LPL-142

LAKE MANAGEMENT STUDY

ARBUTUS LAKE
FOREST COUNTY, WISCONSIN

April 30, 1996

Northern Environmental℠
Hydrologists • Engineers • Geologists

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1.0 EXECUTIVE SUMMARY

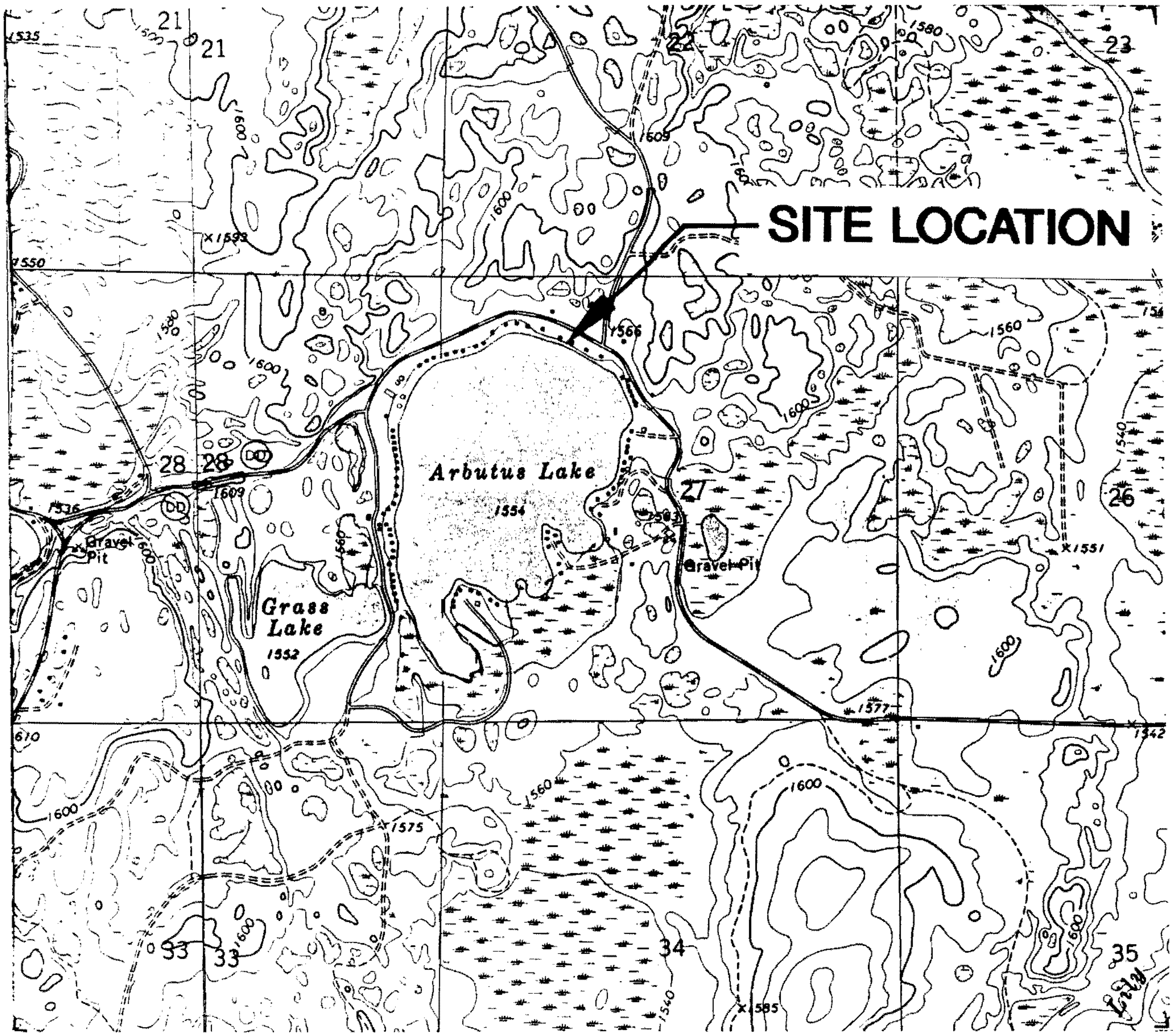
On behalf of the Arbutus Lake Association (ALA), Northern Environmental Technologies, Incorporated (Northern Environmental) completed a lake management study of Arbutus Lake under a Lake Management Planning Grant received by the ALA during Spring 1994. Arbutus Lake is an 168-acre seepage lake located in southwestern Forest County (Figure 1). A water control structure serves as the outlet to the lake. This outlet drains into Grass Lake during high water. The lake has a maximum depth of 28 feet, an average depth of 12 feet, 2.5 miles of shoreline, about 90 dwellings, and an 840-acre watershed (Figure 2). The lake supports a fish population of walleye (stocked by the Arbutus Sportsmen's Club), largemouth bass, and panfish.

During April 1994, Northern Environmental began a two-year lake management study. Specific areas of investigation were chemical and physical characteristics of Arbutus Lake, the watershed, assessment of impacts of an adjacent drainage pipe, and suspect failing septic systems. Final work products include detailed baseline water quality data, a watershed inventory, a septic survey, a project update presentation and report, and a Lake Management Plan.

Water quality data reveals that Arbutus Lake is an oligo-mesotrophic lake. Oligo-mesotrophic lakes have low to medium nutrient levels, low to medium biologic productivity, and good water clarity. Water quality analysis on the drainage pipe water samples revealed that the source of the water is an adjacent 65-acre spruce-tamarack bog located east of Arbutus Lake and east of County Highway 22. The water samples collected are representative of water naturally found in bog environments, most notably having low nutrient and pH values. Concerns voiced by residents should be dismissed, as the bog is actually acting as a watershed buffer to impacts on Consolidated Paper, Incorporated's land.

The Lake Management Plan provides a guideline for maximizing public use without compromising the lake's natural integrity, and addresses the physical and cultural concerns of the lake. Highlights of the Plan include implementing best management practices, preserving the bog wetland area, protecting sensitive areas, distributing lake educational materials, creating a fish management plan, establishing an educational boat launch clean-up day, appointing a volunteer lake monitor, and forming lake committees. Implementing management plans will reduce negative cultural impacts on the lake by stabilizing and protecting water quality.

