BASELINE LIMNOLOGICAL STUDY
WEST ALASKA LAKE
KEWAUNEE COUNTY, WISCONSIN

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1.0 EXECUTIVE SUMMARY

Northern Environmental has completed a baseline limnological study of West Alaska Lake. West Alaska Lake is a 20-acre groundwater drainage lake with a maximum depth of 41 feet. Seven homes are reportedly located around West Alaska Lake and the shoreline is primarily surrounded by wetlands. Groundwater appears to enter the lake from all directions. The lake has a 284-acre watershed in which agriculture contributes the majority of the nutrients to West Alaska Lake. Therefore, efforts should be made to minimize agricultural runoff. Agricultural best management practices (BMPs) can help prevent erosion and nutrient runoff. The Tri-Lakes Association should work with the Kewaunee County Land Conservation Department (LCD) to identify areas of potential concern and implement BMPs as needed.

West Alaska Lake is a dimictic lake meaning it stratifies thermally in the summer and winter and mixes in the spring and fall. Dissolved oxygen levels, while depleted in the hypolimnion in the summer and winter, appear to remain adequate in the epilimnion (shallowest layer in thermally stratified lake) to support fish through the winter. Nutrient analysis indicates that phosphorus is the limiting nutrient controlling aquatic plant growth. Water quality data collectively indicate that West Alaska Lake is a mesotrophic lake. The available information indicates that there is no significant trend towards better or worse water quality/trophic status within the last 12 years. Phosphorus levels may have increased somewhat, however it does not appear to have affected the water clarity. There is not much historical data on West Alaska Lake. Northern Environmental recommends implementing an adequate monitoring system to help track changes within the lake and prevent significant lake problems by identfying problems early. A good program to be involved in is the WDNR Self-Help Citizen Lake Monitoring Network. Every few years, this data should be reviewed collectively to determine if the lake's trophic status has changed.

Twelve different aquatic plants were identified on West Alaska Lake. The most abundant aquatic plant was Chara. Coontail, northern watermilfoil, nitella, white water lily, and spatterdock were the next most abundant species found in August 2003. Since the water depth increases rapidly from the shoreline, West Alaska Lake has a small littoral zone. Therefore aquatic plants are unlikely to grow to nuisance levels in the Lake. No exotic aquatic plants were identified on West Alaska Lake. Northern Environmental recommends periodic surveys to evaluate if exotic species such as Eurasian watermilfoil or curly leaf pondweed have invaded the lake. WDNR planning grants may be available to fund surveys. Also, individual volunteers may be trained in the WDNR self-help monitoring program to identify exotic species. Exotic plants will most likely appear first near the boat launch. If invasives are identified, the Association should complete aquatic herbicide applications at the boat launch to prevent the invasive species from spreading.

An exotic wetland plant, purple loosetrife was noted in a few areas around West Alaska Lake. The Association should manually remove this plant to reduce its chances of spreading throughout the wetland. An alternative is to release a beetle that feeds exclusively on purple loosetrife. Your local DNR or UW extension agent will have more details on this program.

The Tri-Lakes Association should continue to promote membership and activity within the Association. Active associations that generate interest in their lake resources are more likely to have community support for future lake activities, management strategies, or grant funds in the future if needed. If enough interest is generated, the Association may consider developing a survey for lake users. The survey can be used to solicit public opinion and can become a starting point for a lake management plan. While there are not many complicated issues facing West Alaska Lake at this time, a lake management plan may help develop and implement community goals for West Alaska Lake.

2.0 INTRODUCTION AND STUDY GOALS

West Alaska Lake is located in Section 19, Town 24N, Range 25E in the town of Pierce located in eastern Kewaunee County, Wisconsin (Figure 1). The Tri-Lakes Association (the Association) manages West Alaska Lake, as well as nearby East Alaska Lake and Krohns Lake. Very little limnological information was available for West Alaska Lake. Therefore, the Association decided to apply for a Wisconsin Department of Natural Resources (WDNR) lake management planning grant to complete a baseline diagnostic study on West Alaska Lake. The proposed study included water quality monitoring, watershed analysis, a septic system evaluation, and an aquatic plant survey. This report discusses the study's goals, describes the methods used to complete the study, summarizes the lakes physical and chemical properties, describes the aquatic plant community, and provides a recommended action plan for lake management.

2.1 Lake History

The WDNR completed water quality monitoring in 1992. This is essentially the only limnological information available for West Alaska Lake. A copy of the 1992 data is provided in Appendix A.

2.2 Study Goals

The Association established goals in their grant application to set long-term management goals for West Alaska Lake. Ultimately, this baseline study will result in the development of a lake management plan. It is a goal of the Association to have a lake management plan in place to guide the future management of the lake. The baseline study is essential to develop this plan. Long-term goals for West Alaska Lake will likely include, but are not limited to:

- Understand and protect water quality
- Preserve native aquatic plants while controlling and preventing the spread of invasive aquatic plant species
- Protect and improve fish and wildlife habitat
- Improve recreational opportunities

Based on the results of the baseline study, the goals can be refined for a long-term lake management plan.

3.0 INVESTIGATIVE METHODS

The goal of this study is to collect and interpret basic limological data about the lake's physical, chemical, and biological characteristics allowing the Association to make better-educated decisions regarding lake management activities. The study primarily followed the outline in the proposal and grant application, which included aquatic plant surveys, collection of seasonal chemical water quality data, and an evaluation of potential pollutant sources within the watershed.

3.1 Existing Data Review

Many factors influence lake water quality. Water quality governs the assemblage of plants and animals inhabiting a lake. Northern Environmental consulted a wide variety of existing resources to produce data that help illustrate water quality. These data sources include:

- Local and regional pedologic, geologic, limnologic, hydrologic, and hydrogeologic research
- Discussions with Association members
- Relevant predictive models
- Available topographic maps and aerial photographs
- Kewaunee County Land Information or Geographic Information System (GIS) data
- Data from WDNR files

These data sources are instrumental to understanding the past, current, and potential future conditions of the lake and to ensure that study efforts are not duplicated. Important references are listed in Section 9.0 of this report.

3.2 Water Quality Sampling

Water quality data were collected at the location illustrated in Figure 2. Surface water grab samples were analyzed for total phosphorus and/or chlorophyll *a*. Water samples were also collected from the deepest portion of the Lake using a Kemmerer bottle. Water transparency was evaluated using an 8-inch diameter secchi disk. Phosphorus and chlorophyll *a* samples were placed in plastic bottles provided by the Wisconsin State Lab of Hygiene (SLoH). Phosphorus samples were preserved using acid ampules provided by SloH. Samples were shipped or transported by Northern Environmental to SloH in Madison, Wisconsin for laboratory analysis.

Water quality profiles were completed in the deepest portion of the Lake. Select samples were analyzed for dissolved oxygen, temperature, and water clarity. Oxygen concentrations and temperature were measured using a YSI 55 dissolved oxygen meter. Field data collected during 2003 – 2004 is summarized in Table 1. A copy of the laboratory reports is included in Appendix B.

3.3 Land Use Characterization and Nutrient Loading Model

The Lake is located within the West Alaska Lake watershed (Figure 3) composed of forested, agricultural, and rural residential land uses. An evaluation of land use and nutrient runoff within the watershed (Figure 4) was completed.

A relatively simple land management screening model, the Wisconsin Lake Modeling Suite (WiLMS® Version 3.3.13), was used to estimate limited nutrient loading from the watershed. The WiLMS® model predicts phosphorus sediment delivery rates given certain land uses. Unlike more complicated and thorough models, topography of the watershed is not considered. Default data for Sheboygan County was used for net precipitation and annual runoff. Appendix C presents hydrological and morphometric data and land use types used to construct the model, in addition to the predicted phosphorus loadings. Results of the WiLMS® model are discussed in Section 4.3.

3.4 Piezometer Study

To help quantify groundwater inflow and outflow to and from the West Alaska Lake hydraulic head was measured at four piezometer well locations (Figure 5). The piezometers were constructed of 5-foot schedule 40 polyvinyl chloride (PVC) with 1-inch internal diameter pipe fitted with one foot of 0.01-slotted screen at the lower end. The PVC pipe was inserted into the soft sediments at prescribed locations to help determine inflow and outflow areas of West Alaska Lake.

The wells were inserted approximately 2-3 feet into the lake substrate in approximately 1 foot of water. The wells were installed on August 19, 2004 and allowed to reach equilibrium. Measurements were then recorded for static head. The static head was used to determine whether groundwater was entering (higher head then the lake level) or leaving (lower head then the lake level) West Alaska Lake. Water levels were measured using a water level probe and measured to the nearest hundredth of a foot and recorded. Inflow sites are areas of recharge from groundwater and outflow sites are areas of the lake were water is being lost to groundwater. In wells where the static head was level with the lake level, neither inflow nor outflow was occurring.

3.5 Aquatic Plant Survey

One aquatic plant survey was completed in August 2004. The aquatic plant survey was completed in general accordance with the methodology of Jensen and Lound's "An Evaluation of a Survey Technique for Submerged Aquatic Plants". A base map was developed with eight transects distributed evenly around the perimeter of West Alaska Lake (Figure 2). Transects extended perpendicular to the shoreline and were located at points that allowed adequate lake and bay coverage.

