Report

Phase II Lake Study Report

Cedar Lake, Manitowoc County

Scope ID: 99C027

Town of Schleswig Sanitary District No. 1

July 2000

Foth & Van Dyke
consultants · engineers · scientists

Town of Schleswig Sanitary District No. 1
Cedar Lake
Phase II Lake Study Report

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1 Executive Summary

Foth & Van Dyke was retained by the Town of Schleswig Sanitary District No. 1 to conduct a water quality evaluation of Cedar Lake. The Sanitary District received a Lake Management Planning Grant from the Wisconsin Department of Natural Resources (WDNR) which provided funding up to $10,000 for this project with in-kind services and matching funds of 25% provided by the Sanitary District.

This evaluation and report focused on the evaluation of the current trophic status, including additional water quality data generation, the recharge/discharge relationship of groundwater flowing into or out of Cedar Lake, an evaluation of the hydrologic budget for Cedar Lake, and the relationship to the land use practices in the Cedar Lake watershed to the water quality of the lake.

A water quality sampling program was executed to determine the lake's trophic status, to determine phosphorus levels in all areas of the lake, and to compare the water quality of Cedar Lake in 1999/2000 with that of the lake in 1997/98 during which sampling was conducted as part of the Phase I lake study.

Piezometers, groundwater wells designed to evaluate flow direction, were installed in various locations around the lake to determine the extent, if any, of groundwater contribution to Cedar lake. A staff gauge was installed at the lake outlet to determine the rate at which water exists the lake, which provided additional data for the evaluation of the hydrologic budget for the lake.

A sanitary survey was completed as a part of the 1997-98 Phase I project. The results from this survey have been referenced in this report to provide continuity between the two reports and also present discussions on the impacts of septic systems to the water quality of Cedar Lake.

As a part of the watershed evaluation, an analysis of the land cover in the immediate watershed of Cedar lake was conducted, and estimated phosphorus loads based on land cover type were calculated.

The following highlights the findings of the study and the recommendations to the Town of Schleswig Sanitary District No. 1:

Water Quality

Cedar Lake can be classified as a Mesotrophic lake based on the water quality sampling results. A Mesotrophic lake is considered a middle age lake with enough nutrients available to support a healthy biomass. The next stage of aging for a lake is a Eutrophic condition which has excess nutrients and biomass production. The comparison of 1997 data with 1999 data showed water quality declined based on Dissolved Oxygen, all nitrogen compounds, total phosphorus and orthophosphate concentrations. The chlorophyll a and secchi disc measurements showed no change from 1997 to 1999. This testing indicates that Cedar Lake may have an accelerated rate of eutrophication. While two years of test data may be insufficient to cause alarm, the trend toward poor quality water should not be dismissed.

Groundwater Recharge/Discharge

The groundwater movement into or out of the lake varies from one side of the lake to the other. The predominant flow appears to be out of the lake. The east side of lake has groundwater flow into the lake during periods of high groundwater. The west side of the lake had lake water flow out of the lake into the groundwater for all but a short period of highest groundwater. The overall results showed the lake to be a groundwater recharge source with most of the lake area discharging to the groundwater.

This data is beneficial in evaluating potential pollution sources such as septic systems. Septic systems discharge to groundwater carrying nutrients into the groundwater. In the case of Cedar Lake, groundwater flow is generally away from the lake rather than into the lake. Improving or eliminating septic systems will have little impact on water quality of Cedar Lake.

Property owners should consider the potential of their potable well water being contaminated. Where septic systems are between the lake and the well, and the groundwater flow direction is moving from the septic tank to the well area there is a potential for impact to these wells. Potential contaminants of bacteria or nitrates may be present in water samples where the above conditions occur.

Lake Level

Lake levels were measured in 1999. The water level fluctuated by 0.81 feet. The normal water level varies based on the groundwater level and precipitation. An overflow pipe has been installed to limit the maximum water level. This pipe is seldom in operation. The high capacity well is a supplemental water source that provides higher water levels in times of low groundwater and precipitation. Observations in 1999 confirmed that Cedar Lake is a seepage lake with no significant surface water outlet or inlet.

Watershed Analysis

The phosphorus loading to the lake from the watershed is estimated at 61 pounds per year. The existing lake contains about 50 pounds of phosphorus. The goal for long term management should strive to limit phosphorus coming into the lake to the amount that is removed each year. At Cedar Lake, phosphorus is removed through deposition on the lake bottom and weed cutting.

Agricultural land use is the largest category in the watershed and makes up 40% of the total land use. Residential land use is the second largest at 23%. The largest impact land use has is discharging phosphorus to the lake. The residential category provided 94% of the phosphorus to Cedar Lake. Any work done to reduce phosphorus loading should begin on the residential areas around the lake.

Septic systems currently have more than 400 pounds per year of phosphorus discharged to the soil. Where septic systems do discharge to groundwater that enters the lake, there is a potential for phosphorus pollution. Septic systems should be updated or replaced with systems that do not discharge to groundwater (holding tanks, sanitary sewer) in areas that could impact the lake water quality.

Recommendations

It is recommended that the Town of Schleswig Sanitary District No. 1 proceed with the following:

- Complete a Lake Management Plan directed toward maintaining and protecting the water quality of Cedar Lake.

- Evaluate methods of reducing phosphorus loading to the lake.

- Implement one or more water quality improvement alternatives, including:
  - Educate property owners in the District.
  - Upgrade on-site sanitary systems.
  - Consider the benefits of installing public sanitary sewer.

2 Introduction

Cedar Lake is located in the east-central portion of the Town of Schleswig in southwest Manitowoc County. The largest lake in the county, it covers an area of 147 acres, has 3.2 miles of shoreline, a maximum depth of 21 feet, and an average depth of 9 feet. Development has occurred on all developable lots around the lake, and these areas currently are not serviced by public sanitary sewer. All developments adjacent Cedar Lake have private, on-site septic systems which could potentially have a negative impact on the water quality of the lake.

In May, 1997 the Town of Schleswig Sanitary District No. 1 was awarded a Lake Management Planning Grant from the Wisconsin Department of Natural Resources (WDNR) to conduct a study of the water quality of Cedar Lake. This study was completed in the summer of 1998; the executive summary of the study's results is attached in Appendix 2-1. The Sanitary District applied for a second Lake Management Planning Grant in 1999 to conduct additional studies on the lake. The District was awarded funding to undertake Phase II of studies on Cedar Lake.

2.1 Authorization

On April 15, 1999 the Town of Schleswig Sanitary District No. 1 authorized the consulting firm of Foth & Van Dyke to complete Phase II of the lake study for Cedar Lake, and to prepare a report identifying the results. The study resulted in a collaborative effort among Foth & Van Dyke, the Town of Schleswig Sanitary District No. 1, and WDNR personnel.

2.2 Purpose

The purpose of the Phase II lake study was to address the following areas.

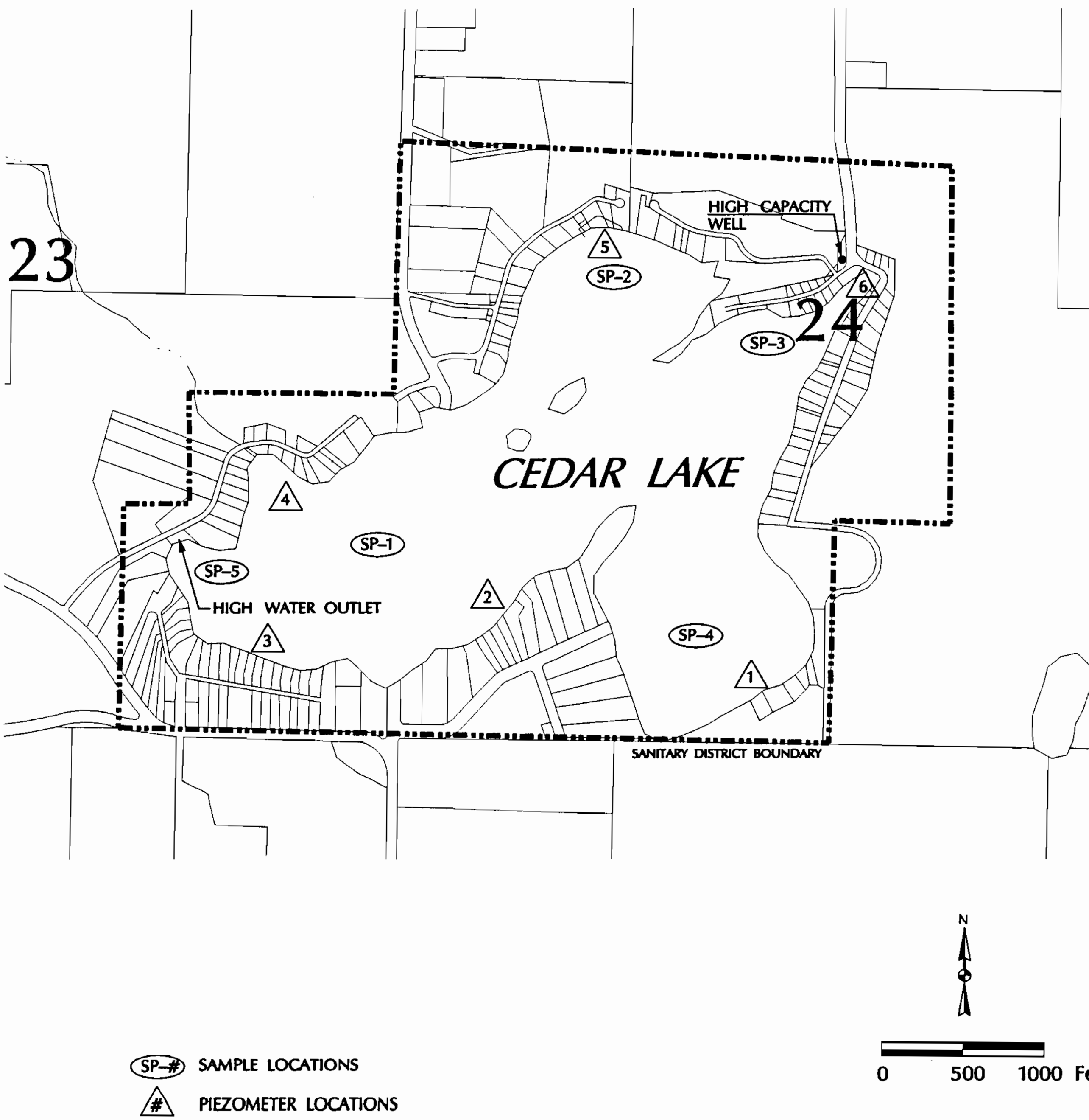
- Obtain additional water quality data to further the water quality sampling history of Cedar Lake,
- determine the extent to which groundwater is a feeding source for the lake,
- determine the flow rate of water leaving the lake, and
- to complete an analysis of the land use and associated phosphorus runoff in the lake's immediate watershed.

The results of this study will be used in conjunction with the results of Phase I of the lake study process to provide the Sanitary District with a sound understanding of the water quality of Cedar Lake and potential sources of pollution to the lake. This report will also provide the District with alternatives to protect and preserve the water quality of Cedar Lake based on the findings of the studies.

2.3 Project Study Area

Map No. 1 illustrates the project study area, including the five water quality sampling locations and the locations where piezometers were installed.

MAP No. 1
PROJECT STUDY AREA:
SAMPLING SITES & PIEZOMETER LOCATIONS
Cedar Lake
Manitowoc County, Wisconsin



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3 Water Quality

The water quality of a lake is dependent upon a number of factors and lake characteristics. Every lake possesses a unique set of physical and chemical characteristics that may change over time. The chemical changes occur on a daily basis, while physical changes (such as plant and algae growth) occur on a seasonal basis. Seasonal changes in the physical characteristics of a lake are common because factors such as surface runoff, groundwater inflow, precipitation, temperature and sunlight are variable. A lake's water quality will vary with the seasonal changes, therefore data must be gathered over a period of time to accurately determine if a lake is experiencing significant changes in water quality and to distinguish between natural variability and human activity impacts.