Milwaukee • St. Paul • Green Bay



SCALE 1" = 2000'

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

CONTOUR INTERVAL 10 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

QUADRANGLE LOCATION

BASE MAP SOURCE: USGS WISCONSIN 7.5 MINUTE TOPOGRAPHIC SERIES, ROBERTS LAKE AND MOLE LAKE, WISCONSIN, 1973

DRAWN BY: BGD	PROJECT: ALA140830	DATE: 04/30/96	ARBUTUS LAKE ASSOCIATION PICKEREL, WISCONSIN
REV. DATE 1/17/96	THIS DRAWING AND ALL INFORMATION CONTAINED THEREON IS THE PROPERTY OF NORTHERN ENVIRONMENTAL INCORPORATED AND SHALL NOT BE COPIED OR USED EXCEPT FOR THE PURPOSE FOR WHICH IT IS EXPRESSLY FURNISHED.		SITE LOCATION AND LOCAL TOPOGRAPHY
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FIGURE 1

2.0 INTRODUCTION

2.1 Background Information

Arbutus Lake is an 168-acre seepage lake located in southwestern Forest County, Wisconsin. A seepage lake is defined as a lake with no inlet or outlet and is fed by precipitation, run off, and ground water. Arbutus Lake does, however, receive some water from the adjacent spruce-tamarack bog, and during high water, drains through a water control culvert into Grass Lake. The lake has a single perennial water control structure as an outlet, a maximum depth of 28 feet, an average depth of 12 feet, and 2.5 miles of shoreline with about 90 dwellings. About 80 percent of the shoreline is developed, while the other 20 percent is mostly wetlands.

2.2 History

Arbutus Lake was formed at the end of the last Ice Age (about 10,000 years ago) in an area underlain by pitted glacial outwash deposits adjacent to a northeast-southwest trending ground moraine. A large piece of glacial ice probably was left behind, and when it melted the basin filled with glacial meltwater forming Arbutus Lake. This type of lake is typically called a "kettle lake". The other small lakes and ponds in the area were formed in a similar manner.

Today, Arbutus Lake is probably being affected by post-settlement human activities. Land-use changes from pre-settlement conifer-hardwood forest to seasonal residential and commercial logging have likely increased nutrient and sediment loads to Arbutus Lake.

2.3 Workplan

During 1994, the Arbutus Lake Association (ALA) received a Lake Management Planning Grant from the Wisconsin Department of Natural Resources (WDNR). The grant was to be used to evaluate Arbutus Lake's trophic state and Arbutus Lake's watershed. A septic system survey and drainage pipe assessment was also completed.

Northern Environmental Technologies, Incorporated (Northern Environmental) coordinated with the ALA to prepare the desired plan and was later contracted to complete the study. The objectives of the project are listed below.

- ▲ Evaluate the physical and chemical characteristics of Arbutus Lake
- ▲ Identify non-point source pollution in the Arbutus Lake watershed
- ▲ Assess the septic systems of Arbutus Lake
- ▲ Assess the impacts of the drainage pipe
- ▲ Produce a Lake Management Plan

This report summarizes the methods used to conduct the study, presents the results, discusses significance of the results, and provides a Lake Management Plan.

3.0 METHODS OF INVESTIGATION

A variety of methods were used to evaluate the water quality, conduct the septic system survey, evaluate the effect of the drainage pipe, determine the watershed characteristics, and prepare the Lake Management Plan. These methods are briefly discussed below, and are described in more detail in Appendix A.

3.1 Chemical and Physical Water Quality Analyses

Northern Environmental personnel collected 12 water quality samples over a two-year period. Two water samples were taken from the water column at Arbutus Lake's deepest point (one sample from one meter below surface and one sample from one meter above the bottom) during each sampling event. Samples were collected at this location since data needed to be collected over the lake's entire depth. Chemical tests determined levels of nutrients, alkalinity, and algae. Dissolved oxygen content, temperature, conductivity, and transparency were measured to classify Arbutus Lake's trophic state. All laboratory tests were performed by the WDNR State Laboratory of Hygiene in Madison.

3.2 Watershed Analyses

Arbutus Lake's watershed was examined using topographic maps, aerial photographs, and nutrient loading. Data was first examined in house and was then field verified. A watershed survey was conducted to determine point source pollution, identifiable discharges and non-point source pollution, and run off into Arbutus Lake.

3.3 Septic System Survey

Northern Environmental personnel performed a septic system survey using a Yellow Springs Instruments (YSI) Model 3000 Temperature-Level-Conductivity (TLC) Meter (YSI 3000-TLC) to determine if any residences were suspected of failing septic systems. Two surveys (July 20, 1994 and August 16, 1994) were performed using the YSI 3000-TLC at 90 different locations in the nearshore zone adjacent to residences, approximately ten feet from shoreline.

3.4 Drainage Pipe Impact Assessment

Northern Environmental personnel collected six water samples during the two year study to analyze the quality of water discharged from the drainage pipe. Five water samples were collected from the drainage pipe outlet on the east shore of the lake. One sample was collected from the drainage pipe inlet in the bog. No water was flowing in the pipe during this sampling event. Chemical tests were performed to determine levels of nutrients, alkalinity, and algae. Temperature, conductivity, and pH were measured to classify the drainage pipe water quality. All laboratory tests were performed by the WDNR State Laboratory of Hygiene in Madison.

3.5 Lake Management Plan

A Lake Management Plan was created by comparing data and test results with accepted management techniques. The result is a document which provides a guideline for managing public use of Arbutus Lake without compromising the lake's natural integrity.

Recommendations in the Plan can be implemented to stabilize and protect Arbutus Lake's water quality.

4.0 RESULTS

4.1 Chemical Characteristics

Chemical characteristics can be grouped into three categories: nutrients (phosphorus and nitrogen), carbonates (alkalinity and pH), and pollution indicators (chloride) (Reference 1). Results are found in Table 1. Phosphorus and nitrogen are vital to microphyte (algae) and macrophyte (milfoil and pondweeds) growth. Chlorophyll a is also included with nutrients because it is a measure of algae content which is directly related to nutrient levels. Chlorophyll is a pigment present in green plants which allows them to produce energy from the sun through photosynthesis.

Concentrations of both soluble phosphorus and total phosphorus were determined. Average spring soluble phosphorus concentrations in Arbutus Lake were 0.002 milligrams per liter (mg/l). This is well below the recommended spring soluble phosphorus level of 0.01 mg/l to prevent algae blooms (Reference 1). The soluble phosphorus median of 243 northeastern Wisconsin lakes is 0.004 mg/l (Reference 2). Total phosphorus results, for Arbutus Lake, averaged 0.0196 mg/l. Total phosphorus levels of 0.025 mg/l are considered average for natural lakes. Lakes with total phosphorus levels below 0.02 mg/l will generally not have nuisance algae blooms (Reference 1). Lakes with total phosphorus levels below 0.01 mg/l are considered to have very good water quality.

Nitrogen levels were measured for ammonia-nitrogen, nitrate and nitrite, kjeldahl nitrogen, and total nitrogen. Ammonia-nitrogen concentrations averaged 0.038 mg/l. Nitrate and nitrite concentrations averaged 0.034 mg/l. Ammonia, nitrate, and nitrite are inorganic forms of nitrogen. If spring inorganic nitrogen levels are below 0.3 mg/l, summer algae blooms are not likely (Reference 1). Average spring inorganic nitrogen levels averaged 0.057 mg/l. Kjeldahl nitrogen is an organic form of nitrogen and is used to quantify total nitrogen. Total nitrogen is calculated by adding nitrate and nitrite to kjeldahl nitrogen. The average concentration of total nitrogen in Arbutus Lake is 0.45 mg/l. The total nitrogen median for 243 northeast Wisconsin lakes is 0.55 mg/l (Reference 2).