Latitude and longitude coordinates at the intersection of the shoreline and the termination of the transect were measured with a global positioning system (GPS). A compass was used to determine transect bearings. Transects proceeded in the direction of the established bearing. Each transect was traversed with a sonar to determine depth. Along each transect, a 10-foot diameter circle (sampling point) was selected in various depth ranges. The circle was subdivided into four quadrants. A general density rating was determined for each quadrant by eye or with a modified aqua-rake. In areas where the bottom could be clearly observed, visual means were used. The rake was thrown into each quadrant, allowed to settle, and was slowly retrieved. A general density rating, based on the following criteria, and observations regarding substrate type were recorded along with the depth in feet.

RAKE RECOVERY OF SPECIES

Recovery	General Density Rating
▲ 0-20% of rake teeth filled	1
▲ 21-40% of rake teeth filled	2
▲ 41-60% of rake teeth filled	3
▲ 61-80% of rake teeth filled	4
▲ 81-100% of rake teeth filled	5

At each sample point, the species encountered were also recorded. If a species could not be identified in the field, a representative specimen was collected and placed on ice in a cooler for transportation. If a specimen could not be identified to the species level, it was referred to by the generic name followed by "sp". Various dichotomous keys and technical publications were used to classify the specimens. Applicable references are listed in Section 9.0.

Estimates of species abundance and density were determined using the recorded data. Specifically, the percent frequency of occurrence was determined by dividing the number of sampling sites at which a species occurred by the total number of sampling sites. Relative frequency was calculated by dividing the number of sample points a species was found in by the total number of occurrences of all species. Species mean density rating was obtained by averaging the density rating for all points where the species occurred.

It should be noted that only primarily floating leaved, free floating and submergent plant species were surveyed. Access to shallow water areas by boat was restricted by floating-leaved and submergent plants, therefore emergent plant communities were not surveyed.

4.0 LAKE AND WATERSHED PHYSIOGRAPHY

4.1 Lake Morphology

West Alaska Lake is a 20-acre groundwater drainage lake with a maximum depth of 41 feet and an average depth of 15 feet. There is one intermittent outflow on the northeast side of the lake. The most detailed bathymetric map available is the WNDR Lake Survey map from 1977. The lake volume is reported as 295.5 acre-feet. Bottom sediments are primarily silt with muck in shallow areas (WDNR, 1977).

4.2 Geology and Soils

The Lake's basin was formed from the melting of an ice mass that was left from a retreating glacier during Wisconsin's last glaciation. Area subsoils are primarily glacial till of the Kewaunee Formation (Mickelson et al, 1984).

The Kewaunee County Soil Survey indicates that the local surficial soils within the watershed consist of one soil association.

Hortonville-Symco: This soil association has well drained and somewhat poorly drained soils with a moderately fine subsoil underlain by medium and moderately coarse glacial till.

4.3 Watershed Land Use and Hydrology

The West Alaska Lake watershed is approximately 256 acres in size. The watershed is illustrated on Figure 3. Development within the watershed is limited to agricultural and low density residential. Based on information from the Kewaunee County Land and Water Conservation Department, the West Alaska Lake watershed has the following land uses:

Agricultural	194 acres
Grassland/Pasture	5 acres
Wooded Uplands	4 acres
Wetland	20 acres
Forested Wetland	6 acres
Barren Land	1.5 acres

There are no major channelized drainage systems in the watershed. One intermittent drainage is illustrated on the USDA soil map entering the lake from the west. Drainage is primarily overland flow. Slopes within the watershed are between 1 and 20 percent.

Phosphorus is typically an important nutrient to a lake's biological dynamics (see also section 5.3.1). Phosphorus can be contributed to a lake ecosystem through storm water runoff. Existing land uses within the watershed were modeled to allow current phosphorus loading to be estimated. The land use categories were determined based on Geographic Information System (GIS) data from the Kewaunee County Land and Water Conservation Department (see previous paragraph). These categories were correlated to the closest category of land use that could be used within the WiLMS® model to evaluate phosphorus loading. The data categories and corresponding land uses follow:

Kewaunee County GIS Data	WiLMS® Model Land Use
Agricultural land	Mixed agriculture
Grassland	Grassland/Pasture
Wetland Vegetation	Wetland
Forested Wetland/Wooded Lowland	Wetland
Wooded Upland	Forested
Barren Land	None

Note: Approximately 7 acres of the agricultural area was run as rural residential. This is an assumed value based on the fact that there are approximately 7 homes on West Alaska Lake.

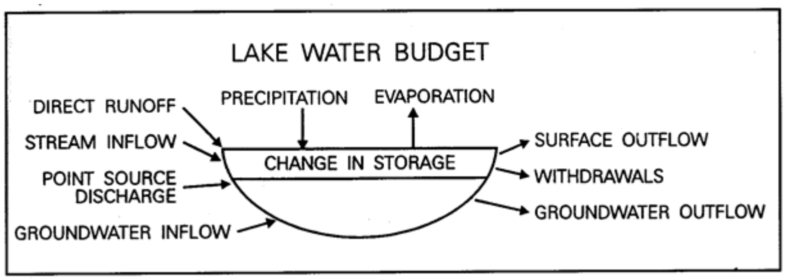
Land uses are illustrated in Figure 4. In addition to West Alaska Lake's water surface, the above land use categories were analyzed for current phosphorus loading. WiLMS® predicts that approximately 161 pounds of phosphorus enter the lake system annually. The land uses and their respective phosphorus contribution to the lake follows:

Land use	Percent (%) of total Phosphorus loading
Agriculture	92
Grassland	1
Wetland	2
Forested	<1
Rural Residential	<1
Lake Surface	4
Septic	1

Agriculture encompasses the most land use within the watershed and also contributes the most nutrients to the lake. This number calculated by the model is believed to be somewhat higher than reality because the model does not take natural buffering capacity or best management practices into account. Model results are included in Appendix C.

4.4 Shallow Groundwater Interactions

A typical water budget is illustrated below.



Source: NALMS, Managing Lakes and Reservoirs

West Alaska Lake receives water from surface water runoff (see also section 4.3), precipitation, and groundwater inflow. The lake loses water to surface water outflow, groundwater outflow, and evaporation. While a full water budget was outside the scope of this grant project, shallow piezometers were installed around the perimeter of the lake to evaluate the shallow groundwater component of the water budget.

Measuring water depths inside the piezometer and outside the piezometer (lake level) on August 21, 2003 indicates that groundwater enters the lake from both the east and west sides of the lake, while groundwater flow appeared to be away from the lake on the north and south ends of the lake. October 27, 2003 measurements indicated that groundwater flows into the lake from all directions. The sampling in August was during drought conditions. Since groundwater levels change seasonally and the groundwater table may rise or fall into soils of varying permeability, additional sampling events may be required or additional piezometers may be needed to fully characterize groundwater flow characteristics around the lake.

4.5 Lake Improvements

Of the 1.03 miles of lake shoreline, most is in a natural wooded state. There are reportedly 7 residential properties on West Alaska Lake. One public boat launch is present at the northeast end of the Lake.

5.0 WATER QUALITY STUDY

The West Alaska Lake request for proposal detailed sampling of select water quality parameters, specifically secchi depth readings, chlorophyll *a* levels, and phosphorus levels during each season of the year. The results of water quality sampling for spring 2003 through winter 2004 are summarized in Table 1. Sampling locations are illustrated in Figure 2. Water quality is very dynamic and varies greatly over time. Therefore, in addition to evaluating the results of the sampling events and parameters, Northern Environmental has included an evaluation of historical water quality data found in WNDR file data. Available historical water quality data is also summarized in Table 1. The data are included in Appendix A.

5.1 Temperature

Water temperature profoundly affects lake characteristics. Temperature influences water circulation patterns, solubility of various compounds, chemical reaction rates, and species and distribution of aquatic plants and animals. The temperature regimens of a lake are controlled by climatic and wind conditions, lake basin morphology, surrounding topography and vegetation, water inflows and outflows, and water chemistry.

Most deeper lakes in Wisconsin thermally stratify. In such lakes, temperature-induced density changes cause a lake to develop three distinct temperature zones. During summer, these zones include the epilimnion (warm surface layer), metalimnion (transitional layer), and the hypolimnion (cold bottom layer). Little mixing occurs between these layers while the lake is stratified. Since the hypolimnion is not exposed at the lake surface, it does not exchange gases with the atmosphere. In eutrophic lakes, decomposing organic debris in the hypolimnion can deplete oxygen, leading to an anoxic hypolimnion. Anoxic water is not habitable for most aquatic life and encourages dissolution of phosphorus from bottom sediment (Shaw, et al., 1994).

In most lakes, thermal stratification breaks down each fall as the atmosphere cools, allowing deeper water formerly trapped in the hypolimnion to mix with surface layers. During winter, many lakes once again stratify. Since water reaches its maximum density at 4° Centigrade (a temperature slightly above the freezing point of water), warmer water is found at depth, while cooler, near-freezing water is found directly below the ice. This inverse temperature stratification is easily disrupted, and lakes usually mix during spring. Mixing can bring large amounts of nutrients to the surface of a lake, enhancing productivity. Lakes that stratify and undergo two periods of mixing are termed “dimitic.”

