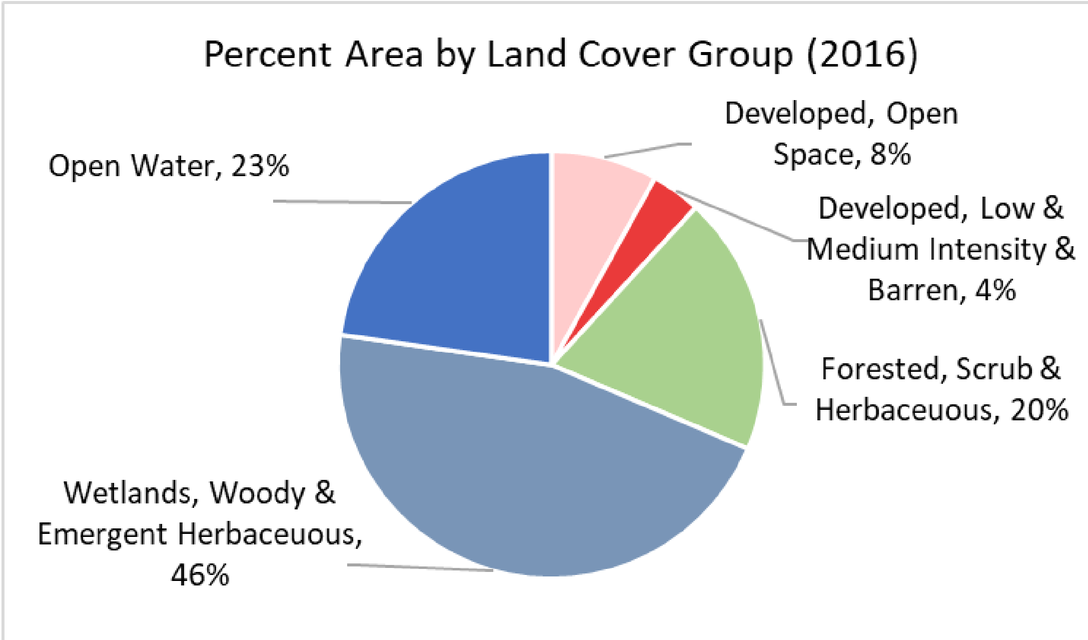

Figure 2-22. Distribution of land uses in the Cedar Lake watershed by percent cover from 2016 data.[39]

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 West 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.

[39] 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>.

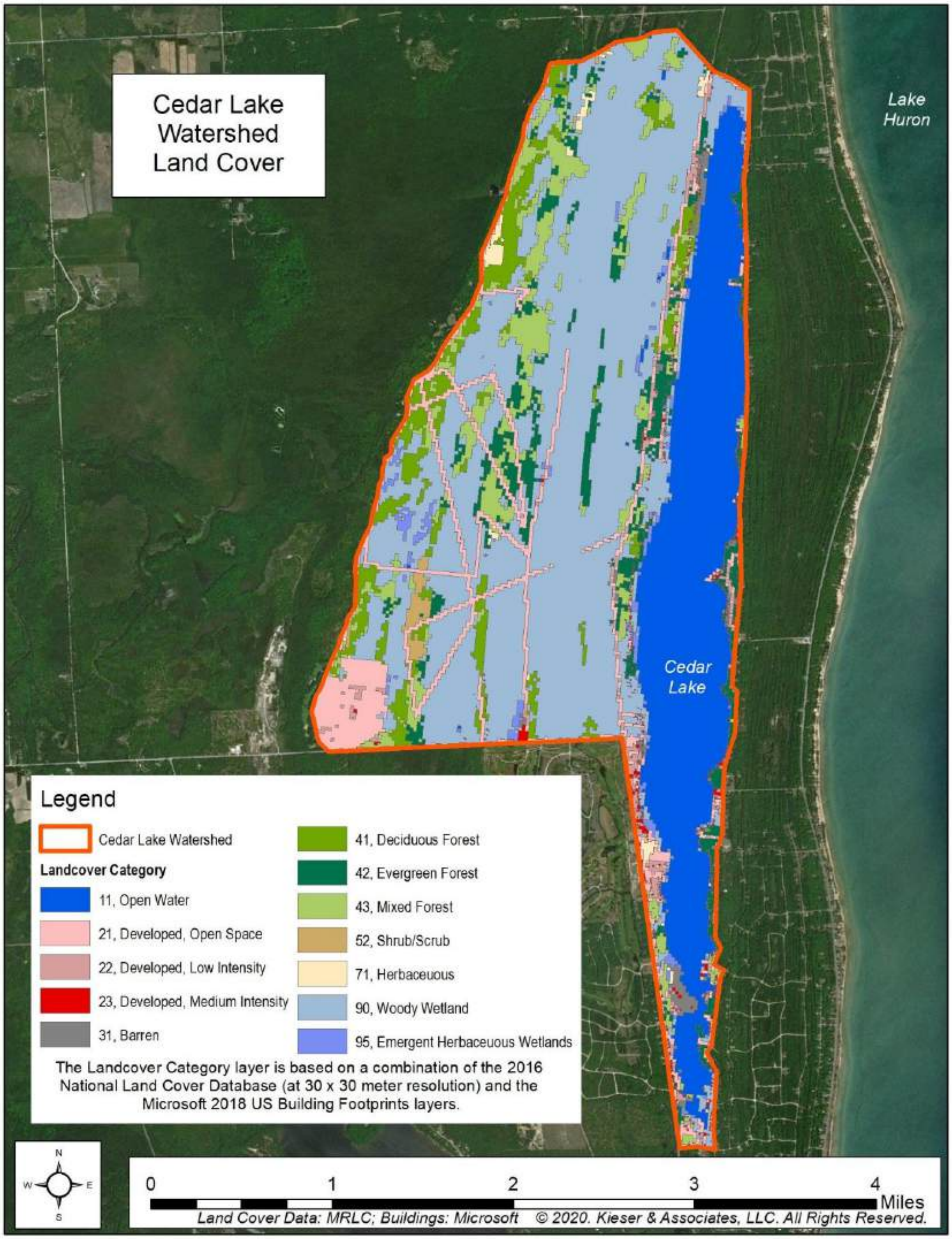

Figure 2-23. 2016 distribution of land use in the Cedar Lake watershed.

Political Characteristics

The majority of the Cedar Lake watershed is in Alcona County and the southern portion of the watershed is in Iosco County.[40] 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:[41, 42]

- **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 subsurface dewatering drains to keep their homes and properties dry. If 50% or more of the residents in the drainage district petition the 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.[43] 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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[40] United States Census Bureau. (2010). Accessible online: <https://www.census.gov/quickfacts/>.

[41] Greenbush Township Planning Commission. (2014). "Greenbush Township Zoning Ordinance." *Accessible online:* <http://www.discovernortheastmichigan.org/downloads/greenbush_township_zoning_ordinance_2015.pdf>.

[42] Oscoda Township. (2011). "Oscoda Township Zoning Ordinance 165." *Accessible online*: <http://www.oscodatownshipmi.gov/1/322/files/oscodazoningordinance13.pdf>.

[43] 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 in order 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.[44] 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.

To inform and affirm the recommendations of the WMP technical update, the originally-developed list of specific watershed concerns 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.

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 and this is represented in several categories in Table 3-1.

In addition to ranking the concerns, 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.

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[44] 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 Uses in the Watershed. **Cedar Lake Watershed 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	L								
Runoff from waterfowl/pet waste to lake (esp. geese)	L								

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

Designated and Desired Uses

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.[45] 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).[46] 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.[47]

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.[48] 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.[49]

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[45] 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.*
[46] 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>.
[47] 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>.
[48] 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>.
[49] 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.[50]

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)

[50] 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, during the development of the WMP the Steering Committee identified the known and suspected pollutants associated with those threats and concerns. 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 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), 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, SC 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 problematic concern in the contributing watershed and immediate surrounds 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. 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 wetland protection (i.e., ordinances) (K)	**H** **H** **H**
2	Diversion (K)	**H**	No wetland 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 & Beavers (K)	**H** **H**
4	Toxicant-contaminated groundwater/surface water (S)	**H**	Historic land uses causing contamination (K)	**H**
5	Infected waterfowl/ wildlife waste runoff/infected snails (K)	**H**	Infected waterfowl and wildlife and presence of suitable host molluscan to continue lifecycle (K)	**H**
6	Stormwater runoff (K)	**H**	Lakeshore management (K) Manicured lawns (K)	**H** **M**
7	Residential fertilizer runoff (K)	**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 (S)	**M**
11	Pet/geese waste runoff (S)	**M**	Improper disposal of pet waste (S) Nuisance geese in yards (no deterrent) (K)	**L** **M**
12	Stream bank erosion (S)	**L**	Intermittent high flows/limited vegetation (S)	**L**
13	Road-stream crossings/culverts (S)	**L**	Deteriorating culverts/infrastructure (S)	**L**

(K)=Known
(S)=Suspected

(H) =High
(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 are a priority for continued benefits to hydrology and ecology in the Jones Ditch contributing area.

In addition, wetland 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.[51] 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 to shallow aquifers on the southeast side. Similar future investigations are considered warranted in area 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 and 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 the aquatic plant manager and fisheries biologist. 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 due to lakefront resident surveys conducted by the AICLA in 2007-2008. The survey results indicated slight to moderate lakeshore erosion 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 West 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

[51] 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 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 material that is likely 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 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).[52] 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 the 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 side, toward Van Etten Lake, it is unlikely that contaminants are entering Cedar Lake by way of shallow groundwater exchange with Van Etten Lake.[53, 54, 55] PFAS contaminants, however, have been found in aquifers as deep as 700 ft underground, so the

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[52] 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>.

[53] Northeastern University. (2020). "Public SSEHRI PFAS Contamination Site Tracker." Accessible online: <https://docs.google.com/spreadsheets/d/10y4u1KG6gegnw3zoTUTbXxQiEqitU1ufPlGvGiETtcg/edit#gid=682068550>.

[54] 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>.

[55] 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.[56, 57] 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.[58, 59, 60] 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.[61] 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.[62] 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 in the *E. coli* water quality standard. The District Health Department No. 2 has measured relatively low levels of *E. coli* at in Cedar Lake at the Greenbush Township beach.[63] Recently sampling for *E. coli* has not measured persistently high or problematic concentrations in Cedar Lake.

As a parallel, but higher pollutant concern, recent summer outbreaks of swimmer's itch (cercarial dermatitis) in Cedar Lake 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 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

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[56] 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.*
[57] 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>.
[58] Brusseau, Mark L., *et al*. (2019). "Comprehensive retention model for PFAS transport in subsurface systems." *Water Research: Vol 148, Jan 2019, pages 41-50.*
[59] Kim, Seung-Kyu. (2007). "Perfluorinated Acids in Air, Rain, Snow, Surface Runoff, and Lakes." *Environmental Science and Technology*.
[60] 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>.
[61] 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>.
[62] Michigan EGLE. (2020). "Michigan Surface Water Information System." Accessible online: <http://www.mcgi.state.mi.us/miswims>.
[63] Michigan DEQ. (2010). "BeachGaurd: Cedar Lake – Greenbush Township Beach." Accessible online: <https://www.egle.state.mi.us/beach/BeachDetail.aspx?BeachID=2456>.

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.[64]

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.[65] 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 introduced 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. This notion is 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. In the 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.

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[64] 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>.

[65] 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 LOAD TO WATER QUALITY

Estimating the 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 nutrient and sediment levels in waterbodies. 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 water bodies. The land use types in a watershed impact the quality and quantity of the runoff. In order to quantify 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 use, a majority of the 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. 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 2005.

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.

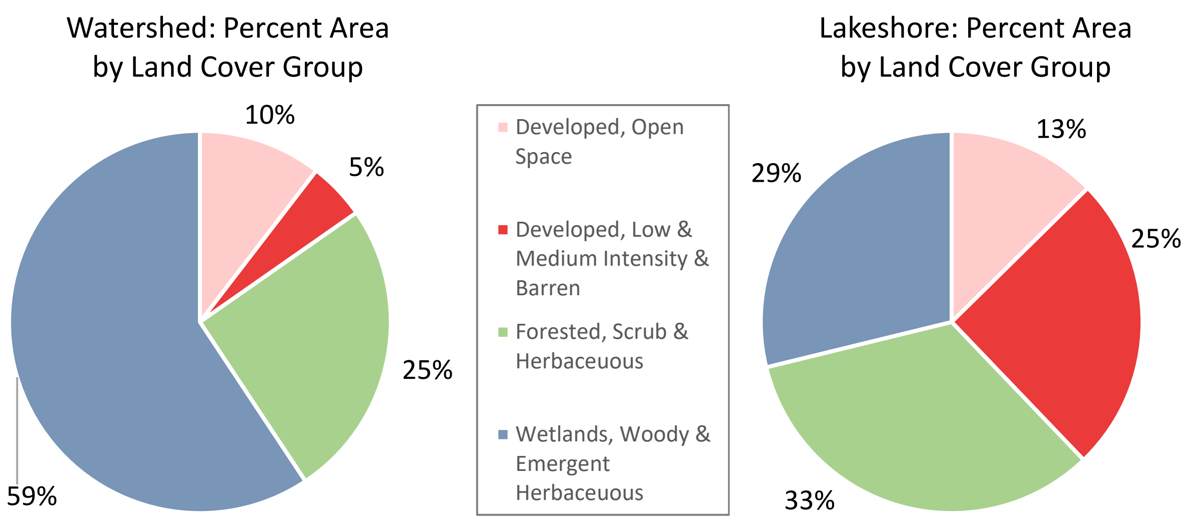

Figure 5-1. Comparison of 2016 land use distribution for the entire watershed and for the Cedar Lake shoreline only.

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.[66] This analysis is included as Attachment E.

Estimation of Pollutant Loads

Phosphorus and sediment loading to Cedar Lake originates from four different source pathways: inflow from a wetland northwest of the lake via Sherman and Jones Ditch, stormwater runoff from shoreline properties, septic system discharges, and atmospheric deposition. Loads from each of these pathways were quantified using appropriate applicable methods as supported by scientific literature, described below.

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

Phosphorus and sediment input 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 drainfields 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. Parts of the lake are also fed by groundwater, but outside of septic system areas, this input is not expected to contribute any significant TP to the lake. This could be confirmed with groundwater sampling in the future. Empirically estimated loads are illustrated in Figure 5-2.

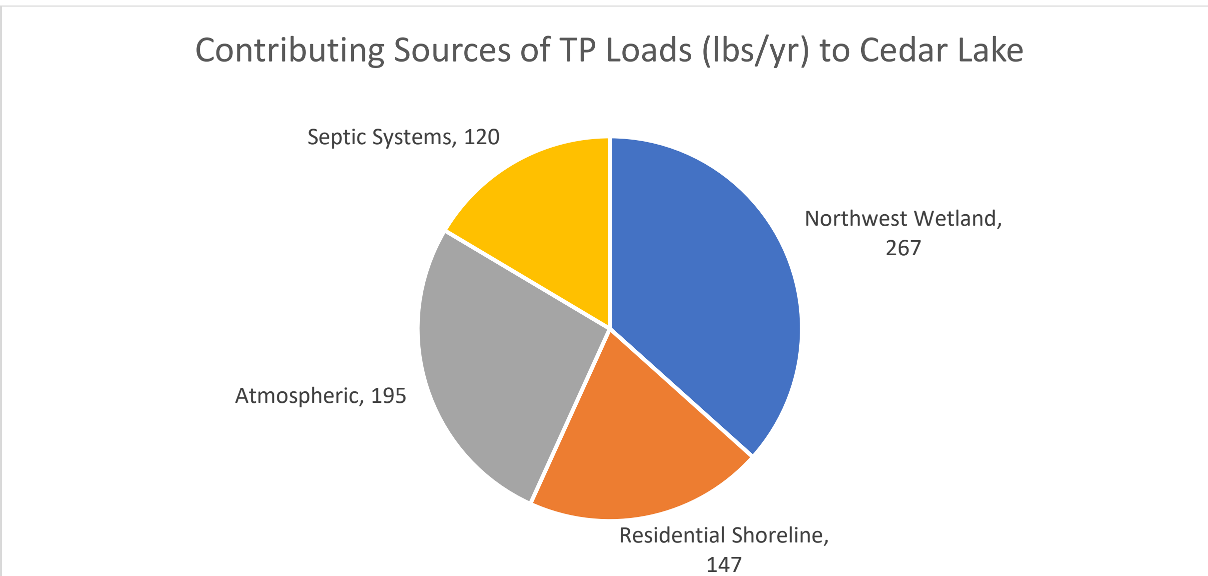

Figure 5-2. Sources and distribution of estimated TP loads to Cedar Lake.

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 relatively low range of 5-7 µg/L for soluble reactive phosphorus (SRP). Published studies have observed median TP concentrations of 4 µg/L[67] and TSS concentrations of 15 mg/L[68] 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, as much of the area east and south of the lake actually drain away towards Lake Huron or Van Etten Lake. A narrow band of land surrounding the lake between its shoreline and the surrounding roads does slope towards the lake and contributes surface runoff. Total phosphorus and sediment loading for this area can be quantified using a unit area loading method where established loading rates (lbs/ac/yr) can be applied to areas to get an annual load (lbs/yr).[69] The 2016 land use classification data were used for this analysis. Developed land uses are responsible for 86% of phosphorus loading and 64% of sediment loading from this region, so even small increases in these land uses could presumably have relatively large impacts on loading to the lake. Annual loads for this region 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.[70] 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., >30 years old as a coarse rule-of-thumb). A method for estimating the contribution of TP to lakes from shoreline

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[67] 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.
[68] Macdonald, J. S., Beaudry, P. G., MacIsaac, E. A., & Herunter, H. E. (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.
[69] Tomasek, M., Hora, M., Wilson, G., & Runke, H. 12. Detailed Assessment of Phosphorus Sources to Minnesota Watersheds.
[70] Tipping, E., Benham, S., Boyle, J. F., Crow, P., Davies, J., Fischer, U., ... & Toberman, H. (2014). Atmospheric deposition of phosphorus to land and freshwater. Environmental Science: Processes & Impacts, 16(7), 1608-1617.

septic system is outlined in Reckhow, *et al.* (1980).[71] 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 users to accurately estimate the 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.

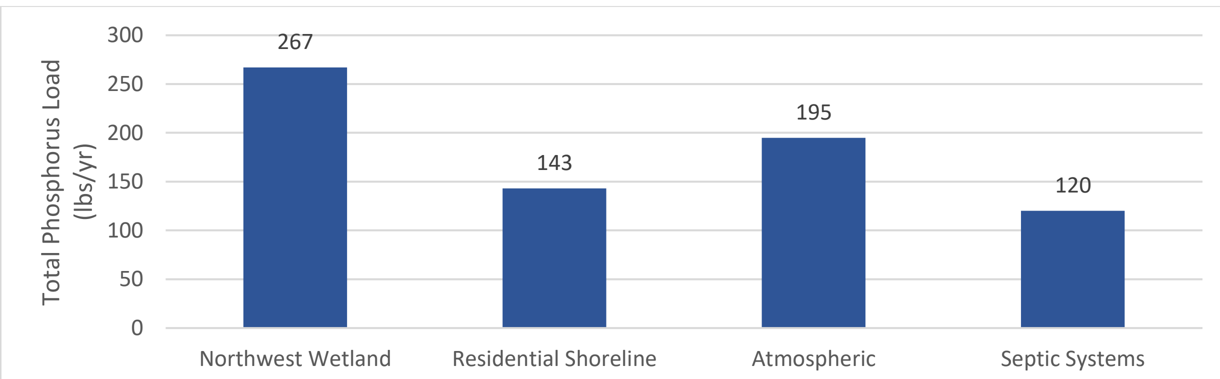

Figure 5-3. Total Phosphorus Nutrient Inputs to Cedar Lake.

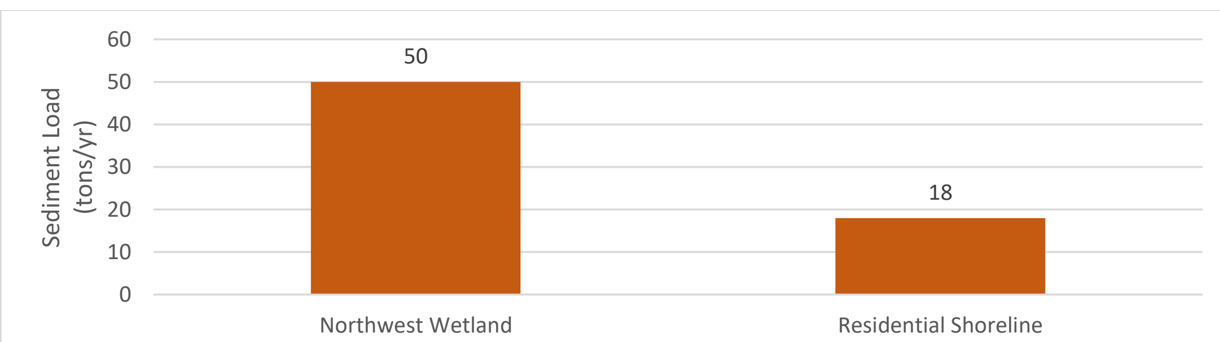

Figure 5-4. Sediment Load Inputs to Cedar Lake.

[71] 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.

Estimation of Hydrologic Runoff

One main reason for updating the WMP for Cedar Lake is to better manage activities in the watershed to protect recharge areas. The two main sources of water to Cedar Lake are 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 loss during dry years, and has since been confirmed with continued watershed hydrology monitoring.[72] The original hydrologic mass balance for Cedar Lake is 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) (4%)
- Groundwater (northeast to Lake Huron) (33%)
- Storm sewers (southeast toward Lake Huron) (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. These data continue to provide useful information on the approximate volume of runoff coming from Sherman Creek and Jones Ditch and the 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 provides quantifiable evidence of beneficial changes resultant from the 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 2014-2020 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

[72] 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.*

2017, and recent instream grade structures within Sherman Creek in 2019, as well as Jones Ditch culvert replacement which improved water release from wetland storage in 2017.

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: Kieser & Associates)*.

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.

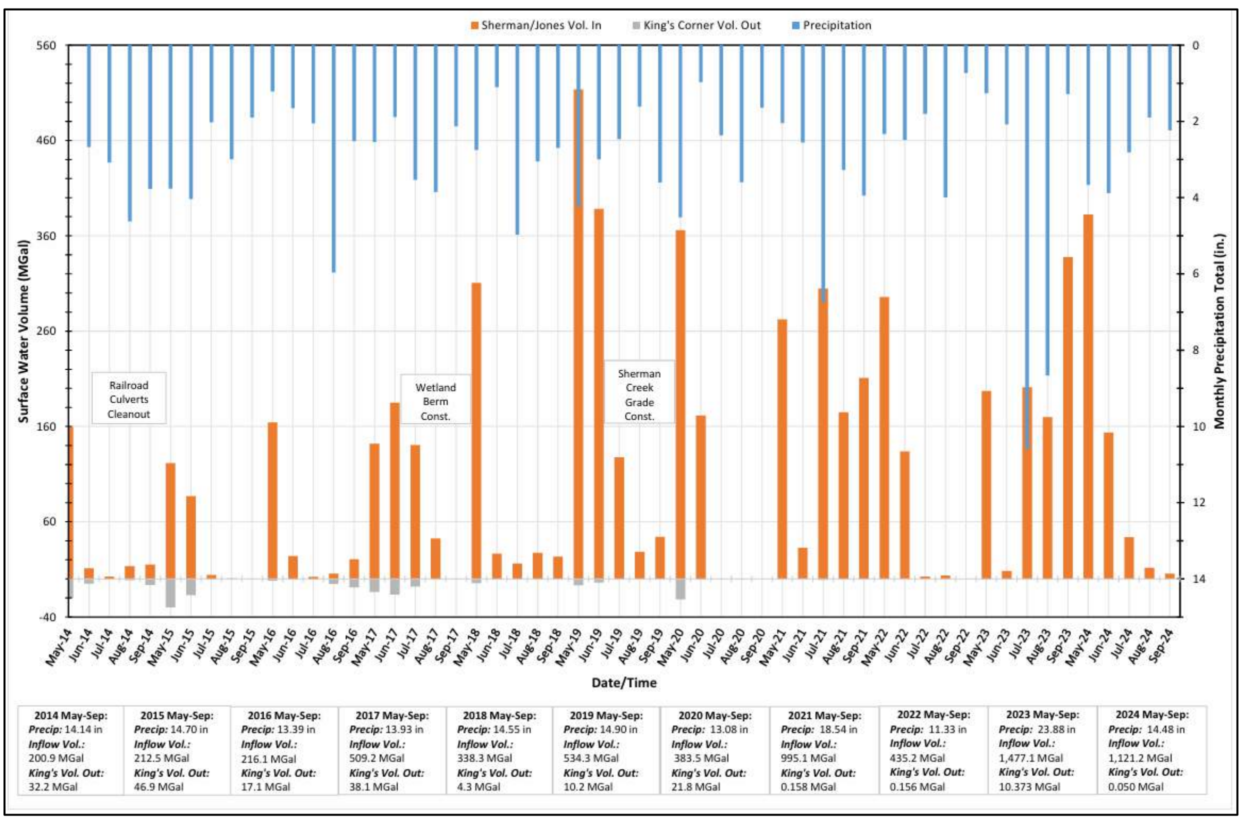

Figure 5-5. May-Sep 2014-2024: Precipitation, Sherman/Jones Ditch Combined Surface water Volume into Cedar Lake, and King's Corner Surface Water Volume Away from Cedar Lake.

The most recent 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, potentially forestalling the need to immediately pursue deep groundwater withdrawal augmentation wells as outlined in the 2011 Augmentation Feasibility Study[73] with subsequent refinements in a 2022 K&A Technical Memorandum.[74]

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 implementation phase of the updated WMP will be how changing runoff patterns in the watershed will affect: 1) pike spawning in Sherman Creek; 2) residents in the northwest wetlands area, and; 3) groundwater levels in the Lakewood Shores housing development.

Critical Areas 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 is having a significant impact on the waterbody.[75] For the purposes of 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. The original SC drew upon the 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, in order to pin-point specific locations in the watershed where protection and restoration 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 for protection.

In general, the large tracts of wetlands in the northwest portion of the watershed have been identified as extremely significant 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 critical for protection are in-lake fish habitat and natural shorelines. While these critical 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 as critical for projects that will provide habitat protection, including educating stakeholders. The remaining critical areas identified in Figure 5-6 have been selected because restoration projects are most needed in these select areas.

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

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

[75] 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 for protection and restoration in the Cedar Lake Watershed

The critical areas in Figure 5-6, numbered 1 through 8, are described as follows:

1. **Sherman Creek:** 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.[76]

2. **Jones Ditch:** 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 West Cedar Lake Road and the lake is naturalized. 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. The ditch and its corridor are one of only two surface water connections between the wetland and lake, and are priority areas for protection. The Jones Ditch culvert beneath West 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 several acres of wetland 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. **Sherman Creek Wetland Drainage:** 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 (including filling and clearing) to protect the storage capacity and water supply to Cedar Lake.

4. **Kings Corner Rd. Diversion:** A culvert is located under Kings Corner Road near West 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

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

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 Rd culvert diversion is critical in order to restore the wetland hydrology and conserve surface water inflows for Cedar Lake.

5. **Lakewood Shores Drainage District:** 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, 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.[77] 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, decreasing 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.

6. **In-lake Fish Habitat:** 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.[78] Monitoring of these habitat areas is being conducted by the Board to update the in-lake and tributary conditions assessment. Updating the critical fish habitat area map is a recommended implementation effort for the WMP technical update (Chapter 7).

7. **Lake Outlet:** 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 drop-box broad weir structure in autumn of 2020. The spillway structure directs water flowing over the lake outlet weir, under Cedar Lake Road, into a small stream to the north, eventually discharging 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

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[77] 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*.
[78] Pullman, D. (2009). "Cedar Lake Greenbush Township, Alcona County, Oscoda Township, Iosco County, Michigan: Management Program Update."

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 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.

8. **Cedar Lake Shoreline:** 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 instilled, severe winter ice floes and latter, 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

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

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.

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 more-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, and wetland 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

- **Objective IX: 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 recharges 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 wetland 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 an issue in Cedar Lake, however, 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.

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.

Progress Toward Original (2011) Implementation Goals and Objectives

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 West 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.[79] 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 West 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,

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

provide increased flood protection, and provide safer working conditions 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 reported 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. **Re-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:
    a. The 2011 MDNR report and the 2018 Northpointe Fisheries Management report provide information related to stocking progress, but limited updates on habitat.

<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 (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. *<u>Milestone</u>:* 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.[80]

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.[81]

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

<u>Objective VI (2011)</u>: 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 bottom sediments at Cedar Lake which resulted in limited information on sediment composition, sediment thickness or water depth in Cedar Lake.

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

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 includes: Implementation of a 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^{TM} 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 SERVES AS 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 1990’s for the purposes of aquatic weed control through contracts with chemical applicators to treat nuisance aquatic plants. This approach was upgraded in the mid-2000’s 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-2000’s, 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	Table 7-1. 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 Drain Commissioners on storage and return issues/options
	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 or more)
III	**Timberlakes Drainage Prevention**
	1. Work with the Drain Commissioner to find solutions to potential future development issues/drainage needs
	2. Identify and pursue opportunities to prevent future drainage issues similar to Lakewood Shores issue

Objective	Table 7-1. **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
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
	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 Lake & Stream Association to maintain knowledge on lake management strategies/practices
	1.1. Expanded testing

Objective	Table 7-1. **WMP Updated Implementation Task**
	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 Objectives 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 prevented 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 West 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.[82] Historic filling of wetlands has also occurred along West 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 West 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.

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[82] 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 wetland 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.[83] 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

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

OBJECTIVE II: 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, the only recourse to address the adverse effects of the existing drainage system is civil litigation, which 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 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 more than 50% 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 would 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

OBJECTIVE III: 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/drainage needs
	2. Identify and pursue opportunities to prevent future drainage issues similar to Lakewood Shores issue

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

<u>OBJECTIVE IV</u>: 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 from the Michigan DNR, 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

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.[84] 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. However, this method requires anglers to voluntarily participate, which may reduce the amount

[84] 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*.

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 (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 two recommendations: Sherman Creek pike spawning improvement assessments, and redear sunfish and swimmer's itch experimental assessments. Assessment of pike spawning improvements in Sherman Creek and Jones Ditch is a high-priority recommendation (Attachment K). This could include development of channel monitoring plans for both waterways and establishing technical and voluntary monitoring programs for assessing spring pike runs.

<u>OBJECTIVE V</u>: 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."[85] Recent lake-management efforts and specific updated short-term management goals include:

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[85] Pullman, D. (2008). "Cedar Lake Greenbush Township, Alcona County, Oscoda Township, Iosco

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.[86] 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 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

County, Michigan: Management Program Update."

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

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 in many cases highly technical tasks that will be an inevitable outgrowth of it, 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 to encourage boat cleaning each time lake users put in or take out at the lake. This, however, has not implemented and was not deemed as a priority for the WMP update.

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. Develop plans for a larger 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

<u>OBJECTIVE VI</u>: 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 in areas where the muck is present. It was important for the SC to understand the potential source of this muck so they could determine if the WMP should address options that assume a fixed amount of muck or options that address accumulation over time.

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).[87] 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.

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

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[87] 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).*

<u>Muck Prevention</u>: 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 the addition of muck accumulation over time. This is therefore considered an implementation, to encourage better lawn care practices for Cedar Lake riparians to reduce muck sediment accumulation. This would include stopping riparian practices of dumping lawn grass clippings and leaves into the lake.

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 lake association to educate and incentivize good lake stewardship practices.

<u>Aeration & Bioaugmentation</u>: Although aeration is not recommended as an implementation priority, a discussion is included here as it was part of original SC conversations to develop the WMP, and a persistent interest in this approach as an alternative to dredging. One outcome of aeration has been to increase dissolved oxygen in stratified lakes. This can be used to prevent fish kills during winter ice-cover in shallow lakes (that do not stratify or deeper ones that do).[88] 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 at decreasing sediment thickness.[89] 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 were not successful. 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 Bacta-Pur (bacteria mix from a manufacturer) 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 loss rate of 3 inches over the 3-month period as the aeration sites. The findings suggested that annual cycling of sediments was occurring.

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[88] 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*.
[89] Limno-Tech, Inc. (1995). "Final Project Report: Evaluation of Aeration and Bioaugmentation for Decreasing Sediment Thickness in Austin Lake, 1995." *Ann Arbor, Michigan*.

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.[90] These results are 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 lake of Michigan, concluding that limited to no benefits were scientifically discernable.

Sediment Dredging: Muck removal is the most effective way to improve the lake bottom sediments. 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, which 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 investigation was deemed necessary 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 use future mapping efforts to select areas to dredge and coordinate disposal of sediments (paying for disposal if 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.[91] 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.

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[90] East Twin Lake Aeration Association. (n.d.). “Aeration Project Report.”

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

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 suggests 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 below lists therefore lists updated WMP recommendations for muck prevention or removal, and 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.

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

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

Throughout the watershed management planning process, the original 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 Michigan Natural Shoreline Partnership's MI Shoreland Stewards Program, including program requirements and incentives, as well as promoting annual stewardship events.[92] 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 for 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 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

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

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

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 decades-old 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.

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 specific tasks for each action.

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[93]	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

Table 7-12 provides the details of the recommended implementation tasks for Objective VIII.

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 biannual 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

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

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.[94] 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.[95] 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.

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

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[94] 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>.
[95] 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>.

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, public engagement and outreach to 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 <u>Annual</u> 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 <u>Annual</u> 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 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 on options to help prevent future Timberlakes drainage impacts on lake levels	$25,000
	2. Identify and pursue Lake Board opportunities to prevent future drainage 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	(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.

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 drainage impacts on lake levels						
2. Identify and pursue Lake Board opportunities to prevent future 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 2000's 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.

Cedar Lake WMP (2025)

Attachment A: Original 2011 WMP Chapter 1

CHAPTER 1: INTRODUCTION

Background

A comprehensive watershed management plan (WMP) represents a framework where watershed needs and solutions are identified to preserve, protect or restore water quality and natural resources around 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 Lake Board) and other interested groups should pursue. Once approved, the complete WMP will serve as a road map for achieving community goals for sustaining Cedar Lake and its watershed. The following chapters of the WMP will: 1) provide background on the watershed and its resources; 2) include a synopsis of designated and desired uses in the watershed; 3) identify watershed concerns, threats, and impairments; 4) define watershed goals and objectives; and 5) recommend a strategy for WMP implementation with approaches and projects for protection and restoration. The WMP also prioritizes the necessary approaches and improvement projects in the watershed, based on timing and funding considerations.

The WMP describes the areas within the watershed that are more crucial, or "critical areas" where protection and restoration actions should be prioritized. Managing these critical areas to minimize impacts from future development, including drainage and diversions from Cedar Lake or increasing urban nutrient and sediment loads to the lake, is vital for protecting the watershed and its resources. The watershed goals identified in the WMP were developed through an integrated analysis of the watershed threats and concerns, designated and desired uses in the watershed, and these critical areas for protection.

WMP Drivers

The need for a comprehensive watershed management plan for the Cedar Lake watershed was realized after results from the hydrologic study were presented to the Lake Board. 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 wetlands complex in the northwest part of the watershed was identified as a major source of water recharge (both through groundwater and intermittent surface flows). Such a land use change as the development in the southeast and the resulting impacts demonstrated to the Lake Board that a watershed planning process to protect the Cedar Lake watershed and its recharge areas was extremely important in order to protect Cedar Lake for future use.

In addition to the findings of the hydrologic study, several other undesirable conditions in the watershed worked as a driver to create a watershed management plan. The Lake Board noted several water quality and resource concerns that required a new approach to managing critical areas and conditions in the watershed, beyond just the lake. Exotic and nuisance aquatic vegetation was exponentially increasing in the lake. Residents were noticing the negative impacts on recreation and aesthetics and demanding action. Fisheries and hydrology studies both indicated that flows from the tributaries and fish-spawning habitat showed declining conditions. The flux of summer lake levels was creating problems with re-suspension of anaerobic sediments, reduction in functional aquatic habitat near the shoreline, and increased nutrient concentration with low lake volumes. The final issue that created demand for developing a WMP was the lack of a cohesive plan to address water resource needs and opportunities.

Prior to the Lake Board's direct involvement, the Alcona-Iosco Cedar Lake Association, Inc. (AICLA), applied for funding through the State of Michigan Department of Environmental Quality for a watershed planning grant. When the grant request was not successful two years in a row, the AICLA petitioned the Lake Board's involvement. At that point the Lake Board agreed to pursue the project and decided to approach the public with the idea of funding the WMP through a tax assessment of the lakeshore residents. The Lake Board contracted with Kieser & Associates, LLC (K&A) in 2008 and work began on developing a WMP and facilitation of the planning process.

Watershed Management Planning Process

One of the preliminary steps in the WMP process is convening a steering committee (SC) to lead the WMP planning process, consult technical resources, and provide local knowledge of the watershed and public's interest. For Cedar Lake, there was a broad-based representation of the local townships, county agencies, natural resource experts, and state representatives. Many of the members of the SC serve on the Lake Board, which has been responsible for nuisance weed management on Cedar Lake. Township and county representatives are important individuals to serve on a SC because they have assessment and planning authority, both of which have been recognized by these agencies as necessary for restoring and protecting Cedar Lake resources. The SC originally planned to meet on a quarterly basis to discuss current watershed conditions and concerns. In order to properly address the issues in the watershed, the group began to meet every other month through 2008 to develop watershed goals and objectives and lay a solid foundation for the WMP. They worked to identify known and suspected pollutants and problematic modifications in the watershed.   Because of their positions in township and county government and other positions in watershed leadership, SC members have a good sense of the public's perceived problems in the watershed, major concerns, and the expectations that must be met.

In April 2009, the SC began to meet on a monthly basis. The committee took on the task of identifying critical areas in the watershed and developing an implementation plan for the WMP. The group discussed ordinances for wetland protection and other approaches to protecting and restoring the natural hydrology in the watershed. Throughout the process, the group worked primarily through consensus to tailor recommendations to fit the needs of the public and the ecosystem of Cedar Lake. The SC meetings were open to the public and a few residents of the watershed and some county and township representatives sat in on some meetings.

The following individuals served on the SC in some capacity. A portion of the group was present at the meetings on a regular basis and participation was encouraged through conference call in the latter part of the WMP planning process:

Gary Adams, Iosco County Drain Commissioner
Caryl Anton, Alcona-Iosco Cedar Lake Association
Russ Anton, Alcona-Iosco Cedar Lake Association
Jim Baier, Oscoda Township Supervisor (*replaced Rob Huebel, former Supervisor*)
Carolyn Brummond, Alcona County Board of Commissioners
Gina Cinquino, Lakewood Shores Property Owners Association
Gary Crawford, SEAS, LLC
Doug Getty, District Health Department
Greg Goudy, Michigan Department of Environmental Quality
Richard Karsen, Sr., Alcona County Road/Drain Commission
Mark Kieser, Kieser & Associates, LLC
Ryan Kruse, Natural Resources Conservation Service
Jamie McCarthy, Kieser & Associates, LLC
Craig Peters, Lakewood Shores Resort & Golf Course
Doug Pullman, Aquest
Edward Roddy, Greenbush Township Supervisor
Roberta Roulo, Iosco County Commission

Steve Sendek, Michigan Department of Natural Resources
Art Winter, Greenbush Township Board of Commissioners
Rick Myrick, Alcona/Iosco County Conservation District

Public Participation Process in WMP Development

The WMP planning process involved consistent commitment and input from a diverse group of individuals serving on the SC. Because many of the SC members from the township and county serve in elected positions, they were particularly aware of public opinion and regularly discussed how elements of the WMP must reflect the public's desires and priorities for the watershed. Public feedback was solicited through surveys distributed by the AICLA to all lake front residents and other local stakeholders. An initial survey was distributed to all lake front residents asking them to identify primary environmental concerns in the watershed. Information from the surveys was collected and compared with SC priorities to ensure all public concerns were expressed and aligned with the final watershed concerns table (see Table 3-1 in Chapter 3).

In addition to these meetings, information regarding the planning process was posted on a project website[1]. To obtain final public comment on the WMP, an executive summary was published in the AICLA's newsletter, *Whispering Waters*, which is distributed to all lake front property owners (member and non-member alike), as well as other interested residents of the area. A feedback form and stamped envelope were included to encourage public comments. In addition, copies of the newsletter were distributed to the Alcona County Library in Harrisville and the Clerk's Office in Oscoda Township. Public announcements were published in the two local newspapers to promote public review of the summary at the library or township office and solicit feedback from those not directly receiving the newsletter.

The feedback form distributed with the AICLA newsletter and to local government buildings asked stakeholders to review the WMP summary and answer the following: 1) are your major lake concerns reflected in the WMP goals, objectives, and approaches; 2) will you support the Lake Board in pursuing the projects and approaches in the summary; and 3) are there specific projects, approaches or activities you support that are not included in the summary? The response forms were sent to more than 700 lakeshore residents and 55 were returned with comments. The majority of the comments received supported the strategy outlined in the WMP summary. More than 60% of the respondents felt major concerns in the watershed were

[1] *Project website can be viewed at: www.kalamazooriver.net/Kieser/Cedar_Lake_WMP/index.htm*

reflected in the goals and objectives. Fewer than 10% responded with a direct answer of “no”. Many of the concerns listed on the feedback forms regarded issues that were actually addressed in the summary in one way or another or are discussed in the full WMP. Some of the main issues found in the feedback forms were:

- General interest in maintaining a healthy lake
- Maintain property values and recreational activities through increased/maintained lake levels
- Stronger rules to ensure water quality protection
- Full support of methods to control nuisance aquatic vegetation in the lake
- Flow/habitat enhancement at Sherman and Jones Creeks
- Improvements at the north spillway

The SC also has committed to developing and distributing a WMP brochure that summarizes the elements of the WMP and presents the implementation schedule to the public. The SC will continue to seek public input after this brochure is sent out to the public. Because the WMP is a living document that will change over time as the SC implements the plan, public feedback will play an important role in shaping management projects and approaches. This will be especially true when tax assessments are required to fund high-priority projects that will benefit lakeshore residents. The Lake Board abides by State of Michigan statute that requires public hearings to solicit stakeholder feedback on funding and tax issues.

Cedar Lake WMP (2025)

Attachment B: CLMP Data Report (2024)

Cooperative Lakes Monitoring Program

Michigan Lakes– Ours to Protect

2024 Data Report for

Cedar Lake, Alcona County

Site ID: 010017

44.5238°N, 83.3307°W

The CLMP is brought to you by:

Michigan Clean Water Corps

EGLE MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

MICHIGAN STATE UNIVERSITY

Michigan Lakes and Streams Association

Huron River Watershed Council

About this report:

This report is a summary of the data that have been collected through the Cooperative Lakes Monitoring Program. The contents have been customized for your lake. The first page is a summary of the Trophic Status Indicators of your lake (Secchi Disk Transparency, Chlorophyll-a, Spring Total Phosphorus, and Summer Total Phosphorus). Where data are available, they have been summarized for the most recent field season, five years prior to the most recent field season, and since the first year your lake has been enrolled in the program.

If you did not take 8 or more Secchi disk measurements or 4 or more chlorophyll measurements, there will not be summary data calculated for these parameters. These numbers of measurements are required to ensure that the results are indicative of overall summer conditions.

If you enrolled in Dissolved Oxygen/Temperature, the summary page will have a graph of one of the profiles taken during the late summer (typically August or September). If your lake stratifies, we will use a graph showing the earliest time of stratification, because identifying the timing of this condition and the depth at which it occurs is typically the most important use of dissolved oxygen measurements.

The back of the summary page will be an explanation of the Trophic Status Index and where your lake fits on that scale.

The rest of the report will be aquatic plant summaries, Score the Shore results, and larger graphs, including all Dissolved Oxygen/Temperature Profiles that you recorded. For Secchi Disk, Chlorophyll, and Phosphorus parameters, you need to have two years of data for a graph to make logical sense. Therefore if this is the first year you have enrolled in the CLMP, you will not receive a graph for these parameters.

Remember that some lakes see a lot of fluctuation in these parameters from year to year. Until you have eight years worth of data, consider all trends to be preliminary.

To learn more about the CLMP monitoring parameters or get definitions to unknown terms, check out the CLMP Manual, found at: **https://micorps.net/wp-content/uploads/2021/03/CLMP-Manual-2019update2_2021.pdf**

Thank you!

The CLMP leadership team would like to thank you for all of your efforts over the past year. The CLMP would not exist without dedicated and hardworking volunteers!

The CLMP Leadership Team is made of: Jo Latimore, Erick Elgin, Jean Roth, Tamara Lipsey, Mike Gallagher, Melissa DeSimone, and Paul Steen

Questions?

If you have questions on this report or believe that the tabulated data for your lake in this report are in error please contact:

Paul Steen (psteen@hrwc.org), CLMP Data Analyst

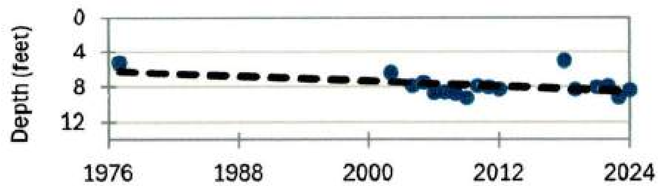
Site ID: 010017

Cedar Lake, Alcona County
2024 CLMP Results

Cooperative Lakes Monitoring Program

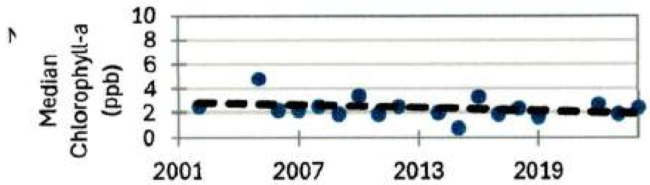
Secchi Disk Transparency (feet)

Year	# Readings	Min	Max	Average	Std. Dev	Carlson TSI
2024	8	7.0	10.0	8.4	1.1	< 46*
2019-2023	40	6.0	11.0	8.4	0.9	47
1977-2018	202	0.5	10.5	7.6	1.5	48
2024 All CLMP Lakes	3348	0.5	85.0	11.7	6.2	43



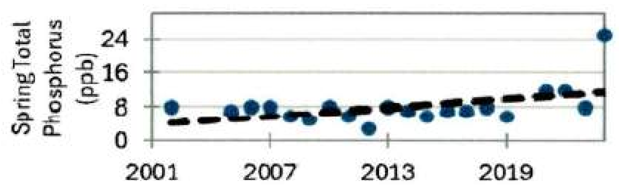
Chlorophyll-a (parts per billion)

Year	# Samples	Min	Max	Median	Std. Dev	Carlson TSI
2024	5	<1.0	3.0	2.4	1.0	39
2019-2023	16	1.0	5.0	1.9	0.8	37
2002-2018	74	<1.0	7.0	1.9	1.1	39
2024 All CLMP Lakes	708	< 1.0	63.0	2.8	7.3	41



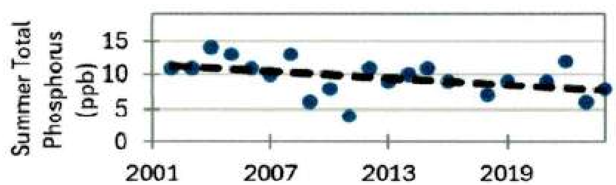
Spring Phosphorus (parts per billion)

Year	# Samples	Min	Max	Average	Std. Dev
2024	1	25.0	25.0	25.0	NA
2019-2023	4	6.0	12.0	9.5	3.0
2002-2018	15	<=3 W	8.0	6.8	1.4
2024 All CLMP Lakes	259	<= 5	140.0	14.3	39.7



Summer Phosphorus (parts per billion)

Year	# Samples	Min	Max	Average	Std. Dev	Carlson TSI
2024	1	8.0	8.0	8.0	NA	34
2019-2023	4	6.0	12.0	9.0	2.4	35
2002-2018	17	<5 T	14.0	9.9	2.6	37
2024 All CLMP Lakes	200	<= 5	4.0	190.0	14.9	18



Dissolved Oxygen and Temperature Profile

This lake does not have recent (within 5 years) dissolved oxygen/water temperature data available. Consider enrolling in this parameter next year. Fish, insects, mollusks, and crustaceans need dissolved oxygen to live in water. By late summer, many lakes stratify, with cold anoxic water on the bottom and warm, oxygen rich water on the surface. Anoxic (oxygen-depleted) water occurring too close to the surface is a sign of nutrient enrichment. Understanding the pattern of dissolved oxygen and water temperature in a lake is important for assessing nutrient problems as well as the health of the biological community.

Summary

Average TSI	2024	2019-2023	1977-2018
Cedar Lake	37	36	38
All CLMP Lakes	41	42	42

With an average TSI score of 37 based on 2024 Secchi transparency, chlorophyll-a, and summer total phosphorus data, this lake is rated between the oligotrophic and mesotrophic classification. The lake leans slightly more oligotrophic than mesotrophic.

While the trends for individual parameters are mixed, monitoring data indicates that overall nutrient levels remain largely unchanged since data collection began.

** = Secchi transparency measurements taken on bottom of lake; not used for TSI index*

<1.0 = Chlorophyll-a: Sample value is less than limit of quantification (<1 ppb).

W= Value is less than the detection limit (<3 ppb)   T = Value reported is less than the reporting limit (5 ppb)

Trophic Status Index Explained

In 1977, limnologist Dr. Robert Carlson developed a numerical scale (0-100) where the numbers indicate the level of nutrient enrichment. Using the proper equations, we can convert results from Summer Total Phosphorus, Secchi Depth, and Chlorophyll-a to this Trophic Status Index (TSI). The TSI numbers are furthermore grouped into general categories (oligotrophic, mesotrophic, eutrophic, and hypereutrophic), to quickly give us a way to understand the general nutrient level of any lake.

The tables below give the results-to-TSI conversions for the water quality data ranges normally seen in the CLMP. The formulas for this conversion can be found in the CLMP manual (link is on page 2 of this report).

Phosphorus (ppb)	TSI Value
<5	<27
6	30
8	34
10	37
12	40
15	43
18	46
21	48
24	50
32	54
36	56
42	58
48	60
>50	>61

Secchi Depth (ft)	TSI Value
>30	<28
25	31
20	34
15	38
12	42
10	44
7.5	48
6	52
4	57
<3	>61

Chlorophyll-a (ppb)	TSI Value
<1	<31
2	37
3	41
4	44
6	48
8	51
12	55
16	58
22	61
>22	>61

TSI for Cedar Lake in 2024	
Average	37
Secchi Disk	<46 (not used for TSI)
Summer TP	34
Chlorophyll-a	39

Oligotrophic <36 | Oligo/Meso 36-40 | Mesotrophic 41-45 | Meso/Eutro 46-50 | Eutrophic 51-61 | Hypereutrophic >61

^ **Average**

^ Total Phosphorus

^ Chlorophyll-a

Oligotrophic: Generally deep and clear lakes with little aquatic plant or algae growth. These lakes maintain sufficient dissolved oxygen in the cool, deep-bottom waters during late summer to support cold water fish, such as trout and whitefish.

Mesotrophic: Lakes that fall between oligotrophic and eutrophic. Mid-ranged amounts of nutrients.

Eutrophic: Highly productive eutrophic lakes are generally shallow, turbid, and support abundant aquatic plant growth. In deep eutrophic lakes, the cool bottom waters usually contain little or no dissolved oxygen. Therefore, these lakes can only support warm water fish, such as bass and pike.

Hypereutrophic: A specialized category of euthrophic lakes. These lakes exhibit extremely high productivity, such as nuisance algae and weed growth.

Aquatic Plants

Cedar Lake does not have aquatic plant data available.

Why is monitoring aquatic plants important?

A major component of the plant community in lakes is the large, leafy, rooted plants. Compared to the microscopic algae the rooted plants are large. Sometimes they are collectively called the "macrophytes" ("macro" meaning large and "phyte" meaning plant). These macrophytes are the plants that people sometimes complain about and refer to as lake weeds.

Far from being weeds, macrophytes or rooted aquatic plants are a natural and essential part of the lake, just as grasses, shrubs and trees are a natural part of the land. Their roots are a fabric for holding sediments in place, reducing erosion and maintaining bottom stability. They provide habitat for fish, including structure for food organisms, nursery areas, foraging and predator avoidance. Waterfowl, shore birds and aquatic mammals use plants to forage on and within, and as nesting materials and cover.

Though plants are important to the lake, overabundant plants can negatively affect fish populations, fishing and other recreational activities. Rooted plant populations increase in abundance as nutrient concentrations increase in the lake. As lakes become more eutrophic rooted plant populations increase. They are rarely a problem in oligotrophic lakes, only occasionally a problem in mesotrophic lakes, sometimes a problem in eutrophic lakes, and often a problem in hypereutrophic lakes.

However, sometimes a lake is invaded by an aquatic plant species that is not native to Michigan. In these cases, even nutrient poor oligotrophic lakes can be threatened. Some of these exotic plants, like Curly-leaf Pondweed, Eurasian Milfoil, Starry Stonewort, and Hydrilla can be extremely disruptive to the lake's ecosystem and recreational activities.

To avoid a takeover by exotic plants, it is necessary to use Integrated Pest Management (IPM) strategies: monitoring, early detection, rapid response, maintenance control, and preventive management. For more information on these strategies, check out Integrated Pest Management for Nuisance Exotics in Michigan Inland Lakes (MSU Extension Water Quality Publication WQ-56, available at https://micorps.net/lake-monitoring/clmp-documents/)

The CLMP offers two parameters on aquatic plants. In the Exotic Aquatic Plant Watch, volunteers concentrate on monitoring and early detection of exotic invasive plants only. In Aquatic Plant Identification and Mapping, volunteers identify all native and non-native plants. In both parameters, volunteers create lake maps or use digital tools to georeference where the plants are found.

Score the Shore

Cedar Lake does not have Score the Shore results.

Why is the Score the Shore parameter important?

Healthy shorelines are an important and valuable component of the lake ecosystem. The shoreline area is a transition zone between water and land, and should be a very diverse environment that provides habitat for a great variety of fish, plants, birds, and other animals. A healthy shoreline area is also essential for maintaining water quality, slowing runoff, and limiting erosion.

However, Michigan's inland lake shorelines are threatened. Extensive development, often combined with poor shoreline management practices, can reduce or eliminate natural shoreline habitat and replace it with lawn and artificial erosion control such as sea walls and rock. As a result, shoreline vegetation is dramatically altered, habitat is lost, and water quality declines.

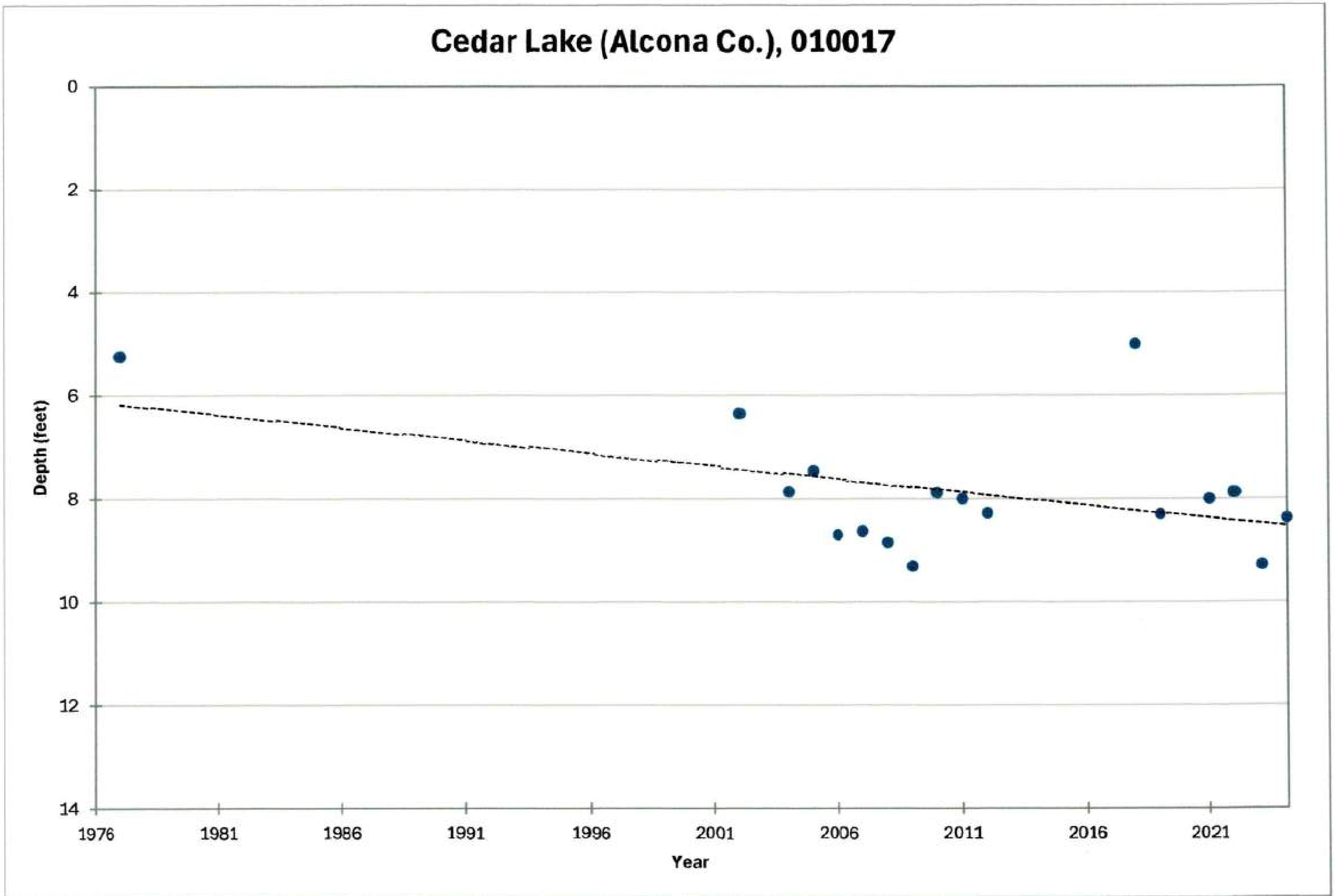
Therefore, in 2019 the MiCorps Cooperative Lakes Monitoring Program introduced a new monitoring program – Score the Shore – that enables volunteers to assess the quality of their lake's shoreline habitat.

The information gathered during this assessment will allow lake communities to identify high-quality areas that can be protected, as well as opportunities for improvement. Score the Shore data, combined with educational resources describing the value of healthy shorelines and how to restore and maintain them, can be incorporated into lake management planning and used for educating lakefront property owners. The Michigan Natural Shoreline Partnership (MNSP) is a collaboration of agencies and professionals that promotes natural shoreline practices to protect Michigan's inland lakes. The MNSP website (www.mishorelinepartnership.org) includes materials and information that can be used in educational efforts. MNSP also offers training for professional educators and landscape contractors, and maintains a list of trained educators who may be available to speak to your community about natural shorelines.

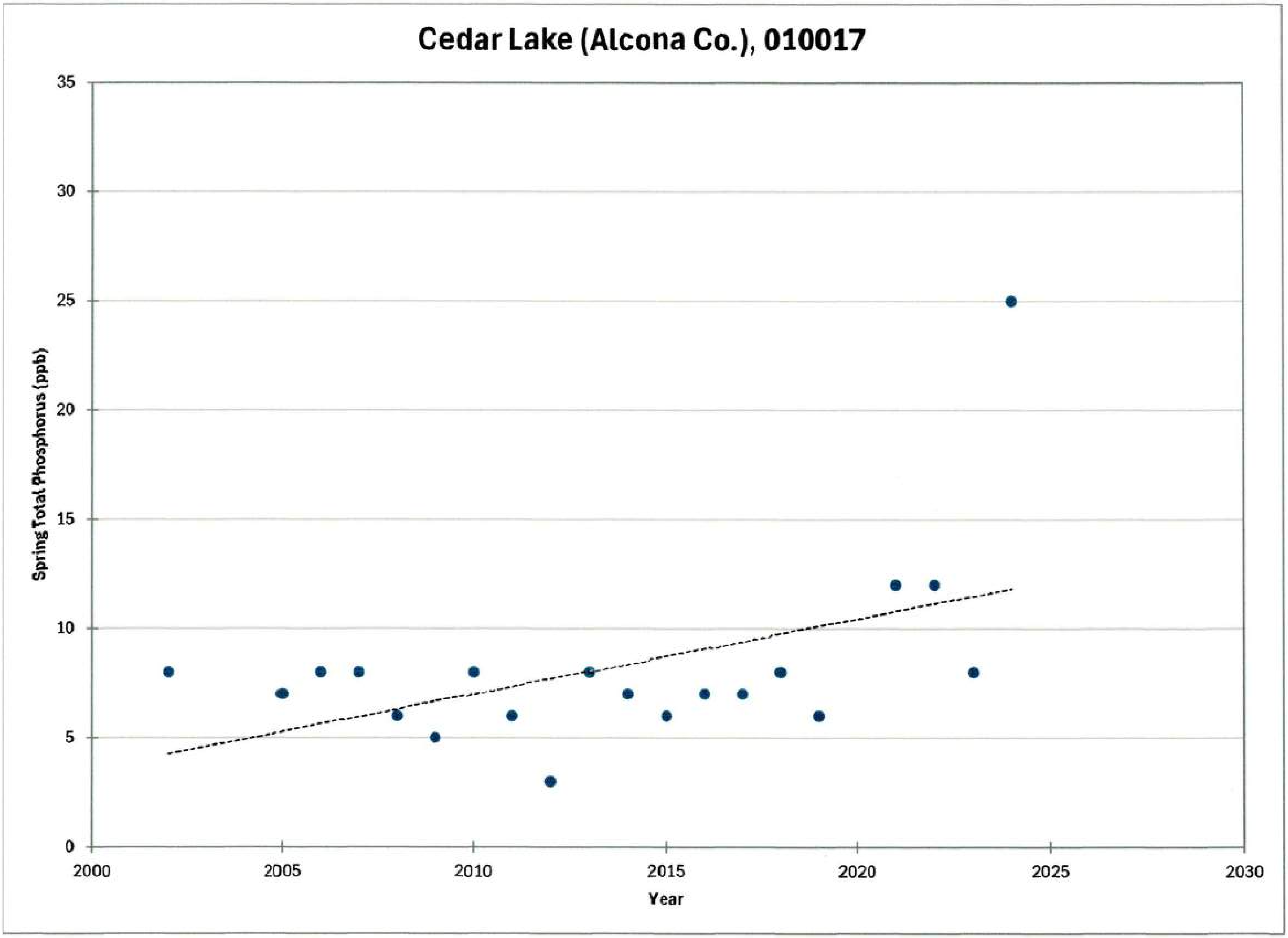
Score the Shore data, just like all CLMP data, will also be available to any interested parties through the MiCorps Data Exchange (www.micorps.net). State agency staff and researchers regularly access CLMP data to better understand and manage Michigan's inland lakes.

Score the Shore is a descriptive process for assessing shoreline quality on Michigan's inland lakes. It is also a valuable educational tool. Score the Shore is not a regulatory program, nor is it intended to tell people what they can and cannot do on their property. The Michigan Department of Environmental Quality's Inland Lakes and Streams Program has responsibility for shoreline protection on public lakes. To learn about their shoreline protection program, including construction permitting and recommendations for shoreline management, visit www.mi.gov/deqinlandlakes.

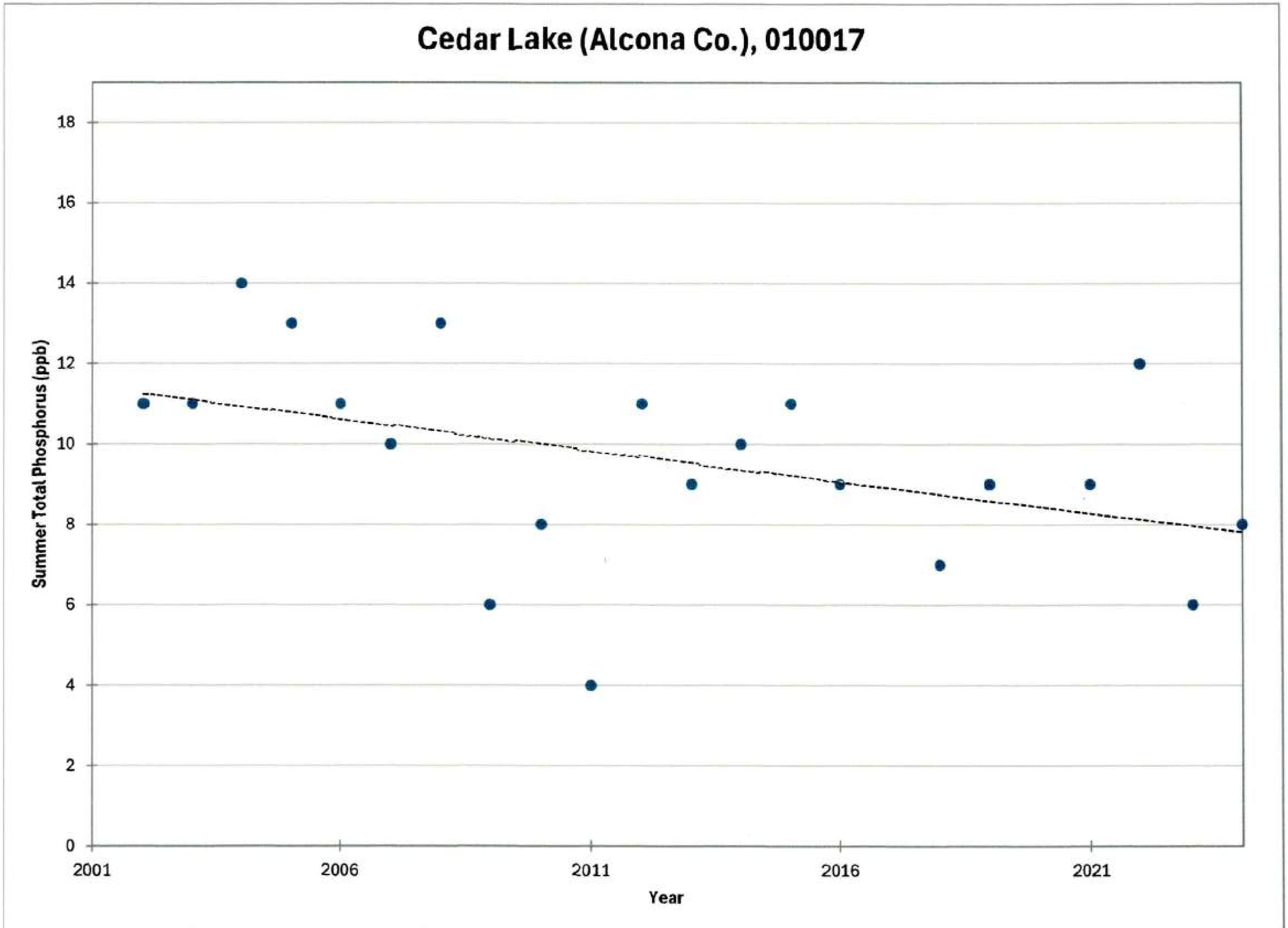
COOPERATIVE LAKES MONITORING PROGRAM
SUMMER MEAN TRANSPARENCY



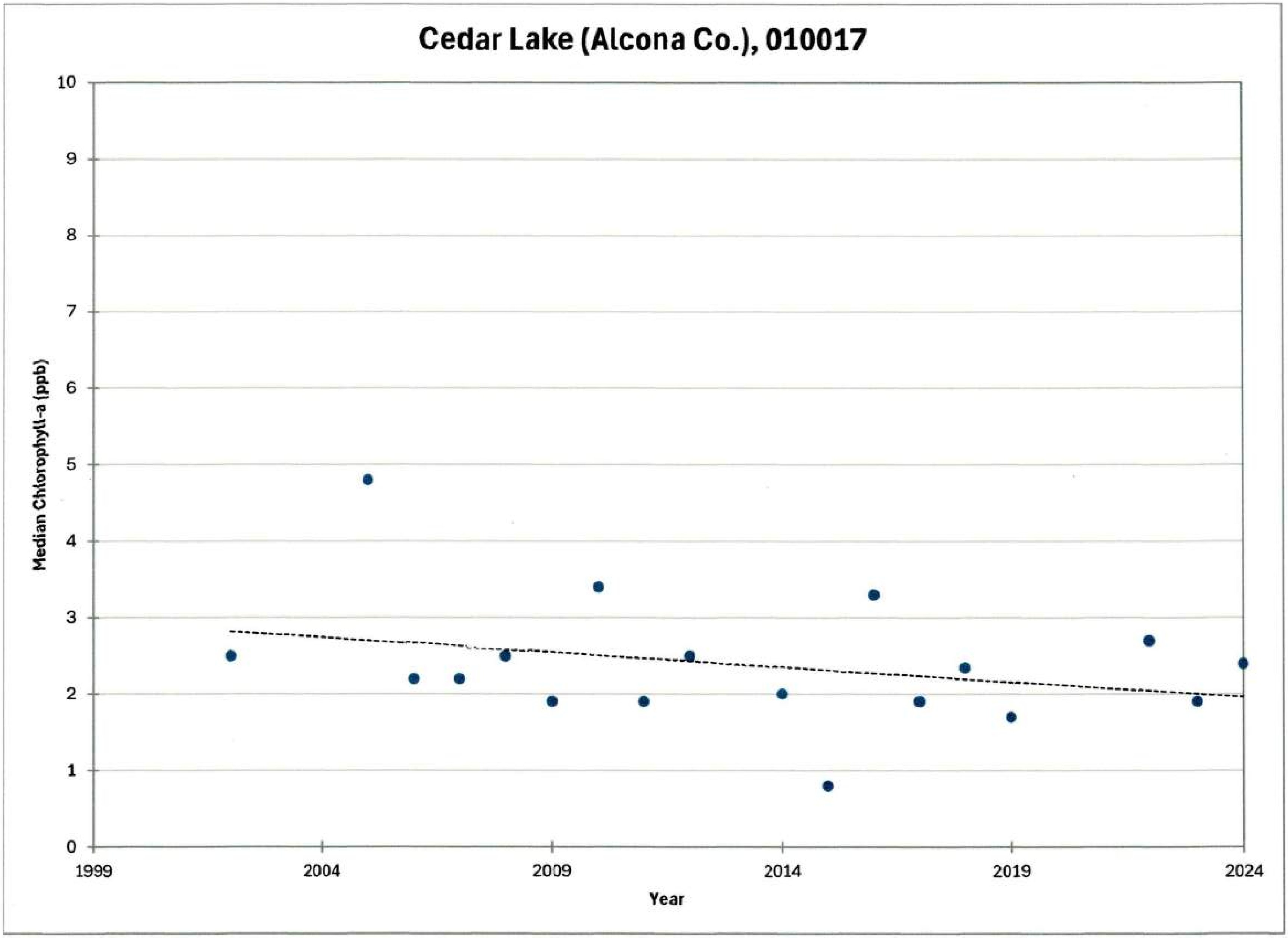
COOPERATIVE LAKES MONITORING PROGRAM
SPRING TOTAL PHOSPHORUS



COOPERATIVE LAKES MONITORING PROGRAM
SUMMER TOTAL PHOSPHORUS



COOPERATIVE LAKES MONITORING PROGRAM
SUMMER MEDIAN CHLOROPHYLL-A



Cedar Lake WMP (2025)

Attachment C: Regional PFAS Contamination – Key Findings & Figures

Cedar Lake Watershed: Regional PFAS Contamination Key Findings and Figures

The technical update to the Cedar Lake Watershed Management Plan (WMP) included the addition of toxicants to the list of known watershed pollutants to reflect recent expressions of PFAS-compound contaminants occurring within the Cedar Lake watershed. The Wurtsmith Air Force Base (WAFB) is the main known source of PFAS pollutants in the region. This WMP attachment contains a discussion, including several key figures, of findings related to ongoing MI EGLE investigations of the sources and extent of PFAS contamination in the region, which is directly impacting Cedar Lake and its watershed.

On July 21st, 2020, the MI Department of Environment, Great Lakes, and Energy (EGLE) produced a conceptual site model for the WAFB including elevation maps, potentiometric maps, and locations in which PFAS compounds are found and their respective concentrations. As suggested by Figure C-1, multiple residential wells on the eastern side of Cedar Lake were found to contain total PFAS concentrations between 10 and 500 ppt. Additionally, groundwater samples on the western and southern sides of Cedar Lake were found to contain PFAS contaminants in similar concentrations (between 10 and 500 ppt).[1]

Since at least 2018, PFAS foams were observed to be forming on the shores of Cedar Lake. In December 2018, foam tested by EGLE on Cedar Lake only had 158 ppt. In Spring 2020, EGLE testing of foams on Cedar Lake produced PFOS (a PFAS-family chemical) concentrations of 7,260 ppt, indicating PFAS contributions into Cedar Lake are still active. The sources of PFAS into Cedar Lake are still being identified by EGLE and have not been confirmed.

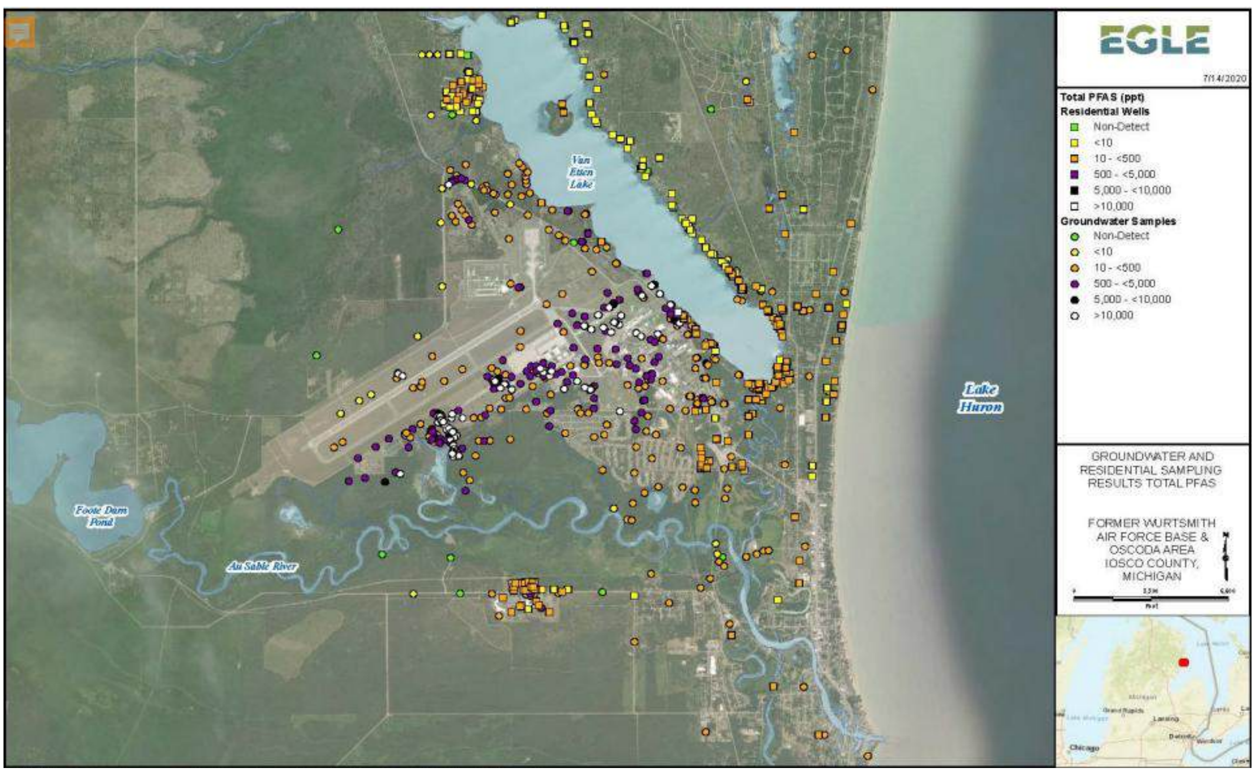


Figure C-1. Groundwater and Residential Sampling Results Map – Total PFAS.[2]

[1] 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>.
[2] Michigan EGLE. (2020). "Oscoda Area Conceptual Site Model."

On June 30, 2020, EGLE released a public notice form suggesting that residents living near Cedar Lake stay away from PFAS foams forming on the shores. A similar notice was issued for Van Etten Lake, which has been more-directly impacted by the WAFB (Figure C-1). Foams tested in Spring 2020 on Van Etten Lake produced an alarmingly high amount of PFAS, with PFOS concentrations at 220,000 ppt, nearly 33-times higher than concentrations of foam on Cedar Lake.[3, 4]

The foam formed by PFAS compounds is somewhat of an elusive substance as not much research has been conducted regarding formation or transport of PFAS foams. Nonetheless, EGLE has denoted several key characteristics of PFAS foam when compared to organic foams. PFAS foams tend to have a brighter white color, are usually lightweight, can be sticky, tends to pile up like shaving cream, and can blow onto the beach. Natural foams are typically browner in color, are persistent, light weight, and not slimy or sticky feeling. Additionally, it is suggested that PFAS foams are their own formations and do not build on existing natural foams.[5, 6]

The means by which PFAS has gotten near Cedar Lake remain somewhat unclear. The potentiometric map shown in Figure C-2 indicates that shallow groundwater flows away from Cedar Lake in both the south and east directions.

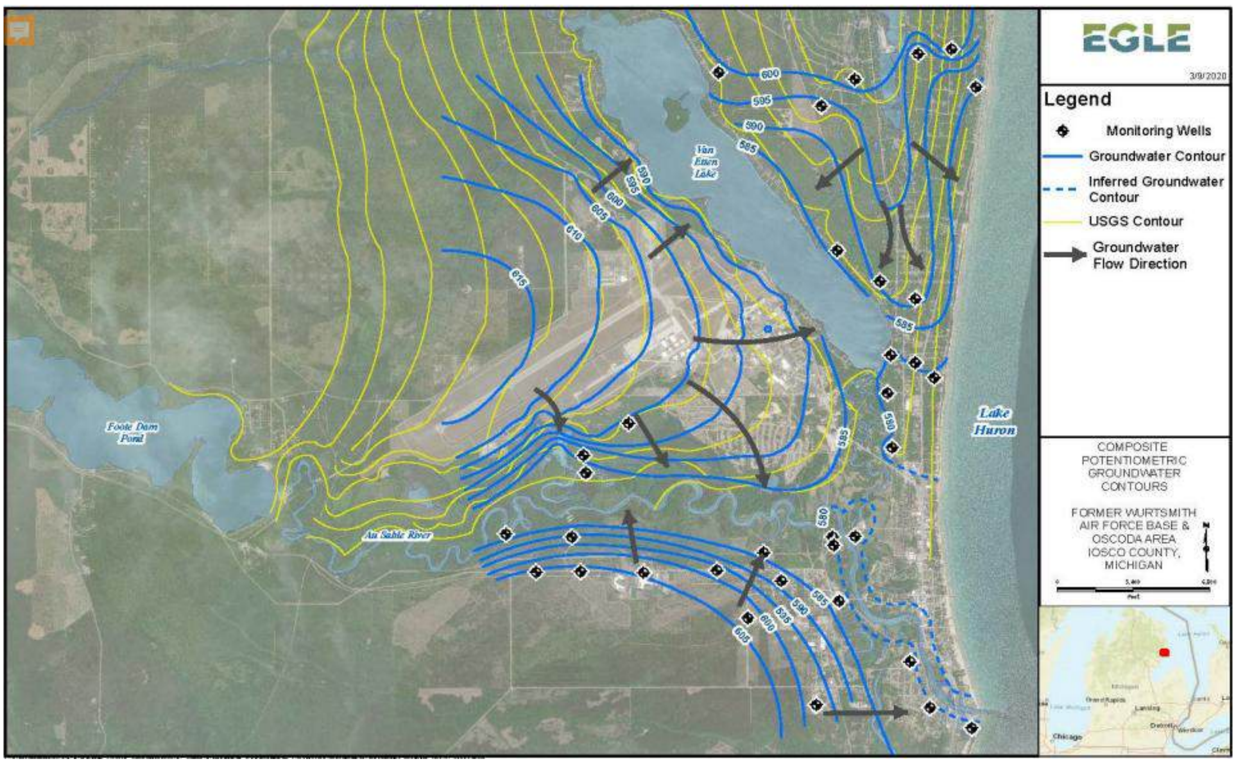


Figure C-2. Composite Potentiometric Groundwater Contours.[7]

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[3] Northeastern University. (2020). "Public SSEHRI PFAS Contamination Site Tracker." Accessible online: <https://docs.google.com/spreadsheets/d/10y4u1KG6gegnw3zoTUTbXxQiEqitU1ufPlGvGiETtcg/edit#gid=682068550>.

[4] 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>.

[5] Michigan EGLE. (2016). "Foam: A Naturally-Occurring Phenomenon." Accessible online: <https://www.michigan.gov/documents/deq/deq-oea-nop-foam_378415_7.pdf>.

[6] Michigan EGLE. (2019). "Foam and PFAS." Accessible online: <https://www.michigan.gov/documents/pfasresponse/PFAS_Foam_Fact_Sheet_657070_7.pdf>.

[7] Michigan EGLE. (2020). "Oscoda Area Conceptual Site Model."

Nevertheless, Figure C-3 shows that well RI-MW003 near Cedar Lake was screened between 2 and 7 feet and had a total PFAS concentration of 29 ppt. Given the expected directions of shallow groundwater flow, it is unlikely that contaminated groundwater near Van Etten Lake is moving toward Cedar Lake by way of shallow groundwater.[8]

Figure C-3. Close-up of Groundwater and Residential Sampling Results Map – East side of Cedar Lake.[9]

EGLE has been working closely with Van Etten Lake in an attempt to remediate the PFAS contaminated groundwater entering that lake system. As of December 6, 2017, EGLE planned a pump and treat style remediation as shown in Figure C-4. While this method limits the amount of PFAS coming into Van Etten Lake, there is not currently a removal plan in place for lake water that is already contaminated with PFAS, and the impacts of this treatment system will not impact Cedar Lake as currently designed.[10]

[8] Michigan DEQ. (December 6, 2017). “Wurtsmith Air Force Base – Public Meeting.” *Presentation by Susan Leeming and Michael Jury, MDEQ*. Accessible online: <https://www.michigan.gov/documents/deq/120617-presentation-MDEQ_608360_7.pdf>.
[9] Michigan EGLE. (2020). “Oscoda Area Conceptual Site Model.”
[10] Michigan DEQ. (December 6, 2017). “Wurtsmith Air Force Base – Public Meeting.”

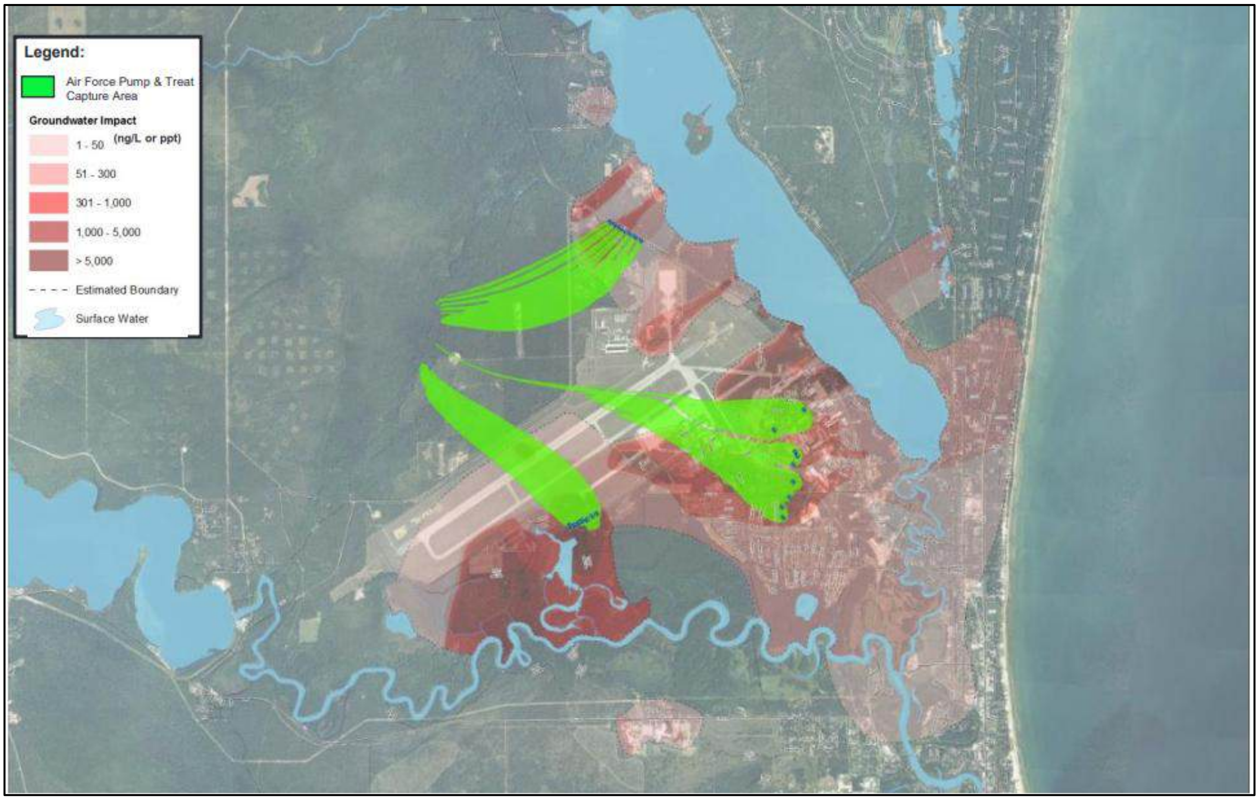

Figure C-4. Van Etten Lake/WAFB Pump & Treat Capture Area.