To determine the water quality and trophic status of Cedar Lake, a sampling program was devised which included testing numerous characteristics of the lake. The following section explains the sampling program and its components, presents the results and analysis of the sampling conducted, and provides conclusions about the water quality of Cedar Lake. First however, it is important to identify the natural aging process experienced by lakes (eutrophication), and the source of the lake's water supply as this contributes to the factors which effect the quality of its water supply. In addition, identification of the water source allows for sound management practices to be selected which reflect the specific characteristics of the lake.

Eutrophication - The Aging Process

The process of eutrophication is a natural aging process which occurs in all lakes whereby a lake progresses from a more oligotrophic to a more eutrophic state. When nutrients such as phosphorus and nitrogen wash into a lake with stormwater or by soil erosion, they fertilize the lake and encourage algae and larger plants to grow. As plants and the animals that feed on them die and decompose, they accumulate on the lake bottom as organic sediments. After hundreds or thousands of years or plant growth and decomposition, the character of a lake may more closely resemble a marsh or a bog.

However, lakes also obtain nutrients from various human activities which can literally make a lake old before its time. This accelerated transition is commonly termed "cultural eutrophication", whereby changes that would normally take centuries may occur over/within one person's lifetime. Nutrients from agriculture, stormwater runoff, urban development, lawn and garden fertilizers, failing septic systems, land clearing, construction site runoff, municipal and industrial wastewater, and recreational activities contribute to the accelerated eutrophication or enrichment of lakes.

Trophic Status Indicators

The trophic state of a water body is an indicator of the nutrient levels and water clarity in a lake. Lakes can be divided into three categories based on their trophic state which include oligotrophic, mesotrophic, and eutrophic. The following provides a description of each trophic state:

Oligotrophic: Young lakes with low productivity which are generally clear, cold, deep, and free of weeds or large algae blooms. Oligotrophic lakes are low in nutrients and therefore do not support plant growth or large fish populations, however are capable of sustaining a desirable fishery of large game fish.

Mesotrophic: These lakes are in an intermediate stage between the oligotrophic and eutrophic stages. They are moderately productive, supporting a diverse community of native aquatic plants. The bottoms of mesotrophic lakes lack oxygen in late summer months or winter periods which limits cold water fish and causes phosphorus cycling from sediments. Overall however, mesotrophic lakes support good fisheries.

Eutrophic: Lakes which are high in nutrients and support a large biomass are categorized as eutrophic. These lakes are usually weedy and/or experience large algae blooms. Most often they support large fish populations, however are also susceptible to oxygen depletion which limits fishery diversity. Rough fish are common in eutrophic lakes.

The trophic state of a lake can be determined by observing three lake characteristics including Total Phosphorus concentration (Total-P) which indicates the amount of nutrients present which are necessary for algae growth, Chlorophyll *a* concentration which is a measure of the amount of algae actually present, and Secchi disc readings which is an indicator of water clarity. As expected, low levels of Total P are related to low levels of Chlorophyll *a*, which are related to high Secchi disc readings.

To determine the trophic state of the lake, the Wisconsin Trophic State Index (WTSI) can be applied to each of the above noted factors. The WTSI converts the actual measurement into a value which is representative of one of the trophic states. Values less than or equal to 39 indicate oligotrophic conditions, values from 40-49 indicate mesotrophic conditions, and values equal to or greater than 50 represent eutrophic conditions.

General Characteristics of Cedar Lake

Cedar Lake is classified as a seepage lake: a seepage lake is a landlocked, natural lake where water levels are maintained by the groundwater table, precipitation, and limited runoff; an intermittent stream outlet may be present. Cedar Lake's water level is primarily maintained by precipitation and groundwater, therefore septic systems or other groundwater contamination sources could cause limited problems to this surface water body. The runoff from various land use and management practices can also cause problems, such as nuisance plant growth, resulting from excess phosphorus being carried into the lake from storm water runoff. Because the lake has no natural outlet, chemicals which enter the lake stay in the lake for long periods of time, unlike lakes which have a continuously flowing natural outlets that provide an exit route for such chemicals. It should be noted however, that the lake district constructed an outlet during the mid-1980's to alleviate significantly high water levels; the outlet is usually dry.

3.1 Sampling Program

The sampling program used to determine the water quality of Cedar Lake was conducted over approximately a one year time period, beginning in April of 1999, and concluding in February, 2000. This sampling program provided additional information to enhance the data collected for the 1997-1998 Phase I monitoring program. Samples for Phase II were taken from the same location of the lake that was sampled in the Phase I study - the deepest point in the lake - which is illustrated on Map 1. Sampling was conducted on six separate occasions including:

- April, 1999 (ice off - spring overturn)
- June, 1999
- July, 1999
- August, 1999
- October, 1999
- February, 2000 (ice on)

Town of Schleswig Sanitary District staff and Foth & Van Dyke personnel performed the water sampling, while laboratory analysis of the samples was completed by the State Laboratory of Hygiene. It was important to obtain samples with ice on, ice off, and in summer months to obtain data representative of the seasonal changes which affect water quality.

As mentioned previously, numerous factors were considered in the sampling program, including:

Dissolved Oxygen	Temperature	Chlorophyll *a*
Total Phosphorus	Orthophosphate	chlorides
pH	Alkalinity	Hardness
Magnesium	Ammonia Nitrogen	Nitrate plus Nitrite Nitrogen
Total Kjeldahl Nitrogen	Calcium	Secchi Disc readings

These factors were measured at various depths in the lake ranging from surface to subsurface. Samples for the majority of these factors were taken on the first and last sample dates at surface and sub-surface levels, however all factors were not sampled on the four other dates. As the primary objective of this study was to determine the trophic status of Cedar Lake, the factors which contribute to making this determination were sampled more frequently than most other factors. These factors include Total Phosphorus (Total P), Chlorophyll *a*, and Secchi Disc readings. For the purposes of this study, orthophosphate and chloride levels were also sampled more frequently, including all sample dates. In addition, dissolved oxygen levels and water temperature were sampled at a number of depths for five of the six sample dates.

The following section provides the results of the sampling program, highlighting the temperature profile, dissolved oxygen levels, those factors which contribute to the determination of the lake's trophic state, and additional parameters which have experienced notable change between the 1997-'98 and 1999-'00 sampling programs.

3.2 Results and Analysis

The complete results of the sampling program conducted on Cedar Lake are displayed in Appendix A. The following section provides a more detailed discussion of the sampling results of Temperature, Dissolved Oxygen levels, Trophic Status Indicators including Total Phosphorous concentrations, Chlorophyll *a* concentrations, and Secchi disc readings, and also the sampling results of other important parameters which have experienced significant change between the 1997-'98 and 1999-'00 sampling programs.

Temperature

Temperature exerts a major influence on biological activity and growth. To a point, the higher the water temperature, the greater the biological activity. Temperature also governs the kinds of organisms that can live in a lake. Fish, insects, zooplankton, phytoplankton, and other aquatic species all have a preferred temperature range. As temperatures get too far above or below this preferred range, the survival of individual species may be limited or eliminated.

Temperature is also important because of its influence on water chemistry. The rate of chemical reactions generally increases at higher temperature, which in turn affects biological activity. An important example of the effects of temperature on water chemistry is its impact on oxygen. Warm water holds less oxygen than cool water, so it may be saturated with oxygen but still not contain enough for survival of aquatic life.

Stratification: Layers of a Lake

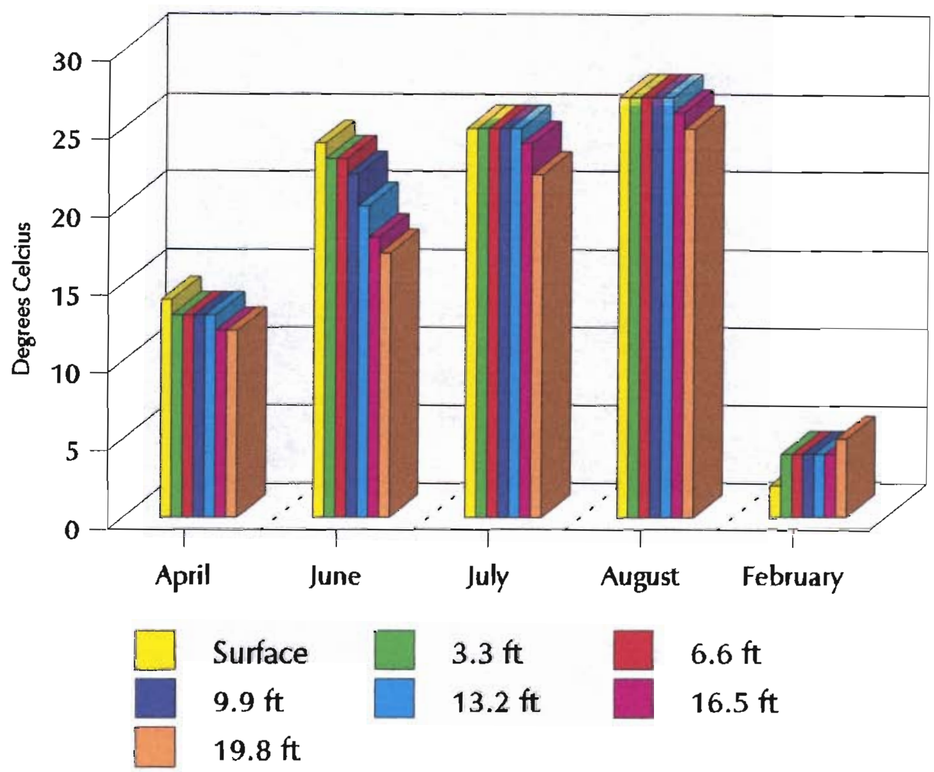
Stratification is a layering effect produced by the warming of the surface waters in many lakes during summer, during which time lake water separates into layers of distinctly different temperature. Upper waters are progressively warmed by the sun and the deeper waters remain cold. Because the layers don't mix, they develop different physical and chemical characteristics, often resembling two different lakes: As a result, oxygen in the bottom waters may become depleted. In autumn, as the upper waters cool to about the same temperature as the lower water, stratification is lost and the whole lake mixes again. This process is called fall turnover. Many lakes experience stratification in winter because ice covers the lake surface. In spring, as ice melts, the surface waters warm, sink, and mix with the deeper water, a process called spring turnover. As summer progresses, the temperature difference (and density difference) between surface and bottom water becomes more distinct, as mentioned previously, and most lakes form three layers. The upper layer, the epilimnion, is characterized by warmer (less dense) water and is the zone of light penetration, where the bulk of productivity or biological growth occurs. The next layer, the metalimnion or thermocline, is a narrow band - colder than the upper and warmer than the lower waters - which helps to prevent mixing between the upper and lower layers. The bottom layer, the hypolimnion, has much colder water. Plant material either decays or sinks to the bottom and accumulates in this stagnant layer. During fall turnover, surface waters cool until they are as dense as the bottom waters and wind action mixes the lake so that water temperature from surface to bottom is the same.

A shallow lake, however, is more likely to be homogeneous from top to bottom. The water is well-mixed by the wind, and physical characteristics such as temperature (and oxygen) vary little with depth. Because sunlight reaches all the way to the bottom, photosynthesis and growth occur throughout the water column. As in a deep lake, decomposition in a shallow lake is higher near the bottom than the top simply due to the fact that when plants and animals die they sink. It is also likely that a larger portion of the water in a shallow lake is influenced by sunlight, and that photosynthesis and growth are proportionately higher.

Temperature Profile of Cedar Lake

Temperature profiles of Cedar Lake were taken from Sample Point #1 at different depths. Figure 3-1 shows that the lake experienced slight stratification during the month of June with a 7° variation, as was expected given the lakes relatively small size and shallow maximum depth of approximately 20 feet. The water remained relatively "mixed", or at approximately the same temperature from top to bottom, throughout the remaining summer months. Overall, the water in Cedar Lake remains mixed year-round, therefore distributing oxygen throughout the lake.