Temperature / depth profiles were measured seasonally in the 2003/2004 sampling events. Review of this data indicates that West Alaska Lake does thermally stratify in the summer and winter, and is therefore, dimitic. Reviewing the temperature profile data (Table 2), one can see that the lake was beginning to stratify on May 1, 2003 and was thermally stratified in August 2003. The winter profile indicates inverse thermal stratification in February 2004. The thermal stratification on dates measured in 2003 and 2004 is illustrated in Figure 7.

5.2 Oxygen

Oxygen solubility varies with temperature, water purity, and atmospheric pressure. More oxygen can dissolve into pure cold water at low elevations. Increasing water temperature, salinity, and elevation decrease oxygen saturation potential. Dissolved oxygen is also affected by biological productivity. Aquatic plants produce oxygen, but plant and animal decomposition and respiration use oxygen. When respiration and decomposition use more oxygen than can be replenished by exchange with the atmosphere and plant oxygen production, oxygen levels decrease. Oxygen can be exhausted in some cases, especially when water cannot freely mix and exchange gases with the atmosphere. Fish kills can occur during winter because ice does not allow air to water oxygen transfer while ice and snow limit light penetration, hindering photosynthetic oxygen production. Although less common, excessive aquatic plant growth and subsequent decomposition of dead organic matter can also cause excessively low dissolved oxygen concentrations. In some lakes, abundant aquatic plant growth can cause dissolved oxygen concentrations to rise above saturation values. Supersaturated oxygen concentrations can also be detrimental to aquatic organisms.

Water should contain at least 5 milligrams per liter (mg/l) oxygen to support a healthy warm-water fishery. To support trout, at least 7 mg/l oxygen should be present. Even though fish can tolerate lower oxygen concentrations for variable periods, low oxygen levels stress the fish, and often promote the success of less desirable species, such as carp and bullheads. West Alaska Lake likely receives significant quantities of groundwater seepage. Under many conditions, groundwater contains very little oxygen. When the water is exposed to the atmosphere, however, oxygen concentrations increase to near saturation. The deepest waters of West Alaska Lake thermally stratify and therefore cannot contact the atmosphere. Decaying organic material consumes oxygen in this deeper water; consequently, little oxygen is found in the deepest portions of the Lake. Oxygen measurements in 2003-2004 suggest that there were oxygen depletions in portions of the lake deeper than 12 feet in the summer. Winter 2004 dissolved oxygen levels were below 4 mg/l at depths greater than 16 feet. Oxygen measurements are listed and illustrated in Table 3 and Figure 7, respectively.

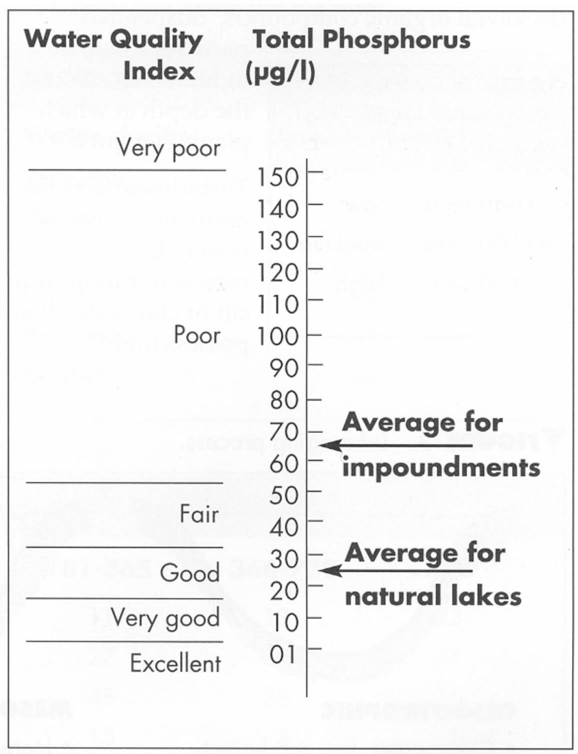
<u>5.3 Nutrients</u>

Nitrogen and phosphorus are macronutrients essential to plant growth. While plants require many compounds to live, most are readily available in sufficient quantities to allow growth. Nitrogen and phosphorus are typically not as available, and the concentrations of one or the other usually limit aquatic plant growth. Consequently, knowing the concentration of these compounds in lake water can help us understand current and potential plant growth limitation factors.

<u>5.3.1 Phosphorus</u>

In 80 percent of Wisconsin lakes, phosphorus is the key nutrient controlling excessive aquatic plant and algae growth (Shaw, et al., 1994). Lake water phosphorus concentrations are usually measured as soluble reactive phosphorus and total phosphorus. Soluble reactive phosphorous is readily available to plants. Consequently, its concentration can vary widely over short periods. A potentially better measure of lake water phosphorus level is total phosphorus, which measures dissolved phosphorus as well as phosphorus in plants and animal fragments suspended in lake water.

Phosphorus is very reactive in the environment, being absorbed by plants and attaching itself tightly to sediments. Consequently, sediments carried by surface water are typically the largest external source of phosphorus to lakes. Phosphorus does not readily dissolve in lake water, forming insoluble precipitate with iron, calcium, and aluminum. Consequently, most fully oxygenated lakes have a net flux of phosphorus to the lake bottom. However, if lake water lacks oxygen, iron precipitates become unstable and release phosphorus to the overlying water. The hypolimnia in eutrophic lakes are often devoid of oxygen during summer, increasing the concentration of phosphorus available to plant growth.



Total phosphorus concentrations for Wisconsin's natural lakes and impoundments. (*Adapted from Lillie and Mason, 1983.*)

Source: UW Extension, Understanding Lake Data

Lake water samples were collected for total phosphorus in 1992 by the WDNR (Table 1). Review of these data indicated that phosphorus levels were low at the surface and very high at the deepest part of the lake. This indicates that during periods of anoxia in the hypolimnion, phosphorus may be released from the sediments. The 1992 data s included in Appendix A.

It should be noted that phosphorus levels are discussed in here in ug/l while other water quality parameters such as nitrogen are expressed in milligrams per liter (mg/l). There are 1,000 micrograms in a milligram.

As part of this 2003-2004 study, total phosphorus concentrations were collected seasonally from surface water samples and in deeper portions of the Lake. West Alaska Lake total phosphorus levels collected at the surface seasonally ranged from 13 to 28 µg/l. Total phosphorus levels at 38 feet in summer 2003 and winter 2004 were 298 µg/l and 131 respectively (Table 1).

The mean surface water concentration measured on West Alaska Lake in 2003-2004 was 22 ug/l. A summary of water quality data collected as part of this study is included as Table 1. Copies of laboratory analytical reports are included in Appendix B. This phosphorus level is consistent with the statewide average for natural lakes and indicates "good" water quality (Lillie and Mason 1983, Shaw et al 1994). The mean total phosphorous concentration measured in 242 northeastern Wisconsin lakes is 19 ug/l (Lillie and Mason, 1983). The slightly higher than average phosphorus concentrations found in West Alaska Lake may relate to in-lake cycling of phosphorus from the sediments (in an anoxic hypolimnion) and also external sources of phosphorus.

5.3.2 Nitrogen

Nitrogen is another nutrient limiting the growth of aquatic plants, usually second in importance to phosphorus. Nitrogen limits the growth of plants in a few Wisconsin lakes. Nitrogen can enter a lake via precipitation (which can have concentrations of nitrogen as high as 0.5 mg/l), breakdown of organic compounds (forming ammonia), and human-induced sources of nitrogen such as fertilizers, sewage effluent, and animal waste. Even though nitrogen demand in vegetated terrestrial soils is high during active growing periods, nitrogen can move through soil and reach groundwater if:

- Vegetation is not actively growing
- Nitrogen supply exceeds vegetative demand
- Nitrogen is injected directly to subsurface sediment (e.g., septic system drainfields)

Once nitrogen "leaches" to the groundwater table, it can migrate freely with groundwater moving towards discharge points such as surface waters, wetlands, and drinking water wells.

Various forms of nitrogen can be found in soils, surface water and groundwater. Water samples are commonly collected and analyzed for these nitrogen forms to determine nutrient cycles, budgets, or limiting nutrients. These forms of nitrogen include:

- Nitrate (NO_3^-) - leaches readily into groundwater

- Nitrite (NO_2^-) - usually present in only trace quantities and is readily transformed to nitrate in oxygenated water.