Arbutus Lake's total nitrogen to total phosphorus ratio is about 24 to 1. When the ratio is greater than 15 to 1, plant and algae growth in the lake is considered phosphorus limited (Reference 1). When the ratio is below 10 to 1, nitrogen is the limiting nutrient for plant and algae growth, values between 10 to 1 and 15 to 1 are considered transitional (Reference 1). Most of Wisconsin Lakes are phosphorus limited.

Concentrations of chlorophyll a generally indicate the amount of algae in lake water. Winter algae blooms also occur when solar input is sufficient through clear ice without snow cover. However, chlorophyll a levels during winter are normally low. Average chlorophyll a concentrations in Arbutus Lake are 3.01 micrograms per liter (μg/l). Values of 10 μg/l or higher are associated with algae blooms. Chlorophyll a readings less than 10 μg/l indicate good water quality (Reference 2).

Alkalinity is one measure of a lake's carbonate system. Alkalinity is represented by carbonate (CO_3^-) and bicarbonate (HCO_3^-). These compounds bond with calcium and/or magnesium. A high alkalinity reading translates into high hardness levels. Hardness relates to presence of soluble minerals in the lake. Northern Environmental water sample data indicates Arbutus Lake has an average alkalinity level of 34 mg/l. This means Arbutus Lakes is a softwater lake. Softwater lakes are more susceptible to acid rain and are less biologically productive than hardwater lakes.

pH is an exponential index of hydrogen ion concentration used to measure acidity. pH is represented on a logarithmic scale from 1 to 14, 7 being neutral. Readings above seven have less hydrogen ions and are basic (alkaline), readings below seven have more hydrogen ions and are considered acidic. Arbutus Lake's average pH reading is 8.2. Most lakes have a pH between 6.0 and 9.0 (Reference 3).

The presence of high chloride levels usually indicated human pollutants like road salt, fertilizers, septic system effluent, and animal wastes. Chloride concentrations of 50 to 100 mg/l are usually associated with septic effluent (Reference 1). The world chloride average for lakes and streams is 7.8 mg/l (Reference 3). The geographic distribution of natural chloride from limestone deposits for Wisconsin indicates Forest County averages about 3 mg/l of chloride in surface waters (Reference 1). Arbutus Lake has an average chloride concentration of 3.11 mg/l. The chloride concentration in Arbutus Lake does not indicate human influences and can be considered normal.

4.2 Physical Characteristics

Physical characteristics include dissolved oxygen content, temperature, specific conductance, and transparency. Physical characteristics were measured and analyzed to help determine the trophic state of Arbutus Lake.

Dissolved oxygen is the amount of gaseous oxygen in water. Gas solubility depends on water temperature, atmospheric pressure, and water salinity. Cold water holds more dissolved oxygen than warm water. Dissolved oxygen is also affected by a lake's biological productivity. Green plants produce oxygen but decomposition and respiration use oxygen. Fish kills can occur in winter because ice does not allow air to water oxygen transfer or photosynthetic oxygen production to balance the loss of oxygen from winter decomposition of organic matter and biologic activity.

The WDNR water quality standard for warm water lakes is 5 mg/l of dissolved oxygen and 7 mg/l of dissolved oxygen for trout waters. These standards are the minimum amount of oxygen required to maintain a healthy fish population. Sufficient dissolved oxygen levels in Arbutus Lake were recorded to an average depth of 20.8 feet in summer months to support warm water fish. During January 1995, sufficient dissolved oxygen for warm water fish (greater than 5 mg/l) was measured to a depth of 27 feet (Figure 3). During January 1996, the dissolved oxygen content was greater than 5 mg/l to a depth of 12 feet (Figure 3). Dissolved oxygen profiles are presented in Figure 3.

Temperature profiles for Arbutus Lake are presented in Figure 4. Water temperature is affected by climate and wind patterns, and influences dissolved oxygen content, solubility of various compounds, and chemical reaction rates. Water temperature varies with depth. When