Figure 3-1
Temperature Profile, SP-1
Cedar Lake



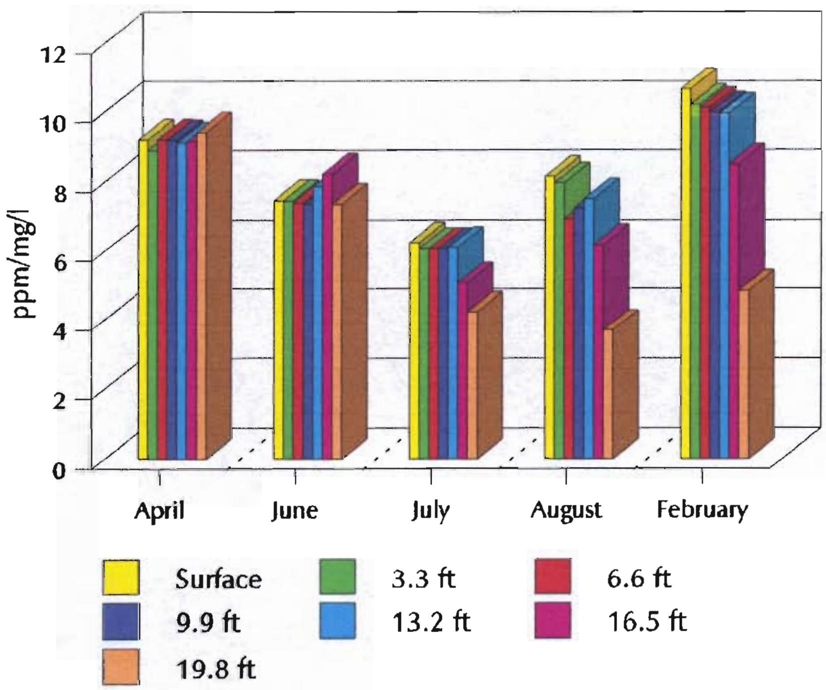
Dissolved Oxygen (D.O.) Concentration

The presence of oxygen in lake water determines where organisms such as fish and zooplankton are found. When water is well-mixed, such as in spring, oxygen is usually present at all depths, thus organisms may be distributed throughout the lake. However, under stratified conditions, little or no oxygen is produced in the hypolimnion. Available oxygen is consumed through decomposition of plant and animal material, and oxygen levels become too low for fish which then must move to the top layer, or epilimnion. If these conditions are prolonged and the upper waters become too warm, cold-water fish such as trout may become stressed and eventually die. In the fall, the lake layers break down and turnover replenishes oxygen to the bottom waters. The formation of ice in water reduces the supply of oxygen to the lake from the overlying air. If oxygen levels fall too low, fish and other aquatic life may die.

The concentration of Dissolved Oxygen present in a lake is important as it supports aquatic life. The solubility of oxygen depends on the temperature of the water - colder water holds more oxygen than warmer water. The amount of D.O. present in lakes at different times of the day, and at different depths, is largely determined by the processes of photosynthesis and respiration. Oxygen is produced when green plants grow (photosynthesis), and is consumed through respiration. Therefore, D.O. levels tend to be higher during daylight hours (when photosynthesis occurs), and lower at night/early morning. In addition, lake depths which are below the reach of sunlight may experience oxygen depletion. Oxygen depletion is especially apparent in winter months where snow cover prevents sunlight from penetrating the water, stopping photosynthesis and causing plants to die; this is termed "winterkill" and occurs in many eutrophic lakes.

In warm water, the water quality standard for D.O. is 5 mg/l, which represents the minimum amount needed for the survival and growth of warm water fish species. D.O. concentrations between 8 mg/l and 10 mg/l indicate saturation. Figure 3-2 illustrates Dissolved Oxygen levels at varying depths in Cedar Lake.

Figure 3-2
Dissolved Oxygen Levels
Cedar Lake



The D.O. levels remained fairly consistent among the varying sample dates and depths ranging from approximately 6 mg/l to 10 mg/l, with the exception of depletion at the lower depths in mid- to late summer and in winter. This is characteristic of lakes which support relatively few plants and animals, whereas D.O. levels fluctuate considerably in lakes with high biological activity.

Trophic Status Indicators

Total Phosphorus Concentration (Total P)

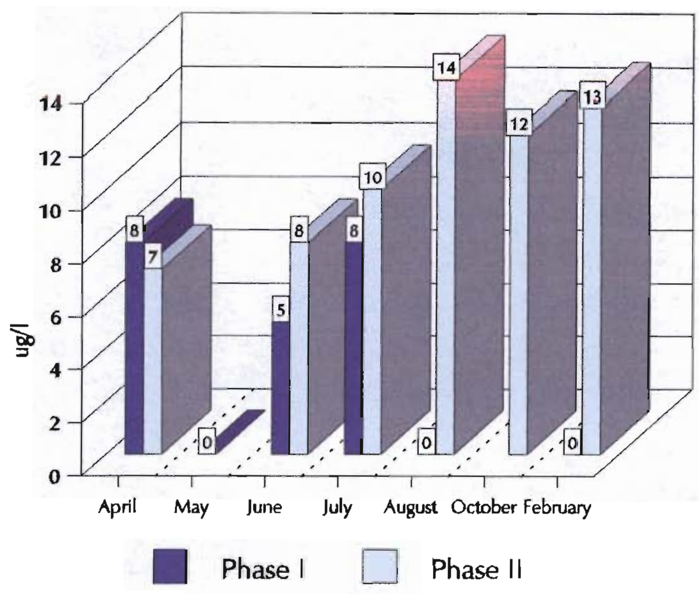
Phosphorus is the key nutrient which influences plant growth in over 80% of the lakes throughout Wisconsin, and also promotes excessive aquatic plant growth. In most lakes, phosphorus is the least available nutrient, so it's abundance, or scarcity, controls the extent of algae growth. For that reason, phosphorus is typically referred to as the limiting nutrient. If more phosphorus is added to the lake from septic tanks, urban or farmland runoff, lawn or garden fertilizers, sewage treatment plants, or other watershed or outside resources, or even if it is released from phosphorus-rich lake bottom sediments, that limitation is taken away and more algae will grow. Under certain conditions, especially when oxygen is absent from bottom waters, phosphorus is released from bottom sediments into the overlying water. In turn, algae clouds water clarity and decreases the depth of light penetration.

Algae are a source of food and energy for fish and other lake organisms, and are a vital part of all lakes. However, excessive amounts or nuisance types of algae can interfere with lake uses by inhibiting the growth of other plants by clouding the water so that it shades them, contributing - as the decay - to oxygen depletion and fish kills, and causing taste and odor problems in water and fish. In addition, it can interfere with the aesthetic environment of the lake causing unsightly algal blooms which float on the lake surface forming scums. The regular occurrence of visible algal blooms often indicates that nutrient levels, especially phosphorus, are too high.

Aquatic plants may also limit many lake uses. Although aquatic plants (macrophytes) serve a vital function for the lake by providing cover, habitat, and even food for fish and other wildlife, an overabundance of rooted and floating plants can limit swimming, fishing, skiing, sailing, and boating activities, and aesthetic appreciation. Excessive plant growth can physically prevent mixing of oxygen through the water.

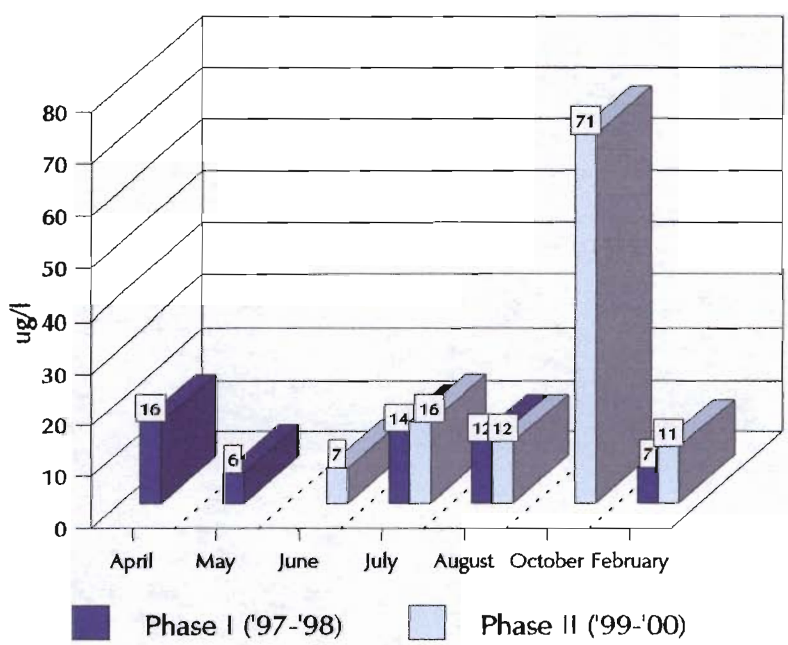
Two types of phosphorus analyses can be conducted which include soluble reactive phosphorus (orthophosphate) and total phosphorus; total phosphorus is a better indicator of the nutrient status of a lake because its levels remain more stable. The concentrations of Total P detected at the surface (0 - 3.3 ft) and sub-surface (13.1 - 19.7 ft) in Cedar Lake are presented in Figures 3-3 and 3-4, respectively, while the corresponding surface and sub-surface WTSI values are presented in Figures 3-5 and 3-6.

Figure 3-3
Total P Concentrations, Phases I & II
SP 1 Surface Sample, Cedar Lake



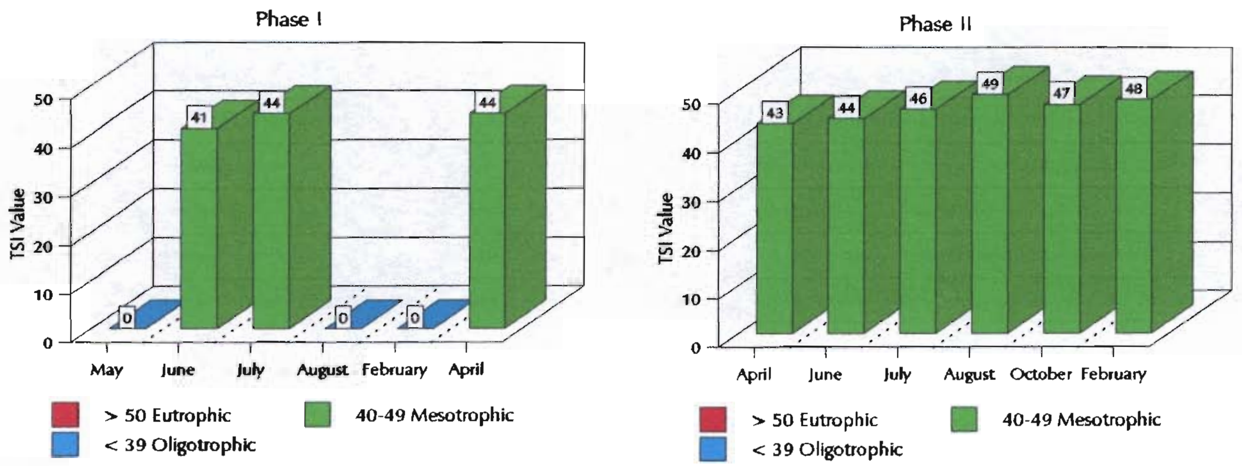
Note: "0" indicates no detection.

Figure 3-4
Total P Concentrations, Phases I & II
SP 1 Sub-Surface Sample, Cedar Lake



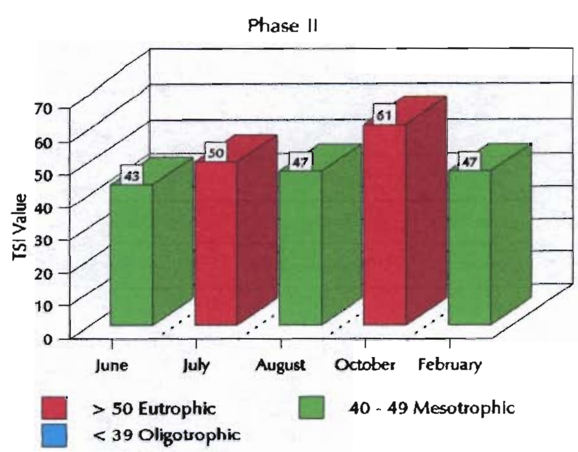
Total P concentrations should be maintained below 20 ug/l for natural lakes in order to prevent nuisance algae blooms (Understanding Lake Data). As indicated in Figure 3-4, the surface Total P concentrations in Cedar Lake remained below 20 ug/l for all samples taken with the highest concentration detected being 14 ug/l near the surface, and 16 ug/l near the lake bottom. However, Total P concentrations overall have increased slightly between the sampling conducted for the Phase I study and the sampling conducted for this study, Phase II.

