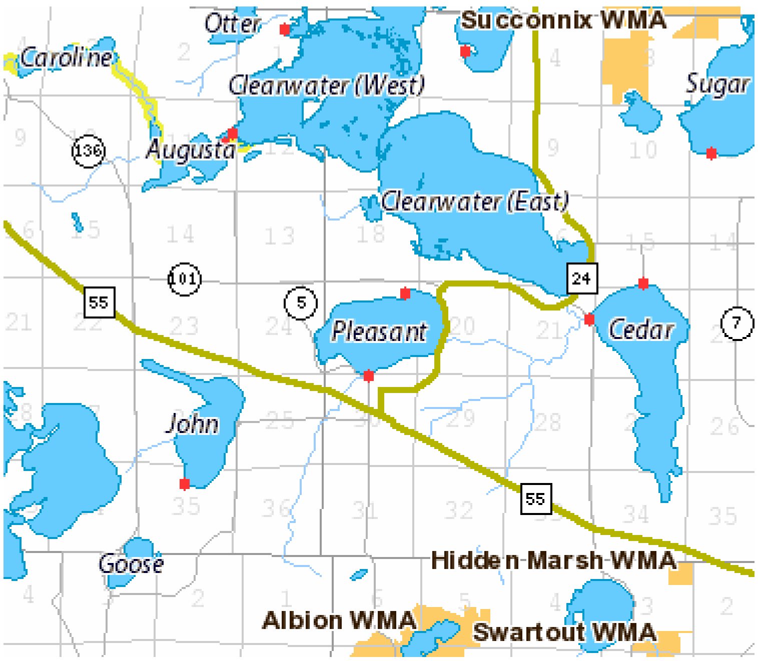
LAKE ASSESSMENT PROGRAM

Pleasant Lake: #86-0251

2005

Wright County, Minnesota



Minnesota Pollution Control Agency

Environmental Analysis and Outcomes Division

March 2006

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March 2006

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SUMMARY AND RECOMMENDATIONS

Pleasant Lake is located in Wright County, in the city of Annandale, MN. This lake has a surface area of 509 acres and a maximum depth of 74 feet. Mean depth of the lake was estimated at 18 feet. The watershed of Pleasant Lake is approximately 4 mi^2 acres (excluding the lake surface area). Land use in the watershed is characterized by open cultivated (46 percent), pasture/grassland (19 percent), forest (14 percent), and residential/urban (12 percent) and water/marsh areas (9 percent). These land use percentages are fairly typical for lake watersheds in the North Central Hardwood Forests (NCHF) ecoregion of the state.

Pleasant Lake was sampled during the summer of 2005 by Minnesota Pollution Control Agency (MPCA) staff and volunteer Tab Ashwill as part of the advanced Citizen Lake-Monitoring Program (CLMP+). Water quality data collected during the study revealed a summer-mean total phosphorus concentration of 31 µg/L, chlorophyll-*a* concentration of 12 µg/L, and a Secchi transparency of 7 feet. All three of these values are well within the typical range exhibited by reference lakes in the NCHF ecoregion. Total phosphorus, chlorophyll-*a,* and Secchi transparency all help to characterize the trophic status of a lake. For Pleasant Lake, these measures indicate *eutrophic* conditions.

Historical data is available for Pleasant Lake in STORET. Secchi transparency data was available dating back to 1971. Total phosphorus and chlorophyll-*a* data was also available, dating back to 1971 and 1981, respectively. There were large gaps in all the data sets, and many of the years had few samples per summer. As a result, trend analysis was conducted for Secchi transparency only. Although transparency varied from year to year, no long-term trend was evident based on the available data.

Two water quality models were used to estimate the water quality of Pleasant Lake based on lake morphometry and watershed characteristics. The MINLEAP water quality model and the Vighi and Chiaudani regression model both provide a means to compare measured water quality of the lake relative to predicted water quality. MINLEAP predicted summer-mean total phosphorus (TP) concentration of 28 µg/L, which is comparable to the 2005 observed summer-mean of 31 µg/L. The Vighi-Chiaudani model predicted a background concentration of 23 µg/L, which is slightly lower than the observed 2005 value. This suggests that Pleasant Lake's TP concentration is comparable to TP concentrations for a lake of this size and depth in the NCHF ecoregion; however, it is above the estimated "background" concentration.

The following recommendations are based on the 2005 Lake Assessment Program (LAP) study of Pleasant Lake:

1. Relatively minor increases in the nutrient loading rates from any watershed or in-lake sources which would increase the in-lake total phosphorus concentrations could further degrade Pleasant Lake. It is essential, therefore, that lake protection efforts be conveyed to all local government groups with land use/zoning authorities for Wright County.
2. The Pleasant Lake Association should be commended for their efforts to date, which include historical participation in the CLMP. To complement these efforts, the Association should develop a plan for protecting the water quality of the lake. This plan, referred to as a lake management plan, should incorporate a series of activities in a prioritized fashion which will aid in the long-term protection and improvement of the lake. The plan should be developed cooperatively by a committee consisting of representatives from state agencies (e.g., MDNR,

BWSR, and MPCA), local units of government, and lake association members. The reference document, Developing a Lake Management Plan, is available on the web at: http://www.shorelandmanagement.org/depth/plan.pdf. The following activities could be included in the plan:

a. The Association should continue participation in the CLMP. Data from this program provides an excellent basis for assessing long-term and year-to-year variations in algal productivity, i.e., trophic status of the lake. At a minimum, measurements should be taken weekly during the summer at site 101.