Figure 3
Arbutus Lake Dissolved Oxygen Profile

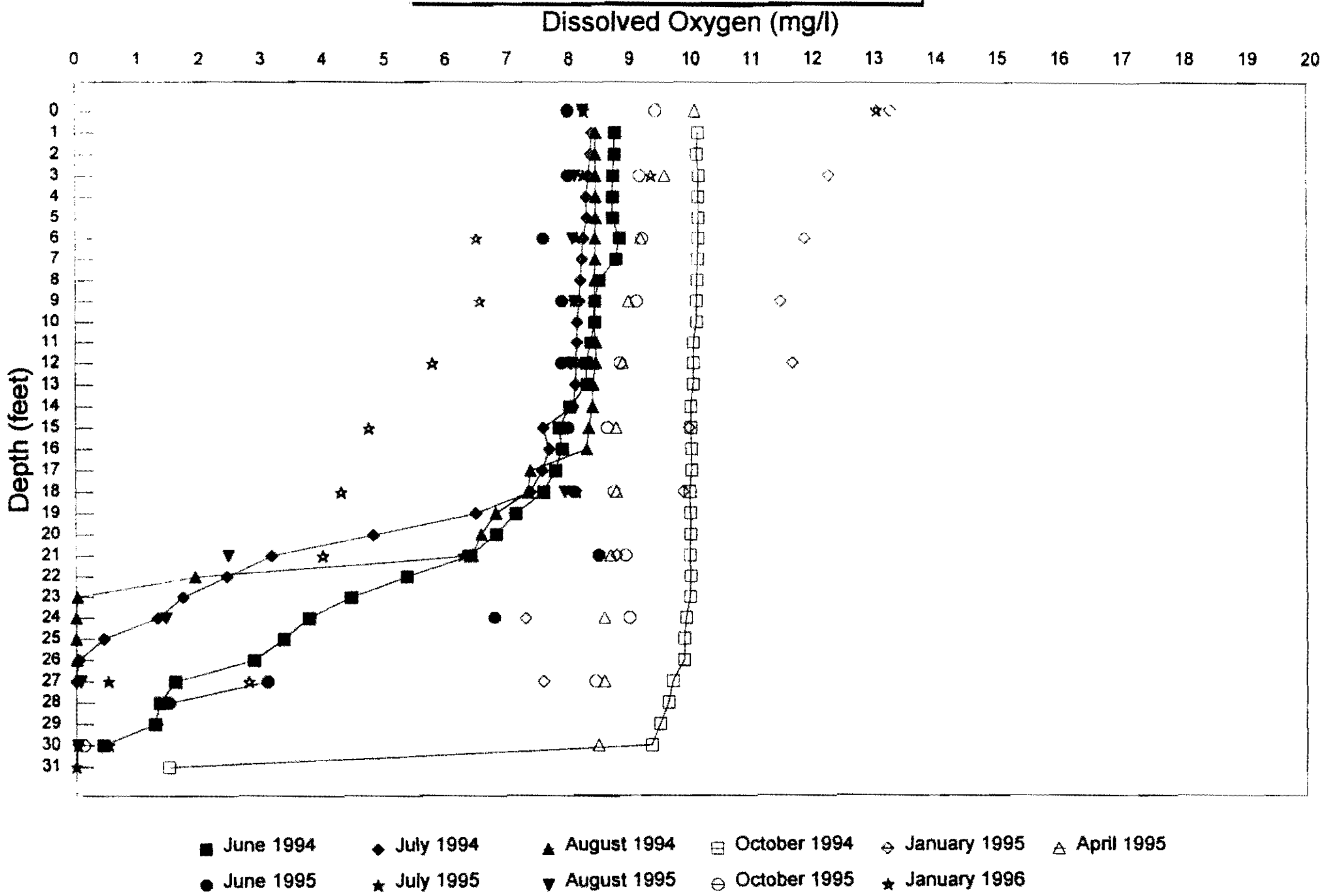
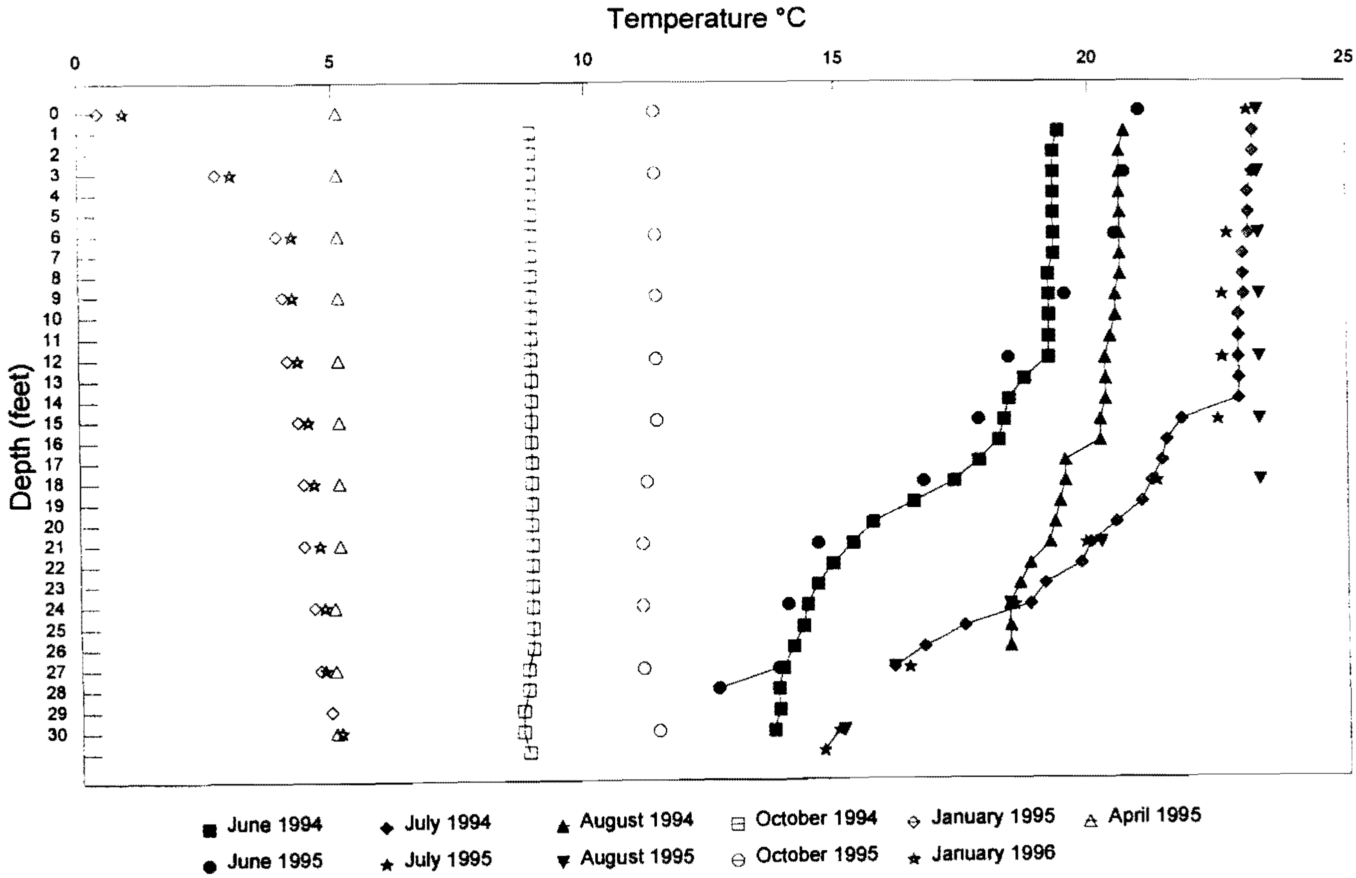


Figure 4
Arbutus Lake Temperature Profile



temperature varies little with depth, lake is termed "mixed". When temperatures vary from the surface to the bottom, the lake is "thermally stratified".

Thermal stratification in shallow lakes often breaks down in summer, resulting in mixing. A dimitic lake is one that has winter ice and mixes during spring and fall. Arbutus Lake is a dimitic lake that thermally stratifies. During summer, thermally stratified lakes have three temperature zone associated with different depths: epilimnion (warm surface layer), metalimnion (transition layer), and hypolimnion (cold-bottom layer). Thermal stratification occurs due to differences in water density associated with temperature. During winter, thermal stratification occurs and warmer (39°F) more dense water sinks to the bottom and colder (32 to 38°F) less dense water stays at the surface under a layer of ice (Figure 4, January 1995 Profile). Mixing occurs in spring and fall when the ice breaks up and before the ice forms. Both mixing events are closely related to local weather and solar input warming and cooling the lake water. Summer mixing can contribute to algae blooms. The lower portion of the hypolimnion is often anoxic (devoid of oxygen). Nutrient rich bottom sediments in an anoxic environment release phosphorous to the water. Summer mixing increases nutrient availability for algae. A similar situation occurs during spring and fall mixing.

Specific conductance or conductivity quantifies the amount of dissolved solids in a lake. Generally, lakes with high conductivity readings are eutrophic (fertile and productive). Conductivity readings are commonly twice the alkalinity levels (Reference 1). Arbutus Lake's average conductivity reading for the two year sample period is 72 micromhos per centimeter (µmhos/cm). Since these values are about twice the alkalinity values, they can be considered normal and not suspect of receiving large quantities of human contaminants. Septic effluent and fertilizers are common human pollutants which can cause high conductivity readings.