Figure 3-5
Total P Concentrations, Phases I & II
SP 1 Surface Sample WTSI Values
Cedar Lake



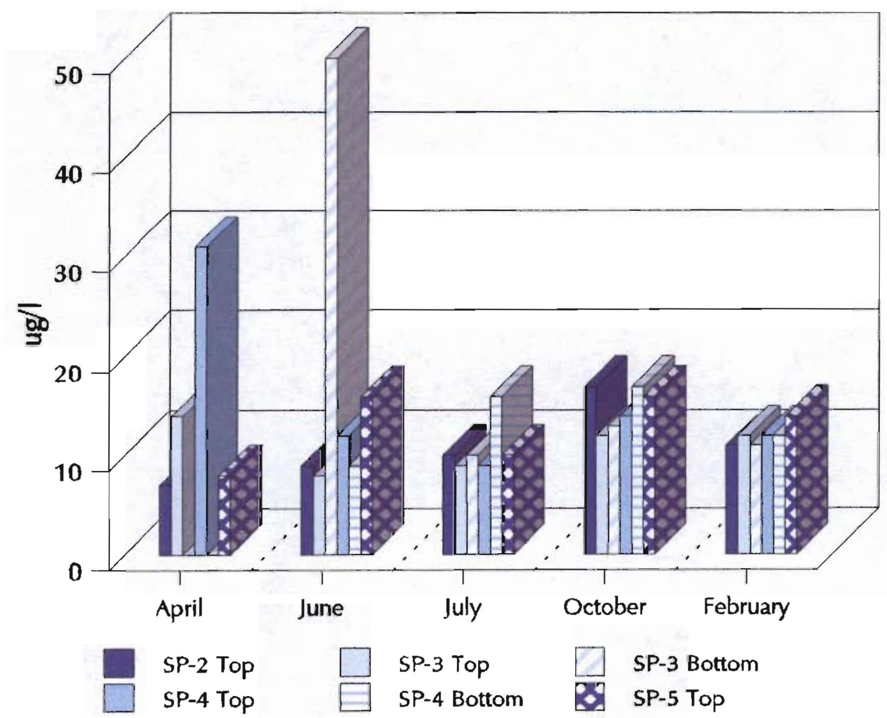
Note: "0" indicates no detection.

Figure 3-6
Total P Concentrations, Phases I & II
SP 1 Sub-Surface Sample WTSI Values
Cedar Lake



Total P concentrations were also analyzed from the four other sample locations identified (See Map 1). The following figure (3-7) illustrates the results of the analysis, while Figure 3-8 identifies the WTSI values for Total P detected at each sample location:

Figure 3-7
Total P Concentrations
SP-2, SP-3, SP-4 & SP-5
Cedar Lake



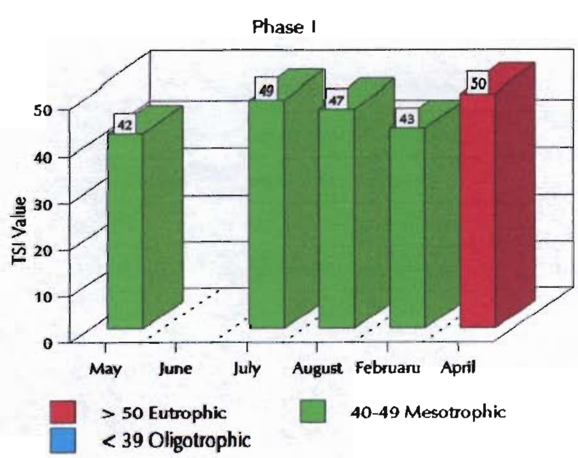
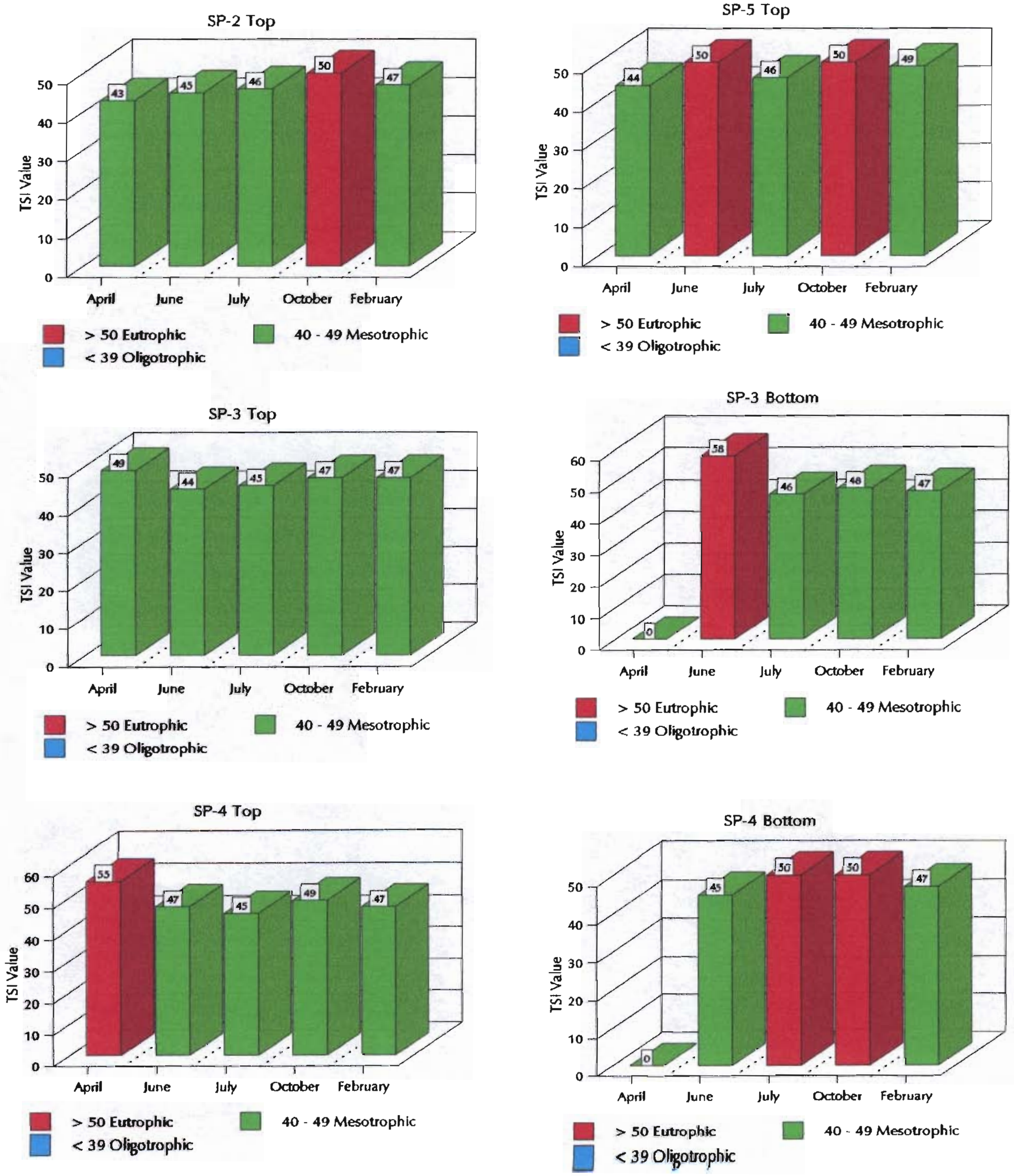


Figure 3-8
Total P Concentrations
SP-2, SP-3, SP-4 & SP-5 Samples, WTSI Values
Cedar Lake



In terms of trophic status, the Total P concentrations found in Cedar Lake indicate that the lake's trophic status is primarily in the upper Mesotrophic range in both the surface and sub-surface in all areas of the lake. However, lower-range eutrophic status was detected on several occasions.

Chlorophyll a Concentration

Chlorophyll *a* is a green pigment which is present in all plant life and is necessary for photosynthesis. The amount of chlorophyll *a* present in a lake is dependent upon the amount of algae present, and is therefore used as a common indicator of water quality. It is also one of three characteristics used to determine the trophic state of a lake. Figure 3-9 identifies the concentration of Chlorophyll *a* detected in Cedar Lake on three occasions, while Figure 3-10 illustrates the corresponding WTSI values.

Figure 3-9
Chlorophyll a Concentrations (ug/l), Phases I and II
Cedar Lake

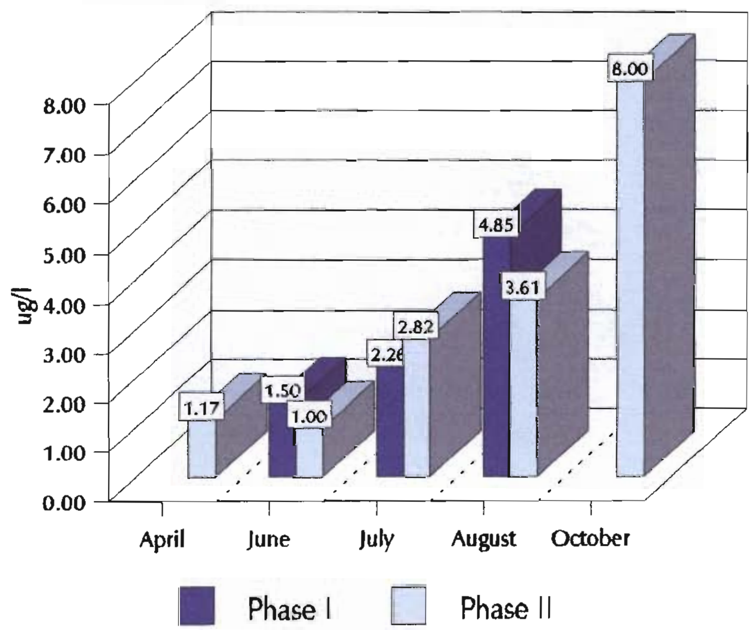
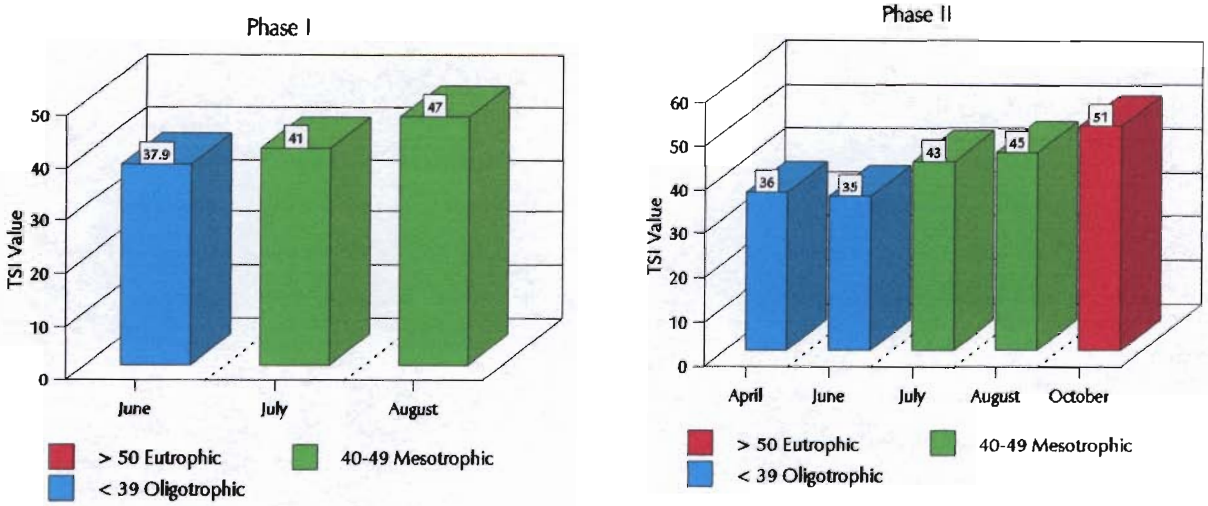


Figure 3-10
Chlorophyll a Concentrations, Phases I & II WTSI Values
Cedar Lake



Based on the results of the Chlorophyll a samples, the trophic status of Cedar Lake was identified as being near the high end of Oligotrophic in early summer and gradually changed to the higher end of mesotrophic status near the end of summer - even reaching eutrophic conditions in fall, indicating the amount of algae in Cedar Lake increased throughout the summer months.