Although Cedar Lake is upgradient of Van Etten and WAFB in regards to shallow groundwater, Cedar Lake is not immune to atmospheric deposition of PFAS compounds. PFAS compounds are surfactants meaning they lower the surface tension of water.[11] Due to lower surface tension, water containing PFAS compounds become airborne more easily and can travel miles away from its point source by wind, rain and snow which may be exacerbated by Cedar Lakes' proximity to Lake Huron.[12] Atmospheric deposition is a source that may be critically overlooked in remediation efforts, but likely contributes to PFAS near Cedar Lake.[13]

Additionally, past research has found PFAS contaminants in deep aquifers (upwards of 240m underground).[14] So, the contamination near Van Etten Lake and WAFB may extend deeper underground than previously thought. However, research also denotes that PFAS compounds largely stay in shallow groundwater indicating this issue may not be a likely transport method impacting Cedar Lake.[15]

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[11] Brusseau, Mark L., *et al.* (2019). "Comprehensive retention model for PFAS transport in subsurface systems." *Water Research: Vol 148, Jan 2019, pages 41-50*.
[12] Kim, Seung-Kyu. (2007). "Perfluorinated Acids in Air, Rain, Snow, Surface Runoff, and Lakes." *Environmental Science and Technology*.
[13] 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>.
[14] Liu, Yan, *et. al.* (2019). "Contamination Profiles of Perfluoroalkyl Substances (PFAS) in Groundwater in the Alluvial-Pluvial Plain of Hutuo River, China." *Water,* 2019 *11*(11), 2316.
[15] 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,* 2019, *214* pp729-737.

One other area of concern, and a possible source of the PFAS-compound contaminants found near Cedar Lake, is Oscoda Township Dump (OTD), located on Kings Corner Road between Loud Drive and Kings Corner Road (Figure C-5).[16] In 2019, OTD conducted 16 groundwater tests in non-residential wells around their grounds. Eleven tests came back positive for PFAS compounds, and 3 of the 11 had total PFAS concentrations exceeding 70 ppt. Importantly, residential wells located near the dump were non-detect (ND) for PFAS compounds. As for PFAS found near Cedar Lake, OTD is perhaps a likely source considering the highest concentrations were found near the south east corner of the dump and potentiometric maps would suggest an almost direct path from the dump to Cedar Lake.[17]

Figure C-5. Location of the former Oscoda Township Dump (orange triangle).

OTD is no longer in commission but is thought to have been a dump site for wastes from WAFB. A letter on file from 1968 confirms that WAFB was sending waste to the dump to be disposed of. This dump did not control waste coming in, did not properly bury and contain wastes, and openly burned wastes without proper permitting.[18] The groundwater flow direction near the dump is generally unknown but thought to be in the southeast direction due to surface water features. Aerial photography from 1998 shows a part of the dump and what seems to be waste that is not contained in anyway (shown in Figure C-6).

[16] Michigan EGLE. (2020). "Oscoda Area Historical Timeline." Michigan PFAS Action Response Team. Accessible online: <https://www.michigan.gov/pfasresponse/0,9038,7-365-86511_82704_97100_97106---,00.html>.
[17] Haglund, Jenny. (July 23, 2019). "Tensions Escalate as Locals Demand Faster PFAS Action."
[18] Haglund, Jenny. (July 23, 2019). "Tensions Escalate as Locals Demand Faster PFAS Action." *Iosco News*. Accessible online: <http://www.iosconews.com/oscoda_press/news/article_8d19635c-ad5b-11e9-9685-0b74e9773081.html>.

Figure C-6. Aerial photograph of the former Oscoda Township Dump from 1998.

The elevation map in Figure C-7 suggests that PFAS contaminated surface water runoff (and groundwater) from OTD could follow the yellow line towards Cedar Lake; these yellow lines are boundaries of old river deltas deposited during the last ice age. Additionally, while EGLE's potentiometric maps shown do not extend all the way to the OTD (Figure C-5), it is possible that groundwater that recharges underneath of OTD follows groundwater flow paths toward Cedar Lake's southwest side, where shallow groundwater gradients are relatively level.

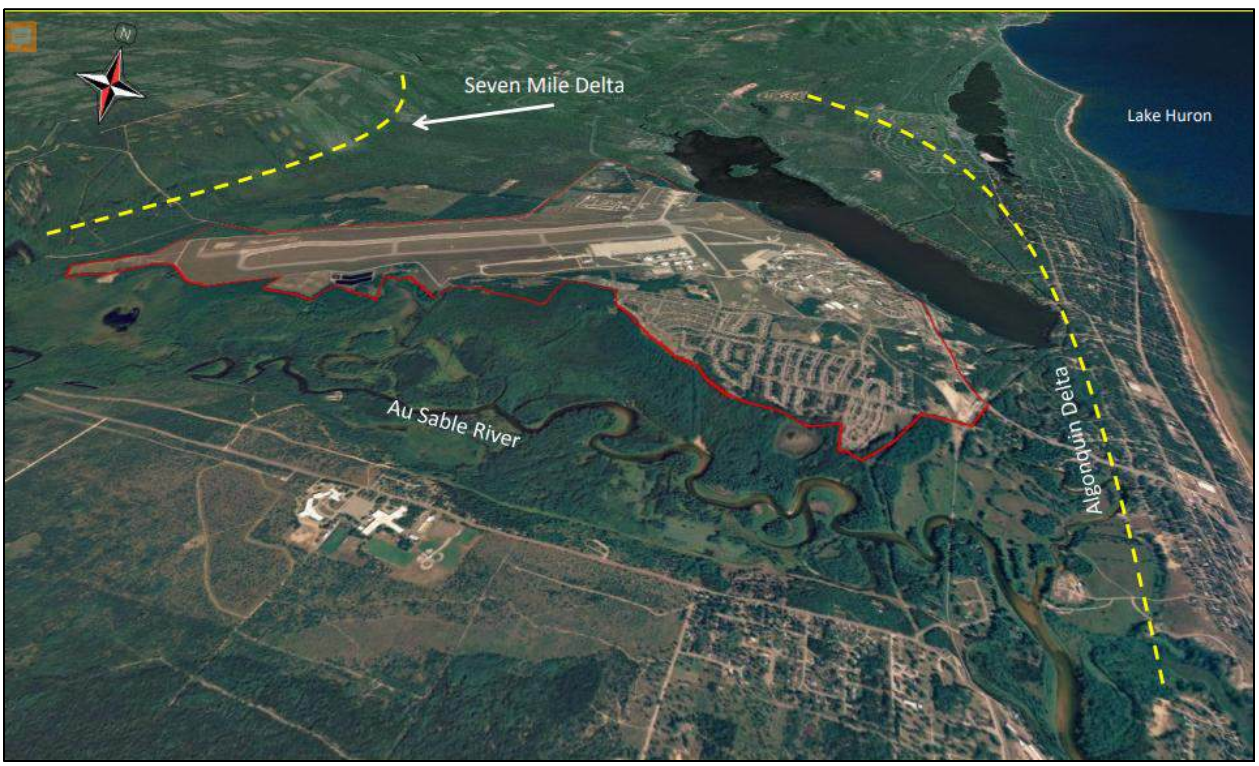

Figure C-7. Elevation Map showing the Algonquin and Seven Mile Delta's in relation to the WAFB and OTD

Cedar Lake WMP (2025)

Attachment D: Aquatic Invasive Species - LakeScan™ Reports (2024)

A Summary of Findings from LakeScan™
Guided Surveys and Analysis of:

Cedar Lake North

Alcona and Iosco Counties

2024 DATA AND ANALYSIS SUMMARY REPORT WITH MANAGEMENT RECOMMENDATIONS

February 25, 2025

Submitted by:

Natalie Crum, Project Manager

Dr. G. Douglas Pullman, PhD, Senior Ecological Adviser

and

Mark S. Kieser, Senior Scientist

Kieser & Associates, LLC

Executive Summary

Kieser & Associates, LLC (K&A) conducted vegetation monitoring on Cedar Lake North (Alcona and Iosco Counties, MI) during the summer of 2024 using LakeScan™ assessment methods. The purpose of these efforts was to assess aquatic vegetation during the summer recreational season in the context of nuisance conditions and management needs/outcomes. LakeScan™ methods combine detailed field data collection with mapping capabilities and whole-lake analyses based on established scientific metrics to score various lake conditions. This approach allows lake managers to readily and consistently identify successful lake management activities, highlight potential issues requiring intervention, and gather critical planning information necessary to improve the ecological and recreational conditions of the lake.

To summarize the overall findings on the lake in 2024, assessed LakeScan™ metrics were averaged across the early and late-season vegetation surveys, revealing that Cedar Lake North met the optimal management goals for all metrics in 2024 (Table ES-1). These findings illustrate improving trends from the conditions observed in 2023, which fell short of the management goals for the Shannon biodiversity index and recreational nuisance presence. These findings additionally indicate that the lake is improving in both species and structural diversity and that nuisance conditions are declining. The high Shannon morphology and biodiversity scores show that the species in the lake are both diverse in type and structure, contributing to greater habitat suitability for aquatic organisms. The consistently high average Floristic Quality Index suggests a high distribution of desirable native plant species and a low distribution of undesirable invasive species. The Algal Bloom Risk rating for Cedar Lake North is “low” reflecting the small proportion of agricultural and urban land use draining to the lake.

Table ES-1 – Summary of lake analysis metrics.

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

The Cedar Lake North early-season LakeScan™ survey was conducted on Monday, July 1, 2024. The most common native species observed during the survey were *Chara* (*Chara sp.*), broadleaf pondweed (*Potamogeton amplifolius)*, Richardson’s pondweed *(Potamogeton richardsonii),* and common bladderwort (*Utricularia vulgaris L*.). Broadleaf pondweed and Richardson’s pondweed were observed at moderate densities around the lake, typically not dense enough to cause any nuisance concerns, except in AROS 370-375, 384, 385, 398, 321, and 341-342, which had broadleaf pondweed growing to the surface.

The aquatic invasive species observed during the early-season survey were hybrid Eurasian watermilfoil (*Myriophyllum spicatum x sibiricum*), *Phragmites* (*Phragmites australis*), and purple loosestrife (*Lythrum salicaria L.*). Distribution of these species was minimal, with Eurasian watermilfoil found in single stand-alone clusters in AROS 342, 343, and 350, *Phragmites* only observed at AROS 361, and purple loosestrife at AROS 340, 351, and 352.

The late-season LakeScan™ survey was conducted on Wednesday, August 7, 2024. The most common native species observed during the survey were, broadleaf pondweed, Richardson's pondweed, and rushes (*Juncus sp.*). In some shoreline AROS locations (321, 338, 347, 348, 371, 373, and 398), tall native pondweeds were growing to the surface which could have caused some minor recreational nuisance conditions, but the patches of pondweeds appeared to be less dense and continuous than what was observed during the early-season survey. The majority of dense native vegetation growth was noted in the excavated trenches (#500 AROS).

The aquatic invasive species observed during the 2024 late-season survey were hybrid Eurasian watermilfoil, *Phragmites*, and purple loosestrife. Eurasian watermilfoil was found in clusters in AROS 357, 358, 368, 567, 577, and 582. The emergent invasive species *Phragmites* and purple loosestrife were found in small clusters along the shoreline, with *Phragmites* at AROS 360, 361, and 364 and purple loosestrife across much of the shoreline.

Over the last five years, variable-leaf watermilfoil (*Myriophyllum heterophyllum)* and hybrid Eurasian watermilfoil coverage on Cedar Lake North have exhibited declining trends (Figure ES-1). Coverage of variable-leaf watermilfoil has decreased by 6% since 2020, remaining consistently under 10% coverage over the last five years (Figure ES-1). Although variable-leaf watermilfoil coverage has declined over the last five years, coverage did increase by roughly 0.4% in the last year, which while minor, might indicate a slight rebound of the species. Eurasian watermilfoil coverage has remained consistently under 1% over the past five years (Figure ES-1). While Eurasian watermilfoil coverages have remained minor across multiple years, the species did increase in coverage by 0.2% in the last year, indicating the possibility of a slight rebound of the species, which was not found during either survey in 2023. Despite slight increases in Eurasian watermilfoil and variable-leaf watermilfoil coverages in the last year, the coverage of these species remains minor and trends are decreasing, indicating that management activities are successfully controlling nuisance watermilfoil populations on a multi-year basis. If milfoil coverage continues to increase in future surveys, alternative management options may need to be explored.

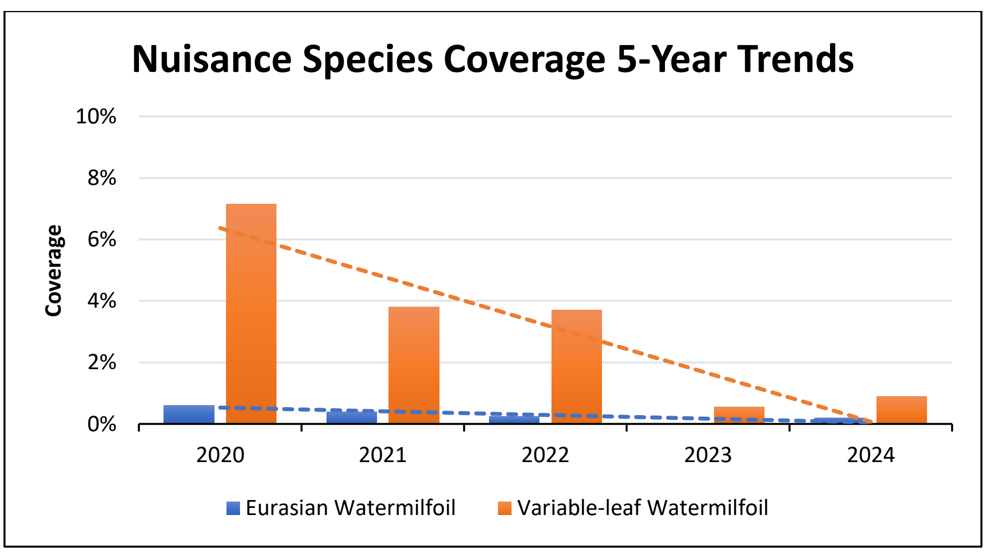

Figure ES-1 – Nuisance species coverage 5-year trends.

Based on 2024 findings, K&A recommends the following management considerations for 2025:

- **Continued management of Eurasian and Variable-leaf watermilfoil.**
    - Watermilfoil coverages have trended downward over the last five years with coverage in 2024 being less than 2%. Thus, current management interventions appear to be effective at suppressing growth and reducing the cumulative coverage of nuisance watermilfoil presence. Despite low coverages in 2024, both species displayed slight increases in coverages over the past year, indicating the possibility of species rebound. Therefore, it is recommended that the Cedar Lake Improvement Board continues exploring management options similar to the ones implemented in 2024 for treating nuisance watermilfoil conditions in the following years.
- **Continued ProcellaCOR applications to treat Eurasian watermilfoil in the northern trenches of Cedar Lake North**.
    - Recent ProcellaCOR applications in Cedar Lake North appear to have been an effective strategy for the management of nuisance hybrid Eurasian watermilfoil. Applications should continue through 2025 to determine if ProcellaCOR continues to be an effective means to control hybrid Eurasian watermilfoil. If coverage trends continue to increase, a re-evaluation of the current treatment regimen may be warranted.
- **Continued monitoring of the coverage and nuisance conditions of variable-leaf watermilfoil.**
    - The treatments in 2020 targeting nuisance variable-leaf watermilfoil were projected to have lasting effects for up to three years. Based on 2021 - 2024 LakeScan™ surveys, the 2020 treatments appear to have continually suppressed nuisance conditions, although the species did have a slight uptick in coverage from 2023 to 2024. It will be important to closely monitor the treatment areas to see if treatment results persist into 2025.
- **Continued monitoring of coverage and nuisance conditions of emergent invasive species.**
    - It will be crucial to monitor and document *Phragmites* coverage in Cedar Lake North following the treatment on September 18, 2024. Close monitoring will reveal the effectiveness of the treatment and inform if follow-up treatments are warranted. An additional on-the-ground survey of the treated areas might be pursued by the lake board to achieve reliable and accurate monitoring data on *Phragmites* populations.
    - Given the increasing shoreline distribution of purple loosestrife, it is recommended that the lake board consider the use of biocontrols over a few seasonal applications to manage the spread of the species. K&A has seen effective, self-sustaining populations of *Galerucella* beetles forage exclusively on purple loosestrife after three years of beetle releases.
- **Monitoring the coverage and nuisance conditions of native pondweed production.**
    - Nuisance pondweed production in Cedar Lake North has been increasing. Pondweeds resembling broad leaf pondweed and Richardson's pondweed may be aggressive hybrids that are increasing in cumulative cover. The Department of the Environment, Great Lakes, and Energy (EGLE) does not permit treatment of pondweeds in many of the nuisance areas in Cedar Lake North. Mechanical harvesting is not regulated in Michigan and can be used as an effective management strategy for nuisance pondweeds where navigation is impaired. This approach should be considered for use if there is a substantial increase in the nuisance production of hybrid native pondweeds.

Table of Contents

1.0. Introduction

Inland lakes are complex systems, and managing them for both ecological health and recreational enjoyment involves balancing goals that are sometimes at odds with one another. Successful lake management requires an understanding of the current ecological and recreational conditions of a lake, as well as how those conditions change over time. The LakeScan™ program combines a detailed data collection methodology with mapping capabilities and whole-lake analysis metrics backed by scientific literature. This analysis allows lake managers to identify successful lake management activities, as well as highlight potential issues requiring intervention. Appropriately targeted aquatic plant suppression can minimize weedy and nuisance species while allowing beneficial species to flourish at ecologically balanced levels supporting healthy lake conditions. This kind of adaptive management system provides a scientifically sound and consistent methodology to better manage lake ecological and recreational conditions.

The LakeScan™ analysis involves collecting data over two vegetation surveys during the critical summer recreational season. These surveys are based on a system where the lake is first divided into biological tiers (Table 1) and then further subdivided into Aquatic Resource Observation Sites (AROS; Figure 1). For each survey, field personnel record the density, distribution, and position in the water column of each aquatic plant species in each AROS, as well as noting any nuisance conditions. Dissolved oxygen profiles, temperature profiles, and Secchi depth are additionally recorded. Other water quality sampling can be included with surveys when requested.

Aquatic plant communities change over the course of a year, so the surveys are split into early and late-season observations. Early-season surveys are scheduled with the goal of taking place within 10 days of early-summer treatments to best observe treatment-targeted and non-targeted vegetation. Late-season surveys are scheduled to occur roughly two months after the early season survey. However, this scheduling is subject to weather and times of increased boat activity.

Table 1 – Biological Tier Descriptions.

Tier*	Description
2	Emergent Wetland
3	Near Shore
4	Off Shore
5	Off Shore, Drop-Off
6	Canals
7	Around Islands and Sandbars
9	Off Shore Island Drop-Off

*Tiers 1 and 8 are reserved for future use.

Figure 1 - Map of Aquatic Resource Observation Sites (AROS).

2.0. Lake and Watershed Characteristics

Location

Counties: Alcona and Iosco

Townships: Greenbush and Oscoda

Township/Range/Section(s): T25N and T24N, R9E Sections: 15, 22, 27, 34, and 3

GPS Coordinates: 44.528853, -83.331903

Morphometry

Total Area: 830 acres

Shoreline Length: 47,339 feet

Maximum Depth: 10 feet

Administrative Management

Management Authority: Cedar Lake Improvement Board

Years in LakeScan™ Program: 2003 to present

2.1. Algal Bloom Risk Level

K&A calculates an algal bloom risk level for each LakeScan™ lake based on the characteristics of its watershed. Agricultural and urban land uses contribute more phosphorus to receiving waters than grasslands or forested land uses; phosphorus being the limiting nutrient that drives algal blooms. Lakes with watersheds that have high proportions of land in agricultural and urban land uses are more likely to be at risk of algal blooms. Not all algal blooms contain cyanobacteria and their associated toxins (Harmful Algal Blooms or HABs). It is important to note that the risk factor reported here is based on a limited watershed analysis. Lakes at high risk of algal blooms should consider more in-depth studies that can identify possible watershed or in-lake improvements to mitigate the risk of HABs.

The algal bloom risk for Cedar Lake South is: **Low**

This risk is a reflection of the summary of watershed land-use composition for Cedar Lake North, which has minor inputs from urban and agricultural sources.

3.0. Dissolved Oxygen and Temperature Profiles

Secchi depth, dissolved oxygen and temperature data were collected during each vegetation survey. Secchi disk transparency is the depth at which a Secchi disk (a flat white or black and white platter, approximately 20 centimeters in diameter) suspended into a lake disappears from the investigator's sight. In general, the greater depth at which the Secchi disk can be viewed, the lower the productivity of the water body. Secchi depth readings of greater than 15 feet can be indicative of low productivity or oligotrophic conditions.[1] Some variation in Secchi disk reporting may be a result of cloud cover, time of day, recent rain events, and recreational lake usage. Dissolved oxygen levels and temperature were measured by K&A using a YSI ProSolo dissolved oxygen meter, calibrated prior to use.

A sufficient supply of dissolved oxygen (DO) in lake water is necessary for most forms of desirable aquatic life. Colder waters contain more dissolved oxygen than warmer waters. In highly productive lakes, oxygen depletion can occur in deeper, unmixed bottom waters during warmer summer months. This decrease in oxygen is due in part to dead algae and other organic matter, such as leaves, grass and plant debris settling to the bottom of the lake and getting consumed, along with oxygen, by organisms in the sediment. DO depletion is most often observed in lake bottom waters during periods of temperature stratification in warmer summer months and, to a lesser degree, under winter ice cover conditions. Shallow lakes, like Cedar Lake, may not experience stratification and would not be expected to have as notable of oxygen depletion in the lake bottom waters compared to deeper bodies of water.

Secchi disk clarity on Cedar Lake North decreased from 9ft (clear to bottom) to 8.1ft between the early and late season surveys. This decrease in water clarity could likely be attributed to a slight increase in lake productivity later in the growing season and/or an increase in turbidity caused by sediment disturbance from swimming, boating, and other recreational activities increasing throughout the summer. The DO and temperature profiles remained consistent across the two surveys with no notable stratification, to be expected due to the shallow depths of the lake (Figures 2 and 3).

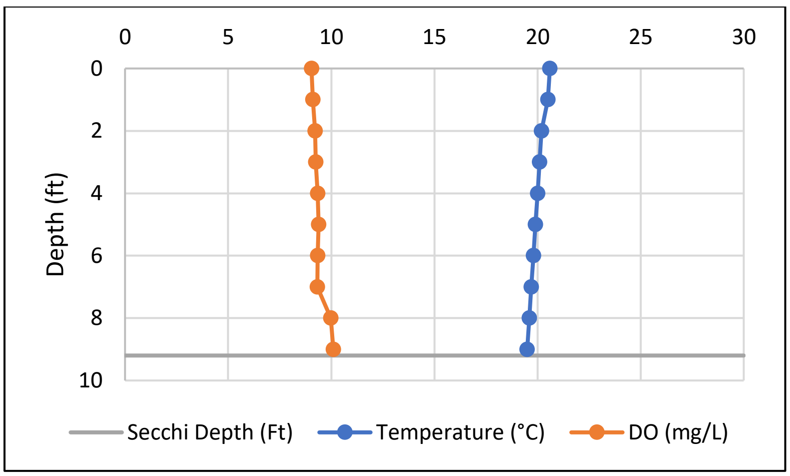

Figure 2 – Early-season survey (7/1/2024) dissolved oxygen and temperature profiles with Secchi depth, taken near AROS 521.

[1]US Geological Survey. 2012. "Water Quality Characteristics of Michigan's Inland Lakes, 2001-10." Scientific Investigations Report 2011–5233. Available online at: https://pubs.usgs.gov/sir/2011/5233/.

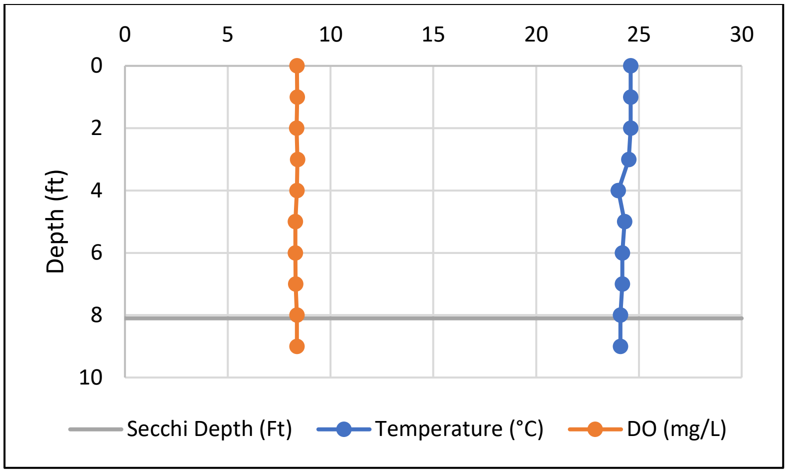

Figure 3 – Late-season survey (8/7/2024) dissolved oxygen and temperature profiles with Secchi depth, taken near AROS 521.

4.0. Aquatic Vegetation

4.1. Early-Season Survey

The Cedar Lake North early-season LakeScan™ survey was conducted on Monday, July 1, 2024. The weather throughout the survey was sunny with temperatures near 72°F and gentle northwestern winds around 3-5 mph. Visibility in the water column was great with a Secchi Disk reading of 9 feet, clear to the bottom. The survey occurred 13 days after the herbicide treatment on Tuesday, June 18, 2024.

A visual depiction of the data on all combined species observed in Cedar Lake North during the early-season survey is displayed using three-dimensional density, which reflects a combination of vegetation density, distribution and height observations for all species observed during the survey (Figure 4). Color-coding is provided for each AROS to spatially depict observed vegetation data. The colors range in a gradient from dark blue which depicts no vegetation observed, to yellow depicting medium density and distribution, to red which depicts high density and distribution of vegetation within the AROS.

The most common native species observed during the survey were *Chara*, broadleaf pondweed, Richardson's pondweed, and common bladderwort. *Chara* was the most commonly observed species and was found at moderate to high densities throughout a majority of observation areas. Broadleaf pondweed and Richardson's pondweed were observed at moderate densities around the lake, often flowering, but typically not dense enough to cause any nuisance concerns. In some shoreline AROS locations (370-375, 384, 385, 398, 321, and 341-342) tall broadleaf pondweed was growing to the surface which were noted as causing nuisance conditions. Variable-leaf watermilfoil was not observed throughout most of the survey, but was common throughout the shallow northern bay of the lake (Figure 5).

The only submerged aquatic invasive species observed in Cedar Lake North during the 2024 early-season survey was hybrid Eurasian watermilfoil. Eurasian watermilfoil was found in single stand-alone clusters in AROS 342, 343, and 350 and did not appear to be very hardy and was expected to drop from the water column on its own (Figure 6). Additionally, the emergent invasive species *Phragmites* and purple loosestrife were found along the shoreline, with *Phragmites* only at AROS 361, and purple loosestrife at AROS 340, 351, and 352, neither causing management concerns at the time of the survey (Figures 7 and 8).

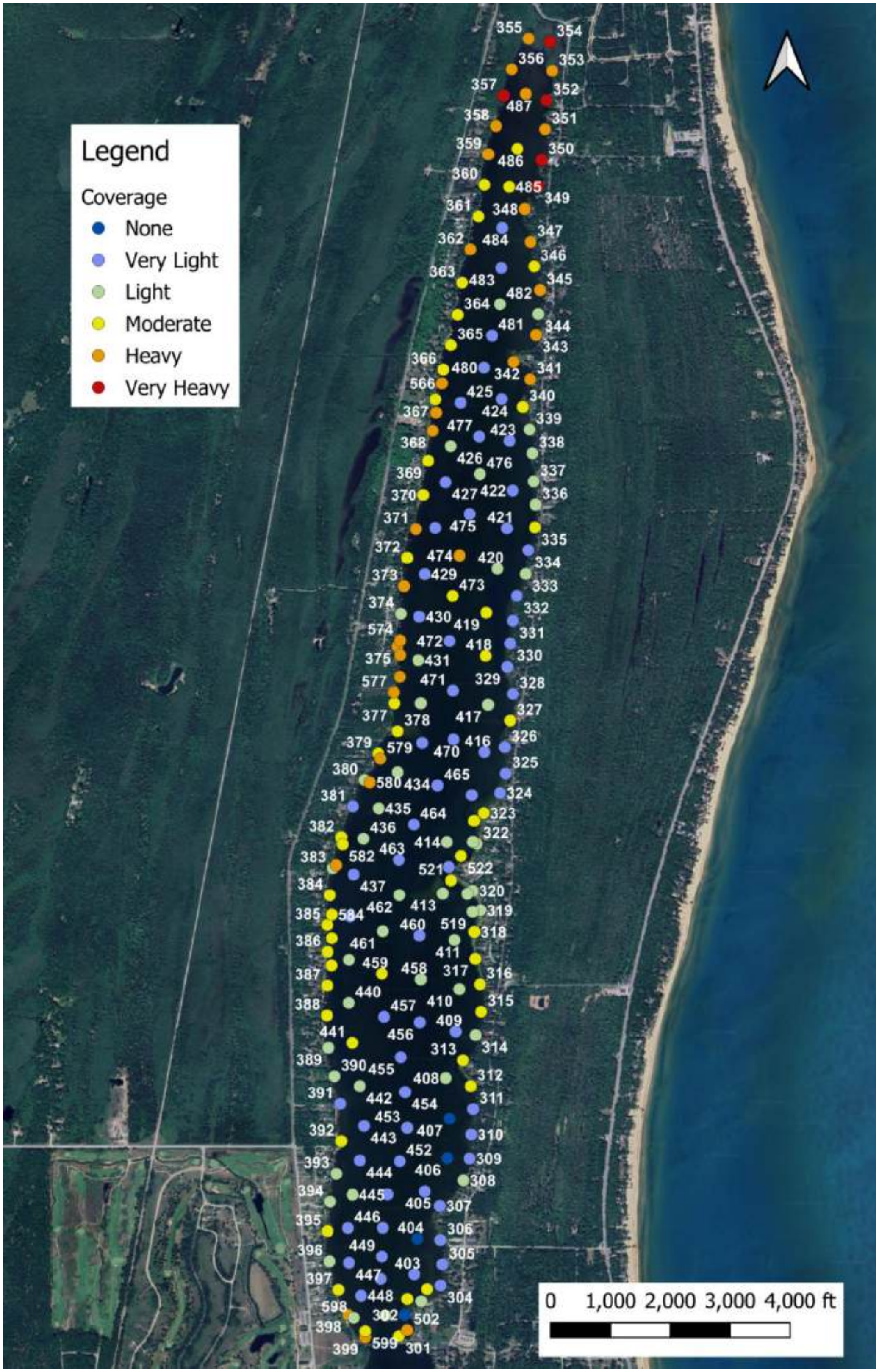

Figure 4 – Early-season survey (7/1/2024) vegetation 3D Density (a function of observed vegetation coverage, and height of all vegetation species).

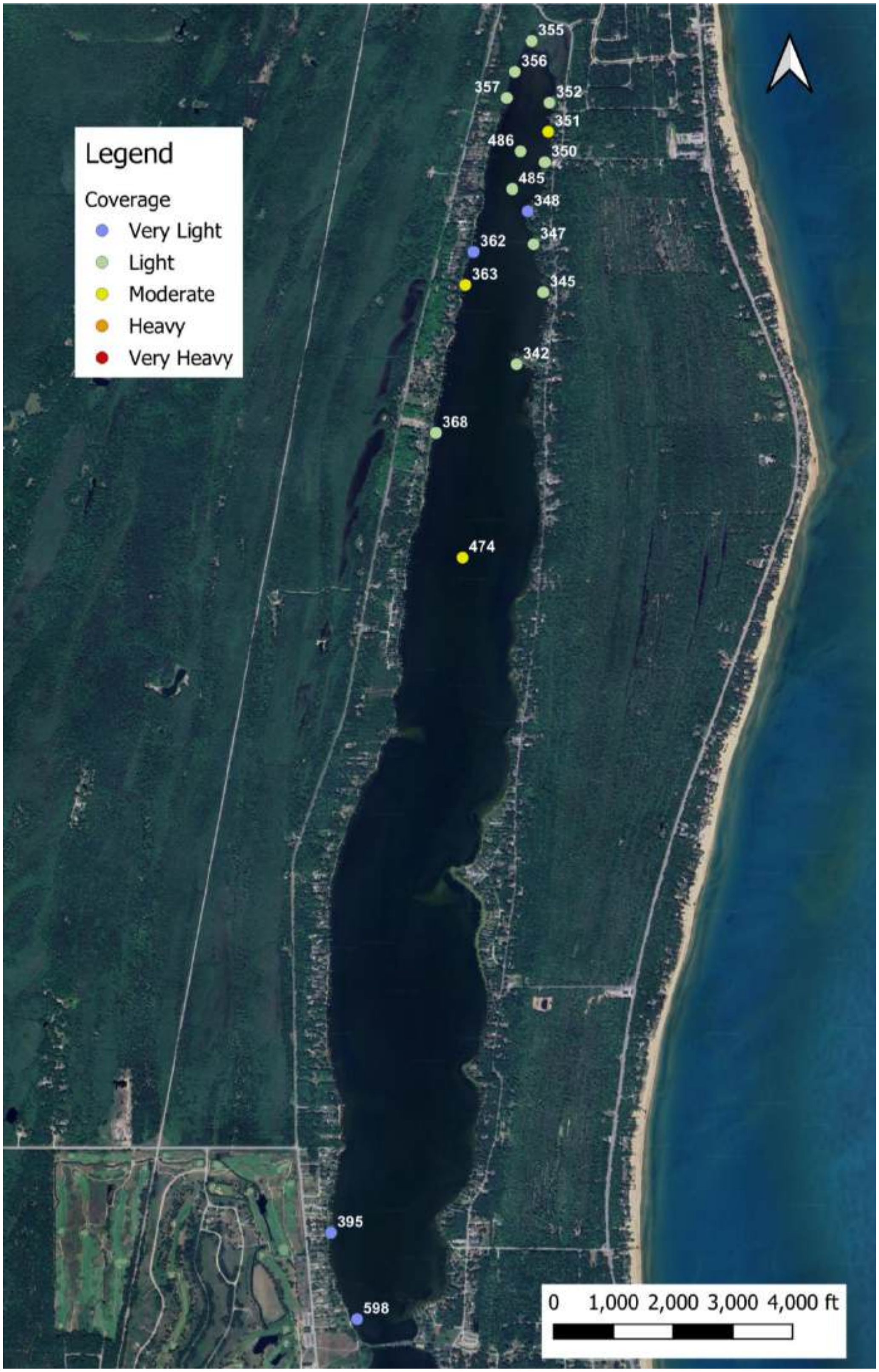

Figure 5 – Early-season (7/1/2024) Variable-leaf watermilfoil coverage (a combination of the LakeScan™ density and distribution observations).

Figure 6 – Early-season (7/1/2024) Eurasian watermilfoil coverage.

Figure 7 – Early-season (7/1/2024) Phragmites coverage.

Figure 8 – Early-season (7/1/2024) purple loosestrife coverage.

4.2. Late-Season Survey

The Cedar Lake North late-season LakeScan™ survey was conducted on Wednesday, August 7, 2024. The weather throughout the survey was sunny with temperatures around 77°F and southeastern winds around 8-12 mph. Visibility in the water column was good with a Secchi Disk reading of 8.1 feet.

A visual depiction of the data on all combined species observed in Cedar Lake North during the late-season survey is displayed using three-dimensional density (Figure 9). The most common native species observed during the survey were *Chara*, broadleaf pondweed, Richardson's pondweed, and rushes. In some shoreline AROS locations (321, 338, 347, 348, 371, 373, and 398) tall native pondweeds were growing to the surface which could cause some minor recreational nuisance conditions. Vegetation growth was the densest in the excavated trenches (#500 AROS) which were typically dominated by *Chara*, wild celery (*Vallisneria americana Michaux),* broadleaf pondweed, and Richardson's pondweed. Similar to conditions observed in the early-season survey, variable-leaf watermilfoil was not commonly observed during the survey, but was found at light coverages in the shallow northern bay of the lake (Figure 10).

The only submerged aquatic invasive species observed in Cedar Lake North during the 2024 late-season survey was hybrid Eurasian watermilfoil. Eurasian watermilfoil was found in clusters in AROS 357, 358, 368, 567, 577, and 582 (Figure 11). The milfoil that was spotted in AROS 342, 343, and 350 in the early-season survey was not observed at the time of the late-season survey. The emergent invasive species *Phragmites* and purple loosestrife were found along the shoreline, with *Phragmites* at AROS 360, 361, and 364. Purple loosestrife was flowering during the time of the survey making it more conspicuous. It was spotted in stand-alone pockets across much of the shoreline (Figure 12). Purple loosestrife was the densest and widely distributed in AROS 340, 352, 358, 360, 368, 376, 380, and 392 (Figure 13).

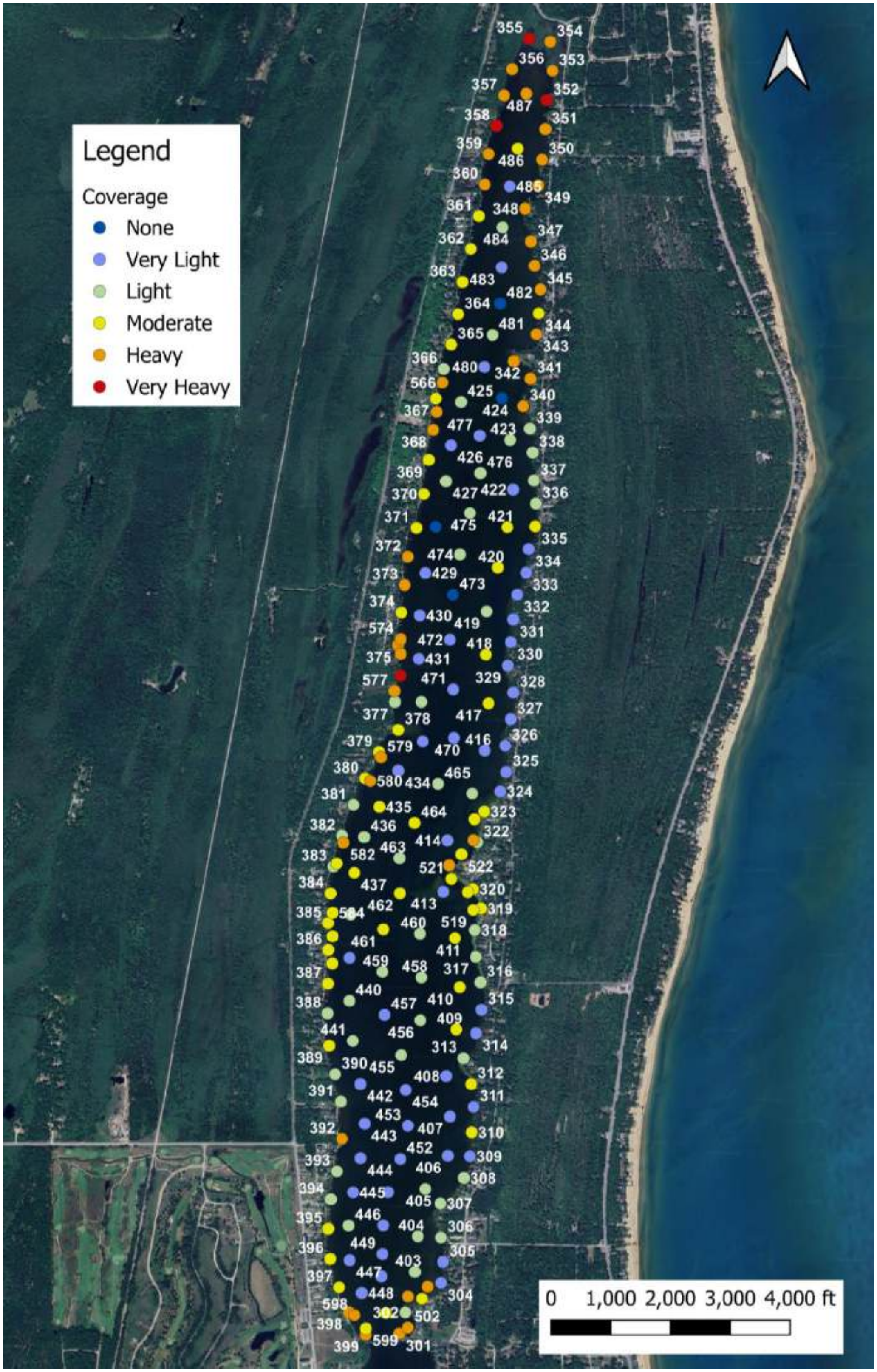

Figure 9 – Late-season survey (8/7/2024) vegetation 3D Density (a function of observed vegetation coverage, and height of all vegetation species).

Figure 10 – Late-season (8/7/2024) Variable-leaf Watermilfoil coverage (a combination of the LakeScan™ density and distribution observations).

Figure 11 – Late-season (8/7/2024) Eurasian watermilfoil coverage.

Figure 12 – Late-season (8/7/2024) Phragmites coverage.

Figure 13 – Late-season (8/7/2024) purple loosestrife coverage.

4.3. Summary Observations for Early and Late-Season Surveys

All aquatic plant species observed during the 2024 vegetation surveys were paired with their associated C-value and recorded for frequency, coverage, and dominance (Table 2). The Coefficient of Conservation, or C-Value, is a qualitative value ranging from 0 to 10 that is assigned to each species representing the estimated probability that it is likely to occur in an environment. A C-value of 0, is given to plants that may be found almost anywhere, while a C-value of 10 is applied to plants that are almost always restricted to high-quality natural areas.[2] 'Frequency' represents the percentage of survey sites (AROS) where a given species was found. 'Coverage' represents the lake bottom spatial cover observed for each species, represented as a percentage of available area. 'Dominance' represents the degree to which a species is more numerous than its competitors.

Table 2- Aquatic Plant Species Observed in 2024.

Common Name	C Value	Frequency		Coverage		Dominance	
		Early '24	Late '24	Early '24	Late '24	Early '24	Late '24
Eurasian Watermilfoil Hybrid	0	1.5%	3.0%	0.1%	0.3%	0.2%	0.5%
Green/Variable Watermilfoil	6	8.9%	4.0%	1.2%	0.6%	2.1%	1.0%
Common Bladderwort	6	34.2%	14.4%	2.3%	1.0%	4.1%	1.8%
Elodea	3	9.9%	0.0%	2.2%	0.0%	3.9%	0.0%
Naiad	6	15.8%	20.8%	1.9%	3.9%	3.5%	7.1%
Chara	7	97.5%	83.2%	18.7%	16.9%	33.3%	30.8%
Flat Stem Pondweed	5	1.0%	0.5%	0.1%	0.1%	0.2%	0.2%
Purple Loosestrife	0	2.5%	29.7%	0.2%	2.2%	0.3%	4.0%
Swamp Loosestrife	7	2.5%	0.0%	0.2%	0.0%	0.3%	0.0%
Richardsons Pondweed	5	37.6%	39.1%	6.7%	7.3%	12.0%	13.3%
Broadleaf Pondweed	6	62.4%	55.4%	7.0%	6.5%	12.4%	11.9%
Hybrid Pondweed	5	25.7%	25.2%	2.9%	2.9%	5.1%	5.3%
Sago Pondweed	3	6.4%	3.0%	1.2%	0.4%	2.1%	0.8%
Thin Leaf Pondweed	4	2.0%	3.5%	0.4%	0.4%	0.7%	0.8%
Wild Celery	7	26.2%	24.8%	3.0%	3.2%	5.3%	5.9%
Rush	8	24.8%	29.2%	2.3%	2.5%	4.1%	4.6%
Waterlily	6	11.9%	16.8%	1.8%	2.6%	3.2%	4.7%
Spadderdock	7	12.4%	16.3%	2.0%	2.2%	3.6%	4.1%
Arrow Arum	6	5.9%	5.0%	1.1%	0.6%	1.9%	1.2%
Cattail	1	7.4%	8.4%	0.9%	1.1%	1.6%	1.9%
Phragmites	0	0.5%	1.5%	0.0%	0.1%	0.1%	20.0%

[2] Michigan Department of Natural Resources Wildlife Division. (n.d.). Floristic Quality Assessment with Wetland Categories and Examples of Computer Applications for the State of Michigan.

4.4. LakeScan™ Metrics

Six important metrics for defining lake conditions are included in the LakeScan™ analyses, where early and late-season scores are averaged for a yearly score and compared against a management goal for each metric (Table 3). Management goals are based on median Michigan lake values (Shannon Biodiversity Index and Shannon Morphology Index), scientific literature (Floristic Quality Index), and professional judgement (Recreational Nuisance Presence and Algal Bloom Risk). Green shading in Table 3 highlights scores meeting management goals, while yellow and red highlights represent scores needing improvement, with red scores being further away from the optimal management goals potentially requiring a higher level of management attention. Descriptions of each of the six metrics are detailed below:

- **Species Richness** – the number of aquatic plant species present in the lake. More species are generally indicative of a healthier ecosystem, but not all species are desirable.
- **Shannon Biodiversity Index** – a measure of aquatic plant species diversity and distribution evenness, indicative of the stability and diversity of the plant community. Also known as the Shannon Expected Number of Species.[3]
- **Shannon Morphology Index** – a measure of aquatic plant morphology type diversity and distribution evenness, indicative of fish and macroinvertebrate habitat quality. This is calculated using morphology types instead of species.
- **Floristic Quality Index**[4] – a measure of the distribution of desirable aquatic plants. This index is used by Midwestern states for aquatic habitats, with higher scores indicative of increased biodiversity and a positive ratio of desirable versus undesirable aquatic plant species.
- **Recreational Nuisance Presence** – the percentage of survey sites that identified aquatic plants inhibiting recreational activities.
- **Algal Bloom Risk** – a calculated algal bloom risk level based on the characteristics of the lake watershed. Lakes with watersheds that have high proportions of land in agricultural and urban land uses are more likely to be at risk of algal blooms because these land uses contribute more phosphorus to receiving waters than grasslands or forests.

Table 3 – 2024 LakeScan™ Metric Results.

LakeScan™ Metric	Score Range	2024 Early Season	2024 Late Season	2024 Average	Management Goal
Species Richness	5 - 30	21	19	20	n/a
Shannon Biodiversity Index	1 -15	10.2	10.1	10.2	> 8.8
Shannon Morphology Index	1 - 10	9.1	8.8	9.0	> 6.3
Floristic Quality Index	1 - 40	27.6	25.7	26.7	> 20
Recreational Nuisance Presence	0 - 100%	9%	5%	7%	< 10%
Algal Bloom Risk	Low-High	n/a	n/a	Low	Low

*n/a = not applicable

[3] Hill, M. O. (1973). Diversity and evenness: a unifying notation and its consequences. *Ecology*, 54(2), 427-432.
[4] Nichols, S. A. (1999). Floristic quality assessment of Wisconsin lake plant communities with example applications. *Lake and Reservoir Management*, 15(2), 133-141.

The assessed LakeScan™ metrics for both the early and late-season surveys on Cedar Lake North met all management goals in 2024. These metrics also had very limited variability between the two surveys, indicating a high level of lake stability throughout 2024. Compared to 2023, which fell short of the management goals for the Shannon biodiversity index and recreational nuisance presence, the survey metrics from 2024 show improving trends. These findings indicate that the lake is improving in both species and structural diversity and that nuisance conditions are declining.

The high Shannon morphology and biodiversity indices indicate that the species in the lake are both diverse in type and structure, contributing to greater habitat suitability for aquatic organisms. The consistently high average Floristic Quality Index suggests a high distribution of desirable, native plant species and a low distribution of undesirable invasive species.

Over the past five years, the Floristic Quality Index on Cedar Lake North has exhibited a positive trend, indicating an increase in desirable, native plants and a decrease in undesirable, invasive aquatic species (Figure 14). Cedar Lake North Lake has met the FQI management score of 20 for the past the last five years, displaying a high level of floristic quality that is maintained from year-to-year by the current management regimen.

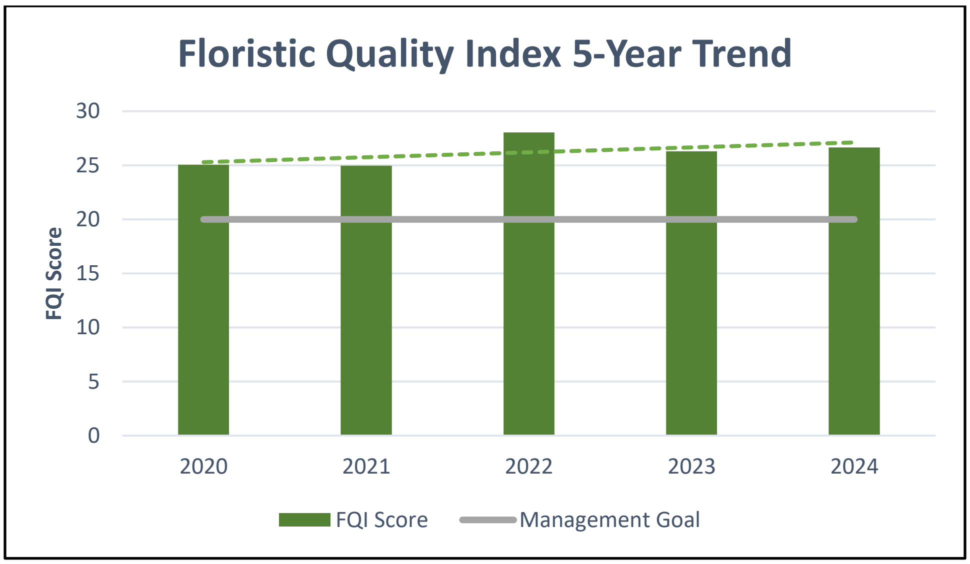

Figure 14 – Floristic Quality Index 5-Year Trend.

Despite Eurasian watermilfoil and variable-leaf watermilfoil coverage increasing slightly from 2023, the coverage of both species has generally declined over the past five years (Figure 15). Variable-leaf watermilfoil coverage on Cedar Lake North has decreased by 6% since 2020 and has remained consistently under 10% coverage throughout the last five years. Although variable-leaf watermilfoil coverage has generally declined over the last five years, coverage did increase by roughly 0.4% in 2024, which while minor, might indicate a rebound of the species. Eurasian watermilfoil coverage has remained consistently under 1% over the past five years. The species did increase in coverage by 0.2% in the last year, indicating a potential of a slight rebound of the species, which was not found during either of the 2023 surveys. Despite slight increases in Eurasian watermilfoil and variable leaf-watermilfoil coverages in the last year, the overall coverage of these species remains minor, indicating that management activities are successfully controlling nuisance watermilfoil populations.

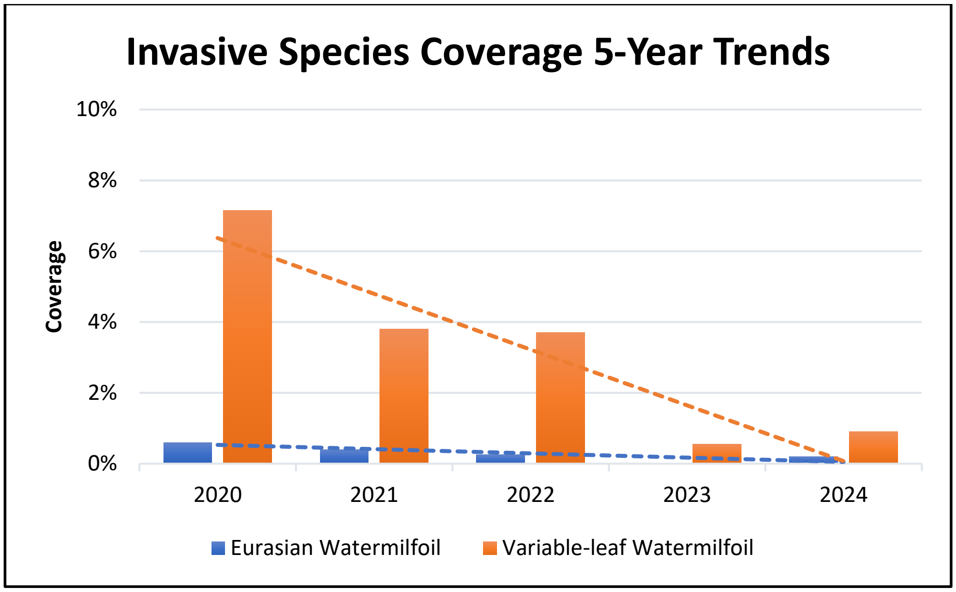

Figure 15 – Nuisance Species Coverage 5-Year Trends.

5.0. Lake Management

There are several species that typically become a nuisance in Michigan's inland lakes, these species are usually targeted for selective control to prevent them from becoming an aesthetic or recreational nuisance and to protect desirable plants that are part of healthy lake ecosystems. More information on common nuisance species in Michigan and their associated management options can be found in Appendix A. Treatment maps and data displaying acreage, herbicides, and targeted species for Cedar Lake North in 2024 can be found in Appendix B (note that the chemical tables provided in the ANC report are not split by North and South lakes).

A total of two chemical herbicide treatments were conducted by Solitude Lake Management on Cedar Lake North in 2024. The first chemical herbicide treatment took place on Tuesday, June 18, 2024, 13 days prior to the early-season survey. Solitude reported that the treatment targeted roughly 13.25 acres using treatment applications that target hybrid Eurasian watermilfoil, curly-leaf pondweed, starry stonewort (*Nitellopsis obtusa*), and algae using Tribune, Cutrine Plus, ProcellaCOR, and Hydrothol 191. The treatment areas were primarily relegated to the excavated trenches on the western edge of the lake; Hydrothol 191 was only used in the northern-most trench.

It is important to note that the "species targeted" descriptors provided by Solitude and included in Appendix B Figure B3 include curly-leaf pondweed and starry stonewort as treated species for the June 18th treatment despite neither of the species being noted in the lake for over a decade. Future species treated references provided by the applicator should be made consistent with pre-season survey findings and mutually-agreed upon target species, for accuracy in reporting. Where new invasive species are suspected by the applicator, immediate notification to K&A should otherwise be made and treatments recommendations discussed.

The second and final chemical herbicide treatment occurred on September 18, 2024, targeting roughly 1.25 acres of *Phragmites* and 4.5 acres of hybrid Eurasian watermilfoil. The treatment regimen targeted species using Tribune, Cutrine plus, Habitat, Aquaneat, and Cygnet plus.

During the early-season survey, which occurred 13 days after the first herbicide treatment, Eurasian watermilfoil was found at 0.1% coverage and grew slightly to 0.3% by the late-season. Both coverages of Eurasian watermilfoil were higher in 2024 than what was observed in 2023 which had 0% coverage across both surveys. However, this species has still maintained low and manageable levels of coverage at less than 1%, indicating a general multi-year success of herbicide treatments on managing the spread of hybrid Eurasian watermilfoil in Cedar Lake North (Figure 16).

Variable-leaf watermilfoil had higher coverages than the Eurasian watermilfoil with 1.2% coverage in the early season and 0.6% in the late season. The slight decline of the species from the early to late-season surveys and the relatively low overall coverages of less than 2%, further demonstrates the effectiveness and long-term success of the treatment regimen for variable-leaf watermilfoil.

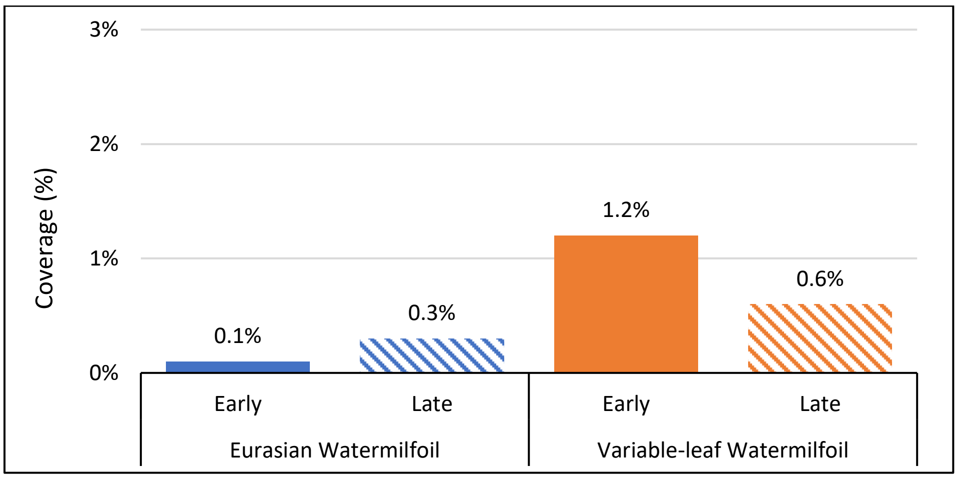

Figure 16 – Changes in coverage across both surveys for targeted species.

5.1. Management Recommendations

Watermilfoil coverages have trended downward over the last five years with coverage in 2024 being less than 2%. Thus, current management interventions appear to be effective at suppressing growth and reducing the cumulative coverage of nuisance watermilfoil presence. Despite low coverages in 2024, both species displayed slight increases in coverages over the past year, indicating the possibility of species rebound. Therefore, it is recommended that the Cedar Lake Improvement Board continues exploring management options similar to the ones implemented in 2024 for treating nuisance watermilfoil conditions in the following years.

Recent ProcellaCOR applications in Cedar Lake North appear to have been an effective strategy for the management of nuisance hybrid Eurasian watermilfoil. Applications should continue through 2025 to determine if ProcellaCOR continues to be an effective means to control hybrid Eurasian watermilfoil. If coverage trends continue to increase, a re-evaluation of the current treatment regimen may be warranted.

The treatments in 2020 targeting nuisance variable-leaf watermilfoil were projected to have lasting effects for up to three years. Based on 2021-2024 LakeScan™ surveys, the 2020 treatments appear to have continually suppressed nuisance conditions, although the species did have a slight uptick in coverage from 2023-2024. It will be important to closely monitor the treatment areas to see if treatment results persist into 2025.

It will be crucial to monitor and document *Phragmites* coverage in Cedar Lake North following the treatment on September 18, 2024. Close monitoring will reveal the effectiveness of the treatment and inform if follow-up treatments are warranted. An additional on-the-ground survey of the treated areas might be pursued by the CLIB to achieve reliable and accurate monitoring data on *Phragmites* populations.

Given the increasing shoreline distribution of purple loosestrife, it is recommended that the lake board consider the use of biocontrols over a few seasonal applications to manage the spread of the species. K&A has seen effective, self-sustaining populations of *Galerucella* beetles forage exclusively on purple loosestrife after three years of beetle releases.

Nuisance pondweed production in Cedar Lake North has been increasing. Pondweeds resembling broad leaf pondweed and Richardson's pondweed may be aggressive hybrids that are increasing in cumulative cover in the lake. The Department of the Environment, Great Lakes, and Energy (EGLE) does not permit treatment of pondweeds in many of the nuisance areas in Cedar Lake North. Mechanical harvesting is not regulated in Michigan and can be used as an effective management strategy for nuisance pondweeds. This approach should be considered for use in 2025 if there is a substantial increase in the nuisance production of hybrid native pondweeds.

6.0. Appendices

6.1. Appendix A: Information About Nuisance and Aquatic Invasive Species

Algal Blooms

Blue green algae blooms are becoming increasingly common in Michigan. Blooms can appear as though green latex paint has been spilled on the water, or resemble an oil slick in enclosed bays or along leeward shores. Blue green algae blooms are usually temporal events and may disappear as rapidly as they appear. Blue green algae blooms are becoming more common for a variety of reasons; however, the spread and impact of zebra mussels has been closely associated with blooms of blue green algae.

Figure A1 - Example blue green algae images from the 2019 LakeScan™ field crew.

Blue green algae are really a form of bacteria known as cyanobacteria. They are becoming an important issue for lake managers, riparian property owners and lake users because studies have revealed that substances made and released into the water by some of these nuisance algae can be toxic or carcinogenic. They are known to have negative impacts on aquatic ecosystems and can potentially poison and sicken pets, livestock, and wildlife. Blue green algae can have both direct and indirect negative impacts on fisheries. Persons can be exposed to the phytotoxins by ingestion or dermal absorption (through the skin). They can also be exposed to toxins by inhalation of aerosols created by overhead irrigation, strong winds, and boating activity.

Approximately one half of blue green algae blooms contain phytotoxins, and this is determined through lab testing. It is recommended that persons not swim in waters where blue green algae blooms are conspicuously present. Specifically, persons should avoid contact with water where blooms appear as though green latex paint has been spilled on the water, or where the water in enclosed bays appears to be covered by an "oil slick". Pets should be prevented from drinking from tainted water. Since blue green algae toxins can enter the human body through the lungs as aerosols, it is suggested that water containing obvious blue green algae blooms not be used for irrigation in areas where persons may be exposed to it.

Blue green algae are not very good competitors with other, more desirable forms of algae. They typically bloom and become a nuisance when resources are limiting or when biotic conditions reach certain extremes. Some of the reasons that blue green algae can bloom and become noxious are listed below:

TP and TN: The total phosphorus (TP) concentration in a water resource is usually positively correlated with the production of suspended algae (but not rooted plants, i.e. seaweed). Very small amounts of phosphorus may result in large algae blooms. If the ratio of total nitrogen (TN) to total phosphorus is low (<20), suspended algae production may become nitrogen limited and noxious blue green algae may dominate a system because they are able to “fix” their own nitrogen from atmospheric sources. Other common and desirable algae are not able to do this.

Biotic Factors: Zebra mussels and zooplankton (microscopic, free-floating animals) are filter feeding organisms that strain algae and other substances out of the lake water for food. Studies have shown that filter-feeding organisms often reject blue green algae and feed selectively on more desirable algae. Over time, and given enough filter feeding organisms, a lake will experience a net loss in “good” algae and a gain in “bad” blue green algae as the “good” algae are consumed and the “bad” algae are rejected back into the water column. This is one of the most disturbing factors associated with the invasion and proliferation of zebra mussels. Lakes that are full of zebra mussels may not support the production of “good” algae and experience a partial collapse of the system of “good” algae that are necessary to support the fishery.

Eurasian Watermilfoil and Hybrids:

Background: Anecdotal evidence suggests that hybrid milfoil has been found in Michigan inland lakes for a long time (since the late 1980’s). University of Connecticut professor Dr. Don Les was the first to determine that there were indeed, Eurasian watermilfoil and northern watermilfoil hybrids in Michigan based on samples sent to his Connecticut lab by Dr. Douglas Pullman, Aquest Corp. in 2003. Experience has proven that it is usually not possible to determine whether the milfoil observed is either Eurasian or hybrid genotype. However, because they play such similar roles in lake ecology, they are simply “lumped together” and referred to collectively as Eurasian watermilfoil. Eurasian watermilfoil is a very common nuisance in many Michigan inland lakes.

Management: Lake disturbance, such as weed control, unusual weather, and heavy lake use can destabilize the lake ecosystem and encourage the sudden nuisance bloom of weeds, like Eurasian watermilfoil. Eurasian watermilfoil is an ever-present threat to the stable biological diversity of the lake ecosystem. Species selective, systemic herbicide combinations have been used to suppress the nuisance production of Eurasian watermilfoil and support the production of a more desirable flora. However, it is becoming much more resistant to herbicidal treatment and herbicide resistant Eurasian watermilfoil and hybrid watermilfoil has been observed in many lakes throughout the Midwest.[5,6] Continued chemical applications can select for herbicide resistant plants, resulting in hybrid watermilfoil.[7] Some research suggests this resistance can be defeated with the use of microbiological system treatments. Milfoil community genetics are dynamic and careful monitoring is needed to adapt to the expected changes in

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[5] Berger, S. T., Netherland, M. D., & MacDonald, G. E. (2015). Laboratory documentation of multiple-herbicide tolerance to fluridone, norflurazon, and topramazone in a hybrid watermilfoil (*Myriophyllum spicatum× M. sibiricum)* population. Weed Science, 63(1), 235-241.

[6] Netherland, M. D., & Willey, L. (2017). Mesocosm evaluation of three herbicides on Eurasian watermilfoil (*Myriophyllum spicatum*) and hybrid watermilfoil (*Myriophyllum spicatum x Myriophyllum sibiricum*): Developing a predictive assay. J. Aquat. Plant Manage, 55, 39-41.

[7] Netherland and Willey, 2017

the dominance of distinct milfoil genotypes. Some of these genotypes may be more herbicide resistant than others and treatment strategies must be adjusted to remain effective in different parts of the lake.

Figure A2 - Example Eurasian Watermilfoil and Hybrids images from the 2019 LakeScan™ field crew.

Starry Stonewort

Background: Starry stonewort, a macroalgae native to northern Eurasia, invaded North American inland lakes after becoming established in the St. Lawrence Seaway/Great Lakes system. Though not positively identified in a Michigan inland lake until 2006, by Aquest Corporation in Lobdell Lake, Genesee County, starry stonewort has likely been present in Michigan's inland lakes since the late 1990's. Since then, this invasive species has spread throughout Michigan. Able to spread by both fragmentation and asexual reproduction, starry stonewort has thrived in Michigan's high-quality oligotrophic and mesotrophic lakes, particularly those with marl sediments. Once established, this opportunistic species will bloom and crash and impose a very significant and deleterious impact on many ecosystem functions. Bloom and crash events are unpredictable and can happen at any time of the year. In some years starry stonewort can become a horrendous nuisance while it can be inconspicuous in others. It can comingle with other similar species and be very difficult to find when it is not blooming.

Management: Starry stonewort is capable of growing to extreme nuisance levels and can significantly impact important ecosystem functions. This species is difficult to control due to its asexual reproductive structures (bulbils) which embed in lake sediments.[8] While many strategies have been employed to manage starry stonewort, no single strategy has emerged as a panacea for controlling infestations.

Diver-assisted suction harvesting (DASH) or diver-assisted hand-pulling of small starry stonewort infestations could reduce populations over time.[9] While these methods can be effective and have high specificity, they are expensive, labor-intensive strategies that require long-term commitment.[10] These strategies may not be viable for large-scale infestations, however, due to their labor-intensive nature

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[8] Glisson, W. J., Wagner, C. K., McComas, S. R., Farnum, K., Verhoeven, M. R., Muthukrishnan, R., & Larkin, D. J. (2018). Response of the invasive alga starry stonewort (*Nitellopsis obtusa*) to control efforts in a Minnesota lake. Lake and Reservoir Management, 34(3), 283-295.

[9] Glisson et al., 2018.

[10] Larkin, D.J., Monfils, A.K., Boissezon, A., Sleithd, R.S., Skawinski, P.M., Welling, C.H., Cahill, B.C., and Karold, K.G. 2018. Biology, ecology, and management of starry stonewort (*Nitellopsis obtusa*; Characeae): A Red-listed Eurasian green alga invasive in North America. https://doi.org/10.1016/j.aquabot.2018.04.003

and their potential for increasing distribution of the target plant species through fragmentation during removal.

Starry stonewort chemical treatments using copper-, diquat-, flumioxazin, and endothall-based algaecides have produced mixed results and long-term management has yet to be achieved using chemical biocides alone.[11] While starry stonewort is susceptible to most selective algaecides, the dense mats of vegetation are very difficult to penetrate and provide reasonable biocide exposure. Consequently, multiple algaecide applications may be required to "whittle down" dense starry stonewort growth if the mats reach sufficient height.

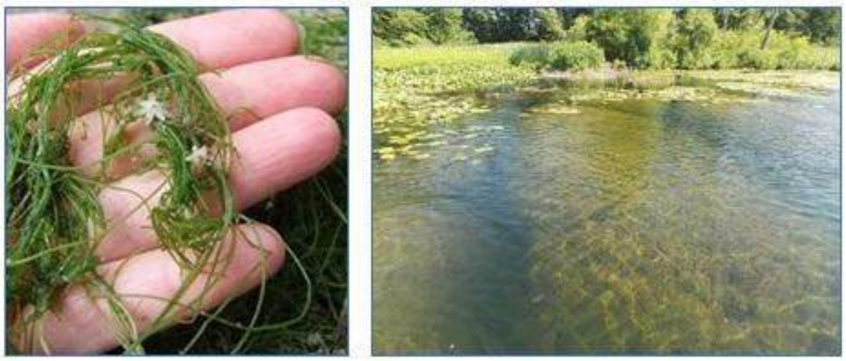

Figure A3 - Example starry stonewort images from the 2019 LakeScan™ field crew.

Curly Leaf Pondweed

Background: Curly leaf pondweed is one of the world's most widespread aquatic plant species. Although it is found worldwide, curly-leaf pondweed is native to only Eurasia. The earliest verifiable records of the plant are from Pennsylvania in the 1840s, and has been found in Michigan since 1910. Curly leaf pondweed is currently found in inland lakes of 34 counties in Michigan, distributed both in the upper and lower peninsulas. [12] Scientific literature suggests that curly leaf pondweed is an aggressively growing species that often expands to nuisance levels when native plants are damaged.

Curly leaf pondweed can create problems such as recreational nuisances, ecological nuisances (by outcompeting native species and reducing light availability to other plants), and degraded fish spawning habitat. Curly leaf pondweed is easily detectable in early spring as it will be one of the few plants readily growing and the first submersed plant to reach the surface. This gives it a competitive advantage and can grow 4 to 5 feet tall before other plants begin germinating from the bottom sediments. As water temperatures rise in late June and early July, curly-leaf pondweed stems begin to die, break down, and can be completely gone by mid-July.[13]

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[11] Pokrzywinski, K. L., Getsinger, K. D., Steckart, B., & Midwood, J. D. (2020). Aligning research and management priorities for *Nitellopsis obtusa* (starry stonewort).
[12] MDEQ. (2018). "State of Michigan's Status and Strategy for Curly-leafed Pondweed (*Potamogeton crispus L.*)." Accessed online: <https://www.michigan.gov/documents/invasives/egle-ais-potamogeton-crispus_708948_7.pdf>.
[13] Hart, Steven, M. Klepinger, H. Wandell, D. Garling, L. Wolfson. (2000). "Integrated Pest Management for Nuisance Exotics in Michigan Inland Lakes." Accessed online: <https://www.michigan.gov/documents/invasives/egle-great-lakes-aquatics-IPM-manual_708904_7.pdf>.

Management: Like other invasive species, curly-leaf pondweed is difficult to control once established and is considered widespread in Michigan. Therefore, prevention of new populations in uninfected waters is the most economical management approach. Several herbicides have been shown to be effective at long-term control of curly-leaf pondweed, but eradication is difficult after establishment. Bottom barriers have shown effectiveness at combating curly-leaf pondweed in small areas, and mechanical harvesting of curly-leaf pondweed can be effective if timed and managed correctly.[14]

The most viable ways to control curly-leaf pondweed is through chemical and physical means after developing an integrated pest management plan. Early infestations may best be controlled by manual removal, diver-assisted suction harvesting (DASH), or benthic barrier use during spring before turions are produced. Aquatic herbicides including endothall, diquat, and flumioxazin are the most effective for general applications. Aquatic herbicides including flumioxazin and imazamox are effective for specific types of application and in specific environments. Chemical treatments are a part of a long-term integrated management plan as the turions are viable for at least 5 years and only diquat, fluridone, and some hormone treatments have shown a reduction of turion development in the laboratory.[15]

Figure A4 - Example curly leaf pondweed image from the 2021 LakeScan™ field crew.

[14] MDEQ, 2018.
[15] MDEQ, 2018.

6.2. Appendix B: Herbicide Applicator Data and Maps

Date of treatment (one per section): 6/18/2024							
Name of person applying chemical: Michael Rohlman							
Name of Company or NA if not applicable: Solitude Lake Management							
Effectiveness: ■ Good (70-100%) ☐ Fair (50-69%) ☐ Poor (less than 50%) ☐ Ineffective (0%)							
Chemical Brand Used	EPA Registration Number	Method of Application	Application Rate (10 lbs./acre, etc.)	Treatment Area Size: (Acres)	Average Depth (Feet)	Total Amount (4 gallons, 10 lbs., etc.)	For Control of: (Plant and/or Algae names)
Tribune	100-1390	Surface Spray/Sub Surface Injection	1 gal/acre	7.5	3	7.5 gal	Eurasion Water Milfoil/Curlyleaf Pondweed
Cutrine Plus	67690-93	Surface Spray/Sub Surface Injection	.33 gal/acre-foot	7.5	3	7.5 gal	Macro-algaeStarry Stonewort
Hydrothol 191	70506-175	Surface Spray/Sub Surface Injection	1.33 pint/acre-foot	4.5	3	2.25 gal	Macro-algaeStarry Stonewort
Procellacor EC	67690-80	Surface Spray/Sub Surface Injection	25.6 fl oz/acre-foot	10.25	6	1574 oz	Eurasion Water Milfoil
Tribune	100-1390	Surface Spray/Sub Surface Injection	1 gal/acre	10.25	6	10.25 gal	Eurasion Water Milfoil/Curlyleaf Pondweed
Cutrine Plus	67690-93	Surface Spray/Sub Surface Injection	.17 gal/acre-foot	8.75	6	8.75 gal	Algae
Aquathol K	70506-176	Surface Spray/Sub Surface Injection	1 gal/acre	3	3	3 gal	Curly-leaf Pondweed

Figure B1 – Solitude Lake Management Aquatic Nuisance Control (ANC) treatment report for Cedar Lake, Alcona and Iosco counties, on June 18, 2024.

Date of treatment (one per section): 9/18/2024							
Name of person applying chemical: Michael Rohlman							
Name of Company or NA if not applicable: Solitude Lake Management							
Effectiveness: ■ Good (70-100%) ☐ Fair (50-69%) ☐ Poor (less than 50%) ☐ Ineffective (0%)							
Chemical Brand Used	EPA Registration Number	Method of Application	Application Rate (10 lbs./acre, etc.)	Treatment Area Size: (Acres)	Average Depth (Feet)	Total Amount (4 gallons, 10 lbs., etc.)	For Control of: (Plant and/or Algae names)
Tribune	100-1390	Surface Spray	2 gal/acre	4.5	3	9 gal	Eurasion Water Milfoil
Cutrine Plus	67690-93	Surface Spray	.33 gal/acre-foot	4.5	3	4.5 gal	Algae
Habitat	241-426-67690	Foliage Spray	2 pint/acre-foot	1.25	1	2.5 pint	Phragmites
Aquaneat	228-365	Foliage Spray	2 pint/acre-foot	1.25	1	2.5 pint	Phragmites
Cygnet Plus	N/A	Foliage Spray	.5 pint/acre-foot	1.25	1	.625 pint	Phragmites

Figure B2 – Solitude Lake Management Aquatic Nuisance Control (ANC) treatment report for Cedar Lake, Alcona and Iosco counties, on September 18, 2024.

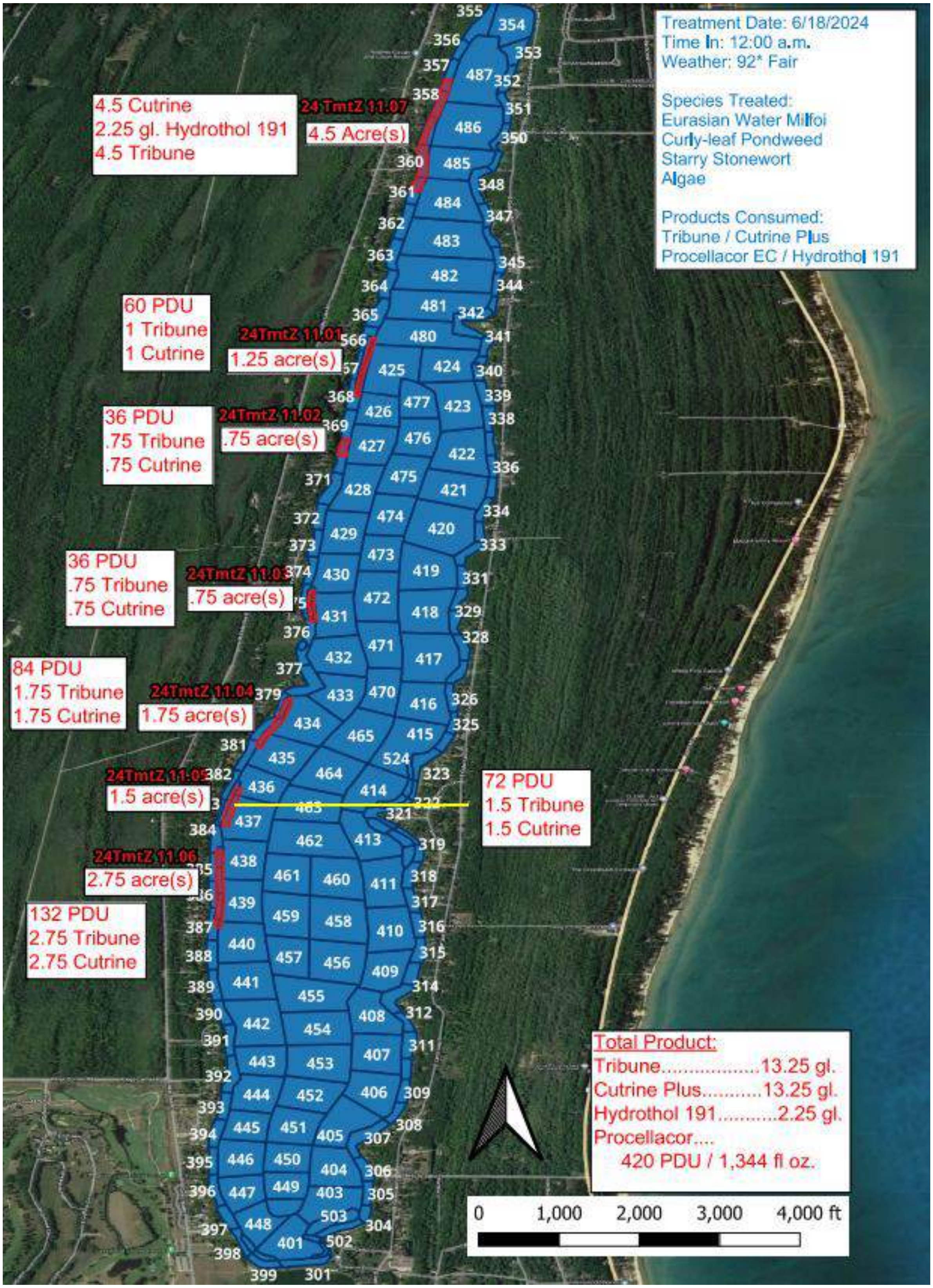

Figure B3 – Solitude Lake Management treatment map for Cedar Lake, Alcona and Iosco counties, on June 18, 2024.

Treatment Date: 9/18/2024
Time In: 12:00 P.M.
Weather: 78* Fair

Species Treated:
Eurasian Water Milfoil
Phragmites

Products Consumed:
Tribune
Cutrine Plus
Habitat
Aqua-neat
Cygnet Plus

Figure B4 – Solitude Lake Management treatment map for Cedar Lake, Alcona and Iosco counties, on September 18, 2024.

A Summary of Findings from LakeScan™
Guided Surveys and Analysis of:

Cedar Lake South

Iosco County

2024 DATA AND ANALYSIS SUMMARY REPORT WITH MANAGEMENT RECOMMENDATIONS

February 25, 2025

Submitted by:
Natalie Crum, Project Manager
Dr. G. Douglas Pullman, PhD, Senior Ecological Adviser
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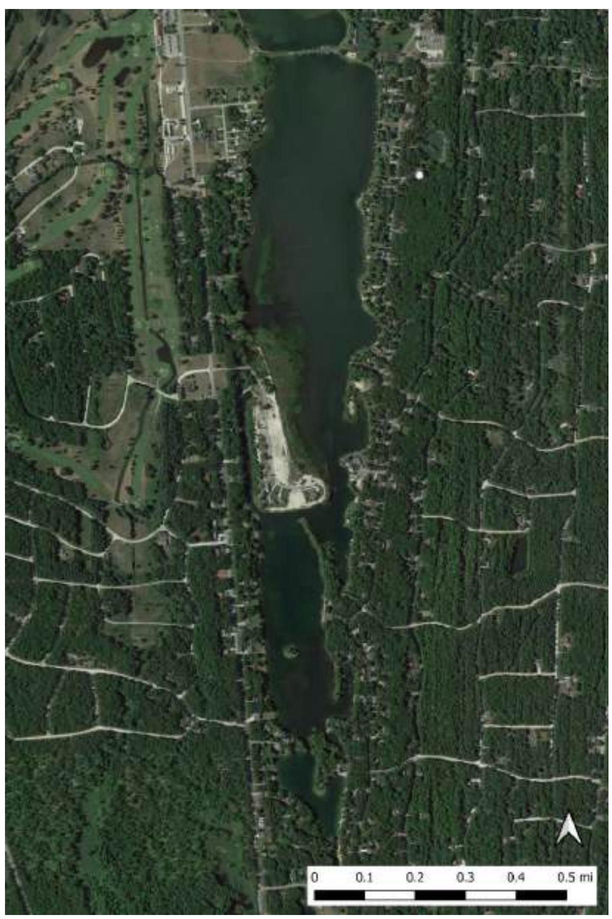
Kieser & Associates, LLC



Executive Summary

Kieser & Associates, LLC (K&A) conducted vegetation monitoring on Cedar Lake South (Iosco County, MI) during the summer of 2024 using LakeScan™ assessment methods. The purpose of these efforts was to assess aquatic vegetation during the summer recreational season in the context of nuisance conditions and management needs/outcomes. LakeScan™ methods combine detailed field data collection with mapping capabilities and whole-lake analyses based on established scientific metrics to score various lake conditions. This approach allows lake managers to readily and consistently identify successful lake management activities, highlight potential issues requiring intervention, and gather critical planning information necessary to improve the ecological and recreational conditions of the lake.

To summarize the overall findings on the lake in 2024, assessed LakeScan™ metrics were averaged across the early and late-season vegetation surveys, revealing that Cedar Lake South met the optimal management goals for all metrics in 2024 (Table ES-1). These findings illustrate stable year-to-year trends when compared to the conditions observed in 2023, which also met all LakeScan™ management goals. These results indicate that the lake continues to have favorable diversity in both species and structure and nuisance conditions are being managed effectively. The consistently high average Floristic Quality Index score on Cedar Lake South suggests a high distribution of desirable native plant species and a low distribution of undesirable invasive species. The Algal Bloom Risk rating for Cedar Lake South is "low" reflecting the small proportion of agricultural and urban land use draining to the lake.

Table ES-1 – Summary of lake analysis metrics.

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

The Cedar Lake South early-season LakeScan™ survey was conducted in the afternoon of Monday, July 1, 2024 and completed in the morning of Tuesday, July 2, 2024. The most common native species observed during the survey were *Chara* (*Chara sp.*), broadleaf pondweed (*Potamogeton amplifolius)*, white waterlily (*Nymphaea odorata*), rushes (*Juncus sp.),* and Richardson's pondweed *(Potamogeton richardsonii)*. Broadleaf pondweeds were observed at moderate densities around the lake, typically not causing any nuisance concerns, except in AROS 256, 257, 268, 269, 276 where broadleaf pondweeds were growing to the surface.

The aquatic invasive species observed in Cedar Lake South during the 2024 early-season survey were hybrid Eurasian watermilfoil (*Myriophyllum spicatum x sibiricum*) and purple loosestrife (*Lythrum salicaria L.*). Eurasian watermilfoil was found in light clusters in AROS 239-242 and 260 and purple loosestrife was found at two shoreline locations (AROS 213 and 220).

The Late-season LakeScan™ survey was conducted in the afternoon of Wednesday, August 7, 2024 and completed in the morning of Thursday, August 8, 2024. The most common native species observed during the survey were *Chara*, broadleaf pondweed, white waterlily, naiad (*Najas sp*.), rushes, and Richardson's pondweed. Native pondweeds were observed at moderate densities around the lake, flowering in many locations, but typically not causing any nuisance concerns except in AROS 200-202, 268-270, 275-277, 222, 237, 231, and 239 where tall pondweeds growing to the surface were observed.

The aquatic invasive species observed during the 2024 late-season survey were hybrid Eurasian watermilfoil and purple loosestrife. Eurasian watermilfoil was found in light clusters in AROS 228 and 238. Purple loosestrife was found at many shoreline locations, but was typically only seen in light stand-alone clusters, not warranting any management recommendations at the time of the survey.

Over the last five years, variable-leaf watermilfoil (*Myriophyllum heterophyllum),* Eurasian watermilfoil, and starry stonewort (*Nitellopsis obtusa*) in Cedar Lake South have exhibited declining trends (Figure ES-1). Coverage of the variable-leaf watermilfoil has decreased by 2% since 2020 and has remained consistently under 3% throughout the last five years (Figure ES-1). Eurasian watermilfoil has remained consistently under 2% coverage over the past five years, but did have the same coverage as last year (0.25%), indicating that the species might have reached a stable population level or is exhibiting resistance to the current management regimen preventing lower coverages from being observed. Starry stonewort which was last found in 2022, was again not found during either survey in 2024, demonstrating the continued success of mitigating the rebound and spread of the species.