Transparency is a function water color and turbidity and is measured by recording secchi disk depths. A secchi disk is a circular plate painted with alternating quadrants of black and white. Depths are recorded when an observer can no longer see the secchi disk as it is lowered from the surface and when it reappears as it is raised to the surface. The two measurements are averaged to give a reading. The deeper the secchi disk reading, the better the water clarity. High algae content in the water usually accounts for shallow secchi disk readings. The average secchi disk reading for Arbutus Lake during the sample period is 14.4 feet (4.4 meters), and indicates very good water clarity.

Total phosphorous, chlorophyll a, and secchi disk depths are used to classify a lake's trophic state. A trophic state is an indicator of water quality. Arbutus Lake's average total phosphorous level is 0.019 mg/l, average chlorophyll a reading is 3.01 µg/l, and average secchi disk depth is 14.4 feet. These three parameters, along with professional judgement, place Arbutus Lake in the oligo-mesotrophic class of trophic states (Reference 2). Arbutus Lake's averaged Carlson Trophic State Index (Table 2) value is 41.5. Oligo-mesotrophic lakes have relatively few algae blooms, low to medium biologic productivity, good water quality, and moderate to good fisheries.

Table 2
Carlson Trophic State Index*

Trophic Category Descriptions

Category *	TSI	Lake Characteristics
Oligotrophic	1-40	Clear water; oxygen rich at all depths, except if close to mesotrophic border; then may have low or no oxygen; cold-water fish likely in deeper lakes.
Mesotrophic	41-50	Moderately clear; increasing probability of low to no oxygen in bottom waters.
Eutrophic	51-70	Decreased water clarity; probably no oxygen in bottom waters during summer, warm-water fisheries only; blue-green algae likely in summer in upper range; plants also excessive.
Hyper-Eutrophic	70-100	Heavy algal blooms throughout the summer; if greater than 80, fish kills are likely in summer and rough fish dominate.

* Adapted for Wisconsin

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4.3 Watershed Analysis

The inventory of the Arbutus Lake watershed identifies the watershed boundary and sensitive areas, illustrates land-use type and location, and evaluates phosphorus loading in the watershed. The following is a comprehensive description of the results of the inventory.

The boundary of the watershed is shown in Figure 2. Figure 1 depicts the topography of the watershed as represented by the United States Geological Survey topographic map (Reference 4). The total watershed area is 840 acres. Arbutus Lake is approximately 168 acres, or 20 percent of the watershed, and thus the watershed to lake ratio is 5 to 1. The larger the watershed to lake ratio, the more impact the watershed has on the lake. Usually, lakes or impoundments with large ratios are more likely to be eutrophic. Lakes with large watersheds have greater surface water inputs. Surface water typically contains higher levels of nutrient and sediments than water from a smaller watershed, mainly because the water has more land to flow over.

4.3.1 Sensitive Areas

Two sensitive areas in the watershed were identified based on natural resource components (Figure 2). These components include woodlands, wetlands, steep slopes, endangered resources, and scenic value. The two areas combined compromise about 262 acres, or 31 percent of the watershed. These sensitive areas represent tracts of land that, if protected or properly managed, will preserve not only the water quality of Arbutus Lake, but also the natural character of the watershed.

Sensitive area #1 is approximately 146 acres in size and consists of a spruce-tamarack bog (approximately 68 acres) and surrounding woodland (approximately 78 acres). The surrounding woodland is defined as a 500-foot buffer zone beginning at the bog edge. Bogs are a specialized wetlands that have plant communities adapted to saturated acidic soil conditions and low nutrient levels. Usually the only water input is rainwater and the soil substrate is peat. Bogs offer good wildlife habitat and often harbor rare plant species because they are usually hard to access and thus are not affected by humans. The property is owned by Consolidated Paper, Incorporated. Local residents suspect the spruce-tamarack bog of affecting the lake's water quality. This issue is addressed in the section examining the effect of the spruce-tamarack bog drainage pipe.

Sensitive area #2 is a large undeveloped wooded area to the north of Arbutus Lake. The total area is approximately 116 acres. This forest is second growth northern mesic conifer-hardwoods. Major tree components include maple, birch, oak, basswood, pine, fir, and hemlock. Over 90 percent of this sensitive area is wooded and provides not only wildlife habitat and open space, but also protects water quality. Wooded areas filter rainfall and run off by allowing soil infiltration, interception, and evapotranspiration. The wildlife habitat quality can be considered high because the forest also contain several small wetlands which provide water and food supply for wildlife. Small ponds and wetlands provide needed habitat for small amphibians and insects, which are important food sources for larger animals. This wooded area in the Arbutus Lake watershed is connected to a larger forest that extends north to St. John's Lake. The large undeveloped woods also provides scenic value by providing "green space" as a backdrop on the north side of Arbutus Lake. Developing this wooded area could significantly change land use and drainage patterns.

4.3.2 Land Use

Land use in the watershed was divided into four main groups: surface water (Arbutus Lake), wetlands, woodlands, and developed land. Land-use groups by acreage are presented in the table below.

ARBUTUS LAKE WATERSHED ANALYSIS

LAND USE	AREA	% WATERSHED
SURFACE WATER	168 ACRES	20.0%
WETLANDS	156 ACRES	18.6%
WOODLANDS	451 ACRES	53.7%
DEVELOPED LAND*	65 ACRES	7.7%
TOTAL WATERSHED	840 ACRES	100.0%

* Developed land includes residential, dump, and road areas.
NOTE: +/- 4 percent error

More than 53 percent of the watershed is woodland, yielding a mostly undeveloped watershed. Most (about 95 percent) of the woodland acreage is found in four areas: 1) sensitive area #2, 2) the forest northwest of the spruce-tamarack bog, 3) the woodland southeast of the spruce-tamarack bog, and 4) the woodland on the south border of the watershed. These areas measure approximately 174 acres, 97 acres, 92 acres, and 65 acres, respectively. Presettlement vegetation in the area around Arbutus Lake was northern mesic conifer-hardwood forest. Today much of northern Wisconsin is second or third growth conifer-hardwood forest. Woodlands in the Arbutus Lake watershed are composed of typical northern mesic forest tree species such as sugar maple, white pine, northern red oak, yellow and paper birch, ironwood, basswood, beech, hemlock, and fir.

The second largest land-use component in the watershed is Arbutus Lake itself, comprising 20 percent of the total area. The lake is approximately 186 acres in size with roughly 2.5 miles of shoreline and three small bays (about 3 acres, 5 acres, and 10 acres) on the south shore. The lake has a maximum depth of approximately 28 feet and a volume of 1925 acre-feet. The deepest spot is in a 25 to 30-foot deep "hole" near the north side of the lake covering about 10 acres.

Wetlands cover 18.6 percent of the watershed. The largest wetland in the watershed is the 68-acre spruce-tamarack bog east of the lake. Two other wetlands, roughly 22 acres and 25 acres in size, are found on the south shore of the lake. The entire south shore was probably wetland before the shoreline was developed. The wetland in the southwest bay provides a "backwater area" for fish and wildlife and is likely an important feeding, breeding, and spawning area. The adjacent area of shallow water in the bay is equally important to fish and wildlife. The other shoreland wetland provides the same values only on a smaller scale, mostly due to its shape. This wetland, which connects two of the small bays, is linked to a much larger wetland to the south by a wooded corridor. This large wetland, about 200 acres in size and outside the Arbutus Lake watershed, drains into Campbell Creek, a tributary to the Lily River. Development around these wetlands will degrade their functional values, specifically wildlife habitat and aesthetics.