Secchi Disc Reading

A Secchi disc reading is a measure of water clarity; it is not a direct measure of water quality related to chemical and physical properties. However, water clarity is often indicative of a lake's overall water quality, especially the amount of algae present. Secchi disc readings are taken by lowering an 8 inch disc into the water, and taking the average of the depth where the disc disappears from sight and where it becomes visible again when raised. The Secchi disc reading can be used to determine the trophic state of a lake. Figure 3-11 provides the Secchi disc readings from Cedar Lake on seven sampling dates, and Figure 3-12 displays the representative WTSI values for these readings.

Figure 3-11
Secchi Disk Readings, Phases I & II
Cedar Lake

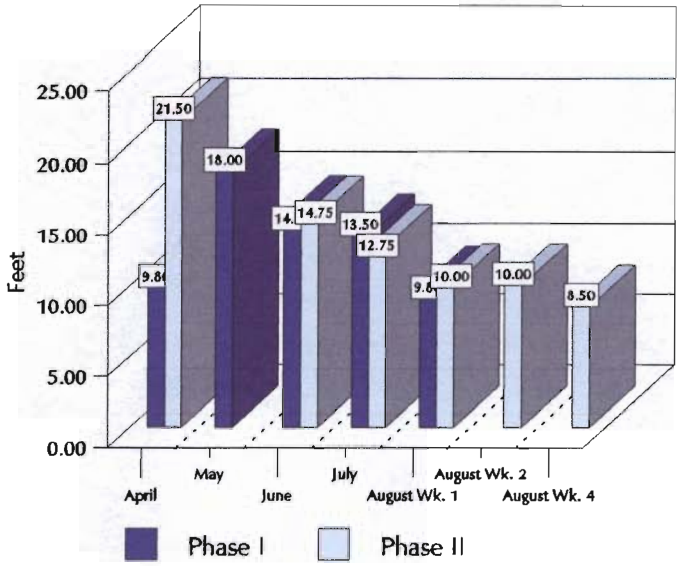


Figure 3-12
Secchi Disk Readings, Phases I & II WTSI Values
Cedar Lake

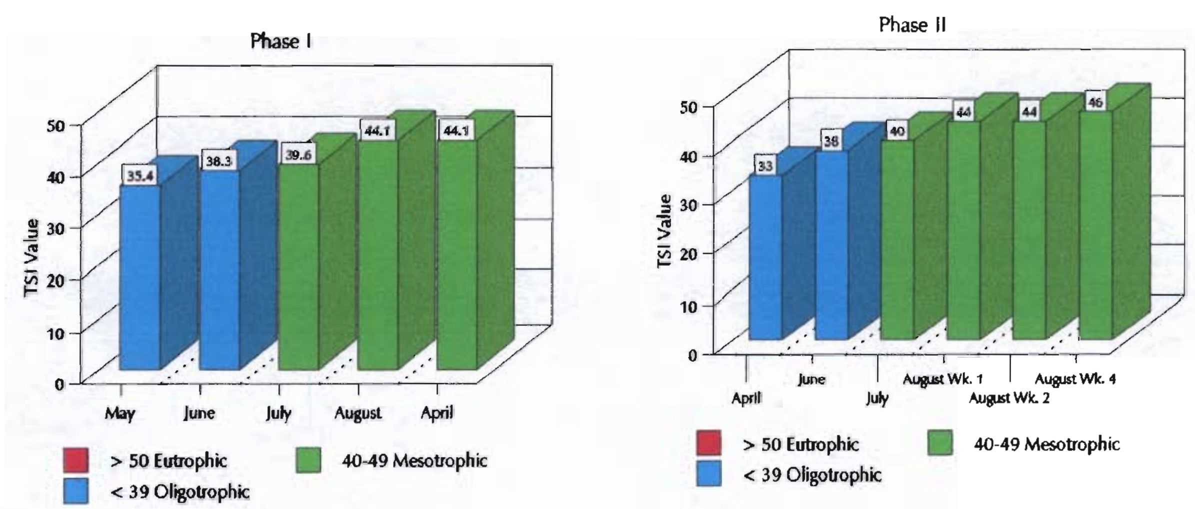


Figure 3-11 depicts that the water clarity of Cedar Lake gradually decreased between April, 1999 and mid-August, 1999, from visibility at 21 feet to visibility at 10 feet, respectively. These readings indicate the lake's water quality ranges from fair to good.

The trophic status of Cedar Lake, as illustrated in Figure 3-12, gradually changed from oligotrophic to mesotrophic during the sampling period.

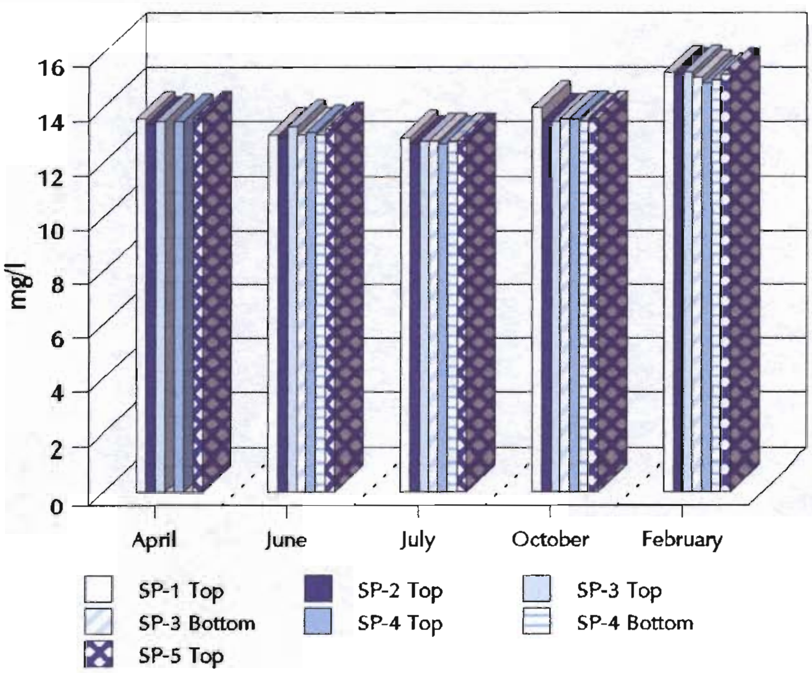
Non-Trophic Status Indicators

Chloride

Chloride is present in Wisconsin waters in small amounts naturally. The highest natural concentrations are found in southeastern Wisconsin with typical values of 10 mg/l or greater. Higher concentrations of chloride is an indicator of possible water pollution. Potential sources of chloride include septic systems, animal waste, fertilizers, and drainage from road salting chemicals.

The chloride values for Cedar Lake were consistently between 12mg/l and 16 mg/l. This is in the range of natural values. While the initial indication is that the potential pollutant chloride sources are not significantly impacting the lake, chloride concentrations can vary from year to year and chloride data should be included in a long term data collection program to track changes.

Figure 3-13
Chloride Concentrations
All Sample Locations, Cedar Lake

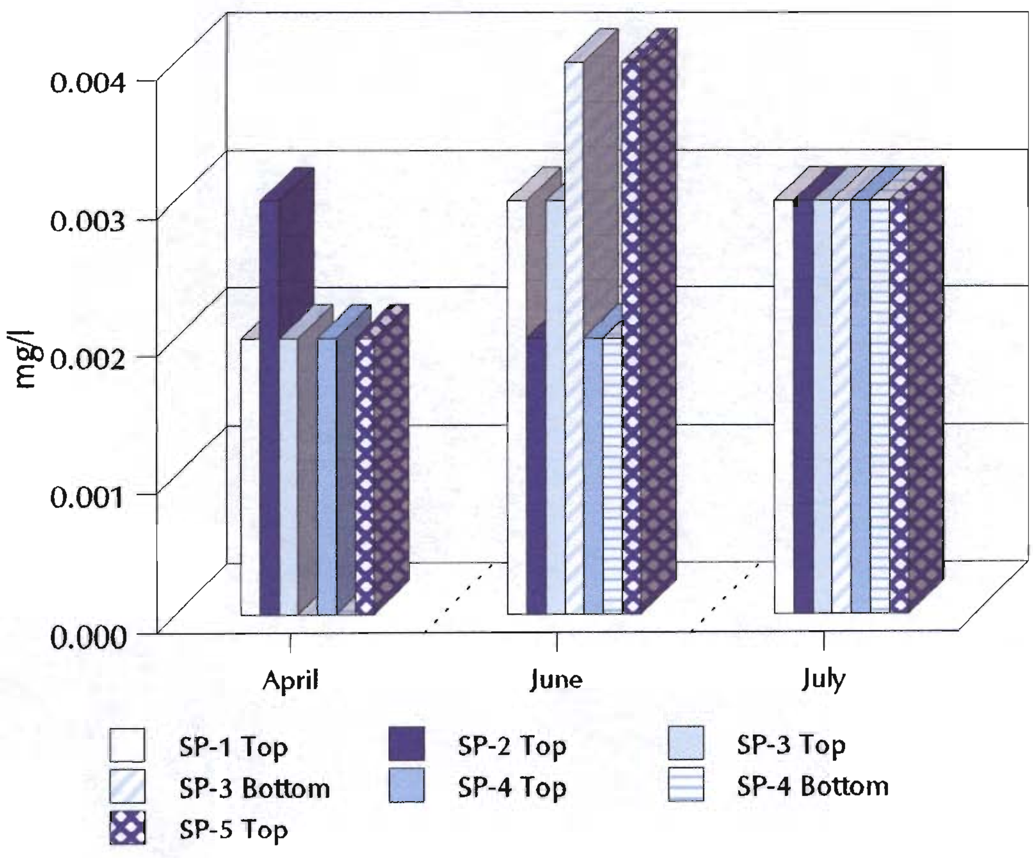


Orthophosphate

This chemical parameter is a measurement of the soluble phosphorus available for algae and weed growth. The concentration of ortho-phosphate will vary during the season in response to algae growth. When algae growth is at its peak, ortho-phosphate concentrations will be at a minimum.

Orthophosphate was measured in samples collected in April, June, July, August, October and February. The concentrations were relatively low in all samples and ranged from 4 ug/l to less than 2 ug/l. The highest concentrations occurred in June and the lowest concentrations occurred in October and February. This data corresponds to the chlorophyll a measurements which followed an opposite pattern. When chlorophyll a concentrations are at their peak, almost all the ortho-phosphate will be removed from the water and this is shown in the data from Cedar Lake.

Figure 3-14
Orthophosphate Concentrations
All Sample Locations
Cedar Lake



Nitrogen (Ammonia, NO2+NO3, and TKN)

Nitrogen is an important plant nutrient. While phosphorus is typically the limiting nutrient for algae growth, nitrogen can be limiting under some circumstances. Nitrogen compounds are present in lakes as inorganic or organic. The inorganic forms are ammonia and nitrite/nitrate ($NO_2 + NO_3$) and these forms are available to plants for growth. The organic form is included in Total Kjeldahl Nitrogen. This form is found in plant and animal tissues.

The data shows a significant increase in nitrogen concentrations from 1997 to 1999. Possible nitrogen sources are lawn fertilizer, agricultural runoff, or domestic sewage from septic systems. These results are consistent with other results which show a trend toward lower water quality.