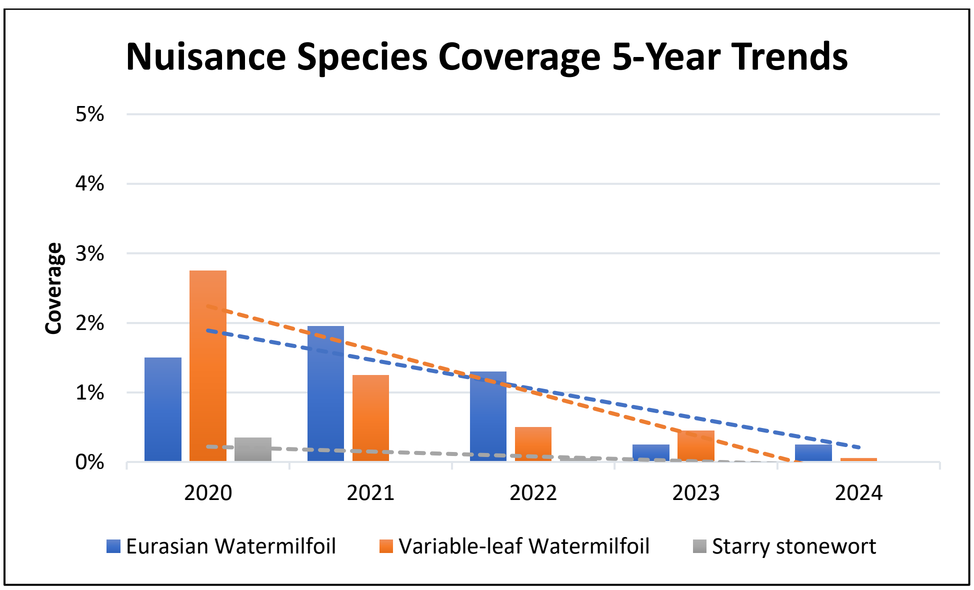


Figure ES-1 – Nuisance species coverage 5-year trends.

Based on 2024 findings, K&A recommends the following management considerations for 2025:

- **Continued management of Eurasian watermilfoil.**
    - Watermilfoil coverages have trended downward over the last five years with average coverage in 2022-2024 at less than 1%. Thus, current management interventions appear to be effective at suppressing growth and reducing the cumulative coverage of nuisance watermilfoil presence. Despite downward five-year trends, Eurasian watermilfoil populations might be stabilizing around 0.25%. While eradication of the species may be unlikely, a harsher management regimen might be explored. Therefore, it is recommended that the Cedar Lake Improvement Board continues exploring management options for effectively treating nuisance watermilfoil conditions in Cedar Lake South.
- **Continued monitoring of coverage and nuisance conditions of variable-leaf watermilfoil.**
    - The treatments in 2020 targeting nuisance variable-leaf watermilfoil were projected to have lasting effects for up to three years. Based on 2021-2024 LakeScan™ surveys, the 2020 treatments appear to have continually suppressed nuisance conditions. It will be important to closely monitor the treatment areas to see if treatment results persist into 2025.
- **Continued monitoring of coverage and nuisance conditions of lily pads and development of a management strategy.**
    - Anecdotes from lake users indicate that nuisance conditions of lily pad growth continue to persist in AROS 206 -211 and 272-276. Treatments in these areas can be conducted with 100 feet of the shoreline, any additional nuisance coverage of the lily pads beyond 100 feet may warrant harvesting which is not limited by distance from the shoreline. It is recommended that a harvesting feasibility study be considered in 2025 to address the growing problem of the lily pads in the lake.
- **Monitoring of coverage and nuisance conditions of native pondweed production.**
    - Nuisance pondweed production in Cedar Lake North has been increasing. Pondweeds resembling broad leaf pondweed and Richardson's pondweed may be aggressive hybrids that are increasing in cumulative cover in the lake. The Department of the Environment, Great Lakes, and Energy (EGLE) does not permit treatment of pondweeds in many of the nuisance areas in Cedar Lake North. Mechanical harvesting is not regulated in Michigan and can be used as an effective management strategy for nuisance pondweeds. This approach should be considered for use in 2025 if there is a substantial increase in the nuisance production of hybrid native pondweeds.
- **Purple loosestrife management considerations.**
    - Given the scattered shoreline distribution of purple loosestrife noted in Cedar Lake South with stand-alone clusters of this emergent wetland invasive species, consideration of voluntary riparian owner removal should be recommended as part of the updated Cedar Lake Watershed Management Plan. Whereas increasing stands noted in Cedar Lake North recommended for potential treatment with biocontrols, observations suggest that proper manual removal efforts along shorelines in Cedar Lake South could be sufficient to limit the growth and spread of this species.

Table of Contents

1.0. Introduction

Inland lakes are complex systems, and managing them for both ecological health and recreational enjoyment involves balancing goals that are sometimes at odds with one another. Successful lake management requires an understanding of the current ecological and recreational conditions of a lake, as well as how those conditions change over time. The LakeScan™ program combines a detailed data collection methodology with mapping capabilities and whole-lake analysis metrics backed by scientific literature. This analysis allows lake managers to identify successful lake management activities, as well as highlight potential issues requiring intervention. Appropriately targeted aquatic plant suppression can minimize weedy and nuisance species while allowing beneficial species to flourish at ecologically balanced levels supporting healthy lake conditions. This kind of adaptive management system provides a scientifically sound and consistent methodology to better manage lake ecological and recreational conditions.

The LakeScan™ analysis involves collecting data over two vegetation surveys during the critical summer recreational season. These surveys are based on a system where the lake is first divided into biological tiers (Table 1) and then further subdivided into Aquatic Resource Observation Sites (AROS; Figure 1). For each survey, field personnel record the density, distribution, and position in the water column of each aquatic plant species in each AROS, as well as noting any nuisance conditions. Dissolved oxygen profiles, temperature profiles, and Secchi depth are additionally recorded. Other water quality sampling can be included with surveys when requested.

Aquatic plant communities change over the course of a year, so the surveys are split into early and late-season observations. Early-season surveys are scheduled with the goal of taking place within 10 days of early-summer treatments to best observe treatment-targeted and non-targeted vegetation. Late-season surveys are scheduled to occur roughly two months after the early season survey. However, this scheduling is subject to weather and times of increased boat activity.

Table 1 – Biological Tier Descriptions.

Tier*	Description
2	Emergent Wetland
3	Near Shore
4	Off Shore
5	Off Shore, Drop-Off
6	Canals
7	Around Islands and Sandbars
9	Off Shore Island Drop-Off

*Tiers 1 and 8 are reserved for future use.

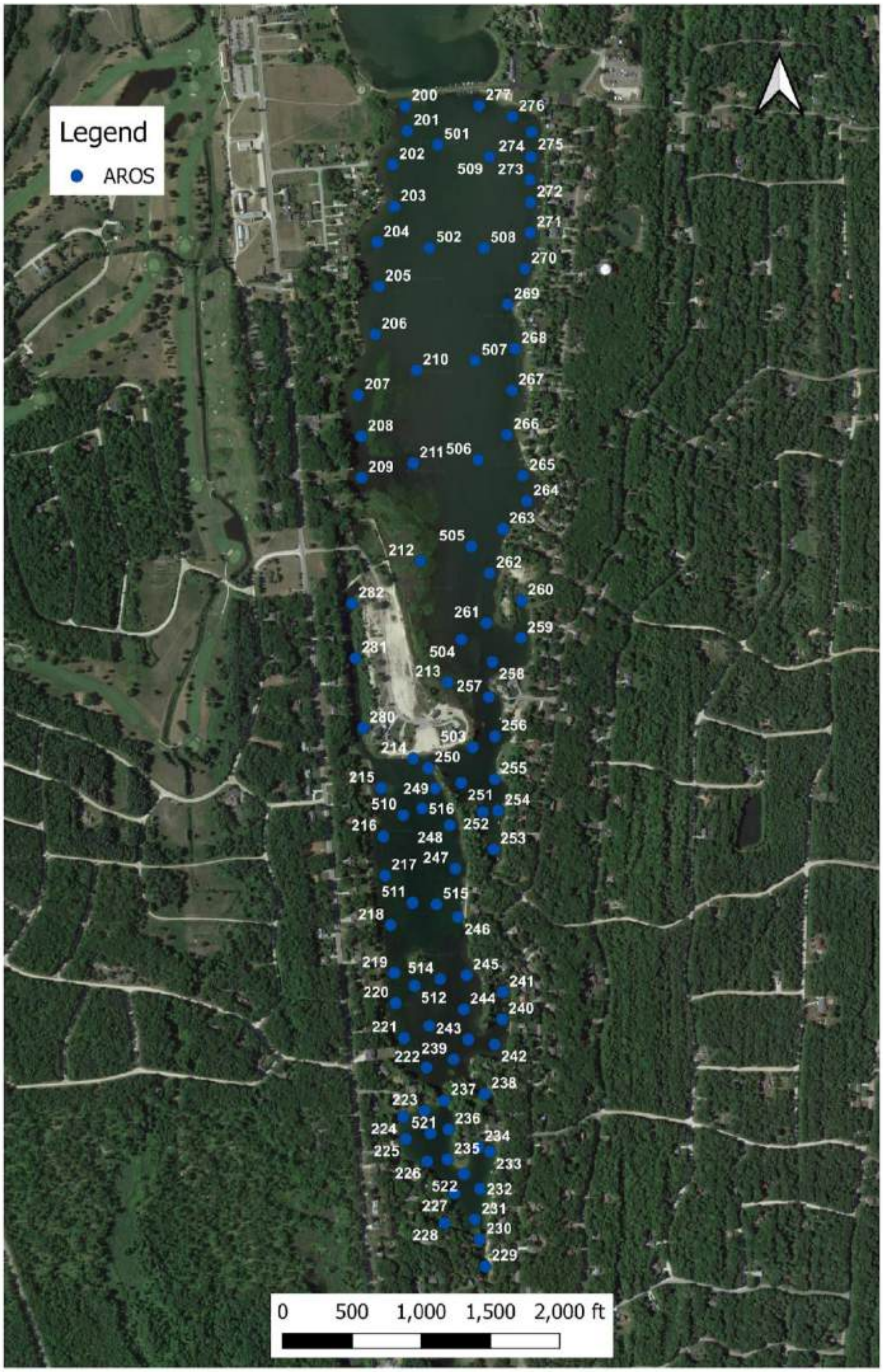


Figure 1 - Map of Aquatic Resource Observation Sites (AROS).

2.0. Water Quality

Location

County: Iosco

Township: Oscoda

Township/Range/Section(s): T24N, R9E Sections: 3 and 10

GPS Coordinates: N 44°29.79996’ W 83°20.04684

Morphometry

Total Area: 78 acres

Shoreline Length: 20,583 feet

Maximum Depth: 12 feet

Administrative Management

Management Authority: Cedar Lake Improvement Board

Years in LakeScan™ Program: 2003 to Present

2.1. Algal Bloom Risk Level

K&A calculates an algal bloom risk level for each LakeScan™ lake based on the characteristics of its watershed. Agricultural and urban land uses contribute more phosphorus to receiving waters than grasslands or forested land uses; phosphorus being the limiting nutrient that drives algal blooms. Lakes with watersheds that have high proportions of land in agricultural and urban land uses are more likely to be at risk of algal blooms. Not all algal blooms contain cyanobacteria and their associated toxins (Harmful Algal Blooms or HABs). It is important to note that the risk factor reported here is based on a limited watershed analysis. Lakes at high risk of algal blooms should consider more in-depth studies that can identify possible watershed or in-lake improvements to mitigate the risk of HABs.

The algal bloom risk for Cedar Lake South is: **Low**

This risk is a reflection of the summary of watershed land-use composition for Cedar Lake South, which has minor inputs from urban and agricultural sources.

3.0. Dissolved Oxygen and Temperature Profiles

Apart from vegetation data, secchi depth, dissolved oxygen and temperature data were additionally collected during each vegetation survey. Secchi disk transparency is the depth at which a Secchi disk (a flat white or black and white platter, approximately 20 centimeters in diameter) suspended into a lake disappears from the investigator's sight. In general, the greater depth at which the Secchi disk can be viewed, the lower the productivity of the water body. Secchi depth readings of greater than 15 feet can be indicative of low productivity or oligotrophic conditions.[1] Some variation in Secchi disk reporting may be a result of cloud cover, time of day, recent rain events, and recreational lake usage. Dissolved oxygen levels and temperature were measured by K&A using a YSI ProSolo dissolved oxygen meter, calibrated prior to use.

A sufficient supply of dissolved oxygen (DO) in lake water is necessary for most forms of desirable aquatic life. Colder waters contain more dissolved oxygen than warmer waters. In highly productive lakes, oxygen depletion can occur in deeper, unmixed bottom waters during warmer summer months. This decrease in oxygen is due in part to dead algae and other organic matter, such as leaves, grass and plant debris settling to the bottom of the lake and getting consumed, along with oxygen, by organisms in the sediment. DO depletion is most often observed in lake bottom waters during periods of temperature stratification in warmer summer months and, to a lesser degree, under winter ice cover conditions. Shallow lakes, like Cedar Lake, may not experience stratification and would not be expected to have as notable of oxygen depletion in the lake bottom waters compared to deeper bodies of water.

Secchi disk clarity on Cedar Lake South was clear to bottom at around 8ft during both surveys, illustrating stability in water clarity throughout the summer of 2024 (Figures 2 and 3). The DO and temperature profiles remained consistent across the two surveys with no notable stratification, which is expected on Cedar Lake due to its shallow depths. Temperatures did increase by roughly 4 °C and DO decreased by nearly 2 mg/L between the early and late-season surveys, reflecting the warmer summer temperatures leading up to the late-season survey.

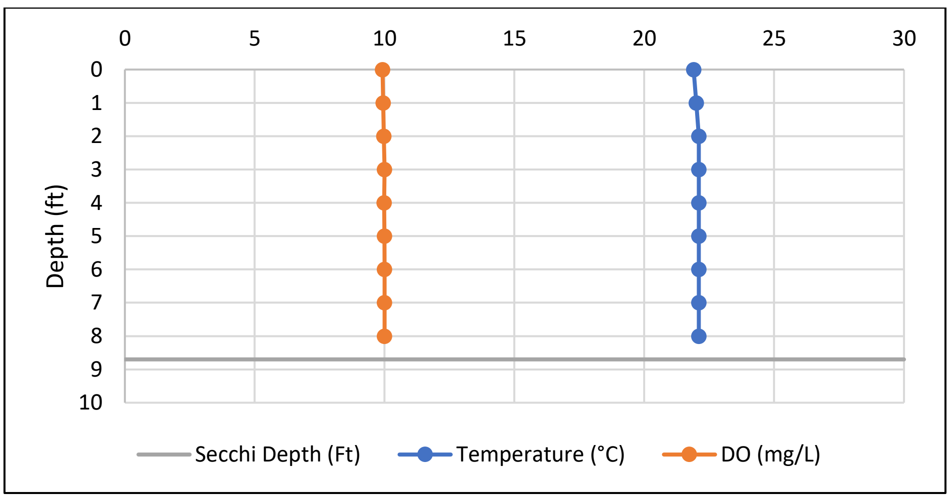


Figure 2 – Early-season survey (7/1/2024) dissolved oxygen and temperature profiles with Secchi depth, taken near AROS 214.

[1] US Geological Survey. 2012. "Water Quality Characteristics of Michigan's Inland Lakes, 2001-10." Scientific Investigations Report 2011–5233. Available online at: https://pubs.usgs.gov/sir/2011/5233/.

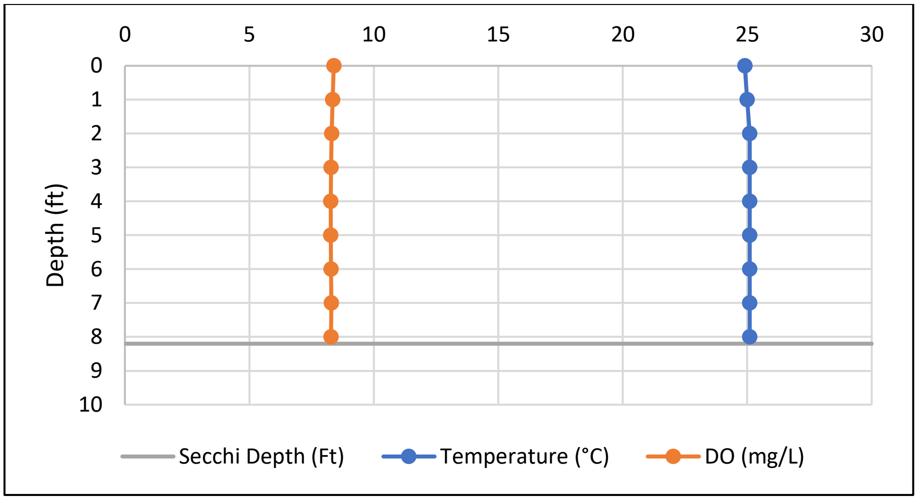


Figure 3 – Late-season survey (8/7/2024 and 8/8/2024) dissolved oxygen and temperature profiles with Secchi depth, taken near AROS 214.

4.0. Aquatic Vegetation

4.1. Early-Season Survey

The Cedar Lake South early-season LakeScan™ survey was conducted in the afternoon of Monday, July 1, 2024 and completed in the morning of Tuesday, July 2, 2024. The weather was sunny on Monday and overcast on Tuesday, with temperatures around 70°F for both days and southeastern winds ranging from 5-13 mph. Visibility in the water column was great with a Secchi Disk reading of 8.7 feet, clear to the bottom. The survey occurred 13 and 14 days after the scheduled herbicide treatment on Tuesday, June 18, 2024.

A visual depiction of the data on all combined species observed in Cedar Lake South during the early-season survey is displayed using three-dimensional density, which reflects a combination of vegetation density, distribution and height observations for all species observed during the survey (Figure 4). Color-coding is provided for each AROS to spatially depict observed vegetation data. The colors range in a gradient from dark blue which depicts no vegetation observed, to yellow depicting medium density and distribution of plant species, to red which depicts high density and distribution of vegetation within the AROS.

The most common native species observed during the early-season survey on Cedar Lake South were *Chara*, broadleaf pondweed, white waterlily, rushes, and Richardson's pondweed*. Chara* was the most commonly observed species, and was found at moderate to high densities throughout a majority of observation areas. Broadleaf pondweeds were observed at moderate densities around the lake, flowering in many locations, but typically not causing any nuisance concerns, except in AROS 256, 257, 268, 269, 276 which had tall broadleaf pondweed growing to the surface which could cause some minor recreational nuisance conditions.

The only submerged aquatic invasive species observed in Cedar Lake South during the 2024 early-season survey was hybrid Eurasian watermilfoil. Eurasian watermilfoil was found in light clusters in AROS 239-242 and 260 (Figure 5). Additionally, the emergent invasive species purple loosestrife was found at two locations along the shoreline (AROS 213 and 220), not causing any management concerns at the time of the survey (Figure 6).

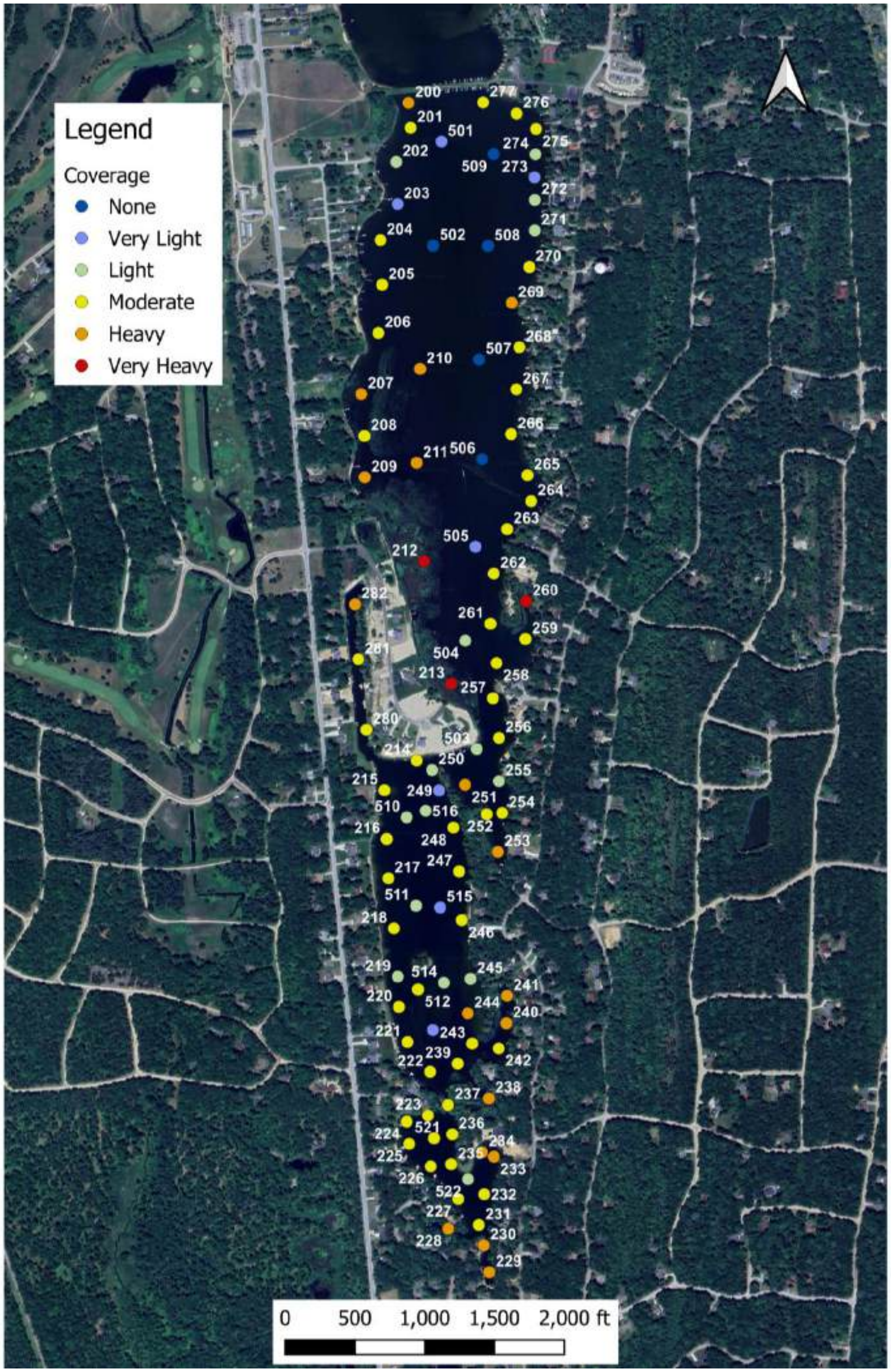


Figure 4 – Early-season survey (7/1/2024 & 7/2/2024) vegetation 3D Density (a function of observed vegetation coverage, and height of all vegetation species).

Figure 5 – Early-season (7/1/2024 & 7/2/2024) Eurasian watermilfoil coverage (a combination of the LakeScan™ density and distribution observations).

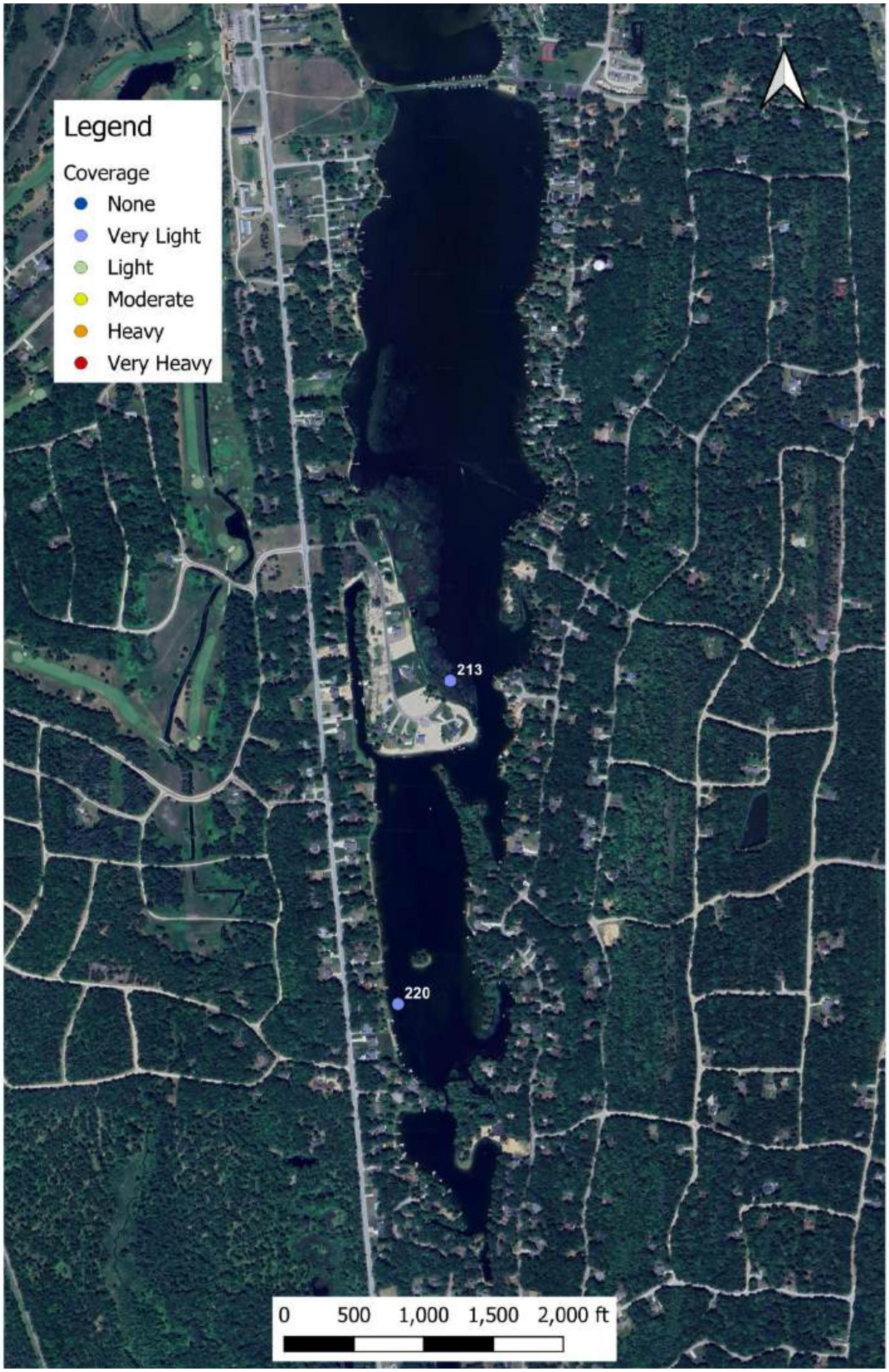


Figure 6 – Early-season (7/1/2024 & 7/2/2024) purple loosestrife coverage.

4.2. Late-Season Survey

The Cedar Lake South Late-season LakeScan™ survey was conducted in the afternoon of Wednesday, August 7, 2024 and completed in the morning of Thursday, August 8, 2024. The weather was sunny on both days, with temperatures around 78°F and southeastern winds ranging from 8 -12 mph. Visibility in the water column was great with a Secchi Disk reading of 8.2 feet, clear to bottom.

A visual depiction of the data on all combined species observed in Cedar Lake South during the late-season survey is displayed using three-dimensional density in Figure 7. The most common native species observed during the survey were *Chara*, broadleaf pondweed, white waterlily, naiad, rushes*,* and Richardson's pondweed*. Chara* was the most commonly observed species, and was found at moderate to high densities throughout a majority of observation areas. Native pondweeds were observed at moderate densities around the lake, flowering in many locations, but typically not causing any nuisance concerns, except in AROS 200-202, 268-270, 275-277, 222, 237, 231, and 239 which had tall pondweeds growing to the surface. Variable-leaf watermilfoil was only found in AROS 226 at the time of the survey (Figure 8).

The only submerged aquatic invasive species observed in Cedar Lake South during the 2024 late-season survey was hybrid Eurasian watermilfoil. Eurasian watermilfoil was found in light clusters in AROS 228 & 238 (Figure 9). The emergent invasive species purple loosestrife was flowering and more conspicuous at the time of the survey, and was found at many shoreline locations, but was typically only seen in light stand-alone clusters, not warranting any CLIB-led management recommendations (Figure 10).

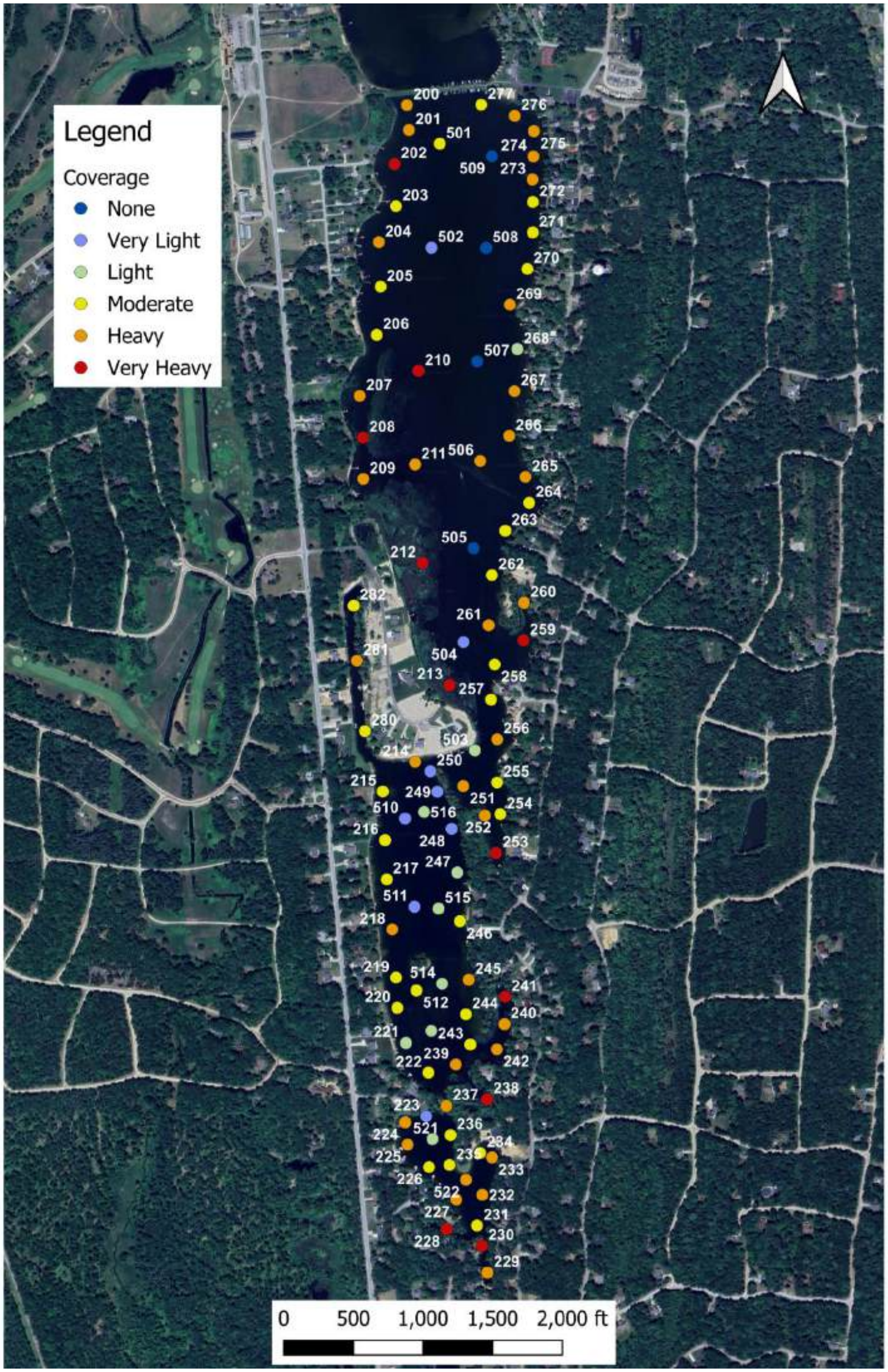


Figure 7 – Late-season survey (8/7/2024 & 8/8/2024) vegetation 3D Density (a function of observed vegetation coverage, and height of all vegetation species).

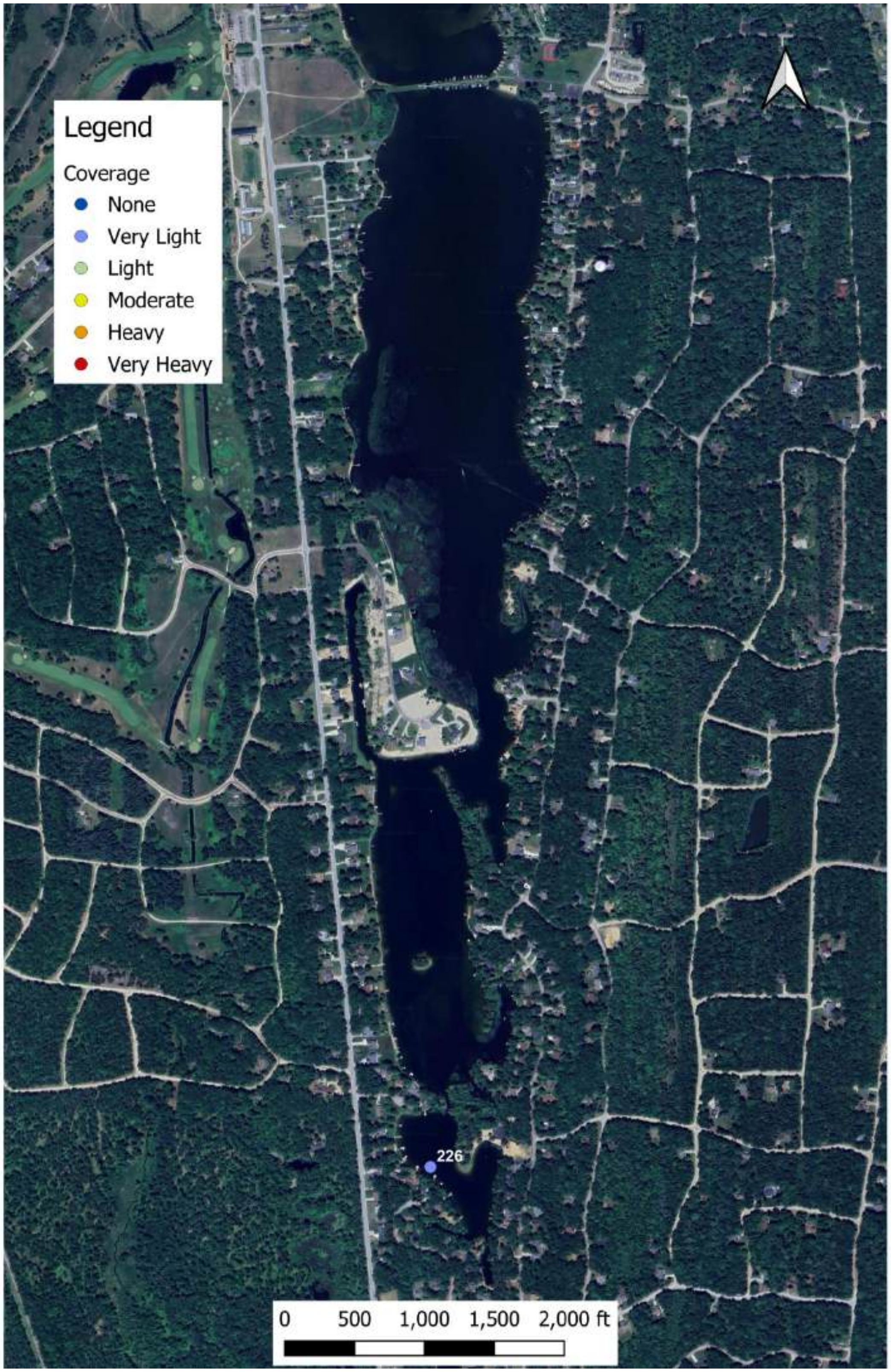


Figure 8 – Late-season (8/7/2024 & 8/8/2024) Variable-leaf watermilfoil coverage (a combination of the LakeScan™ density and distribution observations).

Figure 9 – Late-season (8/7/2024 & 8/8/2024) Eurasian watermilfoil coverage.

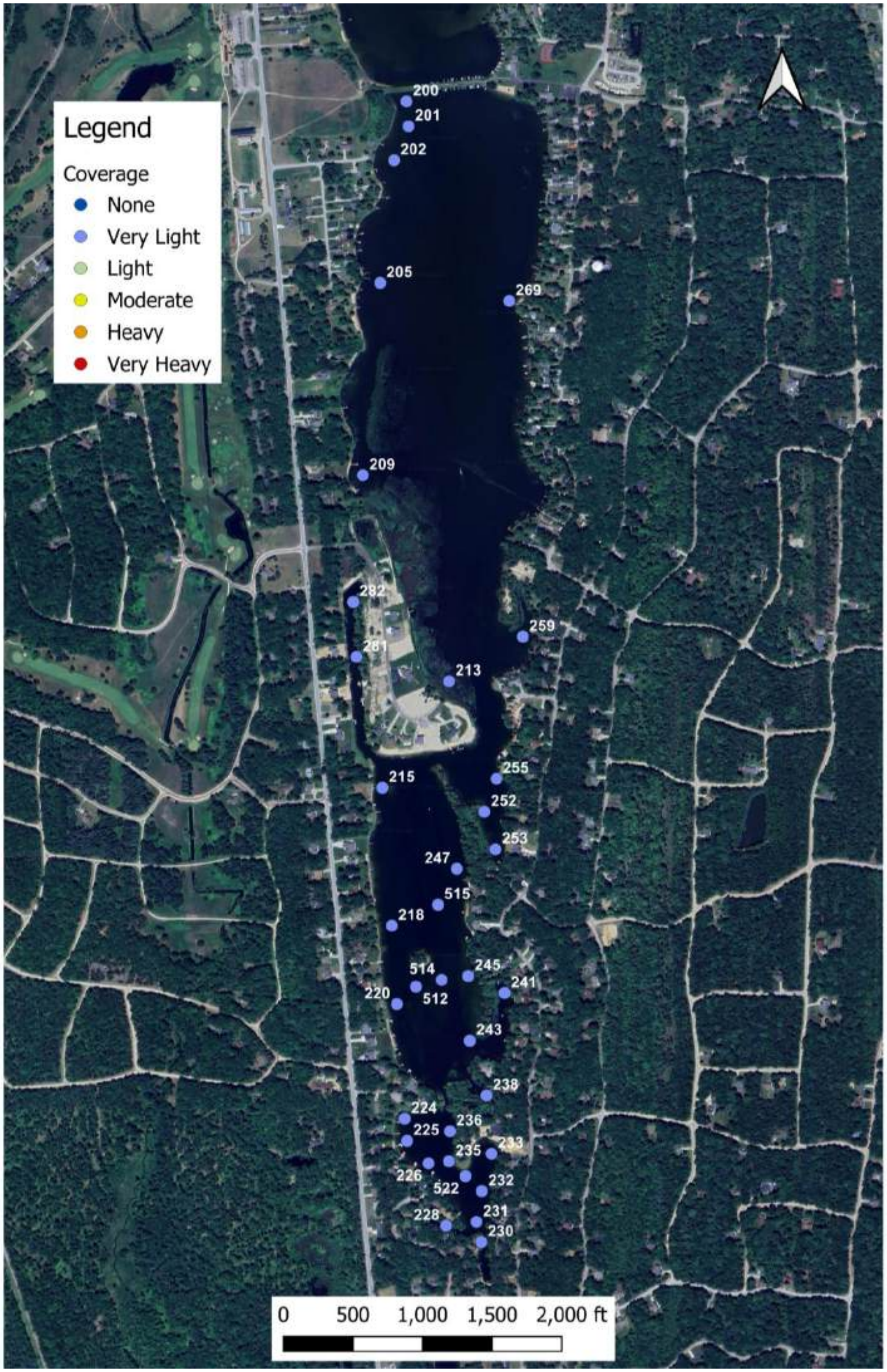


Figure 10 – Late-season (8/7/2024 & 8/8/2024) purple loosestrife coverage.

4.3. Summary Observations for Early and Late-Season Surveys

All aquatic plant species observed during the 2024 vegetation surveys were paired with their associated C-value and recorded for frequency, coverage, and dominance (Table 2). The Coefficient of Conservation, or C-Value, is a qualitative value ranging from 0 to 10 that is assigned to each species representing the estimated probability that it is likely to occur in an environment. A C-value of 0, is given to plants that may be found almost anywhere, while a C-value of 10 is applied to plants that are almost always restricted to high-quality natural settings.[2] 'Frequency' represents the percentage of survey sites (AROS) where a given species was found. 'Coverage' represents the spatial cover observed for each species, represented as a percentage of available area. 'Dominance' represents the degree to which a species is more numerous than its competitors.

Table 2- Aquatic Plant Species Observed in 2024.

Common Name	C Value	Frequency		Coverage		Dominance	
		Early '24	Late '24	Early '24	Late '24	Early '24	Late '24
Eurasian Watermilfoil Hybrid	0	5.1%	2.0%	0.3%	0.2%	0.5%	0.2%
Green/Variable Watermilfoil	6	0.0%	1.0%	0.0%	0.1%	0.0%	0.1%
Common Bladderwort	6	8.1%	7.1%	0.5%	0.4%	0.8%	0.5%
Elodea	3	1.0%	0.0%	0.1%	0.0%	0.2%	0.0%
Naiad	6	18.2%	63.6%	3.5%	14.6%	5.3%	16.0%
Chara	7	90.9%	91.9%	23.0%	18.8%	34.4%	20.5%
Flat Stem Pondweed	5	13.1%	8.1%	1.7%	1.4%	2.5%	1.5%
Water Star Grass	6	3.0%	0.0%	0.3%	0.0%	0.4%	0.0%
Purple Loosestrife	0	2.0%	36.4%	0.1%	2.3%	0.2%	2.6%
Swamp Loosestrife	7	5.1%	2.0%	0.3%	0.1%	0.5%	0.1%
Richardsons Pondweed	5	29.3%	50.5%	4.2%	7.6%	6.3%	8.3%
Broadleaf Pondweed	6	75.8%	70.7%	8.0%	9.0%	12.0%	9.9%
Hybrid Pondweed	5	16.2%	51.5%	2.0%	6.5%	2.9%	7.1%
Sago Pondweed	3	10.1%	12.1%	1.1%	1.5%	1.6%	1.7%
Thin Leaf Pondweed	4	5.1%	5.1%	0.6%	0.6%	0.9%	0.7%
Wild Celery	7	15.2%	34.3%	1.6%	4.2%	2.4%	4.6%
Rush	8	49.5%	45.5%	4.3%	3.8%	6.4%	4.1%
Waterlily	6	58.6%	63.6%	9.2%	10.0%	13.8%	11.0%
Spadderdock	7	20.2%	30.3%	2.7%	6.3%	4.1%	6.9%
Water Shield	6	1.0%	2.0%	0.1%	0.1%	0.1%	0.1%
Floating Leaf Pondweed	5	7.1%	9.1%	0.8%	1.1%	1.2%	1.2%
Smartweed	5	2.0%	3.0%	0.1%	0.2%	0.2%	0.2%
Arrow Arum	6	3.0%	7.1%	0.8%	1.1%	1.1%	1.2%
Iris	5	8.1%	0.0%	0.5%	0.0%	0.8%	0.0%
Cattail	1	11.10%	14.10%	1.10%	1.50%	1.60%	1.60%

[2] Michigan Department of Natural Resources Wildlife Division. (n.d.). Floristic Quality Assessment With Wetland Categories and Examples of Computer Applications for the State of Michigan.

4.4. LakeScan™ Metrics

Six important metrics for defining lake conditions are included in the LakeScan™ analyses, where early and late-season scores are averaged for a yearly score and compared against a management goal for each metric (Table 3). Management goals are based on median Michigan lake values (Shannon Biodiversity Index and Shannon Morphology Index), scientific literature (Floristic Quality Index), and professional judgement (Recreational Nuisance Presence and Algal Bloom Risk). Green shading in Table 3 highlights scores meeting management goals, while yellow and red highlights represent scores needing improvement, with red scores being further away from the optimal management goals potentially requiring a higher level of management attention. Descriptions of each of the six metrics are detailed below:

- **Species Richness** – the number of aquatic plant species present in the lake. More species are generally indicative of a healthier ecosystem, but not all species are desirable.
- **Shannon Biodiversity Index** – a measure of aquatic plant species diversity and distribution evenness, indicative of the stability and diversity of the plant community. Also known as the Shannon Expected Number of Species.[3]
- **Shannon Morphology Index** – a measure of aquatic plant morphology type diversity and distribution evenness, indicative of fish and macroinvertebrate habitat quality. This is calculated using morphology types instead of species.
- **Floristic Quality Index**[4] – a measure of the distribution of desirable aquatic plants. This index is used by Midwestern states for aquatic habitats, with higher scores indicative of increased biodiversity and a positive ratio of desirable versus undesirable aquatic plant species.
- **Recreational Nuisance Presence** – the percentage of survey sites that identified aquatic plants inhibiting recreational activities.
- **Algal Bloom Risk** – a calculated algal bloom risk level based on the characteristics of the lake watershed. Lakes with watersheds that have high proportions of land in agricultural and urban land uses are more likely to be at risk of algal blooms because these land uses contribute more phosphorus to receiving waters than grasslands or forests.

Table 3 – 2024 LakeScan™ Metric Results.

LakeScan™ Metric	Score Range	2024 Early Season	2024 Late Season	2024 Average	Management Goal
Species Richness	5 - 30	24	22	23	n/a
Shannon Biodiversity Index	1 -15	9.8	11.6	10.7	> 8.8
Shannon Morphology Index	1 - 10	7.9	9.3	8.6	> 6.3
Floristic Quality Index	1 - 40	30.4	27.7	29.1	> 20
Recreational Nuisance Presence	0 - 100%	5%	13%	9%	< 10%
Algal Bloom Risk	Low-High	n/a	n/a	Low	Low

*n/a = not applicable

[3] Hill, M. O. (1973). Diversity and evenness: a unifying notation and its consequences. *Ecology*, 54(2), 427-432.
[4] Nichols, S. A. (1999). Floristic quality assessment of Wisconsin lake plant communities with example applications. *Lake and Reservoir Management*, 15(2), 133-141.

The assessed LakeScan™ metrics for both the early and late-season surveys on Cedar Lake North met all management goals in 2024, except for the late-season recreational nuisance presence, which came close but ultimately fell short of the management goal of <10%. The increase in nuisance presence across the two surveys is likely reflective of the observed late-season pondweed growth. Apart from nuisance conditions, the metrics assessed in 2024 had limited fluctuations between the two surveys, indicating a high level of lake stability throughout the summer. These findings are additionally similar to those calculated in 2023, which also fell short of the recreational nuisance presence in the late-season survey, but ultimately met all management goals when averaged across the surveys. These similarities in survey observations from year-to-year indicate that the lake is approaching stability in both species and structural diversity and the presence of nuisance conditions.

The high Shannon morphology and biodiversity indices indicate that the species in the lake are both diverse in type and structure, contributing to greater habitat suitability for aquatic organisms. Both of these metrics improved across the 2024 surveys, indicating that the lake is trending towards higher species diversity, and therefore greater habitat suitability. The consistently high average Floristic Quality Index further reflects this trend, indicating a high distribution of desirable, native plant species and a low distribution of undesirable invasive species.

Over the past five years, the Floristic Quality Index on Cedar Lake North has exhibited a positive trend, indicating an increase in desirable, native plants and a decrease in undesirable, invasive aquatic species such as starry stonewort and Eurasian watermilfoil (Figure 11). Cedar Lake South has met the FQI management score of 20 each year for the past the last five years, indicating that a high level of floristic quality in the lake is being maintained by the current management regimen.

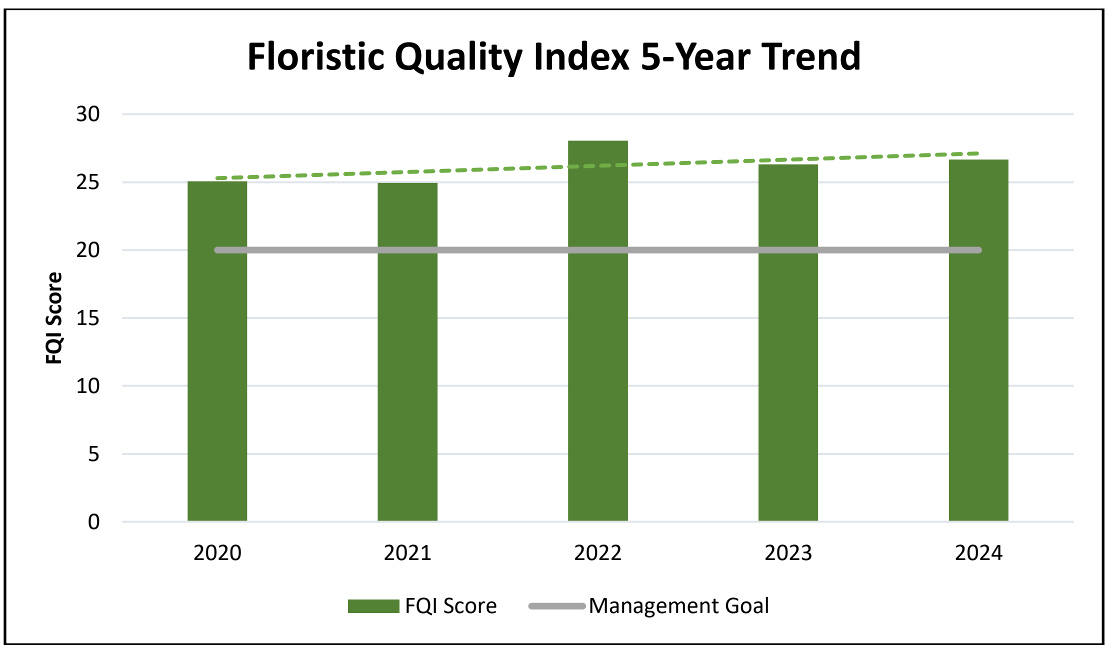


Figure 11 – Floristic Quality Index 5-Year Trend.

Over the last five years, variable-leaf watermilfoil, Eurasian watermilfoil, and starry stonewort in Cedar Lake South have exhibited declining trends (Figure 12). Coverage of variable-leaf watermilfoil has decreased by 2% since 2020 and has remained consistently under 3% throughout the last five years. Eurasian watermilfoil has remained consistently under 2% coverage over the past five years, but did have the same coverage as in 2023 (0.25%), indicating that the species might have reached a stable population level. While eradication of the species may be unlikely, a harsher management regimen might be explored to address this observed stabilization. Starry stonewort, which was last found in 2022, was again not found during either survey in 2024, demonstrating the continued success of mitigating the rebound and spread of the species. The overall coverage of all nuisance species in Cedar Lake South remains minor, indicating that management activities are successfully controlling nuisance species populations on a multi-year basis.

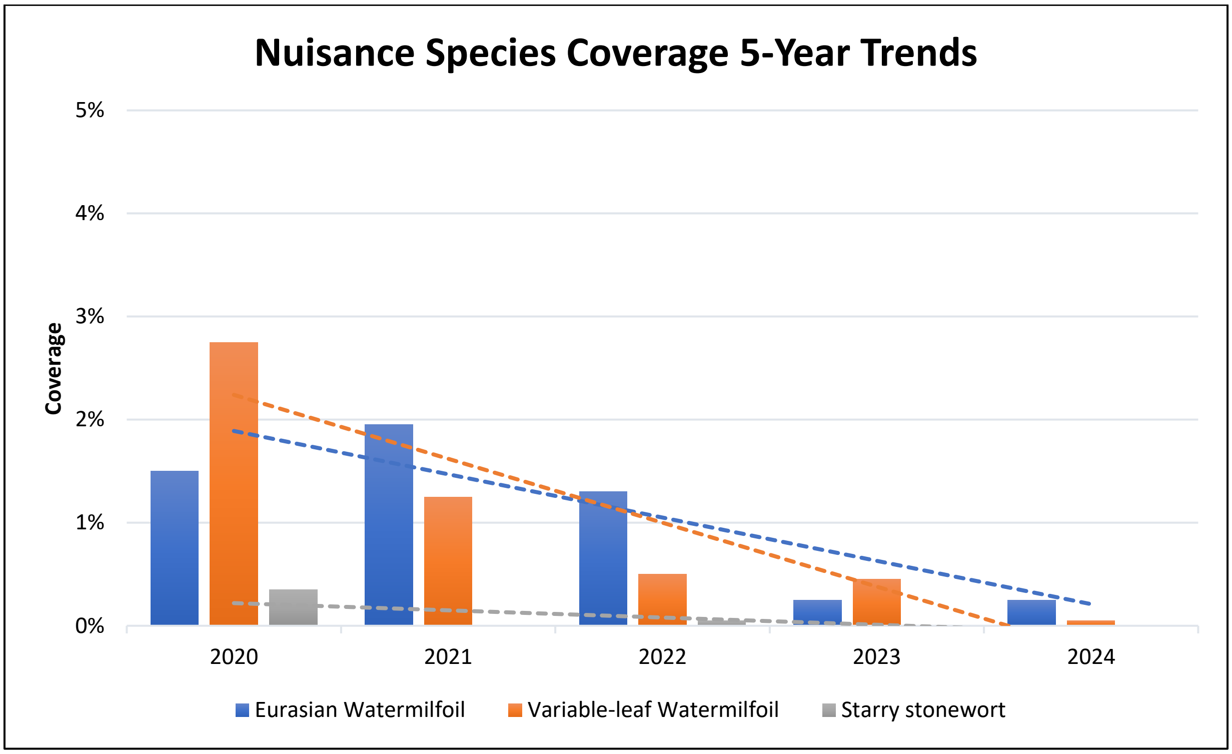


Figure 12 – Nuisance species coverage 5-year trends.

The Algal Bloom Risk rating for Cedar Lake South is “low” reflecting the small proportion of agricultural and urban land use draining to the lake.

5.0. Lake Management

There are several species that typically become a nuisance in Michigan's inland lakes, these species are usually targeted for selective control to prevent them from becoming an aesthetic or recreational nuisance and to protect desirable plants that are part of healthy lake ecosystems. More information on common nuisance species in Michigan and their associated management options can be found in Appendix A. Treatment maps and data displaying acreage, herbicides, and targeted species for Cedar Lake South in 2024 can be found in Appendix B (note that the chemical tables provided in the ANC report are not split by North and South lakes).

A total of two chemical herbicide treatments were conducted by Solitude Lake Management on the Cedar Lake South in 2024. The first chemical herbicide treatment took place on Tuesday, June 18, 2024, 13 and 14 days prior to the early-season survey. Solitude reported that the treatment targeted roughly 4.5 acres with treatment applications that target Eurasian watermilfoil, curly-leaf pondweed, starry stonewort, and algae using Tribune, Cutrine, Aquathol K, and ProcellaCOR. Aquathol K was only used in the shallow channel (AROS 280-282) to alleviate nuisance conditions. The second and final chemical herbicide treatment occurred on September 18, 2024. The treatment targeted roughly 0.25 acres of Eurasian watermilfoil using Tribune and Cutrine Plus in the southernmost channel of the lake.

It is important to note that the "species targeted" descriptors provided by Solitude and included in Appendix B Figure B3 include curly-leaf pondweed and starry stonewort as treated species for the June 18th treatment despite neither of the species being noted during surveys in the previous two years. Future species treated references provided by the applicator should be made consistent with pre-season survey findings and mutually-agreed upon target species, for accuracy in reporting. Where new invasive species are suspected by the applicator, immediate notification to K&A should otherwise be made and treatments recommendations discussed.

During the early-season survey, which occurred 13 and 14 days after the first herbicide treatment, Eurasian watermilfoil was found at 0.3% coverage and decreased slightly to 0.2% by the late-season. The average coverage of Eurasian watermilfoil was the same in 2024 compared to 2023 and the species has maintained low and manageable levels of coverage at less than 1% from 2022-2024, indicating multi-year success of current herbicide treatments on managing the spread of the hybrid Eurasian watermilfoil and repressing nuisance conditions (Figure 13).

Variable-leaf watermilfoil had lower coverages than Eurasian watermilfoil with 0% coverage in the early-season and 0.1% coverage in the late season. The relatively low coverages of less than 1% across both surveys, further demonstrates the effectiveness and long-term success of the current treatment regimen on managing nuisance variable-leaf watermilfoil conditions.

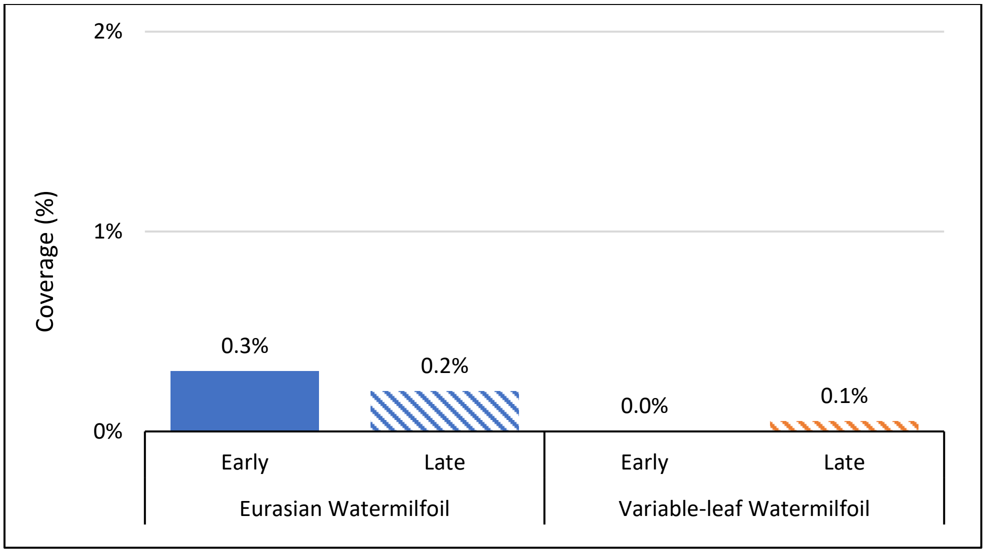


Figure 13 – Changes in coverage across both surveys for targeted species.

5.1. Management Recommendations

Watermilfoil coverages have trended downward over the last five years with average coverage in 2022-2024 at less than 1%. Thus, current management interventions appear to be effective at suppressing growth and reducing the cumulative coverage of nuisance watermilfoil presence. Despite downward five-year trends, Eurasian watermilfoil populations might be stabilizing around 0.25%. While eradication of the species may be unlikely, a harsher management regimen might be explored. Therefore, it is recommended that the Cedar Lake Improvement Board continues exploring management options for effectively treating nuisance watermilfoil conditions in Cedar Lake South.

The treatments in 2020 targeting nuisance variable-leaf watermilfoil were projected to have lasting effects for up to three years. Based on 2021-2024 LakeScan™ surveys, the 2020 treatments appear to have continually suppressed nuisance conditions. It will be important to closely monitor the treatment areas to see if treatment results persist into 2025.

Anecdotes from lake users indicate that nuisance conditions of lily pad growth continue to persist in AROS 206 -211 and 272-276. Treatments in these areas can be conducted with 100 feet of the shoreline; any additional nuisance coverage of the lily pads beyond 100 feet may warrant harvesting which is not limited by distance from the shoreline. It is recommended that a harvesting feasibility study is considered in 2025 to address the growing problem of the lily pads in the lake.

Nuisance pondweed production in Cedar Lake North has been increasing. Pondweeds resembling broad leaf pondweed and Richardson's pondweed may be aggressive hybrids that are increasing in cumulative cover in the lake. The Department of the Environment, Great Lakes, and Energy (EGLE) does not permit treatment of pondweeds in many of the nuisance areas in Cedar Lake South. Mechanical harvesting is not regulated in Michigan and can be used as an effective management strategy for nuisance pondweeds. This approach should be considered for use in 2025 if there is a substantial increase in the nuisance production of hybrid native pondweeds.

Given the scattered shoreline distribution of purple loosestrife noted in Cedar Lake South with stand-alone clusters of this emergent wetland invasive species, consideration of voluntary riparian owner removal should be recommended as part of the updated Cedar Lake Watershed Management Plan. Whereas increasing stands noted in Cedar Lake North recommended for potential treatment with biocontrols, observations suggest that proper manual removal efforts along shorelines in Cedar Lake South could be sufficient to limit the growth and spread of this species.

6.0. Appendices

6.1. Appendix A: Information About Nuisance and Aquatic Invasive Species

Algal Blooms

Blue green algae blooms are becoming increasingly common in Michigan. Blooms can appear as though green latex paint has been spilled on the water, or resemble an oil slick in enclosed bays or along leeward shores. Blue green algae blooms are usually temporal events and may disappear as rapidly as they appear. Blue green algae blooms are becoming more common for a variety of reasons; however, the spread and impact of zebra mussels has been closely associated with blooms of blue green algae.

Figure A1 - Example blue green algae images from the 2019 LakeScan™ field crew.

Blue green algae are really a form of bacteria known as cyanobacteria. They are becoming an important issue for lake managers, riparian property owners and lake users because studies have revealed that substances made and released into the water by some of these nuisance algae can be toxic or carcinogenic. They are known to have negative impacts on aquatic ecosystems and can potentially poison and sicken pets, livestock, and wildlife. Blue green algae can have both direct and indirect negative impacts on fisheries. Persons can be exposed to the phytotoxins by ingestion or dermal absorption (through the skin). They can also be exposed to toxins by inhalation of aerosols created by overhead irrigation, strong winds, and boating activity.

Approximately one half of blue green algae blooms contain phytotoxins, and this is determined through lab testing. It is recommended that persons not swim in waters where blue green algae blooms are conspicuously present. Specifically, persons should avoid contact with water where blooms appear as though green latex paint has been spilled on the water, or where the water in enclosed bays appears to be covered by an "oil slick". Pets should be prevented from drinking from tainted water. Since blue green algae toxins can enter the human body through the lungs as aerosols, it is suggested that water containing obvious blue green algae blooms not be used for irrigation in areas where persons may be exposed to it.

Blue green algae are not very good competitors with other, more desirable forms of algae. They typically bloom and become a nuisance when resources are limiting or when biotic conditions reach certain extremes. Some of the reasons that blue green algae can bloom and become noxious are listed below:

TP and TN: The total phosphorus (TP) concentration in a water resource is usually positively correlated with the production of suspended algae (but not rooted plants, i.e. seaweed). Very small amounts of phosphorus may result in large algae blooms. If the ratio of total nitrogen (TN) to total phosphorus is low (<20), suspended algae production may become nitrogen limited and noxious blue green algae may dominate a system because they are able to "fix" their own nitrogen from atmospheric sources. Other common and desirable algae are not able to do this.

Biotic Factors: Zebra mussels and zooplankton (microscopic, free-floating animals) are filter feeding organisms that strain algae and other substances out of the lake water for food. Studies have shown that filter-feeding organisms often reject blue green algae and feed selectively on more desirable algae. Over time, and given enough filter feeding organisms, a lake will experience a net loss in "good" algae and a gain in "bad" blue green algae as the "good" algae are consumed and the "bad" algae are rejected back into the water column. This is one of the most disturbing factors associated with the invasion and proliferation of zebra mussels. Lakes that are full of zebra mussels may not support the production of "good" algae and experience a partial collapse of the system of "good" algae that are necessary to support the fishery.

Eurasian Watermilfoil and Hybrids:

Background: Anecdotal evidence suggests that hybrid milfoil has been found in Michigan inland lakes for a long time (since the late 1980's). University of Connecticut professor Dr. Don Les was the first to determine that there were indeed, Eurasian watermilfoil and northern watermilfoil hybrids in Michigan based on samples sent to his Connecticut lab by Dr. Douglas Pullman, Aquest Corp. in 2003. Experience has proven that it is usually not possible to determine whether the milfoil observed is either Eurasian or hybrid genotype. However, because they play such similar roles in lake ecology, they are simply "lumped together" and referred to collectively as Eurasian watermilfoil. Eurasian watermilfoil is a very common nuisance in many Michigan inland lakes.

Management: Lake disturbance, such as weed control, unusual weather, and heavy lake use can destabilize the lake ecosystem and encourage the sudden nuisance bloom of weeds, like Eurasian watermilfoil. Eurasian watermilfoil is an ever-present threat to the stable biological diversity of the lake ecosystem. Species selective, systemic herbicide combinations have been used to suppress the nuisance production of Eurasian watermilfoil and support the production of a more desirable flora. However, it is becoming much more resistant to herbicidal treatment and herbicide resistant Eurasian watermilfoil and hybrid watermilfoil has been observed in many lakes throughout the Midwest.[5,6] Continued chemical applications can select for herbicide resistant plants, resulting in hybrid watermilfoil.[7] Some research suggests this resistance can be defeated with the use of microbiological system treatments. Milfoil community genetics are dynamic and careful monitoring is needed to adapt to the expected changes in

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[5] Berger, S. T., Netherland, M. D., & MacDonald, G. E. (2015). Laboratory documentation of multiple-herbicide tolerance to fluridone, norflurazon, and topramazone in a hybrid watermilfoil (*Myriophyllum spicatum× M. sibiricum)* population. Weed Science, 63(1), 235-241.

[6] Netherland, M. D., & Willey, L. (2017). Mesocosm evaluation of three herbicides on Eurasian watermilfoil (*Myriophyllum spicatum*) and hybrid watermilfoil (*Myriophyllum spicatum x Myriophyllum sibiricum*): Developing a predictive assay. J. Aquat. Plant Manage, 55, 39-41.

[7] Netherland and Willey, 2017

the dominance of distinct milfoil genotypes. Some of these genotypes may be more herbicide resistant than others and treatment strategies must be adjusted to remain effective in different parts of the lake.

Figure A2 - Example Eurasian Watermilfoil and Hybrids images from the 2019 LakeScan™ field crew.

Starry Stonewort

Background: Starry stonewort, a macroalgae native to northern Eurasia, invaded North American inland lakes after becoming established in the St. Lawrence Seaway/Great Lakes system. Though not positively identified in a Michigan inland lake until 2006, by Aquest Corporation in Lobdell Lake, Genesee County, starry stonewort has likely been present in Michigan's inland lakes since the late 1990's. Since then, this invasive species has spread throughout Michigan. Able to spread by both fragmentation and asexual reproduction, starry stonewort has thrived in Michigan's high-quality oligotrophic and mesotrophic lakes, particularly those with marl sediments. Once established, this opportunistic species will bloom and crash and impose a very significant and deleterious impact on many ecosystem functions. Bloom and crash events are unpredictable and can happen at any time of the year. In some years starry stonewort can become a horrendous nuisance while it can be inconspicuous in others. It can comingle with other similar species and be very difficult to find when it is not blooming.

Management: Starry stonewort is capable of growing to extreme nuisance levels and can significantly impact important ecosystem functions. This species is difficult to control due to its asexual reproductive structures (bulbils) which embed in lake sediments.[8] While many strategies have been employed to manage starry stonewort, no single strategy has emerged as a panacea for controlling infestations.

Diver-assisted suction harvesting (DASH) or diver-assisted hand-pulling of small starry stonewort infestations could reduce populations over time.[9] While these methods can be effective and have high specificity, they are expensive, labor-intensive strategies that require long-term commitment.[10] These strategies may not be viable for large-scale infestations, however, due to their labor-intensive nature

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[8] Glisson, W. J., Wagner, C. K., McComas, S. R., Farnum, K., Verhoeven, M. R., Muthukrishnan, R., & Larkin, D. J. (2018). Response of the invasive alga starry stonewort (*Nitellopsis obtusa*) to control efforts in a Minnesota lake. Lake and Reservoir Management, 34(3), 283-295.

[9] Glisson et al., 2018.

[10] Larkin, D.J., Monfils, A.K., Boissezon, A., Sleithd, R.S., Skawinski, P.M., Welling, C.H., Cahill, B.C., and Karold, K.G. 2018. Biology, ecology, and management of starry stonewort (*Nitellopsis obtusa*; Characeae): A Red-listed Eurasian green alga invasive in North America. https://doi.org/10.1016/j.aquabot.2018.04.003

and their potential for increasing distribution of the target plant species through fragmentation during removal.

Starry stonewort chemical treatments using copper-, diquat-, flumioxazin, and endothall-based algaecides have produced mixed results and long-term management has yet to be achieved using chemical biocides alone.[11] While starry stonewort is susceptible to most selective algaecides, the dense mats of vegetation are very difficult to penetrate and provide reasonable biocide exposure. Consequently, multiple algaecide applications may be required to "whittle down" dense starry stonewort growth if the mats reach sufficient height.

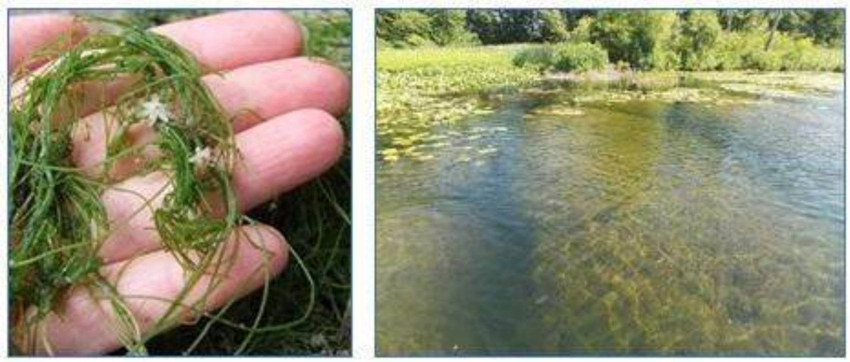

Figure A3 - Example starry stonewort images from the 2019 LakeScan™ field crew.

Curly Leaf Pondweed

Background: Curly leaf pondweed is one of the world's most widespread aquatic plant species. Although it is found worldwide, curly-leaf pondweed is native to only Eurasia. The earliest verifiable records of the plant are from Pennsylvania in the 1840s, and has been found in Michigan since 1910. Curly leaf pondweed is currently found in inland lakes of 34 counties in Michigan, distributed both in the upper and lower peninsulas. [12] Scientific literature suggests that curly leaf pondweed is an aggressively growing species that often expands to nuisance levels when native plants are damaged.

Curly leaf pondweed can create problems such as recreational nuisances, ecological nuisances (by outcompeting native species and reducing light availability to other plants), and degraded fish spawning habitat. Curly leaf pondweed is easily detectable in early spring as it will be one of the few plants readily growing and the first submersed plant to reach the surface. This gives it a competitive advantage and can grow 4 to 5 feet tall before other plants begin germinating from the bottom sediments. As water temperatures rise in late June and early July, curly-leaf pondweed stems begin to die, break down, and can be completely gone by mid-July.[13]

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[11] Pokrzywinski, K. L., Getsinger, K. D., Steckart, B., & Midwood, J. D. (2020). Aligning research and management priorities for *Nitellopsis obtusa* (starry stonewort).
[12] MDEQ. (2018). "State of Michigan's Status and Strategy for Curly-leafed Pondweed (*Potamogeton crispus L*.)." Accessed online: <https://www.michigan.gov/documents/invasives/egle-ais-potamogeton-crispus_708948_7.pdf>.
[13] Hart, Steven, M. Klepinger, H. Wandell, D. Garling, L. Wolfson. (2000). "Integrated Pest Management for Nuisance Exotics in Michigan Inland Lakes." Accessed online: <https://www.michigan.gov/documents/invasives/egle-great-lakes-aquatics-IPM-manual_708904_7.pdf>.

Management: Like other invasive species, curly-leaf pondweed is difficult to control once established and is considered widespread in Michigan. Therefore, prevention of new populations in uninfected waters is the most economical management approach. Several herbicides have been shown to be effective at long-term control of curly-leaf pondweed, but eradication is difficult after establishment. Bottom barriers have shown effectiveness at combating curly-leaf pondweed in small areas, and mechanical harvesting of curly-leaf pondweed can be effective if timed and managed correctly.[14]

The most viable ways to control curly-leaf pondweed is through chemical and physical means after developing an integrated pest management plan. Early infestations may best be controlled by manual removal, diver-assisted suction harvesting (DASH), or benthic barrier use during spring before turions are produced. Aquatic herbicides including endothall, diquat, and flumioxazin are the most effective for general applications. Aquatic herbicides including flumioxazin and imazamox are effective for specific types of application and in specific environments. Chemical treatments are a part of a long-term integrated management plan as the turions are viable for at least 5 years and only diquat, fluridone, and some hormone treatments have shown a reduction of turion development in the laboratory.[15]

Figure A4 - Example curly leaf pondweed image from the 2021 LakeScan™ field crew.

[14] MDEQ, 2018.
[15] MDEQ, 2018.

4.2. Appendix B: Herbicide Applicator Data and Maps

Date of treatment (one per section): 6/18/2024							
Name of person applying chemical: Michael Rohlman							
Name of Company or NA if not applicable: Solitude Lake Management							
Effectiveness: ■ Good (70-100%) ☐ Fair (50-69%) ☐ Poor (less than 50%) ☐ Ineffective (0%)							
Chemical Brand Used	EPA Registration Number	Method of Application	Application Rate (10 lbs./acre, etc.)	Treatment Area Size: (Acres)	Average Depth (Feet)	Total Amount (4 gallons, 10 lbs., etc.)	For Control of: (Plant and/or Algae names)
Tribune	100-1390	Surface Spray/Sub Surface Injection	1 gal/acre	7.5	3	7.5 gal	Eurasion Water Milfoil/Curlyleaf Pondweed
Cutrine Plus	67690-93	Surface Spray/Sub Surface Injection	.33 gal/acre-foot	7.5	3	7.5 gal	Macro-algaeStarry Stonewort
Hydrothol 191	70506-175	Surface Spray/Sub Surface Injection	1.33 pint/acre-foot	4.5	3	2.25 gal	Macro-algaeStarry Stonewort
Procellacor EC	67690-80	Surface Spray/Sub Surface Injection	25.6 fl oz/acre-foot	10.25	6	1574 oz	Eurasion Water Milfoil
Tribune	100-1390	Surface Spray/Sub Surface Injection	1 gal/acre	10.25	6	10.25 gal	Eurasion Water Milfoil/Curlyleaf Pondweed
Cutrine Plus	67690-93	Surface Spray/Sub Surface Injection	.17 gal/acre-foot	8.75	6	8.75 gal	Algae
Aquathol K	70506-176	Surface Spray/Sub Surface Injection	1 gal/acre	3	3	3 gal	Curly-leaf Pondweed

Figure B1 – Solitude Lake Management Aquatic Nuisance Control (ANC) treatment report for Cedar Lake, Alcona and Iosco counties, on June 18, 2024.

Date of treatment (one per section): 9/18/2024							
Name of person applying chemical: Michael Rohlman							
Name of Company or NA if not applicable: Solitude Lake Management							
Effectiveness: ■ Good (70-100%) ☐ Fair (50-69%) ☐ Poor (less than 50%) ☐ Ineffective (0%)							
Chemical Brand Used	EPA Registration Number	Method of Application	Application Rate (10 lbs./acre, etc.)	Treatment Area Size: (Acres)	Average Depth (Feet)	Total Amount (4 gallons, 10 lbs., etc.)	For Control of: (Plant and/or Algae names)
Tribune	100-1390	Surface Spray	2 gal/acre	4.5	3	9 gal	Eurasion Water Milfoil
Cutrine Plus	67690-93	Surface Spray	.33 gal/acre-foot	4.5	3	4.5 gal	Algae
Habitat	241-426-67690	Foliage Spray	2 pint/acre-foot	1.25	1	2.5 pint	Phragmites
Aquaneat	228-365	Foliage Spray	2 pint/acre-foot	1.25	1	2.5 pint	Phragmites
Cygnet Plus	N/A	Foliage Spray	.5 pint/acre-foot	1.25	1	.625 pint	Phragmites

Figure B2 – Solitude Lake Management Aquatic Nuisance Control (ANC) treatment report for Cedar Lake, Alcona and Iosco counties, on September 18, 2024.

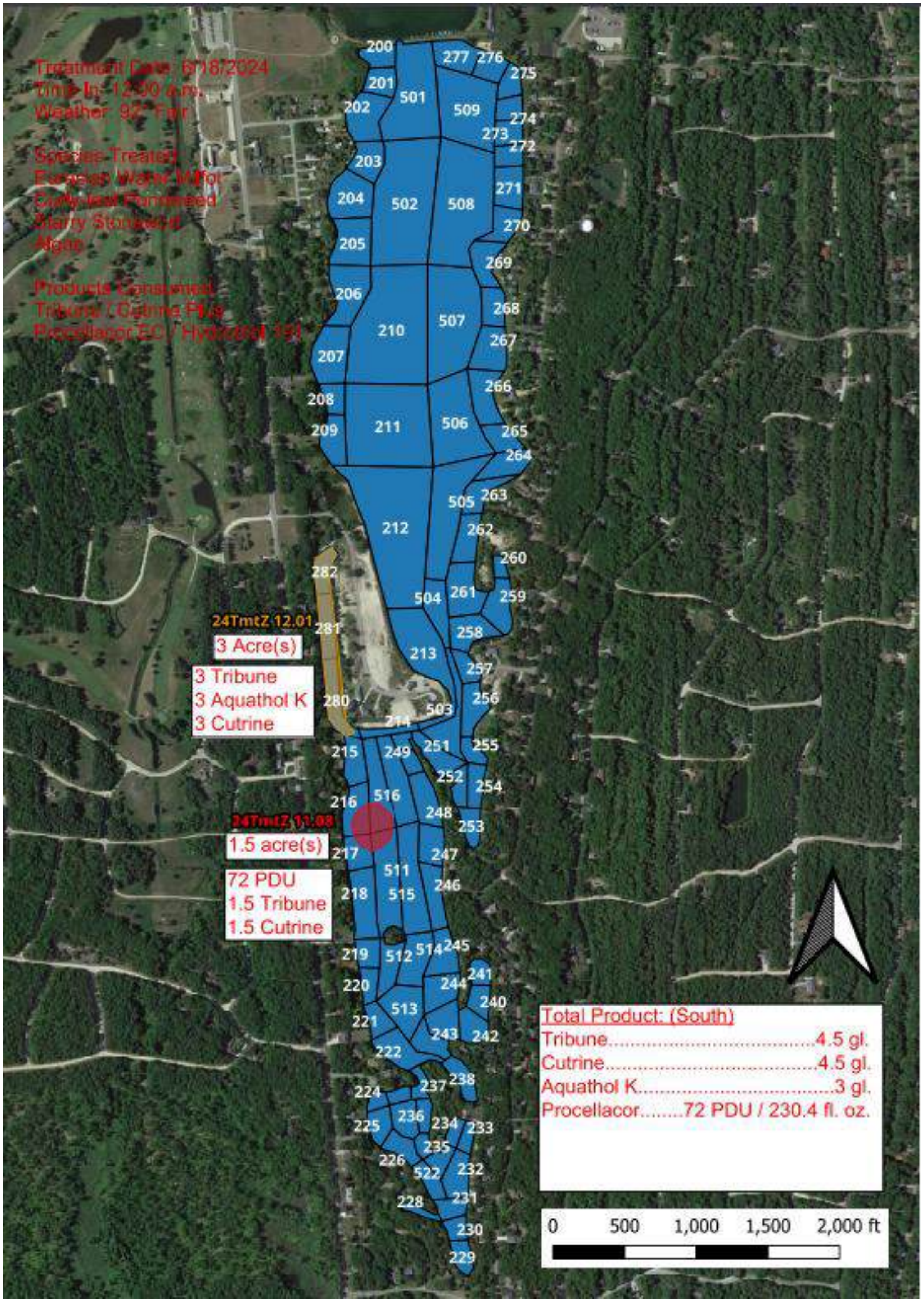

Figure B3 – Solitude Lake Management treatment map for Cedar Lake South, Iosco County, on June 18, 2024.

Treatment Date: 9/18/2024
Time In: 12:00 P.M.
Weather: 78* Fair

Species Treated:
Eurasian Water Milfoil

Products Consumed:
Tribune
Cutrine Plus

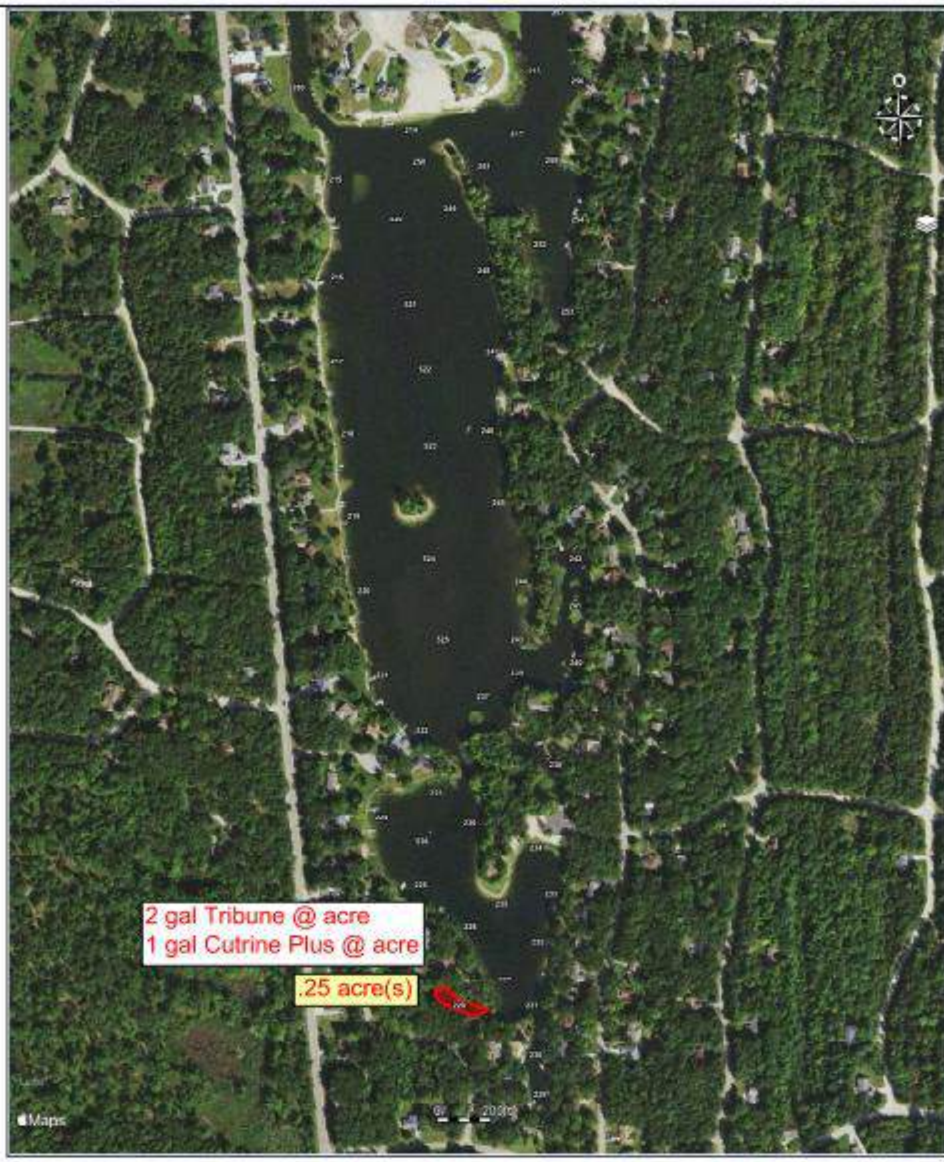

Figure B4 – Solitude Lake Management treatment map for Cedar Lake South, Iosco County, on September 18, 2024.

Cedar Lake WMP (2025)

Attachment E: 2011 WMP Build-Out

Land Use Change

Nonpoint source surface runoff washes nutrients and sediments from the landscape into water bodies. The land use types in a watershed impact the quality and quantity of the runoff. In order to quantify the nutrient and sediment loads to Cedar Lake, percent land use by type was determined using the 2001 land use data layer. Because many of the developed parcels along the shoreline are tree covered, the land use map designates them as "forest" land use. In order to better estimate the true residential land use around Cedar Lake, the 2001 land use layer was updated by visually delineating the urbanized parcels using a 2005 aerial image (USDA, 2005). From this updated inventory of land uses, the majority of the watershed is forest and wetland, which comprise approximately 81% of the land use (not including surface water of Cedar Lake, which covers approximately 22% of watershed, or 1,075 acres). Just over 13% of the watershed is classified as developed (low and high intensity urban and roads) and less than one percent of the land use in the watershed is golf course. The majority of the developed area is located near the shoreline of Cedar Lake and comprises more than 71% of the shoreline land use. Figure 5-1 shows the distribution of land use in the entire watershed compared to the distribution of land use in the shoreline area.

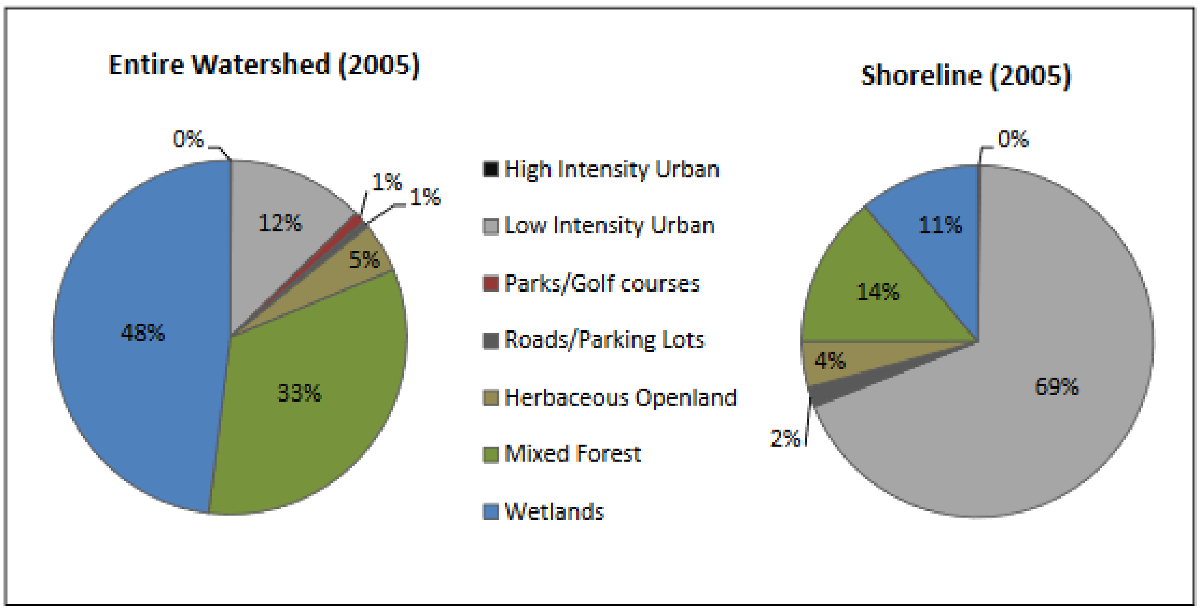

Figure 5-1. Comparison of 2005 land use distribution for the entire watershed and the shoreline area only.