Only 7.7 percent of the watershed is developed. Important components of the developed land include an old dump, a lumber mill, a gravel pit, and residential shoreline development. About 70 percent of the developed land is residential, most of which is concentrated along the west, north, and east shores. Roughly 80 percent of the shoreline is developed, while the remaining 20 percent is wetland. The dump is located on top of a degraded depressional wetland that is located west of Arbutus Lake and north of Grass Lake with access from State Highway 'DD'. About two-thirds of the depressional wetland has been filled. The elevation of the wetland indicates that it may be hydraulically connected to Arbutus Lake, Grass Lake, or both. This means that contaminants (if present) already in the dump could leak into Arbutus Lake.

4.3.3 Phosphorus Loading

As discussed earlier, the larger the watershed, the larger the potential effort on the lake. This effect can be seen in phosphorus loading in a watershed. The table below presents the estimated values for phosphorus loading by land-use type in the watershed. Loading value are presented in kilograms of phosphorus per hectare per year (kg/ha-yr) for each land use type. Total phosphorus loading is in kilograms per year (kg/yr). Phosphorus loading from precipitation is obtained by multiplying the loading value for precipitation by the surface area of the lake. One other source of phospouros in a lake is internal cycling from bottom sediments.

If the watershed area was increased, the overall phosphorus load for each land use type would also increase. Different land uses are assigned different loading values based on criteria developed by John Penuska at the WDNR Lakes Management Section in Madison. All phosphorus numbers used for the loading estimates were "most likely." The "most likely" general phosphorus loading values for associated land use types are as follows:

Agriculture:	0.5 kg/ha-yr
Forest:	0.1 kg/ha-yr
Urban:	1.0 kg/ha-yr
Open grassland:	0.3 kg/ha-yr
Wetland:	0.1 kg/ha-yr
Precipitation:	0.3 kg/ha-yr

PHOSPHORUS LOADING IN THE ARBUTUS LAKE WATERSHED

LAND USE	LOADING #	AREA	P-LOADING
	(kg/ha-yr)	(hectare)	(kg/yr)
Lake	0.3	67.99	20.4
Wetlands	0.1	63.13	6.3
Woodlands	0.1	182.5	18.3
Developed	1	26.3	26.3
TOTAL		**339.94**	**71.3**

NOTE: If low loading value for developed land is used total phosphorus loading would be = 58.2 kg/yr.

4.4 Septic System Survey

The septic system survey utilized a YSI 3000 TLC Meter to screen for failing septic systems by measuring the conductivity of lake water in the near shore zone in front of residences (Figure 5). Ninety readings were taken beginning in the south bay and continuing counter clock-wise around the lake ending on the west side of the lake in the south bay. Conductivity, or specific conductance, is water's ability to conduct electricity. Conductivity is directly related to the amount of total dissolved solids in the water. Failing or leaking septic systems release abnormally high dissolved inorganic chemicals, like chlorides and nitrogen compounds (NO_2^-, NO_3^-, and NH_4^-), due to the fact that the drainage field is not functioning properly. Normal conductivity values are twice the waters hardness value unless the lake is receiving contaminants (Reference 1). Arbutus Lake's hardness values range from 31 to 40 mg/l, and the approximate corresponding conductivity range would be 62 to 80 μmhos/cm. Readings from in front of residences were compared with background conductivity reading taken at the deepest point of the lake one meter above the bottom and one meter below the surface. The average background conductivity reading for the two septic surveys is 80 μmhos/cm, with a range from 74 to 89 μmhos/cm. The average residence reading is 76 μmhos/cm and 77 μmhos/cm, for the July and August surveys, respectively. The range of readings for both surveys is only 8 μmhos/cm, 74 μmhos/cm as the low, and 82 μmhos/cm as the high (Table 3). Due to budget constraints fluormetry was not used to supplement conductivity data. Both surveys were conducted during the weekdays and thus may not represent higher weekend usage of septic systems.

4.5 Drainage Pipe Impact Assessment

Analyses on the six water samples collected from the drainage pipe revealed water quality trends typical of bog systems (Samples-S3: Table 1). Prior to the development around Arbutus Lake, and construction of County Highway DD, the bog and the lake were connected through a series of depressional transition wetlands along the eastern shoreline. This area is now occupied by residences and degraded wetlands connected via the drainage pipe.

Vegetation between the lake and County Highway DD is typical of transitional wetlands between bogs and lakes. The water flowing from the bog into the lake was filtered through the transitional wetlands. Some of this filtering capacity was lost by installing the drainage pipe and degrading the wetland plant communities. An example of one visual impact is the brown staining of the lake bottom near the drainage pipe discharge point which is a result of tannic acid, naturally found in bogs. If the drainage pipe were removed and the transitional wetlands restored, this staining, and other physical and biological processes, would occur in the transitional wetlands. The following is a list of some of the chemical parameters tested and their trends:

- High total dissolved solids
- Low pH
- High organic nitrogen compounds
- High potassium
- Low calcium (as $CaCO_3$)
- High chloride
- Low hardness

These water quality characteristics are typical of bogs which are acidic, have high cation exchange rates, and have abundant organic matter. It is also important to note that the bog buffers upland land uses the same way the transitional wetlands buffer the lake.

5.0 CONCLUSIONS

Arbutus Lake's physical and chemical characteristics indicate that water quality was good to very good during the 1994 to 1996 study. Arbutus Lake can be classed as an oligo-mesotrophic lake. An oligotrophic lake is generally clear, deep, and free of nuisance weeds and algae blooms. Oligo-mesotrophic lakes are moderately low in nutrients and often develop a complex food chain able to support large desirable game fish populations with fair diversity. Average values for nutrient concentrations in Arbutus Lake are below levels which would indicate frequent algal blooms. Total phosphorus concentrations cause Arbutus Lake to be classed oligo-mesotrophic instead of oligotrophic. Chlorophyll a levels were also low, indicative of oligo-mesotrophic lakes. Water clarity was very good, averaging 14.4 feet over the study.

The amount of nutrients and sediments entering Arbutus Lake has probably increased due to cultural influences. A watershed once consisting of mature conifer-hardwood forests is now about 10 percent developed. An undeveloped natural pre-settlement shoreline is now 80 percent developed. Arbutus Lake has total phosphorous levels, secchi disk depths, and chlorophyll a levels which places it in the oligo-mesotrophic category of the trophic classification scheme.

The detailed watershed analysis revealed that the 840-acre watershed is about 10 percent developed, 20 percent wetlands, 20 percent surface water, and 50 percent woodlands. Nutrient loading in the watershed is not significant and the lake itself does not show signs of cultural eutrophication associated with high nutrient loading. The septic system surveys demonstrated that, during the weekdays, there were no septic systems leaking contaminants into the lake, based on the YSI 3000 TLC conductivity readings.