- Ammonia – Produced by bacteria during decomposition of nitrogen containing organic matter. Ammonia in water is measured as the total of ammonium ion (NH_4^+) and ammonia gas (NH3)
- Ammonium – (NH4+) is an ionic form of ammonia in water
- Total Kjeldal Nitrogen (TKN) – Sum of nitrogen in suspended organic matter and ammonium
- Total Inorganic Nitrogen – Sum of Nitrate (NO3), Nitrite (NO2), and Ammonium (NH4+)
- Total Organic Nitrogen – TKN minus Ammonium (NH4+)
- Total Nitrogen – Sum of TKN, Nitrate (NO3), and Nitrite (NO2)

Nitrogen levels were measured for nitrate, nitrite, and TKN in the 2003-2004 season. Total Nitrogen on West Alaska Lake ranged from 0.94 to 1.36 mg/l. A summary of the nitrogen sampling data in 2003 and 2004 is included on Table 1. Copies of laboratory reports are included in Appendix B. The mean total nitrogen concentration in a study of 243 northeastern Wisconsin lakes was 0.66 mg/l (Lillie and Mason, 1983). The higher than average nitrogen may be attributed to nitrogen laden surface water runoff, or failing septic systems leaching to groundwater.

5.3.3 Nitrogen/Phosphorous Ratio

When the ratio of total nitrogen to total phosphorus is greater than 15 to 1, plant and algal growth in a lake is controlled by the amount of phosphorus available and is considered “phosphorus-limited.” 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 (Shaw, et al., 1994). Most Wisconsin lakes are phosphorus-limited.

Available total nitrogen to total phosphorus ratios of West Alaska Lake indicate that the lake is strongly phosphorus limited (Table 1). As such, ample nitrogen is present for aquatic plant growth. An addition of nitrogen to the lake would not cause an increase in aquatic plant or algae growth. Additional phosphorus, however could fuel additional aquatic plant growth and potential algae blooms.

5.4 Chlorophyll *a*

Chlorophyll *a* concentrations correspond to the abundance of algae in lake water. Chlorophyll *a* concentrations respond to seasonal light changes, lake water nutrient content and transparency, aquatic macrophyte growth, temperature, and zooplankton abundance. High chlorophyll *a* concentrations relate to algal blooms. Algal blooms most often occur after spring and fall turnovers in lakes with anoxic hypolimnia when nutrients are released from the sediments. The release of nutrients into the hypolimnia and subsequent mixing of water with the epilimnion during spring turnover causes these nutrients to be readily available to initiate algal blooms. Algal blooms can also occur when other events liberate nutrients into the lake system or otherwise upset nutrient equilibrium. Examples of events that could cause an algal bloom are:

- Severe thunderstorms washing nutrient-laden water or sediment into a lake
- Mid-season circulation of the hypolimnion caused by storms, flood flows, etc.

- Decrease in zooplankton abundance
- Anoxic water conditions destabilizing phosphorus bound in bottom sediments
- Significant manipulation of the macrophyte community

If aquatic macrophytes are destroyed and are not removed from the water, the demand for limiting nutrients is decreased and nutrients are returned to the water from decomposing aquatic plants. This chain of events can cause algal blooms.

In summer 2003, chlorophyll *a* levels were 7.25 µg/l (Table 1). Copies of laboratory reports are included in Appendix B. Northeast Wisconsin lakes mean chlorophyll *a* concentration is 9.3 µg/l. Values of 10 µg/l or higher are associated with algae blooms. Chlorophyll *a* readings less than 5 µg/l indicate very good water quality, while values less than 1 µg/l are indicative of excellent water quality (Lillie and Mason, 1983). These chlorophyll *a* concentrations are below the average levels measured for northeast Wisconsin lakes and (as indicators by themselves) are indicative of good water quality.

5.5 Transparency

Transparency is a function of water color and turbidity and is usually measured with a secchi disk. A secchi disk is an 8-inch circular plate with alternating black and white quadrants fixed to a length of graduated cord. During the middle of the day, the disk is lowered on the shaded side of the boat until an observer can no longer see the secchi disk. The depth is noted, the disk is then raised until it just again is visible, and the depth again is noted. The two measurements are averaged to give a reading. The deeper the secchi disk reading, the clearer the water. High concentrations of algae or suspended sediment usually account for shallow secchi disk readings. In some instances, colored water can also account for low secchi readings.

Water clarity has been measured during the 1992 water quality sampling events completed by DNR. The secchi depth measurements in 1992 averaged 15.3 feet. Secchi depth measurements were also completed during the 2003-2004 study. These depths ranged from 10.1 feet in August to 23.1 feet in February, averaging 16 feet.

Water clarity of 10 feet or greater is considered “good” while 20 feet or greater is considered “very good” (Shaw, et al., 1994). Water clarity of West Alaska Lake is more than the median of 7.9 feet for northeastern Wisconsin lakes.

Bi-monthly depth readings collected over a number of years during open water periods would provide an excellent, low-cost method to evaluate changes in lake clarity that may relate to other changes in the Lakes’ conditions.

5.6 Trophic Status

Total phosphorus, chlorophyll *a*, and secchi disk depths are used to classify the trophic state of a lake. A trophic state is a measure of a lake’s biological productivity. Water resource managers and scientists use the Carlson’s Trophic State Index (TSI) to monitor Wisconsin lakes water quality. Aquatic resource managers use the secchi disk, total Phosphorus, and chlorophyll *a* data and apply Carlson’s TSI to place the water into one of the following categories.

Trophic Category Descriptions

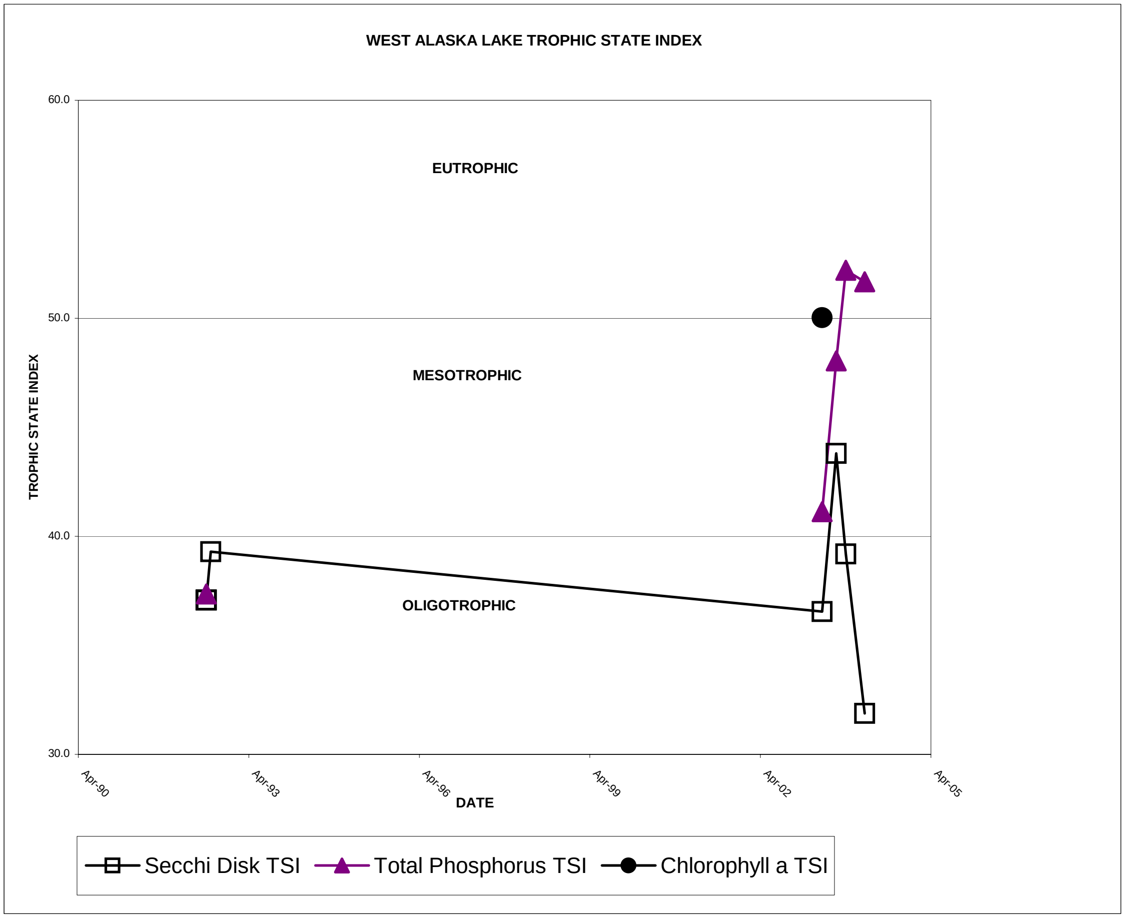
Category	TSI	Lake Characteristics
Oligotrophic	1-40	Clear water; oxygen rich at all depths, except if close to mesotrophic border; then may have low or no oxygen; cold-water fish likely in deeper lakes.
Mesotrophic	41-50	Moderately clear; increasing probability of low to no oxygen in bottom waters.
Eutrophic	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.
Hypereutrophic	70-100	Heavy algal blooms throughout the summer; if > 80, fish kills likely in summer and rough fish dominate.

All lakes undergo a natural aging process, shifting from an oligotrophic state to an eutrophic state. Human activities can accelerate this aging process through agriculture, lawn fertilizers, septic systems, and urban storm sewers. Using the summer 2003 surface water data, (total phosphorus concentration of 21 µg/l, chlorophyll *a* concentration of 7.25 µg/l, and a secchi depth of 10.1 feet), West Alaska Lake is classified as mesotrophic with an average Carlson TSI of 47. Mesotrophic lakes typically have moderately clear water, can develop anoxic hypolinia during the summer, may have excessive aquatic macrophytes, and will normally only support warm-water fisheries.