A predicted future land use map for the watershed was developed from the Land Transformation Model for comparison to the 2005 land use breakdown. This model is a GIS-based land use change model developed by researchers from Michigan State University (Pijanowski, et al., 2000, 2002).[1] The future land use depicts an estimation of what land use potentially will be in 2030 in the Cedar Lake watershed. The land use layer was developed from a model that predicts land use changes by combining spatial rules with artificial neural network routines. Spatial rules take into account a variety of geographical,

[1] The LTM is currently hosted by Purdue University and available at: <http://ltm.agriculture.purdue.edu/ltm.htm>.

political, and demographic parameters such as population density, population growth projections, location of rivers and public lands, distance from roads, and topography (Pijanowski et al., 2002). The final 2030 land use distribution or "build-out" was created by comparing the change in land use type (in acres) of the 2001 to 2030 data layers. The predicted change was then applied to the updated 2005 land use distribution, which relied upon visual delineation of the watershed (from 2005 aerial imagery) and field reconnaissance information.

When comparing the land use distribution from 2005 to 2030, changes in future land use in Cedar Lake show a predicted increase in urban and residential areas as undeveloped areas become built out. As Table 5-1 shows, the largest loss of a single land use category is wetlands, which has a predicted loss of approximately 435 acres. The majority of the lost acreage, which is converted to residential land use (see Figure 5-2), is shown in the northwest wetlands, especially along Kings Corner Road and in the northwest section of the watershed. Loss of more than 100 acres of herbaceous openland is also predicted to occur by 2030, which is also shown in the northwest wetland section of the watershed. Forest land is predicted to increase by 20%, which is a reasonable prediction for the Cedar Lake watershed as wetland areas are filled or drained and upland forest species flourish in areas with reduced groundwater inundation. It is also important to note that the pixel size of the 2001 land use breakdown and 2030 predicted build-out are not equal (30m x 30m and 100m x 100m, respectively); therefore, some of the predicted land use change might be a result of this discrepancy and is not a direct prediction of the model.[2]

Table 5-1. Distribution of land use for the entire watershed and shoreline area from 2005 and 2030 and predicted change in land use by type.

Land Use	Entire Watershed Area (Acres)				Shoreline Area (Acres)			
	2005	**2030**	**Change**	**%**	**2005**	**2030**	**Change**	**%**
High Intensity Urban	4.7	41.8	**37.1**	*790%*	2.0	32.2	**30.2**	*1500%*
Low Intensity Urban	470.0	703.9	**233.9**	*50%*	466.1	571.1	**105.0**	*23%*
Parks/Golf Course	37.4	37.4	**0**	*0%*	0	0	**0**	*0%*
Roads/Parking Lots	22.0	44.5	**22.5**	*102%*	12.2	12.2	**0**	*0%*
Herbaceous Openland	171.2	65.2	**-106.0**	*-61%*	28.7	8.7	**-20.0**	*-70%*
Mixed Forest	1,247.6	1,495.1	**247.5**	*20%*	94.7	39.4	**-55.3**	*-60%*
Wetlands	1,807.5	1,372.5	**-435.0**	*-24%*	75.0	15.0	**-60.0**	*-81%*
Water	1,075	1,075	**0**	*0%*	1,031.0	1,031.0	**0**	*0%*

[2] All land use values are meant to provide a general sense of land use change in the future and help guide watershed management activities, and should not be expected to be an exact representation or prediction of current or future land uses in the watershed.

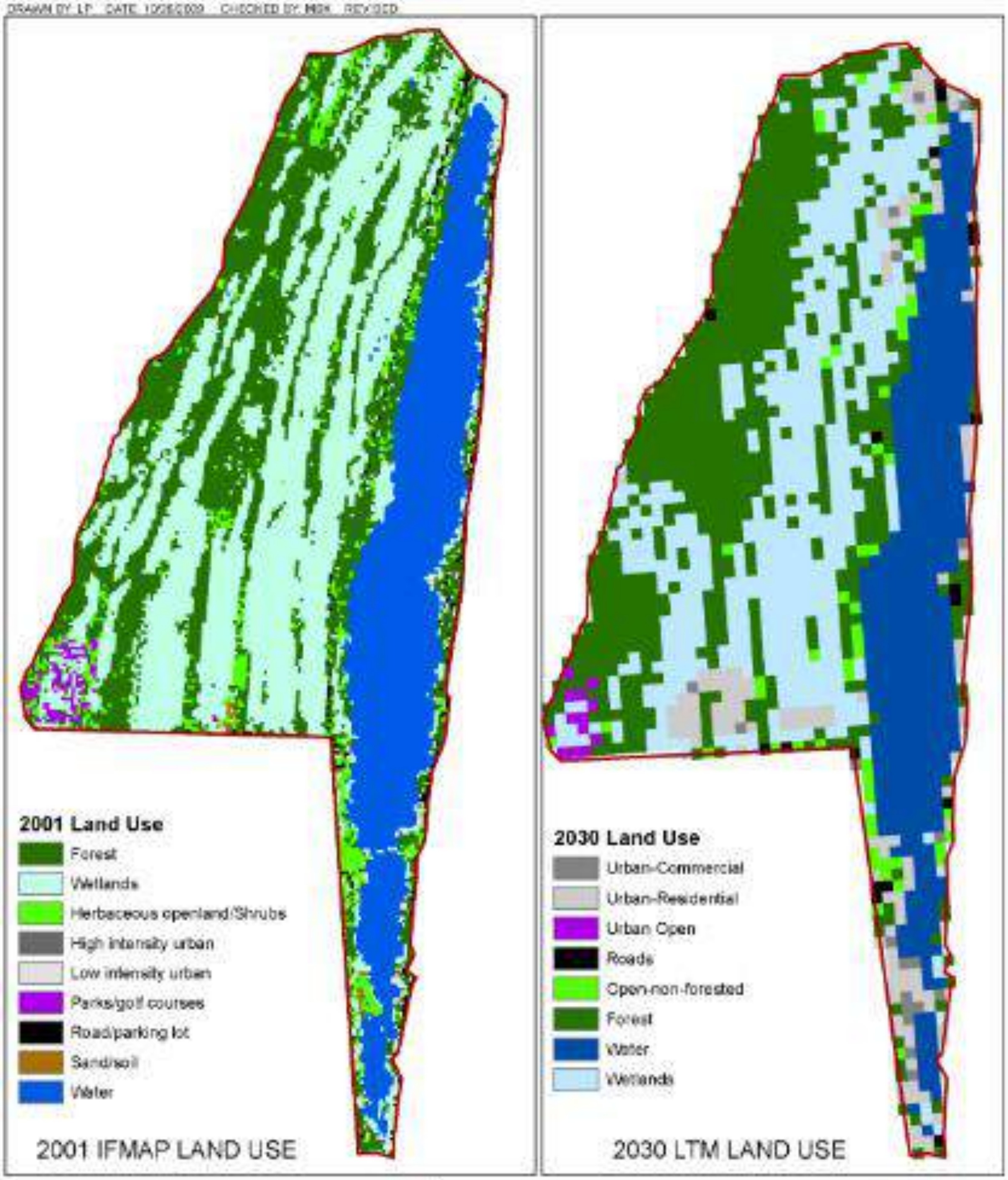

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Figure 5-2. Comparison of 2001 and 2030 land use for the Cedar Lake watershed (note: pixel size is 30x30m in 2001 and 100x100m in 2030).

Cedar Lake WMP (2025)

Attachment F: 2011 WMP Septic System Survey Results

Cedar Lake Septic System Survey and Loading Model Results

A written septic system survey was prepared by K&A and distributed by the Alcona-Iosco Cedar Lake Association (AICLA) to Cedar Lake shoreline property owners in May 2008. The surveys were returned to K&A in June 2008 for analysis. A copy of the survey is included in this document. Respondents provided information on the number of residents (both year-round and seasonal); age of home; age of septic system; septic maintenance schedule; and distance of drain field from the lake. This survey was completed by 190 lakeshore residents, of which 68 were residents located on the northwest side of Cedar Lake.

Previous hydrologic studies of Cedar Lake indicated that only groundwater from the northwest side of the lake feeds into Cedar Lake (K&A, 2006). The remaining area surrounding the lakeshore appears to drain water away from the lake. A total of 68 surveys were completed by residents from the northwest side of the lake (properties located north of Kings Corner Road and on the west Cedar Lake shoreline). Greenbush township plat maps and information from the AICLA indicate that a total of 189 plats border the lake on the northwest side, so approximately 121 residences did not complete a survey. To best account for these incomplete data, the survey results that were available were calculated to obtain averages for: capita years, septic system age, maintenance schedule, and distance of the drain field from the lake. The average capita year was 1.02 and multiplied by the 121 residents to obtain the estimated number of capita years for those residents not accounted for in the survey. This number was then added to the 69.02 capita years obtained from the returned surveys, yielding an estimated total of 192.44 capita years for the northwest side of Cedar Lake.

This number was used in the following equation (Reckhow, et al., 1980).

$W_s = EC_{st} * C_t * AV$ *Equation 3*

Where:
- W_s = Total phosphorus load to the lake from septic systems (pounds/year)
- EC_{st} = Export coefficient to septic tank (pounds/(capita-year)/year)
- C_t = Total number of capita-years/residence
- AV = Sum of all variables influencing delivery of phosphorus to lake (dimensionless)

$AV = EV + SSV$ *Equation 4*

$EV = 0.143[(1-SP) + (1-PA) + (1-DR) + (1-S)]$ *Equation 5*

$SSV = 0.143\ [(1-A) + (1-DS) + (1-M)]$ *Equation 6*

Where:
- EV = environmental variables (dimensionless)
- SSV = septic system variables (dimensionless)
- SP = soil permeability factor (dimensionless)
- PA = phosphorus adsorption capacity factor (dimensionless)
- DR = drainage factor (dimensionless)
- S = slope factor (dimensionless)
- A = age factor (dimensionless)
- DS = distance factor (dimensionless)
- M = maintenance factor (dimensionless)

The same calculations were applied to survey results from the entire lake. A total of 190 surveys were returned regarding septic systems and their maintenance. Greenbush and Oscoda township maps and information from the AICLA indicate that a total of 706 plats border the lake in total, so approximately 516 residences did not complete a survey. To best account for these incomplete data, the survey results that were available were calculated to obtain averages for: capita years, septic system age, maintenance schedule, and distance of the drain field from the lake. Average capita year was 1.14 and multiplied by the 516 residents to obtain the estimated number of capita years for those residents not accounted for in the survey. This number was then added to the 216.89 capita years obtained from the returned surveys, yielding an estimated total of 805.13 capita years for the entire lake. This information was used in the equations above to estimate the approximate phosphorus loads resulting from septic systems.

Septic system variables (SSV) were obtained from survey averages and used in equation 5, above. Using these averages, the assigned factors for SSV could be determined for use in equation 6.

Environmental variables (EV) were determined from soils information obtained from the USDA Soil Surveys of Alcona and Iosco Counties, Michigan (websoilsurvey.nrcs.usda.gov). The soils within the Cedar Lake watershed are listed in Table 1. The soil survey provides specific information on soil permeability, drainage, and other soil properties for each soil type. These parameters were then used to determine EV factor ratings for the above equations. The mid-range of phosphorus adsorption capacity from Table 2 (1300-1600 pounds/acre per top 3 feet of soil) was used for the PA parameter.

Table 1. Soil classification from northwest Cedar Lake lakeshore. [Source: SSURGO soils map and web soil survey map (websoilsurvey.nrcs.usda.gov)]

Soil Types	Code	Estimated % at Shore
Battlefiled Sand	29A	4
Tawas Muck	71	5
Croswell Sand	17B	15
Au Gres Sand	18A	76

The EC_{st} parameter was estimated at 1.3 pounds/capita-year based on estimates used in Reckhow, et al., 1980. This is considered a best estimate based on the number of survey respondents with dishwashers (52.9%). It is unlike that laundry detergents and dishwasher detergents contain substantial amounts of phosphorus, and therefore, would not be contributing substantially to drain field loads.

The estimate for phosphorus loading from the entire shoreline of Cedar Lake was approximately 489 lbs of phosphorus/year. From research and modeling performed by K&A in 2006, results indicate that only the properties on the northwest side of the lake have groundwater contribution to Cedar Lake. For this reason, the surveys from residents on the northwest side of the lake were used to calculate a "contributing load" of phosphorus from septic systems. The results from this model run estimate the loading to Cedar Lake from these septic systems is approximately 115 lbs of phosphorus/year.

Table 2. Variables considered in calculating AV and assigned factors. (Source: Limno-Tech, 1989)

Parameter	Range	Assigned Factors
Soil Permeability	>10	0.75
(in/hr)	1-10	0.5
	0-1	0.25
Phosphorus Adsorption Capacity	1600-2000	.75
(lbs/ac/top 3 feet of soil)	1300-1600	.5
	1000-1300	.25
Soil Drainage	6	.75
(depth to water table)	0.5-1.8	.15
	0	.05
Slope	0	1
(%)	>0-6	1
	>6-12	.75
	>12-18	.75
	>18-25	.5
	>25	.25
Age	0-2.5	1
(years)	>2.5-5	.75
	>5-8	.5
	>8-11	.25
	>11	.05
Maintenance Frequency	0-2	1
(years)	>2-5	.75
	>5-8	.5
	>8-11	.25
	>11	.05
Distance to Lake	<50	.05
(ft)	>50-75	.25
	>75-100	.5
	>100-200	.75
	>200	1

References

Kieser & Associates, LLC. 2006. Phase II Final Report for Additional Hydrologic Evaluation of Cedar Lake with Reference to Lake Levels. Prepared September 18, 2006 for AICLA.

Limno-Tech, Inc. 1989. Variables for Modeling Phosphorus Loading from Septic Systems to Lakeshore.

Reckhow, K. H., Beaulac, M. N., and J. T. Simpson. 1980. Modeling Phosphorus Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients. USEPA 440/5-80-011. Washington, DC.

Septic System Survey Form and Cover Letter

May 16, 2008

Dear Cedar Lake Resident:

The AICLA and Lake Board contracted the environmental engineering firm of Kieser & Associates, LLC (K&A) to assess current water quality conditions in Cedar Lake, facilitate the watershed planning process, and formulate lake improvement options to protect this water body.

In addition to addressing water level issues, our watershed planning efforts focus on phosphorus as a pollutant that can degrade water quality if added to the lake in large quantities. Phosphorus is a naturally occurring element that is found in soil, plants, food, human and animal wastes and used in fertilizers and many soaps. In order to determine the impact of phosphorus on Cedar Lake water quality, we are estimating phosphorus inputs from various sources including its shoreline. One potential source of phosphorus to Cedar Lake from these shoreline areas is septic systems.

We are asking for your help in estimating phosphorus contributions from shoreline septic systems. The AICLA has enclosed a voluntary septic system survey form to be completed by Cedar Lake shoreline residents. All requested information is valuable in assessing septic system contributions to Cedar Lake. We would greatly appreciate your time to provide the most accurate and complete information that you can.

Please assist us in assessing lake water quality. When you complete your survey form, return it to Russ Anton by July 4, 2008.

Thank you for your cooperation. Your responses will be kept confidential. Please direct any questions you may have to Russ Anton of AICLA.

Cedar Lake Shoreline Septic Systems
A Survey for Lake Residents

Optional Information:

Date you completed this form: ___________________

Resident of Cedar Lake home: ____

Owner of home (if different than above): _____________________________________

Address: ____

Necessary Information:

IF YOU ARE PERMANENT YEAR-ROUND RESIDENT, number of permanent residents at the home: _____.

-OR-

IF YOU ARE SEASONAL RESIDENT, number of seasonal residents: _____, approximate length of stay _____ days

If you are seasonal residents, how many people plan to become permanent residents? _____ people in _____ years?

OTHER INFORMATION:

Typical number of annual guests: _____, approximate length of stay _____ days

Age of home: ______ years

Age of septic system: ______ years

Distance of drain field from the lake: _____ feet

Is the septic tank routinely pumped (circle)? Yes or No.
How often? Every _____ years

Additional Optional Information:

_____ years since septic tank last pumped. Reason for pumping (for example, routine maintenance, system filled to capacity, system backed up, etc.) ____________________

____.

_____ years since major septic system repairs. (Describe the repair.)_______________

____.

Please enter the number of each water-using fixture (Please note "w.c." if designed to conserve water):

___Shower head	___Kitchen sink	___Laundry machine
___Bathtubs	___Garbage disposal	___Water softener
___Bathroom sink	___Dishwasher	___Utility sink
___Toilets	___Other kitchen	___Other utilities

Are there any plans for changes to the household water fixtures? _________________

____

Are there any known problems with the septic system? ________________________

____

____

Are there any plans to replace your septic system and if so, when?

____

Thank you for your cooperation. Please return completed surveys to Russ Anton, AICLA President.

Cedar Lake WMP (2025)

Attachment G: WMP Technical Update Steering Committee Presentation

Cedar Lake WMP Update – Overview of the Process

- Watershed Intro:
  2011 vs 2025 WMP Objectives
  Carry-over Objectives in Green; New Objectives in Blue

- Watershed Project Objectives, Achievements & Examples:
  A) 2011 Implementation Strategies – Accomplishments to Date
  Accomplished; Partially Accomplished; Not Accomplished

  …followed by the…

  B) 2025 Updated Implementation Strategies – DRAFT Tables
  New Implementation Strategies

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Cedar Lake Watershed "Critical Areas" for Protection and Restoration

Where have we been… and where are we going?

2011 Objectives v Draft 2025 Objectives

Carried-over Objectives in Green; New Objectives in Blue

2011 Objectives	Draft 2025 Objectives
I. NW Wetlands Protection	I. Lake Level Augmentation *(I & III)*
II. Lakewood Shores Drainage Issues	II. Lakewood Shores Drainage *(II)*
III. Lake Level Augmentation	III. Timberlakes Drainage Prevention
IV. Fisheries Improvements	IV. Fisheries Improvements *(IV)*
V. Invasive Species Management	V. Invasive Species Management *(V)*
VI. Muck Sediment Issues	VI. Muck Management *(VI)*
VII. Natural Shorelines & Lakescaping	VII. Natural Shorelines & Lakescaping *(VII)*
VIII. Water Quality Assessments	VIII. Water Quality Assessments *(VIII)*
~~IX. Conservation Easements~~	IX. DNR Boat Launch Improvements

2011 Objective I: NW Wetlands Protections for Lake Level Augmentation

Accomplished in Green; *Partially Accomplished in Yellow*; *Not Accomplished in Red*

<table>
<tr><th>Objective</th><th>Implementation Project</th><th>Accomplished</th><th>Achievements</th></tr>
<tr><td>I-1</td><td>Create or support a wetland zoning ordinance</td><td>N</td><td></td></tr>
<tr><td rowspan="4">I-2</td><td>Re-Engineer Hydrology of NW Wetlands:</td><td>Y</td><td rowspan="4">2014 – Present: Regular inspections and clean-outs of Railroad Culverts.

2017: Sherman Creek Wetland Berm constructed, a hydrology modification increasing Sherman Creek Wetland water volume entering Cedar Lake by reducing out-of watershed losses to Phelan Creek.

2019: Sherman Creek In-stream Grade Structures installed to delay flashy springtime discharges, naturally extend the seasonal longevity of surface and groundwater flows into Cedar Lake and improve pike spawning habitat.

2021: Augmentation Feasibility Study update completed by K&A.</td></tr>
<tr><td>Store water in wetlands & slowly release through streams</td><td>Y</td></tr>
<tr><td>Reduce surface water diversion at Kings Corner culvert</td><td>Y</td></tr>
<tr><td>Augment water levels by pumping groundwater into wetland</td><td>P</td></tr>
<tr><td rowspan="4">I-3</td><td>Acquisition of property in NW for wetland restoration/public viewing area:</td><td>Y</td><td rowspan="4">2014: CLIB directly purchased 172-acre Sherman Creek Wetland Property.

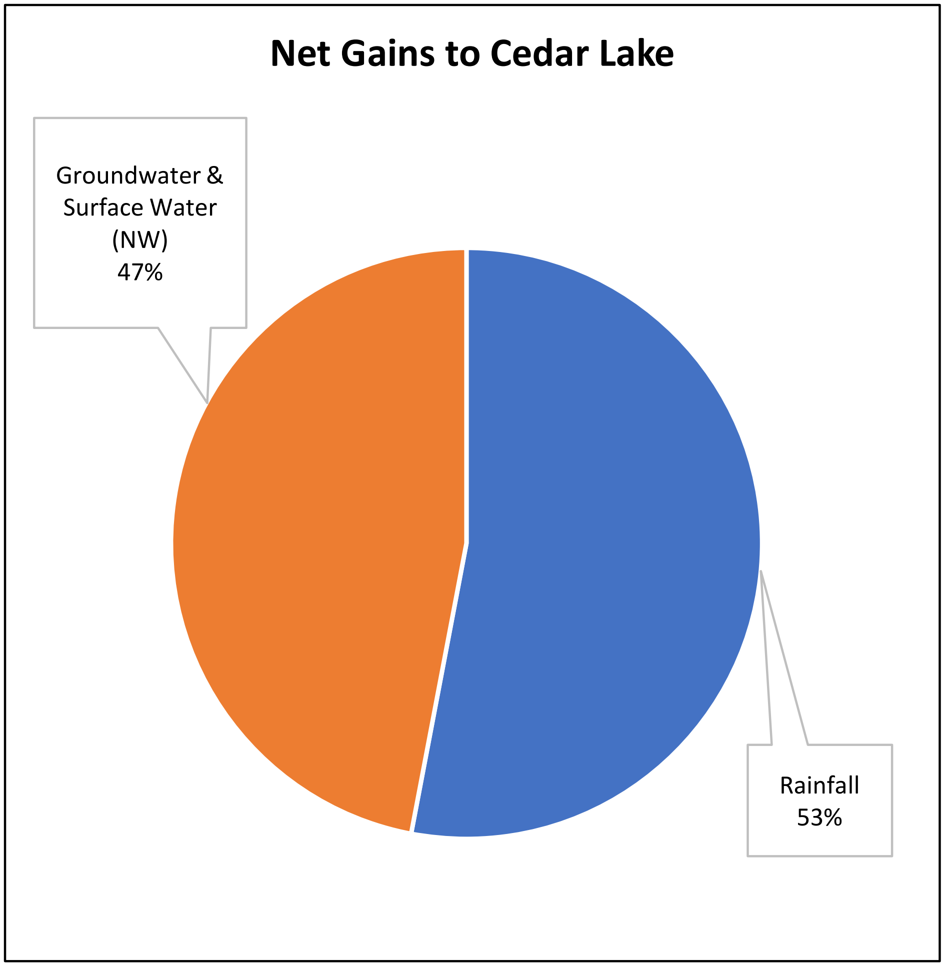
2022: CLIB directly purchased 12-acre Jones Ditch Lakefront/Wetland Property.</td></tr>
<tr><td>1) Direct purchase of land</td><td>Y</td></tr>
<tr><td>2) Donation of conservation easements</td><td>N</td></tr>
<tr><td>3) Purchase of development rights</td><td>Y</td></tr>
</table>

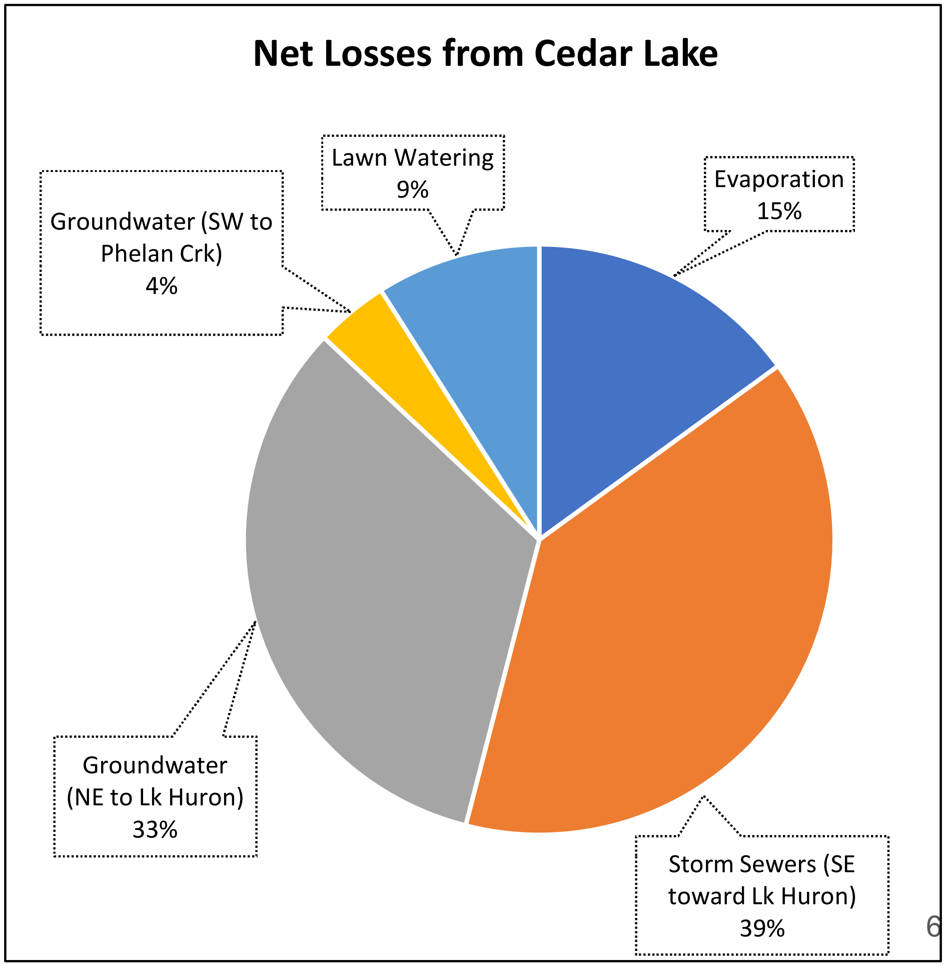
2011 Objective III: Lake Level Augmentation Project Implementation

Accomplished in Green; Partially Accomplished in Yellow; Not Accomplished in Red

Objective	Implementation Project	Accomplished	*Achievements*
III-1	Conduct public hearings and informational session to gain taxpayer support and pass assessment to fund lake level management.	Y	**2015-2019:** Special Assessment District (SAD) for lake management and weed control. **2019/2020:** SAD notice issued in Nov 2019 and passed in 2020 related to the reconstruction of the Cedar Lake outlet structure. **2020-20230:** SAD for lake management and weed control.
III-2	Implement lake level management projects to augment summer lake levels.	Y	***(See: Lake Level Augmentation Achievements from the 2011 Objective I)*** **2011 – Present:** Ongoing monitoring of groundwater and lake level hydrology, including annual reporting with recommendations related to lake level augmentation feasibility options as identified in the WMP and related studies.

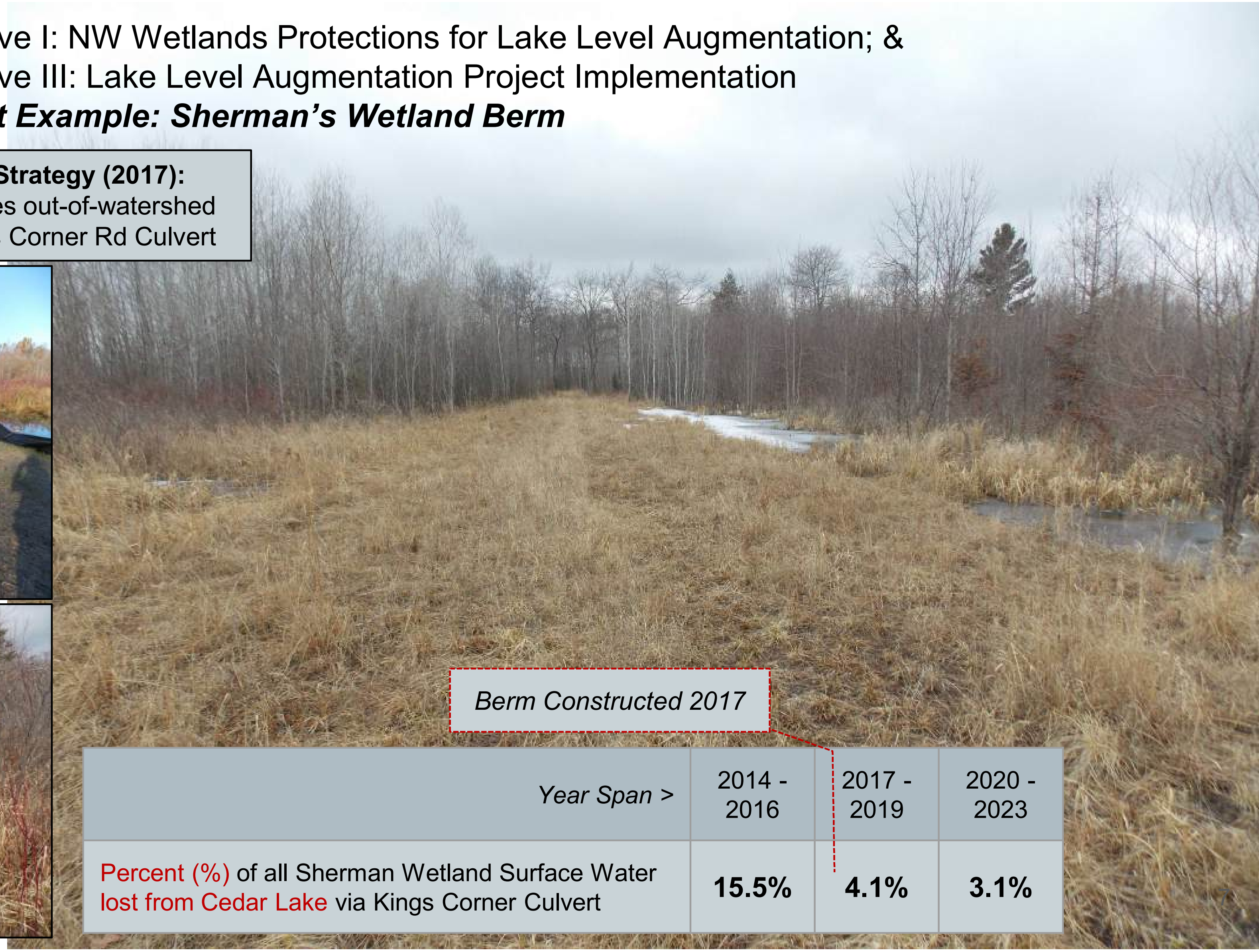
2011 Objective I: NW Wetlands Protections for Lake Level Augmentation; &
2011 Objective III: Lake Level Augmentation Project Implementation
WMP Example: Hydrologic Mass Balance (Watershed Gains & Losses)





2011 Objective I: NW Wetlands Protections for Lake Level Augmentation; &
2011 Objective III: Lake Level Augmentation Project Implementation
2017 Project Example: Sherman's Wetland Berm

Lake Level Augmentation Strategy (2017):
Sherman Wetland Berm reduces out-of-watershed Surface Water Losses to King's Corner Rd Culvert



Berm Constructed 2017

Year Span >	2014 - 2016	2017 - 2019	2020 - 2023
Percent (%) of all Sherman Wetland Surface Water lost from Cedar Lake via Kings Corner Culvert	**15.5%**	**4.1%**	**3.1%**

2011 Objective I: NW Wetlands Protections for Lake Level Augmentation; &
2011 Objective III: Lake Level Augmentation Project Implementation
2019 Project Example: Sherman Creek In-stream Grade Structures

Pre-Construction

Post-Construction

Lake Level Augmentation Strategy (2019):
In-stream Grade Structures reduce flashy spring flows, improving wetland retention and summer slow-release, and enhancing pike-spawning habitat.

2011 Objective I: NW Wetlands Protections for Lake Level Augmentation; &
2011 Objective III: Lake Level Augmentation Project Implementation
2022 Project Example: Cedar Lake Outlet replacement

2011 Objective I: NW Wetlands Protections for Lake Level Augmentation; &
2011 Objective III: Lake Level Augmentation Project Implementation

2011 WMP Lake Level Augmentation Option (*w/ map ID #)*	*DRAFT 2025 WMP* Feasibility Determination
(1) Sherman Creek: Modifications	Implemented (2017 & 2019)
(4) Kings Corner Culvert: Modifications	Alternative Berm Implemented (2017)
(7) Cedar Lake Outlet Spillway: Repairing or Replacing	Implemented (2020)
(2) Jones Ditch: Modifications	Potentially Feasible (short-term)
(3) Groundwater Augmentation Well: Surface Water into Wetlands	Potentially Feasible (long-term)
(5) Lakewood Shores: Drainage Re-circulation	Potentially Feasible (long-term)
(3) Groundwater Augmentation Well: Direct Piping of Water to Lake	Not Feasible (cost)
(4) Phelan Creek: Diversion	Not Feasible (negligible volume)
(6) Lake Huron: Pumping to Cedar Lake	Not Feasible (not permitable)
(7) Cedar Lake Outlet: Harvest Wet Weather Flows	Not Feasible (negligible volume)

2025 Updated Objective I: Lake Level Augmentation (Maintain Lake Water Level)

Accomplished in Green; *Partially Accomplished in Yellow*; *Not Accomplished in Red*; *New Implementation Strategies in Blue*

Objective	Updated Implementation Strategy	*Notes*
I-1	Implement lake level management projects to augment summer lake levels.	*Purpose: Watershed water quality, aquatic ecological systems, and recreational uses depend on adequate Lake Water Level.*
I-2	Summarize feasibility study findings on passive vs. active Lake Augmentation options for the CLIB.	*Clarify roles for the CLIB, DC, AICLA, etc. to address or implement each remaining feasible Lake Augmentation option*
I-3	Support and work to implement wetland zoning ordinance to protect wetland function	*Identify prevailing local, state, federal controls*
I-4	**Re-engineer hydrology of NW wetlands:**	
	I. Assess hydrology of Jones Ditch wetland and determine feasibility of water storage measures.	*Ongoing*
	II. Improve NW Wetlands Railroad Culvert flows: Coordinate with RR reconstruction project.	*See current MIGLP Grant Application for Sherman Creek & Jones Ditch RR culvert maintenance; Sherman channel*
	III. Augment water levels by groundwater pumping into wetland.	*Follow findings of Augmentation Feasibility studies*
	IV. Assess storage and flow improvements in NW wetland and continue ongoing water level monitoring to track hydrology changes and improvements over time.	*Continue Hydrology Monitoring program with annual report.*
I-5	**Acquisition of property in NW for wetland restoration/public viewing area:**	
	1) Direct purchase of land - *Explore purchasing and managing addtl. parcels of land in the NW area*	*(Are there CLIB purchaseable wetlands to the west that provide value; consider wetland mitigation banking; habitat banking options)*
	2) Donation of conservation easements - *Engage with land conservancies to provide technical resources and information to obtain conservation easements from private property owners*	*This could be an AICLA play for NW swamp property owners to protect land but retain hunting/access rights; maybe also cede some GW augmentation rights*

2011 Objective II: Lakewood Shores Drainage Issues

Accomplished in Green; Partially Accomplished in Yellow; Not Accomplished in Red

Objective	Implementation Project	Accomplished	***Achievements***
II-1	Support and work to implement ordinance (wetland or zoning overlay) to prevent building in wetlands/low-lying areas	N	*No known achievements to date.*
II-2	Set up coordination procedures with DEQ & building inspector to ensure building codes are followed and DEQ is notified	N	
II-3	Partner with LSPOA to modify Architectural Standards and develop informational materials for residents about home flood protection	N	
II-4	Hold workshops to educate homeowners on building practices or measures that will reduce flooding	N	
II-5	Conservation easements and other conservation measures on parcels in Lakewood Shores (potentially on grouped parcels)	N	

2011 Objective II: Lakewood Shores Drainage Issues - *Defined*

<u>5. Lakewood Shores Drainage District</u>:

Just outside of the Cedar Lake Watershed but hydrologically linked through a groundwater connection. Cedar Lake naturally loses water to shallow groundwater aquifers on the south end of the lake. Lakewood Shores residential development included a subsurface sewer system to drain naturally-high groundwater to Lake Huron.

Lakewood Shores drainage district was identified as the largest water-loss from Cedar Lake during summer months.

Objective Strategies:

- Educating builders and new residents about the flooding issues around this area is likely the best approach.
- Eliminate the need to expand the existing subsurface drainage system as more building occurs on undeveloped lots in Lakewood Shores.
- Consider creative alternatives such as purchasing undeveloped lots to use for drainage recirculation to Cedar Lake.

Note – Restoration is not a major strategy for this area; residents rely on the existing drainage to keep houses from inundatation with water during wet months.

2025 Updated Objective II: Lakewood Shores Drainage Issues

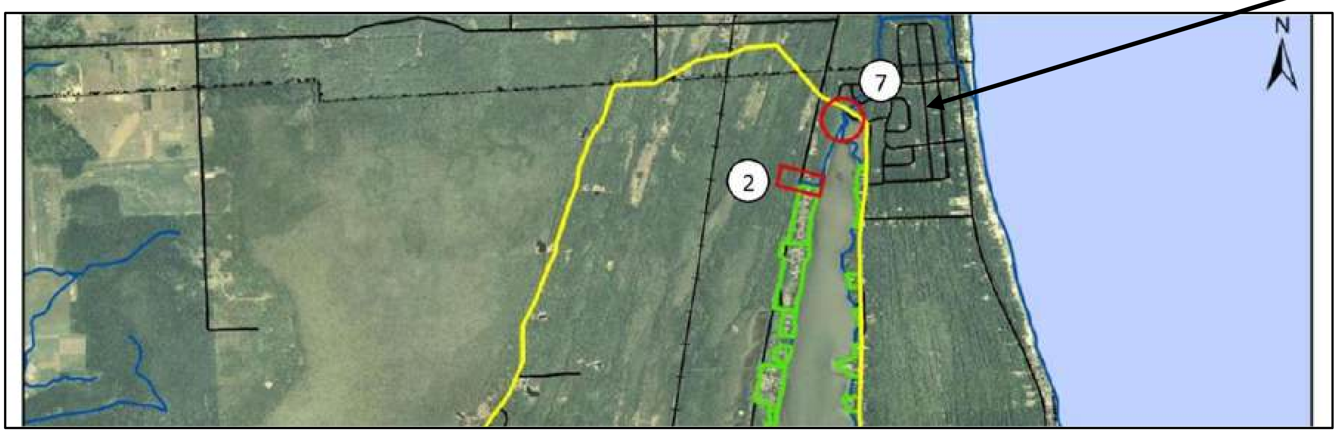
Accomplished in Green; Partially Accomplished in Yellow; Not Accomplished in Red; New Implementation Strategies in Blue

Objective	Updated Implementation Strategy	*Notes*
II-1	Work with the Drain Commissioners on storage and return issues/options	*Responsible Party: Drain Commissioner*
II-2	Purchase tax reverted lands	*Protection; future water storage*
II-3	Wetlands banking (investment for return flow options)	*K&A suggestion*
II-4	Wetland delineations for unbuilt parcels (desktop analysis or more)	*Desktop analysis could happen near-term*
II-5	Support and work to implement ordinance (wetland or zoning overlay) to prevent building in wetlands/low-lying areas	*Still needed? Responsible Party?*
II-6	Set up coordination procedures with DEQ & building inspector to ensure building codes are followed and DEQ is notified	*Still needed? Responsible Party?*
II-7	Partner with LSPOA to modify Architectural Standards and develop informational materials for residents about home flood protection	*Still needed? Responsible Party?*
II-8	Workshops to educate homeowners on building practices or measures that will reduce flooding	*Still needed? Responsible Party?*
II-9	Conservation easements and other conservation measures on parcels in Lakewood Shores	*Still needed? Responsible Party?*

2025 Updated Objective III: Timberlakes Drainage Prevention

Accomplished in Green; Partially Accomplished in Yellow; Not Accomplished in Red; New Implementation Strategies in Blue

Objective	Updated Implementation Strategy	Notes
III-1	Work with the Drain Commissioners to find solutions to potential future development issues/drainage needs.	*Responsible Party: Drain Commissioner*
III-2	Identify and pursue opportunities to prevent future drainage issues similar to Lakewood Shores issue.	*See notes from Objective II*



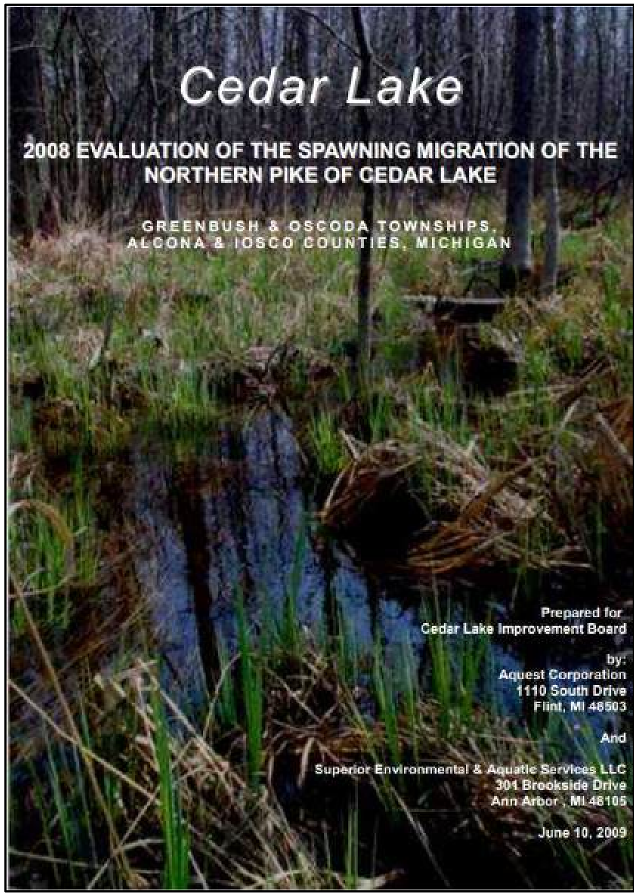
Timberlakes Drainage District:
Surface water flooding and related ditch and stream discharges in the Timberlakes subdivision, just beyond the northern extent of the Cedar Lake watershed and just downstream of the lake outlet structure, were brought to the attention of the CLIB in 2020. Preventing future development-related drainage issues is a primary strategy.

2011 Objective IV: Fisheries Improvements

Accomplished in Green; Partially Accomplished in Yellow; Not Accomplished in Red

Objective	Implementation Project	Accomplished	*Achievements*
IV-1	Re-engineer hydrology of NW wetlands (support fisheries by improving spawning habitat)	Y	**2014:** CLIB directly purchased 172-acre Sherman Creek Wetland Property. **2017:** Sherman Creek Wetland Berm **2019:** Sherman Creek In-Stream Grade Structures **2023:** CLIB directly purchased 12-acre Jones Ditch Wetland Property.
IV-2	Wetlands protection through policy and/or conservation easements	N	
IV-3	**Recommendations from Fisheries Management Reports:**	P	Studies, 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:** Redear sunfish stocking review (Northpointe Fisheries Management) **2018:** Fish population assessment related to redear stocking, reassessing angling benefits (Northpointe Fisheries Management) **2024:** K&A-initiated Fisheries Habitat Study in Jones and Sherman Ditches / wetland properties
	1) Conduct a fish population assessment	Y	
	2) Conduct critical fish habitat assessment	P	
	3) Provide habitat enhancement for walleye and channel catfish and document use	N	
	4) Maintain or increase size and number of adult bass	N	
	5) Re-assess angling benefits and potential for stocking Redear sunfish to establish an increased fishery/increase bluegill spawning habitat	P	

2011 Objective IV: Fisheries Improvements
Fisheries Report Examples



Michigan Dept. of Natural Resources
Status of the Fishery Resource Report *Page 1*

Cedar Lake
Alcona and Iosco counties
Lake Huron watershed, last surveyed 2011

Tim A. Cwalinski, Senior Fisheries Biologist

Environment

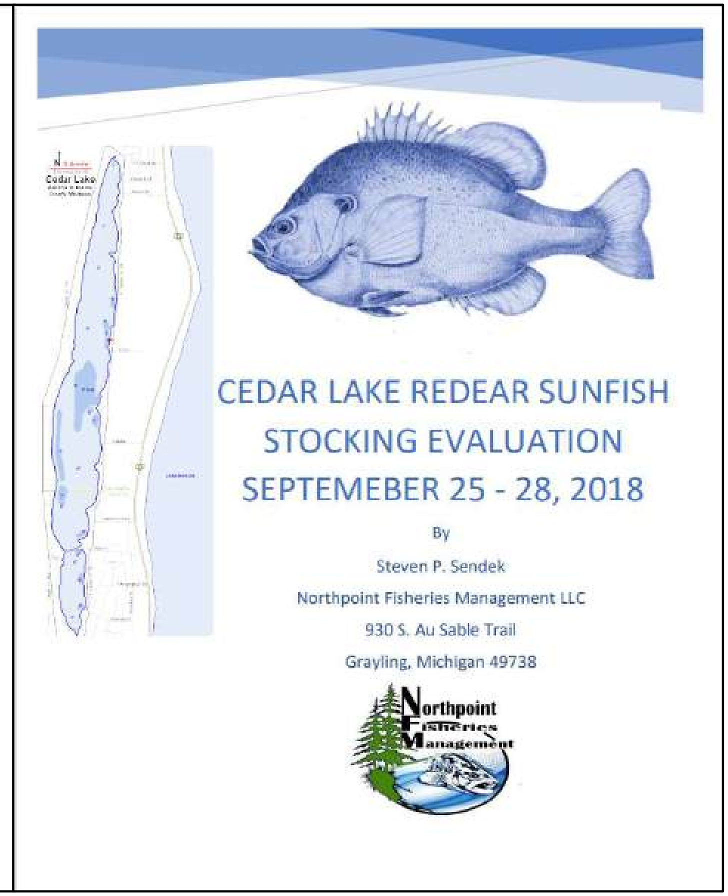
Cedar Lake is 1,075 acres in size and located in both Alcona and Iosco counties in the northern Lower Peninsula of Michigan (Figure 1). It is north of the town of Oscoda and south of Harrisville. The lake lies only a half-mile west of Lake Huron and is 5.9 miles long and averages 0.2 miles wide. The lake is split by a causeway on the southern half. Its maximum depth is approximately 12 feet south of the causeway, and 10 feet north of causeway. Most of the lake is less than five feet deep. The lake has a very small drainage area, which is primarily a lowland swamp west of the lake, and a small creek (Sherman) that drains it. The outlet of Cedar Lake flows through a fixed crest control structure and out a short distance to Lake Huron. Fish passage is not attained through this structure. The control structure was first built in 1954 which replaced a log dam structure of unknown age (Rex Vaughn, Cedar Lake Improvement Board, personal communication). The structure was built as a result of a Circuit Court Order establishing a legal lake level that same year. The structure was revised in 1979, repaired in 2012, and is currently scheduled for renovation in fall 2020. The fixed crest structure and overflow design establishes a legal lake level of 608.2 feet at high water. The structure is maintained under joint authority of the Alcona County Road Commission/drain commissioner and the Iosco County drain commissioner. The acting delegated authority is Alcona County.

The shoreline of Cedar Lake is heavily developed and mostly private. Much of the west shore development has prevented connection to wetlands. Shoreline armoring is significant in Cedar Lake and docks are prevalent. The shallow depth of this natural lake does not lend itself to thermal stratification. The bottom substrate is comprised of primarily sand, marl, and muck. Aquatic vegetation is abundant but tends to grow in pockets. A private applicator, on behalf the Cedar Lake Improvement Board, has applied for permits for 15 chemical treatments of nuisance aquatic vegetation in Cedar Lake since 2005 (Ryan Crouch, Department of Environment, Great Lakes, and Energy, personal communication). Treatments have focused on non-native milfoil and curly leaf pondweed predominantly, but some native vegetation has been targeted. Recent treatments have typically been completed in early June and are often 50-70 acres in size. Later summer treatments have also occurred.

A Department of Natural Resources (DNR) public boat launch exists along the east shore (Figure 2) and offers a paved boat launch and parking for 26 trailers. The standard set of Michigan's fishing regulations apply for Cedar Lake.

History

Historical stocking records for Cedar Lake are lacking and only begin after 1980 (Table 1). Tiger Muskellunge were stocked from 1980 through 1991 to promote increased predator numbers and reduce stunted panfish. This program produced limited results and was followed by a spring fingerling Walleye stocking program that continues today (Table 1). Redear Sunfish and hybrid sunfish were stocked by the Cedar Lake Association from 2010 through 2016.



2025 Updated Objective IV: Fisheries Improvements

Accomplished in Green; Partially Accomplished in Yellow; Not Accomplished in Red; New Implementation Strategies in Blue

Objective	Updated Implementation Strategy	*Notes*
IV-1	Re-engineer hydrology of NW wetlands to support fisheries by improving spawning habitat	*Sherman done, but more potential channel improvement for water flow to support spawning; Jones pending with MWGLP grant*
IV-2	Wetlands protection through policy and/or conservation easements	*Still Needed?*
IV-3	**Follow Recommendations from Fisheries Management Reports:**	
	1) Conduct a fish population assessment, including a sportfishing Creel Census	*I. Online survey; Creel Census targeting sport fishing tournaments* *II. Utilize data for fisheries management*
	2) Conduct critical fish habitat assessments	*K&A 2024-2025 assessment*
	2a) Assess pike spawning improvements in Sherman Creek and fisheries spawning habitat in Jones Creek, using habitat surveys to determine restoration needs.	*I. Monitoring, potentially remote sensing* *II. Fyke net surveys / Pike tagging*
	2b) Conduct an in-lake critical fish habitat assessment update.	*I. For example, a full-lake LakeScan Habitat Survey*
	3) Provide habitat enhancement for walleye and channel catfish and document use	*Re-do this for pike, maybe redear; shallow lake options for walleye—gravel, wetlands access via flowing tributaries*
	3a) MDNR decadal fisheries assessment and walleye fingerling stocking "as needed"	*I. Ensure MDNR fisheries assessment recurs once/decade* *II. Adapt management strategies based on assessments*
	4) Maintain or increase size and number of adult bass	*Fishstick projects*
	5) Re-assess angling benefits and potential for stocking Redear sunfish to establish an increased fishery/increase bluegill spawning habitat	*Note: Redear efforts not favored by DNR; blue-gill spawning approach?* *I. Feasibility experiments* *II. Enclosure stocking & monitoring* *III. Swimmers Itch reporting website*

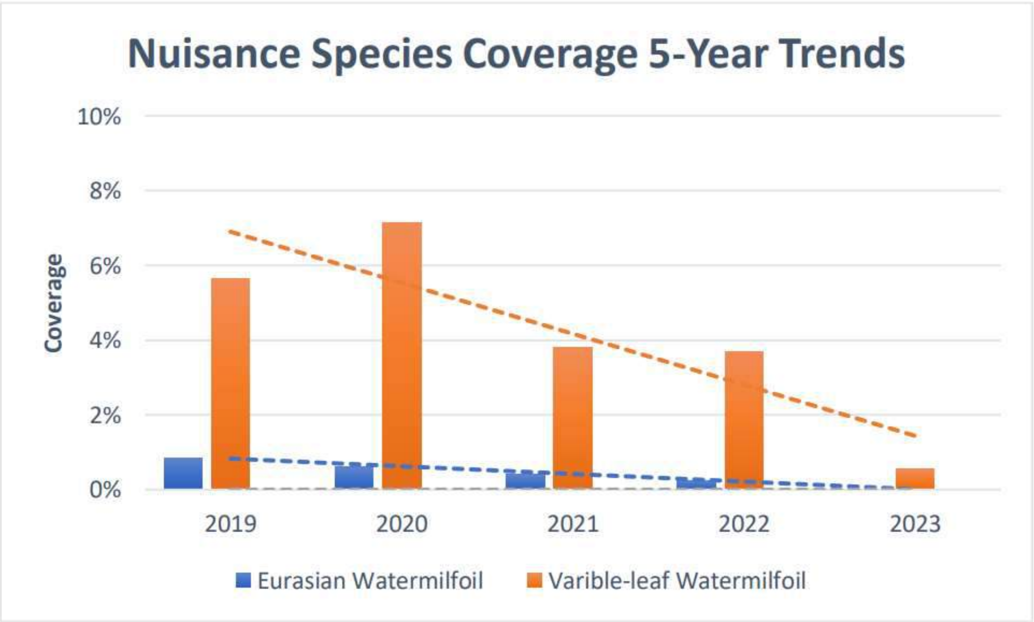
2011 Objective V: Invasive Species Management

Accomplished in Green; Partially Accomplished in Yellow; Not Accomplished in Red

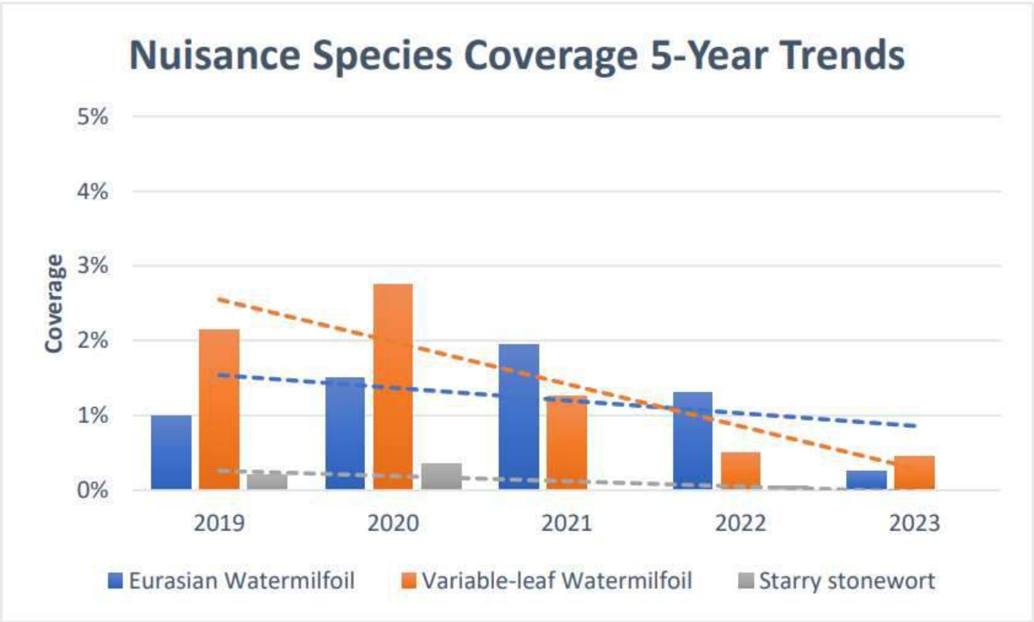
Objective	Implementation Project	Accomplished	*Achievements*
V-1	Education on best practices to reduce transmission of invasive species.	P	***Partial Completion**: Signage implemented at boat launch; Periodic newsletter updates*
V-2	Create boat cleaning station with signage informing lake users about invasive species risks and best practices to reduce the risk of spread.	P	***Partial Completion:** Signage implemented at boat launch, but no cleaning station implemented*
V-3	Develop Cedar Lake Property Owners Guide to promote WMP and educate on invasive species, lakescaping, lawn practices, and fertilizers	N	*No known achievements to date.*
V-4	Develop full Lake Manager contract through the Lake Board to continue adaptive management strategy for lake and recommended future actions/implement WMP strategies	Y	**Ongoing**
V-5	Continue lake treatments for invasive species and noxious weeds and algae growth	Y	**Ongoing:** Annual Aquatic Weed Treatments informed by detailed LakeScan Surveys including before and after treatment surveys to track effectiveness and long-term changes over time.

2011 Objective V: Invasive Species Management

Project Example: LakeScan Survey Findings



North Cedar Lake: Nuisance Species Coverage, 5-yr trend



South Cedar Lake: Nuisance Species Coverage, 5-yr trend

Invasive Species Management Strategy:
Cedar Lake continues to focus on identifying and mitigating invasive and noxious weed and algae growth in order to: *mitigate disturbances to natural lake flora, improve lake ecosystem health, improve recreation opportunities focusing on improving fish habitat, target existing AIS for suppression and monitor new invasive threats, with surveys in support of overall lake water quality and ecosystem health.*

2025 Updated Objective V: Invasive Species Management

Accomplished in Green; Partially Accomplished in Yellow; Not Accomplished in Red; New Implementation Strategies in Blue

Objective	Updated Implementation Strategy	*Notes*
V-1	Education on best practices to reduce transmission of invasive species	*Purple Loostrife and Phragmites controls?*
V-2	Create boat cleaning station with signage informing lake users about invasive species risks and best practices to reduce the risk of spread.	*Boat Launch Cleaning Station still desired?*
V-3	Develop Cedar Lake Property Owners Guide to promote WMP and educate on invasive species, lakescaping, lawn practices, and fertilizers	*Engage Lake Manager to complete this task?*
V-4	Lake Manager contract through the Lake Board to continue adaptive management strategy for lake and recommended future actions/implement WMP strategies	*Need clarity on roles, responsibilities, and restrictions (who can do what?)*
V-5	Continue lake treatments for noxious weeds and algae growth, *with a focus on mitigating disturbances to natural lake flora, improving lake ecosystem health, improving recreation opportunities focusing on improving fish habitat, targeting existing AIS for suppression and monitoring new invasive threats, and surveying in support of overall lake water quality*.	*Consider discussing other control methods to support chemical treatments: DASH, biocontrols; NW septic discharges and algae growth/blooms, harvesting*

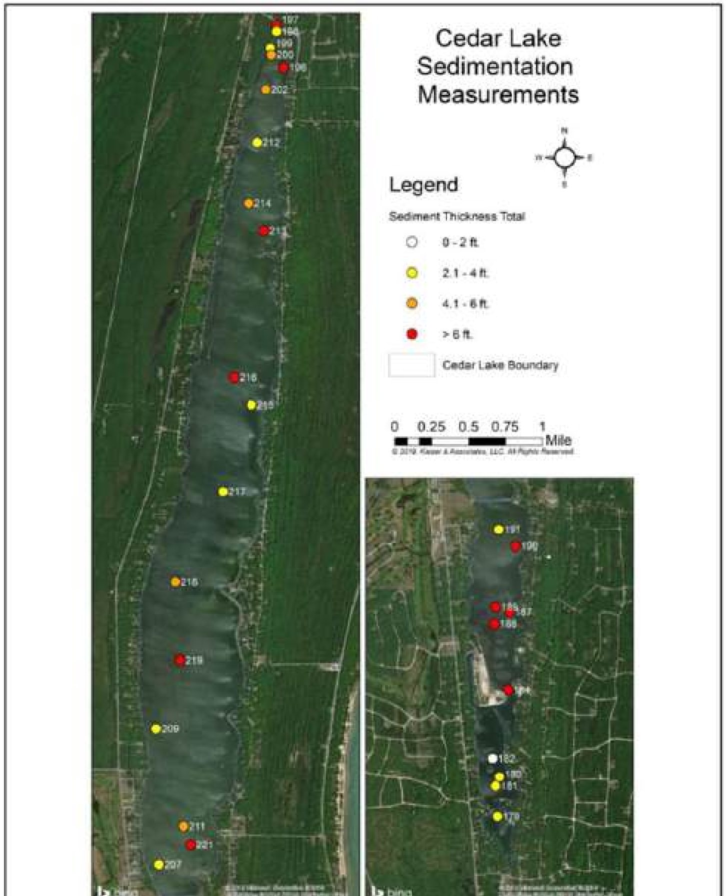
2011 Objective VI: Muck Sediment Issues

Accomplished in Green; Partially Accomplished in Yellow; Not Accomplished in Red

Objective	Implementation Project	Accomplished	Achievements
VI-1	Pursue option of dredging lake bottom to remove existing sediments/muck from Cedar Lake (feasibility).	Y	**2019 – 2021:** Updated Feasibility Assessments Completed: K&A first conducted a detailed sediment thickness study including bathymetric mapping to characterize the sediments and assess dredging feasibility. Then, K&A conducted sediment sampling of select locations based on the sediment thickness assessments. Recommendations from these feasibility studies showed that whole-lake dredging is highly cost-prohibitive due to the nature of Cedar Lake sediments, the volume and potential negative impacts of dredging, and the chemical analysis of sediments which showed how special disposal would be necessary for disposing of lake bottom sediments.
VI-2	Conduct educational workshop and distribute information during the summer regarding best lawn care practices	N	*No known achievements to date.*
VI-3	Start a "Lake Stewards" program promoting lakeshore/water quality stewardship	N	
VI-4	Cedar Lake Property Owners Guide	N	

2011 Objective VI: Muck Sediment Issues

2019 Project Example: Sediment Volume and Chemical Analyses



K&A sediment thickness assessment results for each assessment station waypoint for Cedar Lake, 5/20/19 – 5/22/19.

Attachment C

KIESER & ASSOCIATES

2025 *Updated* Objective VI: Muck Sediment Issues

Accomplished in Green; Partially Accomplished in Yellow; Not Accomplished in Red; New Implementation Strategies in Blue

Objective	Updated Implementation Strategy	*Notes*
VI-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.	*Re-present existing info. Lay out strategy for piloting any other approaches; address approaches for locally pursued dredging options*
	Public Education: Present the findings of the Dredging Feasibility Study (levels & chemical analyses) to "put this subject to bed"	
	Public Education: Distribute information to residents regarding best lawn care practices and how this relates to Muck accumulation	
	Promoting lakeshore/water quality stewardship in relation to reducing Muck.	
VI-2	Conduct educational workshop and distribute information during the summer regarding best lawn care practices	*Partner with MSU extension*
VI-4	Cedar Lake Property Owners Guide	*K&A could help with AICLA on primary topics; quick reference to all topics; relevant webpage without recreating something that always requires updates*

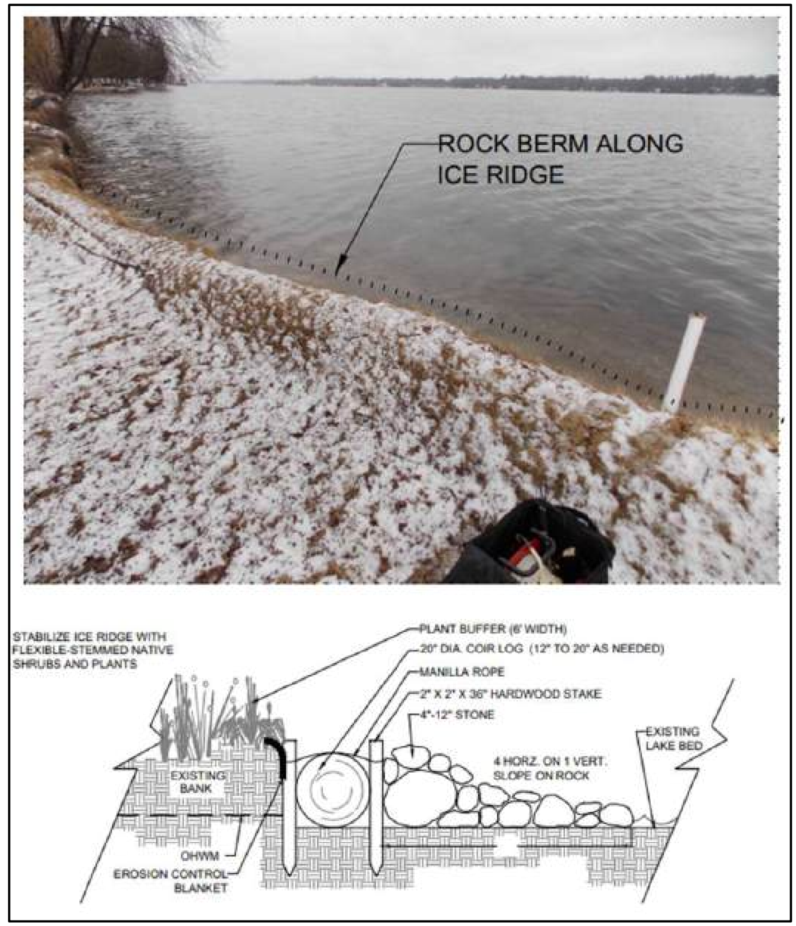
2011 Objective VII: Natural Shorelines & Lakescaping

Accomplished in Green; Partially Accomplished in Yellow; Not Accomplished in Red

Objective	Implementation Project	Accomplished	*Achievements*
VII-1	Educate residents on lakescaping benefits and techniques	P	*Periodic newsletter updates*
VII-2	Partner with LSPOA and lakefront property owners to implement a native vegetation buffer demonstration site in highly visible area around lake	*P*	*Public Lakescaping Demo completed at the LSPOA causeway beach in 2012, however, demo site is no longer vegetated following reconstruction in this area.*
VII-3	Incorporate natural lakescaping and buffers into "Lake Stewards" program	N	*No known achievements to date.*
VII-4	Hold "Lake Stewards" event each year with: a tour to showcase lakescaping sites, native plant exchange or sale, and educational workshop	N	
VII-5	Cedar Lake Property Owners Guide	N	

2011 Objective VII: Natural Shorelines & Lakescaping
Project Examples

2012 Lakewood Shores POA: Original Natural Shoreline Demonstration Planting Project



K&A 2019 Draft: Natural Shoreline Concept for Cedar Lake Ice Ridges

2025 Updated Objective VII: Natural Shorelines & Lakescaping

Accomplished in Green; Partially Accomplished in Yellow; Not Accomplished in Red; New Implementation Strategies in Blue

Objective	Updated Implementation Strategy	*Notes*
VII-1	Educate residents on lakescaping benefits and techniques, & partner with lakefront property owners who implement native vegetation buffers, to utilize these as demonstration sites around the lake	*Partner with LSPOA?* *Tie into fisheries analyses?*
VII-2	Cedar Lake Property Owners Guide	*K&A could help with AICLA on primary topics; quick reference to all topics; relevant webpage without recreating something that always requires updates*

2011 Objective VIII: Water Quality Assessments

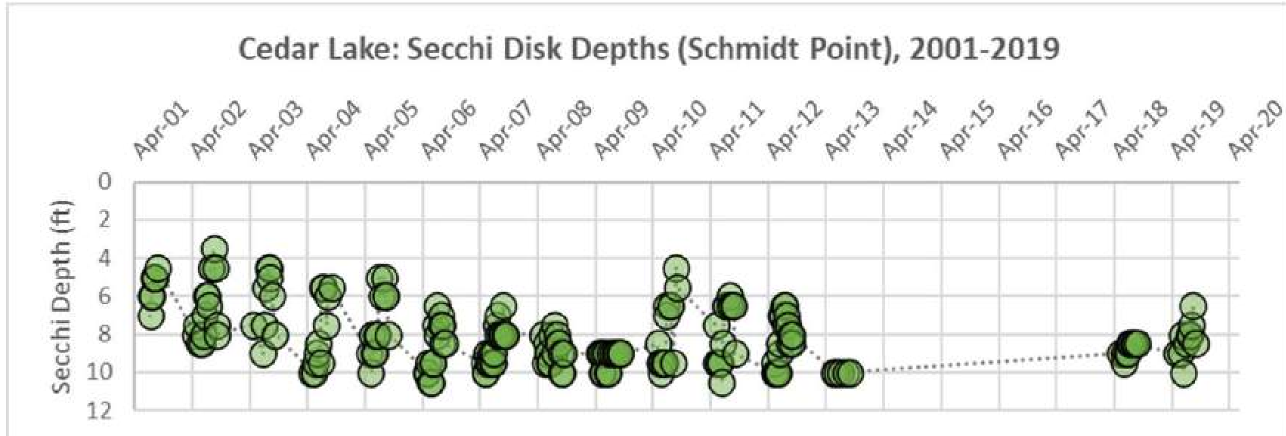
Accomplished in Green; Partially Accomplished in Yellow; Not Accomplished in Red

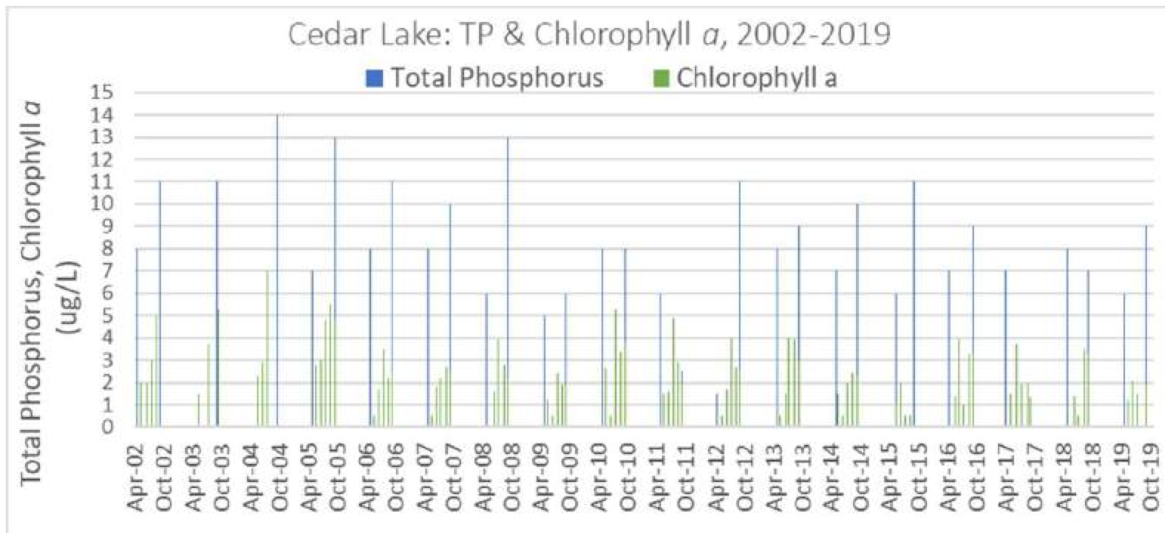
Objective	Implementation Project	Accomplished	***Achievements***
VIII-1	Continue involvement with Michigan Lake & Stream Association to maintain knowledge on lake management strategies/practices	Y	*Ongoing relationship with MLSA – CLMP*
VIII-2	Educate residents on proper septic system maintenance, clean out, and repair (and incorporated into "Lake Stewards" program)	N	*No known achievements to date.*
VIII-3	Document and track persistent water quality problems and pursue site-specific water quality sampling	P	*Ongoing relationship with MLSA – CLMP, however, there are gaps in the Data Record*

2011 Objective VIII: Water Quality Assessments
Project Examples

Samples from Augmentation Well PFAS sampling, 2021 (K&A)

K&A-compiled Data for Secchi Depth, TP, & Chl. *a*, collected by CLMP / MLSA





2025 *Updated* Objective VIII: Water Quality Assessments

Accomplished in Green; Partially Accomplished in Yellow; Not Accomplished in Red; New Implementation Strategies in Blue

Objective	Updated Implementation Strategy	*Notes*
VIII-1	Continue involvement with Michigan Lake & Stream Association to maintain knowledge on lake management strategies/practices	
	Expanded testing.	Tributaries; supplement with CLMP data
	NW Shoreline septic system contribution to the lake	Possible site-specific sampling
	Expand *E coli* testing to western shoreline.	County sampling
VIII-2	Educate residents on proper septic system maintenance, clean out, and repair (and incorporated into "Lake Stewards" program)	*Lake Stewards Program relevant?* *NW Shoreline Coalition project?*
VIII-3	Document and track persistent water quality problems and pursue site-specific water quality sampling	*If CLMP up and running again, this needs to be a part of ONGOING WQ monitoring; site-specific to be a part.*
VIII-4	PFAS: Public Education – state of the issue and changes since the WMP was written in 2011.	Summarize sampling to date and relevant outcomes
	PFAS: Additional state testing.	State and county

2011 Objective IX: Conservation Easements

Note: This Objective has been removed and the Strategies have been integrated into other updated Objectives.

Accomplished in Green; Partially Accomplished in Yellow; Not Accomplished in Red

Objective	Implementation Project	*Achievements*
IX-1	Engage with land conservancies to provide technical resources and information to obtain conservation easements from private property owners	*No known achievements to date.*
IX-2	Explore the option of purchasing and managing important parcels of land in the NW watershed area	*See original WMP Objectives I & III*

2025 *Updated* Objective IX: DNR Boat Launch Improvements

Accomplished in Green; Partially Accomplished in Yellow; Not Accomplished in Red; New Implementation Strategies in Blue

Objective	Implementation Project	*Notes*
IX-1	Structural issue due to prop washing especially during low lake levels; users getting their boat trailers stuck.	Need DNR support
IX-2	Redesign and implement Launch that can handle the size of boats during all lake level conditions.	Need DNR support

Cedar Lake WMP (2025)

Attachment H: Lake Manager & Watershed Contractor Position Descriptions

Cedar Lake WMP Update: Role of the Lake Manager

Lake Manager (not aquatic herbicide applicators) must demonstrate the following expertise and experience for managing aquatic plant communities and Aquatic Invasive Species (AIS) to meet Cedar Lake ecological and recreational goals (see www.cedarlakewmp.net for reference):

1. Comprehensive monitoring, assessment and management efforts that must include:

    a. Consideration of physical and biological conditions of lake and surroundings

    b. Twice per growing system comprehensive plant community surveys documenting and assessing conditions in all 1,075 acres of the northern and southern sections of the lake with aquatic vegetation

    c. Documentation of progress towards established vegetation management goals using scientific and/or empirically based methods, metrics and/or indices that include, at a minimum:
        i. Species Richness
        ii. Biodiversity
        iii. Morphology
        iv. Floristic Quality
            (1) Consultants must provide peer-reviewed literature and agency support references for proposed metrics
            (2) Consultants must demonstrate how proposed monitoring and assessment methods will provide continuity with existing long-term database tracking and management methods
            (3) The CLIB is not interested in non-scientific indices or metrics for “sediment hardness” or “biovolume” from sonar readings

    d. Descriptions of survey observations for each species in lake ecosystem terms at a minimum for:
        i. Frequency
        ii. Coverage
        iii. Dominance

    e. Easily interpreted graphic illustrations of vegetation conditions from all surveys

    f. Near real-time client electronic access to vegetation mapping following surveys

    g. Coordination and directives to treatment contractors to ensure progress towards identified management needs and targeted goals during the recreational season

    h. Annual reports that detail monitoring methods, quantified outcomes and plant community changes related to management applications, with recommendations for alternative management approaches if select applications are not meeting goals

2. Consultant must document their relevant experience to provide these services with successful project demonstrations of:

    a. Chemical treatments for AIS and nuisance native species with demonstrated staff expertise with specifying applications, rates, and permitting recognizing relevant restrictions/constraints/toxicity

    b. Mechanical removal (harvesting), bidding, and oversight

    c. Physical removal
        i. Small-scale hand removal, bidding, and oversight
        ii. At-scale Diver Assisted Suction Harvesting (DASH) design, bidding, monitoring, and oversight

    d. Use of Bio-controls and their application

    e. Use of chemical and biological adjuvants

    f. Physical barrier assessment, design, and installation oversight

    g. Other unique management expertise that may apply to Cedar Lake

Cedar Lake WMP Update: Role of the Watershed Consultant

Consultant must provide the CLIB with qualifications that demonstrate expertise and experience with the following skills to lead the management of lake and watershed needs identified in the approved Watershed Management Plan (see www.cedarlakewmp.net for reference):

1. Leadership, development and updating of EPA Nine Elements-Approved watershed management plans (not lake management plans)

2. Long-term (>5-year) lake water level monitoring program design, implementation, data analysis and management of an extensive array of surface and groundwater level loggers

3. Watershed and lake hydrological modeling for assessment, planning, design, reporting and management for addressing complex surface water/groundwater hydrology impacting seasonal lake levels

4. Lake level augmentation studies, risk assessment, design, costing and permitting to manage fluctuating lake levels

5. Watershed/surface water hydrology assessment, engineering design and management including wetlands and stream restoration with integration of ecological and habitat improvements for fisheries

6. Watershed loading assessment with strategy development, design, and implementation to address issues impacting lake water quality

7. Assessment and evaluation of large-scale dredging projects through monitoring, design and permitting

8. Siting, design, and implementation of natural shorelines Cedar Lake Improvement Board

9. Fisheries habitat assessment, improvement project design, monitoring, and implementation

10. Surface and groundwater monitoring (including for PFAS)

11. Client website development and maintenance

12. Work with Lake Improvement Boards under Part 309 of Michigan's Natural Resources and Environmental Protection Act 451 of 1994 (NREPA)

13. Successful NREPA Part 301 and 303 permitting

14. Detailed budget tracking, administrative reporting

Attachment I: Cedar Lake WMP (2025) Implementations Strategy Table

Obj/Task#	Implementation Project (Task, Process, or BMP)	Key Steps/Process	Priority	Output/Outcome	Lake/Watershed Benefit	Key Organizations	Technical Assistance	Cost Range	Funding Source
I	**Lake Level Augmentation**								
I-1	Implement lake level management projects to augment summer lake levels	Continue with CLIB-led projects/Evaluate benefits, implement with available funding	H	Technical memos/Project implementation	Enhanced recreational season water levels/Water quality protection in watershed	CLIB, Drain Commissioners (DC), stakeholders	Watershed consultant, EGLE, DCs	M-H	CLIB, drain fees, grants
I-2	Summarize feasibility study findings on passive vs. active Lake Augmentation options for the CLIB	Clarify roles for the CLIB, DC, AICLA, etc. to address or implement each remaining/Indentification of remaining, new feasible Lake Augmentation options	H	Memorandum by Watershed consultant/Publicly defined project leadership roles	Enhanced recreational season water levels/stakeholder clarity for project leads	CLIB, DCs	Watershed consultant	L	CLIB
I-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.	Compilation of relevant, prevailing wetlands protection for NW watershed and eastern watershed boundry wetlands/Watershed consultant coordination with CLIB	L	Memorandum by Watershed consultant/Protection options for townships and County agency reviews of permit applications	Habitat and watershed storage preservation and enhancement	CLIB, Townships, County Road Commissions, DCs, Zoning Boards	Watershed consultant, EGLE, townships, DCs, CLIB attorney	L	CLIB
I-4	Re-engineer hydrology of NW wetlands:								
I-4.1	Assess hydrology of Jones wetland and determine feasibility of water storage measures.	Continue hydrology monitoring/conduct relevant feasibility studies of wetland-Jones Ditch connections	H	Feasibility studies/Enhancement projects to improve water storage and connection to the lake	Water storage enhancement and ecological connection to the lake	CLIB, Lake State RR, EGLE	Watershed consultant, DNR, fisheries consultant	M	CLIB, grants
I-4.2	Improve NW Wetlands Railroad Culvert flows: Coordinate with RR reconstruction project	Implement MWGLP grant/perform tasks to improve RR culvert water passage	H	Conceptual engineering plans and capital improvement options for culvert improvements or replacements/Free flow of 500 acres of wetland situated west of the RR tracks towards Cedar Lake connecting these to the lake	Enhanced summer wet-weather transmission of wetland-captured rainfall to the lake/stabilized lake levels	CLIB, MWGLP, Lake State RR, EGLE, DNR	Watershed consultant, DNR	H	Grants
I-4.3	Explore future project benefits for Sherman Creek improvements: water supply and habitat	Feasibility analysis for improving water passage from upper stream stretch east of RR culvert/CLIB approval for analysis	L-M	Engineering plans for ditch restoration/Improved transmission of water flows through potential stream gradient changes	Improved water flow into lake/improved stream channel flow improvements	CLIB, Lake State RR, EGLE	Watershed consultant	M-H	CLIB
I-4.4	Assess storage and flow improvements in NW wetland and continue ongoing water level monitoring to track hydrology changes and improvements over time	Continued hydrology monitoring/Annual review and analysis of findings with ongoing watershed improvement projects	L-M	New data analyses/Options for additional wetland hydrology improvements	Enhanced summer wet-weather transmission of wetland captured rainfall/Ecological beneficial wetland water balance through summer	CLIB	Watershed consultant	L	CLIB

Obj/Task#	Implementation Project (Task, Process, or BMP)	Key Steps/Process	Priority	Output/Outcome	Lake/Watershed Benefit	Key Organizations	Technical Assistance	Cost Range	Funding Source
I-5	Acquisition of property in NW for wetland restoration/enhancements where beneficial								
I-5.1	Direct purchase - Explore purchasing and managing addtl. parcels of land in the NW area	From I-4.4, determine value of CLIB land purchases for enhanced long-term wetlands protection and project opportunities/CLIB-initiated purchase inquiries and purchases	L	Review of parcel purchase options and benefits are opportunities avail/secured and protected wetlands	Lake and watershed protection of natural wetlands and uplands from future development	CLIB	Real estate agents, land surveyors, watershed consultant	M	CLIB
I-5.2	Donation of conservation easements -Engage with land conservancies to provide technical resources and information to obtain conservation easements from private property owners	Connect CLIB with land conservancies/determine mutually overlapping objectives	L	Developed relationships/identified property types for easement considerations	Protection of undeveloped lands	CLIB, AICLA, land conservantices, DNR, EGLE	Land conservancies	L	CLIB, land conservancies
II	**Lakewood Shores Drainage Issues**								
II-1	Work with the Drain Commissioners on storage and return issues/options	Preliminary assessment of water level benefits with Lakewood Shores infrastructure alternatives considered suitable by CLIB/Determine feasible options/costs	M-H	Implementable control options to reduce GW losses/Input to DC for refined engineering feasibility study	Reduced rate of water loss through existing stormwater/underdrain system	CLIB, DC	Watershed consultant	L-M	CLIB, Lakewood Shores
II-2	Purchase tax reverted lands	Identify tax reverted parcels near lake/determination of relevance to Objective II-2	L	Identified parcels relevant to Objective II-2 findings/Purchase of tax reverted lands	Protecion and/or wetland restoration of undeveloped lands where underdrain system no longer necessary	CLIB, Lakewood Shores	Watershed consultant	L	CLIB
II-3	Wetlands banking (investment for return flow options)	Data compilation from Objective II-4 to be mapped and observed for contiguous bundles of wetland or restorable wetlands/Mapped contiguous wetland	M	Potential investment consideration for a wetland banker/private wetland bank in potentially strategic location to	Wetlands protected in perpetuity yielding in perpetuity GW level benefits/Ecological restoration of previously drained cedar swamp	CLIB, Lakewood Shores	Watershed consultant	H	Private wetlands mitigation banker
II-4	Wetland delineations for unbuilt parcels (desktop analysis or more)	Analysis of current and/or modified wetlands/desktop analysis and windshield survey	M	Map of relevant wetland parcels/targets for purchase or use	Contiguous wetland parcels for protection/restoration at scale	CLIB, Lakewood Shores, DC	Watershed consultant	L	CLIB
III	**Timberlakes Drainage Prevention**								
III-1	Work with the Drain Commissioner to find solutions to potential future development issues/drainage needs	Collaborate with DC on drainage priorities/Consult on potential options and impacts to avoid similar Lakewood Shores water loss rates	M	Communications with DC/Protection of GW levels at edge of lake	Protection against unneccessary GW losses in areas with no development and/or need for enhanced drainage	CLIB,Timberlakes, DC	Watershed consultant, DC's engineer	L	DC
III-2	Identify and pursue opportunities to prevent future drainage issues similar to Lakewood Shores issue	Ensure proposed options do not impact lake levels/review proposed engineering plans	M	Communications with DC/Input on plans to protect lake levels	Mitigation of GW losses	CLIB,Timberlakes, DC	Watershed consultant, DC's engineer	L	DC

Obj/Task#	Implementation Project (Task, Process, or BMP)	Key Steps/Process	Priority	Output/Outcome	Lake/Watershed Benefit	Key Organizations	Technical Assistance	Cost Range	Funding Source
IV	**Fisheries Improvements**								
IV-1	Re-engineer hydrology of NW wetlands to support fisheries by improving spawning habitat access	Implement MWGLP grant/perform tasks for lower Jones Ditch channel	H	Engineering plans for ditch restoration/Fish-passable channel connecting lake to wetlands	Spring spawning access to 1,000 acres for wetland/Ecological connection for pike spawning and other migrating fish species	CLIB, MWGLP, EGLE, DNR	Watershed consultant, DNR, fisheries consultant	H	Grants
IV-2	Fisheries Management								
IV-2.1	Conduct a fish population assessment, including a sportfishing Creel Census	Develop online survey for voluntary creel census targeting sport fishing tournaments/Utilize data for fisheries management	L	Catch data/Correlate to recreational fishing conditions	Feedback from anglers over time	AICLA, CLIB, tournament organizers	Watershed consultant	L	CLIB/AICLA
IV-2.2	Conduct critical fish habitat assessments	Complete current assessment/Data processing and reporting	M	Compiled report/Correlation to new fish passage data	Determination of potential improvement needs	AICLA, CLIB	Watershed consultant	L	CLIB
IV-2.2.a	Assess pike spawning improvements in Sherman Creek and fisheries spawning habitat in Jones Ditch using habitat surveys to determine restoration needs	Develop and implement channel monitoring plans for Sherman and Jones/Establish technical and voluntary monitoring program for spring pike run	M	Report/Establishment of current conditions for future comparisons	Data will inform fisheries response to Jones Ditch channel restoration	CLIB, AICLA, DNR	Watershed consultant, DNR	L	CLIB, grants
IV-2.2.b	Conduct an in-lake critical fish habitat assessment update	Conduct periodic in-lake survey every 5 years/Use same approach as 2025 survey methods	L	Report/Documentation of any changes or improvements in habitat conditions	Identification of improvements are additional needs	CLIB, AICLA	Watershed consultant	L	CLIB
IV-2.3	Provide fisheries habitat enhancements	Indentify suitable options for coarse woody habitat of substrate/develop from in-lake survey	L	Options and costs/permitted improvements	Increased fish populations	CLIB, AICLA	Watershed consultant, DNR	L	CLIB, grants
IV-2.3.a	MDNR decadal fisheries assessment and walleye fingerling stocking "as needed"	Collaborate with DNR on assessment schedule and stocking plans/Request DNR supporting documentation and expectations of outcomes	M	Comprehensive fish survey data/Comparisons to historic survey outcomes in the context of Jones Ditch improvements	Critical information for understanding fisheries improvements or changes over time	DNR	DNR	L	State of MI
IV-3	Re-assess angling benefits and potential for stocking Redear sunfish to establish an increased fishery/increase bluegill spawning habitat	Conduct research pilot studies to determine sustainablity of potential Redear stocking at-scale		Research findings to support or refute potential benefits of this stocking/actionable information for wise decision-making for stocking investments	Enhanced fishery/potential reduction of snail/clam populations to reduce swimmer's itch prevalence	AICLA, CLIB, Universities,	Lake Manager, DNR, fisheries consultant	L	Grants (for research)

Obj/Task#	Implementation Project (Task, Process, or BMP)	Key Steps/Process	Priority	Output/Outcome	Lake/Watershed Benefit	Key Organizations	Technical Assistance	Cost Range	Funding Source
V	**Invasive Species Management**								
V-1	Education on best practices to reduce transmission of invasive species	Standardize AIS narratives and messaging for educational outreach and meetings	M	Lake-wide knowledge and understanding of AIS transmission and best practices for prevention	Improved biodiversity and fisheries by reduction of AIS spread through lake resident education of prevention.	CLIB / AICLA	Lake Manager	L	CLIB/AICLA
V-2	Ensure adequate educational signage informing lake users about invasive species risks and best practices to reduce the risk of spread	Identify effective additional locations for AIS signage at high-traffic/high-use public areas	M	Educational intervention for lake users prior to launching boats / during lake use	Improved biodiversity and fisheries by reduction of AIS spread through lake resident education of prevention.	CLIB / AICLA	Lake Manager	L	CLIB/AICLA
V-3	Lake Manager contract through the Lake Board to continue adaptive management strategy for lake and recommended future actions/implement WMP strategies	Continuing to refine, as needed, the Lake Manager position to fill requirements (see WMP Attachment H)	H	Professional Lake Manager to provided technical guidance, regular assessment, and recommendations for AIS management	Improved biodiversity and fisheries with monitored outcomes of AIS spread and reduction through direct intervention against AIS through applied adaptive management techniques.	CLIB / AICLA	Lake Manager	H	CLIB
V-4	Continue lake treatments for noxious weeds and algae growth	Based on Lake Manager recommendations, target AIS with appropriate mitigation and management strategies to prevent spread and reduce recreational/ecological nuisances.	H	Direct action to mitigate/reduce/prevent the spread of AIS in Cedar Lake	Improved biodiversity and fisheries by reduction of AIS spread through direct intervention against AIS with chemical or physical management interventions	CLIB / AICLA	Lake Manager	H	CLIB
VI	**Muck Sediment Issues**								
VI-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	Compile existing CLIB studies in the context of CedarLake-wide applications and cost implications/Summarize for public consumption for the CLIB and AICLA	H	Comparative costs/denotation of exhorbitant lake-wide dredging costs	Lake resident education around a single summary based on factual conditions for lake-wide dredging	CLIB/AICLA	Watershed consultant	L	CLIB
VI-1.1	Public Education: Present the findings of the Dredging Feasibility Study (levels & chemical analyses)	Prepare a concise summary/distribute via CLIB and AICLA webpages/newsletters	M	Summry of cost realities/consensus around exhorbitant costs and constraints for lake-wide applications	Re-focus on other implementable options for lake level management	CLIB/AICLA	Watershed consultant	L	CLIB

Obj/Task#	Implementation Project (Task, Process, or BMP)	Key Steps/Process	Priority	Output/Outcome	Lake/Watershed Benefit	Key Organizations	Technical Assistance	Cost Range	Funding Source
VI-1.2	Public Education: Distribute information to residents regarding best lawn care practices and how this relates to Muck accumulation	Prepare a concise summary for AICLA use and distribution	M	Summary of actions for riparision/increased awareness and improved stewardship	Reduced rate of nearshore sediment loading	AICLA	Watershed consultant	L	CLIB
VI-1.3	Promoting lakeshore/water quality stewardship in relation to reducing Muck	Develop consistent information/introduce at routine meetings and events	M	Simple variety of messages/reaching multiple generations of riparians	Consistently applied knowledge shared with neighbors for reducing inputs	AICLA	Watershed consultant	L	CLIB
VI-2	Create a Cedar Lake Property Owners Guide including muck sediment issues	Develop a stet-by-step guide for property owners using available materials	M	Simple guidance/shared knowledge	Improved water quality	AICLA	MSU Extension	L	AICLA
VI-3	Perform appropriate pilot/feasibility scale studies to determine costs, benefits, and possibilities prior to any at-scale project commitments	Develop a simple framework for feasibility studies and pilot projects for any new, untried processes proposed for use at scale on the lake/process will apply to all studies ensuring there are sound metrics	L	Scientific guidance to ensure appropriate testing/avoidance of wasteful investments on unproven technologies	Avoidance of wasteful expenditures to otherwise invest in known and quantifiable lake and watershed improvement opportunities	CLIB	Watershed consultant	L	CLIB
VII	**Natural Shorelines & Lakescaping**								
VII-1	Educate residents on lakescaping benefits and techniques, & partner with lakefront property owners who implement native vegetation buffers, to utilize these as demonstration sites	Provide citations for and access to MI publications/develop a list of references	L	Potentially interested parties given connections to resources/potential shoreline restoration projects by homeowners	Nearshore habitat improvements/reduced soil erosion into the lake	AICLA	MSU Extension	L	AICLA
VII-2	Create a Cedar Lake Property Owners Guide including lakescaping benefits and techniques	Creation of a simple step-wise process for education, designs applicable for Cedar Lake given water level fluctuations and select options	L	Model shoreline guidance for Cedar Lake/interested lakeowner shoreline updates	Engagement with residents connecting shoreline improvements with habitat and water quality benefits	AICLA	MSU Extension, Watershed consultant	L	AICLA, CLIB
VIII	**Water Quality Assessments**								
VIII-1	Continue involvement with Michigan Lake & Stream Association to maintain knowledge on lake management strategies/practices	Annual attendence at the MLSA confernce and membership/CLMP training and participation	M	Accessibility to prevailing lake issues in MI/active engagement	Shared knowledge and access to new technology opportunities	AICLA/CLIB	MSU Extension, Watershed consultant, Lake Manager	L	AICLA, CLIB
VIII-1.1	Expanded Testing	Determine prevailing WQ issues/identify monitoring needs	M	WQ monitoring plans/WQ data	Assessing issues on a timely basis for representative responses to protect WQ	AICLA/CLIB	MSU Extension, Watershed consultant, Lake Manager	L	AICLA, CLIB

Obj/Task#	Implementation Project (Task, Process, or BMP)	Key Steps/Process	Priority	Output/Outcome	Lake/Watershed Benefit	Key Organizations	Technical Assistance	Cost Range	Funding Source
VIII-1.2	NW Shoreline septic systems – assessing contributions to the Lake	Determine potential loading inputs/engage homeowners with relevant information of local WQ impacts to shoreline	L	Site-specific WQ monitoring/determination of potentially localized impacts	WQ protection	CLIB/AICLA	Watershed consultant	L	CLIB
VIII-1.3	Expand E.coli testing to western shoreline	Provide additional nearshore WQ monitoring in shoreline stretches with septic systems contributing to the lake in the NW shoreline areas	L	Site-specific WQ monitoring/determination of potentially localized impacts	Determination of septic system discharges impacting lake WQ	CLIB/AICLA	Watershed consultant	L	CLIB
VIII-2	Educate residents on proper septic system maintenance, clean out, and repair	Provide septic system maintenance information for residents/make available through mailings, websites	L	Simplified yet valuable information for all homeowners with septic systems	WQ protection	CLIB/AICLA	MSU Extension	L	AICLA, CLIB
VIII-3	Document and track persistent water quality problems and pursue site-specific water quality sampling	Conduct periodic WQ monitoring of Sherman Creek and Jones Ditch/establish bi-ennial schedule and as-needed options	L	Sampling plan/periodic monitoring	WQ protection	CLIB/AICLA	Watershed consultant	L	CLIB
VIII-4	PFAS: Public Education –state of the issue and changes since the WMP was written in 2011	Update WMP with relevant/recent monitoring data a summation of public healther advisories	L	Share public health advisories through website and newsletters	Public health protection	CLIB/AICLA	EGLE, county health departement, Watershed consultant	L	CLIB
VIII-4.1	PFAS: Additional state testing	Remain in communication with state and county agencies typically conduction monitoring/establish periodic communications and remain engaged in regional monitoring discussions and percieved Cedar Lake monitoring needs	L	Requests to agencies for additional monitoring/updated WQ information	Public health protection	CLIB/AICLA	EGLE, county health departement	L	State, County
IX	**DNR Boat Launch Improvements**								
IX-1	Structural issue due to prop washing especially during low lake levels; users getting their boat trailers stuck	Meet with DNR representatives on-site to review needs, options and potential funding to address/Contact DNR to initiate communication process	M	Determination of state options to address/implement plans to start process	Public Access Safety	CLIB, AICLA, DNR, EGLE	Watershed consultant	M	State, possible local CLIB/AICLA match
IX-1.1	Redesign and implement Launch that can accommodate boats in all lake level conditions	Determine who and how the launch will be designed/ensure designs meet needs	M	Determine most suitable option/approval and funding to implement	Public Access Safety	DNR	Watershed consultant, state engineering consultant	M	State, possible local CLIB/AICLA match

Cedar Lake WMP (2025)

Attachment J: 2011 WMP Wetland Protections Materials

APPENDIX E: SAMPLE DEQ WETLAND ORDINANCE
PROVIDED BY: MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY and HURON RIVER WATERSHED INITIATIVE
DATE: MARCH 2003
To find out if a wetlands inventory has been conducted by DEQ for your county, go to *www.michigan.gov/*deq and click on Water, then Wetlands Protection, the Preliminary Wetland Inventories, or call DEQ for more information at 517-241-8169 in Lansing or 1-800-662-9278.