Water analysis correlated the drainage pipe discharge water to natural water characteristics of bog systems. Based on the fact that the bog and the hydrologic flow are natural parts of the watershed, concerns about significant negative impacts from the drainage pipe should be dismissed.

Wetlands serve as open spaces increasing the aesthetics and natural beauty of a lake. Many people indicate that peace and tranquility are very important to lake front owners. To assure that present levels of wildlife, water quality, and aesthetics are maintained, steps should be taken to protect the wetlands in the watershed. The wetlands in the south bays and near the boat launch are ideal for enhancement and preservation. The south bays are important for fish and wildlife, while the wetlands at the boat launch are degraded and in an ideal location for public education. These wetland sensitive areas act as natural buffers to human activities and impacts. The wetlands around Arbutus Lake are an integral part of the hydrology in the lake's watershed.

Stabilizing water quality and increasing public awareness while protecting the lake can be accomplished by implementing the recommended Lake Management Plan. Not all of the recommendations need to be implemented, but all of them will provide benefits for the lake and for the community.

6.0 LAKE MANAGEMENT PLAN

Lake planning projects should present recommendations in a Lake Management Plan (Table 4). Creating a long-term management plan is important for Arbutus Lake residents. Management recommendations take into account effectiveness, negative effects, and costs. Effectiveness relates to longevity of the management technique, probability of success, and whether or not the technique addresses the cause of the problem or the effect of the problem.

Management techniques are divided into watershed management and in-lake management techniques (Reference 5). Watershed management techniques focus on watershed-wide issues such as agricultural and rural point and non-point source pollutants. In-lake management techniques focus on a lake's physical issues like nuisance aquatic plants, algal blooms, and fisheries; and policy issues like recreational uses and zoning ordinances.

6.1 Watershed Management Techniques

Implementing best management practices (BMPs) in the Arbutus Lake watershed are the most effective methods for controlling non-point source pollutants. Implementation costs vary greatly between management techniques, however, most are eligible for cost-sharing under Chapter NR 120, Wisconsin Administrative Code. A list of applicable BMPs can be found in Table 5 (References 5 and 6).

Preserving sensitive areas will allow these areas to continue to act as buffers for Arbutus Lake. Preserving the wooded upland portion of sensitive area #1 would be difficult due to the value of the land to Consolidated Paper, Incorporated. However, preserving the bog portion may be more feasible from both ALA's and Consolidated Paper, Incorporated's point of view. The bog area does not have significant timber value. Options for preserving the bog include: purchasing, rezoning, preservation easements, and deed restrictions.

Developing the wooded areas north of Arbutus Lake, in sensitive area #1, would also negatively affect water quality, and should be discouraged. One option is to zone the land as "conservancy" so that the land is taxed less and the owner has less incentive to develop the land. Forest management or silviculture management practices would also help protect the areas. Purchasing sensitive areas would be eligible for 75 percent project funding up to $100,000.00 under the WDNR Lake Protection Grants. An assessment could be performed to determine the exact size and functional values of the land. This assessment would be used to supplement the application for the grant. Because these sensitive areas protect water quality, compliment BMPs, and protect the natural ecosystem, this project is a good candidate for a grant. The 1994 to 1995 fiscal budget for this grant program was over $1.3 million (Reference 7).

A WDNR publication titled *Life on the Edge...Owning Waterfront Property* should be distributed to all Arbutus Lake home owners. This publication describes in layperson terms issues and regulations regarding purchasing and owning waterfront property. It also provides information on improving shoreline habitat and water quality for new and existing homes. At a cost of about $5.00 per publication, all lake home owners could receive a copy for about $450.00.

TABLE 4

Lake Management Plan

I. WATERSHED MANAGEMENT TECHNIQUES

Implement Best Management Practices

Protect Sensitive Areas

Distribute Educational Materials: *Life of the Edge* (WDNR Publication)

II. IN-LAKE MANAGEMENT TECHNIQUES

Physical:

- Create Fish Management Plan: Survey and Assessment
- Create Educational Boat Launch Clean Up Day
- Enhance Boat Launch Wetland Enhancement
- Protect South Bay Wetlands

Policy:

- Form Recreational Use Committee
- Form Exotic Species Control Committee
- Create Zoning Committee

Table 5 Best Management Practices

Cropland Practices:

- Change crop rotations
- Change from cropland to grassland
- Contour cropping
- Strip cropping
- Field diversions
- Terraces
- Grassed waterways
- Reduced tillage
- Nutrient management
- * Pesticide management (Lawn Care)

Cropland, Urban, and Other Area Practices:

- * Critical area stabilization
- Grade stabilization structures
- * Shoreline and streambank protection (including fish structures)
- * Shoreline buffers
- * Wetland restoration
- Livestock exclusion from woodlots
- Well abandonment

Silviculture

- * Ground cover maintenance
- * Road and skid trail management
- * Riparian zone management
- * Herbicide/Pesticide Management

Urban Practices:

- Street sweeping
- Leaf collection
- Pet waste ordinances
- * Construction site erosion control ordinance
- Infiltration basins
- * Infiltration trenches
- * Porous pavement
- * Grassed swales
- Wet basins
- Detention basins
- Wetland basins
- Covering materials being stored
- * Disturbed Area Limits

Note:

* = Specific to Arbutus Lake

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6.2 In-Lake Management Techniques

Fisheries are an important part of lake systems. Public interest in fisheries is evident by the formation of the Arbutus Lake Sportsmen Club. Not only do fisheries provide recreation as sport fishing, but they also directly relate to a lake's productivity. Eutrophic lakes often have larger fish populations but typically also have more rough fish, like carp. The first step in a fish management plan is to examine the fish population. The United States Fish and Wildlife Service and the WDNR should be contacted for information on funding. Fish survey techniques such as shocking and netting can be used to sample the population, and after an assessment and plan is approved, management can proceed. In the past, Arbutus Lake has been stocked with primarily walleye. A fish management plan would assess this practice and determine what specie is the most viable to stock. A fish management plan for oligo-mesotrophic lakes, like Arbutus Lake, may include installing artificial reefs, managing aquatic plants, and stocking fish. The survey could be funded by a grant under a second Lake Management Planning Grant.

An educational boat launch clean-up day would give the Arbutus Lake Association a chance to clean up trash and debris from around the east shore boat launch. An educational bulletin board could be constructed to display a lake map, boating regulations, and fishing information. A garbage can with an animal proof top could be placed at the launch to help keep it clean. The event could also be designed to be a fund raiser. Earth Day 1997 (April 22, 1997) would be ideal.

The wetlands at the boat launch should be protected from vehicles and trailer parking. Flowering wetland plants could be seeded or planted to increase the aesthetic appeal of the wetlands. Such plants include iris (blue), cardinal flower (red), and marsh marigold (yellow). An educational board could also be erected explaining wetland values and the enhancement project.