Trophic classification of Wisconsin lakes based on chlorophyll *a*, water clarity measurements, and total phosphorus values. (*Adapted from Lillie and Mason, 1983.*)

Trophic class	**Total phosphorus** µg/l	**Chlorophyll *a*** µg/l	**Secchi Disc** feet
Oligotrophic	3	2	12
	10	5	8
Mesotrophic	18	8	6
	27	10	6
Eutrophic	30	11	5
	50	15	4

Sampling events by WDNR in 1992 also provided secchi disk and total Phosphorus data that was also used to establish the TSI of West Alaska Lake. Historical TSI values were calculated from these sample results and are illustrated in the following graph.



Historical TSI values vary from oligotrophic to slightly eutrophic. The total phosphorus values are more eutrophic parameter than the secchi disk TSI values.

6.0 AQUATIC PLANTS

Aquatic plants are vital to the health of a water body. Unfortunately, much too often, people refer to all rooted aquatic plants as weeds and their ultimate goal is to eradicate them. This line of thinking must be avoided when trying to manage the entire lake ecosystem. Rooted macrophytes are extremely important for the well being of the lake community and posses many positive attributes. These attributes are what make the littoral zone the most important and productive aquatic habitat in freshwater lakes. However, aquatic macrophytes can become a nuisance when exotics plant species occupy large portions of a lake. Excessive aquatic plant growth can negatively affect recreational activities. When “managing” aquatic plants, it is important to maintain a well-balanced, stable, and diverse aquatic plant community that contain high percentages of desirable native vegetation.

6.1 The Ecological Role of Aquatic Plants

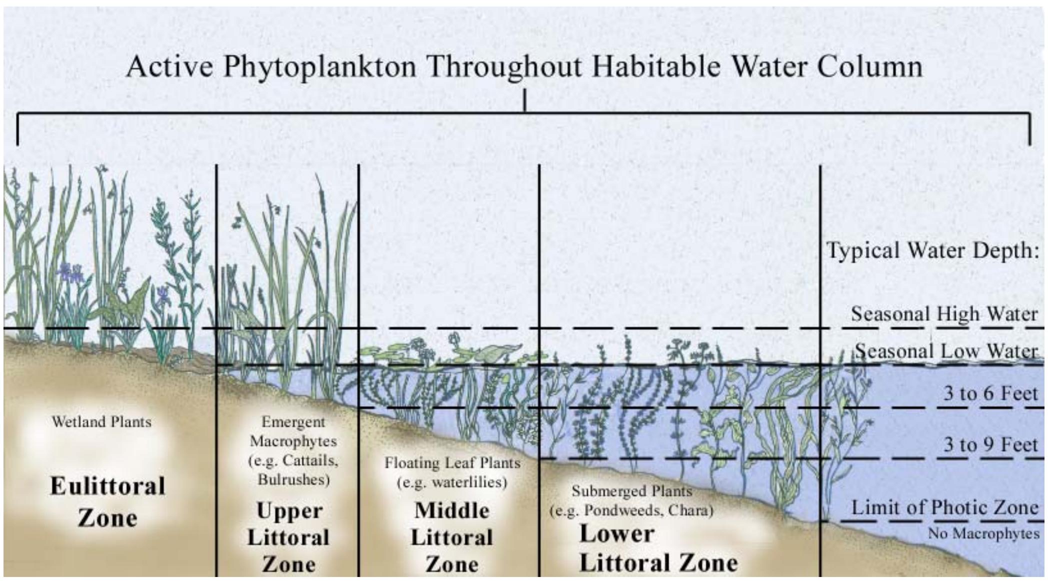
Aquatic plants can be divided into two major groups: microphytes (phytoplankton and epiphytes) composed mostly of single-celled algae, and macrophytes that include macroalgae, flowering vascular plants, and aquatic mosses and ferns. Wide varieties of microphytes co-inhabit all hospitable areas of a lake. Their abundance depends solely on light, nutrient availability, and other environmental factors. In contrast, macrophytes are predominantly found in distinct habitats in the littoral (shallow near shore) zone where sufficient light can penetrate to the lake bottom. The littoral zone is subdivided into four distinct transitional zones: the eulittoral, upper littoral, middle littoral, and lower littoral (Wetzel, 1983).

Eulittoral Zone: Includes the area between the highest and lowest seasonal water levels, and often contains many wetland plants.

Upper Littoral Zone: Dominated by emergent macrophytes and extends from the water edge to water depths between 3 and 6 feet.

Middle Littoral Zone: Occupies water depths of 3 to 9 feet, extending lakeward from the upper littoral zone. The middle littoral zone is dominated by floating-leaf plants.

Lower Littoral Zone: Extends to a depth equivalent to the limit of the photic zone, which is defined as percent of surface light intensity.



Relationship of phytoplankton and macrophyte communities.

The abundance and distribution of aquatic macrophytes are controlled by other factors than dissolved nutrient availability. These factors include light availability, lake trophic status as it relates to nutrients and water chemistry, sediment characteristics, and wind energy. Lake morphology and watershed characteristics relate to these factors independently and in combination (NALMS, 1997).

In many instances aquatic plants serve as indicators of water quality due to the sensitive nature of plants to water quality parameters such as water clarity and nutrient levels. To grow, aquatic plants must have adequate supplies of nutrients. Microphytes and free-floating macrophytes (e.g., duckweed) derive all their nutrients directly from the water. Rooted macrophytes can absorb nutrients from water and/or sediment. Therefore, the growth of phytoplankton and free-floating aquatic plants is regulated by the supply of critical available nutrients in the water column. In contrast, rooted aquatic plants can normally continue to grow in nutrient-poor water if lake sediment contains adequate nutrient concentrations. Nutrients removed by rooted macrophytes from the lake bottom may be returned to the water column when the plants die. Consequently, killing aquatic macrophytes may increase nutrients available for algal growth.

In general, an inverse relationship exists between water clarity and macrophyte growth. That is, water clarity is usually improved with increasing abundance of aquatic macrophytes. Two possible explanations are postulated. The first is that the macrophytes and epiphytes out-compete phytoplankton for available nutrients. Epiphytes derive essentially all of their nutrient needs from the water column. The other explanation is that aquatic macrophytes stabilize bottom sediment and limit water circulation, preventing resuspension of solids and nutrients (NALMS, 1997).

If aquatic macrophytes are reduced in abundance, water clarity can suffer. Water clarity reductions can further reduce the vigor of macrophytes by restricting light penetration, reducing the size of the littoral zone, and further reducing water clarity. Studies have shown that if 30 percent or less of the area of a lake occupied by aquatic plants is controlled, water clarity will generally not be affected. However, lake water clarity will likely be reduced if 50 percent or more of the macrophytes are controlled (NALMS, 1997).

Aquatic plants also play a key role in the ecology of a lake system. Aquatic plants provide food and shelter for fish, wildlife and invertebrates. Plants also improve water quality by protecting shorelines and the lake bottom, improving water quality, adding to the aesthetic quality of the lake and impacting recreational activities.

6.2 Aquatic Plant Survey

6.2.1 2003 Aquatic Plant Survey

Aquatic macrophytes on West Alaska Lake were surveyed during August 2003. This survey was conducted when aquatic plant growth would be optimal for macrophytes that are present during different periods of the year that would be conclusive to observing the greatest number of species present. 2003 aquatic plant survey transect and sample point locations are illustrated in Figure 8. Information gathered during the survey concluded that West Alaska Lake has moderate species diversity and a low amount of biomass. Twelve species of free-floating, floating leaved and submerged aquatic vascular plants were identified during the survey and two algal species were identified during the survey. Aquatic macrophyte species identified in the Lake are summarized in Table 3. August distribution of aquatic plant species is illustrated in Figures 8.

During the August survey, the most abundant species found was *Chara sp.* (Chara / Muskgrass) with a 75 percent frequency of occurrence (percent of sample points containing that species) in August (Table 4). Chara / Muskgrass had a 26 percent relative frequency (the frequency of occurrence compared to the occurrence of all species) in August. Ceratophyllum demersum (Coontail) was the second most abundant species in August with a 44 percent frequency of occurrence in August. Coontail had a 15 percent relative frequency in August. *Myriophyllum sibiricum* (Northern watermilfoil) was the third most abundant species in August with a 41 percent frequency of occurrence and a 14 percent relative frequency.

The species with the highest mean density rating (the average density rating for all sample points where a species was present) for the August survey was *Nitella sp.* (Nitellas). The second highest mean density rating for the August survey was *Nymphaea odorata* (White water lily) and the third highest mean density rating was *Nuphar variegata* (Spatterdock). Frequency of occurrence, relative frequency and mean density ratings is summarized on Table 4.