WETLANDS PROTECTION

[COMMUNITY], MICHIGAN

Ord. No __ effective __

An Ordinance for the control and preservation of wetlands within the [community] and to protect the wetlands of the [community] from sedimentation, destruction, and misuse; to prescribe the powers, duties and functions of the [community] enforcing agency; to establish permits and a fee schedule; to establish design standards, specifications, and bond requirements; to provide for variance and exceptions; to provide for inspections and enforcement; to provide for violations, remedies and penalties thereof; and to provide for severability and effective date of the Ordinance.

THE [COMMUNITY] HEREBY ORDAINS:

SECTION 1. GENERAL

Section 1.1 - Findings

The Board of the [community] finds that wetlands are indispensable and fragile resources that provide many public benefits, including maintenance of water quality through nutrient cycling and sediment trapping as well as flood and storm water runoff control through temporary water storage, slow release, and groundwater recharge. In addition, wetlands provide open space; passive outdoor recreation opportunities; fish and wildlife habitat for many forms of wildlife, including migratory waterfowl, and rare, threatened or endangered wildlife and plant species; and pollution treatment by serving as biological and chemical oxidation basins.

Preservation of the remaining [community] wetlands is necessary to maintain hydrological, economic, recreational, and aesthetic natural resource values for existing and future residents of the [community], and therefore the [community] Board declares a policy of no net loss of wetlands. Furthermore, the [community] Board declares a long term goal of net gain of wetlands to be accomplished through review of degraded or destroyed wetlands in the [community], and through cooperative work with landowners, using incentives and voluntary agreements to restore wetlands.

To achieve these goals, and with authority from Section 30307(4) of Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended MCL 324.30307(4) (hereinafter the Wetlands Protection Act), the [community] Board finds that local regulation of wetlands is necessary in [community]. Pursuant to Article 4, Section 52 of the Constitution of the State of Michigan, the conservation and development of natural resources of the state is a matter of paramount public concern in the interest of the health, safety, and general welfare of the people. The [community] Board therefore finds that this Ordinance is essential to the long term health, safety, and general welfare of the people of the [community], and to the furtherance of the policies set forth in Part 17, Michigan Environmental Protection Act, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended MCL 324.1701 et. seq. (hereinafter the Michigan Environmental Protection Act) and the Wetlands Protection Act.

Section 1.2 - Purpose

The purposes of this Ordinance are to provide for:

A. The protection, preservation, replacement, proper maintenance, restoration, and use in accordance with the character, adaptability, and stability of the [community]'s wetlands, in order to prevent their pollution or contamination; minimize their disturbance and disturbance to the natural habitat therein; and prevent damage from erosion, siltation, and flooding.

B. The coordination of and support for the enforcement of applicable federal, state, and county statutes, ordinances and regulations including but not limited to the Wetlands Protection Act, enforced by the Michigan Department of Environmental Quality which is hereinafter referred to as the MDEQ.

C. Compliance with the Michigan Environmental Protection Act which imposes a duty on government agencies and private individuals and organizations to prevent or minimize degradation of the environment which is likely to be caused by their activities.

D. The establishment of standards and procedures for the review and regulation of the use of wetlands.

E. A procedure for appealing decisions.

F. The establishment of enforcement procedures and penalties for the violation of this Ordinance.

G. Creation of a board to assist in the protection of wetlands and to build public support for the values of wetlands.

Section 1.3 - Construction and Application.

The following rules of construction apply in the interpretation and application of this Section:

A. In the case of a difference of meaning or implication between the text of this Section and any caption or illustration, the text shall control.

B. Particulars provided by way of illustration or enumeration shall not control general language.

C. It is the intent of this ordinance to allow reasonable use of private property.

D. Any ambiguities perceived in this ordinance are to be resolved by the entity administering the ordinance, in accordance with Section 7.

Section 1.4 - Applicability to Private and Public Agency Activities and Operations.

The provisions of this Ordinance, including wetlands use permit requirements and criteria for wetlands use permit approval, shall apply to activities and operations proposed by federal, state, local and other public agencies as well as private and public organizations and individuals except as may be exempt by law.

SECTION 2 - DEFINITIONS

Section 2.1 - Definition of Terms

Terms not specifically defined shall have the meaning customarily assigned to them:

CONTIGUOUS means any of the following:

1. A permanent surface water connection or any other direct physical contact with an inland lake or pond, a river or stream, one of the Great Lakes, or Lakes St. Clair.

2. A seasonal or intermittent direct surface water connection to an inland lake or pond, a river or stream, one of the Great Lakes, or Lakes St. Clair.

3. A wetland is partially or entirely located within five hundred (500') feet of the ordinary high water mark of an inland lake or pond or a river or stream or is within 1,000 feet of the ordinary high watermark of one of the Great Lakes or Lake St. Clair, unless it is determined by the MDEQ, pursuant to R. 281.924 of the administrative rules promulgated under the Wetlands Protection Act (hereinafter Wetlands Administrative Rules*)*, that there is no surface water or groundwater connection to these waters.

4. Two (2) or more areas of wetlands separated only by barriers, such as dikes, roads, berms, or other similar features, but with any of the wetland areas contiguous under the criteria described in Subsections (1)(2) or (3) of this definition.

ELECTRIC DISTRIBUTION LINE: means underground lines below 30 kilovolts and lines supported by wood poles.

ELECTRIC TRANSMISSION LINE: means those conductors and their necessary supporting or containing structures located outside of buildings that are used for transmitting a supply of electric energy, except those lines defined as a electric distribution line.

FILL MATERIAL means soil, rocks, sand, waste of any kind, or any other material that displaces soil or water or reduces water retention potential.

LOT: means a designated parcel, tract, building site or other interest in land established by plat, subdivision, conveyance, condominium master deed, or as otherwise permitted by law, to be used, developed or built upon as a unit.

MINOR DRAINAGE: includes ditching and tiling for the removal of excess soil moisture incidental to the planting, cultivating, protecting, or harvesting of crops or improving the productivity of land in established use for agriculture, horticulture, silviculture, or lumbering.

MITIGATION shall mean: (1) methods for eliminating or reducing potential impact to regulated wetlands; or (2) creation of new wetlands to offset unavoidable and permitted loss of existing wetlands.

PERSON means an individual, sole proprietorship, partnership, corporation, association, municipality, this state, and instrumentality or agency of this state, the federal government, or an instrumentality or agency of the federal government, or other legal entity.

PIPELINES HAVING A DIAMETER OF 6 INCHES OR LESS: means a pipe which is equal to or less than what is commonly referred to as a 6-inch pipe and which has an actual measured outside diameter of less than 6.75 inches.

[COMMUNITY] BOARD shall mean the legislative body of [community].

WETLAND means land characterized by the presence of water at a frequency and duration sufficient to support, and that under normal circumstances does support, wetland vegetation or aquatic life and is commonly referred to as a bog, swamp or marsh and which is any of the following:

1. All wetlands subject to regulation by the MDEQ including wetlands:

(a) Contiguous to the Great Lakes or Lake St. Clair, an inland lake or pond, or a river or a stream.

(b) Not contiguous to the Great Lakes, an inland lake or pond, or a river or stream; and more than 5 acres in size; except this subparagraph shall not be of effect, except for the purpose of inventorying, in counties of less than 100,000 population until the MDEQ certifies to the commission it has substantially completed its inventory of wetlands in that county.

(c) Not contiguous to the Great Lakes, an inland lake or pond, or a river or stream; and 5 acres or less in size if the MDEQ determines that protection of the area is essential to the preservation of the natural resources of the state from pollution, impairment, or destruction and the department has so notified the owner; except this subparagraph may be utilized regardless of wetland size in a county in which subparagraph (ii) is of no effect; except for the purpose of inventorying, at the time.

2. Other wetlands subject to regulation by the [community] including:

(a) Wetlands two (2)acres or greater in size, whether partially or entirely contained within the project site, which are not contiguous to the Great Lakes or Lake St. Clair, an inland lake or pond, or a river or a stream.

(b) Wetlands smaller than two (2) acres in size which are not contiguous to the Great Lakes or Lake St. Clair, an lake or pond, or a river or a stream, and are determined to be essential to the preservation of the natural resources of the [community] as provided for in Section 7.6 of this Ordinance.

WETLAND CONSULTANT shall mean a person or persons knowledgeable in wetland protection and delineation who is identified by the [community] to make wetlands determinations, to delineate wetlands, and to advise the [community] on wetland resource policy, education, and restoration. Any firm or individual appointed on a contractual basis.

WETLAND VEGETATION means plants that exhibit adaptations to allow, under normal conditions, germination or propagation and to allow growth with at least their root systems in water or saturated soil.

WETLANDS ADMINISTRATOR shall mean a person(s) knowledgeable in wetlands protection, appointed by the [community] legislative body to administer this Ordinance and to carry out certain duties hereunder. Any firm or individual appointed on a contract basis.

WETLANDS BOARD shall mean the body of the [community] which makes decisions on wetlands use permit appeals and advises the [community] on wetlands resource policy, education and restoration.

WETLANDS MAP refers to the [community] wetlands inventory map, based on the National Wetlands Inventory Map of the U.S. Fish and Wildlife Service; the Michigan Resource Information System Mapping (MIRIS) of the State of Michigan ; the soils maps of the Soil Conservation Service, aerial photography, and onsite inspections.*[community would explain here the sources of its map.]*

WETLANDS USE PERMIT shall mean the [community] approval required for activities in wetlands described in Section 7 of this Ordinance.

SECTION 3 - RELATIONSHIP TO STATE AND FEDERAL PERMIT REQUIREMENTS

Whenever persons requesting a wetlands use permit are also subject to state and/or federal permit requirements, the following shall apply:

A. The [community] shall have jurisdiction for the regulation of wetlands under this Ordinance concurrent with the jurisdiction of the Michigan Department of Environmental Quality.

B. Approvals under this Ordinance shall not relieve a person of the need to obtain a permit from the MDEQ and/or the U.S. Army Corps of Engineers, if required.

C. Issuance of a permit by the MDEQ and/or the U.S. Army Corps of Engineers shall not relieve a person of the need to obtain approval under this Ordinance, if applicable.

SECTION 4. ADMINISTRATION

Section 4.1 - [community] Wetlands Map

The [community] Wetlands Map is a guide to the location of wetlands in [community]. The Wetlands Map shall be used in the administration of this Ordinance.

The Wetlands Map, together with all explanatory matter thereon and attached thereto, as may be amended through the Wetlands Verification and Delineation process, is hereby adopted by reference and declared to be a part of this Ordinance. The Wetlands Map shall be on file in the office of the [community] Clerk.

The Wetlands Map shall serve as a general guide for the location of wetlands. The Wetlands Map does not create any legally enforceable presumptions regarding whether property that is or is not included on the Wetlands Map is or is not a wetland.

The Wetlands Verification Process, as set forth herein, shall be used to verify wetlands on properties where wetlands are shown on the Wetlands Map or on properties where wetlands exist as defined in Section 2.1 herein. The Wetlands Delineation Process, as set forth herein, shall be used to establish the actual boundaries of wetlands in the [community]. The identification of the precise boundaries of wetlands on a project site shall be the responsibility of the applicant subject to review and approval by the [community] Wetland Consultant. Verification and delineation under this ordinance does not constitute a federal or state wetland jurisdiction or boundary decision.

A. Wetlands Verification Process

1. The [community] or property owners of wetlands may initiate a verification of the areas shown on the Wetlands Map as wetlands or on properties where wetlands exist as defined in Section 2.1 herein. The verification shall be limited to a finding of wetlands or no wetlands by the Wetlands Administrator. The finding shall be based on, but not limited to, aerial photography, topographical maps, site plans, and field verification.

2. In the event that there is a finding of no wetlands on the property, then no further determination would be required.

3. The applicant shall pay fees for the Wetlands Verification Process as established in Section 9.1.

B. Wetlands Delineation Process

Prior to the issuance of any permit or land development approval for a property which is shown to include wetlands on the Wetlands Map, the applicant may be required to provide a wetlands delineation to the [community]. The Wetlands Administrator, in consultation with the Wetland Consultant, shall determine whether a delineation is required, based on the proximity and relationship of the project to the wetlands. A delineation shall be required when a wetlands use permit is requested.

1. To establish actual wetlands boundaries on a property, the applicant shall provide a survey or dimensional site plan, drawn at the scale required by [community]'s site plan review requirements, showing property lines, buildings and any points of reference along with the wetlands boundaries, according to one of the following:

(a) Wetlands delineation by the Michigan Department of Environmental Quality (MDEQ).

(b) Wetlands delineation by the applicant's wetlands consultant subject to review and approval by the Wetland Consultant.

2. Where a wetlands delineation is required by this Section, the Wetland Consultant shall establish wetlands boundaries following receipt of the above required information and after conducting a field investigation.

3. The applicant shall pay fees for the Wetlands Delineation Process as established in Section 9.1.

C. Map Amendment

1. The Planning Commission shall make recommendations to the [community] Board for revisions to the Wetlands Map whenever new and substantial data for wetlands become available.

2. The [community] shall insure that each record owner of property on the property tax roll shall be notified of any amendment to the Wetlands Map. The notice shall include the following information:

(a) the [community] Wetlands Map has been amended;

(b) the location to review the map;

(c) the owner's property may be designated as wetlands on the map;

(d) the [community] has an Ordinance regulating wetlands;

(e) the map does not necessarily include all of the wetlands within the [community] that may be subject to the Wetlands Ordinance.

Section 4.2. Wetlands Board

There is hereby created a Wetlands Board:

A. The Wetlands Board shall consist of five (5) residents of the [community] appointed by the [community] Board upon recommendation of the Planning Commission; four of whom shall have knowledge and experience in the areas of botany, soils, geology, hydrology, or natural resources. One member of the Wetlands Board shall be a member of the [community] Board. The initial terms of appointment shall be as follows: 2 individuals for 3 years, 2 individuals for 2 years, and 1 individual for 1 year. Thereafter, appointments shall be for a term of three years. The term of the [community] Board representative to the Wetlands Board shall be concurrent with the term of office.

B. The Wetlands Board shall establish rules of procedure.

C. The Wetlands Board is authorized to undertake activities to protect wetlands including the following:

1. Conduct public hearings and review appeals of wetlands use permit, mitigation, and/or restoration decisions made by the Wetlands Administrator, the Planning Commission or the [community] Board.

2. Serve in an advisory role in setting policy guidelines on wetlands issues in the [community].

3. Identify conflicts between wetlands protection and present [community] ordinances, [community] operating procedures, and [community] activities.

4. Provide recommendations and assist in map administration.

5. Coordinate with the Michigan Department of Environmental Quality in keeping up-to-date on issues affecting wetlands protection.

6. Recommend a program to protect and acquire important wetlands through tax incentives, donation, development rights, easements, land exchange, purchase, and other means.

7. Develop education programs for the public and for [community] schools. The program should promote the values of wetlands and awareness of the hazards and threats to wetlands. The program should be particularly targeted to landowners with wetlands and emphasize how best to protect wetlands values on their property.

8. Develop an adopt-a-wetlands program for interested citizens to participate more directly in preservation of specific wetlands.

9. Review degraded or destroyed wetlands in the [community] for possibility of rehabilitation or restoration.

D. Members of the Wetlands Board shall receive a stipend as determined from time to time by resolution of the [community] Board.

E. The [community] Board has sole and exclusive discretion for removal of members of the Wetlands Board with or without a hearing.

SECTION 5 - ACTIVITIES IN WETLAND

Section 5.1 - Activities Prohibited Without First Obtaining A Wetlands Use Permit

Except as otherwise provided by Section 5.2, it shall be unlawful for any person to do any of the following in a wetland unless and until a wetlands use permit is obtained from the [community] pursuant to this Ordinance.

A. Deposit or permit the placing of fill material in a wetland.

B. Dredge, remove or permit the removal of soil or minerals from a wetland.

C. Construct, operate or maintain any use or development in a wetland.

D. Drain surface water from a wetland.

Section 5.2 - Activities Not Requiring A Permit

Notwithstanding the prohibitions of Section 5.1, the following uses are allowed in a wetland without a wetlands use permit, unless otherwise prohibited by statute, ordinance or regulation:

A. Fishing, trapping, or hunting.

B. Swimming or boating.

C. Hiking.

D. Grazing of animals.

E. Farming, horticulture, silviculture, lumbering, and ranching activities, including plowing, irrigation, irrigation ditching, seeding, cultivating, minor drainage, harvesting for the production of food, fiber, and forest products, or upland soil and water conservation practices. Wetlands altered under this subsection shall not be used for a purpose other than a purpose described in this subsection without a permit from [community].

F. Maintenance or operation of serviceable structures in existence on October 1, 1980 or constructed pursuant to the Wetlands Protection Act or former Act No. 203 of the Public Acts of 1979.

G. Construction or maintenance of farm or stock ponds.

H. Maintenance, operation, or improvement which includes straightening, widening, or deepening of the following which is necessary for the production or harvesting of agricultural products:

1. An existing private agricultural drain.

2. That portion of a drain legally established pursuant to the drain code of 1956, Act No. 40 of the Public Acts of 1956, being sections 280.1 to 280.630 of the Michigan Compiled Laws, which has been constructed or improved for drainage purposes.

3. A drain constructed pursuant to other provisions of the Wetlands Protection Act or former Act No. 203 of the Public Acts of 1979.

I. Construction or maintenance of farm roads, forest roads, or temporary roads for moving mining or forestry equipment, if the roads are constructed and maintained in a manner to assure that any adverse effect on the wetland will be otherwise minimized.

J. Drainage necessary for the production and harvesting of agricultural products if the wetland is owned by a person who is engaged in commercial farming and the land is to be used for the production and harvesting of agricultural products. Except as otherwise provided in the Wetlands Protection Act, wetland improved under this subdivision after October 1, 1980 shall not be used for nonfarming purposes without a permit from [community]. This subdivision shall not apply to a wetland which is contiguous to a lake or stream, or to a tributary of a lake or stream, or to a wetland that the MDEQ has determined by clear and convincing evidence to be a wetland that is necessary to be preserved for the public interest, in which case a permit is required.

K. Maintenance or improvement of public streets, highways, or roads, within the right-of-way and in such a manner as to assure that any adverse effect on the wetland will be otherwise minimized. Maintenance or improvement does not include adding extra lanes, increasing the right-of-way, or deviating from the existing location of the street, highway, or road.

L. Maintenance, repair, or operation of gas or oil pipelines and construction of gas or oil pipelines having a diameter of 6 inches or less, if the pipelines are constructed, maintained, or repaired in a manner to assure that any adverse effect on the wetland will be otherwise minimized.

M. Maintenance, repair, or operation of electric transmission and distribution power lines and construction of distribution power lines, if the distribution power lines are constructed, maintained, or repaired in a manner to assure that any adverse effect on the wetland will be otherwise minimized.

N. Operation or maintenance, including reconstruction of recently damaged parts, of serviceable dikes and levees in existence on October 1, 1980 or constructed pursuant to the Wetlands Protection Actor former Act No. 203 of the Public Acts of 1979 .

O. Construction of iron and copper mining tailings basins and water storage areas.

P. An activity in a wetland that was effectively drained for farming before October 1, 1980 and that on and after October 1, 1980 has continued to be effectively drained as part of an ongoing farming operation is not subject to regulation under this ordinance.

Q. A wetland that is incidentally created as a result of one or more of the following activities is not subject to regulation under this ordinance:

1. Excavation for mineral or sand mining, if the area was not a wetland before excavation. This exemption does not include a wetland on or adjacent to a water body of 1 acre or more in size.

2. Construction and operation of a water treatment pond or lagoon in compliance with the requirements of state or federal water pollution control regulations.

3. A diked area associated with a landfill if the landfill complies with the terms of the landfill construction permit and if the diked area was not a wetland before diking.

SECTION 6 - APPLICATION

Application for approval, appeal, and issuance of wetlands use permits shall be concurrent with the application for approval, appeal, and issuance of other necessary [community] approvals. The applicant for a wetlands use permit shall submit four copies of the following to the [community]:

A. An application completed in full, on a form supplied by the Michigan Department of Environmental Quality, together with any supplemental information necessary relative to isolated wetlands under 2 acres.

B. A wetlands delineation including, but not limited to the following information: dominant tree, sapling, shrub and herb vegetation; presence or lack of accepted wetland hydrology indicators; analysis of soil including a description of the soil profile to at least 20 inches and comparison to [county] County Soil Survey, and plan views of the wetland(s) delineated. Plan views shall be represented in a manner that allows comparison to the Wetlands Map.

C. Soil drainage and stormwater management plans.

D. A mitigation plan, if the proposed activity will result in the loss of wetland resources. In order to adequately review a proposed mitigation plan, the following information shall be provided to the [community]:

1. A brief overview of the plan including the short-range and long-range objectives for vegetation, hydrology, grading, and monitoring.

2. A schedule of all mitigation activities, including coordination with other local and state agencies, if applicable.

3. A planting plan and plant list for the area(s) to be established. The use of native plants characteristic of local conditions is encouraged. Species should be selected based on the need for wildlife, restoration, landscaping, and recovery. The [community] Building Department shall, in consultation with knowledgeable persons, maintain and update a list of botanical species that are considered invasive. Mitigation activities shall be performed without the use of invasive species.

4. A grading and soil erosion control plan including existing and proposed conditions.

5. A description of all soils and materials to be used including their approximate volumes and origin.

6. Hydro-geological information sufficient to determine the site's suitability for the mitigation.

7. Construction detail drawings for planting, soil erosion control, stabilization, water conveyance, and all other items necessary to facilitate the review.

E. A cover letter signed by the applicant including the following information:

1. Name, address, and phone number of applicant.

2. Name of project and brief description (one sentence).

3. Date upon which the activity is proposed to commence.

4. Explanation of why the project meets the wetlands use permit standards and criteria contained in this Ordinance.

5. List of all federal, state, county or other local government permits or approvals required for the proposed project including permit approvals or denials already received. In the event of denials, the reasons for denials shall be given. Attach copies of all permits that have been issued.

6. Identification of any present litigation involving the property.

7. Size of total wetland, size of affected wetland and cubic yards of fill.

F. For a wetlands use permit approval required in conjunction with a site plan, plat or other proposed land use, the applicant shall at the time of application elect to have the application processed under either Subsection (1) or (2) below:

1. The wetlands use permit application shall be reviewed either prior to or concurrent with the review of the site plan, plat or other proposed land use submitted by the applicant. [Community] will need to complete the review within the 90-day review period limitation pursuant to the Wetlands Protection Act. However, the land use review may not be completed at the time the decision is rendered on the wetlands use permit application. Therefore, election of this alternative may require a reopening of the wetlands use permit application if the land use approval is inconsistent with the wetlands use permit approval; or,

2. The wetlands use permit application shall be reviewed and acted upon concurrent with the review of the site plan, plat or other proposed land use submitted by the applicant, and the 90-day review period limitation specified in the Wetlands Protection act shall thereby be extended accordingly.

G. Copies of wetland permit applications filed with the MDEQ and forwarded to the [community] in accordance with Section 30307(6) of Wetlands Protection Act shall become part of the application for a [community] wetlands use permit.

H. An Application shall not be considered properly received by the [community], nor shall the 90-day review period limitation specified in the Wetlands Protection Act commence until all information required by this section has been submitted.

SECTION 7 - REVIEW

SECTION 7.1 - Method of Review of Wetlands Use Permit Application

A. Whenever a wetlands use permit is required, applicant may request an administrative meeting with the Wetlands Administrator to review the proposed activity in light of the purposes of this Ordinance.

B. Upon receipt of an application, the [community] shall insure that all required information including a wetlands delineation has been submitted. The receipt of the application shall constitute permission from the owner to complete an on-site investigation. Applicant will pay fees as established in Section 9.1.

C. The [community] Clerk shall transmit one copy of the application and supporting materials to the [community] Wetland Consultant to confirm the boundaries of the wetland and to review the proposal in light of the purpose and review standards of Section 7 and other applicable sections of this Ordinance.

D. The Wetland Consultant shall prepare and transmit a report and recommendation to the Wetlands Administrator documenting the review required by Section 7.1 D.

E. Upon receipt of an application, the [community] Clerk shall:

1. Transmit one copy of the application, along with any state fees received, to the MDEQ.

2. Cause to be published a notice of the application and the date and time for submission of written public comments in a newspaper of general circulation in the [community], except for activities proposed on a single family lot.

3. Advise the applicant of his/her obligation to post the subject property with a sign that shall be no less than ten (10) square feet in size. The sign shall be clearly visible from the abutting street(s) and shall state that an application has been filed for a wetlands use permit on the property.

Section 7.2 - Wetlands Use Permit Decisions by the Wetlands Administrator

The following process shall apply to wetlands use permit decision by the Wetlands Administrator:

A. For wetlands use permit applications submitted in conjunction with activities that do not require approval by the Planning Commission and/or [community] Board, the Wetlands Administrator shall approve, approve with modifications, or deny the application within 90 days after receipt of an application. If the Wetlands Administrator does not make a final determination on the application within ninety (90) days after receipt of a complete application, then the permit application shall be considered approved, except where the 90-day limit has been extended pursuant to Section 6.F.2

B. Persons wishing to comment on the application must submit their comments in writing to the Wetlands Administrator prior to the date and time set in the notice. Persons wishing to receive notice of the Wetlands Administrator's decision must submit a written request to the Wetlands Administrator.

C. After completing the review and reviewing the written comments, the Wetlands Administrator shall approve, approve with modifications or conditions, or deny the wetlands use permit application in accordance with the standards of this Ordinance. The denial of a permit shall be accompanied by a written statement of all reasons for the denial. The Wetlands Administrator shall report the decision to the Wetlands Board, [community] Planning Commission and [community] Board, and the MDEQ.

D. When a wetlands use permit is approved, approved with modifications, or denied, written notice shall be sent to the applicant and to all persons who have requested notice of the Wetlands Administrator's decision.

Section 7.3 - Wetlands Use Permit Decisions by Planning Commission or the [community] Board

The following process shall apply to wetlands use permit decisions by the [community] Planning Commission or by the [community] Board:

A. Wetlands use permit applications submitted in conjunction with a related land development activity shall be decided by the same entity that decides the related land development activity. The Wetlands Administrator shall transmit application materials and the report and recommendation prepared by the Wetland Consultant to the Planning Commission or [community] Board as applicable.

B. After review and study of the application materials, the Wetland Consultant's report and recommendation, the [community] Planning Commission or [community] Board as applicable may hold one public hearing after publication in a newspaper of general circulation in the [community] not less than ten (10) days nor more than sixty (60) days prior to the date of the hearing. Such notice shall indicate the place, time and subject of the hearing and the place and time the proposed wetlands use permit may be examined. The wetlands use permit hearing may be held in conjunction with a review of the related land use requests.

C. In the event of a public hearing, notice shall be sent by mail or personal delivery to the owners of property for which approval is being considered, and to all owners of property, as listed on the most recent tax roll, within 600 feet of the boundary of the property in question. Notification need not be given to more than one (1) occupant of a structure, except that if a structure contains more than one (1) dwelling unit or spatial area owned or leased by different persons, one (1) occupant of each unit shall receive notice. In the case of a single structure containing more than four (4) dwelling units, notice may be given to the manager or owner of the structure who shall be requested to post the notice at the primary entrance to the structure. A notice containing the time, date, place and purpose of the hearing shall be posted on the subject property at least eight (8) days prior to the hearing. The posting sign shall be no less than ten (10) square feet in size, shall be clearly visible from the abutting street(s), and shall state that an application has been filed for a wetlands use permit.

D. After completing the review, the Planning Commission or [community] Board, as applicable, shall approve, approve with modifications, or deny the application within ninety (90) days after receipt of a complete application, in accordance with this Ordinance. If the [community] Planning Commission or the [community] Board, as applicable, does not make a final determination on the application within ninety (90) days after receipt of a complete application, then the permit application shall be considered approved, except where the 90-day limit has been extended pursuant to Section 6.F.2.

E. Written notice shall be sent to the applicant and the MDEQ upon approval, approval with modifications, or denial of a wetlands use permit by the [community]. The denial of a permit shall be accompanied by a written statement of all reason for denial.

Section 7.4 - Appeals Of Decisions Of The Wetlands Administrator, Planning Commission, or Board

The following process shall apply to appeals of decisions made by the Wetlands Administrator, the Planning Commission, or the [community] Board as applicable:

A. Any person who is aggrieved by the approval, approval with modifications, or denial of a wetlands use permit by the Wetlands Administrator, the Planning Commission, or by the [community] Board, may appeal the decision to the Wetlands Board. A written letter containing the specific reasons for appeal shall be filed with the [community] Clerk within ten (10) calendar days after the date of the decision to be appealed. Timely filing of an appeal shall have the effect of suspending the effect of the permit pending the outcome of the appeal. In the event that the person(s) filing the appeal do not own property within 600 feet of the wetland affected, the Planning Commission shall determine whether the person(s) are aggrieved.

B. Standard of Review. Based upon the record, in considering the appeal, the Wetlands Board shall affirm the original decision unless it finds an abuse of discretion by the entity deciding the wetlands use permit.

C. After a hearing, the Wetlands Board shall determine that the decision of the Wetlands Administrator, Planning Commission, or [community] Board be affirmed, affirmed with modification, or reversed. The Wetlands Board's decision shall be based on written findings.

Section 7.5 - Wetlands Use Permit Conditions

A. The Wetlands Administrator, the Planning Commission, or the [community] Board, as applicable, shall attach any reasonable conditions considered necessary to ensure that the intent of this Section will be fulfilled, to minimize or mitigate damage or impairment to, encroachment in or interference with nature resources and processes within the wetlands, or to otherwise improve or maintain the water quality. Any conditions related to wetland mitigation shall follow the provisions of Section 8 of this Ordinance.

B. The Wetlands Administrator, the Planning Commission, or the [community] Board, as applicable, shall fix a reasonable time to complete the proposed activities.

C. If the Wetlands Administrator, the Planning Commission, or the [community] Board, as applicable determines that there is a potential for adverse impacts to wetlands not authorized by the wetlands use permit or off-site property, they will require the applicant to file with the [community] a cash bond or irrevocable bank letter of credit in an amount, estimated by the Wetland Consultant to be required to address those impacts.

D. A wetlands use permit shall be conditioned upon compliance with all other requirements of ordinance and law, including site plan, plat or land use approval as applicable, and issuance of a permit by the MDEQ, if required under the Wetlands Protection Act. In cases where a MDEQ permit allows activities not permitted by the wetlands use permit approval granted under this Section, the restrictions of the approval granted under this Section shall govern.

E. Wetlands use permits for seasonal operations need not be renewed annually unless otherwise stated in the permit.

F. Any change that materially increases the size or scope of the operation and that affects the criteria considered in approving the permit as determined by the Wetlands Administrator, the Planning Commission, or the [community] Board, as applicable, shall require the filing of a new wetlands use permit application.

G. Any temporary, seasonal, or permanent operation that is discontinued for two (2) years or two (2) seasons shall be presumed to have been abandoned and the wetlands use permit automatically voided.

H. Any permit granted under this Ordinance may be revoked or suspended by the Planning Commission or [community] Board ,as applicable, after notice and an opportunity for a hearing, for any of the following causes:

1. A violation of a condition of the permit.

2. Misrepresentation or failure to fully disclose relevant facts in the application.

3. A change in a condition that requires a temporary or permanent change in the activity.

I. An applicant who has received a wetlands use permit under this Ordinance shall comply with the following in connection with any construction or other activity on the property for which the wetlands use permit has been issued:

1. Maintain soil erosion control structures and measures, including but not limited to, silt fences, straw bale berms, and sediment traps. The permittee shall provide for periodic inspections throughout the duration of the project.

2. Maintain clear delineation of the wetlands (so marked by the Wetlands Administrator or Wetland Consultant during the on-site inspection) so that such locations are visible to all construction workers.

3. Post on the site, prior to commencement of work on the site and continuing throughout the duration of the project, a copy of the approved wetlands use permit containing the conditions of issuance, in a conspicuous manner such that the wording of said permit is available for public inspection.

J. The wetlands use permit shall remain effective for a time period coincidental with any other land use permit reviewed and approved concurrent with the wetlands use permit. If applied for prior to the expiration date and concurrent with the expiring land use permit, the applicant may be granted an extension that corresponds to additional time granted for the underlying land use permit. Extensions shall be approved by the same person or body that made the original decision. The maximum number of extensions shall coincide with the maximum number allowed for the underlying land use permit.

K. When there is no other activity or permit involved, the wetlands use permit shall remain effective for one (1) year. A maximum of a one (1) year extension may be approved.

Section 7.6 - Regulation Criteria For Non-Contiguous Wetlands Less Than (2) Two Acres In Area.

A. A wetlands use permit shall be approved with respect to a non-contiguous wetland less than two (2) acres in area unless the Planning Commission or [community] Board determines that the wetland is essential to the preservation of the natural resources of the [community]. It shall not be the burden of the property owner to prove that the wetland is not essential to the preservation of the natural resources of the community.

B. All non-contiguous wetland areas of less than two (2) acres which appear on the Wetlands Map, or which are otherwise identified during a field inspection by the [community], shall be analyzed for the purpose of determining whether such areas are essential to the preservation of the natural resources of the [community]. If there is to be a denial of a wetlands use permit in a non-contiguous wetland area of less than two (2) acres, then, on the basis of data gathered by or on behalf of the [community], findings shall be made in writing and given to the applicant stating the basis for the determination that such wetland is essential to preservation of the natural resources of the [community]. In order to make such a determination, there shall be a finding that one (1) or more of the following exist within such wetland:

1. The site supports state or federal endangered or threatened plants, fish, or wildlife appearing on a list specified in Section 36505 of Part 365, Endangered Species Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended.

2. The site represents what is identified as a locally rare or unique ecosystem.

3. The site supports plants or animals of an identified local importance.

4. The site provides groundwater recharge documented by a public agency.

5. The site provides flood and storm control by the hydrologic absorption and storage capacity of the wetland.

6. The site provides wildlife habitat by providing breeding, nesting, or feeding grounds or cover for forms of wildlife, waterfowl, including migratory waterfowl, and rare, threatened, or endangered wildlife species.

7. The site provides protection of subsurface water resources and provision of valuable watersheds and recharging groundwater supplies.

8. The site provides pollution treatment by serving as a biological and chemical oxidation basin.

9. The site provides erosion control by serving as a sedimentation area and filtering basin, absorbing silt and organic matter.

10. The site provides sources of nutrients in water food cycles and nursery grounds and sanctuaries for fish.

C. In connection with the determination whether the wetland is essential to the preservation of the natural resources of the [community], the property owner shall make an election and response under Subsection 1 or 2 below, relative to each non-contiguous wetland area less than two (2) acres.

1. In lieu of having the [community] or its Wetland Consultant proceed with the analysis and determination, the property owner may acknowledge that one (1) or more of the criteria in Subsections (B-1) through (B-10) above, exist on the wetland in question, including a specification of the one or more criteria which do exist; or

2. An election to have the [community]or its Wetland Consultant proceed with the analysis of whether each of the criterion in Subsections (B-1) through (B-10) exist or do not exist in the wetland in question, including specific reasons for the conclusion in respect to each criteria

D. If the [community] determines that the wetland is not essential to the preservation of the natural resources of the [community], the [community]'s decision shall be so noted on the Wetland Map, at the time it is amended. The requested activity shall be approved subject to all other applicable laws and regulations.

E. If the [community] determines that the wetland is essential to the preservation of the natural resources of the [community], and the [community] has found that one or more of the criteria set forth exist at the site, the [community] shall notify the applicant in writing stating the reasons for determining the wetland to be essential to the preservation of the natural resources.

After determining that a wetland less than two (2) acres in size is essential to the preservation of the natural resources of the [community], the wetland use permit application shall be reviewed according to the standards in Section 7.7.

Section 7.7 - Review Standards for Wetlands Use Permits

The criteria to evaluate wetlands use permits under this Ordinance and to determine whether a permit is granted are as follows:

A. A permit for any activity listed in Section 5.1 shall not be approved unless the [community] determines that the issuance of a permit is in the public interest, that the permit is necessary to realize the benefits derived from the activity, and that the activity is otherwise lawful.

In determining whether the activity is in the public interest, the benefit that reasonably may be expected to accrue from the proposal shall be balanced against the reasonably foreseeable detriments of the activity. The decision shall reflect the national, state, and local concern for the protection of natural resources from pollution, impairment, and destruction. The following general criteria shall be considered:

1. The relative extent of the public and private need for the proposed activity.

2. The availability of feasible and prudent alternative locations and methods to accomplish the expected benefits from the activity.

3. The extent and permanence of the beneficial or detrimental effects that the proposed activity may have on the public and private uses to which the area is suited, including the benefits the wetlands provide.

4. The probable impact of each proposal in relation to the cumulative effect created by other existing and anticipated activities in the watershed.

5. The probable impact on recognized historic, cultural, scenic, ecological, or recreational values and on the public health or fish or wildlife.

6. The size of the wetland being considered.

7. The amount of remaining wetland in the general area.

8. Proximity to any waterway.

9. Economic value, both public and private, of the proposed land change to the general area.

10. Findings of necessity for the proposed project that have been made by federal or state agencies.

B. A wetlands use permit shall not be issued unless it is shown that an unacceptable disruption will not result to the aquatic resources . In determining whether a disruption to the aquatic resources is unacceptable, the criteria set forth in Section 30302 of the Wetlands Protection Act and Subsection A of this section shall be considered. A permit shall not be issued unless the applicant also shows either of the following:

1. The proposed activity is primarily dependent upon being located in the wetland.

2. A feasible and prudent alternative does not exist.

SECTION 8 - WETLAND MITIGATION

Section 8.1 - Findings That Wetland Loss Is Unavoidable

Mitigation shall not be considered a substitute for making all prudent attempts to avoid wetland impacts.

A. Prior to considering a proposal for wetland mitigation, the Wetlands Administrator, the Planning Commission or the [community] Board, as applicable shall make all of the following findings:

 1. That all feasible and prudent efforts have been made to avoid the loss of wetland.

 2. That all practical means have been considered to minimize wetland impacts.

 3. That it is practical to replace the wetland which will be unavoidably eliminated.

 4. That all alternatives for preserving wetlands have been evaluated and found to be impractical, inappropriate, or ineffective.

B. To ensure no net loss of wetlands in the [community], mitigation shall be required in instances where there are losses of wetland resources and where the Wetlands Administrator, the Planning Commission or the [community] Board, as applicable have made the findings required in Section 8.1.A.

Section 8.2 - Criteria For Approving Proposals For Wetland Mitigation.

If the Wetlands Administrator, Planning Commission or the [community] Board, as applicable, determines that it is practical to replace the wetlands that will be impacted, mitigation plans shall be approved only if all of the following criteria are met:

A. That the mitigation plan provides for the substantial replacement of the predominant functional values of the wetland to be lost. Mitigated wetlands shall be replaced at a minimum of 1.5 new acres of wetland to 1 lost acre. A larger replacement ratio may be required if the lost wetlands are deemed to have exceptional value.

B. That the mitigation plan provides for no net loss of wetland resources unless the Wetlands Administrator, the Planning Commission or the [community] Board, as applicable determines that the net loss will result in a minimum negative impact upon wetlands, and attendant natural resources under all of the circumstances.

C. Mitigation shall be provided on-site where practical and beneficial to the wetland resources. If mitigation on-site is not practical and beneficial, then mitigation in the immediate vicinity, within the same watershed, of the permitted activity may be considered. Only if all of these options are impractical shall mitigation be considered elsewhere.

D. The mitigation plan will comply with all applicable federal, state, and local laws.

E. A plan to monitor preserved and replacement wetlands over a minimum of five years has been specified. The plan shall include the following information:

 1. Schedule and list of activities to be contracted and conducted related to the site's hydrology, including sub-surface and surface water for a period of at least five years.

A report and recommendation on the hydrologic conditions of the site should be submitted to the [community] annually.

2. Schedule and list of activities to be contracted and conducted related to the site's plant establishment and control of invasive exotic species for a period of at least five years. A report and recommendation on the plant establishment of the site should be submitted to the [community] annually.

3. To assure that the objectives established in the mitigation plan are successful, the monitoring plan should indicate the mechanisms necessary to execute the recommendations from the annual reports and provide for additional monitoring after the five-year period.

Section 8.3 - Other Mitigation Requirements

A. Wetland mitigation and monitoring plans shall become conditions to the wetlands use permit and shall be the responsibility of the applicant.

B. Financial assurances that mitigation is accomplished as specified by the permit condition may be required by Wetlands Administrator, Planning Commission or [community] Board, as applicable.

C. Any mitigation activity shall be completed before initiation of other permitted activities, unless a phased concurrent schedule can be agreed upon between the Wetlands Administrator, Planning Commission or [community] Board, as applicable, and the applicant.

D. Wetland mitigation plans that create less than two (2) acre wetlands shall be designed and constructed to meet one of the conditions listed in Section 7.6 B.1-10.

SECTION 9 - FEES, PENALTIES AND ENFORCEMENT

Section 9.1 - Fees

Applications for a wetlands use permit under this Section shall be accompanied by a non-refundable administrative application fee in an amount specified from time to time by resolution of the [community]. In addition an applicant shall pay an escrow fee in an amount determined from time to time by resolution of the [community] Board for the estimated cost of outside consultant(s) who may be retained by the [community] in connection with the review of the application. In the event the cost of the services of the consultant(s) is less than the escrow fee, the applicant shall be refunded the balance. In the event the cost of the services of the consultant(s) exceeds the amount of the escrow fee, the applicant shall provide to the [community] and additional escrow amount equivalent to no less than one-half (1/2) the original escrow amount. All review of the wetlands use permit application shall cease until such additional escrow amount is deposited with the [community], and the number of days during which all review of the wetlands use permit application is ceased shall be deducted from the time limits within which the [community] would otherwise act upon the application. In the event the cost of the services of the consultant(s) is less than the subsequent escrow fee(s), the applicant shall be refunded the balance. A denial of an application for a wetlands use permit shall not affect the applicant's obligation to pay the fees provided for in this Section.

Section 9.2 - Penalties And Enforcement

A. Penalties

1. If, on the basis of information available to the [community], the [community] finds that a person is in violation of this Ordinance or of a condition set forth in a permit, the [community] shall issue an order requiring the person to comply with the prohibitions or conditions, or the [community] shall take such enforcement action as it deems appropriate.

(a) If a person acts in violation of this ordinance [community] may issue a stop work order on construction or shall refuse a certificate of occupancy or other construction permits related to the project whenever there is a failure to comply with the provisions of this Ordinance.

(b) An order issued under subsection (1) shall state with reasonable specificity the nature of the violation and shall specify a time for compliance, not to exceed 30 days, which the [community] determines is reasonable, taking into account the seriousness of the violation and good faith efforts to comply with acceptable requirements.

2. A person who violates any provision of this Ordinance shall be responsible for a civil infraction for which the court may impose a civil fine of not less than $100.00 nor no more than $10,000 per day of violation plus all costs, direct or indirect, which the [community] has incurred in connection with the violation.

3. In addition to the penalties provided in subsection (3), the court may order a person who violates this Ordinance to restore as nearly as possible the wetland affected by the violation to its original condition immediately before the violation, and may issue any other orders permitted by law. The restoration may include the removal of fill material deposited in a wetland or the replacement of soil, sand, minerals, or plants.

B. Injunction

Any activity conducted in violation of this section is declared to be a nuisance *per se*, and the [community] may commence a civil suit in any court of competent jurisdiction for an order abating or enjoining the violation, and/or requiring restoration of the wetland as nearly as possible to its condition before the violation.

Section 9.3 Reporting and Record Keeping

A. Any citizen observing what he or she believes or suspects may be an instance of noncompliance with the provisions of this Ordinance may report the observation to any official or employee of the [community].

B. Any report received pursuant to Subsection A of this Section shall be forwarded immediately to the [community] Ordinance Officer and the [community] Clerk.

C. [community] Ordinance Officer Duties

1. The [community] Ordinance Officer shall inspect the site of the suspected noncompliance as soon as is reasonably practical, but in no case later than the close of business five (5) business days after receiving the report.

2. The [community] Ordinance Officer shall complete an entry for the report into the Compliance Docket.

3. The [community] Ordinance Officer may enlist the expertise of the Wetlands Administrator if necessary to determine whether a violation of this Ordinance has occurred.

4. The [community] Ordinance Officer shall take any actions within his or her authority necessary to ensure this Ordinance is enforced.

D. Compliance Docket

The [community] Ordinance Officer shall maintain a Compliance Docket at the community] Office. The Docket shall be used to identify all properties or uses of properties which have been evaluated for compliance with this Ordinance. The Docket shall be available to the public upon demand during normal business hours. The Docket shall contain the following information:

1. Date: the date the Docket entry was initiated.

2. Address/Location of Property: the street address, if available, or descriptive text or vicinity map sufficient to enable citizens to identify the property in question

3. Permit or Docket Number: If it has been determined that the use being made of the property does not require a wetlands use permit from [community], a Docket number shall be assigned. Otherwise, the Permit number shall be maintained.

4. Compliance Status: A record shall be made of whether the use being made of the property is in compliance with the provisions of this Ordinance, the date the determination was made, and the name(s) of the [community] official and/or consultant who made the determination.

5. Sidwell property number.

E. Violation Docket

The [community] Ordinance Officer shall maintain a Violation Docket at the [community] Office. The Docket shall be used to track the status of violations of this Ordinance. The Violation Docket shall contain the following information, as it becomes available:

1. Date: the date the Docket entry was initiated

2. The permit or Docket number: This number shall be the same number as is used to identify the property in the Compliance Docket.

3. Address/Location of property: The street address, if available, or descriptive text or vicinty map sufficient to enable citizens to identify the property in question.

4. Nature of violation.

5. Date violation confirmed.

6. Name of person confirming the violation.

7. Enforcement action taken.

8. Date of enforcement action taken.

9. Outcome of enforcement action: If outcomes are appealed by the property owner or any other party, each appeal shall be noted, and its outcome shall also be noted under this heading.

SECTION 10 - STATE NOTIFICATION

Section 10.1 - Notice to the Michigan Department of Environmental Quality

The [community] shall notify the MDEQ of the adoption of this Ordinance. The [community] shall cooperate with the MDEQ in the enforcement of the Wetlands Protection Act as to wetlands under the MDEQ's jurisdiction as defined under this Ordinance.

SECTION 11 - ORDINANCE CONFLICT

Section 11.1 - Abrogation and Conflict of Authority

Nothing in this Ordinance shall be interpreted to conflict with present or future state statutes in the same subject matter; conflicting provisions of this Ordinance shall be abrogated to, but only to, the extent of the conflict. Moreover, the provisions of this Ordinance shall be construed, if possible, to be consistent with and in addition to relevant state regulations and statutes. If any part of this Ordinance is found to be invalid or unconstitutional by any court of competent jurisdiction, such portion shall be deemed a separate, distinct and independent provision. Such finding shall not affect the validity of the remaining portions thereof, and the remainder of the Ordinance shall remain in force. Rights and duties that have matured, penalties which have been incurred, proceedings which have begun and prosecutions for violations of law occurring before the effective date of this Ordinance are not affected or abated by this Ordinance.

SECTION 12 - PROPERTY TAX ASSESSMENT

If a wetlands use permit is denied by the [community], a landowner may appear at the annual Board of Review for the purpose of seeking a re-valuation of the affected property for assessment purposes to determine its fair market value under the use restriction.

SECTION 13 - EFFECTIVE DATE

This Ordinance shall take full force and effect upon [date], following final publication of said Ordinance.

SECTION 14 - CERTIFICATION

I, ____________________, Clerk of the [community], do hereby certify that the foregoing is a true and correct copy of an Ordinance adopted at first reading by the [community] Board at a regular meeting on _________________ and adopted at second and final reading by said Board at a regular meeting of said Board on _______________________.

To: Cedar Lake Steering Committee **Date:** 05/22/2009

From: Jamie McCarthy, K&A **Enclosure:** Policy Options Table

Re: Cedar Lake Watershed Management Planning Policy Options

A major component of any watershed management plan is an implementation plan and schedule detailing the proposed best management practices, projects, and education plans that will be implemented in the watershed after the planning process is complete. As part of the Cedar Lake watershed management planning process, policy and ordinance options will be discussed in order to propose the best means of protecting wetland habitat and groundwater recharge (i.e., groundwater and surface water inputs to the lake) and minimizing lake level impacts from future development in wetlands (lake drainage).

At the upcoming Steering Committee (SC) meeting scheduled on June 9, K&A will lead the SC through a discussion and decision-making process on potential ordinances and policies related to wetland protection. The attached document outlines the potential policy options using information from other Michigan townships that have implemented similar policies. During the SC meeting, the committee will discuss and select the most appropriate and feasible policy option(s) (with the ability to add or delete language, as needed). In order to work through these materials in an efficient manner, please read through and become familiar with the attached policy options prior to the June 9 meeting.

After the SC discusses and selects the policy option(s) best suited for Cedar Lake and the surrounding townships/counties, K&A will recommend a series of "next steps" and an estimate for the potential "level of effort" involved in implementing such a policy. This document, along with all of the policy options, will be included in the watershed management plan and be incorporated into the implementation schedule. If the selected policy is taken from an existing Michigan township ordinance example, model ordinance language can be provided as an appendix to the watershed management plan. To be clear, the plan will identify what should be pursued; future implementation efforts beyond the plan will be needed to institute the recommendations.

Attachment I.1

Example Ordinance and Policy Components

GENERAL PARTS OF AN ORDINANCE	WETLAND ORDINANCE	ZONING ORDINANCE	MODIFY BUILDING CODE	TASKS
Statement of the purpose of the ordinance/policy	**Purpose:** 1) Provide protection and appropriate use of wetlands within the township in order to minimize disturbance of these vital natural features. 2) Coordinate the provisions of this ordinance with state law, as well as to provide for coordinated enforcement of wetland protection laws and requirements by responsible township, county and state officials. 3) To establish procedures for the processing of applications for permits involved in the permitted use of wetlands in the township. (A)	**Purpose:** 1) To provide for the protection and preservation of wetlands, environmentally sensitive areas, groundwater, and fish and wildlife habitat, and the functions and services they provide to the township and its residents. 2) To uniformly apply an additional set of regulations to established zoning districts related to the protection of environmental areas due to development. (The benefits of an overlay policy include the ability to respond to land use issues that affect multiple zoning districts/areas, preserve natural features, and enhance public awareness) (B)	**Purpose:** to add an additional set of building code requirements for homes being built in floodplain or flood-prone areas to protect property values, to alleviate future flooding and public health issues associated with flooded homes, and to eliminate or reduce costs to taxpayers caused by flooding.	• Determine overall goal or purpose of an ordinance or policy • Determine what model would work best in your township or wetland/ natural areas in your township **GOALS:** 1) Protect wetlands (to preserve gw recharge to Lake and protect fish spawning) 2) Minimize lake elevation impacts and flooding issues
Area covered under the ordinance/policy	**Wetlands:** as defined by Public Act 451 (Wetlands Protection Regulation, Part 303: "Land characterized by presence of water at a frequency and duration sufficient to support, and that under normal circumstances does support, wetland vegetation and aquatic life; commonly referred to as bog, swamp or marsh." **Drainageways, greenbelt/buffers, floodplains** **State Regulated:** contiguous to or within 1000 ft of Great Lakes; 500 ft of stream, lake or pond but are greater than 5 acres and in counties with 100,000 pop.; not contiguous and less than 5 acres in size if DEQ has determined the wetlands are essential to the preservation of state's natural resources and has so notified the property owner(s). (C)	**Overlay:** options include 1) Floodplains, watersheds, lake shore lands, river corridors, environmentally sensitive areas, high risk erosion areas, and wetlands 2) Other areas identified by the county or township that are ecologically important or sensitive to development or affects thereof	**Coverage Area:** 1) Lands located in the 100-year floodplain 2) Areas identified on the wetland map as part of the township's master plan 3) Other flood-prone areas identified by the township (and mapped) or environmentally sensitive areas	• Review wetlands maps of the township and county soils maps • Overlay wetlands information onto township zoning map(s) [*counties or townships provide overlays of parcel lines]* • Determine what critical areas the ordinance will cover (Wetlands and floodplains? What size wetland? Only those not regulated by State or Feds?)
Wetland inventory map, overlay map, or coverage area	1) Review of the USFWS National Wetlands Inventory and other relevant data layers. The delineated areas will require special use permits and/or site plan reviews when development is	1) An overlay map will be created and incorporated into the townships master planning map. The overlay will include environmentally sensitive areas determined by the township and a	Additional building codes will not likely be implemented for all building/development projects in the township, so an area must be delineated or criteria selected where	• Decide what information would be used to develop a map -- will it be a wetlands map, natural resources

	proposed. A GIS map will be created and incorporated into the township general development master plan. It will be used by township boards and officials to identify areas which may be subject to federal, state or local regulation. 2) Delineation of wetland boundaries on individual parcels or sites shall be the responsibility of the township but chargeable to the property owner. The wetland map shall not be considered a substitute for on-site field inspection. The applicant for a use approval shall be responsible for identifying boundaries of protected wetlands located on the project site. The landowner is responsible for having the locations of protected wetlands on the project site identified and marked by qualified personnel of either the MDEQ or consulting firm competent in this field. (A)	public notice will be issued regarding the new map and how a copy can be obtained. 2) The overlay map will include environmentally sensitive areas in the township where specific building codes, setbacks, impervious surface limits, increased vegetation removal limits and other codes exists; options: • Floodplain (100 year) or flood-prone areas • Wetlands identified through USFWS National Wetlands Inventory and DEQ MIRIS layer • Stream corridors • Greenbelt areas • All surface waterbodies • Unique wildlife/fish habitat • Groundwater recharge/protection areas	these building codes will be required. This could be a zoning overlay district, general wetlands map, environmentally sensitive areas, etc.	protection area map, a zoning overlay map, etc? • Determine what select areas (floodplains, buffers, drainageways) or critical wetlands need protection
Information about the permit/development process	1) Application must be submitted to the zoning board to request land use in delineated wetland areas. 2) The application will include drawings of the proposed activities. 3) Use application shall be submitted to the township for a preliminary review of subdivision plats, site plans, lot splits, grading approvals or building permits. 4) Applications will also be forwarded to the DEQ and approval may need to be issued from state wetland's program as well. (D)	For development in the overlay zone, regardless of zoning (and when a special use permit is not required), a site plan review will be required. The site plan review will have an environmental component to protect resources outlined in the zoning ordinance. The site plan will be reviewed by a township administrator or Zoning Board and approved if all of the conditions are met for development (outlined below). One copy of approval will be sent to building inspector to issue building permit and confirm site plan, one copy to property owner, and one copy for township records. (B)	Additional building codes will be added for development in select areas. The code will stipulate building foundation requirements in terms of elevation and design. Impervious cover from driveways, house footprint, patios, and other out buildings will be limited. Vegetation should remain insofar as practical aside from clearing for initial building and "regular" mowing and pruning or for agricultural purposes.	• After selecting a type of policy (wetland or zoning ordinance or building code addition), determine what elements need to be incorporated to meet purpose/goal of policy • Use options here to discuss/select components
Standards of the ordinance or policy	1) The review board or administrator will determine whether the activity is in the public interest, the benefit which would reasonably be expected to accrue from the proposal shall be	**Preservation or all natural vegetation**, insofar as practical (or greater percent in this area than is required elsewhere) • Sites 1 acre or larger will require	1) **Removal of vegetation**: a certain percent of clearing will be allowed for initial building/development. Natural vegetation should be	• Further develop/discuss the specific regulations or requirements that the selected policy will require

	balanced against the reasonably foreseeable detriments of the activity, taking into consideration the local, state and national concern for the protection and preservation of natural resources from pollution, impairment and/or destruction. [A list of general criteria that will be applied in undertaking this balancing test is listed below the table.] 2) An approval shall not be granted unless it is shown that an unacceptable disruption will not result to the aquatic resources. An approval shall not be granted unless the applicant also shows either of the following: • The proposed activity is primarily dependent upon being located in the wetlands or, • A feasible and prudent alternative does not exist. 3) Upon application for a wetland use permit, approval shall be granted unless the Township Board determines that the wetland is essential to the preservation of the natural resources of the township. A list of criteria that shall be considered in making this determination is listed below the table. (A)	**stormwater management practices** to prevent flooding and protect natural resources • **Natural areas** (swales, creeks, ponds, wetlands, etc.) shall be protected/ preserved insofar as practical in their natural state • **Elevation of buildings** above 100 year floodplain (or greater in certain areas) • **Other building codes** related to foundations to be applied in this area to avoid flooding issues • **Limited impervious surface** area of driveway, patios, house footprint, other out buildings, etc. • **Limit filling or wetland areas** insofar as practical for the specific site plan (B)	protected/undisturbed insofar is practical (a building code may require specific guidance on this criteria/standard). 2) **Impervious cover**: the footprint of driveways, concrete patios, house footprint, and other out buildings or impervious surfaces will be limited to a practical ratio of house:driveway:lot size (or other standard). 3) **Foundations**: building foundations in wetland areas or flood-prone areas will need specific building/structural solutions to protect a home from flooding; including elevation requirements (1 - 3 ft above 100 year floodplain), sump options, or undergrade drainage structures. 4) **Site filling**: filling of wetland areas (no regulated by state or federal law) will be limited to a ratio or percent of the lot for building foundations.	• Decide what resource will need to be consulted to fully develop the ordinance or policy • Assign tasks for the group members
Penalties for violating the ordinance/policy	A civil infraction and fine schedule may be necessary for (re)development on property already grandfathered under this ordinance: 1st offense $75.00 2nd offense $150.00 3rd offense $325.00 4th offense (or more) $500.00 **Or:** require developer to obtain wetlands permit before issuing building permit. (A)	Denial of land use permit, and therefore building permit. Persons building without necessary permits are subject to established fines and/or prosecution.	Denial of building permit or not passing final building inspection for occupancy (or interim inspections). Person building without necessary permits are subject to established fines and/or prosecution.	• Determine what penalties or deterrents are necessary to maximize compliance with a new ordinance/policy and result in the best protection of wetlands, floodplain areas, property values, public health and safety, etc.

(A) Fabius Township Compliation of the Wetlands Protection Ordinance. Ordinance Number 70, as Amended by Ordinance Number 90, 93, and 120. Effective April 21, 1999. Fabius Township, St. Joseph County, Michigan.
(B) LSA, Associates, LLC. Four Townships Water Resources Council's Site Plan Review for Water Quality Protection.
(C) State of Michigan Natural Resources and Environmental Protection Act, Part 303 of Public Act 451, as Amended (1994).
(D) Cannon Township Wetlands Protection Ordinance. Ordinance Number 2005-1. Cannon Township, Kent County, Michigan.

<u>Criteria to determine whether a project is in the public interest</u>:
(1) The relative extent of the public and private need for the proposed activity.

(2) The availability of feasible and prudent alternative locations and methods to accomplish the expected benefits from the activity, including alternatives which are off-site or on other commercially available properties.

(3) The extent and permanence of the beneficial or detrimental effects which the proposed activity may have on the public and private use to which the area is suited, including the benefits the wetland provides.

(4) The probable impact on the proposal in relation to the cumulative effect created by other existing and anticipated activities in the watershed.

(5) The probable impact on recognized historic, cultural, scenic, ecological, or recreational values and on the public health or fish or wildlife.

(6) The size and quality of the wetland being considered.

(7) The amount and quality of the wetland being considered.

(8) Proximity to any waterway.

(9) Extent to which upland soil erosion adjacent to protected wetlands or drainageways is controlled.

(10) Economic value, both public and private, of the proposed land change to the general area.

(11) Findings of necessity for the proposed project which have been made by other state or local agencies.

<u>Criteria to determine if the wetland is essential to the protection of a natural resource</u>:

(1) The site supports state or federal endangered or threatened plants, fish or wildlife appearing on a list specified in Section 36060 of the Act.

(2) The site represents what is identified as a locally rare or unique ecosystem.

(3) The site supports plants or animals of an identified local importance.

(4) The site provides groundwater recharge documented by a public agency.

(5) The site provides flood and storm control by the hydrologic absorption and storage capacity of the wetland.

(6) The site provides wildlife habitat by providing breeding, nesting or feeding grounds or cover for forms of wildlife, waterfowl, including migratory waterfowl, and rare, threatened or endangered wildlife species.

(7) The site provides protection of subsurface water resources and provision of valuable watersheds and recharging underground supplies.

(8) The site provides pollution treatment by serving as a biological and chemical oxidation basin.

(9) The site provides erosion control by serving as a sedimentation area and filtering basin, absorbing silt and organic matter.

(10) The site provides sources of nutrients in water food cycles and nursery grounds and sanctuaries for fish.

Legal Cases Related to Wetlands in Michigan

Submitted as part of the Model Wetlands Ordinance Project
to the MDEQ Coastal Management Program
by the Huron River Watershed Council
March 31, 2002

Overview

As part of it project to develop a model wetlands ordinance, the Huron River Watershed Council (HRWC) conducted a literature search for case histories involving legal challenges to wetland regulations. HRWC searched through the legal summaries section of the last 20 years of the *Planning and Zoning News* publication, contacted every community in Michigan on record with the MDEQ as having a wetlands ordinance, and conducted several internet-based searches through newspaper and legal databases.

Conclusions

The first conclusion to draw from this initial survey of legal cases regarding wetlands laws is that very little information is readily available describing local courts, where most of the wetlands-related cases occur. In order to obtain a more complete picture of the legal environment, much more time is needed to travel to each community to meet with its attorney and search through its legal files. Phone surveying was helpful, but often the government representative with whom we spoke (whether they were the clerk, planner, or building official) was not able (or willing) to conduct what they said would be an extensive file search. Indeed, even when we were able to obtain a written decision on a particular case, key information was often missing. Apparently, decisions made in the district and circuit courts are not organized or summarized in any particular way, as State Court records are.

The second conclusion to draw is that most lawsuits that we were able to find were settled in some way before a definitive decision needed to be made by a judge. Out of seven wetlands related cases about which we were able to find information, only two resulted in a decision regarding the wetlands ordinance. In the Superior Township case, the Judge decided for the developer, agreeing that the building of a farm road is a "permitted activity" not requiring a permit from the wetlands ordinance. The Judge did cite the provision of the ordinance that requires farm roads, even though they are exempt, to be "constructed and maintained in a manner to assure that any adverse effect on the wetlands will be otherwise minimized." So, the township can still prosecute the developer if he fails to minimize the road's effects on wetlands. In the Master Key Northern v. Ann Arbor case, the judge categorically sided with the City, saying that their wetlands ordinance is indeed constitutional.

Cases decided out of court (i.e. before a judge could make a final decision about an ordinance):

Cisne vs. City of Orchard Lake Village
The Cisne's owned 3.79 acres on Orchard Lake. They proposed to build a 22' wide, 140' long home on 7' stilts in a wetlands. They applied for and received a permit from MDEQ (after two years of negotiations), but were denied a local permit. They filed litigation. The MDEQ approval was appealed by Orchard Lake Shore Property Owners Association. That appeal was dismissed by the administrative law judge, but the Association is appealing that decision.

The City and the Cisne's agreed to a consent judgement that granted the wetlands permit with many conditions. Conditions include: installation of erosion controls during construction, removal of invasive species from the wetland, a restrictive covenant prohibiting removal of any native vegetation, acknowledgement that sewer and water may not be available (which would then void the permit altogether), planting of new shrubs in wetland, that the boardwalk be constructed by hand and not cause removal of any vegetation, and that vegetation must continue to grow under house and boardwalk. The house has never been built.

Final decision: The DEQ's approval of a permit pressured the local community into reaching a consent agreement, so the legal process never reached the point where a court really ruled anything regarding the legality of their wetlands. However, the consent judgement did give the community the power to condition a permit on a number of stringent conditions on building in the wetland.

Wixom Wetland Case
The Land and Water Management Division of the MDEQ is currently in a lawsuit regarding a parcel of land in Wixom, Oakland County. Part of the plaintiff's argument is that the local wetland law supercedes the States. The case is still pending.

Waterford Township v. Kurtz

In 1990, property owner Kurtz applied to the MDNR for permission to fill a wetland to install a seawall. The MDNR denied the permit. The Township also informed him he needed to apply for a Township permit. Kurtz began the work anyway in 1991. He refused to cease until the police were called and a cease and desist order was issued. Kurtz continued to work in the area, and the Township obtained a temporary restraining order. .

The Township cited Kurtz for violating their wetlands ordinance. In Oakland County Circuit Court, the Township tried to prove him negligent for damaging the wetland behind his house and sought a permanent injunction to keep him from landscaping the yard, and asked for several thousand dollars in attorney fees. In turn, the property owners filed a counter suit that charged that their constitutional rights had been violated.

All of those conditions were dropped in an out of court settlement, where the court dismissed both suits, saying it was no longer possible to determine the original wetland boundary and therefore whether a violation had occurred. The court also ordered that protection of the remaining wetlands occur.

Final decision: Dismissal of case and each party agrees to drop all legal actions. Wetland will be delineated, soil erosion fencing will be placed along wetland boundary, and landscaping will occur up to the wetland boundary.

Genoa Township:
Property owners were denied a building permit to build within the 25 foot setback from a wetlands. They appealed to the zoning board of appeals and were denied. They filed a suit claiming the denial of their appeal was improper, because a variance was necessary for reasonable use of the property, and since the property owners' consultant determined wetland boundaries that were different from those determined by the Township. They claimed that the zoning restrictions on their property rendered it unusable, and that is a takings. An official determination was never made, but it appears the Court sided with the property owners, who revised their original application for a land use permit and it was approved.

Charter Township of Independence

A property owner obtained a wetlands permit from the State, but the Township denied the project under the local ordinance. The property owner brought a lawsuit against the township in court. The DEQ's approval of a permit pressured the local community into agreeing to allow him to build a scaled back version of the original.

West Bloomfield:
They have had several cases. According to sources familiar with those cases, none of the challenges resulted in anything begin struck down in court that is in the model ordinance.

Cases where a court did make a final decision regarding a local ordinance:

Court of Appeals: Frericks v. Highland Township, March 13, 1998
Frericks purchased property zoned A1 (10 acre lots) and requested rezoning to R1B (1.5 acre lots). The Township Board approved rezoning to R1A (3 acre lots). Frericks sued, saying R1A was a taking. The trial court ruled this density was unreasonable and arbitrary, since this lot size is not necessary to protect legitimate interests about pollution, septic systems, increased traffic, threat of inadequate fire protection, or conformance to master plan.

Frericks then appealed to the Court of Appeals, charging that the way the ordinance calculated allowable buildable area (it didn't include wetlands and floodplains) was invalid since regulations of wetlands was under the perview of the State. The Court disagreed.

Conclusion: While this decision was not directly involving a wetland ordinance, it has important implications for local ordinances. Local communities can remove environmentally sensitive areas when calculating allowable buildable area on development parcels.

<u>Superior Twp vs. Patrick Sieloff</u>
Superior brought charges against property owner Sieloff in 1998. Sieloff was engaged in farming activities – constructing a farm road and planting trees. The court ruled that while the building of a farm road is an activity permitted without a wetlands permit, the ordinance does reference a standard the defendant has to meet in the building and maintenance of the road. He can put in the farm road as long as the road is constructed and maintained in a manner to assure that any adverse effect on the wetlands will be otherwise minimized.

Conclusion: The charges against the property owner by Superior Township are premature, because the building of a farm road is a permitted activity under the ordinance. But the township can prosecute if the road fails to minimize effects on wetlands.

<u>Zealy v. City of Waukesha, 548 NW2d 528 (1996)</u> *Note: this case occurred in Wisconsin, not Michigan, but the final decision is an important one regarding takings law.*
The property at issue was a 10.4 acre plot of land that had been zoned, at different times, for agricultural uses, for residential uses, and for business uses. By 1985, 8.2 acres of Zealy's property were zoned as a conservancy district, because of wetlands on that part of the property. Of the remaining portion of Zealy's property, 1.57 acres were zoned for residential use, and .57 acres were zoned for business. Under the rezoning, the property classified as a conservancy district could not be used for residential purposes. Zealy claimed that the reclassification of the 8.2 acres of his land from residential to a conservancy district decreased the value of that part of his property from $200,000 to $4,000. The trial court dismissed Zealy's claim, holding that the parcel should be considered as a whole.

The appeals court reversed, on the rationale that the property should be viewed with respect to its different segments, and not as a whole. The Wisconsin Supreme Court reversed the appeals court and affirmed the decision of the lower court. The facts of Zealy's case showed that the conservancy zoning only applied to part of his property, not all of it. The zoning only reduced (rather than destroyed) the value of Zealy's property, viewed as a whole. According to the Supreme Court of Wisconsin, there was no taking.

<u>Master Key Northern v. City of Ann Arbor</u>
In 1998, Master Key Northern applied for site plan approval and a wetland use permit for a development in the City of Ann Arbor. The planning commission denied the site plan and the permit. Master Key Northern filed a lawsuit alleging that the Wetland Protection and Natural Features chapters of the City Ordinance violated due process and were beyond the power of a local community. The Court disagreed, saying that the plaintiff

was not without legal remedy since he did not file an appeal. The Court also wrote that the City does have the discretion to approve or deny site plans, and it is done duty-bound to approve them, as the plaintiff claimed. The Court also wrote that the case is not “ripe” for a consideration of takings because all the appeals had not yet been exhausted. The Court also ruled that the wetlands ordinance is constitutionally valid in that it is not vague.

Final decision: the City of Ann Arbor Wetland Protection Section, which is part of its zoning ordinance, is constitutionally valid, and provides the proper process.

Cedar Lake WMP (2025)

Attachment K: Priority Fisheries Details

INTRODUCTION

Attachment K provides additional detail and key implementation steps for two priority fisheries recommendations in the Cedar Lake WMP technical update (Chapter 7, Objective IV):

1) Sherman Creek pike spawning improvement assessments, and
2) Redear sunfish biocontrol experiment and swimmer's itch assessments.

1) KEY STEPS: Sherman Creek Pike Spawning Improvement Assessments

A priority purpose for the wetland hydrology restoration implementations in the Sherman Creek wetlands area was to enhance the hydrology in the wetland complex to prolong water flow from the wetlands to Cedar Lake later in the spring and early summer (in line with the strategies discussed in Objective III). Flows from Sherman Creek continue to be continuously monitored to evaluate the impacts of those improvement projects. Monitoring data from Sherman Creek shows that, historically, the creek flows stop some time during early June. The pike assessment noted that extending the duration of flow in the creek (especially during dry years) will enable fry to stay in the creek longer, which will ultimately increase their success once they emigrate to Cedar Lake.

Hydrology monitoring also continues at Jones Creek, which has not been targeted for improvement projects by the CLIB, however, has experienced hydrologic modifications due to a culvert replacement in 2017. These two creeks are the main supply of surface water to the lake. Sustained flows during early summer months would not only improve overall lake levels, but also would restore the severely damaged pike emigration. K&A's current monitoring efforts focus on understanding the balance between enhancing the Northern Pike spawning habitat and utilizing the wetland complex to supply more surface water to the lake during dry years.

Early-spring to early-summer direct monitoring of northern pike spawning in Sherman Creek is recommended in addition to ongoing water level monitoring, following the outline below:

Task 1: Pike Habitat and Spawn Surveys:

- Fisheries habitat survey using LakeScan™ metrics and additional metrics as appropriate for the wetlands and nearshore relevant to the Sherman Creek spawning area (repeat every 2nd or 3rd year):
    - Determine any areas where habitat restoration should occur and target those areas for habitat restoration in-line with other management activities or implementations.
- Utilize continuous in-stream temperature and level monitoring network to inform critical temporal monitoring periods.
- Conduct a northern pike visual spring spawn monitoring program within the critical Sherman Creek spawning areas.

Task 2: Northern Pike Camera Monitoring:

- Research and determine feasibility, efficiency, potential costs and potential technology options for monitoring spring spawn using live-camera or motion-sensitive camera surveys during the critical spawning period.

- Install cameras as appropriate based on research, at specific creek locations, to be monitored annually for fish presence, abundance, timing, and other appropriate indicators, on a seasonal basis.

Task 3: Fyke net surveys:

- Install fyke nets during the initial spring spawn surveys to obtain more specific abundance estimates of population during a set period of time.
- Use length and weight measurements of captured northern pike for Proportional stock density estimates.
- Establish management goals based on findings.

Task 4: Northern pike tagging

- Determine which form of tags will be deployed.
- Set up an online or passive at-launch drop-box style survey platform for anglers to report fish caught with tags.
- Utilize survey data to assess and describe northern pike population estimates.
- Adapt northern pike-specific tasks of the fisheries management plan based on mark recapture study and estimated growth and mortality rates.

2) KEY STEPS: Redear Sunfish and Swimmer's Itch 2021

In 2020 Freshwater Solutions LLC conducted a comprehensive survey of the schistosomes that are causative agents for swimmer's itch on Cedar Lake. Additional biodiversity assessments of waterfowl hosts, invertebrate snail hosts and the parasites were included in the survey. In 2018 a Novel species of schistosome parasite was discovered in Michigan by Freshwater Solutions. Sampling results indicate that this Novel Schistosome species inhabits Cedar lake. The Novel schistosome is the overwhelmingly dominant species in Cedar lake and several sample areas derived severe infestation levels. Canada geese and Planorbidae family of snails (*Helisoma sp*.), commonly known as ramshorn snails, have been determined as definitive and intermediate hosts to the Novel schistosome species. Based on the report by Freshwater Solutions LLC, the Novel Schistosomes species in Cedar lake are the highest recorded since they were initially discovered in 2018.[1]

Mallard ducks and Canada Geese, the most common species observed, made up 94% of the summer resident waterfowl community for Cedar Lake, Canada Geese were the most common. Additionally, Cedar lake mollusk surveys observed the *Helisoma sp*. of snail at higher abundances than all other species of snail. Heavy populations of both Canada geese and the *Helisoma sp.* of snail in Cedar lake are likely the main reasons for the soaring number of swimmer's itch reports. Ultimately, the report concludes with few recommendations for how to proceed in reducing the swimmer's itch in Cedar lake.[2]

[1] Reimink, R. & Hannigton, P. (September 2020). "Comprehensive Lake Assessment: Alcona-Iosco Cedar Lake Association (AICLA) 2020 Final Report." *Freshwater Solutions*.
[2] Reimink, R. & Hannigton, P. (September 2020). "Comprehensive Lake Assessment: Alcona-Iosco Cedar Lake Association (AICLA) 2020 Final Report." *Freshwater Solutions*.

Swimmer's Itch Web Application

Swimmer's itch is an overwhelming problem in Cedar lake. Solutions to mitigate this problem are limited, however, an immediate reporting and notification system for Cedar lake residents could reduce exposure. Kieser & Associates proposes to set up a website where residents can report swimmer's itch outbreaks. Unlike *swimmersitch.info*, outbreaks will be automatically mapped on the website for Cedar lake and residents may sign up to receive immediate and automatic notifications when as outbreaks are reported.