The south bay wetlands are an integral part of the fish and wildlife habitat as well as the aesthetic beauty of Arbutus Lake. Protecting these wetlands from development and boating pressures is very important. Boating regulations restricting access during critical times for fish and wildlife such as breeding, nesting, and rearing times are very important.

The Arbutus Lake Association should create committees to address recreational use, exotic species control, and county zoning laws. All committees should be composed of volunteers with an appointed non-paid committee chairperson. The recreational use committee can produce a lake-use map and monitor disputes between lake users to reduce conflict. The exotic species control committee should monitor the presence of purple loosestrife, eurasian milfoil, and zebra mussels. Non-native species can cause serious ecologic problems for lakes. The earlier non-native populations are identified, the better the chance to control them. Zoning changes can be monitored by a land-use committee that attends county zoning meetings and rezoning cases. Monitoring policy issues in a lake community is important for understanding, implementing, and assessing management techniques.

6.3 Funding

Funding for BMPs may be available through Priority Watershed Projects on a cost-share basis if the project is successfully petitioned. To complete a fisheries management plan and perform limited chemical analysis of the water quality, the ALA should apply for a second Lake Management Planning Grant. The lake association should also apply for a WDNR Lake Protection Grant. Lake Protection Grants are available for purchasing land or easements, restoring wetlands, and developing local regulations to protect water quality. Purchasing the northern woodlands, protecting the south bay wetlands, creating an educational information board at the boat launch, and enhancing the wetlands surrounding the boat launch could all be funded under a Lake Protection Grant. Protection grants fund 75 percent of project costs up to $100,000.00. Costs for distributing WDNR educational materials, totaling $450.00, should be covered by the ALA.

The remaining management techniques are volunteer positions. Volunteer committees should be formed to monitor issues in the watershed. The volunteer committees should be lake enthusiasts and members of the ALA. This may increase membership and strengthen the association by having members more involved and by addressing recreational use and zoning issues.

Northern Environmental can provide services to apply for another Lake Management Grant and for a Lake Protection Grant. Both grant programs are WDNR funded. Northern Environmental can provide services and technical expertise for any of the aforementioned programs if the ALA chooses to implement these management techniques.

7.0 REFERENCES

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3) Horne, A., and C. Goldman, *Limnology*, McGraw-Hill, New York, 1994.

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5) United States Geological Survey, *Roberts Lake Quadrangle, Wisconsin, 7.5 Minute Series,* 1973.

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APPENDIX A

INVESTIGATIVE METHODS

Investigative Methods

Chemical and Physical Analysis

All water samples for chemical analysis were collected with a Kemmerer sampling bottle. Laboratory tests were performed by the Wisconsin Department of Natural Resources (WDNR) certified State Lab of Hygiene to meet requirements prescribed in the lake planning grant. Samples were taken one meter below the lake's surface and one meter above the lake's bottom in the deepest portion of the lake. Sample depths and location were chosen to reflect the entire water column, including the photic and anoxic zones. Chemical parameters for sampling are listed and described below.

A. Phosphorous: Phosphorous is usually the compound regulating algae and aquatic macrophyte growth. Phosphorous is available in two forms, soluble and particulate (total phosphorous). The soluble form is dissolved and readily available for uptake by floating and suspended plants. Total phosphorous is useful to plants with root systems absorbing nutrients from the sediments. Total phosphorous is considered a better indicator of a lake's nutrient status than soluble phosphorous because its level is more stable than soluble reactive phosphorous, which can vary in concentration over short time periods.

B. Nitrogen: Nitrogen is another nutrient limiting the growth of aquatic plants, second in importance to phosphorous. Nitrogen can be found in lakes in many forms including nitrate, nitrite, ammonium, and Kjeldahl nitrogen. Nitrite is usually present in trace quantities, and is readily transformed to nitrate in oxygenated water. The inorganic nitrate and ammonium forms are most beneficial to plants and algae. Sources from which nitrogen can enter a lake include precipitation, which can have concentrations of nitrogen as high as 0.5 milligrams per liter (mg/l), and breakdown of organic tissues. However, concentrations of nitrogen found in surface waters are usually related to human activities within the watershed. Manmade sources of nitrogen include agricultural wastes, fertilizers, and human sewage. If the ratio of total phosphorous to total nitrogen is more than 15 to 1, the nutrient system is considered phosphorous limited.

C. Chlorophyll _a_: Chlorophyll _a_ is a green pigment present in all green plant life which is vital for photosynthesis. The levels of chlorophyll _a_ relate directly to the amount of algae present. The concentrations are expected to be highest during summer months with increased photosynthesis. High chlorophyll _a_ results are associated with algae blooms and eutrophic lakes.

D. Alkalinity: Alkalinity is an indicator of the buffering capacity and susceptibility to acid rain. Laboratory analysis quantifies carbonates (HCO_3) and bicarbonates (CO_3) present in the water. Most Northern Wisconsin lakes are set in glacial deposits composed of quartz, sand, and other insoluble minerals which contain little limestone resulting in low alkalinity, while Southeastern lakes have higher alkalinity levels due to the dolomite bedrock.

E. pH: pH is an expression of the negative logarithm of hydrogen ion (H^+) concentration. pH is measured on a scale of 1 to 14 with pH values above 7 considered alkaline (less H^+ ions), below 7 acidic (more H^+ ions), and 7 neutral. Alkaline waters buffer against acid rain. Acid rain entering the lake will have the effect of lowering the lake's pH level, bringing it closer to neutral and thus reducing the lake's acid rain buffering capacity. pH was measured using a Cole-Parmer hand held pH meter, calibrated to pH ten and pH seven. Measurements were taken one meter below the surface and one meter above the bottoms.

Physical analysis parameters include dissolved oxygen content, temperature, conductivity, and transparency. Dissolved oxygen and temperature profiles were gathered using a Yellow Springs Instrument Model 59 Meter. Measurements were recorded at one-foot intervals in the deepest part of the lake. Conductivity readings were taken from samples one meter below the surface and one meter above the bottom using a Cole-Parmer hand held TDS Test-3™ calibrated to 700 μmhos per centimeter (μmhos/cm). Transparency was measured using a standard secchi disk or the shaded side of the sampling boat. Readings are an average of the depth at which the disk disappeared and reappeared.

Watershed Analysis

A watershed boundary was delineated using a United States Geological Survey 7.5 minute topographic map and the quarter-quarter section direction of flow method. Information was compared with aerial photographs and confirmed in the field. Field investigations were also performed to identify land use types, areas of steep slopes, non-point source pollution, and wetlands.

Lake Management Plan

The Lake Management Plan was created by comparing physical characteristics of the lake with accepted lake management techniques. A plan of the lake should set goals for preserving the natural integrity of the lakes without limiting expectations or use by the local residents. Management techniques were selected by weighing the cost of implementation against effectiveness of achieving a given goal.