Most aquatic macrophytes are found growing in an area with a suitable substrate and where they are able to maximize their ability to absorb varying levels of light intensity. The littoral zone, the depth to which light penetrates permitting photosynthesis and colonization of aquatic macrophytes for West Alaska Lake is between zero and fifteen feet. West Alaska Lake is mostly composed of soft sediments in shallow near shore areas that are able to support higher numbers of aquatic macrophyte populations due to rich mineral content. Aquatic plant distribution is summarized on Table 4 and Table 5, respectively. August aquatic plant distribution is illustrated in Figure 8.

6.2.1.1 Free-Floating Plants

The free-floating aquatic plant species identified during the 2003 aquatic plant surveys are listed in Table 3. A brief description about these plants follows.

Lemna minor (Small Duckweed)

Small Duckweed
Source: University of Florida Website

Lemna minor (Small Duckweed), is a common free-floating aquatic plant. Duckweed has round oval shaped leaf bodies called fronds. These fronds float individually or in groups on the waters surface. Duckweed reproduces commonly by budding. The plants obtain nutrients from the water by absorbing nutrients through its leaf undersurface and dangling roots. Duckweed is a nutritious food source for a variety of waterfowl. Duckweed can reproduce at tremendous rates sometimes doubling in number in as little of three to five days (Borman, et al., 1997).

6.2.1.2 Floating-Leaf Plants

The submerged aquatic plant species identified during the 2003 aquatic plant surveys are listed in Table 3. A brief description about these plants follows.

Nuphar variegata (Spatterdock)

Nuphar variegata (Spatterdock), was found in many shallow water areas at West Alaska Lake. Spatterdock shows a preference for soft sediment and water that is 6 feet or less in depth. Floating leaves emerge in early summer from rhizomes that are actively growing in the soft sediments. Flowering occurs throughout the summer and supports a yellow flower. Floating leaves provide shelter and shade for fish as well as habitat for invertebrates (Borman, et al., 1997).


Spatterdock
Source: University of Florida Website

Nymphaea odorata (White Water Lily)


White Water Lily
Source: University of Florida Website

Nymphaea odorata (White Water Lily) have a flexible stalk with a round floating leaf. Most of the leaves float on the waters surface. White Water Lily is found growing in a variety of sediment types in waters less than 6 feet deep. Floating leaves emerge in early summer from rhizomes that are growing in the soft sediments. Flowering occurs throughout the summer and supports a white flower. The floating leaves provide shelter and shade for fish as well as habitat for invertebrates (Borman, et al., 1997).

6.2.1.3 Submergent Plants

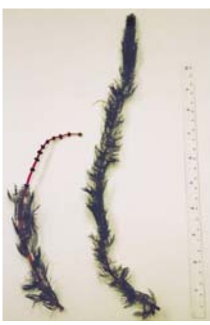
The submerged aquatic plant species identified during the 2003 aquatic plant surveys are listed in Table 4. A brief description about these plants follows.

Ceratophyllum demersum (Coontail)

Coontail (*Ceratophyllum demersum*) is a submergent aquatic plant. Unlike most other submergent aquatic plants, coontail is not rooted and can drift, making it tolerant to higher water levels. Because it does not have roots, it absorbs nutrients dissolved in the lake water. Coontail provides excellent shelter and foraging opportunities for fish and invertebrates, and waterfowl consume its foliage and fruit (Borman, et al., 1997). Coontail is also commonly misidentified and mistaken for *Myriophyllum spicatum* (Eurasian watermilfoil).


Coontail
Source: UW Herbarium Website

Myriophyllum sibiricum (Northern watermilfoil)


Northern watermilfoil
Source: UW Herbarium Website

Northern watermilfoil (*Myriophyllum sibiricum*) has light colored stems that emerge from rootstalks and rhizomes. Stems are sparingly branched and fairly erect in water. Leaves are divided like a feather, with 5-12 pairs of thread-like leaflets. Leaves are arranged in whorls. Northern watermilfoil can also reach nuisance levels posing problems for recreational and navigational patron. Waterfowl eat the foliage and fruit of northern watermilfoil, while beds of this plant provide cover and foraging opportunities for fish and invertebrates. Northern watermilfoil is usually found growing in soft sediment in fairly clear-water lakes and can grow in depths over 12 feet deep.

Pomatogeton pectinatus (Sago Pondweed)

Sago pondweed (*Pomatogeton pectinatus*) resembles two other pondweeds with needle-like leaves, but sago pondweed tends to be much more common. The fruit and tubers of sago pondweed are very important food sources for waterfowl, while leaves and stems provide shelter for small fish and invertebrates (Borman, et al., 1997).


Sago Pondweed
Source: UW Herbarium Website

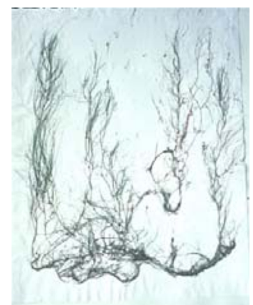
Najas flexilis (Slender Naiad)

Slender Naiad
Source: UW Herbarium Website

Slender Naiad (*Najas flexilis*) or sometimes called bushy pondweed has fine branched stems that emerge from a slight rootstalk. Leaves are paired, but there are some sometimes bunches of smaller leaves. Slender Naiad can grow in very shallow to several meters in depth. Waterfowl, marsh birds, and muskrats consume the stems, leaves, and seeds of naiad. The foliage produces forage and shelter opportunities for fish and invertebrates (Borman, et al., 1997).

Potamogeton diversifolius (Water-thread Pondweed)

Potamogeton diversifolius (Water-thread Pondweed) has freely-branched stems that emerge from a slender, buried rhizome. Submersed leaves are narrow and linear. There is one obvious midvein bordered by a single row of lacunar cells. Stipules are fused to the leaf for one-third to one-half of their length. Floating leaves are shaped like an ellipse. New shoots are produced in spring from overwintering rhizomes. Flowering occurs by midsummer and fruit is evident by late summer. Fruit produced by water-thread pondweed can be a locally important food source for a variety of ducks and geese. The plant is also grazed by muskrat, deer and beaver. Leaves and stems may be colonized by invertebrates and offer foraging opportunities for fish. (Borman, et al., 1997).



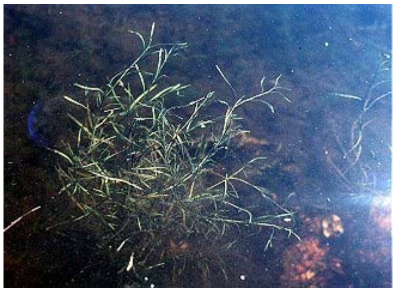
Water-thread Pondweed
Source: UW Herbarium Website

*Potamogeton zosteriformis (*Flat-stem Pondweed)

Flat-stem Pondweed
Source: UW Herbarium Website

Potamogeton zosteriformis (Flat-stem Pondweed) is freely-branched stems of flat-stem pondweed emerge from a slight rhizome. The stems are strongly flattened and have an angled appearance. Stiff linear leaves have a prominent midvein and many fine, parallel veins. The firm stipules are free in the leaf axils. No floating leaves are produced. Flat-stem pondweed is most commonly confused with *Zosterella dubia* (water stargrass). The size an arrangement of the leaves is similar, but the leaves of water stargrass lack a prominent midvein. Flat-stem pondweed is commonly grazed by waterfowl including redhead and green-winged teal. Flat-stem pondweed offers habitat for invertebrates and offers foraging opportunities for fish (Borman, et al., 1997).

Zosterella dubia (Water stargrass)



Water stargrass
Source: UW Herbarium Website

Zosterella dubia (Water stargrass) has slender freely branched stems that emerge from a buried rhizome. The narrow, alternate leaves attach directly to the stem with no leaf stalk and lack a prominent midvein. Water stargrass is often mistaken for a pondweed. Leaves of water stargrass lack a definite midvein and when it is in flower, the yellow blossoms separate it from pondweeds. Water stargrass grows in a variety of water depths and will tolerate reduced water clarity. Water stargrass can be locally important source of food for geese and ducks including northern pintail, blue winged teal and wood duck. It offers good cover and foraging opportunities for fish.

Chara sp. (Muskgrass / Chara)

Chara sp.
Source: University of Florida Website

Although muskgrass (*Chara sp.*) looks like a higher plant, it actually is a multi-celled algae. Muskgrass is usually found in hard waters and prefers muddy or sandy substrate and can often be found in deeper water than other plants. Waterfowl eat muskgrass spores. Muskgrass beds provide valuable habitat for small fish and invertebrates. Muskgrass is also a favorite waterfowl food and extremely valuable fish habitat. The rhizoids slow the movement and suspension of sediments and benefit water quality in the ability to stabilize the lake bottom (Borman, et al., 1997).

Nitella sp.(Nitella)

Nitella (*Nitella sp*.) is a type of algae that looks like a higher plant. This plant has no conductive tissue and has simple anchoring structures called rhizoids rather than true roots. Nitella is similar in appearance to muskgrass and is often found in similar habitats. However, Nitella sp. can be identified from chara or muskgrass by the stems and branches having smooth rather than lined and encrusted branches and also look like they are made of green gelatin while those of muskgrass are harsh and rigid (Borman, et al., 1997).