Swimmers Itch Long-term approach

Currently, management options for controlling swimmer's itch are limited, especially for this particular novel species, and not very effective as a long-term solution. However, a solution that may reduce the density and abundance of snails that host the Shistosome, and help to mitigate the frequency of swimmer's itch outbreaks could be through the introduction of redear sunfish (*Lepomis microlophus*). Redear sunfish are a molluscivore fish species, which means, this species specifically targets muscles and snails as the primary source of their diet. Increased snail predation in Cedar lake could reduce the overall abundance of the species of snail which hosts the swimmer's itch Schistosome and ultimately lower the number of outbreaks which occur. Noatch and Whitledge (2011) observed a gradual decline in the number of snails present in aquaculture ponds after stocking redear sunfish.[3] Redear sunfish were also found to be the most productive, US native fish species, for controlling rams-horns snail (*Helisoma anceps*). Additionally, redear sunfish preferred rams-horn snail over zebra mussels.[4]

The combination of Canada geese and the *Helisoma sp.* of snail facilitate outbreaks of swimmer's itch in Cedar lake. Reducing the density of this snail species would lower the abundance of nuisance cercariae that leads to swimmer's itch. Successfully, stocking redear sunfish could decrease the abundance of *Helisoma sp.* of snails in Cedar lake and effectively reduce and control swimmer's itch outbreaks.

Stocking Redear Sunfish

Redear sunfish were first stocked in Michigan beginning in the 1980s to create a "trophy-panfish" fishery. Most successful lakes stocked with redear sunfish were in the southeastern portion of Michigan. However, few attempts had ever been made to stock redear sunfish in northern Michigan. Prior to Cedar lake only two attempts had been made north of Clare County, MI, an unnamed lake in Montmorency County and Devoe Lake in Ogemaw County.[5] There are no records available post-stocking from the unknown lake. Extensive net surveys were conducted on Devoe Lake and resulted in not catching any redear sunfish. However, this was an unfair test since the lake was only stocked once. [6]

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[3] Noatch, M. R. and Whitledge, G. W. (2011). "An Evaluation of Hydrated Lime and Predator Sunfish as a Combined Chemical-Biological Approach for Controlling Snails in Aquaculture Ponds." *North American Journal of Aquaculture*. 73: 53-59.

[4] French, J. R. P., III & Morgan, M. N. (1995). "Preference of Redear Sunfish on Zebra Mussels and Rams-Horn Snails." *Journal of Freshwater Ecology* 10:1, 49-55.

[5] Retrieved from the DNR Fish Stocking Data Base, available online at: https://www2.dnr.state.mi.us/fishstock/

[6] Towns, G. (2003). Redear Sunfish Management in Michigan. Michigan Department of Natural Resources. Technical report, Number 2003-3.

Cedar lake attempted to stock redear sunfish from 2010-2016 with poor results. However, this was also an unfair test; DNR stocking records show that redear sunfish stocking densities were well below the state recommend stocking densities for redear sunfish. Redear sunfish were stocked in Cedar lake at an average of only four fish per acre. The MDNR recommends stocking two-inch fall fingerling redear sunfish at a rate of 50-200 per acre.[7] More commonly, redear sunfish are stocked at a rate of 100 fish acre for three years in succession. Subsequent stocking may not be necessary, but if survival to adult size has been low, alternate-year stocking may be used to maintain the fishery.[8] It is possible that Cedar lake habitat conditions such as cooler temperatures, shallow lake bathymetry, and low productivity are not suitable to support a redear sunfish population.[9] However, small-sized redear sunfish stocked at extremely low rates may account for the lack of success.[10] Although, an extensive literature review reveals that redear sunfish may survive in more northern Michigan lakes if stocked appropriately.

Twomey et al. (1984)[11] reported temperature and latitude tolerances which were derived from data obtained during the 1950s and 1960s. The studies indicated that growing seasons with more than 180 frost-free days are optimal for redear. However, surveys have shown that several redear sunfish populations in Michigan have thrived for the past 40 years in areas having an average of only 150 to 160 days of frost-free growing season.[12] According to the Farmers Almanac Greenbush, MI has an average growing season of 151 days.[13]

Michigan DNR states redear sunfish do best in typical Michigan warmwater lakes that are high in marl, low in turbidity, and are not heavily influenced by rivers or riverine species.[14] Trautman (1981)[15] reported that wherever the redear sunfish has been introduced into water north of its original range, it has essentially adapted to non-flowing waters that were relatively clear and that contained some aquatic vegetation.[16] Additionally, Lakes that have good pumpkinseed populations have proven to be good candidates for redear sunfish introductions. Up until recently, Cedar lake has proven to have a healthy pumpkinseed population.[17] However, a redear sunfish introduction is likely to reduce pumpkinseed populations because these species compete for similar food items, although, it is unlikely that pumpkinseeds would become extirpated.[18]

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[7] Towns, G. (2003). "Redear Sunfish Management in Michigan. Michigan Department of Natural Resources." *Technical report, Number 2003-3*.
[8] Dexter, J. L., Jr. & O'Neal, R. P. (2004). "Michigan fish stocking guidelines II: with periodic updates." *Michigan Department of Natural Resources,* Fisheries Species report 32, Ann Arbor.
[9] Sendek, S. P. (2018). "Cedar Lake Redear Sunfish Stocking Evaluation September 25-28, 2018." *Northpoint Fisheries Management, LLC.* Grayling, Michigan.
[10] Sendek, S. P. (2018).
[11] Twomey, K. A., G. Gebhart, O. E. Maughan, and P. C. Nelson. (1984). "Habitat suitability index models and instream flow suitability curves: redear sunfish." *U.S. Fish and Wildlife Service*, FWS/OBS-82/10.79.
[12] Towns, G. (2003).
[13] Available online at: https://www.almanac.com/gardening/frostdates#
[14] Dexter, J. L., Jr., and R. P. O'Neal, editors. (2004).
[15] Trautman, M. B. (1981). "The fishes of Ohio." *The Ohio State University Press*, Columbus, Ohio.
[16] Towns, G. (2003).
[17] Cwalinkski, T. A. (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.
[18] Dexter, J. L., Jr., and R. P. O'Neal, editors. (2004).

It is unknown at this time if redear sunfish can survive in Cedar lake and few attempts have been made to stock lakes north of Clare County, MI. Based on the information that has been provided, no true assessment has ever been done to determine if redear sunfish would or would not survive in northern Michigan lakes. This information suggests that there is a reason to believe that if stocked correctly, redear sunfish could survive in Cedar Lake.

Stocking Cedar lake with redear sunfish at the correct stocking rates for three years would undoubtedly be a costly experiment. Because of this, we propose that an overwinter experiment be done to determine the success of redear sunfish in Cedar lake. Redear sunfish would be monitored overwinter within a mesocosm. For this, a location (or multiple locations) in cedar lake will be chosen by the fall of 2021, here an experimental enclosure will be placed. This enclosure is meant to overwinter a small population of redear sunfish. The enclosure will be stocked prior to the fall of 2021 with two-inch fingerling redear sunfish and monitored into the spring of 2022. If in spring, it is found that redear sunfish have survived the winter successfully, then presumably, a redear sunfish population stocked at the whole-lake level could survive within Cedar lake. If deemed successful, redear may be stocked to act as a potential biocontrol to regulate the snail population within Cedar lake with the hopes of ultimately reducing swimmer's itch outbreaks.

Before stocking redear sunfish at the whole-lake level a snail assessment will be conducted during the summer of 2022. This will be one to determine the relative abundance of ramshorn snails (*Helisoma sp.*) within Cedar lake. Having a baseline snail population abundance will allow further monitoring to be completed to determine how successful redear sunfish are at controlling the snail populations. Additionally, we may be able to monitor this with data from the Cedar lake swimmer's itch reporting web application, if created.

In fall of 2022 redear sunfish will be stocked at a rate of between 50-200 fish per acre (50,000-200,000 total redear sunfish). Ideally, the first year of stocking would be done at higher rates. A small monitoring survey could be conducted in the spring of 2023 to ensure redear sunfish survived the winter before continuing to stock. Three years of stocking will be completed within the stocking range of 50-200 fish per acre (Stocking years: 2022, 2023, 2024). During either the spring or fall of 2025, a fisheries monitoring assessment will be completed using various size gear types. Based on this survey we can establish population abundance, lengths, and growth rates. If after three years, redear sunfish have successfully established in Cedar lake a follow up snail survey may be conducted to determine if the redear sunfish population has had in impact on abundance.

KEY ORGANIZATIONS

Cedar Lake Improvement Board
Fishery Management Consultant
Michigan DNR

Cedar Lake WMP (2025)

Attachment L: Technical Reports – Cedar Lake Sediments

KIESER&ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

TECHNICAL MEMORANDUM

To:	Rex Vaughn, Cedar Lake Improvement Board	**Date:**	August 22, 2019
From:	Josh Kieser, Field Manager Mark Kieser, Senior Scientist Susan Benston, GIS Specialist	**cc:**	Doug Pullman
RE:	**Bathymetric Mapping and Sediment Assessment Survey**		

1. Introduction

Kieser & Associates, LLC (K&A) was retained by the Cedar Lake Improvement Board (CLIB) to perform bathymetric mapping and sediment thickness assessments of Cedar Lake. Objectives included the creation of a bathymetric map of the lake bottom in fine detail, as well as an assessment of sediment thickness measurements from sediment surface to a confining sand or clay till layer below accumulated muck. These tasks align with the stated objectives of the Cedar Lake WMP for understanding and potentially addressing organic muck sediment build-up in Cedar Lake.[1] The outcomes of these efforts are summarized herein and illustrated by the maps and graphs in Attachments A-E. Additionally, recommended next steps are included toward a pathway to best assess options for addressing muck accumulation.

2. Cedar Lake Bathymetry

K&A field staff conducted bathymetric mapping efforts from May 20-22, 2019. This involved piloting a vessel equipped with GPS and sonar technologies throughout the entirety of Cedar Lake while maintaining approximately 100ft wide passes to ensure thorough coverage of the lake bottom. GPS and sonar data were digitally recorded at less-than-one-second intervals throughout the data collection process. K&A processed these data to create a bathymetric map in fine detail. The data were also uploaded to the Biobase™ online platform to retain the sonar log and to assist with analyses of the sonar track comparisons of lake bathymetry and lake bottom composition.[2]

The detailed bathymetric map is included herein as Attachment A. Separate files, suitable for printing at a larger scale, are being provided to the CLIB under separate cover. The aforementioned Biobase-generated lake bottom composition map is included for reference as Attachment B.

3. Cedar Lake Sediment Assessment

During the bathymetric mapping process, K&A field staff collected supplemental data on sediment thickness and sediment compression using a specialized suite of manual assessment tools. Sediment assessment stations were chosen to provide a representative sampling of the

[1] http://www.cedarlakewmp.net/
[2] https://www.biobasemaps.com/

potential sediment thicknesses at various depths and locations throughout Cedar Lake. A GPS waypoint was recorded at each station. The sediment assessment method was performed twice at each station with results averaged during data analysis. Field data collection included: 1) water depth (via sonar), 2) manual water depth measurement, 3) sediment compression testing, and 4) sediment thickness measurements. Descriptions of these assessment methods are outlined in Section 3.1 of this memorandum.

Sediment compression and sediment thickness were calculated by subtracting the water depth as recorded in field data collection steps 1 and 2 from the total depths recorded in methods 3 and 4, respectively. Field data and calculations for the northern wetlands portions of Cedar Lake, the northern main body of the lake, and areas south of the causeway are found in Tables 1-3, respectively. Additional analyses of these results are discussed in Section 4 of this memorandum.

Attachment C provides a map of K&A sediment thickness data plotted at the sediment assessment stations throughout Cedar Lake. Attachment D includes graphs of the data for each assessment station, alongside images of the sonar log and the Biobase composition maps for comparison. Attachment E defines areas of the lake subsequently used to estimate volumes of muck sediments.

3.1. Description and Purpose of Sediment Assessment Methods

The methods used in this assessment are summarized as follows.

1. Water depth (Sonar): Measured using a Lowrance Elite-7ti sonar depth finder unit with an HDI 83/200kzH transducer.

2. Manual water depth: Measured by gently lowering a Secchi disk to the lake bottom and recording the depth from the water surface. The purpose of this assessment is to confirm the sonar depth reading at the specific location used to assess the amount of loose, flocculent sediment on the lake bottom under the following methods.

Figure 1. K&A sediment compression tool.

3. Sediment compression: Measured by lowering a 5lb conical steel weight (Figure 1) to 1ft above the lake bottom, then allowing the tool to free-fall, thereby compressing the organic sediment, and recording the depth of from the water surface to compute penetration in relation to the sediment surface. The purpose of this assessment is to understand how the top layer of organic muck sediment responds to the force of compression, a valuable metric for assessing the feasibility of certain management options. This is also done to gather data that might corroborate "sediment hardness" maps produced through BioBase™ data processing of water depths. Anecdotally, this method provides some insight as to the question: "If someone stepped onto the lake bottom here, how far down might they sink into the muck?"

4. Sediment thickness: Measured by penetrating the lake bottom with a thin, metered aluminum rod of 12ft length until it reached the "hard pan" below the organic sediment layer and recording the depth from the water surface. The purpose of this assessment is to understand the total thickness of organic sediment accumulation above a more impenetrable sand or clay till layer reflective of a glacial hard pan. This method is important for any future calculations of sediment volumes in Cedar Lake and for determining the feasibility and potential need for future sediment management strategies.

4.0. Results & Analysis

This section provides the results and analyses of the May 2019 Cedar Lake sediment assessments. Tables 1-3 contain relevant field data and results of the sediment assessments for northern wetlands, northern and southern portions of the lake, respectively. (Refer to Attachment C for sediment station locations.) Where sediment thickness is reported as greater than (">") a depth in feet, this indicates that these areas exceeded the capacity of the measurement rod length. Results reported as "NC" indicate no sediment thickness data were computed due to a water depth at or near 12 feet. Weather conditions during each portion of the survey are included with each table.

Table 1. Sediment Assessment Data Table, Cedar Lake – Northern Wetlands Area.

Date: *5/21/2019* ***Assessor:*** *J. Kieser* ***Weather:*** *Winds NE 5-10mph then E/ESE 3-7mph, Temps 50-56F.*
Date: *5/22/2019* ***Assessor:*** *J. Kieser* ***Weather:*** *Winds ESE 6-13mph, Temps 42-51, Light rain*

GPS Waypoint	Water Depth	Sediment Compression	Sediment Thickness
	ft	*ft*	*ft*
196	2.0	2.0	6.2
197	2.1	0.9	7.9
198	1.8	0.6	2.8
199	1.2	1.9	3.3
200	1.8	1.9	4.2

Table 2. Sediment Assessment Data Table, Cedar Lake – Northern Portion of Lake (NC means not calculated).

Date: *5/21/2019* ***Assessor:*** *J. Kieser* ***Weather:*** *Winds NE 5-10mph then E/ESE 3-7mph, Temps 50-56F*
Date: *5/22/2019* ***Assessor:*** *J. Kieser* ***Weather:*** *Winds ESE 6-13mph, Temps 42-51, Light rain*

GPS Waypoint	Water Depth	Sediment Compression	Sediment Thickness
	ft	*ft*	*ft*
196	2.0	2.0	6.2
197	2.1	0.9	7.9
198	1.8	0.6	2.8
199	1.2	1.9	3.3
200	1.8	1.9	4.2
202	2.0	2.0	4.7
207	4.2	1.7	2.1
209	4.8	2.5	3.2
211	4.5	1.8	5.5

212	3.8	1.6	3.7
213	3.9	2.1	>8.1
214	4.0	2.0	5.8
215	9.3	3.2	NC
216	4.7	2.6	7.1
217	7.8	1.4	3.9
218	5.0	3.0	4.4
219	4.6	2.7	6.2
221	4.5	1.9	>7.5

Table 3. Sediment Assessment Data Table, Cedar Lake – Southern Portion of Lake (NC means not calculated).

Date: *5/20/2019* ***Assessor:*** *J. Kieser* ***Weather:*** *Winds NNW 10-12mph, Temps 48-51F*
Date: *5/21/2019* ***Assessor:*** *J. Kieser* ***Weather:*** *Winds NE 5-10mph then E/ESE 3-7mph, Temps 50-56F*

GPS Waypoint	Water Depth	Sediment Compression	Sediment Thickness
	ft	*ft*	*ft*
179	5.0	1.0	2.3
180	4.5	0.5	3.2
181	3.6	1.9	3.2
182	11.5	1.5	NC
184	5.1	4.7	6.1
187	4.0	2.8	>8.0
188	2.3	1.6	9.0
189	3.0	2.5	8.2
190	3.3	3.5	>8.7
191	5.0	1.0	3.7

Further assessments of the direct sediment measurements were conducted by estimating the sediment compression layer and total sediment thickness as seen in sonar log images found in Attachment D. Figures 2 and 3 illustrate the results of these comparisons.

The comparison illustrated in Figure 2 shows a relatively strong correlation between sonar readings of the uppermost soft muck layer and compression test data. This correlation could eventually be used to map areas where the softest surficial sediments are noted. (No correlations were identified between BioBase™ "hardness" data maps that provided with interpolated bathymetric mapping data, and sediment compression testing field results.)[3]

[3] BioBase™ hardness data are often used by other lake consultants in Michigan to suggest soft, muck bottom treatment areas for laminar flow aeration. Hardness "maps" are also used as the metric for inferring how such aeration has "hardened" the surficial muck sediment layer. Of particular note is how the BioBase™ software guidance specifically denotes the need to correlate their reported "hardness" data with actual field measurements. K&A is not aware of any such correlations ever attempted or reported in LFA projects that purport to have "hardened" muck sediments. As K&A found no such correlations here, we are not reporting on hardness mapping that was provided by BioBase™ with Cedar Lake bathymetric data and mapping. Examples of such maps for Cedar Lake are, however, included in Attachment D herein.)

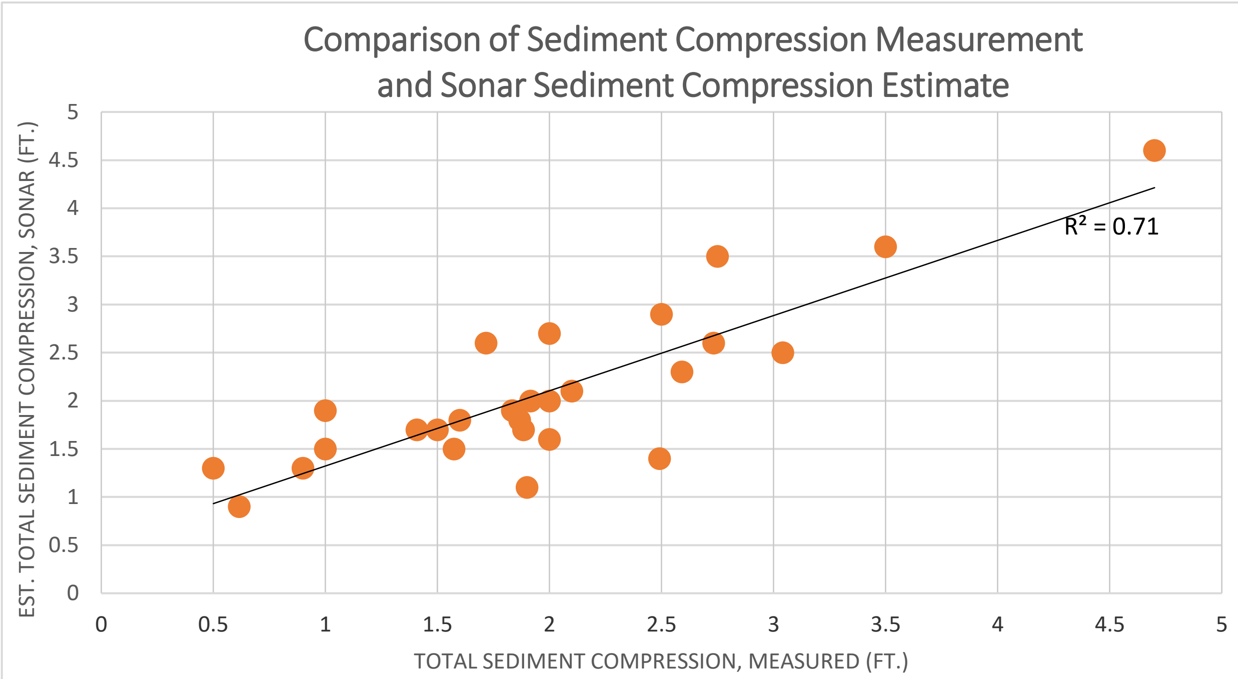


Figure 2. Sediment compression measurements compared to estimated sonar sediment compression layer.

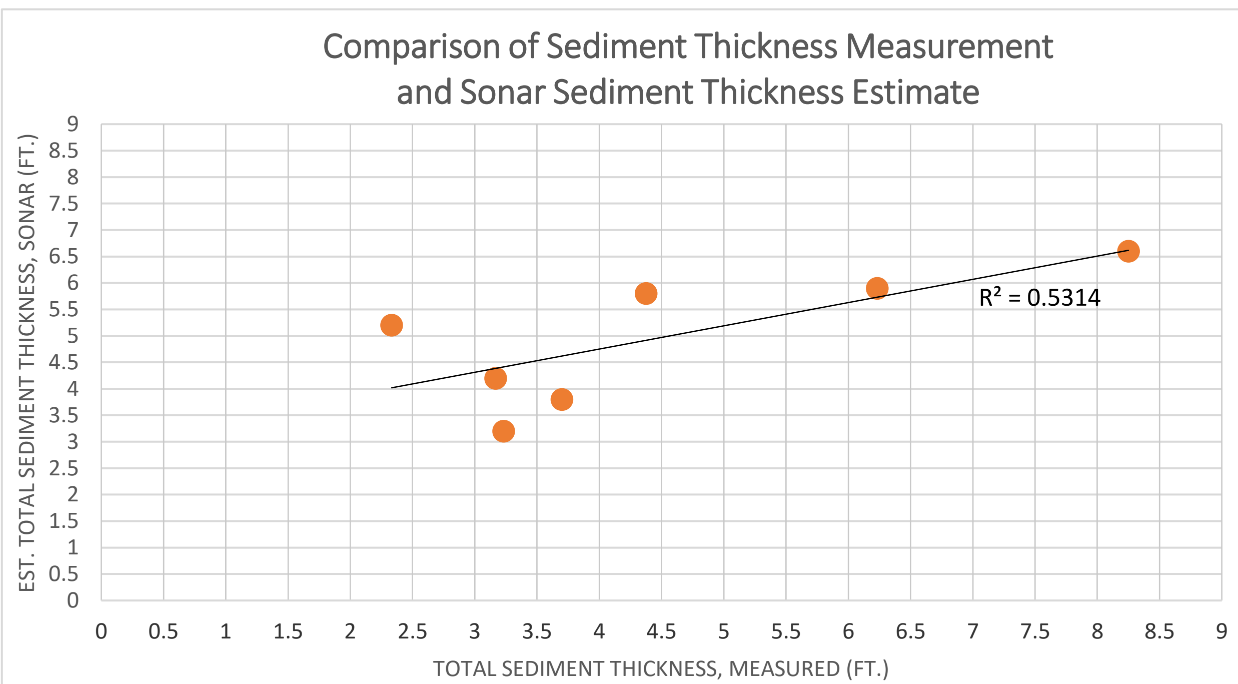


Figure 3. Sediment thickness measurements compared to estimated sonar sediment thickness layer.

With a relatively weak correlation in Figure 3, K&A would not suggest at this time, that sonar readings of sediment thickness could be derived for the entire sonar reading database. This partially relates to certain sonar images being omitted from this analysis due to limited visibility of the total sediment thickness reading from the sonar database when the unit's auto-range capability for depth precluded visual imagery. In addition, the limited length of the sediment thickness rod did not allow for physical thickness measurements of the muck stratum at select water depth locations.

Finally, sediment thickness measurements were used to preliminarily estimate the volume of organic muck sediment throughout the lake. For this analysis, the lake was divided into three portions: 1) open water in the northern-most wetland area and Cedar Lake outlet; 2) main body of Cedar Lake north of the causeway (excluding the northern wetlands area), and; 3) Cedar Lake south of the causeway. For each portion of Cedar Lake, the average sediment thickness (in yards) calculated with available measurements from Tables 1-3, was multiplied by the lake's surface area (yards^2) for areas with depths generally greater than 4 feet (which is equivalent to about a 100-foot distance from the water's edge along shorelines). Other areas excluded from muck volume calculations included deeper trenches as determined by 2019 bathymetry. Attachment E shows the areas delineated for volume calculations in each of the three areas of the lake; Table 4 presents the corresponding surface areas. The resulting calculations for initial estimates of muck sediment volume reported as million yards^3 as shown in Table 5.

Table 4. Surface areas for mapped lake sediments and corresponding waypoints included in each area.

Cedar Lake Mapped Sections	Waypoints	Surface Area (yards^2)
Northern Wetland	196, 197, 198, 199, 200	40,345
Main Body North of Causeway	202, 212, 213, 214, 215, 216, 217, 218, 221, 209, 207, 211, 219	3,261,402
South of Causeway	179, 180, 181, 182, 184, 187, 188, 189, 190, 191	468,937

Table 5. Average sediment thickness and estimated volumes of organic muck sediment volume throughout Cedar Lake.

Average Sediment Thickness – Northern Wetland	**Estimated Sediment Volume**
yards	***Million cubic yards***
1.6	0.06
Average Sediment Thickness – Main Body North of Causeway	**Estimated Sediment Volume**
yards	***Million cubic yards***
1.7	5.54
Average Sediment Thickness – South of Causeway	**Estimated Sediment Volume**
yards	***Million cubic yards***
1.9	0.89

5. Discussion

Accumulated muck sediments appear to be relatively evenly distributed across Cedar Lake given observed depths to an underlying hard pan layer. This constrains physical muck sediment removal options in any areas 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. This would dictate a fairly active removal effort to continuously cover more area versus an option to dredge at greater depths in more static locations whereby deepened areas would allow over time, muck from non-dredged areas to more evenly re-distribute over time. Such active mechanical removal constraints add costs to dredging operations.

Considering the three lake segments, it is likely that any form of physical sediment removal at scale with dredging would necessarily focus on areas away from shorelines where there was uniformity in water depth and sediment thickness. (Hence, the rationale for not including shoreline and trench areas.) It would also be less likely that sediment removal in the northern-most wetland areas would occur because of habitat disturbance and likely lower frequency of recreational uses that would benefit from increased depths (for example, recreational boating, water skiing, jet skiing). Physical sediment removal in the southern-most portions of the lake would require finesse with mechanical operations due to more variable bathymetry and shoreline non-linearity. Muck removal in the main body of the lake would be more accommodating to larger scale mechanical operations.

Notable here in these preliminary discussions is that muck sediments in previously un-dredged portions of Cedar Lake have a history of about 10,000-12,000 years of accumulation since the last glacial retreat. Though this very preliminary, initial study did not attempt to address the age or accretion rate of sediments, it would be prudent to weigh the costs of muck sediment management with the accrual rates under current aquatic vegetative growth conditions. As denoted in the Cedar Lake Watershed Management Plan, the lake does not receive any significant sediment inputs from tributaries or the shoreline. Thus, accumulated muck is largely attributable to the natural aging of lakes through seasonal growth and die-off of plants growing in the lake.

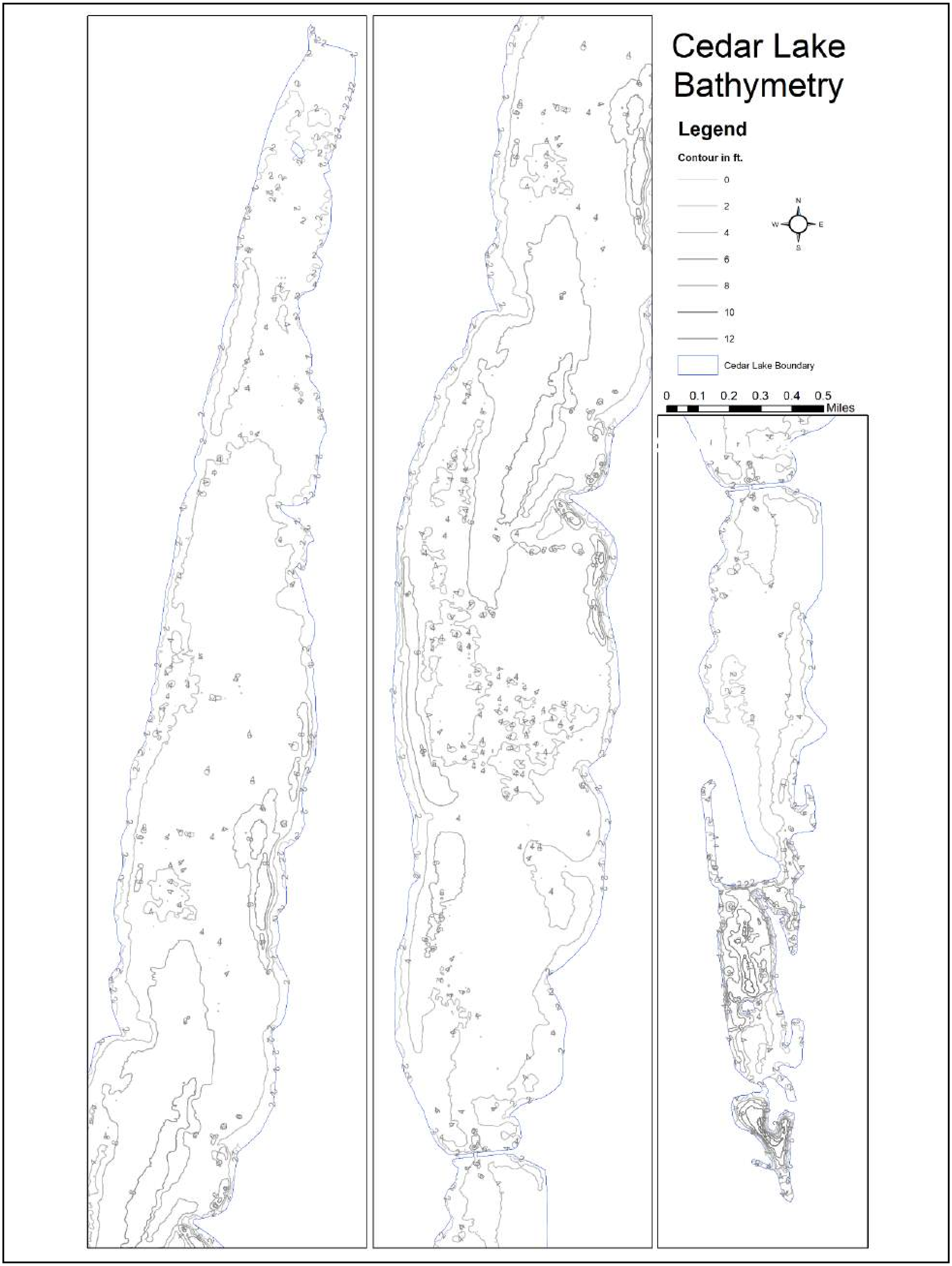
Seasonal/annual aquatic plant die-off is of course somewhat accelerated by treatment and subsequent re-growth of troublesome aquatic plants such as hybridized Eurasian Watermilfoil. Forecasting future lake water quality and aquatic plant responses to muck removal must also be considered. This could be partially achieved by more specifically examining plant growth conditions in "trench" areas at selective locations along the Cedar Lake shoreline. These previously dredged trenches seem to accumulate more extensive plant growths (D. Pullman, personal communication, 2019) than other open water, undisturbed sediment areas. As sediment removal is a major disturbance to the natural balance of any lake, a whole host of considerations must be taken into account beyond just contracting and permitting conditions necessary for physical removal and disposal of dredge spoils. Certainly costs will weigh into any decision-making process. Considering that perhaps the theoretically most efficient cost/cubic yard of material removed/disposed might be $0.50, ~6.5 million cubic yards dredge materials from the main body and southern lake presents a price tag of over $3,000,000. Commonly, the average low-cost dredging operation is closer to $1/cubic yard. Selective dredging and/or other alternatives could be examined in future discussions.

6. Recommended Next Steps

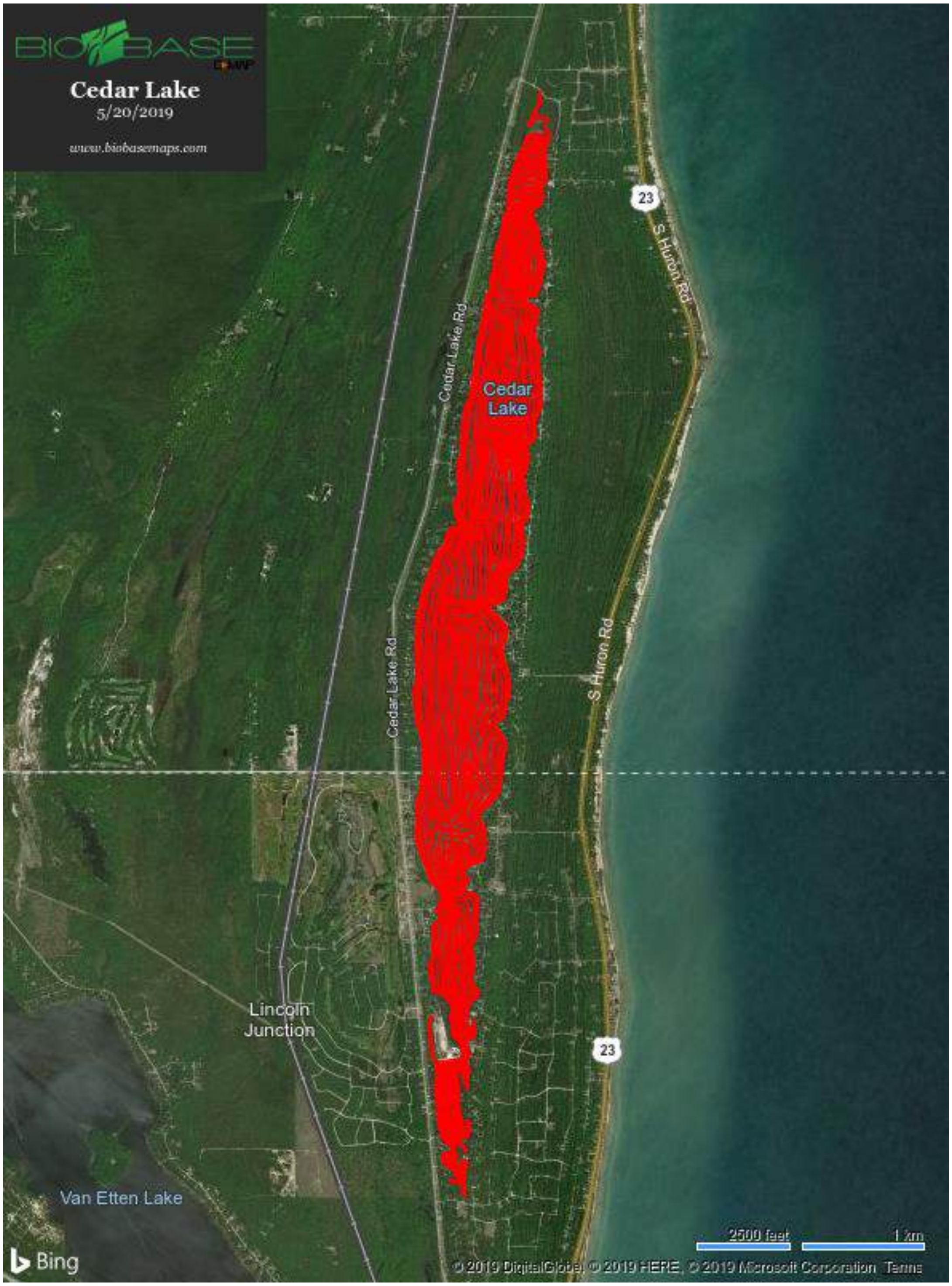
Based on the results of the bathymetric mapping and sediment assessment survey, K&A recommends the following as next steps toward further development of potential future management strategies related to muck sediment management:

- Discuss the potential scope and costs of a major sediment management effort with AICLA/CLIB, likelihood of success and pros and cons.
- If there are specific dredging interests, conduct strategic conversations with state regulatory agencies to determine their willingness to potentially permit dredging activities on Cedar Lake.
- If permittable, develop preliminary cost estimates for implementing various sediment removal strategies including soil disposal and/or alternative approaches. Such options might include:
    - Large scale dredging
    - Selective area dredging
    - Innovative re-use for dredge spoils (to reduce over disposal costs)
    - Alternative deployment of shoreline mat installations on a home-by-home basis
    - Other non-traditional options[4]
- Develop and implement a scope of work for contaminant analysis of sediment chemistry and organic matter content in strategically targeted areas to assess dredge disposal/permitting constraints.
- Determine management strategies, timeline and costs in relation to the Cedar Lake WMP and permitting needs for pursuing desired strategies.

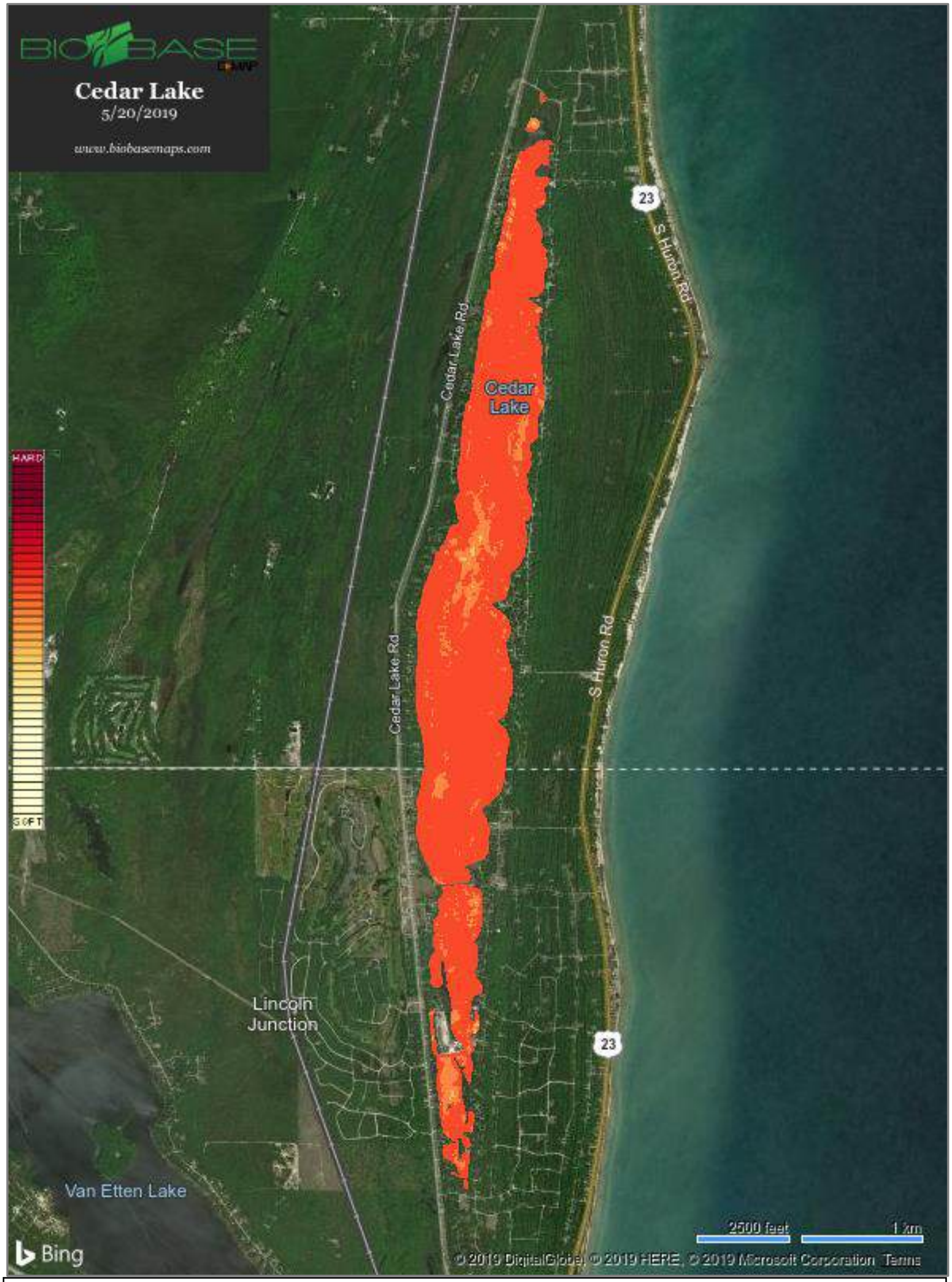
[4] Laminar Flow Aeration with Bioaugmentation (LFA) is a popularized 'sediment' treatment technique being deployed in several Michigan Lakes and other selective locations in the U.S. Consultant reporting has suggested a host of benefits could be/have been achieved over 1 to several years of application. Some of these reported results are anecdotally supported by lake users. Purported benefits have included muck reduction, sediment 'hardening', nuisance aquatic plant control, and nuisance algal bloom control. The state of Michigan in 2017 instituted new permitting and monitoring requirements around these applications out of concern for known and/or suspected ecological disruptions with some lake applications. K&A has directly studied a number of these applications stemming back to the mid-1990s and has yet to find conclusive and irrefutable examples of reproducible and directly measured benefits. This is not to cast aspersions, rather to set the backdrop for Cedar Lake such that if any LFA approach is ever considered, pilot demonstrations under controlled conditions should be a mandatory prerequisite to demonstrate benefits before any funds are committed for full-scale application. K&A has found no peer-reviewed scientific literature published to date that specifically supports the contention of the broad-scale LFA benefits touted in applications based on our exhaustive reviews conducted to date. Of the few directly applicable publications, none could find demonstrable scientific evidence to support claims.



Attachment A

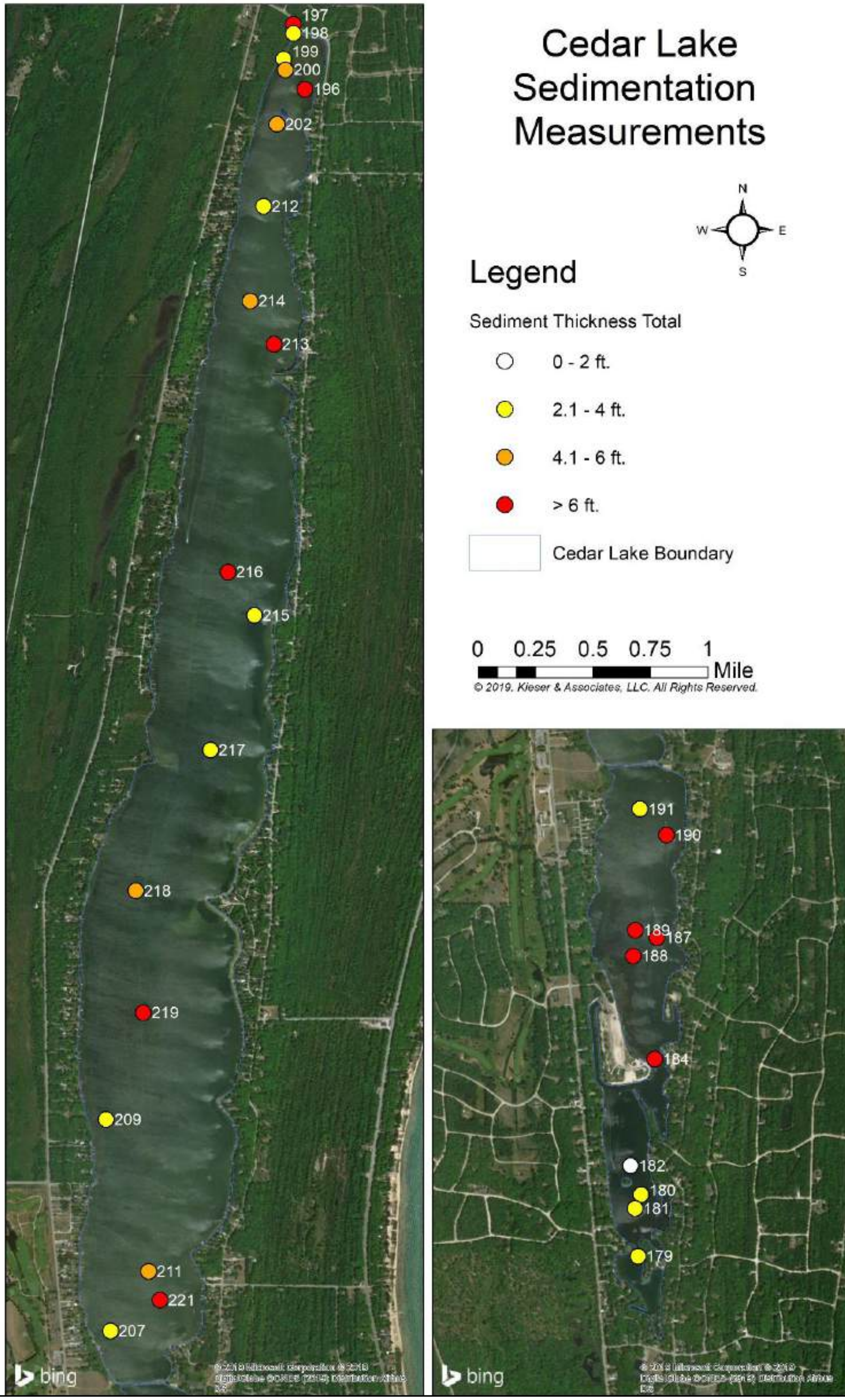


GPS track of K&A bathymetric mapping and sediment assessment survey efforts on Cedar Lake, 5/20/19 – 5/22/19.



Biobase lake bottom composition (hardness) layer for Cedar Lake, 5/20/19 – 5/22/19.
This map is meant to be used for comparative purposes only.

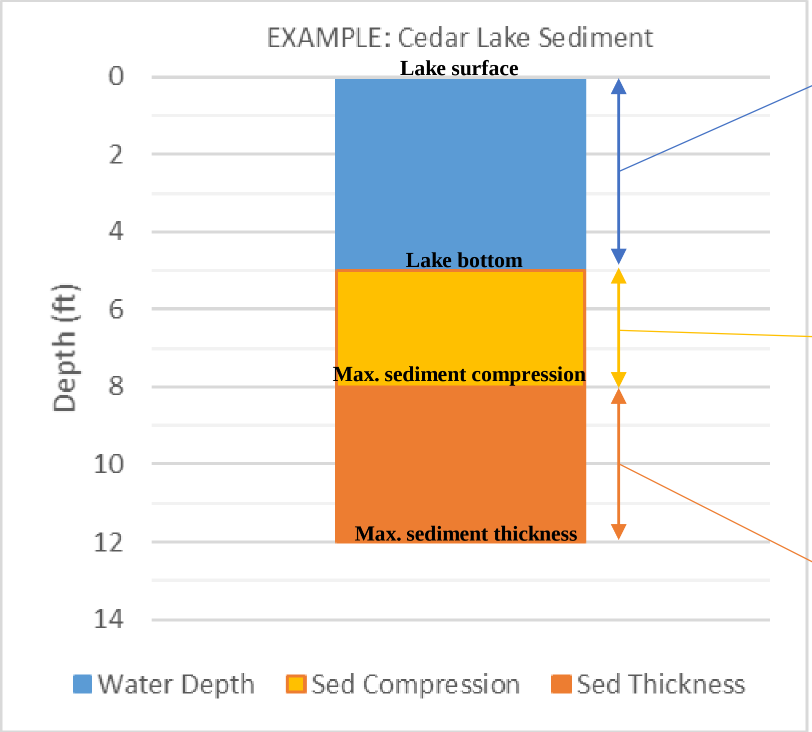
The Biobase composition algorithms estimate the acoustic reflectivity of the lake bottom by processing the sonar signal. Signals "bounce" more on hard lake bottoms and are "absorbed" more on soft lake bottoms. Note that composition is not available at depths <1.5ft. More information about the Biobase composition layer can be found at: <https://blog.biobasemaps.com/2019/04/11/composition-algorithm-improved/>



K&A sediment thickness assessment results for each assessment station waypoint for Cedar Lake, 5/20/19 – 5/22/19.

Description of Cedar Lake Sediment Assessment Graphs

GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
Assessment Location	*Lake surface to lake bottom*	*Lake surface to max. sediment compression*	*Lake surface to max. sediment thickness (hard-pan)*
EXAMPLE	5	8	12



Manual water depth: Distance from the lake surface to the top of the organic sediment (lake bottom).

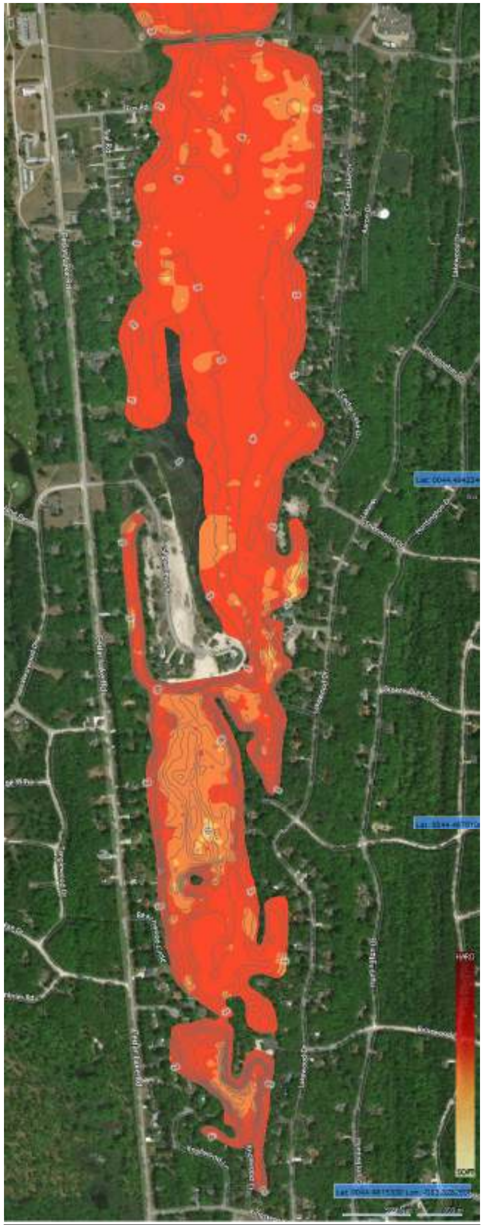
Sediment compression: Measured by lowering a 5lb conical steel weight to 1ft above the lake bottom, then allowing the tool to free-fall, thereby compressing the organic sediment, and recording the depth from the water surface.

The purpose of this assessment is to understand how the top layer of organic muck sediment responds to the force of compression. This method is meant to help answer the question: If someone stepped onto the lake bottom here, how far down might they sink into the muck?

Sediment thickness: Measured by penetrating the lake bottom with a thin, metered aluminum rod of 12ft length until it reached the "hard pan" below the organic sediment layer and recording the depth from the water surface.

The purpose of this assessment is to understand the total depth of organic sediment accumulation above the impenetrable sand or clay till layer. This method is important for any future calculations of sediment volumes in Cedar Lake and for determining the feasibility and potential need for future management strategies.

Cedar Lake South sediment assessment station waypoints



Cedar Lake South Biobase composition layer, for comparative use.

Attachment D	Cedar Lake Sediment Assessment: May 2019	KIESER & ASSOCIATES ENVIRONMENTAL SCIENCE & ENGINEERING

GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
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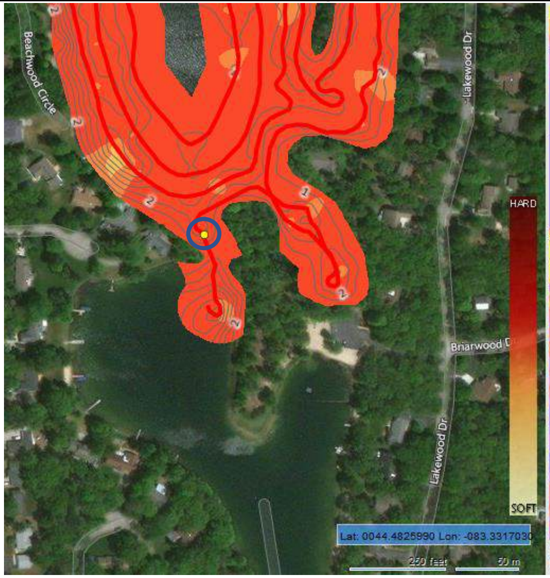
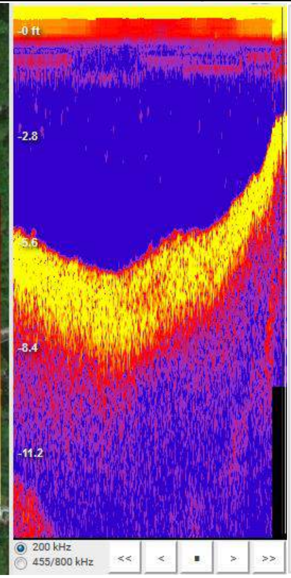
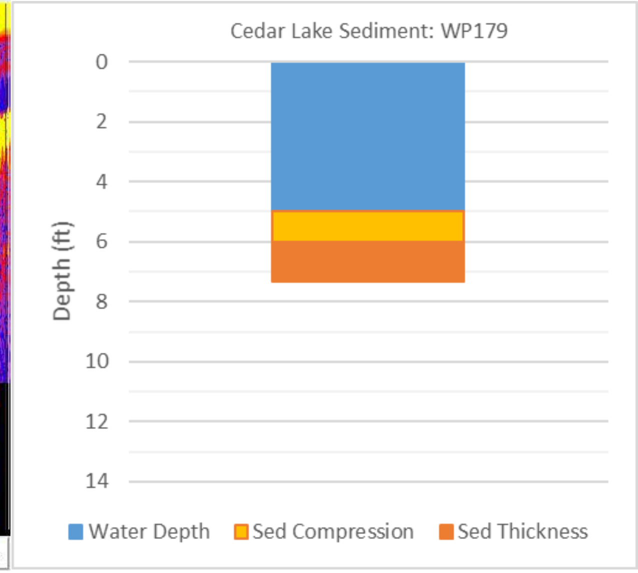
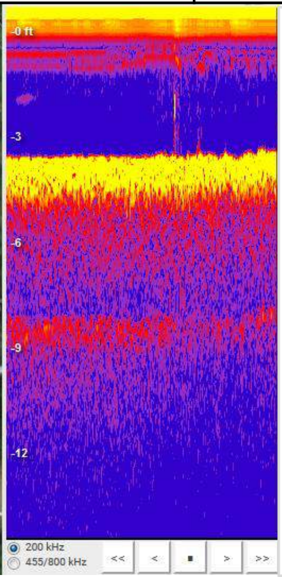
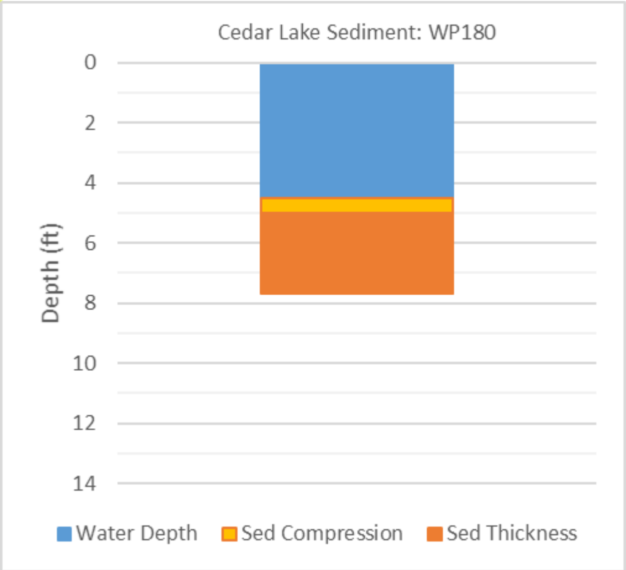






GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
180	4.5	5	7.67





GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
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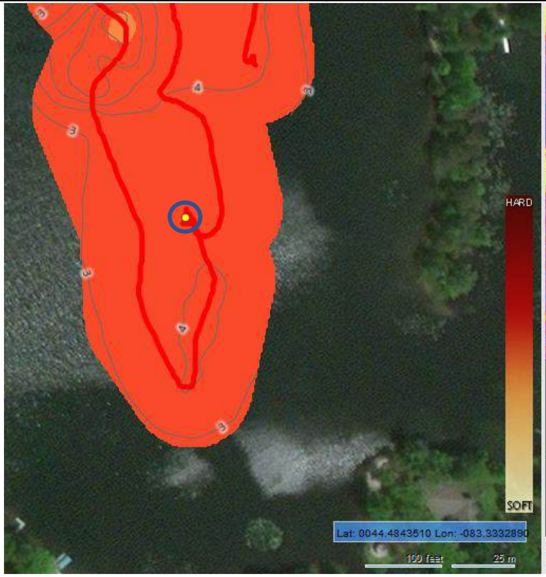
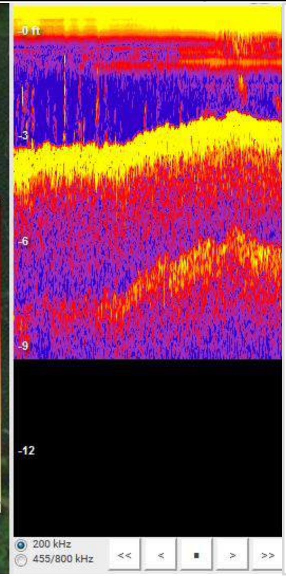
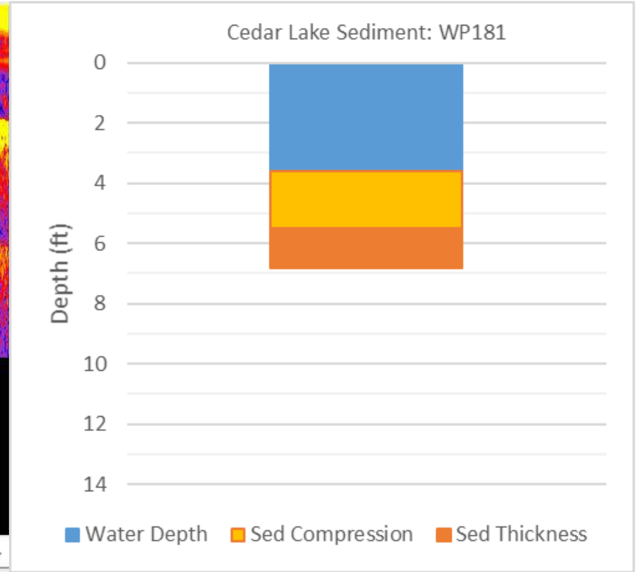
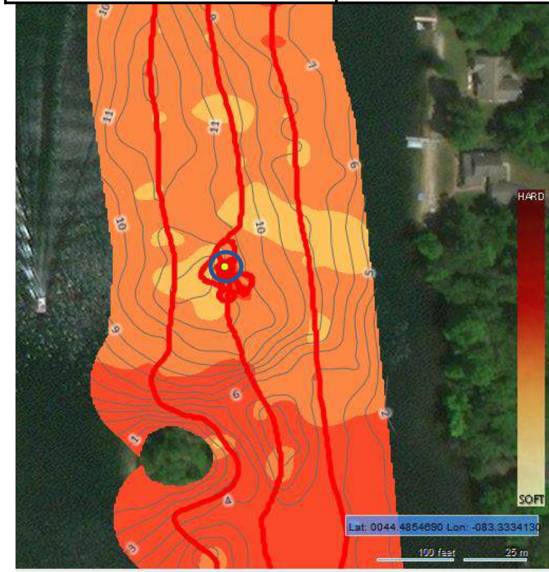
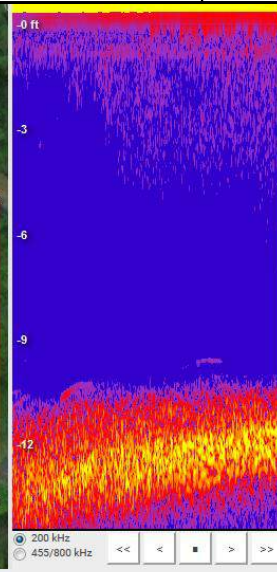


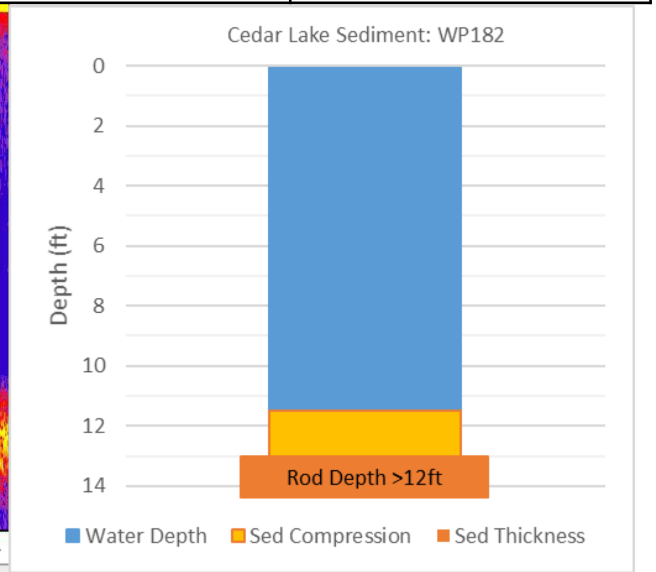




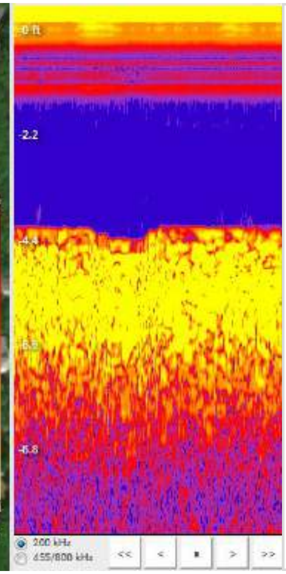
GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
182	11.5	13	>14

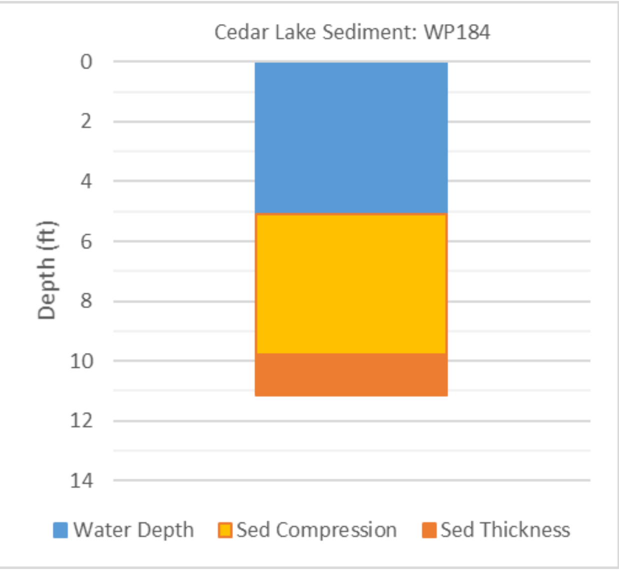






GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
184	5.1	9.8	11.16





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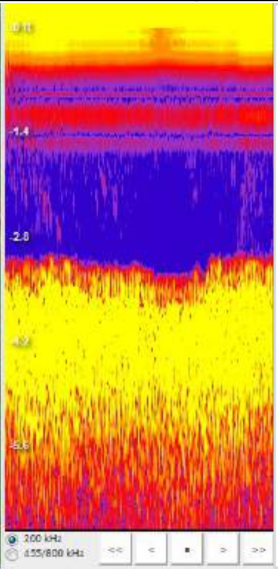
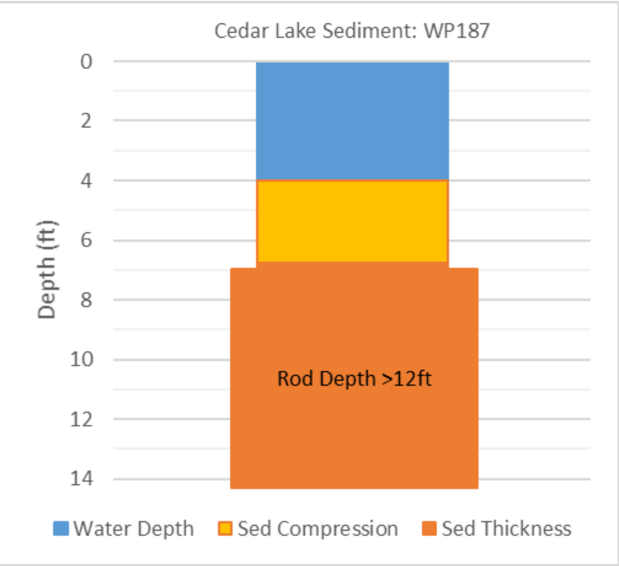
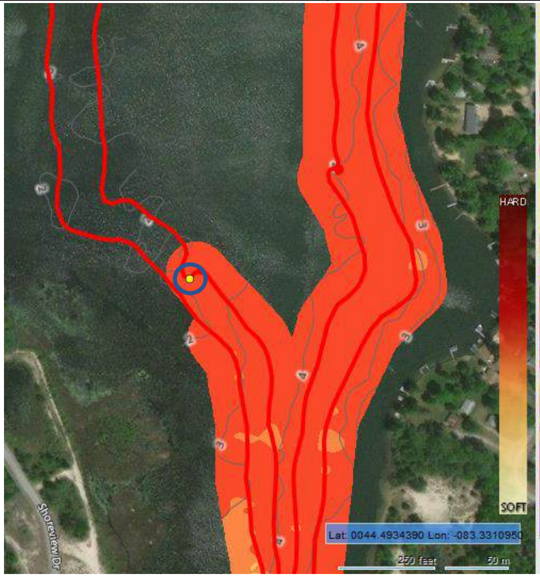
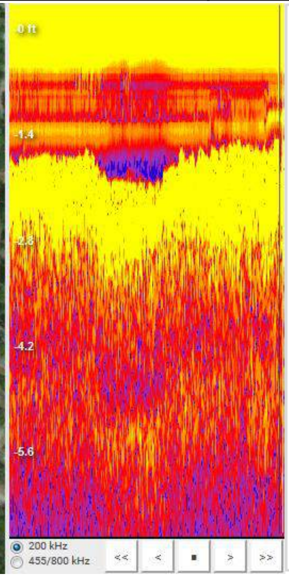
187	4	6.75	>14

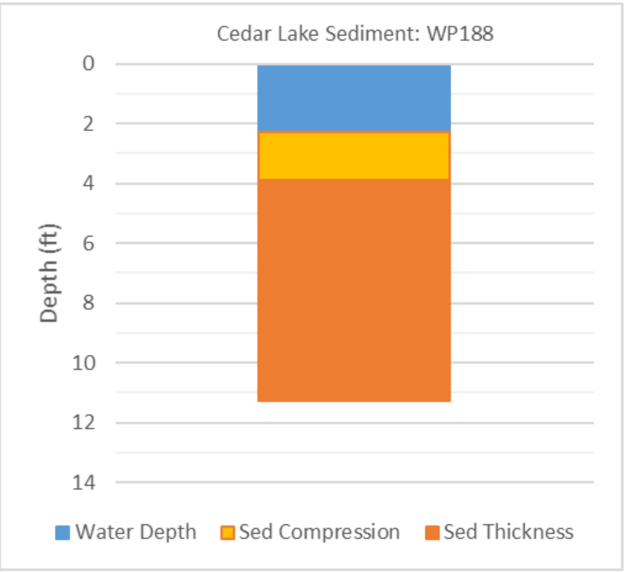




GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
188	2.3	3.9	11.29







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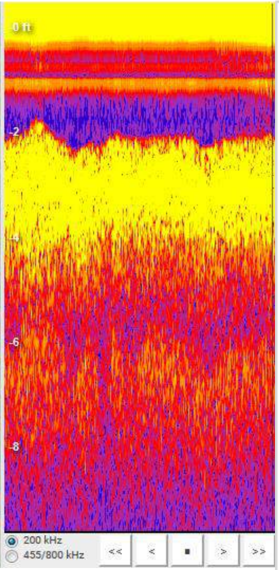
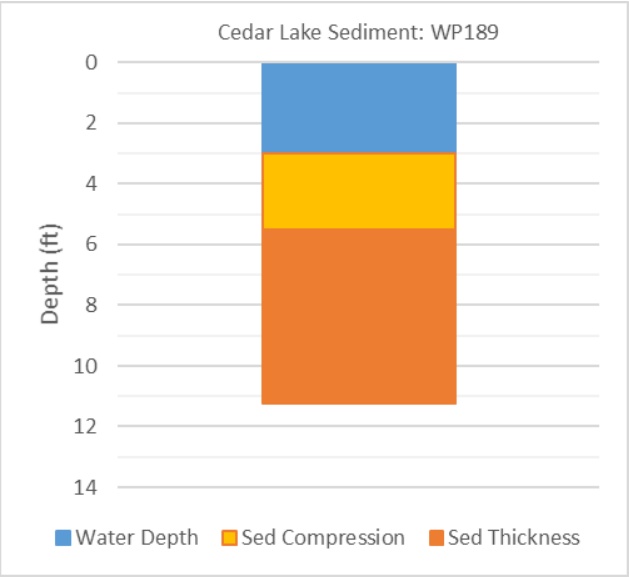
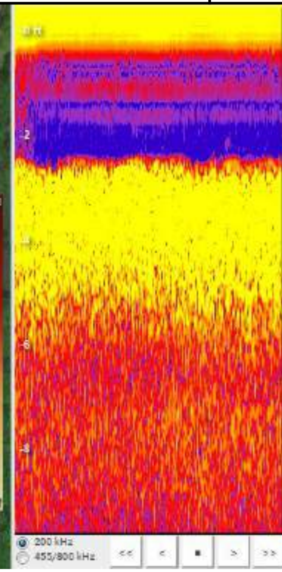
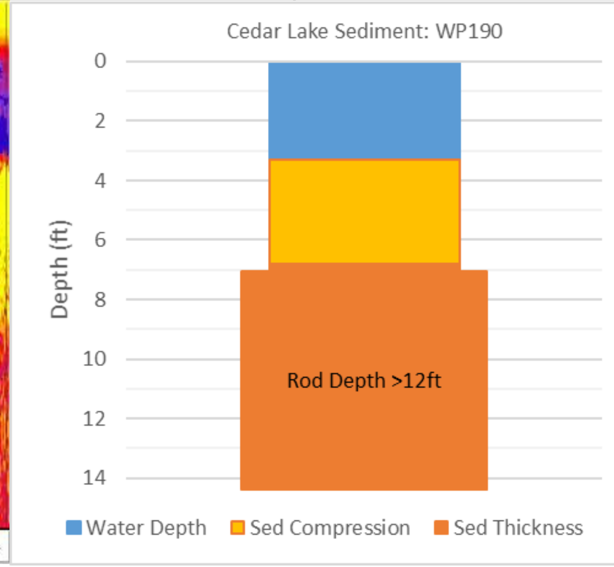
189	3	5.5	11.25



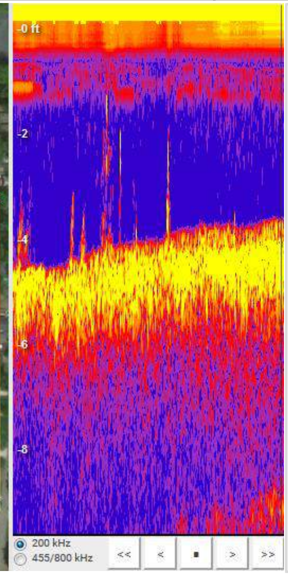


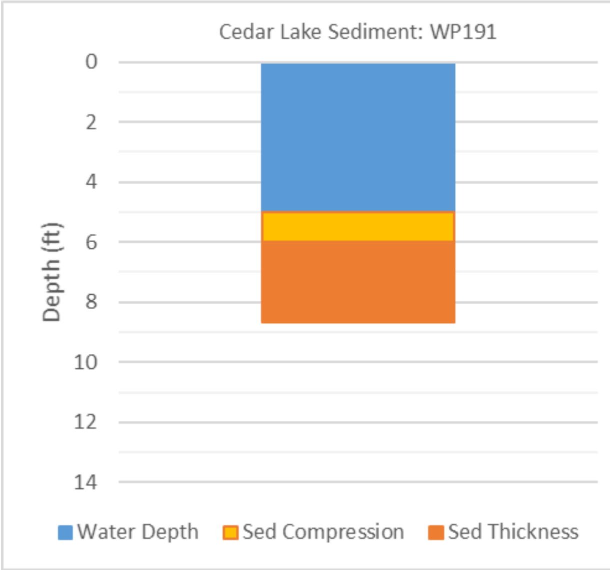
GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
190	3.3	6.8	>14



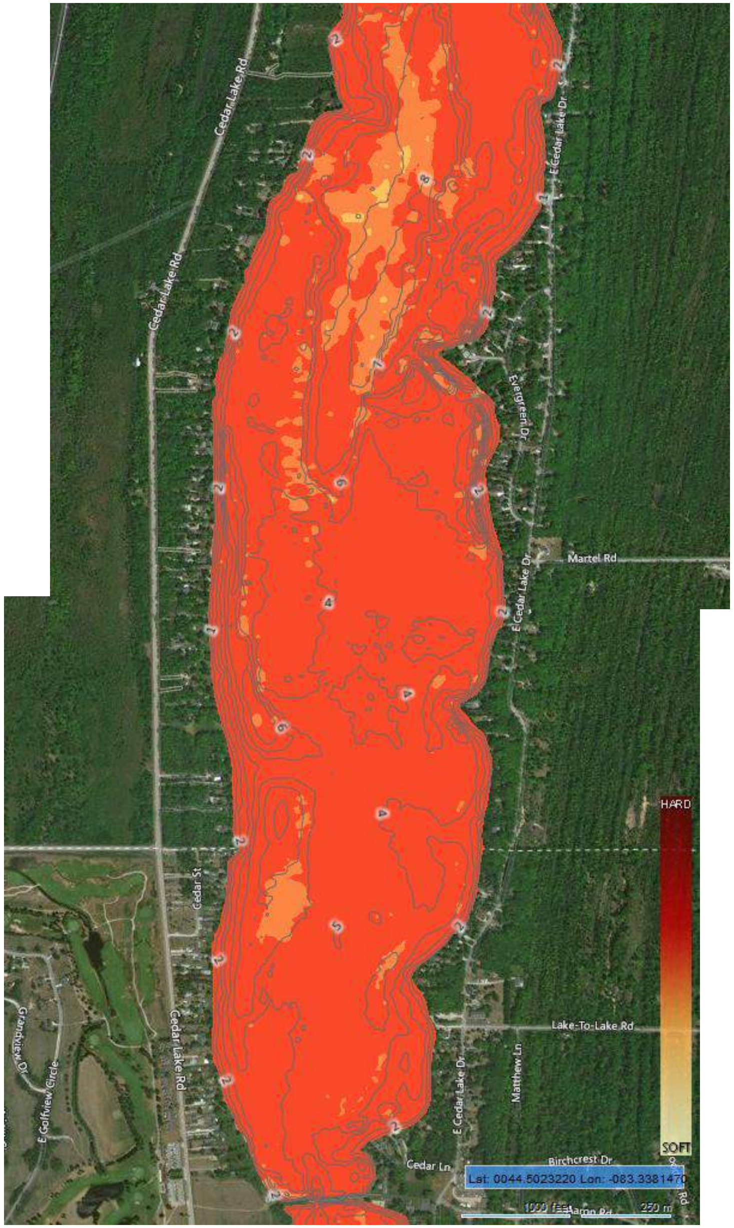


GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
191	5	6	8.67





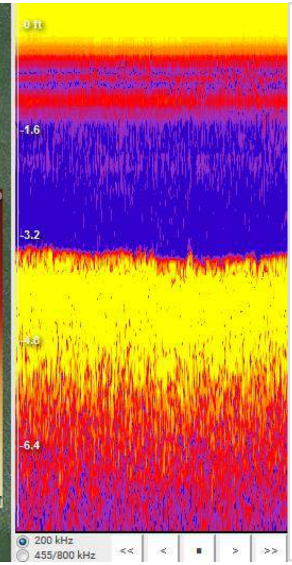
Cedar Lake North (part 1) sediment assessment station waypoints

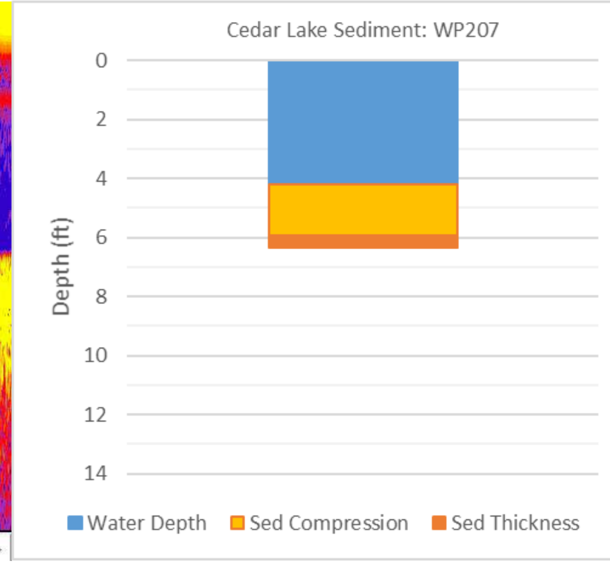


Cedar Lake North (part 1) Biobase composition layer, for comparative use.