Figure 3-15
Ammonia & NO2+NO3 Concentrations
All Sample Locations
Cedar Lake

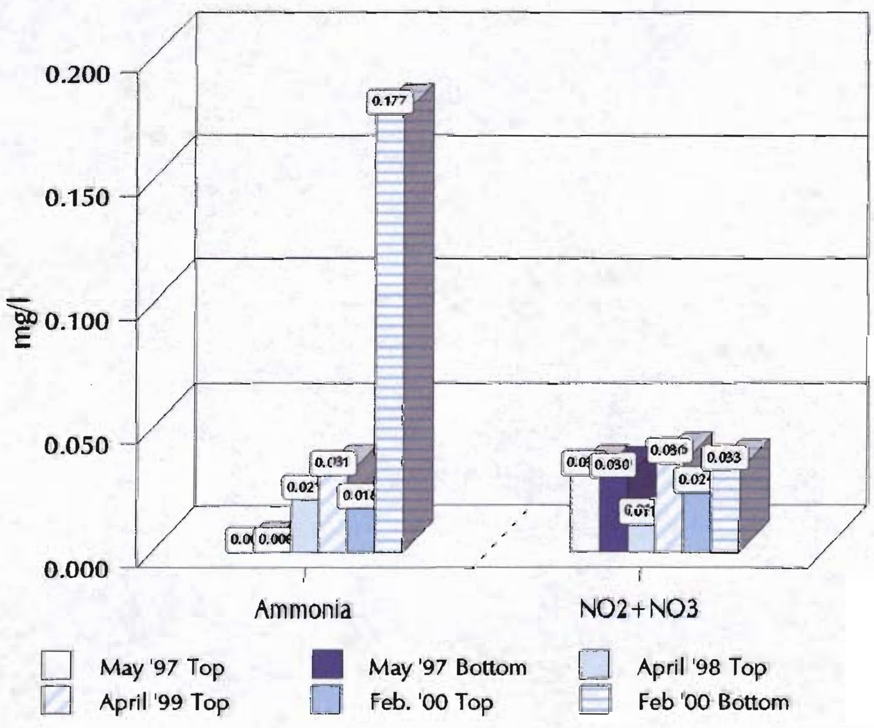
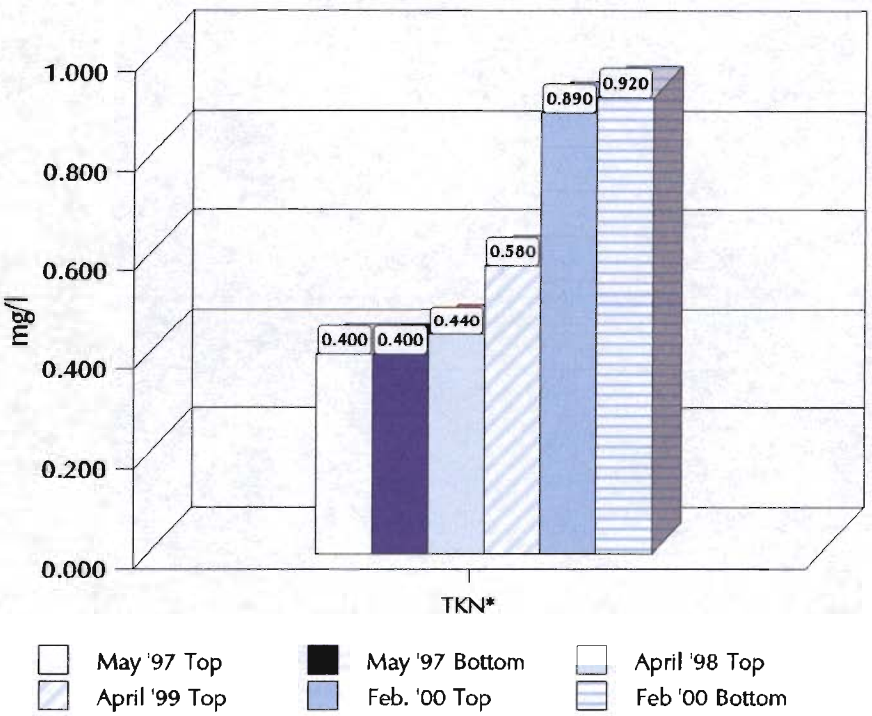


Figure 3-16
TKN* Concentrations
All Sample Locations
Cedar Lake



* TKN = Total Kjeldahl Nitrogen

3.3 Conclusions

Temperature

The lake does not have strong stratification characteristic and has demonstrated a somewhat mixed condition for most of the year, meaning that the temperature of the water remains relatively stable from the top to the bottom of the lake. This is expected as the maximum depth of the lake is approximately 20 feet. Because the lake remains mixed, oxygen is distributed rather evenly throughout the lake for most of the year, as concluded from the D.O. concentrations. There are times, during the summer periods when some weak stratification has been seen. This is more evident in the DO readings than temperature.

Dissolved Oxygen

Typical of mesotrophic lakes, DO concentrations were lower at the bottom of the lake in summer and winter. At no time was the DO completed depleted even at the lowest depth. The DO concentrations were adequate for fish and other aquatic organism survival although fish likely moved out of the deepest areas when the DO was low.

The DO concentrations were lower in 1999 than in 1997 for measurements taken at the same location. This was particularly true in the summer months when DO concentrations were a lower by 1 mg/l or more. While the DO concentrations are good, the downward trend is an indication that water quality may be gradually decreasing.

Total Phosphorus

Concentrations of Total P were consistently in the mid to upper mesotrophic range. Several values were in the eutrophic range.

When Total P data from 1997 and 1999 taken at SP-1 are compared, the 1999 data are noticeably higher than in 1997. This is true of both the surface samples and the sub-surface samples. While the concentrations are still in the mesotrophic range, the trend to decreasing water quality is of some concern.

Chlorophyll a

Measurements of chlorophyll a were more variable than other parameters. Early in the year, the concentrations were in the oligotrophic range while concentrations in October were in the eutrophic range. This pattern of increased algae growth from spring to fall matches the data collected in 1997. The values from 1997 to 1999 were nearly identical.

Secchi Disc

The secchi disc measurements had values that followed the trend of chlorophyll a. The water clarity decreased from early in the season and corresponded to increased algae concentrations. The secchi disc readings for 1999 were nearly identical to values from 1997.

Orthophosphate

Concentrations of orthophosphate were relatively low throughout the year and were below the level of detection in fall and winter. When compared to 1997, the ortho-phosphate concentrations were higher in 1999.

Nitrogen

Inorganic and organic nitrogen compounds increased from 1997 to 1999. This trend is consistent with the increase in nutrients in Cedar Lake.

Summary

The water quality parameters showed Cedar Lake to be a mesotrophic lake with adequate DO for fish and other aquatic life. Phosphorus concentrations were below levels where nuisance algae blooms occur. Algae concentrations increased from spring to fall. The comparison of 1997 data with 1999 data showed water quality declined based on Dissolved Oxygen, all nitrogen compounds, and total and ortho phosphorus concentrations. However, the reason for the decline in water quality is not easily determined. Potential factors include: increased nutrient load, weather conditions (i.e., temperature, wind, ice cover, seasonal weed and algae growth), and weed harvesting activity. The chlorophyll a and secchi disc measurements showed no change from 1997 to 1999. This testing indicates that Cedar Lake may have an accelerated rate of eutrophication. While two years of test data may be insufficient to cause alarm, the trend toward poor quality water should not be dismissed.

4 Groundwater Recharge/Discharge and Lake Level

4.1 Groundwater Recharge/Discharge

Cedar Lake is influenced by groundwater. The lake is classified as a seepage lake in which water levels are maintained by groundwater, precipitation and limited runoff. The lake has a small tributary area and an intermittent outlet. The water level in the lake is primarily determined by groundwater. The groundwater elevation influences the lake levels from two perspectives, on the east end of the lake, the groundwater flows into the lake, acting as a source of water for the system. On the west end of the lake the water typically flows out of the lake into the groundwater. The groundwater elevation at the west end controls the rate at which the surface water will discharge to the groundwater, therefore controlling the lake levels in a second manner. The major water input to the lake is a high capacity well that pumps groundwater into the lake.

Foth & Van Dyke installed groundwater piezometers along the lakeshore in six locations (See Map No. 1). These piezometers were monitored weekly over the summer months in 1999. The results are shown in Appendix 4-1. The purpose of the piezometers was to determine groundwater flow direction. If the piezometer has a water level in the well lower than the adjacent lake level, then groundwater is flowing out of the lake at that point. If the piezometer has a higher water level than the adjacent lake level, then groundwater is flowing into the lake at that point.

The piezometer measurements showed a significant seasonal variation in water level in the piezometers. In general, the water levels were highest in June, July and August. The water levels were lower in the spring and fall. These water levels correspond to the rainfall in 1999. Precipitation was below normal in early spring, above normal in May, June and July, and well below normal in late summer and fall. The piezometers on the east end of the lake (#1 and #6) had significant periods of time where the water level in the piezometers was higher than the adjacent lake. This showed groundwater flowing into the lake and corresponded to the higher groundwater and rainfall periods. The piezometers on the west side of the lake (#2, #3, and #4) had almost all readings showing lower water levels in the piezometers than in the lake. This data showed water from the lake discharging to groundwater.

The piezometer measurements show that on the average, lake water is discharged to groundwater. This condition may be exaggerated by the high capacity well which raises the lake level when in operation. Without the well, the lake level would be lower but the level would tend to seek the level of the groundwater and less water would be discharged to groundwater.

The groundwater quality around the lake will affect the lake water quality. This is particularly true on the east side of the lake where groundwater discharges to the lake seasonally during higher groundwater periods. On the west side of the lake, groundwater will have an impact on water quality less frequently. Adequate groundwater elevation to have groundwater discharge into the lake occurred briefly during the 1999 study period.

The practical application for this data is that septic systems around the lake do not necessarily discharge to the lake. On the west side of the lake, groundwater generally moves away from the lake and septic systems have little impact on the lake water quality. On the east side of the lake, groundwater moves into the lake when groundwater is high as evidenced by the data collected during 1999. Improvements to septic systems should focus on the east side of the lake.

Many residences have septic systems between the lake and their drinking water well. Since the groundwater flows away from the lake in most conditions, it is likely that the septic system effluent travels toward the well. This situation may contribute to nitrate and/or coliform bacteria in drinking water wells.

4.2 Lake Level

The water level in Cedar Lake varied in 1999 by 0.81 feet. The highest level was in June during a period of high precipitation and high groundwater. The lowest level was in fall when precipitation and groundwater levels were low. The lake normally has no surface discharge. If water levels are extremely high, there is an overflow pipe on the west end of the lake to drain excess water. The lake level is less prone to wide fluctuations than other lakes due to the high capacity well that is located on the northeast lake shore. This groundwater source adds water to the lake to prevent water levels from getting too low. If water levels get high, water is discharged from the lake to the groundwater or through the overflow pipe.

5 Sanitary Survey

A sanitary survey was distributed to all property owners within the Town of Schleswig Sanitary District No. 1 in July, 1997, as part of the Phase I lake study. The purpose of the survey was to collect input regarding private wastewater and water supply systems to aid in evaluating the potential impact of private sanitary systems on the water quality of Cedar Lake. All residences located along the lakeshore are currently equipped with private, on-site septic systems, including septic tanks and fields, holding tanks, mound systems and other systems. Private septic systems can potentially have a negative impact on the water quality of the lake if they are improperly installed (including poor location selection) or maintained. The waste products of these systems contain nutrients which promote nuisance plant and algae growth. If these waste products enter the lake, the process of eutrophication can be accelerated and water quality may decrease.

The overall results of the survey and on-site observations are highlighted in this section.

5.1 1997 Sanitary Survey and On-Site Observation Results and Analysis

Survey responses were received from nearly 50% of all property owners of land along the Cedar Lake shoreline. The complete results of the Sanitary Survey are included in Appendix 5-1.

Based on the data collected from the sanitary survey and the observations from the field study, the following conclusions can be drawn:

- Over two-thirds of the on-site sanitary systems within the Town of Schleswig Sanitary District No. 1 are conventional septic systems, however only approximately one-third of the property in the District is suitable for this type of system due to steep slopes, low areas, small lots grouped together, etc.