Nitella sp.
Source: Washington State Department of Ecology Website

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

West Alaska Lake is a 21-acre groundwater drainage lake with a maximum depth of 41 feet and an average depth of 15 feet. Since the lake is less than 50 acres, it has been designated a no motor boat lake. Electric trolling motors are allowed. Seven homes are located around West Alaska Lake. The shoreline is primarily surrounded by wetlands and wooded areas. Groundwater appears to enter the lake from all directions. The lake has 248-acre watershed with the primary land use being agricultural. The nutrient loading model indicates that runoff from agriculture contributes the most nutrients to the lake.

West Alaska Lake is a dimictic lake meaning it stratifies thermally in the summer and winter and mixes in the spring and fall. Dissolved oxygen levels, while depleted in the hypolimnion in the summer and winter, appear to remain adequate in the epilimnion (shallowest layer in thermally stratified lake) to support fish through the winter.

Nutrient analysis indicates that phosphorus is the limiting nutrient controlling aquatic plant growth. Water quality data collectively indicate that West Alaska Lake is a mesotrophic lake although water clarity readings indicating oligotrophic status and recent total phosphorus readings indicating eutrophic TSI values. The available information indicates that there may be an increase in total phosphorus in West Alaska Lake. The water clarity on West Alaska is exceptional. The most abundant aquatic plants in August 2003 were chara, coontail, northern watermilfoil, nitella, white water lily and spatterdock.

7.2 Recommendations

While West Alaska Lake's overall water quality does not appear to be deteriorating and the aquatic plants do not appear to be a nuisance at this time, the following items are suggestions and recommendations to improve, maintain, and monitor West Alaska Lake.

7.2.1 Water Quality Monitoring

West Alaska Lake water quality is determined to be good and shows no significant long term declining water quality trend. An adequate monitoring system can help track changes within the lake and prevent significant lake problems by identifying problems early. A good program to be involved in is the WDNR Self-Help Citizen Lake Monitoring Network. Using the self help program, volunteers may also collect water chemistry parameters, temperature, and dissolved oxygen data.

The WDNR provides all sampling equipment. Training of the volunteers is provided by either DNR or University of Wisconsin - Extension staff. Volunteers then collect samples. The information can be used by WDNR and other lake experts to track changes in the lake's health. For more information on volunteer monitoring, visit the following DNR web page on the internet: http://dnr.wi.gov/org/water/fhp/lakes/selfhelp/. Or contact your local DNR lake professionals for more information. Northern Environmental recommends completing volunteer monitoring on West Alaska Lake according to the following parameters and schedule.

Parameter	Frequency
Water clarity	Spring, Monthly in Summer, Fall, Winter
Total phosphorus	Spring, Summer, Fall, Winter
Dissolved Oxygen, Temperature	Spring, Summer, Fall, Winter
Chlorophyll *a*	Spring, Summer

Every few years, this data should be reviewed collectively to determine if the lake's trophic status has changed. A lake management planning grant could pay for updating and interpreting this lake data. If the data suggest consistent trophic state values, then the expenditures for formal active lake management actions may not be warranted. However, if the lake's clarity, chlorophyll *a*, or phosphorus levels indicate a reduction in water quality or lake users notice a perceived change in water quality, then the Association may consider completing a full lake water budget and nutrient budget to determine the sources of water quality deterioration. After that is completed, the Association may consider completing a feasibility study for controlling the nutrient sources of concern.

7.2.2 Watershed Management

Since agriculture is the land use that was predicted to contribute the majority of the nutrients to West Alaska Lake, efforts should be made to minimize agricultural runoff. Agricultural best management practices (BMPs) can help prevent erosion and nutrient runoff. The Tri-Lakes Association should work with the Kewaunee County LCD to identify areas of potential concern and implement BMPs as needed. Ensure that agricultural BMPs such as minimal tillage and proper nutrient management are being used within the watershed. The county land conservation department has information on BMPs. Cost sharing is available for agricultural BMPs.

One approach may be to complete a watershed wide survey of farms and agricultural land for problem areas. If sufficient topographic information is available, the watershed could be divided into subwatersheds. Large scale BMP such as a settling basins could be designed for subwatersheds with the greatest number of problems. Farm specific BMPs for barnyards and cropland could also be implemented.

If a large scale BMP such as a settling basin within the watershed can be demonstrated to achieve significant reductions in nutrients to West Alaska Lake, this may also be eligible for WDNR lake planning and protection grant funds. As always, contact your local WDNR grant specialist and lake staff to discuss your project ideas and the potential for funding sources.

7.2.3 Aquatic Plants

Since the water depth increases rapidly from the shoreline, West Alaska Lake has a small littoral zone. Therefore, aquatic plants are unlikely to grow to nuisance levels in the Lake. Northern Environmental recommends periodic surveys to evaluate if exotics such as Eurasian watermilfoil or curly leaf pondweed have invaded the lake. WDNR planning grants and aquatic invasive species (AIS) grants may be available to fund surveys. Also, individual volunteers may be trained in the WDNR self-help monitoring program to identify exotic species. Exotic plants will most likely appear first near the boat launch.

An exotic wetland plant, purple loosetrife was noted in a few areas around West Alaska Lake. The Association should manually remove this plant to reduce it's chances of spreading. An alternative is to release a beetle that feeds exclusively on purple loosetrife. Your local DNR or UW extension agent will have more details on this program.

7.2.4 General Lake Management

The Tri-Lakes Association should continue to promote membership and activity within the Association. Active associations that generate interest in their lake resources are more likely to have community support for future lake activities, management strategies, or grant funds in the future if needed.

If enough interest is generated, the Association may consider developing a survey for lake users. The survey can be used to solicit public opinion and can become a starting point for a lake management plan. While there are not many complicated issues facing West Alaska Lake at this time, a lake management plan may help develop community goals for West Alaska Lake, prioritize goals, and implement strategies to achieve those goals.

The decision to implement lake protection projects is largely a decision unique to each lake and each lake group. Some lake groups aggressively pursue lake protection projects, while others may be content with maintaining the current state of water quality. Each lake and each lake organization has different challenges and goals.

8.0 GLOSSARY

The following section is largely adapted from a University of Wisconsin Extension Publication entitled *Understanding Lake Data* (Shaw, et al., 1994).

Algae: One-celled (phytoplankton) or multi-cellular plants either suspended in water (plankton) or attached to rocks, rooted aquatic plants, and other substrates (epiphytes). Their abundance, as measured by the amount of chlorophyll a (green pigment) in an open water sample, is commonly used to help classify the trophic status of a lake. Algae are essential to the lake ecosystems and provide the food base for most lake organisms, including fish. Phytoplankton abundance and specie distribution vary widely from day to day, as life cycles are short.

Alkalinity: A measure of the amount of carbonates, bicarbonates, and hydroxide present in water. Low alkalinity is the main indicator of susceptibility to acid rain. Increasing alkalinity is often related to increased algae productivity. Expressed as mg/l of calcium carbonate ($CaCO_3$) or as microequivalents per liter (µeq/l). 20 µeq/l = 1 mg/l of $CaCO_3$.

Ammonia: A form of nitrogen found in organic materials and many fertilizers. It is the first form of nitrogen released when organic matter decays, can be used by most aquatic plants, and is, therefore, an important nutrient. Ammonia converts rapidly to nitrate (NO_3^-) if oxygen is present. The conversion rate is related to water temperature. Ammonia is toxic fish at relatively low concentrations in pH-neutral or alkaline water. Under acidic conditions, non-toxic ammonium ions (NH_4^+) form, but at high pH values, the toxic ammonium hydroxide (NH_4OH) occurs. The water quality standard for fish and aquatic life is 0.02 mg/l of NH_4OH. At a pH of 7 and a temperature of 68˚F (20˚C), the ratio of ammonium ions to ammonium hydroxide is 250:1; at pH of 8, the ratio is 26:1.

Anion: Refers to the chemical ions present that carry a negative charge in contrast to cations, which carry a positive charge. There must be equal amounts of positive and negative charged ions in any water sample. Following are the common anions in decreasing order of concentration for most lakes: bicarbonate (HCO_3^-), sulfate $SO_4^=$), chloride (Cl^-), carbonate ($CO_3^=$), nitrate (NO_3^-), nitrate (NO_2^-), and phosphates ($H_2PO_4^-$, $HPO_4^=$, and $PO_4^=$).

Aquatic invertebrates: Aquatic animals without an internal skeletal structure, such as insects, mollusks, and crayfish.

Blue-green algae: Algae that are often associated with problem blooms in lakes. Some produce chemicals toxic to other organisms, including humans. They often form floating scum as the die. Many can fix atmospheric nitrogen (N_2) to provide their own nutrient source.

Calcium: The most abundant cation found in Wisconsin lakes. Its abundance is related to the presence of calcium-baring minerals in the lake watershed, and reported in mg/l as calcium carbonate ($CaCO_3$) or mg/l as calcium ion (Ca^{++}).

Cation: Refers to chemical ions present that carry a positive charge. The common cations present in lakes in normal order of decreasing concentrations follow: calcium (Ca^{++}), magnesium (Mg^{++}), potassium (K^{+}), sodium (Na^{+}), ammonium (NH_4^{+}), ferric iron (Fe^{+++}) or ferrous iron (Fe^{++}), manganese (Mn^{++}), and hydrogen (H^{+}).