Attachment D | **Cedar Lake Sediment Assessment: May 2019** | KIESER & ASSOCIATES ENVIRONMENTAL SCIENCE & ENGINEERING

GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
207	4.2	5.92	6.33





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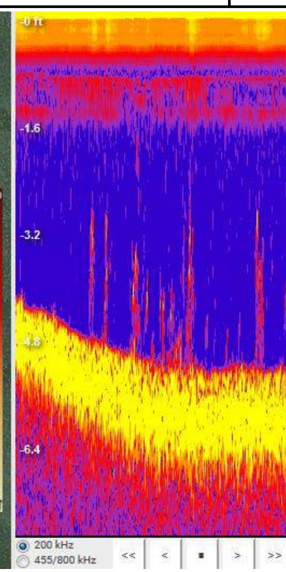

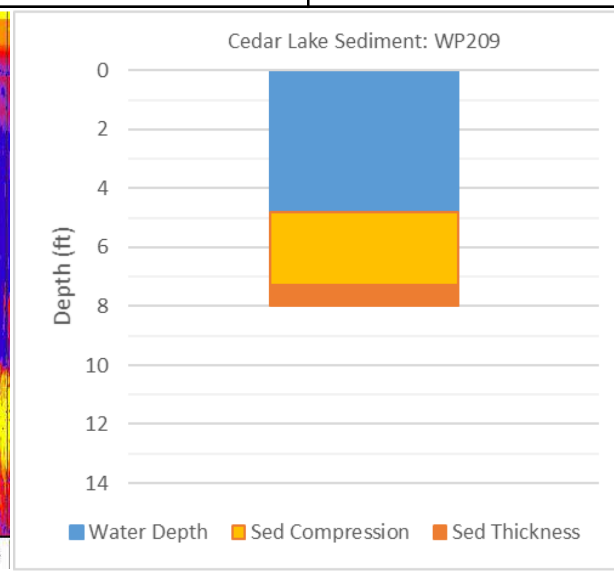

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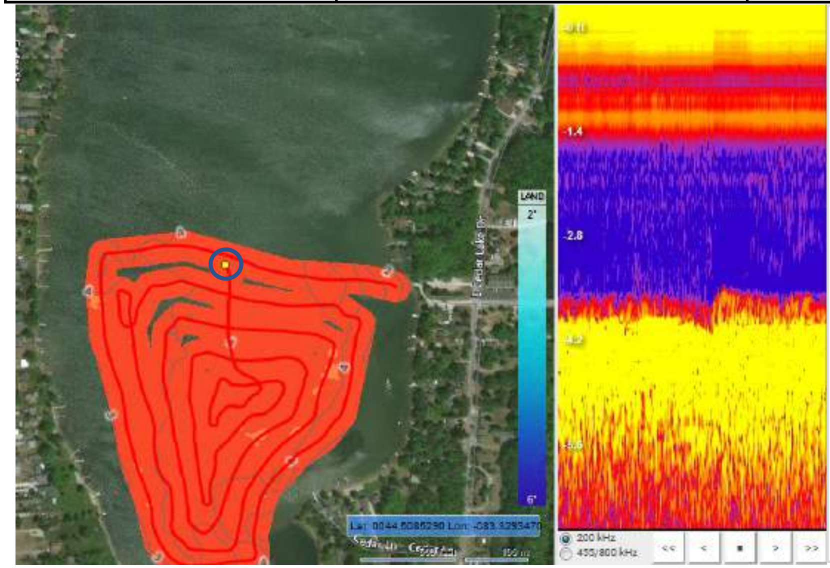

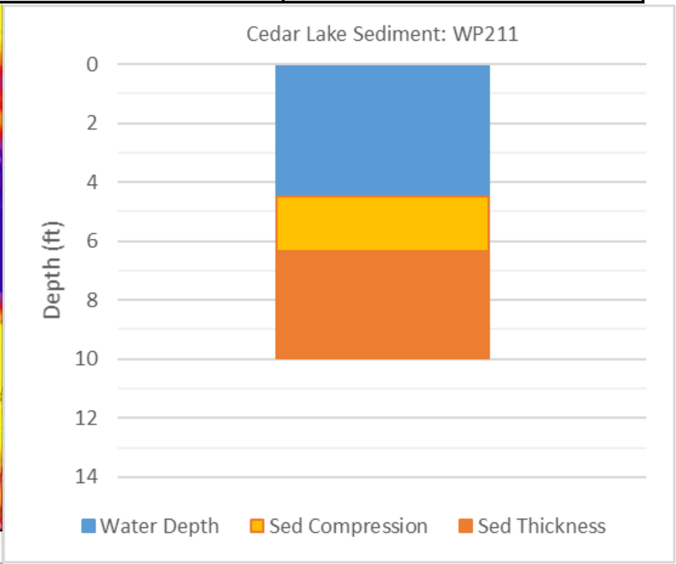

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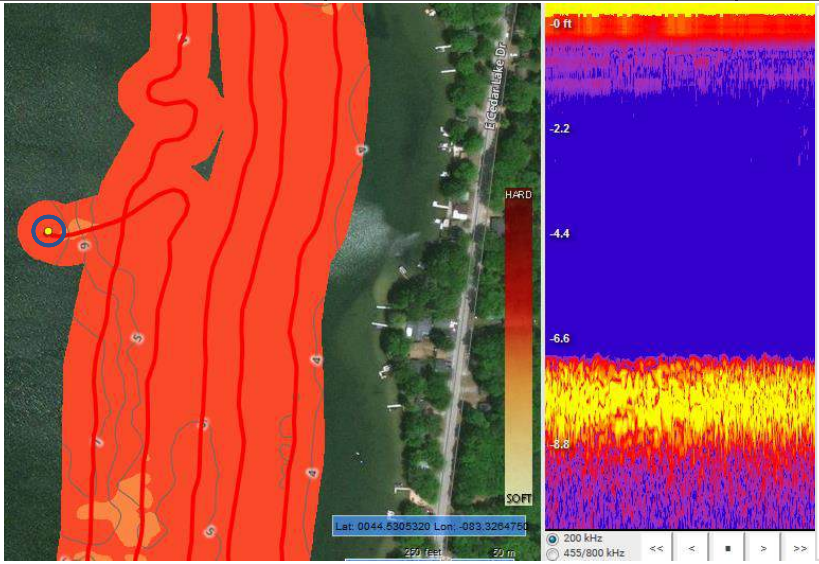

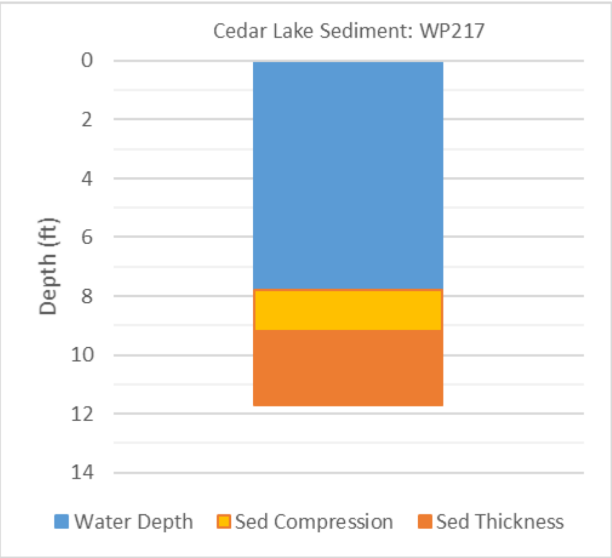

GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
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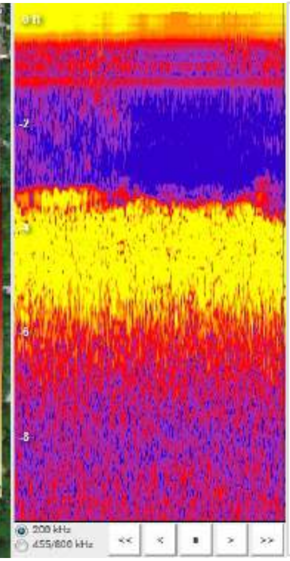

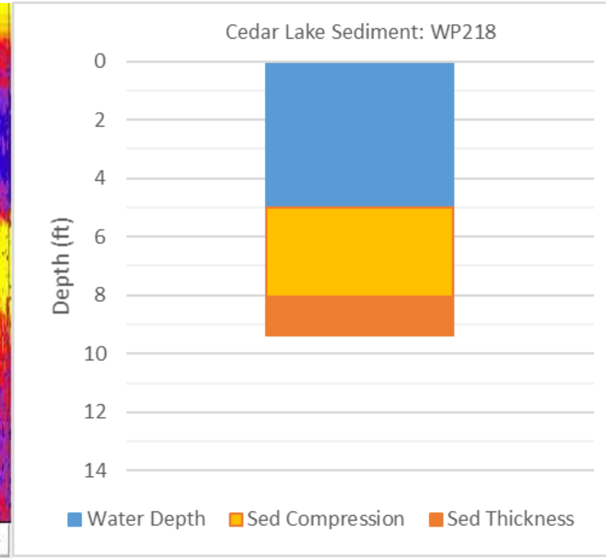

GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
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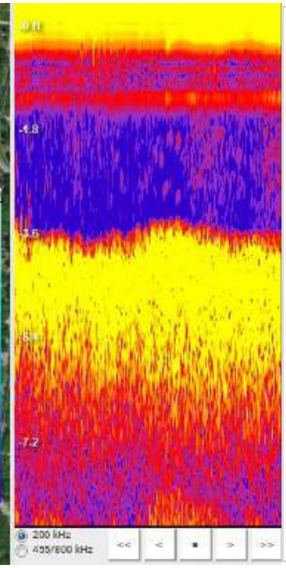

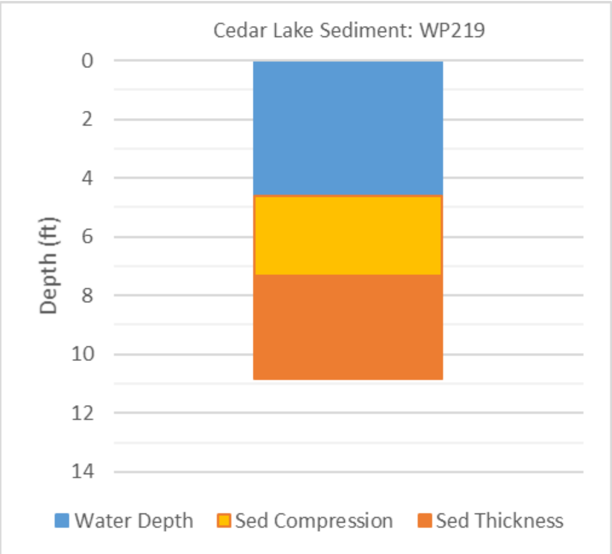

GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
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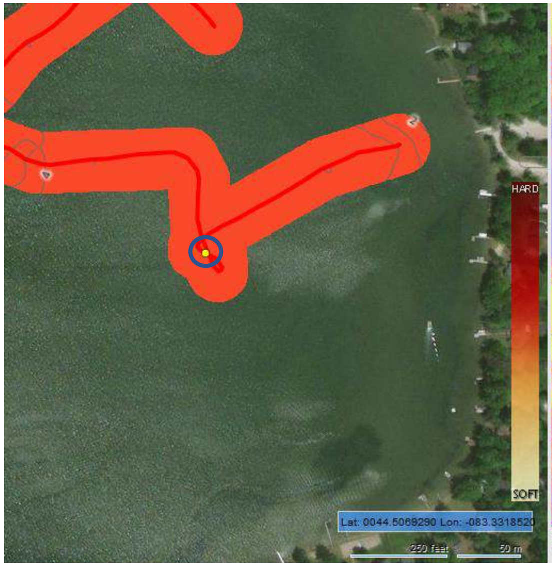
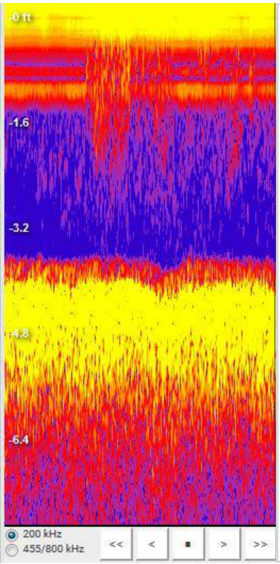
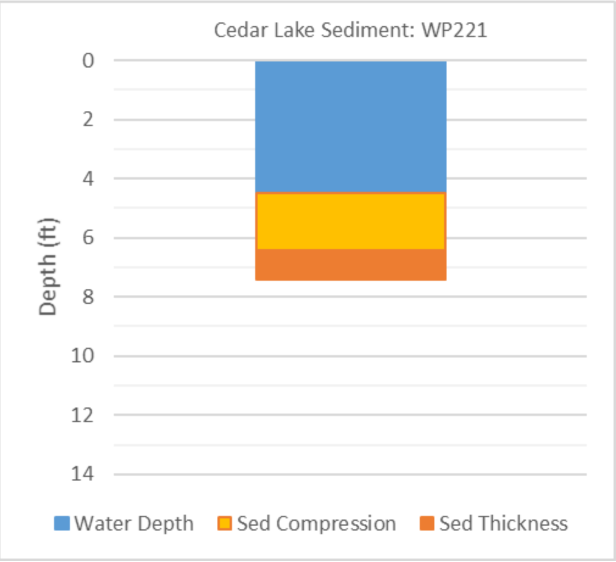
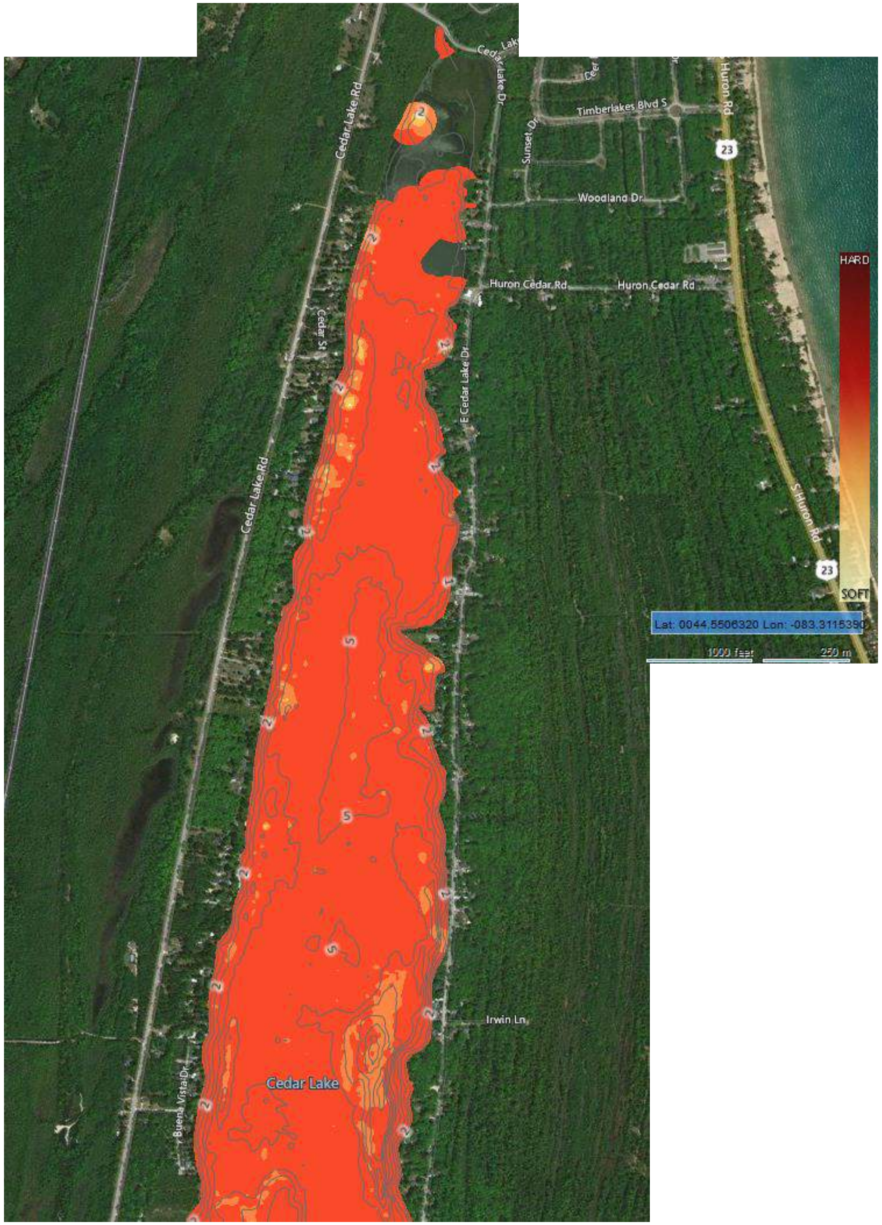






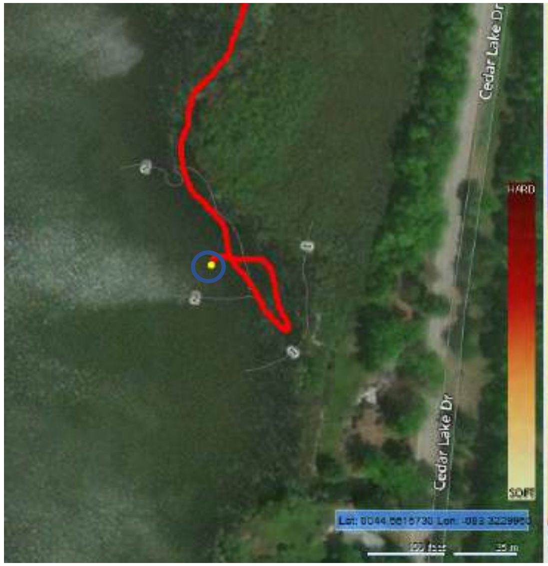
Cedar Lake North (part 2) sediment assessment station waypoints

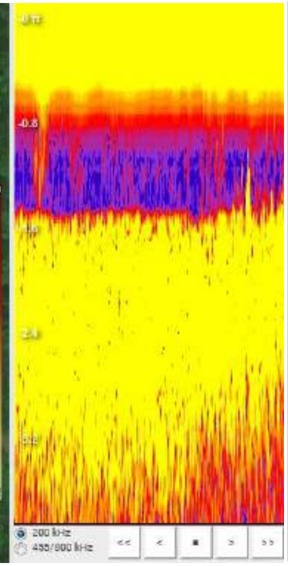


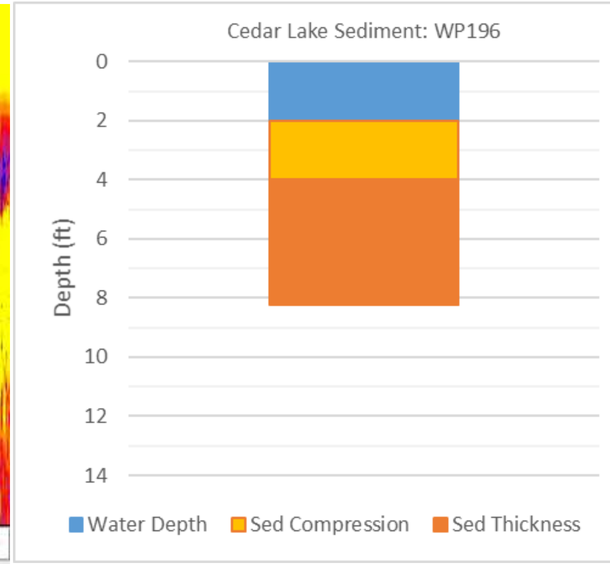
Cedar Lake North (part 2) Biobase composition layer, for comparative use.

Attachment D	Cedar Lake Sediment Assessment: May 2019	KIESER & ASSOCIATES ENVIRONMENTAL SCIENCE & ENGINEERING

GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
196	2	4	8.25







GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
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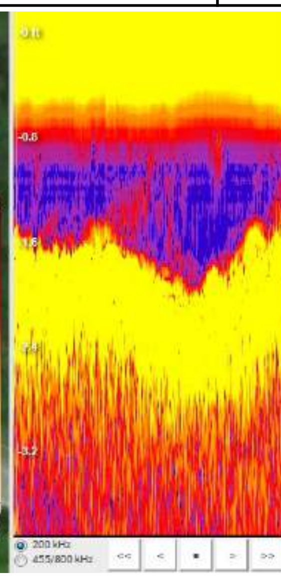

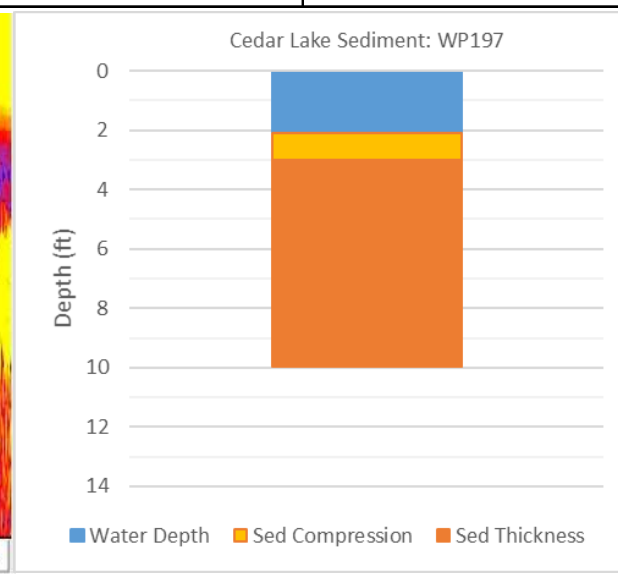

GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
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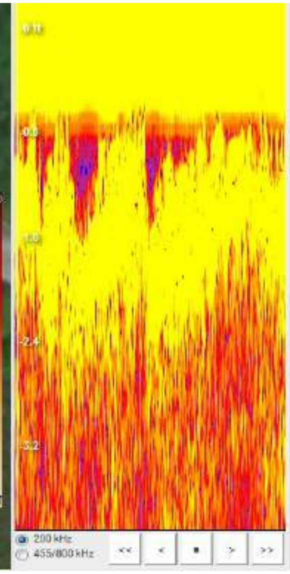

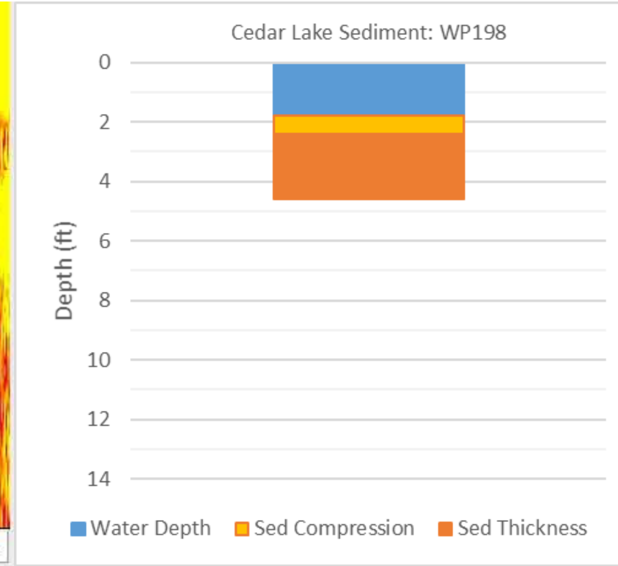

GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
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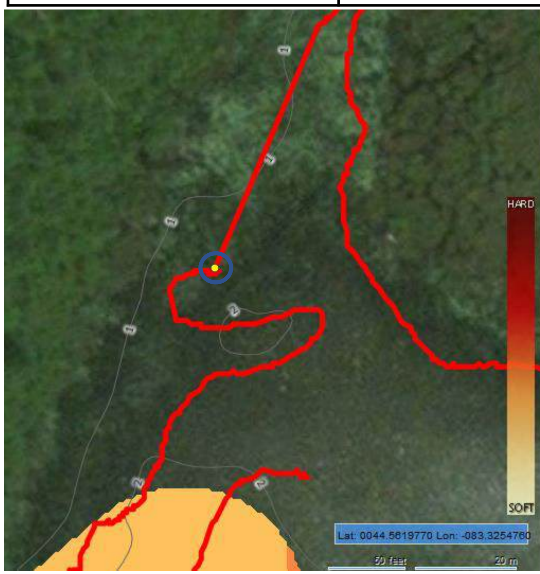
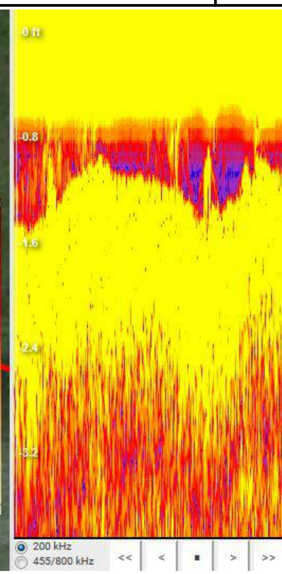
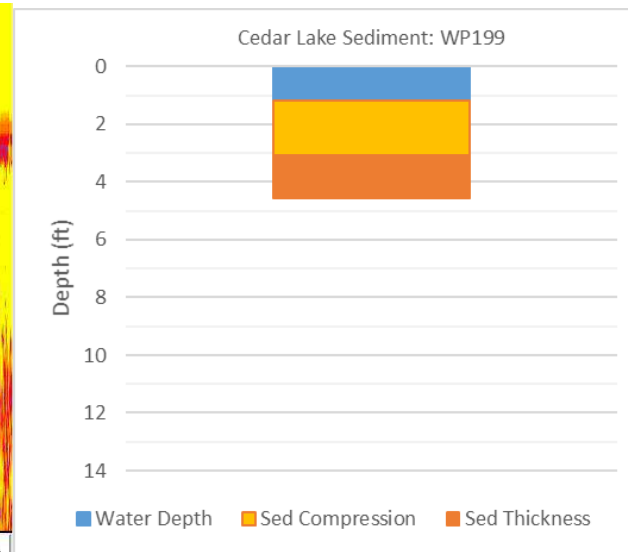
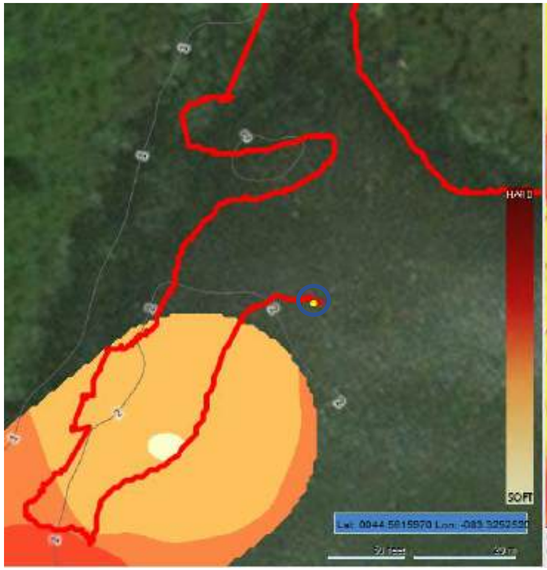
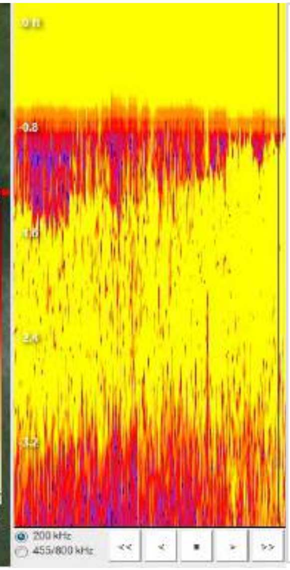
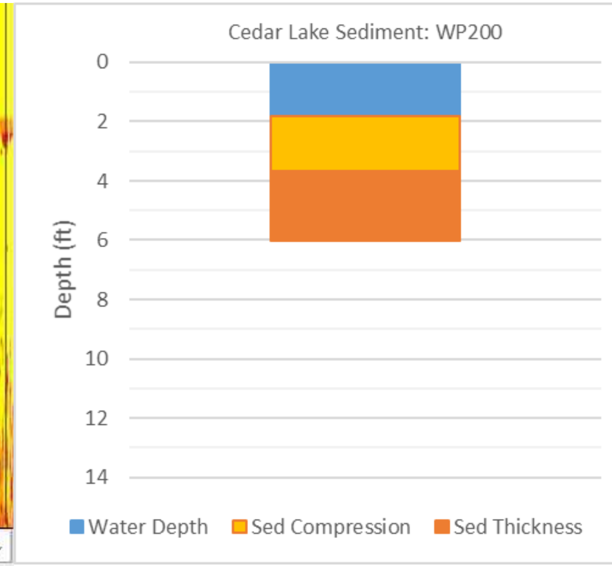


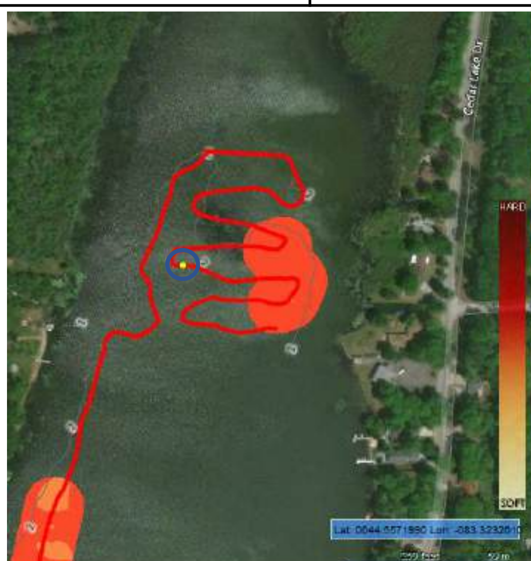
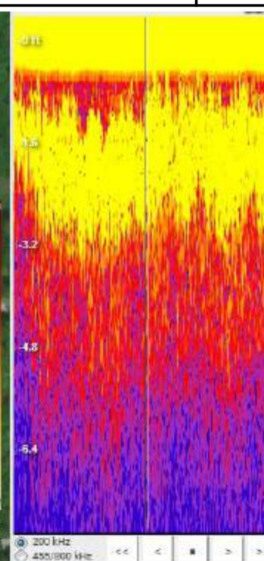
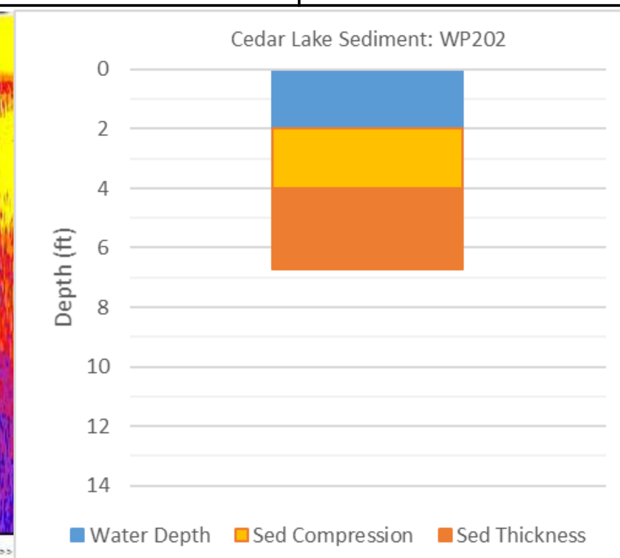




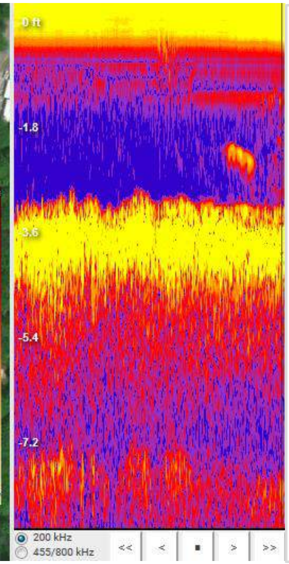
GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
200	1.8	3.67	6.04

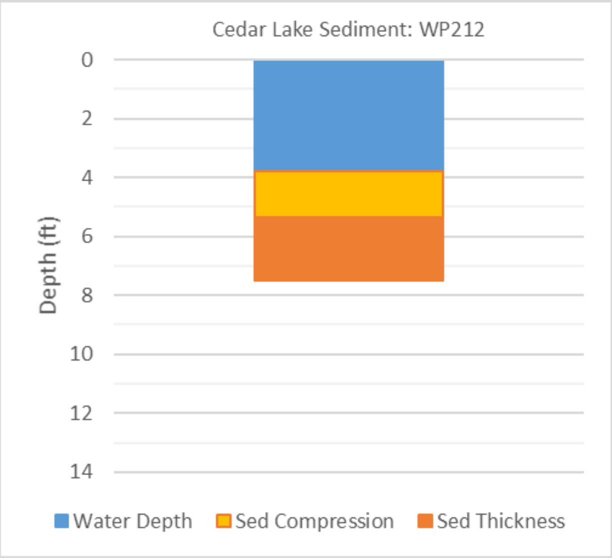




GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
202	2	4	6.71

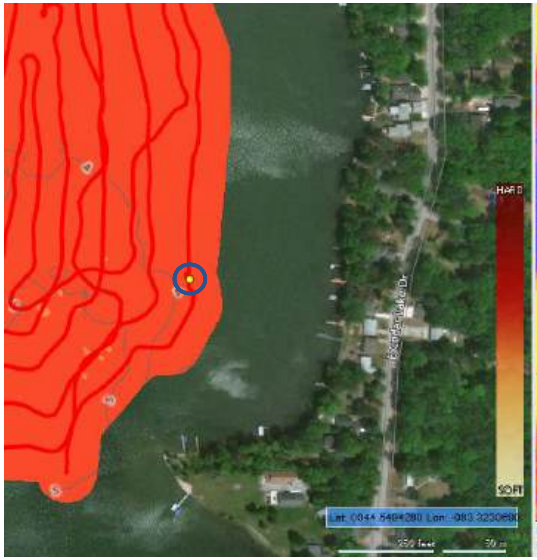




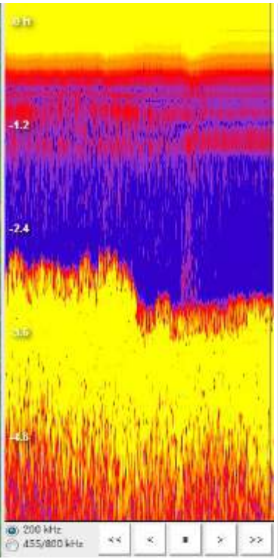
GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
212	3.8	5.37	7.5

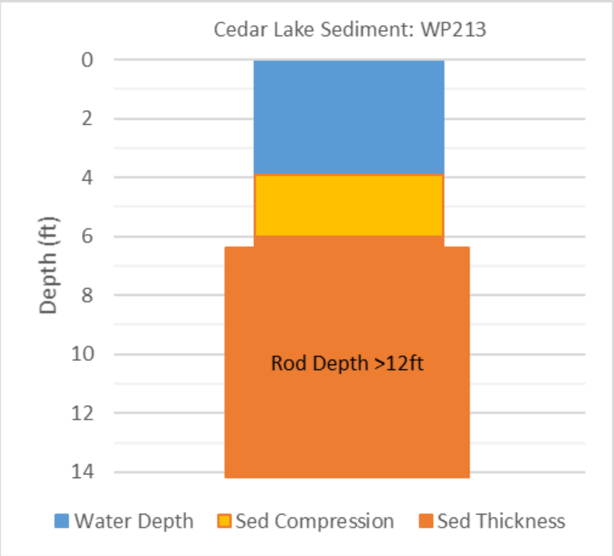




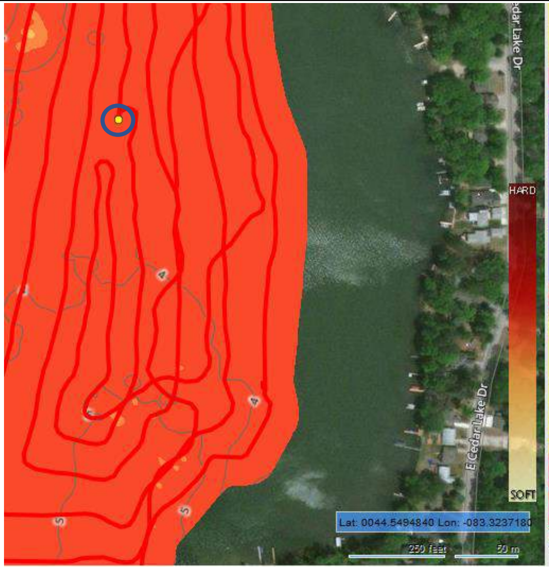
GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
213	3.9	6	>14

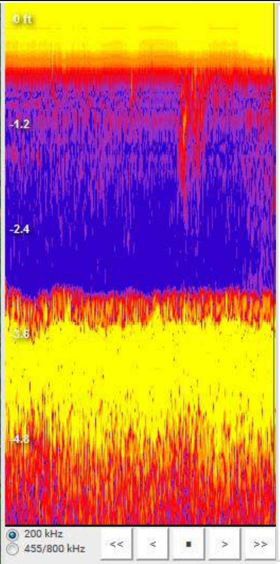


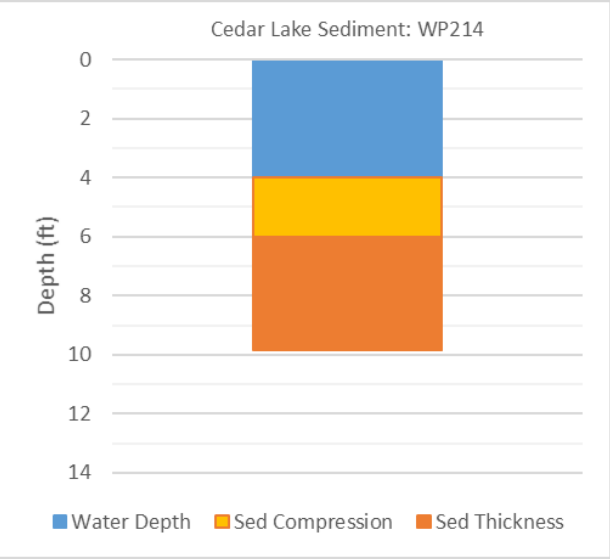




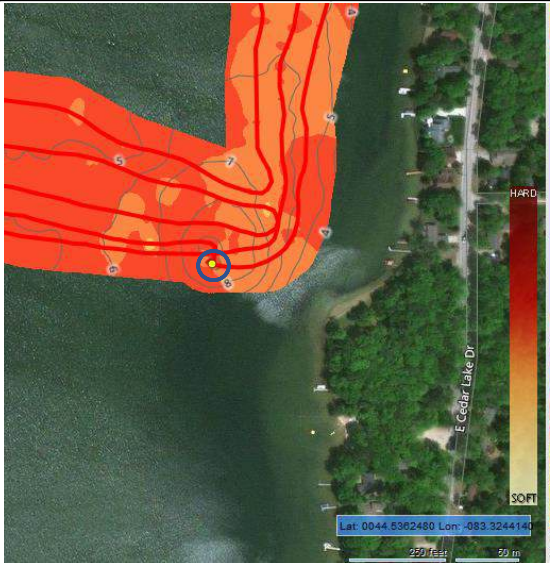
GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
214	4	6	9.83

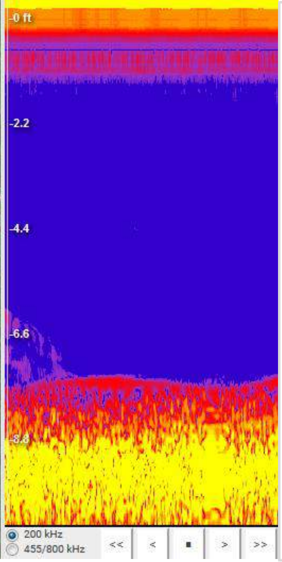


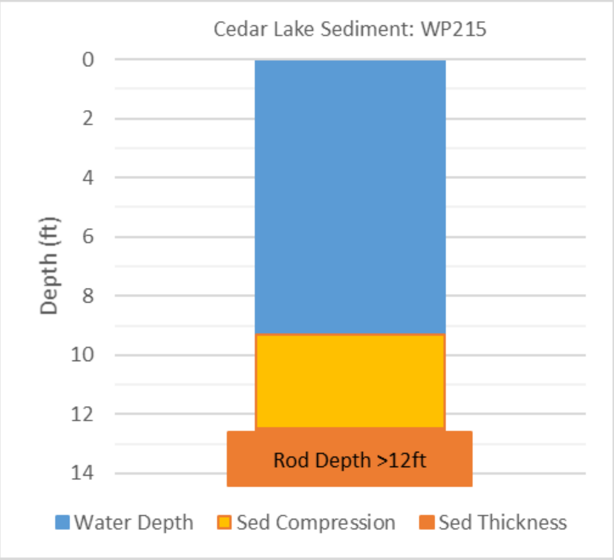




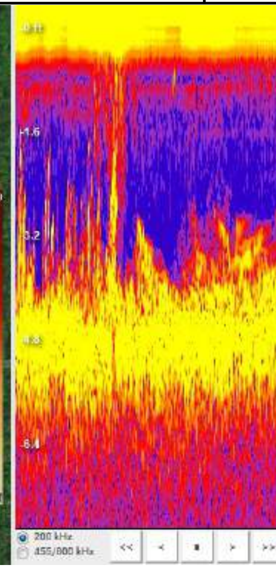
GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
215	9.3	12.5	>14

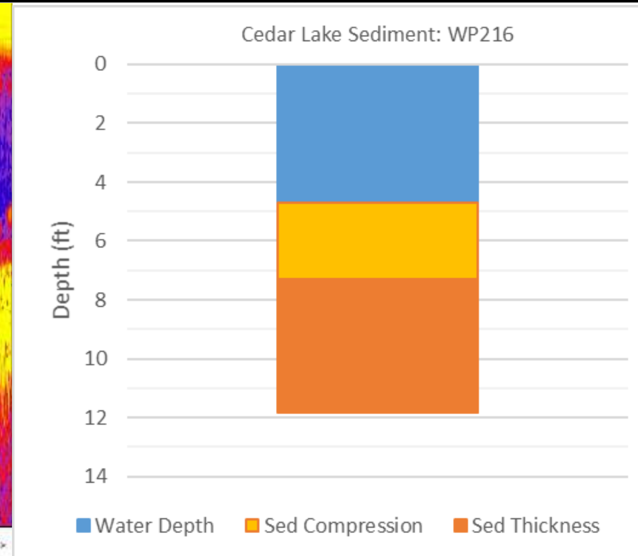


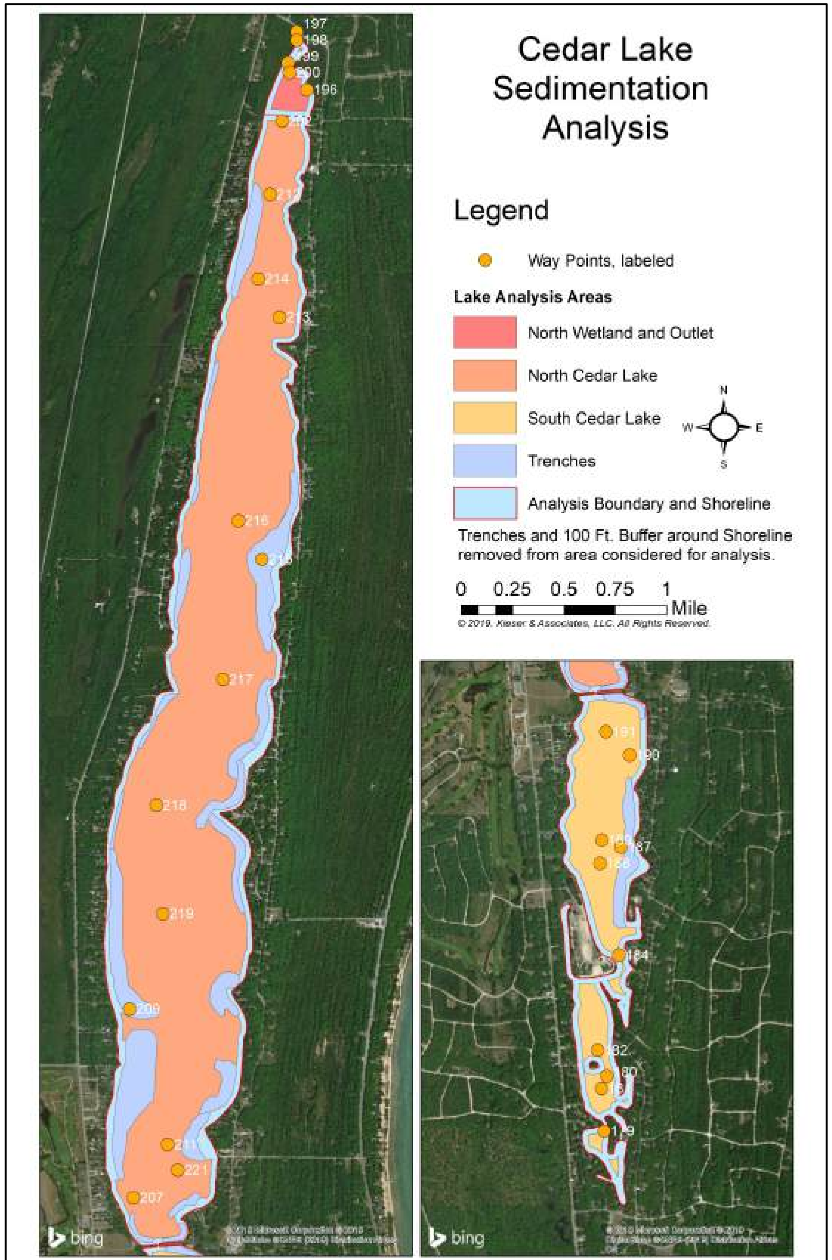




GPS Waypoint	Water Depth (ft)	Compression Total Depth (ft)	Thickness Total Depth (ft)
216	4.7	7.29	11.83







Cedar Lake sediment assessment station waypoints; bathymetrically identified trenches; and North Wetland and Outlet, North Cedar Lake and South Cedar Lake Potential Dredging Areas

KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

TECHNICAL MEMORANDUM

To:	Rex Vaughn, Chairman Cedar Lake Improvement Board	**Date:**	March 23, 2022
From:	Mark Kieser, Kieser & Associates	**cc:**	Doug Pullman, Aquest

RE: **Cedar Lake Sediment Chemistry Assessment**

Background & Purpose

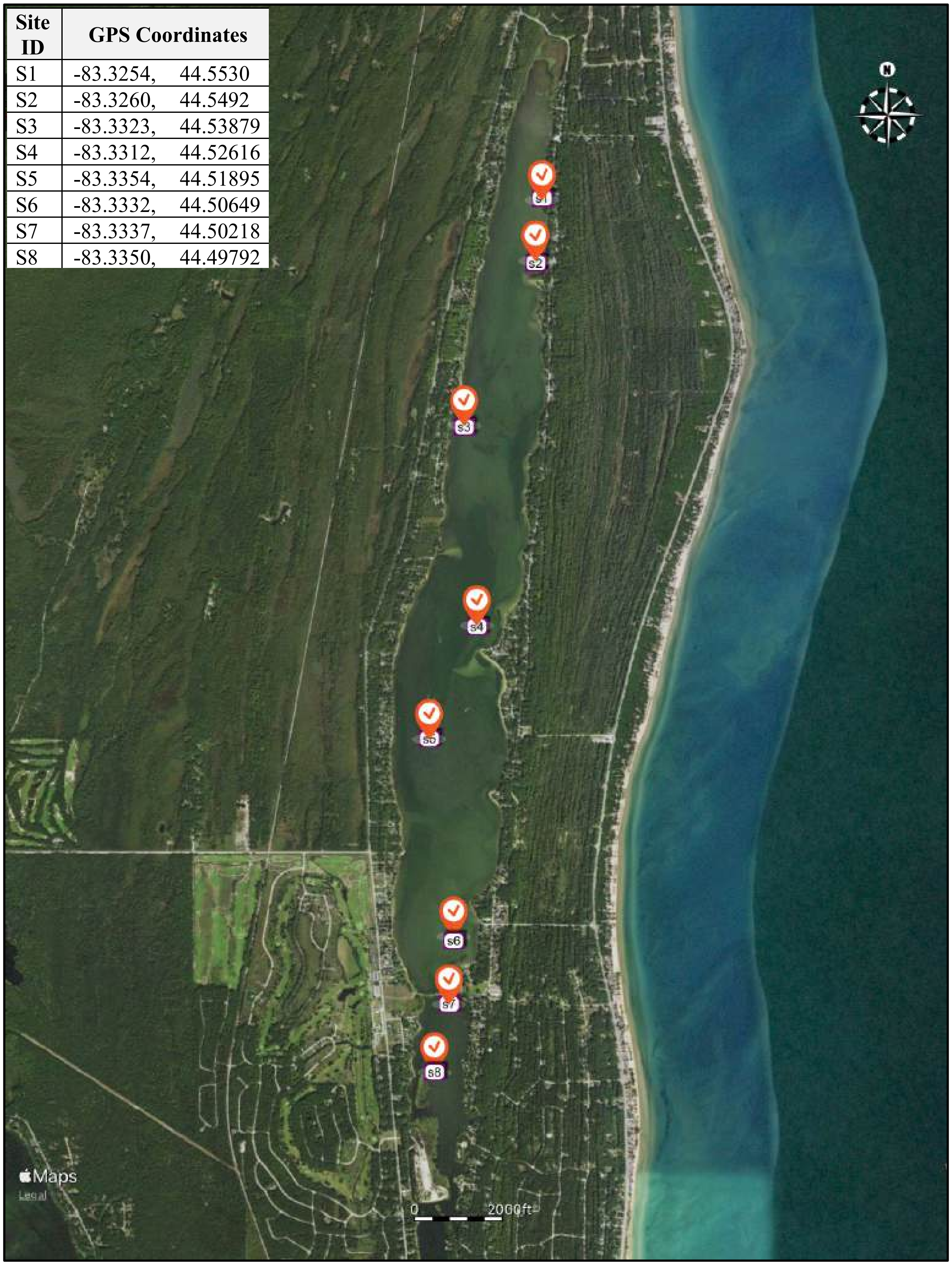
Kieser & Associates (K&A) was retained by the Cedar Lake Improvement Board (CLIB) to conduct sampling of surficial lake bottom sediments in select locations in Cedar Lake. Laboratory analysis of samples was to include Michigan-10 metals, polynuclear aromatic hydrocarbons (PAHs), and PFAS compounds. K&A also conducted additional field assessments including sediment thickness and compression mirroring K&A's May 2019 assessment. This included visual descriptions and measures of a manual-push sediment core tube at each of eight (8) sampling stations. Sampling stations were chosen to reflect more-shoreward areas of the lake bottom regions assessed during the 2019 effort. The purpose of this overall sampling and assessment effort was to initially identify any pollutant factors or sediment characteristics which would limit potential future dredging efforts or increase costs associated with contaminated sediment disposal.

Section 1 of this Technical Memorandum describes the sediment sampling and assessment locations and methods. Section 2 provides the field assessment data and characterizes sediments based on field collection efforts. Section 3 provides analytical methods and results with comparison of lab results Michigan EGLE screening guidelines for dredging projects. Section 4 discusses the results and implications sampling results which Section 5 identifies K&A recommendations and next steps if some form of dredging was pursued. Attachment A provides the laboratory analytical reports.

1.0. Sediment Sampling & Assessment

1.1. Sampling Locations

Figure 1 maps the Cedar Lake sediment sampling and assessment locations from 8/25/21.



Site ID	GPS Coordinates	
S1	-83.3254,	44.5530
S2	-83.3260,	44.5492
S3	-83.3323,	44.53879
S4	-83.3312,	44.52616
S5	-83.3354,	44.51895
S6	-83.3332,	44.50649
S7	-83.3337,	44.50218
S8	-83.3350,	44.49792

Figure 1. Cedar Lake sediment sampling and assessment locations, 8/25/21.

1.2. Sampling & Assessment Methods

1.1. Sediment Compression & Thickness Assessment Methods

The methods used in this assessment are summarized as follows.

A. Water depth (Sonar): Measured using a Lowrance Elite-7ti sonar depth finder unit with an HDI 83/200kzH transducer.
B. Manual water depth: Measured by gently lowering a Secchi disk to the lake bottom and recording the depth from the water surface. The purpose of this assessment is to confirm the sonar depth reading at the specific location used to assess the amount of loose, flocculent sediment on the lake bottom under the following methods.
C. Sediment compression: Measured by lowering a 5-lb conical steel weight to 1 ft above the lake bottom, then allowing the tool to free-fall, thereby compressing the organic sediment, and recording the depth from the water surface to compute penetration in relation to the sediment surface. The purpose of this assessment is to understand how the top layer of organic muck sediment responds to the force of compression, a valuable metric for assessing the feasibility of certain management options. Anecdotally, this method provides some insight as to the question: "If someone stepped onto the lake bottom here, how far down might they sink into the muck?"
D. Sediment thickness: Measured by penetrating the lake bottom with a thin, metered aluminum rod of 12-ft length until it reached the "hard pan" below the organic sediment layer and recording the depth from the water surface. The purpose of this assessment is to understand the total thickness of organic sediment accumulation above a more impenetrable sand or clay till layer reflective of a glacial hard pan. This method is important for any future calculations of sediment volumes in Cedar Lake and for determining the feasibility and potential need for future sediment management strategies.

1.2. Sediment Core Collection Method

Sediment cores were collected by manually pushing a 2-inch diameter clear plastic core tube of 12-ft length into the lake bottom sediment until a semi-solid plug was felt, or as far as considered safely possible to ensure intact extraction of core tube contents. The exposed end of the tube was capped and the core was slowly raised from the water. Care was taken in this process to retain any sediment layering within the tube. Core tubes were photographed and any visually apparent layering of sediments was measured, described, and recorded.

1.3. Sediment Grab Sampling Methods

Sediment grab sampling involves collecting a discrete grab sample of a top layer of sediment using a Petite Ponar dredge slowly lowered into the top layer of sediment and quickly snapped closed. For this sampling effort, each sample grab collected a 6-inch vertical layer of sediment, with the top of the sampler positioned at 3-6 inches below the top-most flocculent layer of lake bottom sediment as estimated through visual assessment of the manual sediment core. The Ponar dredge was thoroughly decontaminated with deionized water and Liquinox non-phosphate soap and a natural-fiber brush between sampling sites.

2.0. Sediment Characterization

This section provides tables and graphs illustrating the Cedar Lake sediment assessment field data collected by K&A on 8-25-21. Appendix B contains photographs of each sediment core tube and sediment grab sample assessed. Table 1 provides the sediment compression and sediment total thickness averages for the 8-25-21 sampling event at S1-S8. These data are graphed in Figure 2.

Table 1. Sediment compression and total thickness site averages and water depth.

Site ID	Water Depth (ft)	AVG Sediment Compression (ft)	AVG Sediment Thickness (ft)
S1	1.9	1.5	7.8
S2	2.1	1.2	8.5
S3	3.6	1.4	6.3
S4	4.8	1.8	>7.2
S5	2.5	2.5	6.4
S6	3.0	1.4	8.6
S7	2.4	2.2	9.5
S8	2.1	1.2	8.4

Three distinct layers were identified within each manual sediment core collected at each station: a loose flocculent layer (top of sediment), an unconsolidated sediment layer below the flocculent surface layer, and a consolidated layer which formed the sediment core tube "plug." An in-tact core tube could not be retrieved at S3 due to the uniformly unconsolidated nature of the second and third sediment layer. Table 2 provides the measurement core layer measurements for each manual core observed. These data are graphed for comparison to sediment compression and thickness measurements in Figure 2.

Table 2. Sediment core tube measurements of visible sediment layers.

Site ID	Water Depth (ft)	Total Length of Sediment Retrieved in Core Tube (ft)	Flocculent Layer Thickness (ft)	Unconsolidated Sediment Layer Thickness below Flocculence (ft)	Consolidated "Plug" Layer below Loose Sed (ft)
S1	1.9	3.08	0.33	2.00	0.75
S2	2.1	1.91	0.33	0.58	1.00
S3	3.6	--	--	--	--
S4	4.8	1.74	0.50	0.58	0.66
S5	2.5	1.91	0.25	0.66	1.00
S6	3.0	2.17	0.25	0.75	1.17
S7	2.4	2.84	0.42	1.50	0.92
S8	2.1	2.34	0.67	0.67	1.00

Table 3 provides descriptions of sediment grab samples at each sampling site. The sediment grab sample approximate depths are also graphed in Figure 2.

Site ID	Water Depth (ft)	Sediment Grab Sample Approximate Depth Range Below Water Surface (ft)	Sediment Grab Sample Description
S1	1.9	2.2 – 2.7	Viscous, lumpy, sandy, grey/brown, some organic matter (OM), moderate organic smell
S2	2.1	2.5 – 3.0	Loose, smooth, grey/tan, sandy, minor OM, dark brown flecks, moderate organic smell
S3	3.6	4.0 – 4.5	Loose, smooth, fine sand, no coagulation, grey/brown, minor OM, strong organic odor
S4	4.8	5.2 – 5.7	Viscous, loose, gelatinous globs, grey brown w/ green/tan mottling, some OM, strong organic smell
S5	2.5	2.9 – 3.4	Loose, sandy, gelatinous solids, brown grey, some OM, minor smell
S6	3.0	3.6 – 4.1	Very loose, sandy, grey/tan, mostly smooth, minor OM, moderate organic odor
S7	2.4	2.8 – 3.3	Loose with gelatinous layer, viscous, plant and algal OM bits, dark brown/grey, mild organic smell
S8	2.1	2.4 – 2.9	Very fine sand, very loose, smooth uniform, brown/tan, some OM, minor odor

Figure 2 shows how the measured sediment compression and total thickness compare to the approximate measurements of sediment layering based on visual observations of the sediment core tubes. Sediment grab samples at all sites were collected within the measured compressed layer and the corresponding unconsolidated top layer as measured in the core tube. The exception is S8, collected within the compressable layer and the corresponding flocculent layer as measured in the core tube.

A mentioned previously, an in-tact core could not be collected at S3 due to the uniformly unconsolidated nature of the sediment. At S2, S6, S7, and S8, the sediment compression layer related closely (within 0.4-ft) to the sum of the flocculent and unconsolidated top layer of sediments as measured within the core tube. At S1, S4, and S5, measurement of these layers differed considerably. At S1, the unconsolidated core tube layer was identified as well below the compression layer, while at S4 and S5, the unconsolidated core tube layer was identified as transitioning to a consolidated layer well-within the compression layer. At S4, sediment total thickness from the water's surface was measured as greater than the total length of the measuring device (12-ft), represented by an orange arrow in Figure 2.

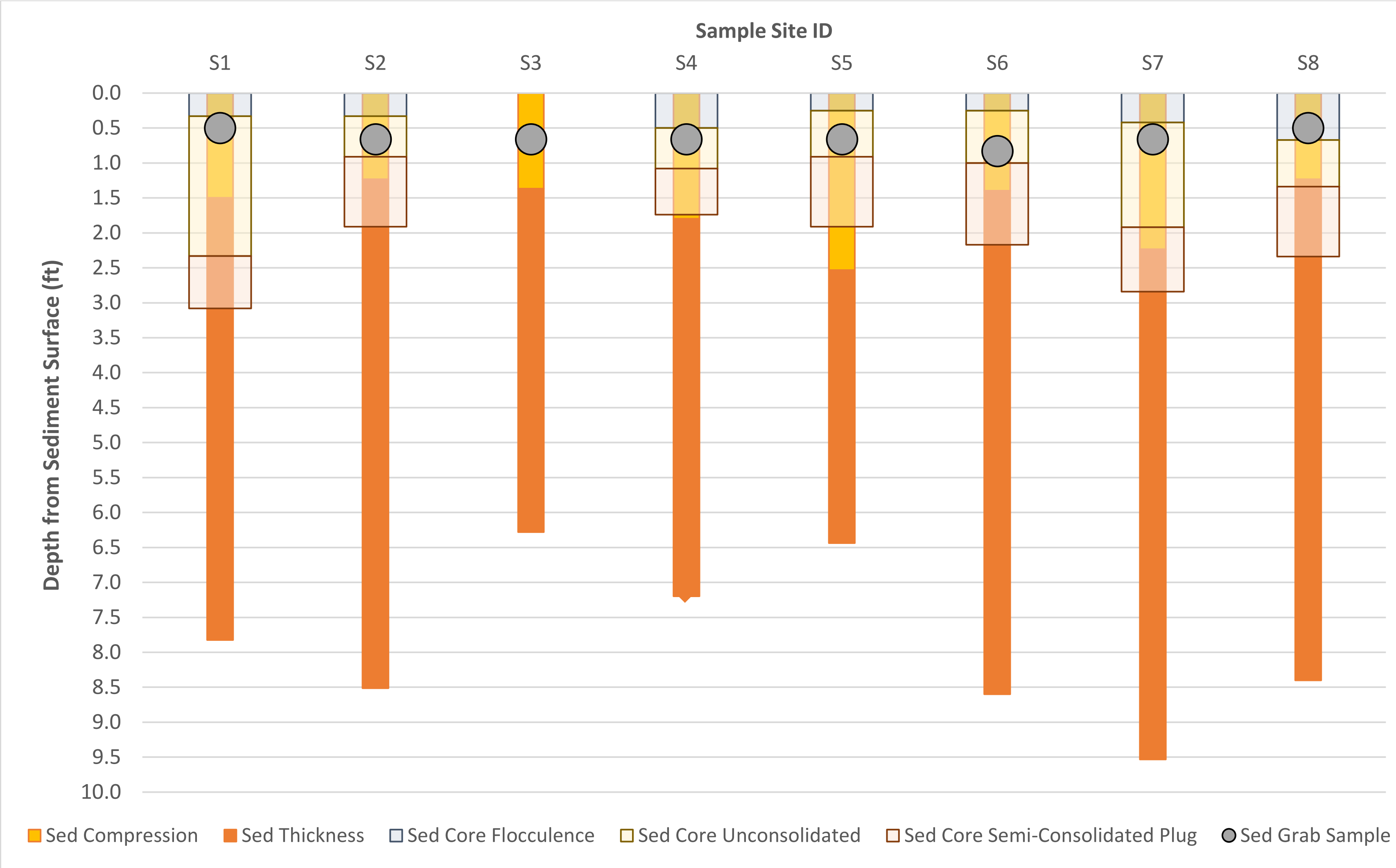


Figure 2. Cedar Lake sediment compression and total thickness overlaid with measured visual assessment of sediment core layers and approximate sediment grab sample depth.

3.0. Analytical Results

3.1. Analytical Methods

Analytical laboratory parameters were analyzed by Merit Laboratory, of Lansing, MI. Table 3 provides details for the laboratory analytical parameters.

Table 3. Analytical parameters, parameter type, units, and analytical laboratory reporting limits and methods for the 2020 Asylum Lake stormwater monitoring program.

Analytical Parameter	Analytical Laboratory	Unit	Analytical Method
MI-10-Metals	Merit	mg/kg	SW6020A (Metals) SW3050B (Metals Digestion) SW7471B (Mercury & Digestion)
Polyaromatic Hydrocarbons (PAHs)	Merit	µg/kg	SW8270D
PFAS	Merit	ng/kg	ASTM D7968-17M
Total Solids	Merit	%	SM2540B

3.2. Analytical Results

Tables 4, 5, and 6 provide the analytical laboratory results for MI-10-Metals, PAHs, and PFAS compounds, respectively. Each table also provides the total percent solids for each sample set. Tables 4 and 5 compare results to the MI EGLE 2018 Sediment Testing for Dredging Projects WRD-048 policy and procedure table providing aquatic life and wildlife screening guidelines.[1] For each table, any analyte detected above the WRD-048 screening guideline for that specific parameter is emboldened and highlighted in red. Analytes reported as below the laboratory analytical reporting limit, which have a less-than sign, but above the WRD-048 screening guideline, were reported at a relatively high detection limit due to their low percentage of total solids. These sample analytes were re-analyzed by Merit Laboratories as replicate samples using wet-weight analyses, at K&A's request, and the replicate wet-weight sample results for those analytes are included beneath the dry-weight results in the results tables below.

Analytical parameters for MI-10-Metals (Table 4), were the only analytes detected above the laboratory reporting limit for all sample sets. Two samples, S5 and S7, were found to be above the WRD-048 screening guideline for lead. All samples analyzed for selenium were found to be below the laboratory reporting limit but above the WRD-048 screening guideline for selenium, so a wet-weight replicate result is included.

All sediment samples for PAHs and PFAS were found to be below the analytical laboratory reporting limit, as shown in Tables 5 and 6. Several PAH sample results were below the reporting limit but above the WRD-048 screening guideline, so replicate wet-weight results are included for anthracene, benzo(a)anthracene, chrysene, fluorene, naphthalene, and phenanthrene.

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[1] Michigan Department of Environmental Quality. (13 April 2018). "Subject: Sediment Testing for Dredging Projects." *Water Resources Division Policy and Procedure.* Number: WRD-048.

Table 4. Sediment sample results for MI-10-Metals, relative to EGLE Water Resource Division Policy and Procedure # WRD-048, Sediment Testing for Dredging Projects (data in units of mg/kg).

Sampling Location: Metals Analyte	Laboratory Reported Results								Aquatic Life and Wildlife Screening Guidelines[1]
	S1	S2	S3	S4	S5	S6	S7	S8	
Total Solids (%)	4.5	5.0	3.6	3.5	2.4	2.9	1.8	2.2	NA
Arsenic (Al)	6.87	4.90	10.7	8.69	13.4	7.05	12.1	4.94	33.00
Barium (Ba)	60.4	47.2	60.5	62.8	85.1	55.3	94.0	69.3	NA
Cadmium (Cd)	1.35	1.22	2.17	1.64	4.62	1.06	3.57	2.74	4.98
Chromium (Cr)	10.3	8.57	10.5	11.0	19.4	11.1	27.3	17.9	111.00
Copper (Cu)	33.0	22.0	46.6	27.8	65.0	27.1	65.8	42.2	149.00
Lead (Pb)	49.5	39.0	78.5	57.2	**161**	29.1	**128**	64.2	128.00
Mercury (Hg)	0.116	0.091	0.145	0.102	0.269	<0.100	0.323	0.209	1.06
Selenium (Se)	<5.0	<4.0	<6.0	<5.0	<8.0	<6.0	<11.0	<8.0	1.90
Selenium (*Wet-Weight Replicate*)	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	1.90
Silver (Ag)	<0.25	<0.20	<0.30	<0.25	<0.40	<0.30	<0.55	<0.40	NA
Zinc (Zn)	110	89.3	155	119	286	84.8	282	185	459.00

[1] Michigan Department of Environmental Quality. (13 April 2018). "Subject: Sediment Testing for Dredging Projects." *Water Resources Division Policy and Procedure.* Number: WRD-048. Page 8 of 9.

Table 5. Sediment sample results for PAHs, EGLE Water Resource Division Policy and Procedure # WRD-048, Sediment Testing for Dredging Projects (data in units of µg/kg).

Sampling Location: / PAH Analyte	Laboratory Reported Results								Aquatic Life and Wildlife Screening Guidelines[1]
	S1	S2	S3	S4	S5	S6	S7	S8	
Total Solids (%)	4.5	5.0	3.6	3.5	2.4	2.9	1.8	2.2	NA
Acenaphthene	<500	<500	<700	<700	<1000	<800	<1400	<1100	NA
Acenaphthylene	<500	<500	<700	<700	<1000	<800	<1400	<1100	NA
Anthracene	<500	<500	<700	<700	<1000	<800	<1400	<1100	845
Anthracene (*Wet-Weight Replicate*)	<300	<300	<300	<300	<300	<300	<300	<300	845
Benzo(a)anthracene	<500	<500	<700	<700	<1000	<800	<1400	<1100	1,050
Benzo(a)anthracene (*Wet-Weight Replicate*)	<300	<300	<300	<300	<300	<300	<300	<300	1,050
Benzo(a)pyrene	<500	<500	<700	<700	<1000	<800	<1400	<1100	1,450
Benzo(b)fluoranthene	<500	<500	<700	<700	<1000	<800	<1400	<1100	NA
Benzo(k)fluoranthene	<500	<500	<700	<700	<1000	<800	<1400	<1100	NA
Benzo(ghi)perylene	<500	<500	<700	<700	<1000	<800	<1400	<1100	NA
Chrysene	<500	<500	<700	<700	<1000	<800	<1400	<1100	1,290
Chrysene (*Wet-Weight Replicate*)	<300	<300	<300	<300	<300	<300	<300	<300	1,290
Dibenzo(ah)anthracene	<500	<500	<700	<700	<1000	<800	<1400	<1100	NA
Fluoranthene	<500	<500	<700	<700	<1000	<800	<1400	<1100	2,230
Fluorene	<500	<500	<700	<700	<1000	<800	<1400	<1100	536
Fluorene (*Wet-Weight Replicate*)	<300	<300	<300	<300	<300	<300	<300	<300	536
Indeno(1,2,3-cd)pyrene	<500	<500	<700	<700	<1000	<800	<1400	<1100	NA
Naphthalene	<500	<500	<700	<700	<1000	<800	<1400	<1100	561
Naphthalene (*Wet-Weight Replicate*)	<300	<300	<300	<300	<300	<300	<300	<300	561
Phenanthrene	<500	<500	<700	<700	<1000	<800	<1400	<1100	1,170
Phenanthrene (*Wet-Weight Replicate*)	<300	<300	<300	<300	<300	<300	<300	<300	1,170
Pyrene	<500	<500	<700	<700	<1000	<800	<1400	<1100	1,520
2-Methylnaphthalene	<500	<500	<700	<700	<1000	<800	<1400	<1100	NA
1-Methylnaphthalene	<500	<500	<700	<700	<1000	<800	<1400	<1100	NA

[1] Michigan Department of Environmental Quality. (13 April 2018). "Subject: Sediment Testing for Dredging Projects." *Water Resources Division Policy and Procedure.* Number: WRD-048. Page 8 of 9.

Table 6. Sediment sample results for PFAS (data in units of ng/kg).

Sampling Location: PFAS Parameter	Laboratory Reported Results							
	S1	S2	S3	S4	S5	S6	S7	S8
Total Solids (%)	7.4	6.6	5.2	5.6	4.8	5.0	4.5	4.6
PFBA	<630	<690	<1200	<780	<1200	<1300	<1700	<1100
PFPeA	<310	<340	<610	<390	<590	<640	<830	<550
4:2 FTSA	<310	<340	<610	<390	<590	<640	<830	<550
PFHxA	<310	<340	<610	<390	<590	<640	<830	<550
PFBS	<310	<340	<610	<390	<590	<640	<830	<550
PFHpA	<310	<340	<610	<390	<590	<640	<830	<550
PFPeS	<310	<340	<610	<390	<590	<640	<830	<550
6:2 FTSA	<310	<340	<610	<390	<590	<640	<830	<550
PFOA	<310	<340	<610	<390	<590	<640	<830	<550
PFHxS	<310	<340	<610	<390	<590	<640	<830	<550
PFHxS-LN	<310	<340	<610	<390	<590	<640	<830	<550
PFHxS-BR	<310	<340	<610	<390	<590	<640	<830	<550
PFNA	<310	<340	<610	<390	<590	<640	<830	<550
8:2 FTSA	<310	<340	<610	<390	<590	<640	<830	<550
PFHpS	<310	<340	<610	<390	<590	<640	<830	<550
PFDA	<310	<340	<610	<390	<590	<640	<830	<550
N-MeFOSAA	<310	<340	<610	<390	<590	<640	<830	<550
EtFOSAA	<310	<340	<610	<390	<590	<640	<830	<550
PFOS	<310	<340	<610	<390	<590	<640	<830	<550
PFOS-LN	<310	<340	<610	<390	<590	<640	<830	<550
PFOS-BR	<310	<340	<610	<390	<590	<640	<830	<550
PFUnDA	<310	<340	<610	<390	<590	<640	<830	<550
PFNS	<310	<340	<610	<390	<590	<640	<830	<550
PFDoDA	<310	<340	<610	<390	<590	<640	<830	<550
PFDS	<310	<340	<610	<390	<590	<640	<830	<550
PFTrDA	<310	<340	<610	<390	<590	<640	<830	<550
FOSA	<310	<340	<610	<390	<590	<640	<830	<550
PFTeDA	<310	<340	<610	<390	<590	<640	<830	<550
11Cl-PF3OUdS	<310	<340	<610	<390	<590	<640	<830	<550
9Cl-PF3ONS	<310	<340	<610	<390	<590	<640	<830	<550
ADONA	<310	<340	<610	<390	<590	<640	<830	<550
HFPO-DA	<310	<340	<610	<390	<590	<640	<830	<550

4.0. Discussion

Based on sediment testing results, lead samples from S5 and S7 (Table 4) are at or above EGLE's Aquatic Life and Wildlife Screening Guidelines. This suggests that 25% of sediment that might be targeted for a lake-wide dredging effort could require special handling and disposal restrictions. In the previous 2019 K&A Technical Memorandum that examined potential quantities of dredged sediments, K&A denoted that average, low-cost dredging operations where there is no sediment contamination may cost about $1/cubic yard.[2] If there were ample land disposal opportunities adjacent to the lake, and sediments required no special handling, K&A forecasted a most generous cost estimate of $0.50/cubic yard.

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.

5.0 Recommendations

With the presence of lead in a portion of sediment that could be dredged, and the resultant cost increase for a large-scale, lake-wide operation, projected costs suggest that such a dredging effort is cost infeasible for Cedar Lake. Selective dredging of areas that do not exceed state guidelines is possible, however, substantial sediment sampling would be necessary to assess the feasibility of this option. For any dredging operation, upfront preparation, design, permitting and oversight costs need to be considered in any efforts. A 12% cost of actual dredging is a reasonable consideration for such support costs.

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[2] K&A, 2019. Technical Memorandum: Bathymetric Mapping and Sediment Assessment Survey. Submitted to Rex Vaughn, Cedar Lake Improvement Board, August 22, 2019, 32 pp. See: https://img1.wsimg.com/blobby/go/a080ee0a-11db-41bd-8830-a064f9457faa/downloads/Cedar%20Lake%20Bathymetry-Sediment%20Final%20Memorandu.pdf?ver=1647356532177

Appendix A

Laboratory Analytical Results

Merit Laboratories, Inc.

Analytical Laboratory Report

Supplemental Report

Report ID: S27504.01(02)
Generated on 09/27/2021
Replaces report S27504.01(01) generated on 09/02/2021

Report to

Attention: Josh Kieser
Kieser & Associates
536 E. Michigan Ave. Ste 300
Kalamazoo, MI 49007

Phone: 269-344-7117 FAX:
Email: JKieser@kieser-associates.com

Addtional Contacts: Doug Ervin, Becky Hough

Report produced by

Merit Laboratories, Inc.
2680 East Lansing Drive
East Lansing, MI 48823

Phone: (517) 332-0167 FAX: (517) 332-6333

Contacts for report questions:
John Laverty (johnlaverty@meritlabs.com)
Barbara Ball (bball@meritlabs.com)

Report Summary

Lab Sample ID(s): S27504.01-S27504.08
Project: Cedar Lake
Collected Date(s): 08/25/2021
Submitted Date/Time: 08/25/2021 15:30
Sampled by: Josh Kieser
P.O. #:

Table of Contents

Maya Murshak
Technical Director

General Report Notes

Analytical results relate only to the samples tested, in the condition received by the laboratory.
Methods may be modified for improved performance.
Results reported on a dry weight basis where applicable.
'Not detected' indicates that parameter was not found at a level equal to or greater than the reporting limit (RL).
40 CFR Part 136 Table II Required Containers, Preservation Techniques and Holding Times for the Clean Water Act specify that samples for acrolein and acrylonitrile need to be preserved at a pH in the range of 4 to 5 or if not preserved, analyzed within 3 days of sampling.
QA/QC corresponding to this analytical report is a separate document with the same Merit ID reference and is available upon request.
Full accreditation certificates are available upon request. Starred (*) analytes are not NELAP accredited.
Samples are held by the lab for 30 days from the final report date unless a written request to hold longer is provided by the client.
Report shall not be reproduced except in full, without the written approval of Merit Laboratories, Inc.
Limits for drinking water samples, are listed as the MCL Limits (Maximum Contaminant Level Concentrations)
PFAS requirement: Section 9.3.8 of U.S. EPA Method 537.1 states "If the method analyte(s) found in the Field Sample is present in the FRB at a concentration greater than 1/3 the MRL, then all samples collected with that FRB are invalid and must be recollected and reanalyzed."
Samples submitted without an accompanying FRB may not be acceptable for compliance purposes.

Report Narrative

Selenium and PNA reported with and without the total solids correction per client request

Laboratory Certifications

Authority	Certification ID
Michigan DEQ	#9956
DOD ELAP/ISO 17025	#69699
WBENC	#2005110032
Ohio VAP	#CL0002
Indiana DOH	#C-MI-07
New York NELAC	#11814
North Carolina DENR	#680
North Carolina DOH	#26702
Alaska CSLAP	#17-001
Pennsylvania DEP	#68-05884

Qualifier Descriptions

Qualifier	Description
!	Result is outside of stated limit criteria
B	Compound also found in associated method blank
E	Concentration exceeds calibration range
F	Analysis run outside of holding time
G	Estimated result due to extraction run outside of holding time
H	Sample submitted and run outside of holding time
I	Matrix interference with internal standard
J	Estimated value less than reporting limit, but greater than MDL
L	Elevated reporting limit due to low sample amount
M	Result reported to MDL not RDL
O	Analysis performed by outside laboratory. See attached report.
R	Preliminary result
S	Surrogate recovery outside of control limits
T	No correction for total solids
X	Elevated reporting limit due to matrix interference
Y	Elevated reporting limit due to high target concentration
b	Value detected less than reporting limit, but greater than MDL
e	Reported value estimated due to interference
j	Analyte also found in associated method blank
p	Benzo(b)Fluoranthene and Benzo(k)Fluoranthene integrated as one peak.
x	Preserved from bulk sample

Glossary of Abbreviations

Abbreviation	Description
RL/RDL	Reporting Limit
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
SW	EPA SW 846 (Soil and Wastewater) Methods
E	EPA Methods
SM	Standard Methods
LN	Linear
BR	Branched

Method Summary

Method	Version
SM2540B	Standard Method 2540 B 2011
SW3050B	SW 846 Method 3050B Revision 2 December 1996
SW3546	SW 846 Method 3546 Revision 0 February 2007
SW6020A	SW 846 Method 6020A Revision 1 February 2007
SW7471B	SW 846 Method 7471B Revision 2 February 2007
SW8270D	SW 846 Method 8270D Revision 4 February 2007

Sample Summary (8 samples)

Sample ID	Sample Tag	Matrix	Collected Date/Time
S27504.01	S1	Sludge	08/25/21 08:45
S27504.02	S2	Sludge	08/25/21 09:00
S27504.03	S3	Sludge	08/25/21 09:25
S27504.04	S4	Sludge	08/25/21 09:45
S27504.05	S5	Sludge	08/25/21 10:05
S27504.06	S6	Sludge	08/25/21 10:20
S27504.07	S7	Sludge	08/25/21 10:35
S27504.08	S8	Sludge	08/25/21 10:50

Lab Sample ID: S27504.01
Sample Tag: S1
Collected Date/Time: 08/25/2021 08:45
Matrix: Sludge
COC Reference: 139655

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	1L Amber	None	Yes	9.6	IR
1	125ml Plastic	HNO3	Yes	9.6	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3050B	09/02/21 10:30	CCM	
PNA Extraction*	Completed	SW3546	08/26/21 12:00	JWR	
Mercury Digestion	Completed	SW7471B	09/02/21 10:45	JRH	

Inorganics

Method: SM2540B, Run Date: 08/31/21 13:45, Analyst: ELR

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Total Solids*	4.5	1		%	1		

Metals

Method: SW6020A, Run Date: 09/02/21 12:27, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Arsenic	6.87	2.5		mg/kg	2258	7440-38-2	
Barium	60.4	2.5		mg/kg	2258	7440-39-3	
Cadmium	1.35	0.25		mg/kg	2258	7440-43-9	
Chromium	10.3	2.5		mg/kg	2258	7440-47-3	
Copper	33.0	2.5		mg/kg	2258	7440-50-8	
Lead	49.5	1.25		mg/kg	2258	7439-92-1	
Selenium	Not detected	5.0		mg/kg	2258	7782-49-2	
Selenium (Replicate 01)	Not detected	0.40		mg/kg	102		T
Silver	Not detected	0.25		mg/kg	2258	7440-22-4	
Zinc	110	2.5		mg/kg	2258	7440-66-6	

Method: SW7471B, Run Date: 09/02/21 14:25, Analyst: JRH

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Mercury	0.116	0.065		mg/kg	641	7439-97-6	

Organics - Semi-Volatiles

Polynuclear Aromatics, Method: SW8270D, Run Date: 08/27/21 20:20, Analyst: PL

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Acenaphthene	Not detected	500		ug/kg	1	83-32-9	K
Acenaphthylene	Not detected	500		ug/kg	1	208-96-8	K
Anthracene	Not detected	500		ug/kg	1	120-12-7	K
Benzo(a)anthracene	Not detected	500		ug/kg	1	56-55-3	K
Benzo(a)pyrene	Not detected	500		ug/kg	1	50-32-8	K
Benzo(b)fluoranthene	Not detected	500		ug/kg	1	205-99-2	K
Benzo(k)fluoranthene	Not detected	500		ug/kg	1	207-08-9	K
Benzo(ghi)perylene	Not detected	500		ug/kg	1	191-24-2	K
Chrysene	Not detected	500		ug/kg	1	218-01-9	K

T-No correction for total solids
K-Elevated reporting limit due to low total solids

Lab Sample ID: S27504.01 (continued)

Sample Tag: S1

Polynuclear Aromatics, Method: SW8270D, Run Date: 08/27/21 20:20, Analyst: PL (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Dibenzo(ah)anthracene	Not detected	500		ug/kg	1	53-70-3	K
Fluoranthene	Not detected	500		ug/kg	1	206-44-0	K
Fluorene	Not detected	500		ug/kg	1	86-73-7	K
Indeno(1,2,3-cd)pyrene	Not detected	500		ug/kg	1	193-39-5	K
Naphthalene	Not detected	500		ug/kg	1	91-20-3	K
Phenanthrene	Not detected	500		ug/kg	1	85-01-8	K
Pyrene	Not detected	500		ug/kg	1	129-00-0	K
2-Methylnaphthalene	Not detected	500		ug/kg	1	91-57-6	K
1-Methylnaphthalene	Not detected	500		ug/kg	1	90-12-0	K

Polynuclear Aromatics (Replicate 01), Method: SW8270D, Run Date: 08/27/21 20:20, Analyst: PL

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Acenaphthene	Not detected	300		ug/kg	1	83-32-9	T
Acenaphthylene	Not detected	300		ug/kg	1	208-96-8	T
Anthracene	Not detected	300		ug/kg	1	120-12-7	T
Benzo(a)anthracene	Not detected	300		ug/kg	1	56-55-3	T
Benzo(a)pyrene	Not detected	300		ug/kg	1	50-32-8	T
Benzo(b)fluoranthene	Not detected	300		ug/kg	1	205-99-2	T
Benzo(k)fluoranthene	Not detected	300		ug/kg	1	207-08-9	T
Benzo(ghi)perylene	Not detected	300		ug/kg	1	191-24-2	T
Chrysene	Not detected	300		ug/kg	1	218-01-9	T
Dibenzo(ah)anthracene	Not detected	300		ug/kg	1	53-70-3	T
Fluoranthene	Not detected	300		ug/kg	1	206-44-0	T
Fluorene	Not detected	300		ug/kg	1	86-73-7	T
Indeno(1,2,3-cd)pyrene	Not detected	300		ug/kg	1	193-39-5	T
Naphthalene	Not detected	300		ug/kg	1	91-20-3	T
Phenanthrene	Not detected	300		ug/kg	1	85-01-8	T
Pyrene	Not detected	300		ug/kg	1	129-00-0	T
2-Methylnaphthalene	Not detected	300		ug/kg	1	91-57-6	T
1-Methylnaphthalene	Not detected	300		ug/kg	1	90-12-0	T

K-Elevated reporting limit due to low total solids

T-No correction for total solids

Lab Sample ID: S27504.02
Sample Tag: S2
Collected Date/Time: 08/25/2021 09:00
Matrix: Sludge
COC Reference: 139655

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	1L Amber	None	Yes	9.6	IR
1	125ml Plastic	HNO3	Yes	9.6	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3050B	09/02/21 10:30	CCM	
PNA Extraction*	Completed	SW3546	08/26/21 12:00	JWR	
Mercury Digestion	Completed	SW7471B	09/02/21 10:45	JRH	

Inorganics

Method: SM2540B, Run Date: 08/31/21 13:45, Analyst: ELR

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Total Solids*	5.0	1		%	1		

Metals

Method: SW6020A, Run Date: 09/02/21 12:31, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Arsenic	4.90	2.0		mg/kg	1852	7440-38-2	
Barium	47.2	2.0		mg/kg	1852	7440-39-3	
Cadmium	1.22	0.20		mg/kg	1852	7440-43-9	
Chromium	8.57	2.0		mg/kg	1852	7440-47-3	
Copper	22.0	2.0		mg/kg	1852	7440-50-8	
Lead	39.0	1.0		mg/kg	1852	7439-92-1	
Selenium	Not detected	4.0		mg/kg	1852	7782-49-2	
Selenium (Replicate 01)	Not detected	0.40		mg/kg	93		T
Silver	Not detected	0.20		mg/kg	1852	7440-22-4	
Zinc	89.3	2.0		mg/kg	1852	7440-66-6	

Method: SW7471B, Run Date: 09/02/21 14:27, Analyst: JRH

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Mercury	0.091	0.055		mg/kg	532	7439-97-6	

Organics - Semi-Volatiles

Polynuclear Aromatics, Method: SW8270D, Run Date: 08/27/21 20:37, Analyst: PL

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Acenaphthene	Not detected	500		ug/kg	1	83-32-9	K
Acenaphthylene	Not detected	500		ug/kg	1	208-96-8	K
Anthracene	Not detected	500		ug/kg	1	120-12-7	K
Benzo(a)anthracene	Not detected	500		ug/kg	1	56-55-3	K
Benzo(a)pyrene	Not detected	500		ug/kg	1	50-32-8	K
Benzo(b)fluoranthene	Not detected	500		ug/kg	1	205-99-2	K
Benzo(k)fluoranthene	Not detected	500		ug/kg	1	207-08-9	K
Benzo(ghi)perylene	Not detected	500		ug/kg	1	191-24-2	K
Chrysene	Not detected	500		ug/kg	1	218-01-9	K

T-No correction for total solids
K-Elevated reporting limit due to low total solids

Lab Sample ID: S27504.02 (continued)
Sample Tag: S2

Polynuclear Aromatics, Method: SW8270D, Run Date: 08/27/21 20:37, Analyst: PL (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Dibenzo(ah)anthracene	Not detected	500		ug/kg	1	53-70-3	K
Fluoranthene	Not detected	500		ug/kg	1	206-44-0	K
Fluorene	Not detected	500		ug/kg	1	86-73-7	K
Indeno(1,2,3-cd)pyrene	Not detected	500		ug/kg	1	193-39-5	K
Naphthalene	Not detected	500		ug/kg	1	91-20-3	K
Phenanthrene	Not detected	500		ug/kg	1	85-01-8	K
Pyrene	Not detected	500		ug/kg	1	129-00-0	K
2-Methylnaphthalene	Not detected	500		ug/kg	1	91-57-6	K
1-Methylnaphthalene	Not detected	500		ug/kg	1	90-12-0	K

Polynuclear Aromatics (Replicate 01), Method: SW8270D, Run Date: 08/27/21 20:37, Analyst: PL

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Acenaphthene	Not detected	300		ug/kg	1	83-32-9	T
Acenaphthylene	Not detected	300		ug/kg	1	208-96-8	T
Anthracene	Not detected	300		ug/kg	1	120-12-7	T
Benzo(a)anthracene	Not detected	300		ug/kg	1	56-55-3	T
Benzo(a)pyrene	Not detected	300		ug/kg	1	50-32-8	T
Benzo(b)fluoranthene	Not detected	300		ug/kg	1	205-99-2	T
Benzo(k)fluoranthene	Not detected	300		ug/kg	1	207-08-9	T
Benzo(ghi)perylene	Not detected	300		ug/kg	1	191-24-2	T
Chrysene	Not detected	300		ug/kg	1	218-01-9	T
Dibenzo(ah)anthracene	Not detected	300		ug/kg	1	53-70-3	T
Fluoranthene	Not detected	300		ug/kg	1	206-44-0	T
Fluorene	Not detected	300		ug/kg	1	86-73-7	T
Indeno(1,2,3-cd)pyrene	Not detected	300		ug/kg	1	193-39-5	T
Naphthalene	Not detected	300		ug/kg	1	91-20-3	T
Phenanthrene	Not detected	300		ug/kg	1	85-01-8	T
Pyrene	Not detected	300		ug/kg	1	129-00-0	T
2-Methylnaphthalene	Not detected	300		ug/kg	1	91-57-6	T
1-Methylnaphthalene	Not detected	300		ug/kg	1	90-12-0	T

K-Elevated reporting limit due to low total solids
T-No correction for total solids

Lab Sample ID: S27504.03
Sample Tag: S3
Collected Date/Time: 08/25/2021 09:25
Matrix: Sludge
COC Reference: 139655

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	1L Amber	None	Yes	9.6	IR
1	125ml Plastic	HNO3	Yes	9.6	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3050B	09/02/21 10:30	CCM	
PNA Extraction*	Completed	SW3546	08/26/21 12:00	JWR	
Mercury Digestion	Completed	SW7471B	09/02/21 10:45	JRH	

Inorganics

Method: SM2540B, Run Date: 08/31/21 13:45, Analyst: ELR

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Total Solids*	3.6	1		%	1		

Metals

Method: SW6020A, Run Date: 09/02/21 12:34, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Arsenic	10.7	3.0		mg/kg	2516	7440-38-2	
Barium	60.5	3.0		mg/kg	2516	7440-39-3	
Cadmium	2.17	0.30		mg/kg	2516	7440-43-9	
Chromium	10.5	3.0		mg/kg	2516	7440-47-3	
Copper	46.6	3.0		mg/kg	2516	7440-50-8	
Lead	78.5	1.5		mg/kg	2516	7439-92-1	
Selenium	Not detected	6.0		mg/kg	2516	7782-49-2	
Selenium (Replicate 01)	Not detected	0.40		mg/kg	91		T
Silver	Not detected	0.30		mg/kg	2516	7440-22-4	
Zinc	155	3.0		mg/kg	2516	7440-66-6	

Method: SW7471B, Run Date: 09/02/21 14:28, Analyst: JRH

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Mercury	0.145	0.070		mg/kg	694	7439-97-6	

Organics - Semi-Volatiles

Polynuclear Aromatics, Method: SW8270D, Run Date: 08/27/21 20:54, Analyst: PL

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Acenaphthene	Not detected	700		ug/kg	1	83-32-9	K
Acenaphthylene	Not detected	700		ug/kg	1	208-96-8	K
Anthracene	Not detected	700		ug/kg	1	120-12-7	K
Benzo(a)anthracene	Not detected	700		ug/kg	1	56-55-3	K
Benzo(a)pyrene	Not detected	700		ug/kg	1	50-32-8	K
Benzo(b)fluoranthene	Not detected	700		ug/kg	1	205-99-2	K
Benzo(k)fluoranthene	Not detected	700		ug/kg	1	207-08-9	K
Benzo(ghi)perylene	Not detected	700		ug/kg	1	191-24-2	K
Chrysene	Not detected	700		ug/kg	1	218-01-9	K

T-No correction for total solids
K-Elevated reporting limit due to low total solids

Lab Sample ID: S27504.03 (continued)
Sample Tag: S3

Polynuclear Aromatics, Method: SW8270D, Run Date: 08/27/21 20:54, Analyst: PL (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Dibenzo(ah)anthracene	Not detected	700		ug/kg	1	53-70-3	K
Fluoranthene	Not detected	700		ug/kg	1	206-44-0	K
Fluorene	Not detected	700		ug/kg	1	86-73-7	K
Indeno(1,2,3-cd)pyrene	Not detected	700		ug/kg	1	193-39-5	K
Naphthalene	Not detected	700		ug/kg	1	91-20-3	K
Phenanthrene	Not detected	700		ug/kg	1	85-01-8	K
Pyrene	Not detected	700		ug/kg	1	129-00-0	K
2-Methylnaphthalene	Not detected	700		ug/kg	1	91-57-6	K
1-Methylnaphthalene	Not detected	700		ug/kg	1	90-12-0	K

Polynuclear Aromatics (Replicate 01), Method: SW8270D, Run Date: 08/27/21 20:54, Analyst: PL

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Acenaphthene	Not detected	300		ug/kg	1	83-32-9	T
Acenaphthylene	Not detected	300		ug/kg	1	208-96-8	T
Anthracene	Not detected	300		ug/kg	1	120-12-7	T
Benzo(a)anthracene	Not detected	300		ug/kg	1	56-55-3	T
Benzo(a)pyrene	Not detected	300		ug/kg	1	50-32-8	T
Benzo(b)fluoranthene	Not detected	300		ug/kg	1	205-99-2	T
Benzo(k)fluoranthene	Not detected	300		ug/kg	1	207-08-9	T
Benzo(ghi)perylene	Not detected	300		ug/kg	1	191-24-2	T
Chrysene	Not detected	300		ug/kg	1	218-01-9	T
Dibenzo(ah)anthracene	Not detected	300		ug/kg	1	53-70-3	T
Fluoranthene	Not detected	300		ug/kg	1	206-44-0	T
Fluorene	Not detected	300		ug/kg	1	86-73-7	T
Indeno(1,2,3-cd)pyrene	Not detected	300		ug/kg	1	193-39-5	T
Naphthalene	Not detected	300		ug/kg	1	91-20-3	T
Phenanthrene	Not detected	300		ug/kg	1	85-01-8	T
Pyrene	Not detected	300		ug/kg	1	129-00-0	T
2-Methylnaphthalene	Not detected	300		ug/kg	1	91-57-6	T
1-Methylnaphthalene	Not detected	300		ug/kg	1	90-12-0	T