- Over 40 percent of sanitary systems in the Town of Schleswig Sanitary District No. 1 are more than 15 years old, while another 25 percent can be assumed to be over 15 years old (ages unknown by owners). Codes may have been more lenient at the time these systems were constructed, therefore they may not be ideally located or constructed by today's standards.

- All survey respondents indicated that no problems were experienced with their systems, however they may not be educated on how to detect wastewater discharging to the surface or discharging indirectly.

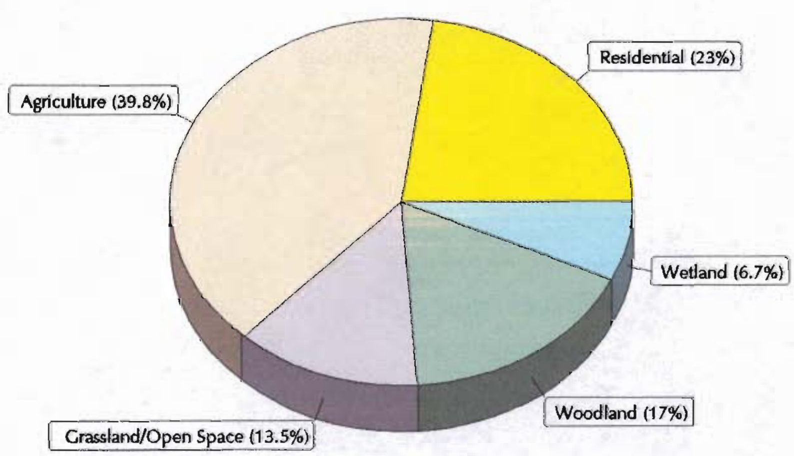
Therefore, it is possible that some sanitary systems within the District are discharging wastewater into Cedar Lake and contributing to the accelerated eutrophication of the lake or provide a potential threat to the potable water wells in the area.

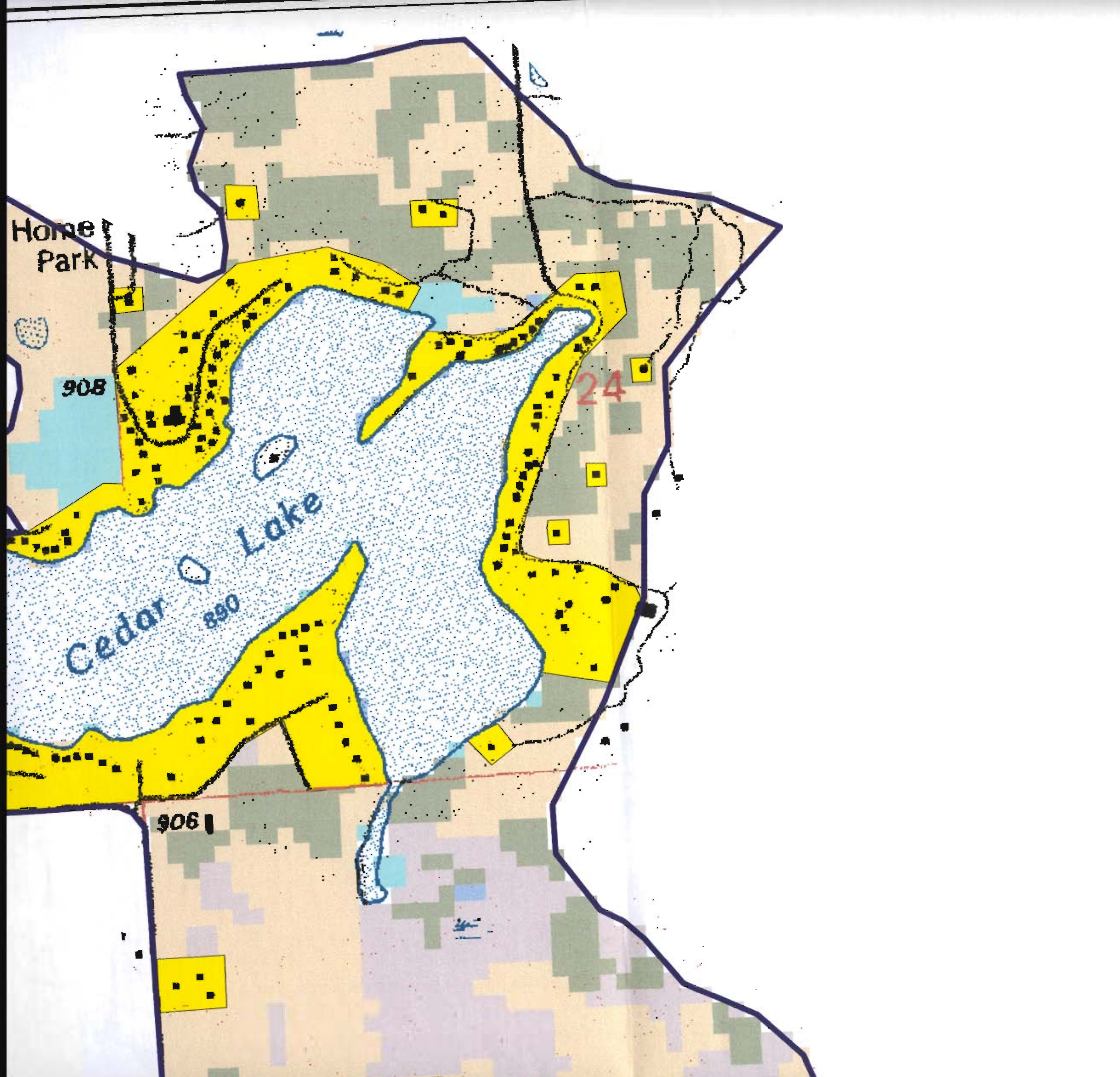
6 Watershed Analysis

A watershed is an area of land in which water drains to a common point, such as a stream, lake or wetland. A lake reflects its watershed because the watershed contributes both the water required to maintain a lake, and the majority of pollutants which enter the lake. Therefore, effective lake management programs must include watershed management practices, as lake problems generally cannot be solved without controlling the sources in the watershed. Managing the watershed to control nonpoint pollutants such as nutrients, soil, and other substances which originate over a relatively broad area is essential to protecting water quality. Water running over the land picks up these materials and transports them to the lake, either directly in runoff or through a tributary stream, drainage system, or groundwater. Water running off a lawn or driveway during a heavy rain is an example of nonpoint source runoff. Land uses such as agriculture, construction, and roadways contribute higher nonpoint pollutant loads than other land uses such as forests. Controlling nonpoint pollution sources can usually be achieved by implementing best management practices. However, it must be noted that nonpoint pollution sources are harder to identify, isolate, and control than point sources (distinct sources such as a wastewater treatment plant or an industrial facility). Controlling the water that runs from the land's surface into the lake is important as lakes receive water directly from drainage of the surrounding land (watershed) and precipitation.

The watershed, or land area, which drains into Cedar Lake was delineated by Foth & Van Dyke and is illustrated on Map No. 2. The map was prepared using LandSat imagery which is made available by the WDNR. Figure 6-1 summarizes the land use classifications within the watershed and the total acreage and percentage of land use each comprises.

Figure 6-1
Existing Land Cover
Cedar Lake Watershed, Manitowoc County

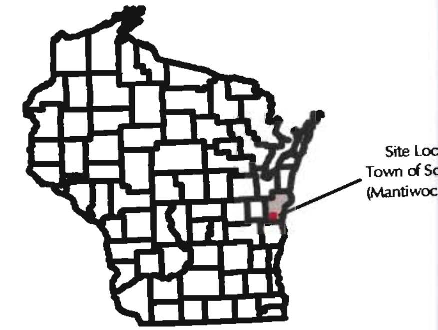




MAP 2

LAND COVER &
U.S.G.S. QUADRAN
CEDAR LAKE WATERSHED

Manitowoc County, Wisconsin



State of Wisconsin

- Residential / Built-
- Agriculture
- Woodlands
- Wetlands
- Open Space
- Surface Water
- Cedar Lake Water

This drawing is neither a legally recorded map nor a su
not intended to be used as one. This drawing is a com
records, information and data used for reference purp

Source: U.S.G.S. 7.5-minute topographic quadrangle - Sch
Classification derived from LANDSAT Thematic Map
satellite imagery from 1991, 1992, and 1993
The classification has been smoothed to a one acre mini
unit (4 contiguous pixels) from the original 30-meter
Wetlands less than one acre and open water pixels were
Classification was done by the Wisconsin DNR - Geo Se
Watershed delineation done by Foth and Van Dyk

Approximately 40% of Cedar Lake's watershed is comprised of agricultural land. This is followed by residential use which comprises about 23% of the land area in the watershed, the majority of which is located along the lakeshore and backlot areas. Nearly all shoreland areas have been converted to residential lots. Some woodlands and open space areas exist within the watershed and comprises approximately 17% and 13.5% of the total land use within the watershed, respectively.

Not all areas of the watershed are equal pollutant contributors. By identifying those critical areas that contribute excessive amounts of soil and nutrients to the lake, the most effective controls can be developed. For example, agricultural runoff carrying animal wastes, soil, and nutrients can be a critical pollutant contributor. Urban runoff from lawns, gardens, streets, and rooftops may be significant sources of sediment, oils and greases, nutrients, and heavy metals to lakes. Construction and forestry activities can provide significant quantities of sediments, especially during rainstorms. In large watersheds, the contributions from urban, forestry, and agricultural areas are generally more significant than those from lakeshore homes. However, in small watersheds, lakeside residential activities may be more critical pollutant contributors.

An estimation of sediment and nutrient (phosphorus) loading to Cedar Lake was calculated based on the existing land uses illustrated in Map No. 2. The estimation was calculated using a WDNR model. The model makes assumptions based on previous studies of phosphorus loading from runoff or domestic wastewater. The results of the calculation are identified in Table 6-1.

Table 6-1
Existing Sediment and Nutrient Loading (in lbs/yr)
Cedar Lake Watershed

Land Use Class	Acreage	Sediment (lbs/yr)	Phosphorus (lbs/yr)	Zinc (lbs/yr)	Lead (lbs/yr)
Residential	113.8	21,622.0	56.9	22.8	22.8
Agriculture	196.4	4,910.0	2.0	0.0	1.0
Grassland/Open Space	66.5	1,662.5	0.7	0.0	0.3
Woodland/Forested	84.1	2,102.5	0.8	0.0	0.4
Wetlands	32.9	822.5	0.3	0.0	0.2
Total	**493.7**	**31,119.5**	**60.7**	**22.8**	**24.7**

Source: Foth & Van Dyke, 2000; WDNR nutrient model.

Another significant phosphorus source is from domestic wastewater. The potential phosphorus from this source can be estimated based on the following:

130 homes
2.5 people per home
⅔ full-time occupancy average per home
0.006 lbs phosphorus/person

Total phosphorus from wastewater is estimated at 477 lbs/year. Of this amount, about 15% is removed in the septic tanks. The remaining 400 pounds is discharged to the soil for treatment and disposal. Phosphorus is generally removed efficiently by soil through the process of adsorption on soil particles. All soils have a finite capacity for retaining and adsorbing phosphorus. When that capacity is reached, phosphorus will pass through the soil to the groundwater and potentially discharge into the lake. Providing good wastewater treatment and keeping this source of phosphorus out of the lake should be part of a long term lake management plan.

Cedar Lake is sensitive to phosphorus loading because it is a seepage lake with no continuous outlet. Any phosphorus that enters the lake remains in the lake unless it is removed in plants or settles to the bottom as a solid particle. Cedar Lake contains about 431 million gallons of water. With an average total phosphorus concentration of 14 ug/l, the average amount of phosphorus in the water is 50 pounds. The watershed evaluation identified an annual phosphorus load of 61 pounds with a potential additional load from septic systems. Each year phosphorus is removed by weed harvesting and by sedimentation. To keep the phosphorus concentration the same in the lake, phosphorus must be removed at the same rate as it is added to the lake. Based on the increase in phosphorus concentrations in the lake, it appears that more phosphorus is being added to the lake than is being removed each year.