Chloride: Chlorine in the chloride ion (Cl^{-}) form has very different properties from chlorine gas (Cl_2), which is used for disinfecting. The chloride ion (Cl^{-}) in lake water is commonly considered an indicator of human activity. Agricultural chemicals, human and animal wastes, and road salt are the major sources of chloride in lake water.

Chlorophyll *a*: Green pigment present in all plant life and necessary for photosynthesis. The amount present in lake water depends on the amount of algae and is, therefore, commonly used as a water-quality indicator.

Color: Measured in color units that relate to a standard. A yellow-brown natural color is associated with lakes or rivers receiving wetland drainage. The average color value for Wisconsin lakes is 39 units, with the color of state lakes raging from zero to 320 units. Color also affects light penetration, and therefore, the depth at which plants can grow.

Concentration units: Express the amount of a chemical dissolved in water. The most common ways chemical data are expressed is in mg/l and micrograms per liter (µg/l). One mg/l is equal to one part per million (ppm). To convert µg/l to mg/l, divide by 1000 (e.g., 30 µg/l = 0.03 mg/l). To convert mg/l to µg/l, multiply by 1000 (e.g., 0.5 mg/l = 500 µg/l). Microequivalents per liter (µeq/l) is also sometimes used, especially for alkalinity; it is calculated by dividing the weight of the compound by 1000 and then dividing that number into the mg/l.

Conductivity (specific conductance): Measures the ability of water to conduct an electric current. Conductivity is reported in micromhos per centimeter (µmhos/cm) or an equivalent in microsiemens (µs), and is directly related to the total dissolved inorganic chemicals in the water. Values are commonly two times the water hardness unless the water is receiving high concentrations of contaminants introduced by humans.

Drainage basin: The total land area that drains toward the lake.

Drainage lakes: Lakes fed primarily by streams and with outlets into streams or rivers. They are more subject to surface runoff problems but generally have shorter residence times than seepage lakes. Watershed protection is usually needed to manage lake water quality.

Epiphyte: See “Algae”

Filamentous algae: Algae that forms filaments or mats attached to sediment, weeds, piers, etc.

Food chain: The sequence of algae being eaten by small aquatic animals (zooplankton) that in turn are eaten by small fish that are then eaten by larger fish, and eventually by people or predators. Certain chemicals, such as polychlorinated biphenyls (PCBs), mercury, and some pesticides, can be concentrated from very low levels in the water to toxic levels in animals through this process.

Groundwater discharge lake: Often referred to as a spring-fed lake; has large amounts of groundwater as its source, and a source outlet. Areas of high groundwater inflow may be visible as springs or sand boils. Groundwater drainage lakes often have intermediate retention times with water quality dependent on groundwater quality.

Hardness: The quantity of multivalent cations, primarily calcium (Ca^{++}) and magnesium (Mg^{++}) in the water, expressed as mg/l of $CaCO_3$. Amount of hardness relates to the presence of soluble minerals, especially limestone and dolomite, in the lake watershed.

Hypolimnion: see "Stratification"

Ion: A charged atom or group of atoms that have separated from an ion of the opposite charge. In water, some chemical molecules separate into cations (positive charge) and anions (negative charge). Thus, the number of cations equals the number of anions.

Insoluble: Incapable of dissolving in water.

Kjeldahl nitrogen: The most common analysis run to determine the amount of organic nitrogen in water. The test includes ammonium and organic nitrogen.

Limiting factor: The nutrient or condition in shortest supply relative to plant growth requirements. Plants will grow until stopped by this limitation; for example, phosphorous in summer, temperature or light in fall or winter.

Macrophytes: see "Rooted aquatic plants."

Marl: White to gray accumulation on lake bottoms caused by precipitation of calcium carbonate ($CaCO_3$) in hard water lakes. Marl may contain many snail and clamshells, which also are $CaCO_3$. While it gradually fills in lakes, marl also precipitates phosphorous, resulting in low algae populations and good water clarity. In the past, marl was recovered and used to lime agricultural fields.

Metalimnion: see "Stratification."

Nitrate: An inorganic form of nitrogen important for plant growth. Nitrogen is in this stable form when oxygen is present. Nitrate (NO_3^-) often contaminates groundwater when water originates from manure pits, fertilized fields, lawns, or septic systems. High levels of nitrate-nitrogen (over 10 mg/l) are dangerous to infants and expectant mothers. A concentration of nitrate-nitrogen (NO_3^-N) plus ammonium-nitrogen (NH_4^-N) of 0.3 mg/l in spring will support summer algae blooms if enough phosphorous is present.

Nitrite: A form of nitrogen that rapidly converts to nitrate (NO_3^-) and is usually included in the NO_3^- analysis.

Overturn: Fall cooling and spring warming of surface water increases density and gradually makes temperature and density uniform from top to bottom. This allows wind and wave action to mix the entire lake. Mixing allows bottom waters to contact the atmosphere, raising the oxygen content of the water. However, warming may occur too rapidly in the spring for mixing to be effective, especially in small sheltered kettle lakes.

Phosphorus: Key nutrient influencing plant growth in more than 80% of Wisconsin lakes. Soluble reactive phosphorus is the amount of phosphorus in solution that is available to plants. Total phosphorus includes the amount of phosphorus in solution (reactive) and in particulate form.

Photosynthesis: Process by which green plants convert carbon dioxide (CO_2) dissolved in water to sugar and oxygen using sunlight for energy. Photosynthesis is essential in producing a food base for a lake and is an important source of oxygen for many lakes.

Phyloplankton: see “Algae.”

Precipitate: A solid material that forms and settles out of water as a result of certain negative ions (anions) combining with positive ions (cations).

Retention time: The average length of time water resides in a lake, ranging from several days in small impoundments to many years in large seepage lakes. Retention time (turnover rate or flushing rate) is important in determining the impact of nutrient inputs. Long retention times result in recycling and greater nutrient retention in most lakes. Calculate retention time by dividing the volume of water passing through the lake per year by the lake volume.

Respiration: The process by which aquatic organisms convert organic material to energy. It is the reverse of photosynthesis. Respiration consumes oxygen (O_2) and releases carbon dioxide (CO_2). It also takes place as organic matter decays.

Rooted aquatic plants Refers to higher (multi-celled) plants growing in or near water. Macrophytes are beneficial to lakes because they produce oxygen and provide substrate for fish habitat and aquatic insects. Overabundance of such plants, especially problem species, is related to shallow water depth and high nutrient levels.

Secchi disc: An 8-inch diameter plate with alternating quadrants painted black and white that is used to measure water clarity (light penetration). The disc is lowered into water until it disappears from view. It is then raised until just visible. An average of the two depths, taken from the shaded side of the boat, is recorded as the Secchi disc reading. For best results, the readings should be taken on sunny, calm days.

Sedimentation: Accumulated organic and inorganic matter on the lake bottom. Sediment includes decaying algae and weeds, marl, and soil and organic matter eroded from the watershed of the lake.

Seepage lakes: Lakes without a significant inlet or outlet, fed by rainfall and groundwater. Seepage lakes lose water through evaporation and groundwater moving on a downgradient. Lakes with little groundwater inflow tend to be naturally acidic and most susceptible to the effects of acid rain. Seepage lakes often have long residence times, and lake levels fluctuate with local groundwater levels. Water quality is affected by groundwater quality and the use of land on the shoreline.

Soluble: Capable of being dissolved.

Stratification: The layering of water due to differences in density. The greatest density of water occurs at 39˚F (4˚C). As water warms during the summer, cool water remains near the bottom. Wind mixing determines the thickness of the warm surface water layer (epilimnion), which usually extends to a depth of about 20 feet. The narrow transition zone between the epilimnion and cold bottom water (hypolimnion) is called the metalimnion or thermocline.

Suspended solids: A measure of the particulate matter in a water sample expressed in milligrams per liter. When measured on inflowing streams, it can be used to estimate the sedimentation rate of lakes or impoundments.

Thermocline: see “Stratification.”

Transparency: see “Secchi disc.”

Trophic state: The degree to which a lake is enriched with nutrients, increasing the production of rooted aquatic plants and algae. The extent to which this process has occurred is reflected in a lake’s trophic classification: oligotrohic (nutrient poor), mesotrophic (moderately productive), and eutrophic (very productive and fertile).

Watershed: see “Drainage basin.”

Zooplankton: Microscopic or barely visible animals that often eat algae. These suspended plankton are an important component of the lake food chain and ecosystem. For many fish, they are the primary source of food.

9.0 REFERENCES

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APPENDIX A

WATER QUALITY SAMPLE LABORATORY REPORTS

APPENDIX B

WiLMS® MODEL RESULTS

APPENDIX C

2003 AQUATIC PLAN MACROPHYTE SURVEY DATA

BASELINE LIMNOLOGICAL STUDY

WEST ALASKA LAKE
KEWAUNEE COUNTY, WISCONSIN

WDNR LAKE PLANNING
GRANT NO. LPL-874-03

August 12, 2004