K-Elevated reporting limit due to low total solids
T-No correction for total solids

Lab Sample ID: S27504.04
Sample Tag: S4
Collected Date/Time: 08/25/2021 09:45
Matrix: Sludge
COC Reference: 139655

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	1L Amber	None	Yes	9.6	IR
1	125ml Plastic	HNO3	Yes	9.6	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3050B	09/02/21 10:30	CCM	
PNA Extraction*	Completed	SW3546	08/26/21 12:00	JWR	
Mercury Digestion	Completed	SW7471B	09/02/21 10:45	JRH	

Inorganics

Method: SM2540B, Run Date: 08/31/21 13:45, Analyst: ELR

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Total Solids*	3.5	1		%	1		

Metals

Method: SW6020A, Run Date: 09/02/21 12:37, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Arsenic	8.69	2.5		mg/kg	2405	7440-38-2	
Barium	62.8	2.5		mg/kg	2405	7440-39-3	
Cadmium	1.64	0.25		mg/kg	2405	7440-43-9	
Chromium	11.0	2.5		mg/kg	2405	7440-47-3	
Copper	27.8	2.5		mg/kg	2405	7440-50-8	
Lead	57.2	1.25		mg/kg	2405	7439-92-1	
Selenium	Not detected	5.0		mg/kg	2405	7782-49-2	
Selenium (Replicate 01)	Not detected	0.40		mg/kg	84		T
Silver	Not detected	0.25		mg/kg	2405	7440-22-4	
Zinc	119	2.5		mg/kg	2405	7440-66-6	

Method: SW7471B, Run Date: 09/02/21 14:30, Analyst: JRH

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Mercury	0.102	0.085		mg/kg	833	7439-97-6	

Organics - Semi-Volatiles

Polynuclear Aromatics, Method: SW8270D, Run Date: 08/27/21 21:11, Analyst: PL

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Acenaphthene	Not detected	700		ug/kg	1	83-32-9	K
Acenaphthylene	Not detected	700		ug/kg	1	208-96-8	K
Anthracene	Not detected	700		ug/kg	1	120-12-7	K
Benzo(a)anthracene	Not detected	700		ug/kg	1	56-55-3	K
Benzo(a)pyrene	Not detected	700		ug/kg	1	50-32-8	K
Benzo(b)fluoranthene	Not detected	700		ug/kg	1	205-99-2	K
Benzo(k)fluoranthene	Not detected	700		ug/kg	1	207-08-9	K
Benzo(ghi)perylene	Not detected	700		ug/kg	1	191-24-2	K
Chrysene	Not detected	700		ug/kg	1	218-01-9	K

T-No correction for total solids
K-Elevated reporting limit due to low total solids

Lab Sample ID: S27504.04 (continued)
Sample Tag: S4

Polynuclear Aromatics, Method: SW8270D, Run Date: 08/27/21 21:11, Analyst: PL (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Dibenzo(ah)anthracene	Not detected	700		ug/kg	1	53-70-3	K
Fluoranthene	Not detected	700		ug/kg	1	206-44-0	K
Fluorene	Not detected	700		ug/kg	1	86-73-7	K
Indeno(1,2,3-cd)pyrene	Not detected	700		ug/kg	1	193-39-5	K
Naphthalene	Not detected	700		ug/kg	1	91-20-3	K
Phenanthrene	Not detected	700		ug/kg	1	85-01-8	K
Pyrene	Not detected	700		ug/kg	1	129-00-0	K
2-Methylnaphthalene	Not detected	700		ug/kg	1	91-57-6	K
1-Methylnaphthalene	Not detected	700		ug/kg	1	90-12-0	K

Polynuclear Aromatics (Replicate 01), Method: SW8270D, Run Date: 08/27/21 21:11, Analyst: PL

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Acenaphthene	Not detected	300		ug/kg	1	83-32-9	T
Acenaphthylene	Not detected	300		ug/kg	1	208-96-8	T
Anthracene	Not detected	300		ug/kg	1	120-12-7	T
Benzo(a)anthracene	Not detected	300		ug/kg	1	56-55-3	T
Benzo(a)pyrene	Not detected	300		ug/kg	1	50-32-8	T
Benzo(b)fluoranthene	Not detected	300		ug/kg	1	205-99-2	T
Benzo(k)fluoranthene	Not detected	300		ug/kg	1	207-08-9	T
Benzo(ghi)perylene	Not detected	300		ug/kg	1	191-24-2	T
Chrysene	Not detected	300		ug/kg	1	218-01-9	T
Dibenzo(ah)anthracene	Not detected	300		ug/kg	1	53-70-3	T
Fluoranthene	Not detected	300		ug/kg	1	206-44-0	T
Fluorene	Not detected	300		ug/kg	1	86-73-7	T
Indeno(1,2,3-cd)pyrene	Not detected	300		ug/kg	1	193-39-5	T
Naphthalene	Not detected	300		ug/kg	1	91-20-3	T
Phenanthrene	Not detected	300		ug/kg	1	85-01-8	T
Pyrene	Not detected	300		ug/kg	1	129-00-0	T
2-Methylnaphthalene	Not detected	300		ug/kg	1	91-57-6	T
1-Methylnaphthalene	Not detected	300		ug/kg	1	90-12-0	T

K-Elevated reporting limit due to low total solids
T-No correction for total solids

Lab Sample ID: S27504.05

Sample Tag: S5

Collected Date/Time: 08/25/2021 10:05

Matrix: Sludge

COC Reference: 139655

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	1L Amber	None	Yes	9.6	IR
1	125ml Plastic	HNO3	Yes	9.6	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3050B	09/02/21 10:30	CCM	
PNA Extraction*	Completed	SW3546	08/26/21 12:00	JWR	
Mercury Digestion	Completed	SW7471B	09/02/21 10:45	JRH	

Inorganics

Method: SM2540B, Run Date: 08/31/21 13:45, Analyst: ELR

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Total Solids*	2.4	1		%	1		

Metals

Method: SW6020A, Run Date: 09/02/21 12:39, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Arsenic	13.4	4.0		mg/kg	3700	7440-38-2	
Barium	85.1	4.0		mg/kg	3700	7440-39-3	
Cadmium	4.62	0.40		mg/kg	3700	7440-43-9	
Chromium	19.4	4.0		mg/kg	3700	7440-47-3	
Copper	65.0	4.0		mg/kg	3700	7440-50-8	
Lead	161	2.0		mg/kg	3700	7439-92-1	
Selenium	Not detected	8.0		mg/kg	3700	7782-49-2	
Selenium (Replicate 01)	Not detected	0.40		mg/kg	89		T
Silver	Not detected	0.40		mg/kg	3700	7440-22-4	
Zinc	286	4.0		mg/kg	3700	7440-66-6	

Method: SW7471B, Run Date: 09/02/21 14:32, Analyst: JRH

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Mercury	0.269	0.120		mg/kg	1191	7439-97-6	

Organics - Semi-Volatiles

Polynuclear Aromatics, Method: SW8270D, Run Date: 08/27/21 21:29, Analyst: PL

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Acenaphthene	Not detected	1,000		ug/kg	1	83-32-9	K
Acenaphthylene	Not detected	1,000		ug/kg	1	208-96-8	K
Anthracene	Not detected	1,000		ug/kg	1	120-12-7	K
Benzo(a)anthracene	Not detected	1,000		ug/kg	1	56-55-3	K
Benzo(a)pyrene	Not detected	1,000		ug/kg	1	50-32-8	K
Benzo(b)fluoranthene	Not detected	1,000		ug/kg	1	205-99-2	K
Benzo(k)fluoranthene	Not detected	1,000		ug/kg	1	207-08-9	K
Benzo(ghi)perylene	Not detected	1,000		ug/kg	1	191-24-2	K
Chrysene	Not detected	1,000		ug/kg	1	218-01-9	K

T-No correction for total solids

K-Elevated reporting limit due to low total solids

Lab Sample ID: S27504.05 (continued)
Sample Tag: S5

Polynuclear Aromatics, Method: SW8270D, Run Date: 08/27/21 21:29, Analyst: PL (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Dibenzo(ah)anthracene	Not detected	1,000		ug/kg	1	53-70-3	K
Fluoranthene	Not detected	1,000		ug/kg	1	206-44-0	K
Fluorene	Not detected	1,000		ug/kg	1	86-73-7	K
Indeno(1,2,3-cd)pyrene	Not detected	1,000		ug/kg	1	193-39-5	K
Naphthalene	Not detected	1,000		ug/kg	1	91-20-3	K
Phenanthrene	Not detected	1,000		ug/kg	1	85-01-8	K
Pyrene	Not detected	1,000		ug/kg	1	129-00-0	K
2-Methylnaphthalene	Not detected	1,000		ug/kg	1	91-57-6	K
1-Methylnaphthalene	Not detected	1,000		ug/kg	1	90-12-0	K

Polynuclear Aromatics (Replicate 01), Method: SW8270D, Run Date: 08/27/21 21:29, Analyst: PL

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Acenaphthene	Not detected	300		ug/kg	1	83-32-9	T
Acenaphthylene	Not detected	300		ug/kg	1	208-96-8	T
Anthracene	Not detected	300		ug/kg	1	120-12-7	T
Benzo(a)anthracene	Not detected	300		ug/kg	1	56-55-3	T
Benzo(a)pyrene	Not detected	300		ug/kg	1	50-32-8	T
Benzo(b)fluoranthene	Not detected	300		ug/kg	1	205-99-2	T
Benzo(k)fluoranthene	Not detected	300		ug/kg	1	207-08-9	T
Benzo(ghi)perylene	Not detected	300		ug/kg	1	191-24-2	T
Chrysene	Not detected	300		ug/kg	1	218-01-9	T
Dibenzo(ah)anthracene	Not detected	300		ug/kg	1	53-70-3	T
Fluoranthene	Not detected	300		ug/kg	1	206-44-0	T
Fluorene	Not detected	300		ug/kg	1	86-73-7	T
Indeno(1,2,3-cd)pyrene	Not detected	300		ug/kg	1	193-39-5	T
Naphthalene	Not detected	300		ug/kg	1	91-20-3	T
Phenanthrene	Not detected	300		ug/kg	1	85-01-8	T
Pyrene	Not detected	300		ug/kg	1	129-00-0	T
2-Methylnaphthalene	Not detected	300		ug/kg	1	91-57-6	T
1-Methylnaphthalene	Not detected	300		ug/kg	1	90-12-0	T

K-Elevated reporting limit due to low total solids
T-No correction for total solids

Lab Sample ID: S27504.06
Sample Tag: S6
Collected Date/Time: 08/25/2021 10:20
Matrix: Sludge
COC Reference: 139655

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	1L Amber	None	Yes	9.6	IR
1	125ml Plastic	HNO3	Yes	9.6	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3050B	09/02/21 10:30	CCM	
PNA Extraction*	Completed	SW3546	08/26/21 12:00	JWR	
Mercury Digestion	Completed	SW7471B	09/02/21 10:45	JRH	

Inorganics

Method: SM2540B, Run Date: 08/31/21 13:45, Analyst: ELR

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Total Solids*	2.9	1		%	1		

Metals

Method: SW6020A, Run Date: 09/02/21 12:42, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Arsenic	7.05	3.0		mg/kg	2903	7440-38-2	
Barium	55.3	3.0		mg/kg	2903	7440-39-3	
Cadmium	1.06	0.30		mg/kg	2903	7440-43-9	
Chromium	11.1	3.0		mg/kg	2903	7440-47-3	
Copper	27.1	3.0		mg/kg	2903	7440-50-8	
Lead	29.1	1.5		mg/kg	2903	7439-92-1	
Selenium	Not detected	6.0		mg/kg	2903	7782-49-2	
Selenium (Replicate 01)	Not detected	0.40		mg/kg	84		T
Silver	Not detected	0.30		mg/kg	2903	7440-22-4	
Zinc	84.8	3.0		mg/kg	2903	7440-66-6	

Method: SW7471B, Run Date: 09/02/21 14:34, Analyst: JRH

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Mercury	Not detected	0.100		mg/kg	1000	7439-97-6	

Organics - Semi-Volatiles

Polynuclear Aromatics, Method: SW8270D, Run Date: 08/27/21 21:46, Analyst: PL

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Acenaphthene	Not detected	800		ug/kg	1	83-32-9	K
Acenaphthylene	Not detected	800		ug/kg	1	208-96-8	K
Anthracene	Not detected	800		ug/kg	1	120-12-7	K
Benzo(a)anthracene	Not detected	800		ug/kg	1	56-55-3	K
Benzo(a)pyrene	Not detected	800		ug/kg	1	50-32-8	K
Benzo(b)fluoranthene	Not detected	800		ug/kg	1	205-99-2	K
Benzo(k)fluoranthene	Not detected	800		ug/kg	1	207-08-9	K
Benzo(ghi)perylene	Not detected	800		ug/kg	1	191-24-2	K
Chrysene	Not detected	800		ug/kg	1	218-01-9	K

T-No correction for total solids
K-Elevated reporting limit due to low total solids

Lab Sample ID: S27504.06 (continued)
Sample Tag: S6

Polynuclear Aromatics, Method: SW8270D, Run Date: 08/27/21 21:46, Analyst: PL (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Dibenzo(ah)anthracene	Not detected	800		ug/kg	1	53-70-3	K
Fluoranthene	Not detected	800		ug/kg	1	206-44-0	K
Fluorene	Not detected	800		ug/kg	1	86-73-7	K
Indeno(1,2,3-cd)pyrene	Not detected	800		ug/kg	1	193-39-5	K
Naphthalene	Not detected	800		ug/kg	1	91-20-3	K
Phenanthrene	Not detected	800		ug/kg	1	85-01-8	K
Pyrene	Not detected	800		ug/kg	1	129-00-0	K
2-Methylnaphthalene	Not detected	800		ug/kg	1	91-57-6	K
1-Methylnaphthalene	Not detected	800		ug/kg	1	90-12-0	K

Polynuclear Aromatics (Replicate 01), Method: SW8270D, Run Date: 08/27/21 21:46, Analyst: PL

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Acenaphthene	Not detected	300		ug/kg	1	83-32-9	T
Acenaphthylene	Not detected	300		ug/kg	1	208-96-8	T
Anthracene	Not detected	300		ug/kg	1	120-12-7	T
Benzo(a)anthracene	Not detected	300		ug/kg	1	56-55-3	T
Benzo(a)pyrene	Not detected	300		ug/kg	1	50-32-8	T
Benzo(b)fluoranthene	Not detected	300		ug/kg	1	205-99-2	T
Benzo(k)fluoranthene	Not detected	300		ug/kg	1	207-08-9	T
Benzo(ghi)perylene	Not detected	300		ug/kg	1	191-24-2	T
Chrysene	Not detected	300		ug/kg	1	218-01-9	T
Dibenzo(ah)anthracene	Not detected	300		ug/kg	1	53-70-3	T
Fluoranthene	Not detected	300		ug/kg	1	206-44-0	T
Fluorene	Not detected	300		ug/kg	1	86-73-7	T
Indeno(1,2,3-cd)pyrene	Not detected	300		ug/kg	1	193-39-5	T
Naphthalene	Not detected	300		ug/kg	1	91-20-3	T
Phenanthrene	Not detected	300		ug/kg	1	85-01-8	T
Pyrene	Not detected	300		ug/kg	1	129-00-0	T
2-Methylnaphthalene	Not detected	300		ug/kg	1	91-57-6	T
1-Methylnaphthalene	Not detected	300		ug/kg	1	90-12-0	T

K-Elevated reporting limit due to low total solids
T-No correction for total solids

Lab Sample ID: S27504.07
Sample Tag: S7
Collected Date/Time: 08/25/2021 10:35
Matrix: Sludge
COC Reference: 139655

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	1L Amber	None	Yes	9.6	IR
1	125ml Plastic	HNO3	Yes	9.6	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3050B	09/02/21 10:30	CCM	
PNA Extraction*	Completed	SW3546	08/26/21 12:00	JWR	
Mercury Digestion	Completed	SW7471B	09/02/21 10:45	JRH	

Inorganics

Method: SM2540B, Run Date: 08/31/21 13:45, Analyst: ELR

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Total Solids*	1.8	1		%	1		

Metals

Method: SW6020A, Run Date: 09/02/21 12:45, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Arsenic	12.1	5.5		mg/kg	5041	7440-38-2	
Barium	94.0	5.5		mg/kg	5041	7440-39-3	
Cadmium	3.57	0.55		mg/kg	5041	7440-43-9	
Chromium	27.3	5.5		mg/kg	5041	7440-47-3	
Copper	65.8	5.5		mg/kg	5041	7440-50-8	
Lead	128	2.75		mg/kg	5041	7439-92-1	
Selenium	Not detected	11.0		mg/kg	5041	7782-49-2	
Selenium (Replicate 01)	Not detected	0.40		mg/kg	91		T
Silver	Not detected	0.55		mg/kg	5041	7440-22-4	
Zinc	282	5.5		mg/kg	5041	7440-66-6	

Method: SW7471B, Run Date: 09/02/21 14:36, Analyst: JRH

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Mercury	0.323	0.160		mg/kg	1563	7439-97-6	

Organics - Semi-Volatiles

Polynuclear Aromatics, Method: SW8270D, Run Date: 08/27/21 22:03, Analyst: PL

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Acenaphthene	Not detected	1,400		ug/kg	1	83-32-9	K
Acenaphthylene	Not detected	1,400		ug/kg	1	208-96-8	K
Anthracene	Not detected	1,400		ug/kg	1	120-12-7	K
Benzo(a)anthracene	Not detected	1,400		ug/kg	1	56-55-3	K
Benzo(a)pyrene	Not detected	1,400		ug/kg	1	50-32-8	K
Benzo(b)fluoranthene	Not detected	1,400		ug/kg	1	205-99-2	K
Benzo(k)fluoranthene	Not detected	1,400		ug/kg	1	207-08-9	K
Benzo(ghi)perylene	Not detected	1,400		ug/kg	1	191-24-2	K
Chrysene	Not detected	1,400		ug/kg	1	218-01-9	K

T-No correction for total solids
K-Elevated reporting limit due to low total solids

Lab Sample ID: S27504.07 (continued)
Sample Tag: S7

Polynuclear Aromatics, Method: SW8270D, Run Date: 08/27/21 22:03, Analyst: PL (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Dibenzo(ah)anthracene	Not detected	1,400		ug/kg	1	53-70-3	K
Fluoranthene	Not detected	1,400		ug/kg	1	206-44-0	K
Fluorene	Not detected	1,400		ug/kg	1	86-73-7	K
Indeno(1,2,3-cd)pyrene	Not detected	1,400		ug/kg	1	193-39-5	K
Naphthalene	Not detected	1,400		ug/kg	1	91-20-3	K
Phenanthrene	Not detected	1,400		ug/kg	1	85-01-8	K
Pyrene	Not detected	1,400		ug/kg	1	129-00-0	K
2-Methylnaphthalene	Not detected	1,400		ug/kg	1	91-57-6	K
1-Methylnaphthalene	Not detected	1,400		ug/kg	1	90-12-0	K

Polynuclear Aromatics (Replicate 01), Method: SW8270D, Run Date: 08/27/21 22:03, Analyst: PL

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Acenaphthene	Not detected	300		ug/kg	1	83-32-9	T
Acenaphthylene	Not detected	300		ug/kg	1	208-96-8	T
Anthracene	Not detected	300		ug/kg	1	120-12-7	T
Benzo(a)anthracene	Not detected	300		ug/kg	1	56-55-3	T
Benzo(a)pyrene	Not detected	300		ug/kg	1	50-32-8	T
Benzo(b)fluoranthene	Not detected	300		ug/kg	1	205-99-2	T
Benzo(k)fluoranthene	Not detected	300		ug/kg	1	207-08-9	T
Benzo(ghi)perylene	Not detected	300		ug/kg	1	191-24-2	T
Chrysene	Not detected	300		ug/kg	1	218-01-9	T
Dibenzo(ah)anthracene	Not detected	300		ug/kg	1	53-70-3	T
Fluoranthene	Not detected	300		ug/kg	1	206-44-0	T
Fluorene	Not detected	300		ug/kg	1	86-73-7	T
Indeno(1,2,3-cd)pyrene	Not detected	300		ug/kg	1	193-39-5	T
Naphthalene	Not detected	300		ug/kg	1	91-20-3	T
Phenanthrene	Not detected	300		ug/kg	1	85-01-8	T
Pyrene	Not detected	300		ug/kg	1	129-00-0	T
2-Methylnaphthalene	Not detected	300		ug/kg	1	91-57-6	T
1-Methylnaphthalene	Not detected	300		ug/kg	1	90-12-0	T

K-Elevated reporting limit due to low total solids
T-No correction for total solids

Lab Sample ID: S27504.08
Sample Tag: S8
Collected Date/Time: 08/25/2021 10:50
Matrix: Sludge
COC Reference: 139655

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	1L Amber	None	Yes	9.6	IR
1	125ml Plastic	HNO3	Yes	9.6	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Metal Digestion	Completed	SW3050B	09/02/21 10:30	CCM	
PNA Extraction*	Completed	SW3546	08/26/21 12:00	JWR	
Mercury Digestion	Completed	SW7471B	09/02/21 10:45	JRH	

Inorganics

Method: SM2540B, Run Date: 08/31/21 13:45, Analyst: ELR

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Total Solids*	2.2	1		%	1		

Metals

Method: SW6020A, Run Date: 09/02/21 12:48, Analyst: CCM

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Arsenic	4.94	4.0		mg/kg	3905	7440-38-2	
Barium	69.3	4.0		mg/kg	3905	7440-39-3	
Cadmium	2.74	0.40		mg/kg	3905	7440-43-9	
Chromium	17.9	4.0		mg/kg	3905	7440-47-3	
Copper	42.2	4.0		mg/kg	3905	7440-50-8	
Lead	64.2	2.0		mg/kg	3905	7439-92-1	
Selenium	Not detected	8.0		mg/kg	3905	7782-49-2	
Selenium (Replicate 01)	Not detected	0.40		mg/kg	86		T
Silver	Not detected	0.40		mg/kg	3905	7440-22-4	
Zinc	185	4.0		mg/kg	3905	7440-66-6	

Method: SW7471B, Run Date: 09/02/21 14:37, Analyst: JRH

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Mercury	0.209	0.135		mg/kg	1316	7439-97-6	

Organics - Semi-Volatiles

Polynuclear Aromatics, Method: SW8270D, Run Date: 08/27/21 22:20, Analyst: PL

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Acenaphthene	Not detected	1,100		ug/kg	1	83-32-9	K
Acenaphthylene	Not detected	1,100		ug/kg	1	208-96-8	K
Anthracene	Not detected	1,100		ug/kg	1	120-12-7	K
Benzo(a)anthracene	Not detected	1,100		ug/kg	1	56-55-3	K
Benzo(a)pyrene	Not detected	1,100		ug/kg	1	50-32-8	K
Benzo(b)fluoranthene	Not detected	1,100		ug/kg	1	205-99-2	K
Benzo(k)fluoranthene	Not detected	1,100		ug/kg	1	207-08-9	K
Benzo(ghi)perylene	Not detected	1,100		ug/kg	1	191-24-2	K
Chrysene	Not detected	1,100		ug/kg	1	218-01-9	K

T-No correction for total solids
K-Elevated reporting limit due to low total solids

Lab Sample ID: S27504.08 (continued)

Sample Tag: S8

Polynuclear Aromatics, Method: SW8270D, Run Date: 08/27/21 22:20, Analyst: PL (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Dibenzo(ah)anthracene	Not detected	1,100		ug/kg	1	53-70-3	K
Fluoranthene	Not detected	1,100		ug/kg	1	206-44-0	K
Fluorene	Not detected	1,100		ug/kg	1	86-73-7	K
Indeno(1,2,3-cd)pyrene	Not detected	1,100		ug/kg	1	193-39-5	K
Naphthalene	Not detected	1,100		ug/kg	1	91-20-3	K
Phenanthrene	Not detected	1,100		ug/kg	1	85-01-8	K
Pyrene	Not detected	1,100		ug/kg	1	129-00-0	K
2-Methylnaphthalene	Not detected	1,100		ug/kg	1	91-57-6	K
1-Methylnaphthalene	Not detected	1,100		ug/kg	1	90-12-0	K

Polynuclear Aromatics (Replicate 01), Method: SW8270D, Run Date: 08/27/21 22:20, Analyst: PL

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Acenaphthene	Not detected	300		ug/kg	1	83-32-9	T
Acenaphthylene	Not detected	300		ug/kg	1	208-96-8	T
Anthracene	Not detected	300		ug/kg	1	120-12-7	T
Benzo(a)anthracene	Not detected	300		ug/kg	1	56-55-3	T
Benzo(a)pyrene	Not detected	300		ug/kg	1	50-32-8	T
Benzo(b)fluoranthene	Not detected	300		ug/kg	1	205-99-2	T
Benzo(k)fluoranthene	Not detected	300		ug/kg	1	207-08-9	T
Benzo(ghi)perylene	Not detected	300		ug/kg	1	191-24-2	T
Chrysene	Not detected	300		ug/kg	1	218-01-9	T
Dibenzo(ah)anthracene	Not detected	300		ug/kg	1	53-70-3	T
Fluoranthene	Not detected	300		ug/kg	1	206-44-0	T
Fluorene	Not detected	300		ug/kg	1	86-73-7	T
Indeno(1,2,3-cd)pyrene	Not detected	300		ug/kg	1	193-39-5	T
Naphthalene	Not detected	300		ug/kg	1	91-20-3	T
Phenanthrene	Not detected	300		ug/kg	1	85-01-8	T
Pyrene	Not detected	300		ug/kg	1	129-00-0	T
2-Methylnaphthalene	Not detected	300		ug/kg	1	91-57-6	T
1-Methylnaphthalene	Not detected	300		ug/kg	1	90-12-0	T

K-Elevated reporting limit due to low total solids

T-No correction for total solids

Merit Laboratories Login Checklist

Lab Set ID: S27504
Client: KIESER (Kieser & Associates)
Project: Cedar Lake
Submitted: 08/25/2021 15:30 Login User: PFD

Attention: Josh Kieser
Address: Kieser & Associates
536 E. Michigan Ave. Ste 300
Kalamazoo, MI 49007

Phone: 269-344-7117 FAX:
Email: JKieser@kieser-associates.com

Selection			Description	Note
Sample Receiving				
01.	[X] Yes [ ] No [ ] N/A		Samples are received at 4C +/- 2C Thermometer #	IR 9.6
02.	[X] Yes [ ] No [ ] N/A		Received on ice/ cooling process begun	
03.	[ ] Yes [X] No [ ] N/A		Samples shipped	
04.	[ ] Yes [X] No [ ] N/A		Samples left in 24 hr. drop box	
05.	[ ] Yes [ ] No [X] N/A		Are there custody seals/tape or is the drop box locked	
Chain of Custody				
06.	[X] Yes [ ] No [ ] N/A		COC adequately filled out	
07.	[X] Yes [ ] No [ ] N/A		COC signed and relinquished to the lab	
08.	[X] Yes [ ] No [ ] N/A		Sample tag on bottles match COC	
09.	[ ] Yes [X] No [ ] N/A		Subcontracting needed? Subcontacted to:	
Preservation				
10.	[X] Yes [ ] No [ ] N/A		Do sample have correct chemical preservation	
11.	[ ] Yes [X] No [ ] N/A		Completed pH checks on preserved samples? (no VOAs)	Preserved bottles will not be used
12.	[ ] Yes [X] No [ ] N/A		Did any samples need to be preserved in the lab?	
Bottle Conditions				
13.	[X] Yes [ ] No [ ] N/A		All bottles intact	
14.	[X] Yes [ ] No [ ] N/A		Appropriate analytical bottles are used	
15.	[X] Yes [ ] No [ ] N/A		Merit bottles used	
16.	[X] Yes [ ] No [ ] N/A		Sufficient sample volume received	
17.	[ ] Yes [X] No [ ] N/A		Samples require laboratory filtration	
18.	[X] Yes [ ] No [ ] N/A		Samples submitted within holding time	
19.	[ ] Yes [ ] No [X] N/A		Do water VOC or TOX bottles contain headspace	

Corrective action for all exceptions is to call the client and to notify the project manager.

Client Review By: ________________________________ Date:______________

Merit Laboratories Bottle Preservation Check

Lab Set ID: S27504 Submitted: 08/25/2021 15:30

Client: KIESER (Kieser & Associates)

Project: Cedar Lake

Initial Preservation Check: 08/31/2021 09:05 MMC

Preservation Recheck (E200.8): N/A

Attention: Josh Kieser
Address: Kieser & Associates
536 E. Michigan Ave. Ste 300
Kalamazoo, MI 49007

Phone: 269-344-7117 FAX:
Email: JKieser@kieser-associates.com

Sample ID	Bottle / Preservation	pH (Orig)	Add ml	pH (New)	Notes
S27504.01	125ml Plastic HNO3	<2			
S27504.02	125ml Plastic HNO3	<2			
S27504.03	125ml Plastic HNO3	<2			
S27504.04	125ml Plastic HNO3	<2			
S27504.05	125ml Plastic HNO3	<2			
S27504.06	125ml Plastic HNO3	<2			
S27504.07	125ml Plastic HNO3	<2			
S27504.08	125ml Plastic HNO3	<2			

Merit Laboratories, Inc.

2680 East Lansing Dr., East Lansing, MI 48823
Phone (517) 332-0167 Fax (517) 332-4034
www.meritlabs.com

C.O.C. PAGE # ______ OF ______

139655

CHAIN OF CUSTODY RECORD

REPORT TO

CONTACT NAME	Josh Kieser
COMPANY	Kieser & Associates
ADDRESS	536 E Michigan Ave
CITY	Kalamazoo
STATE	MI
ZIP CODE	49007
PHONE NO.	(269) 344-7117
FAX NO.	
P.O. NO.	
E-MAIL ADDRESS	jKieser@Kieser-associates.com
QUOTE NO.	
PROJECT NO./NAME	Cedar Lake
SAMPLER(S) - PLEASE PRINT/SIGN NAME	Josh Kieser

INVOICE TO

☒ SAME

CONTACT NAME	
COMPANY	
ADDRESS	
CITY	
STATE	
ZIP CODE	
PHONE NO.	
E-MAIL ADDRESS	

TURNAROUND TIME REQUIRED ☐ 1 DAY ☐ 2 DAYS ☐ 3 DAYS ☒ STANDARD ☐ OTHER ______

DELIVERABLES REQUIRED ☒ STD ☐ LEVEL II ☐ LEVEL III ☐ LEVEL IV ☐ EDD ☐ OTHER ______

MATRIX CODE: GW=GROUNDWATER WW=WASTEWATER S=SOIL L=LIQUID SD=SOLID SL=SLUDGE DW=DRINKING WATER O=OIL WP=WIPE A=AIR W=WASTE

ANALYSIS (ATTACH LIST IF MORE SPACE IS REQUIRED)

Certifications: ☐ OHIO VAP ☐ Drinking Water ☐ DoD ☐ NPDES

Project Locations: ☐ Detroit ☐ New York ☐ Other ______

MERIT LAB NO. (FOR LAB USE ONLY)	DATE	TIME	SAMPLE TAG IDENTIFICATION-DESCRIPTION	MATRIX	# OF BOTTLES	NONE	HCl	HNO_3	H_2SO_4	NaOH	MeOH	OTHER	PFAS	MI-10-Metals	PAH'S	Special Instructions
27504.01	8-25-21	8:45A	S1	S	6	5		1					X	X	X	27505(PFAS).01
.02		9:00A	S2	S	6	5		1					X	X	X	.02
.03		9:25A	S3	S	6	5		1					X	X	X	.03
.04		9:45A	S4	S	6	5		1					X	X	X	.04
.05		10:05A	S5	S	6	5		1					X	X	X	.05
.06		10:20A	S6	S	6	5		1					X	X	X	.06
.07		10:35A	S7	S	6	5		1					X	X	X	.07
.08		10:50A	S8	S	6	5		1					X	X	X	.08

RELINQUISHED BY: SIGNATURE/ORGANIZATION	Zach Horton ☐ Sampler	DATE 8-25-21	TIME 3:00p
RECEIVED BY: SIGNATURE/ORGANIZATION	[signature]	DATE 8/25/21	TIME 1530
RELINQUISHED BY: SIGNATURE/ORGANIZATION		DATE	TIME
RECEIVED BY: SIGNATURE/ORGANIZATION		DATE	TIME
RELINQUISHED BY: SIGNATURE/ORGANIZATION		DATE	TIME
RECEIVED BY: SIGNATURE/ORGANIZATION		DATE	TIME

SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS

SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS

NOTES: TEMP. ON ARRIVAL 9.6

PLEASE NOTE: SIGNING ACKNOWLEDGES ADHERENCE TO MERIT'S SAMPLE ACCEPTANCE POLICY

Analytical Laboratory Report

Report ID: S27505.01(01)
Generated on 09/16/2021

Report to

Attention: Josh Kieser
Kieser & Associates
536 E. Michigan Ave. Ste 300
Kalamazoo, MI 49007

Phone: 269-344-7117 FAX:
Email: JKieser@kieser-associates.com

Addtional Contacts: Doug Ervin, Becky Hough

Report produced by

Merit Laboratories, Inc.
2680 East Lansing Drive
East Lansing, MI 48823

Phone: (517) 332-0167 FAX: (517) 332-6333

Contacts for report questions:
John Laverty (johnlaverty@meritlabs.com)
Barbara Ball (bball@meritlabs.com)

Report Summary

Lab Sample ID(s): S27505.01-S27505.08
Project: Cedar Lake
Collected Date(s): 08/25/2021
Submitted Date/Time: 08/25/2021 15:30
Sampled by: Josh Kieser
P.O. #:

Table of Contents

Maya Murshak
Technical Director

General Report Notes

Analytical results relate only to the samples tested, in the condition received by the laboratory.
Methods may be modified for improved performance.
Results reported on a dry weight basis where applicable.
'Not detected' indicates that parameter was not found at a level equal to or greater than the reporting limit (RL).
40 CFR Part 136 Table II Required Containers, Preservation Techniques and Holding Times for the Clean Water Act specify that samples for acrolein and acrylonitrile need to be preserved at a pH in the range of 4 to 5 or if not preserved, analyzed within 3 days of sampling.
QA/QC corresponding to this analytical report is a separate document with the same Merit ID reference and is available upon request.
Full accreditation certificates are available upon request. Starred (*) analytes are not NELAP accredited.
Samples are held by the lab for 30 days from the final report date unless a written request to hold longer is provided by the client.
Report shall not be reproduced except in full, without the written approval of Merit Laboratories, Inc.
Limits for drinking water samples, are listed as the MCL Limits (Maximum Contaminant Level Concentrations)
PFAS requirement: Section 9.3.8 of U.S. EPA Method 537.1 states "If the method analyte(s) found in the Field Sample is present in the FRB at a concentration greater than 1/3 the MRL, then all samples collected with that FRB are invalid and must be recollected and reanalyzed."
Samples submitted without an accompanying FRB may not be acceptable for compliance purposes.

Report Narrative

There is no additional narrative for this analytical report

Laboratory Certifications

Authority	Certification ID
Michigan DEQ	#9956
DOD ELAP/ISO 17025	#69699
WBENC	#2005110032
Ohio VAP	#CL0002
Indiana DOH	#C-MI-07
New York NELAC	#11814
North Carolina DENR	#680
North Carolina DOH	#26702
Alaska CSLAP	#17-001
Pennsylvania DEP	#68-05884

Qualifier Descriptions

Qualifier	Description
!	Result is outside of stated limit criteria
B	Compound also found in associated method blank
E	Concentration exceeds calibration range
F	Analysis run outside of holding time
G	Estimated result due to extraction run outside of holding time
H	Sample submitted and run outside of holding time
I	Matrix interference with internal standard
J	Estimated value less than reporting limit, but greater than MDL
L	Elevated reporting limit due to low sample amount
M	Result reported to MDL not RDL
O	Analysis performed by outside laboratory. See attached report.
R	Preliminary result
S	Surrogate recovery outside of control limits
T	No correction for total solids
X	Elevated reporting limit due to matrix interference
Y	Elevated reporting limit due to high target concentration
b	Value detected less than reporting limit, but greater than MDL
e	Reported value estimated due to interference
j	Analyte also found in associated method blank
p	Benzo(b)Fluoranthene and Benzo(k)Fluoranthene integrated as one peak.
x	Preserved from bulk sample

Glossary of Abbreviations

Abbreviation	Description
RL/RDL	Reporting Limit
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
SW	EPA SW 846 (Soil and Wastewater) Methods
E	EPA Methods
SM	Standard Methods
LN	Linear
BR	Branched

Method Summary

Method	Version
ASTM D7968-17M	ASTM Method D7968 - 17 Modified (Isotopic Dilution)
SM2540B	Standard Method 2540 B 2011

Parameter Summary

Parameter	Synonym	Cas #
PFBA	Perfluorobutanoic Acid	375-22-4
PFPeA	Perfluoropentanoic Acid	2706-90-3
4:2 FTSA	4:2 Fluorotelomer Sulfonic Acid	757124-72-4
PFHxA	Perfluorohexanoic Acid	307-24-4
PFBS	Perfluorobutane sulfonic Acid	375-73-5
PFHpA	Perfluoroheptanoic Acid	375-85-9
PFPeS	Perfluoropentane Sulfonic Acid	2706-91-4
6:2 FTSA	6:2 Fluorotelomer Sulfonic Acid	27619-97-2
PFOA	Perfluorooctanoic Acid	335-67-1
PFHxS	Perfluorohexane Sulfonic Acid	355-46-4
PFHxS-LN	Perfluorohexane Sulfonic Acid - LN	355-46-4-LN
PFHxS-BR	Perfluorohexane Sulfonic Acid - BR	355-46-4-BR
PFNA	Perfluorononanoic Acid	375-95-1
8:2 FTSA	8:2 Fluorotelomer Sulfonic Acid	39108-34-4
PFHpS	Perfluoroheptane Sulfonic Acid	375-92-8
PFDA	Perfluorodecanoic Acid	335-76-2
N-MeFOSAA	N-methyl perfluorooctanesulfonamidoacetic acid	2355-31-9
EtFOSAA	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid	2991-50-6
PFOS	Perfluorooctane Sulfonic Acid	1763-23-1
PFOS-LN	Perfluorooctane Sulfonic Acid - LN	1763-23-1-LN
PFOS-BR	Perfluorooctane Sulfonic Acid - BR	1763-23-1-BR
PFUnDA	Perfluoroundecanoic Acid	2058-94-8
PFNS	Perfluorononane Sulfonic Acid	68259-12-1
PFDoDA	Perfluorododecanoic Acid	307-55-1
PFDS	Perfluorodecane Sulfonic Acid	335-77-3
PFTrDA	Perfluorotridecanoic Acid	72629-94-8
FOSA	Perfluorooctane Sulfonamide	754-91-6
PFTeDA	Perfluorotetradecanoic Acid	376-06-7
11Cl-PF3OUdS	11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9
9Cl-PF3ONS	9-chlorohexadecafluoro-3-oxanone1-sulfonic acid	756426-58-1
ADONA	4,8-dioxa-3H-perfluorononanoic acid	919005-14-4
HFPO-DA	Hexafluoropropylene oxide dimer	13252-13-6

Analytical Laboratory Report

Sample Summary (8 samples)

Sample ID	Sample Tag	Matrix	Collected Date/Time
S27505.01	S1	Sludge	08/25/21 08:45
S27505.02	S2	Sludge	08/25/21 09:00
S27505.03	S3	Sludge	08/25/21 09:25
S27505.04	S4	Sludge	08/25/21 09:45
S27505.05	S5	Sludge	08/25/21 10:05
S27505.06	S6	Sludge	08/25/21 10:20
S27505.07	S7	Sludge	08/25/21 10:35
S27505.08	S8	Sludge	08/25/21 10:50

Analytical Laboratory Report

Lab Sample ID: S27505.01
Sample Tag: S1
Collected Date/Time: 08/25/2021 08:45
Matrix: Sludge
COC Reference: 139655

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	15ml Centrifuge Tube	None	Yes	9.6	IR
1	250ml Plastic	None	Yes	9.6	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Initial wt. (g) / Final wt. (g) / Volume (ml)*	11.30/6.98/10	ASTM D7968-17M	09/09/21 15:00	KCV	

Inorganics

Method: SM2540B, Run Date: 08/27/21 17:20, Analyst: ELR

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Total Solids*	7.4	1		%	1		

Organics

28 PFAs, Method: ASTM D7968-17M, Run Date: 09/11/21 22:05, Analyst: KCV

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
PFBA*	Not detected	630		ng/kg	31.3	375-22-4	
PFPeA*	Not detected	310		ng/kg	31.3	2706-90-3	
4:2 FTSA*	Not detected	310		ng/kg	31.3	757124-72-4	
PFHxA*	Not detected	310		ng/kg	31.3	307-24-4	
PFBS*	Not detected	310		ng/kg	31.3	375-73-5	
PFHpA*	Not detected	310		ng/kg	31.3	375-85-9	
PFPeS*	Not detected	310		ng/kg	31.3	2706-91-4	
6:2 FTSA*	Not detected	310		ng/kg	31.3	27619-97-2	
PFOA*	Not detected	310		ng/kg	31.3	335-67-1	
PFHxS*	Not detected	310		ng/kg	31.3	355-46-4	
PFHxS-LN*	Not detected	310		ng/kg	31.3	355-46-4-LN	
PFHxS-BR*	Not detected	310		ng/kg	31.3	355-46-4-BR	
PFNA*	Not detected	310		ng/kg	31.3	375-95-1	
8:2 FTSA*	Not detected	310		ng/kg	31.3	39108-34-4	
PFHpS*	Not detected	310		ng/kg	31.3	375-92-8	
PFDA*	Not detected	310		ng/kg	31.3	335-76-2	
N-MeFOSAA*	Not detected	310		ng/kg	31.3	2355-31-9	I
EtFOSAA*	Not detected	310		ng/kg	31.3	2991-50-6	
PFOS*	Not detected	310		ng/kg	31.3	1763-23-1	
PFOS-LN*	Not detected	310		ng/kg	31.3	1763-23-1-LN	
PFOS-BR*	Not detected	310		ng/kg	31.3	1763-23-1-BR	
PFUnDA*	Not detected	310		ng/kg	31.3	2058-94-8	
PFNS*	Not detected	310		ng/kg	31.3	68259-12-1	
PFDoDA*	Not detected	310		ng/kg	31.3	307-55-1	I
PFDS*	Not detected	310		ng/kg	31.3	335-77-3	
PFTrDA*	Not detected	310		ng/kg	31.3	72629-94-8	I
FOSA*	Not detected	310		ng/kg	31.3	754-91-6	
PFTeDA*	Not detected	310		ng/kg	31.3	376-06-7	I1
11Cl-PF3OUdS*	Not detected	310		ng/kg	31.3	763051-92-9	

I-Matrix interference with internal standard
1-IS recovery < 10%

Analytical Laboratory Report

Lab Sample ID: S27505.01 (continued)
Sample Tag: S1

28 PFAs, Method: ASTM D7968-17M, Run Date: 09/11/21 22:05, Analyst: KCV (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
9Cl-PF3ONS*	Not detected	310		ng/kg	31.3	756426-58-1	
ADONA*	Not detected	310		ng/kg	31.3	919005-14-4	
HFPO-DA*	Not detected	310		ng/kg	31.3	13252-13-6	

Analytical Laboratory Report

Lab Sample ID: S27505.02
Sample Tag: S2
Collected Date/Time: 08/25/2021 09:00
Matrix: Sludge
COC Reference: 139655

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	15ml Centrifuge Tube	None	Yes	9.6	IR
1	250ml Plastic	None	Yes	9.6	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Initial wt. (g) / Final wt. (g) / Volume (ml)*	11.49/7.08/10	ASTM D7968-17M	09/09/21 15:00	KCV	

Inorganics

Method: SM2540B, Run Date: 08/27/21 17:20, Analyst: ELR

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Total Solids*	6.6	1		%	1		

Organics

28 PFAs, Method: ASTM D7968-17M, Run Date: 09/11/21 22:25, Analyst: KCV

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
PFBA*	Not detected	690		ng/kg	34.4	375-22-4	
PFPeA*	Not detected	340		ng/kg	34.4	2706-90-3	
4:2 FTSA*	Not detected	340		ng/kg	34.4	757124-72-4	
PFHxA*	Not detected	340		ng/kg	34.4	307-24-4	
PFBS*	Not detected	340		ng/kg	34.4	375-73-5	
PFHpA*	Not detected	340		ng/kg	34.4	375-85-9	
PFPeS*	Not detected	340		ng/kg	34.4	2706-91-4	
6:2 FTSA*	Not detected	340		ng/kg	34.4	27619-97-2	
PFOA*	Not detected	340		ng/kg	34.4	335-67-1	
PFHxS*	Not detected	340		ng/kg	34.4	355-46-4	
PFHxS-LN*	Not detected	340		ng/kg	34.4	355-46-4-LN	
PFHxS-BR*	Not detected	340		ng/kg	34.4	355-46-4-BR	
PFNA*	Not detected	340		ng/kg	34.4	375-95-1	
8:2 FTSA*	Not detected	340		ng/kg	34.4	39108-34-4	
PFHpS*	Not detected	340		ng/kg	34.4	375-92-8	
PFDA*	Not detected	340		ng/kg	34.4	335-76-2	
N-MeFOSAA*	Not detected	340		ng/kg	34.4	2355-31-9	
EtFOSAA*	Not detected	340		ng/kg	34.4	2991-50-6	
PFOS*	Not detected	340		ng/kg	34.4	1763-23-1	
PFOS-LN*	Not detected	340		ng/kg	34.4	1763-23-1-LN	
PFOS-BR*	Not detected	340		ng/kg	34.4	1763-23-1-BR	
PFUnDA*	Not detected	340		ng/kg	34.4	2058-94-8	
PFNS*	Not detected	340		ng/kg	34.4	68259-12-1	
PFDoDA*	Not detected	340		ng/kg	34.4	307-55-1	
PFDS*	Not detected	340		ng/kg	34.4	335-77-3	
PFTrDA*	Not detected	340		ng/kg	34.4	72629-94-8	
FOSA*	Not detected	340		ng/kg	34.4	754-91-6	
PFTeDA*	Not detected	340		ng/kg	34.4	376-06-7	I1
11Cl-PF3OUdS*	Not detected	340		ng/kg	34.4	763051-92-9	
9Cl-PF3ONS*	Not detected	340		ng/kg	34.4	756426-58-1	

I-Matrix interference with internal standard   1-IS recovery < 10%

Lab Sample ID: S27505.02 (continued)
Sample Tag: S2

28 PFAs, Method: ASTM D7968-17M, Run Date: 09/11/21 22:25, Analyst: KCV (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
ADONA*	Not detected	340		ng/kg	34.4	919005-14-4	
HFPO-DA*	Not detected	340		ng/kg	34.4	13252-13-6	

Analytical Laboratory Report

Lab Sample ID: S27505.03
Sample Tag: S3
Collected Date/Time: 08/25/2021 09:25
Matrix: Sludge
COC Reference: 139655

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	15ml Centrifuge Tube	None	Yes	9.6	IR
1	250ml Plastic	None	Yes	9.6	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Initial wt. (g) / Final wt. (g) / Volume (ml)*	10.17/6.99/10	ASTM D7968-17M	09/09/21 15:00	KCV	

Inorganics

Method: SM2540B, Run Date: 08/27/21 17:20, Analyst: ELR

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Total Solids*	5.2	1		%	1		

Organics

28 PFAs, Method: ASTM D7968-17M, Run Date: 09/12/21 19:24, Analyst: KCV

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
PFBA*	Not detected	1,200		ng/kg	60.5	375-22-4	
PFPeA*	Not detected	610		ng/kg	60.5	2706-90-3	
4:2 FTSA*	Not detected	610		ng/kg	60.5	757124-72-4	
PFHxA*	Not detected	610		ng/kg	60.5	307-24-4	
PFBS*	Not detected	610		ng/kg	60.5	375-73-5	
PFHpA*	Not detected	610		ng/kg	60.5	375-85-9	
PFPeS*	Not detected	610		ng/kg	60.5	2706-91-4	
6:2 FTSA*	Not detected	610		ng/kg	60.5	27619-97-2	
PFOA*	Not detected	610		ng/kg	60.5	335-67-1	
PFHxS*	Not detected	610		ng/kg	60.5	355-46-4	
PFHxS-LN*	Not detected	610		ng/kg	60.5	355-46-4-LN	
PFHxS-BR*	Not detected	610		ng/kg	60.5	355-46-4-BR	
PFNA*	Not detected	610		ng/kg	60.5	375-95-1	
8:2 FTSA*	Not detected	610		ng/kg	60.5	39108-34-4	
PFHpS*	Not detected	610		ng/kg	60.5	375-92-8	
PFDA*	Not detected	610		ng/kg	60.5	335-76-2	
N-MeFOSAA*	Not detected	610		ng/kg	60.5	2355-31-9	
EtFOSAA*	Not detected	610		ng/kg	60.5	2991-50-6	
PFOS*	Not detected	610		ng/kg	60.5	1763-23-1	
PFOS-LN*	Not detected	610		ng/kg	60.5	1763-23-1-LN	
PFOS-BR*	Not detected	610		ng/kg	60.5	1763-23-1-BR	
PFUnDA*	Not detected	610		ng/kg	60.5	2058-94-8	
PFNS*	Not detected	610		ng/kg	60.5	68259-12-1	
PFDoDA*	Not detected	610		ng/kg	60.5	307-55-1	
PFDS*	Not detected	610		ng/kg	60.5	335-77-3	
PFTrDA*	Not detected	610		ng/kg	60.5	72629-94-8	
FOSA*	Not detected	610		ng/kg	60.5	754-91-6	
PFTeDA*	Not detected	610		ng/kg	60.5	376-06-7	
11Cl-PF3OUdS*	Not detected	610		ng/kg	60.5	763051-92-9	
9Cl-PF3ONS*	Not detected	610		ng/kg	60.5	756426-58-1	
ADONA*	Not detected	610		ng/kg	60.5	919005-14-4	

Lab Sample ID: S27505.03 (continued)
Sample Tag: S3

28 PFAs, Method: ASTM D7968-17M, Run Date: 09/12/21 19:24, Analyst: KCV (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
HFPO-DA*	Not detected	610		ng/kg	60.5	13252-13-6	

Analytical Laboratory Report

Lab Sample ID: S27505.04
Sample Tag: S4
Collected Date/Time: 08/25/2021 09:45
Matrix: Sludge
COC Reference: 139655

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	15ml Centrifuge Tube	None	Yes	9.6	IR
1	250ml Plastic	None	Yes	9.6	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Initial wt. (g) / Final wt. (g) / Volume (ml)*	11.73/7.13/10	ASTM D7968-17M	09/09/21 15:00	KCV	

Inorganics

Method: SM2540B, Run Date: 08/27/21 17:20, Analyst: ELR

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Total Solids*	5.6	1		%	1		

Organics

28 PFAs, Method: ASTM D7968-17M, Run Date: 09/11/21 23:04, Analyst: KCV

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
PFBA*	Not detected	780		ng/kg	38.8	375-22-4	
PFPeA*	Not detected	390		ng/kg	38.8	2706-90-3	
4:2 FTSA*	Not detected	390		ng/kg	38.8	757124-72-4	
PFHxA*	Not detected	390		ng/kg	38.8	307-24-4	
PFBS*	Not detected	390		ng/kg	38.8	375-73-5	
PFHpA*	Not detected	390		ng/kg	38.8	375-85-9	
PFPeS*	Not detected	390		ng/kg	38.8	2706-91-4	
6:2 FTSA*	Not detected	390		ng/kg	38.8	27619-97-2	
PFOA*	Not detected	390		ng/kg	38.8	335-67-1	
PFHxS*	Not detected	390		ng/kg	38.8	355-46-4	
PFHxS-LN*	Not detected	390		ng/kg	38.8	355-46-4-LN	
PFHxS-BR*	Not detected	390		ng/kg	38.8	355-46-4-BR	
PFNA*	Not detected	390		ng/kg	38.8	375-95-1	
8:2 FTSA*	Not detected	390		ng/kg	38.8	39108-34-4	
PFHpS*	Not detected	390		ng/kg	38.8	375-92-8	
PFDA*	Not detected	390		ng/kg	38.8	335-76-2	
N-MeFOSAA*	Not detected	390		ng/kg	38.8	2355-31-9	
EtFOSAA*	Not detected	390		ng/kg	38.8	2991-50-6	
PFOS*	Not detected	390		ng/kg	38.8	1763-23-1	
PFOS-LN*	Not detected	390		ng/kg	38.8	1763-23-1-LN	
PFOS-BR*	Not detected	390		ng/kg	38.8	1763-23-1-BR	
PFUnDA*	Not detected	390		ng/kg	38.8	2058-94-8	
PFNS*	Not detected	390		ng/kg	38.8	68259-12-1	
PFDoDA*	Not detected	390		ng/kg	38.8	307-55-1	
PFDS*	Not detected	390		ng/kg	38.8	335-77-3	
PFTrDA*	Not detected	390		ng/kg	38.8	72629-94-8	
FOSA*	Not detected	390		ng/kg	38.8	754-91-6	
PFTeDA*	Not detected	390		ng/kg	38.8	376-06-7	
11Cl-PF3OUdS*	Not detected	390		ng/kg	38.8	763051-92-9	
9Cl-PF3ONS*	Not detected	390		ng/kg	38.8	756426-58-1	
ADONA*	Not detected	390		ng/kg	38.8	919005-14-4	

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Analytical Laboratory Report

Lab Sample ID: S27505.04 (continued)

Sample Tag: S4

28 PFAs, Method: ASTM D7968-17M, Run Date: 09/11/21 23:04, Analyst: KCV (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
HFPO-DA*	Not detected	390		ng/kg	38.8	13252-13-6	

Analytical Laboratory Report

Lab Sample ID: S27505.05
Sample Tag: S5
Collected Date/Time: 08/25/2021 10:05
Matrix: Sludge
COC Reference: 139655

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	15ml Centrifuge Tube	None	Yes	9.6	IR
1	250ml Plastic	None	Yes	9.6	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Initial wt. (g) / Final wt. (g) / Volume (ml)*	10.57/7.03/10	ASTM D7968-17M	09/09/21 15:00	KCV	

Inorganics

Method: SM2540B, Run Date: 08/27/21 17:20, Analyst: ELR

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Total Solids*	4.8	1		%	1		

Organics

28 PFAs, Method: ASTM D7968-17M, Run Date: 09/12/21 19:43, Analyst: KCV

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
PFBA*	Not detected	1,200		ng/kg	58.9	375-22-4	
PFPeA*	Not detected	590		ng/kg	58.9	2706-90-3	
4:2 FTSA*	Not detected	590		ng/kg	58.9	757124-72-4	
PFHxA*	Not detected	590		ng/kg	58.9	307-24-4	
PFBS*	Not detected	590		ng/kg	58.9	375-73-5	
PFHpA*	Not detected	590		ng/kg	58.9	375-85-9	
PFPeS*	Not detected	590		ng/kg	58.9	2706-91-4	
6:2 FTSA*	Not detected	590		ng/kg	58.9	27619-97-2	
PFOA*	Not detected	590		ng/kg	58.9	335-67-1	
PFHxS*	Not detected	590		ng/kg	58.9	355-46-4	
PFHxS-LN*	Not detected	590		ng/kg	58.9	355-46-4-LN	
PFHxS-BR*	Not detected	590		ng/kg	58.9	355-46-4-BR	
PFNA*	Not detected	590		ng/kg	58.9	375-95-1	
8:2 FTSA*	Not detected	590		ng/kg	58.9	39108-34-4	
PFHpS*	Not detected	590		ng/kg	58.9	375-92-8	
PFDA*	Not detected	590		ng/kg	58.9	335-76-2	
N-MeFOSAA*	Not detected	590		ng/kg	58.9	2355-31-9	
EtFOSAA*	Not detected	590		ng/kg	58.9	2991-50-6	
PFOS*	Not detected	590		ng/kg	58.9	1763-23-1	
PFOS-LN*	Not detected	590		ng/kg	58.9	1763-23-1-LN	
PFOS-BR*	Not detected	590		ng/kg	58.9	1763-23-1-BR	
PFUnDA*	Not detected	590		ng/kg	58.9	2058-94-8	
PFNS*	Not detected	590		ng/kg	58.9	68259-12-1	
PFDoDA*	Not detected	590		ng/kg	58.9	307-55-1	
PFDS*	Not detected	590		ng/kg	58.9	335-77-3	
PFTrDA*	Not detected	590		ng/kg	58.9	72629-94-8	
FOSA*	Not detected	590		ng/kg	58.9	754-91-6	
PFTeDA*	Not detected	590		ng/kg	58.9	376-06-7	
11Cl-PF3OUdS*	Not detected	590		ng/kg	58.9	763051-92-9	
9Cl-PF3ONS*	Not detected	590		ng/kg	58.9	756426-58-1	
ADONA*	Not detected	590		ng/kg	58.9	919005-14-4	

Lab Sample ID: S27505.05 (continued)
Sample Tag: S5

28 PFAs, Method: ASTM D7968-17M, Run Date: 09/12/21 19:43, Analyst: KCV (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
HFPO-DA*	Not detected	590		ng/kg	58.9	13252-13-6	

Analytical Laboratory Report

Lab Sample ID: S27505.06
Sample Tag: S6
Collected Date/Time: 08/25/2021 10:20
Matrix: Sludge
COC Reference: 139655

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	15ml Centrifuge Tube	None	Yes	9.6	IR
1	250ml Plastic	None	Yes	9.6	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Initial wt. (g) / Final wt. (g) / Volume (ml)*	10.18/7.05/10	ASTM D7968-17M	09/09/21 15:00	KCV	

Inorganics

Method: SM2540B, Run Date: 08/27/21 17:20, Analyst: ELR

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Total Solids*	5.0	1		%	1		

Organics

28 PFAs, Method: ASTM D7968-17M, Run Date: 09/11/21 23:43, Analyst: KCV

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
PFBA*	Not detected	1,300		ng/kg	63.9	375-22-4	
PFPeA*	Not detected	640		ng/kg	63.9	2706-90-3	
4:2 FTSA*	Not detected	640		ng/kg	63.9	757124-72-4	
PFHxA*	Not detected	640		ng/kg	63.9	307-24-4	
PFBS*	Not detected	640		ng/kg	63.9	375-73-5	
PFHpA*	Not detected	640		ng/kg	63.9	375-85-9	
PFPeS*	Not detected	640		ng/kg	63.9	2706-91-4	
6:2 FTSA*	Not detected	640		ng/kg	63.9	27619-97-2	I
PFOA*	Not detected	640		ng/kg	63.9	335-67-1	
PFHxS*	Not detected	640		ng/kg	63.9	355-46-4	
PFHxS-LN*	Not detected	640		ng/kg	63.9	355-46-4-LN	
PFHxS-BR*	Not detected	640		ng/kg	63.9	355-46-4-BR	
PFNA*	Not detected	640		ng/kg	63.9	375-95-1	
8:2 FTSA*	Not detected	640		ng/kg	63.9	39108-34-4	
PFHpS*	Not detected	640		ng/kg	63.9	375-92-8	
PFDA*	Not detected	640		ng/kg	63.9	335-76-2	
N-MeFOSAA*	Not detected	640		ng/kg	63.9	2355-31-9	
EtFOSAA*	Not detected	640		ng/kg	63.9	2991-50-6	
PFOS*	Not detected	640		ng/kg	63.9	1763-23-1	
PFOS-LN*	Not detected	640		ng/kg	63.9	1763-23-1-LN	
PFOS-BR*	Not detected	640		ng/kg	63.9	1763-23-1-BR	
PFUnDA*	Not detected	640		ng/kg	63.9	2058-94-8	
PFNS*	Not detected	640		ng/kg	63.9	68259-12-1	
PFDoDA*	Not detected	640		ng/kg	63.9	307-55-1	
PFDS*	Not detected	640		ng/kg	63.9	335-77-3	
PFTrDA*	Not detected	640		ng/kg	63.9	72629-94-8	
FOSA*	Not detected	640		ng/kg	63.9	754-91-6	
PFTeDA*	Not detected	640		ng/kg	63.9	376-06-7	
11Cl-PF3OUdS*	Not detected	640		ng/kg	63.9	763051-92-9	
9Cl-PF3ONS*	Not detected	640		ng/kg	63.9	756426-58-1	

I-Matrix interference with internal standard

Lab Sample ID: S27505.06 (continued)
Sample Tag: S6

28 PFAs, Method: ASTM D7968-17M, Run Date: 09/11/21 23:43, Analyst: KCV (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
ADONA*	Not detected	640		ng/kg	63.9	919005-14-4	
HFPO-DA*	Not detected	640		ng/kg	63.9	13252-13-6	

Lab Sample ID: S27505.07

Sample Tag: S7

Collected Date/Time: 08/25/2021 10:35

Matrix: Sludge

COC Reference: 139655

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	15ml Centrifuge Tube	None	Yes	9.6	IR
1	250ml Plastic	None	Yes	9.6	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Initial wt. (g) / Final wt. (g) / Volume (ml)*	9.67/6.99/10	ASTM D7968-17M	09/09/21 15:00	KCV	

Inorganics

Method: SM2540B, Run Date: 08/27/21 17:20, Analyst: ELR

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Total Solids*	4.5	1		%	1		

Organics

28 PFAs, Method: ASTM D7968-17M, Run Date: 09/12/21 20:22, Analyst: KCV

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
PFBA*	Not detected	1,700		ng/kg	82.9	375-22-4	
PFPeA*	Not detected	830		ng/kg	82.9	2706-90-3	
4:2 FTSA*	Not detected	830		ng/kg	82.9	757124-72-4	
PFHxA*	Not detected	830		ng/kg	82.9	307-24-4	
PFBS*	Not detected	830		ng/kg	82.9	375-73-5	
PFHpA*	Not detected	830		ng/kg	82.9	375-85-9	
PFPeS*	Not detected	830		ng/kg	82.9	2706-91-4	
6:2 FTSA*	Not detected	830		ng/kg	82.9	27619-97-2	
PFOA*	Not detected	830		ng/kg	82.9	335-67-1	
PFHxS*	Not detected	830		ng/kg	82.9	355-46-4	
PFHxS-LN*	Not detected	830		ng/kg	82.9	355-46-4-LN	
PFHxS-BR*	Not detected	830		ng/kg	82.9	355-46-4-BR	
PFNA*	Not detected	830		ng/kg	82.9	375-95-1	
8:2 FTSA*	Not detected	830		ng/kg	82.9	39108-34-4	
PFHpS*	Not detected	830		ng/kg	82.9	375-92-8	
PFDA*	Not detected	830		ng/kg	82.9	335-76-2	
N-MeFOSAA*	Not detected	830		ng/kg	82.9	2355-31-9	
EtFOSAA*	Not detected	830		ng/kg	82.9	2991-50-6	
PFOS*	Not detected	830		ng/kg	82.9	1763-23-1	
PFOS-LN*	Not detected	830		ng/kg	82.9	1763-23-1-LN	
PFOS-BR*	Not detected	830		ng/kg	82.9	1763-23-1-BR	
PFUnDA*	Not detected	830		ng/kg	82.9	2058-94-8	
PFNS*	Not detected	830		ng/kg	82.9	68259-12-1	
PFDoDA*	Not detected	830		ng/kg	82.9	307-55-1	
PFDS*	Not detected	830		ng/kg	82.9	335-77-3	
PFTrDA*	Not detected	830		ng/kg	82.9	72629-94-8	
FOSA*	Not detected	830		ng/kg	82.9	754-91-6	
PFTeDA*	Not detected	830		ng/kg	82.9	376-06-7	
11Cl-PF3OUdS*	Not detected	830		ng/kg	82.9	763051-92-9	
9Cl-PF3ONS*	Not detected	830		ng/kg	82.9	756426-58-1	
ADONA*	Not detected	830		ng/kg	82.9	919005-14-4	

Lab Sample ID: S27505.07 (continued)
Sample Tag: S7

28 PFAs, Method: ASTM D7968-17M, Run Date: 09/12/21 20:22, Analyst: KCV (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
HFPO-DA*	Not detected	830		ng/kg	82.9	13252-13-6	

Analytical Laboratory Report

Merit Laboratories, Inc.

Lab Sample ID: S27505.08
Sample Tag: S8
Collected Date/Time: 08/25/2021 10:50
Matrix: Sludge
COC Reference: 139655

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	15ml Centrifuge Tube	None	Yes	9.6	IR
1	250ml Plastic	None	Yes	9.6	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Initial wt. (g) / Final wt. (g) / Volume (ml)*	11.07/7.09/10	ASTM D7968-17M	09/09/21 15:00	KCV	

Inorganics

Method: SM2540B, Run Date: 08/27/21 17:20, Analyst: ELR

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
Total Solids*	4.6	1		%	1		

Organics

28 PFAs, Method: ASTM D7968-17M, Run Date: 09/12/21 00:22, Analyst: KCV

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
PFBA*	Not detected	1,100		ng/kg	54.6	375-22-4	
PFPeA*	Not detected	550		ng/kg	54.6	2706-90-3	
4:2 FTSA*	Not detected	550		ng/kg	54.6	757124-72-4	
PFHxA*	Not detected	550		ng/kg	54.6	307-24-4	
PFBS*	Not detected	550		ng/kg	54.6	375-73-5	
PFHpA*	Not detected	550		ng/kg	54.6	375-85-9	
PFPeS*	Not detected	550		ng/kg	54.6	2706-91-4	
6:2 FTSA*	Not detected	550		ng/kg	54.6	27619-97-2	
PFOA*	Not detected	550		ng/kg	54.6	335-67-1	
PFHxS*	Not detected	550		ng/kg	54.6	355-46-4	
PFHxS-LN*	Not detected	550		ng/kg	54.6	355-46-4-LN	
PFHxS-BR*	Not detected	550		ng/kg	54.6	355-46-4-BR	
PFNA*	Not detected	550		ng/kg	54.6	375-95-1	
8:2 FTSA*	Not detected	550		ng/kg	54.6	39108-34-4	I
PFHpS*	Not detected	550		ng/kg	54.6	375-92-8	
PFDA*	Not detected	550		ng/kg	54.6	335-76-2	
N-MeFOSAA*	Not detected	550		ng/kg	54.6	2355-31-9	
EtFOSAA*	Not detected	550		ng/kg	54.6	2991-50-6	
PFOS*	Not detected	550		ng/kg	54.6	1763-23-1	
PFOS-LN*	Not detected	550		ng/kg	54.6	1763-23-1-LN	
PFOS-BR*	Not detected	550		ng/kg	54.6	1763-23-1-BR	
PFUnDA*	Not detected	550		ng/kg	54.6	2058-94-8	
PFNS*	Not detected	550		ng/kg	54.6	68259-12-1	
PFDoDA*	Not detected	550		ng/kg	54.6	307-55-1	
PFDS*	Not detected	550		ng/kg	54.6	335-77-3	
PFTrDA*	Not detected	550		ng/kg	54.6	72629-94-8	
FOSA*	Not detected	550		ng/kg	54.6	754-91-6	
PFTeDA*	Not detected	550		ng/kg	54.6	376-06-7	
11Cl-PF3OUdS*	Not detected	550		ng/kg	54.6	763051-92-9	
9Cl-PF3ONS*	Not detected	550		ng/kg	54.6	756426-58-1	

I-Matrix interference with internal standard

Lab Sample ID: S27505.08 (continued)
Sample Tag: S8

28 PFAs, Method: ASTM D7968-17M, Run Date: 09/12/21 00:22, Analyst: KCV (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
ADONA*	Not detected	550		ng/kg	54.6	919005-14-4	
HFPO-DA*	Not detected	550		ng/kg	54.6	13252-13-6	

Merit Laboratories Login Checklist

Lab Set ID: S27505
Client: KIESER (Kieser & Associates)
Project: Cedar Lake
Submitted: 08/25/2021 15:30 Login User: PFD

Attention: Josh Kieser
Address: Kieser & Associates
536 E. Michigan Ave. Ste 300
Kalamazoo, MI 49007

Phone: 269-344-7117 FAX:
Email: JKieser@kieser-associates.com

Selection				Description	Note
Sample Receiving					
01.	[ ] Yes	[X] No	[ ] N/A	Samples are received at 4C +/- 2C Thermometer #	IR 9.6
02.	[X] Yes	[ ] No	[ ] N/A	Received on ice/ cooling process begun	
03.	[ ] Yes	[X] No	[ ] N/A	Samples shipped	
04.	[ ] Yes	[X] No	[ ] N/A	Samples left in 24 hr. drop box	
05.	[ ] Yes	[ ] No	[X] N/A	Are there custody seals/tape or is the drop box locked	
Chain of Custody					
06.	[X] Yes	[ ] No	[ ] N/A	COC adequately filled out	
07.	[X] Yes	[ ] No	[ ] N/A	COC signed and relinquished to the lab	
08.	[X] Yes	[ ] No	[ ] N/A	Sample tag on bottles match COC	
09.	[ ] Yes	[X] No	[ ] N/A	Subcontracting needed? Subcontacted to:	
Preservation					
10.	[X] Yes	[ ] No	[ ] N/A	Do sample have correct chemical preservation	
11.	[ ] Yes	[ ] No	[X] N/A	Completed pH checks on preserved samples? (no VOAs)	
12.	[ ] Yes	[X] No	[ ] N/A	Did any samples need to be preserved in the lab?	
Bottle Conditions					
13.	[X] Yes	[ ] No	[ ] N/A	All bottles intact	
14.	[X] Yes	[ ] No	[ ] N/A	Appropriate analytical bottles are used	
15.	[X] Yes	[ ] No	[ ] N/A	Merit bottles used	
16.	[X] Yes	[ ] No	[ ] N/A	Sufficient sample volume received	
17.	[ ] Yes	[X] No	[ ] N/A	Samples require laboratory filtration	
18.	[X] Yes	[ ] No	[ ] N/A	Samples submitted within holding time	
19.	[ ] Yes	[ ] No	[X] N/A	Do water VOC or TOX bottles contain headspace	

Corrective action for all exceptions is to call the client and to notify the project manager.

Client Review By: ______________________________ Date: ______________

Merit Laboratories, Inc.

2680 East Lansing Dr., East Lansing, MI 48823
Phone (517) 332-0167 Fax (517) 332-4034
www.meritlabs.com

C.O.C. PAGE # ______ OF ______ 139655

CHAIN OF CUSTODY RECORD

REPORT TO

CONTACT NAME: Josh Kieser
COMPANY: Kieser & Associates
ADDRESS: 536 E Michigan Ave
CITY: Kalamazoo STATE: MI ZIP CODE: 49007
PHONE NO.: (269) 344-7117 FAX NO.: P.O. NO.:
E-MAIL ADDRESS: jKieser@Kieser-associates.com QUOTE NO.:

INVOICE TO

CONTACT NAME: ☒ SAME
COMPANY:
ADDRESS:
CITY: STATE: ZIP CODE:
PHONE NO.: E-MAIL ADDRESS:

PROJECT NO./NAME: Cedar Lake
SAMPLER(S) - PLEASE PRINT/SIGN NAME: Josh Kieser

TURNAROUND TIME REQUIRED ☐ 1 DAY ☐ 2 DAYS ☐ 3 DAYS ☒ STANDARD ☐ OTHER ______

DELIVERABLES REQUIRED ☒ STD ☐ LEVEL II ☐ LEVEL III ☐ LEVEL IV ☐ EDD ☐ OTHER ______

MATRIX CODE: GW=GROUNDWATER WW=WASTEWATER S=SOIL L=LIQUID SD=SOLID SL=SLUDGE DW=DRINKING WATER O=OIL WP=WIPE A=AIR W=WASTE

ANALYSIS (ATTACH LIST IF MORE SPACE IS REQUIRED)

Certifications: ☐ OHIO VAP ☐ Drinking Water ☐ DoD ☐ NPDES
Project Locations: ☐ Detroit ☐ New York ☐ Other ______

MERIT LAB NO. FOR LAB USE ONLY	YEAR DATE	TIME	SAMPLE TAG IDENTIFICATION-DESCRIPTION	MATRIX	# OF BOTTLES	NONE	HCl	HNO_3	H_2SO_4	NaOH	MeOH	OTHER	PFAS	MI-10-Metals	PAH's	Special Instructions
27504.01	8-25-21	8:45A	S1	S	6	5		1					X	X	X	27505(PFAS).01
.02		9:00A	S2	S	6	5		1					X	X	X	.02
.03		9:25A	S3	S	6	5		1					X	X	X	.03
.04		9:45A	S4	S	6	5		1					X	X	X	.04
.05		10:05A	S5	S	6	5		1					X	X	X	.05
.06		10:20A	S6	S	6	5		1					X	X	X	.06
.07		10:35A	S7	S	6	5		1					X	X	X	.07
.08		10:50A	S8	S	6	5		1					X	X	X	.08

RELINQUISHED BY: SIGNATURE/ORGANIZATION: Zach Harrison ☐ Sampler DATE: 8-25-21 TIME: 3:00p
RECEIVED BY: SIGNATURE/ORGANIZATION: [signature] DATE: 8/25/21 TIME: 1530
RELINQUISHED BY: SIGNATURE/ORGANIZATION: DATE: TIME:
RECEIVED BY: SIGNATURE/ORGANIZATION: DATE: TIME:

RELINQUISHED BY: SIGNATURE/ORGANIZATION: DATE: TIME:
RECEIVED BY: SIGNATURE/ORGANIZATION: DATE: TIME:
SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS
SEAL NO. SEAL INTACT YES ☐ NO ☐ INITIALS
NOTES: TEMP. ON ARRIVAL 9.6

PLEASE NOTE: SIGNING ACKNOWLEDGES ADHERENCE TO MERIT'S SAMPLE ACCEPTANCE POLICY

Cedar Lake WMP (2025)

Attachment M: WMP Education Program Priorities Table

Cedar Lake WMP: Education Program Strategy

Education Topic	Priority
Lake Levels & Augmentation: Educate stakeholders and hold public educational meetings to present updated findings of Augmentation Feasibility studies and recommendations for implementation of future augmentation projects. Create and disseminate a lake-user online survey to garner feedback on perceptions of lake level issues, on augmentation implementations to date, and for recommended future augmentation implementation projects.	H
Lakewood Shores Drainage: Hold workshops to educate homeowners and builders on practices or measures that will reduce the risk of flooding in homes.	M
Timberlakes Drainage: Hold workshops to educate potential builders on practices or measures to prevent shallow groundwater losses from new construction.	L
Cedar Lake Fisheries: Create and disseminate a fisheries online survey to garner feedback on perceptions of fisheries issues, on and for recommended future fisheries improvement projects. Design and implement creel survey. Continue to educate the public on fisheries-related management efforts, such as a potential creel limit and habitat protection areas to avoid when fishing (AICLA regularly educates on these issues).	H
Aquatic Invasive Species: Create and distribute a homeowner's guide to Cedar Lake to educate watershed residents about aquatic invasive species and potential threats. Install additional educational signage at high-traffic and high-use areas. Regularly post important information regarding invasive species and nuisance aquatic plants in local newsletters, newspapers, and other sources.	M
Muck Sediments: 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.	H
Natural Lakeshores: Implement a Cedar Lake Homeowners Guide to educate the public on good residential practices, benefits of native buffers and lakescaping, and promote workshops to educate the public on priority topics. Lake resident online survey to garner feedback on perceptions of natural shorelines and of the demonstration project, including positive and negative perceptions, risks, limitations, and desires for shoreline improvements on Cedar Lake.	M
Water Quality: Update WMP website to include information on PFAS groundwater contamination sampling and links to status updates for Cedar Lake. Educate the public on methods and benefits of natural shorelines, proper pet waste disposal, how to deter waterfowl from yards and public areas, and proper septic system maintenance and clean-out schedule.	H

Cedar Lake WMP (2025)

Attachment N: 2011 WMP –

Land Conservation Materials

A Powerful New Incentive for Private Land Conservation
Michigan Public Act 446 of 2006

What Does Public Act 446 Do?

Under current Michigan law, the taxable value of a parcel of property may not increase from one year to the next by more than 5% or the increase in the consumer price index, whichever is lower, until there is a transfer of ownership. When the property is sold or transferred, the assessment is "uncapped" and the parcel is taxed upon its state equalized value (SEV: 50% of its true cash value). This reassessment upon transfer creates a "pop-up" property tax.

P.A. 446, introduced as Senate Bill 1004, eliminates the "pop-up" property tax on the transfer of lands enrolled in a voluntary conservation agreement (also known as "conservation easement"). [1]

How Does This Benefit Conservation?

Until the signing of Senate Bill 1004 on December 7, 2006, property taxes on conservation lands, like developed lands, jumped dramatically upon their sale or transfer. Property taxes on conservation lands rose significantly even though their development is permanently limited.

This provided a disincentive for landowners to enter into conservation agreements. To afford the higher taxes, new landowners needed the option of developing the land. The elimination of the pop-up tax on conservation lands means that both current and future landowners have a strong incentive to keep the affected lands intact with habitat, environmental and scenic benefits. This law gives protected conservation property the same tax treatment as protected farmland.

How Does This Benefit Private Landowners?

The Act prevents the taxable value of conservation property from "popping-up" to the state equalized value when it is transferred. This means a potential direct tax savings of hundreds or thousands of dollars per year for new owners of the land.

What's an Example of How the New Law Works?

An 80-acre non-farm property with a current taxable value of $43,000 and a state equalized value of $252,000 would have been subject to $4,395 in annual property tax payments after transfer. Under the new law, if the 80 acres are all enrolled in a conservation agreement, annual property taxes will remain at their current level after transfer -- $750 per year. This means **an annual savings of $3,645**. Over a 50-year span, the new landowner will realize an estimated $149,131 in value from the change.

How Do I Find Out More?

Contact your local land conservancy, accountant and tax advisor to learn how the new law could benefit you.

[1] Residences and buildings on the lands are still subject to reassessment to the current SEV.

USING THE CONSERVATION TAX INCENTIVE

In 2015 Congress enacted one of the most powerful conservation measures in decades: the enhanced federal tax incentive for conservation easement donations.

The permanent conservation easement tax incentive is a powerful tool that helps Americans conserve their land voluntarily.

For land trusts across the country, the permanent incentive represents vastly increased opportunities to protect the special places in their widely varied communities.

If you own land with important natural, agricultural or historic resources, donating a conservation easement can be a prudent way to both save the land you love forever and to realize significant federal tax savings.

This short brochure summarizes the conservation easement tax incentive and provides answers to some frequently asked questions. For the latest information and for guidance on individual properties, please contact your local land trust, which can be located at www.findalandtrust.org.

Land Trust Alliance
Together, conserving the places you love

FREQUENTLY ASKED QUESTIONS

WHAT IS A CONSERVATION EASEMENT?

A conservation easement, also called a conservation agreement, is a voluntary and legally binding agreement between a landowner and a land trust or government agency.

When a landowner donates an easement to a land trust or public agency, she or he is giving away some of the rights associated with the land. The easement permanently limits uses of the donated parcel in order to protect its conservation values, as specified in the Internal Revenue Code (IRC) 170(h).

Conservation easements offer private landowners flexibility in protecting their land. For example, a donating landowner can retain the right to grow crops on a parcel while, at the same time, relinquishing the right to build additional structures on the parcel.

The land trust is responsible for making sure that a landowner adheres to the conservation terms of the easement. An easement may apply to all or a portion of the property and may or may not allow for public access to the property. A landowner who has donated a conservation easement can sell the land or pass it on to heirs, and future owners of the property are bound by the terms of the easement.

HOW DOES THE PERMANENT, ENHANCED TAX INCENTIVE WORK?

If a conservation easement is voluntarily donated to a land trust or government agency, and if it benefits the public by permanently protecting important conservation resources, it can qualify as a charitable tax deduction on the donor's federal income tax return.

First enacted temporarily in 2006, the tax incentive was made permanent in 2015 and increases the benefits to landowners by:

- Raising the deduction a donor can take for donating a conservation easement to 50%, from 30%, of his or her annual income;
- Extending the carry-forward period for a donor to take a tax deduction for a conservation agreement to 15 years from 5 years; and
- Allowing qualifying farmers and ranchers to deduct up to 100% of their income, increased from 50%.

Easements vary greatly in value. In general, the highest easement values are found on tracts of open space under high development pressure. In some jurisdictions, placing an easement on one's land may also result in property tax savings for the landowner.

1. What is an example of the financial benefit that the permanent tax incentive provides a landowner?

Prior to 2015, a landowner earning $50,000 a year who donated a $1 million conservation easement could take a $15,000 deduction (30% of his or her income) for the year of the donation and for an additional five years, generating a total of $90,000 in tax deductions.

The new, permanent incentive allows that landowner to deduct $25,000 (50% of income) for the year of the donation and for each of an additional 15 years. This would result in a total of $400,000 in deductions.

If the landowner is a farmer or rancher, he or she can deduct $50,000 (100% of income) in the first year and then for each of the following 15 years, realizing a maximum of $800,000 in deductions.

2. Can anyone deduct more than the value of his or her gift of an easement?

One can never deduct more than the fair market value of the gift. The permanent incentive simply allows landowners to deduct more of that fair market value.

3. Who qualifies as a farmer or rancher?

The 2015 law defines a farmer or rancher as someone who receives more than 50% of his or her gross income from "the trade or business of farming." The law references IRC 2032A(e)(5) to define activities that count as farming, including:

- Cultivating the soil or raising or harvesting any agricultural or horticultural commodity (including the raising, shearing, feeding, caring for, training and management of animals) on a farm;
- Handling, drying, packing, grading or storing on a farm any agricultural or horticultural commodity in its unmanufactured state, but only if the owner, tenant or operator of the farm regularly produces more than one-half of the commodity so treated; and
- The planting, cultivating, caring for or cutting of trees, or the preparation (other than milling) of trees for market.

For an easement to qualify for a farmer or rancher, it must contain a restriction requiring that the land remain "available for agriculture." This provision also applies to farmers who are organized as C corporations. Additionally, Alaska Native Corporations are eligible as farmers or ranchers.

4. Do these changes apply to gifts of land?

The expanded incentive does not apply to gifts of land in fee. It only applies to gifts that qualify under IRC 170(h)(2), such as conservation easements. A landowner considering the donation of land should consult an attorney to determine whether the structure of his or her gift should be changed to take advantage of the permanent incentive.

5. When does the permanent incentive apply?

The permanent incentive applies to all conservation easements donated after December 31, 2014.

6. What other restrictions apply?

Conservation easement donations must comply with "conservation purposes" as defined in IRC 170(h). A donated easement must be a true gift. It must protect significant natural, agricultural or historic resources that public agencies or land trusts want to have conserved. A donated easement cannot serve to simply prevent development on a property or be part of a "quid pro quo" agreement in exchange for a government action, such as issuance of a building permit or a zoning change.

7. Will donors who use this provision be audited by the IRS?

Taking advantage of the 2015 law should not affect one's likelihood of being audited. However, all donors should note that the IRS does pay attention to donations of property that are high in value, including donations of conservation easements.

This makes it important for donors and their advisors to know and follow the law, utilize a reputable professional appraiser who has experience in the appraisal of conservation easements and donate to a well-established, reputable land trust that has adopted and implemented *Land Trust Standards and Practices.*

WHAT IS THE ROLE OF THE LAND TRUST?

Voluntarily donating a permanent conservation easement is a major commitment for a landowner that requires careful planning and independent legal advice.

Donating an easement also necessitates a strong working partnership with a land trust. A landowner should allow sufficient time for the careful drafting of baseline documentation, creation of maps and production of a professional property appraisal. Land trusts will want to review the appraisal before accepting the gift, and landowners should understand that a land trust may decline to accept a donation that does not meet both the legal requirements and the land trust's charitable mission and strategic plan.

ACKNOWLEDGEMENTS

There are many people to thank for the 2015 conservation tax incentive victory. We extend one grand thank you from the Alliance to all of you.

The Alliance has been leading a team effort to achieve this since 2000, when we convened land trust leaders from across the country to build a consensus on what tax policies would best address the need to expand land conservation.

This legislation would not have happened without the leadership of Senators Dean Heller (NV) and Debbie Stabenow (MI), Representatives Mike Kelly (PA) and Mike Thompson (CA), and many of their colleagues. These leaders know that the conservation work of land trusts is important to their communities and broadly supported by their constituents.

For the latest information visit **www.lta.org/policy**.

ABOUT THE ALLIANCE

Founded in 1982, the Land Trust Alliance is a national conservation organization representing over 1,100 land trusts. The Alliance works to save the places people need and love by strengthening land conservation throughout America. Please visit our website at **www.landtrustalliance.org** for more information on:

- Finding a local or regional land trust
- The latest federal tax laws concerning conservation easement donations
- Examples of how private landowners work with land trusts to protect their land
- Publications and resources for landowners

Land Trust Alliance
Together, conserving the places you love

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Washington, DC 20036
202.638.4725
www.landtrustalliance.org

www.facebook.com/landtrustalliance
www.twitter.com/ltalliance

Cover photos: Top–Harlen Persinger, photographer; Bottom–Scott Bauer, USDA/ARS.