7 Alternatives for Water Quality Improvements

The following presents some alternatives which may be implemented to improve the water quality of Cedar Lake, and to slow the process of eutrophication. Alternatives include educating Town of Schleswig Sanitary District No. 1 landowners on ways they can contribute to improving the lake's water quality, improvements that can be made to sanitary systems, weed harvesting, and the installation of a public sanitary sewer system.

7.1 Education

There are numerous ways individual landowners can contribute to maintaining or improving the water quality of Cedar Lake through various land practices. Land owners should be provided with educational material explaining proper land practices and the benefits of them. This is especially important for Cedar lake as it has been identified that nutrient runoff from residential land uses is impacting the water quality of the lake.

A number of human activities add nutrients to the water which promote excessive plant growth. The best long-term solution to control/prevent excessive plant and algae growth and improve water quality then is to prevent surplus nutrients and sediments from entering the water. Surface water runoff is a major source of nutrients and sediments in lakes. It should be noted, however, that variations in the natural environment (i.e. temperature, weather conditions, etc..) can also cause excessive plant growth.

This section identifies the ways in which private landowners can help to improve the lake's water quality by reducing surface water runoff and controlling soil erosion:

Landscaping Along the Waterfront

Landscaping along the shoreline is best kept in its natural state and provides several benefits which include:

- Protecting the water quality of the lake by filtering nutrients and pollutants from runoff before reaching the lake.
- Preserving the beauty of the shoreline by preserving the natural appearance and screening development from view.
- Providing wildlife habitat.
- Protecting the shoreline from erosion.
- Shading lakeshore water minimizing aquatic plant growth near shore.
- Low-maintenance care.

These benefits can be achieved by doing the following:

- Preserve Natural Shoreline Buffers: Leave the shoreline in a natural state if it has not yet been altered. In areas where the land slopes to the water, construct a berm back from the shore to detain runoff, allowing time for infiltration and evaporation of water.(local zoning regulations restrict shoreline vegetation removal).

- Restore Shoreline Buffer Areas: Leave a strip of unmowed grass, preferably 20 feet wide or more, along the shoreline; native flowers, shrubs and grasses will naturally grow in this area. Native species, including trees, may also be planted in these areas to add variety and provide more immediate results without requiring the use of fertilizers. The wider the buffer area, the greater the benefits.

- Shoreline Paths: Create pathways to the shoreline which follow natural contours rather than descend straight downslope to minimize erosion. Use wood chips or gravel for paving so runoff is not directed into the lake.

- Limit paved or impermeable areas. Dominating the landscape with driveways, patios, decks, and roofs increases the amount and velocity of runoff, carrying sediments and nutrients which cause nuisance plant growth, damage aquatic habitat, hinder recreational activities, and speed the eutrophication of the lake. Reduce the amount of runoff from driveways and patios by constructing them with porous paving bricks, and diverting water to areas where it can evaporate or soak into the soil.

- Minimize land slopes. Keeping the land as flat as possible reduces erosion. Terracing should be used to flatten areas of steep slope, such as those along the east shore of Cedar Lake.

Lawn/Garden Care

It was observed during the field study that much of the lake is surrounded by well-kept lawns. The fertilizers and pesticides frequently used to maintain these laws and gardens can reach the water and negatively affect the water quality of the lake. A minimal amount of lawn area is recommended to maintain good water quality; ideally, native, low-maintenance groundcovers should be planted in place of lawn. There are ways however, to care for lawns and gardens which will preserve the water quality of the lake, including:

- Proper use of fertilizers and pesticides, including the use of no- or low-phosphorus containing fertilizers. Use fertilizer only if there is a nutrient deficiency present as shown by a soil test. For pesticides, avoid application 1) if rain is likely, 2) near the shoreline, and 3) near a well, do not dispose of them down a toilet or drain, do not mix different pesticides, and carefully follow the directions on the label.

- Choose a grass type or groundcover that is appropriate for your site and soils which requires minimal maintenance, fertilizer and pesticide application.

- Leave grass clippings on the lawn. This will provide up to one-half of the nitrogen the lawn needs. Do not burn grass clippings and leaves near the shore or rake them into the water.

- Do not mow more than ⅓ of the height of grass blades. Set the mower blade to 2 - 2 ½".

- Locate gardens away from the shoreline.

- Control garden pests by using natural controls and pest predators rather than pesticides.

- Add nutrients to gardens by composting aquatic weeds.

- Divert runoff from waterways. Downspouts should be directed to areas where infiltration can occur and not to areas of steep slope. Planting beds are a good location to direct downspout runoff.

- During construction, minimize soil disturbance and revegetate bare areas as soon as possible.

7.2 Sanitary System Improvements

Properly functioning sanitary systems are designed to remove the majority of disease-causing organisms and some nutrients and chemicals from household water and wastewater, keeping them from entering surface water and groundwater. However, these systems are not designed to treat many water-soluble pollutants. It is necessary, therefore, to take extra care in the maintenance of private sanitary systems, especially those located near surface waters or where groundwater is close to the surface. Malfunctioning, unmaintained, or improperly installed sanitary systems can result in the release of nutrients such as phosphorus which encourage nuisance weed and algae growth in the lake.

The following provides improvements that can be made to upgrade malfunctioning or improperly installed/located sanitary systems, and also identifies ways in which property owners can reduce the risk of a malfunctioning sanitary system through proper maintenance and waste reduction practices.

Based on the sanitary survey results and on-site observations presented in Section 54, there are sanitary system improvements which can and should be made to failing systems, and to reduce the risk of malfunctioning systems discharging wastewater into Cedar Lake. These improvements include:

- Relocate drainage fields on sites away from the lake, especially in areas of steep slope (i.e. uphill/across street from property if possible).

- Construct a cluster system with a number of other residents whereby one sanitary system has the capacity to be shared by multiple households. This is especially encouraged in areas where many small lots are grouped together and sufficient room is not available for individual systems. Nine households located on the south side of Cedar Lake currently have this type of system in operation.

- Change from conventional septic systems to holding tanks in areas of steep slope, where small lots are grouped together, and in low areas. Holding tanks can be successful if properly maintained.

- The Sanitary District could develop ordinances allowing them to keep records of septic, mound and holding tank pumping frequencies for all systems in the District. This would encourage proper system maintenance.

In addition to sanitary system improvements, several recommendations are identified for properly maintaining private sanitary systems, whereby increasing the life of the system, reducing the chances of system malfunction, and more importantly reducing the incidence of allowing pollutants and nutrients to enter the lake (and groundwater):

- Decrease the amount of water used. There are several ways this can be achieved including using water-efficient appliances and flow restrictors, not letting faucets run unnecessarily, do dishes/laundry only when needed (full loads), etc.

- Use no- or low-phosphate laundry detergents and minimize the use of fabric softeners and water additives which contain phosphates. Detergents with less than 0.5% phosphate are considered low phosphate; usually liquid detergents are free of phosphates. Do not use detergents which contain fillers.

- Do not dump/pour products which contain contaminants, including pesticides, household chemicals, and solvents, or oil or grease down drains, on the ground, or down the driveway. Try to use products that are non-hazardous or less-hazardous.

- Divert discharge from wash water and water softeners from the lake; direct this water to the sanitary system.

- Avoid the use of garbage disposals.

- Don't drain sump pump water into the sanitary system, as this could increase the chance of a system overload.

- Have conventional and mound system tanks pumped at least once every year or every other year. Have holding tanks pumped upon alarm.

Malfunctioning sanitary systems can be detected by the following:

- Backup of sewage in drains or basement.
- Wet areas or ponded water over the drain field.
- Grass over the drain field is bright green (indicates effluent at the surface).
- An increase in aquatic plant growth along property's shoreline.
- Drains or toilets drain slowly.
- Sewage odors.
- Bacteria or nitrates detected in a nearby well water test.
- Biodegradable dye flushed through the system is detectable in the lake.

7.3 Weed Harvesting

The Sanitary District currently conducts mechanical weed harvesting to control aquatic plants by remove (excess) plant materials from the lake which impair recreational and aesthetic opportunities.

7.4 Sanitary Sewer

The installation of public sanitary sewer for the Town of Schleswig Sanitary District No. 1 is another alternative available to improve the water quality of Cedar Lake. A feasibility study of wastewater collection and treatment method alternatives for the Sanitary District was conducted in 1995 by Foth & Van Dyke. The results of the study found that the best alternative would be a combined gravity/low pressure sewer for wastewater collection. All wastewater would be pumped to the City of Kiel for treatment and disposal.

There are numerous advantages to proceeding with the installation of a public sanitary sewer system, including:

- Eliminates contamination of lake waters.
- Improves drinking water quality.
- Eliminates waste trucks in the District.
- Improves the value of properties.

- Eliminates the need for replacement systems.
- Improves overall environmental impact
- Eliminates maintenance of on-site systems

There are however, a few disadvantages to installing public sanitary sewer. The first disadvantage is the cost and associated unit assessments per RUE. Second is the inconvenience created due to construction of the system, however this occurs only initially for a limited time. Third, the installation of public sanitary sewer may promote growth within the district.

8 Recommendations

This section provides recommendations which the Town of Schleswig Sanitary District No. 1 should implement to maintain and protect the water quality of Cedar Lake.

8.1 Lake Management Plan

It is recommended that the Town of Schleswig Sanitary District No. 1 prepare a Lake Management Plan. A Lake Management Plan identifies the plan of action to be taken towards maintaining and protecting the water quality of a lake, including determining needs, setting goals, gathering and analyzing information, and developing alternative courses of action. Activities which could be included in the plan are:

- Water Testing
- Educational Programs for Lake Residents
- Develop Management and Implementation Plans for Lake Protection
- Evaluating and Developing Ordinances Related to Sanitation, Zoning, or Pollution Control

8.2 Evaluate Methods of Reducing Phosphorus Loading to the Lake

This report showed phosphorus concentrations have increased since the initial study in 1997. Cedar Lake is sensitive to pollution because it has no natural outlet and chemicals will tend to build up in the lake. Methods of reducing phosphorus loading to the lake, or removing phosphorus from the lake, should be considered and included in the Lake Management Plan. Some methods include:

- Weed harvesting, including extensive fall harvesting.
- Upgrading septic systems - particularly on the east side of the lake.
- Implement a public outreach program to inform residents on ways to reduce phosphorus at home.
- Consider controlling/managing boating practices that may cause erosion or sediment disturbance
- Land use planning to minimize land use impacts on the lake.
- Test high capacity well for phosphorus.
- Consider chemical treatment of lake.

The installation of a public sanitary sewer system is another method of protecting the lake water quality and groundwater quality around the lake. Testing has shown that most of the septic systems drain away from the lake but this situation may lead to potential drinking water well contamination rather than lake pollution. Sanitary sewer will provide a long term method of reducing pollution to the lake and groundwater.

9 Implementation

The Town of Schleswig Sanitary District No. 1 can begin the process of implementing the recommendations provided in Section 8 by applying for grants to assist with costs, sending out educational flyers to the property owners throughout the District, and planning for the installation of a public sewer system.

Lake Management Planning Grants are available from the Wisconsin Department of Natural Resources which provide cost sharing for the development of lake management plans and related activities. There are two application cycles to apply for these grants which include February 1 and August 1 of each year.

In addition, Lake Management Protection Grants are also available to assist in with the costs of implementing the recommendations of a lake management plan. The development of local regulations and ordinances, and lake improvement activities may be funded through these grants. Applications are accepted on May 1 of every year.

Educational flyers should be distributed to all property owners within the Town of Schleswig Sanitary District No. 1, identifying ways they can contribute to the protection of Cedar Lake's water quality.

The District should begin planning for the installation of a public sewer system in the future to ensure the protection of the water quality of Cedar Lake and the groundwater quality around the lake. On-site systems, even if upgraded, still pose the threat of nutrients and contaminants discharging into the lake thereby accelerating the process of eutrophication. Therefore, to ensure the protection of the water quality of Cedar Lake and the groundwater used for drinking and bathing, public sanitary sewer should be installed.