b. The continued education of homeowners around the lake, with respect to septic system, lawn maintenance, and shoreline protection may be beneficial. Staff from the MPCA and the Minnesota Department of Natural Resources (MDNR), along with the county officials, such as staff from Minnesota Extension Service, the Wright Soil and Water Conservation District and the Wright County Planning and Zoning Office could provide assistance in these areas.

c. Further development in the immediate watershed of the lake should occur in a manner that minimizes water quality impacts on the lake. Consideration to setback provisions, lot size, and septic systems will be important in providing water quality protection. Every effort should be make to ensure that proper BMP's (best management practices – land management activities used to control nonpoint source pollution) are used to minimize the amount of stormwater that enters the lake. The MDNR and county shoreland regulations will be important in these regards and should be strictly enforced. The Association, in conjunction with the City and Watershed District, should explore additional safeguards in land-use, zoning, and shoreline protection that could be included in a long-term plan to address future development activity within the immediate watershed.

d. Maintenance of shoreline vegetation (both upland and aquatic) is very important. Soil erosion from the construction of roads and homes should be minimized. The disturbance or the removal of vegetation on bluffs or slopes should be avoided. A vegetation survey mapping the location, abundance and diversity of the aquatic plants in Pleasant Lake is recommended. This will help the Association track the location and abundance of any exotic plants such as curly-leaf pondweed and also protect any sensitive native species.

e. The Association should continue to seek representation on boards or commissions that address land management activities so that their impact can be minimized. Safeguarding the shoreland ordinance from those who would choose to weaken it should be a priority for Pleasant Lake as well as other lake associations in Wright County. The pamphlet "Your Lake and You," available from the North American Lake Management Society (www.nalms.org), may be a useful educational tool in this area.

f. The Association is encouraged to be aware of the possible nutrient and sediment sources such as urban and agricultural runoff, septic systems, lawn fertilizer, and the effects of activities in the total watershed that change drainage patterns, such as wetland removal, creating new wetland discharges to the lake, or major alterations in lake use. As these activities occur within the watershed, the Association is encouraged to make sure that the water quality effects are minimized with the use of best management practices (BMPs) for water quality. Some of the county and state offices mentioned above may be of help in this regard.

3. The 2005 water quality of Pleasant Lake was good relative to other lakes in the NCHF ecoregion. It could, however, exhibit a measurable decline in transparency and increases in the amount of algae from a fairly small increase of in-lake total phosphorus. Changing land use practices, poor management of shorelands, failure to maintain (pump) septic tanks, and draining of wetlands in the watershed provide the greatest likelihood for changes in phosphorus loading. Particular attention should be paid to increased urbanization in the watershed that may allow for increased stormwater draining to the lake.

   Conversely, a reduction of the amount of nutrients that enter the lake may result in improved transparency and a reduction in algal concentrations. One means of reducing nutrient input is by implementing BMPs in the watershed. Technical assistance in BMP implementation may be available through local resource management agencies. The Association can work with the Wright SWCD to examine land use practices in the watershed and develop strategies for reducing the transport of nutrients to the lake. It may be wise to first focus efforts on the area of the watershed near the lake. There may be few opportunities (or the need) to implement BMPs on existing land use. However, opportunities may arise during road building, construction or other activities which may result in increased sediment and phosphorus loading to the lake.

   Restoring or improving wetlands in the watershed may also be beneficial for reducing the amount of nutrients or sediments which reach Pleasant Lake. The U.S. Fish and Wildlife Service may be able to provide technical and financial assistance for these activities.

   MPCA's Clean Water Partnership Program is also an option for further assessing and dealing with nonpoint sources of nutrients in the watershed. However, since there is extensive competition for CWP funding, it may be in the best interest of the Pleasant Lake Association to continue to work with the Wright SWCD, Wright County Planning and Zoning staff, and the local townships to do as much as possible to protect the condition of the lake by means of local ordinances and education of shoreland and watershed residents. If these steps prove to be inadequate or the lake condition declines (as evidenced by a significant reduction in Secchi transparency), application to CWP may then be appropriate. A CWP may not be needed at that time but a repeat of a LAP level effort may be necessary to understand and document changes in total phosphorus, chlorophyll-*a* and Secchi within the lake.

4. Should a CWP application be deemed necessary, this report serves as a foundation upon which further studies and assessments may be based. The next step would be to define water and nutrient sources to the lake in a much more detailed fashion. These detailed studies would allow the estimation of reasonably accurate total phosphorus (and ortho-phosphorus), total nitrogen (and inorganic nitrogen) and water in and out-flow summaries. This should be accomplished prior to implementation of any extensive in-lake restoration techniques.

LAKE ASSESSMENT PROGRAM: Pleasant Lake 2005

INTRODUCTION

Pleasant Lake was sampled by the Minnesota Pollution Control Agency (MPCA) during the summer of 2005 as a part of the Lake Assessment Program (LAP). This program is designed to assist lake associations or municipalities in the collection and analysis of baseline water quality data in order to assess the trophic status of their lakes. The general work plan for LAP includes Association participation in the Citizen Lake-Monitoring Program (CLMP), cooperative examination of land use and drainage patterns in the watershed of the lake, and an assessment of the data by MPCA staff.

This study was conducted at the request of the Association, whose members are interested in identifying sources of pollution to the lake, characterizing the quality of the lake, and developing a program to assist in lake management. Pleasant Lake was sampled on three occasions during the summer and fall of 2005 by MPCA staff and on six occasions by volunteer Tab Ashwill as part of the advanced Citizen Lake-Monitoring Program (CLMP+). In addition, several years of data were available for Pleasant Lake from the CLMP is incorporated into this report.

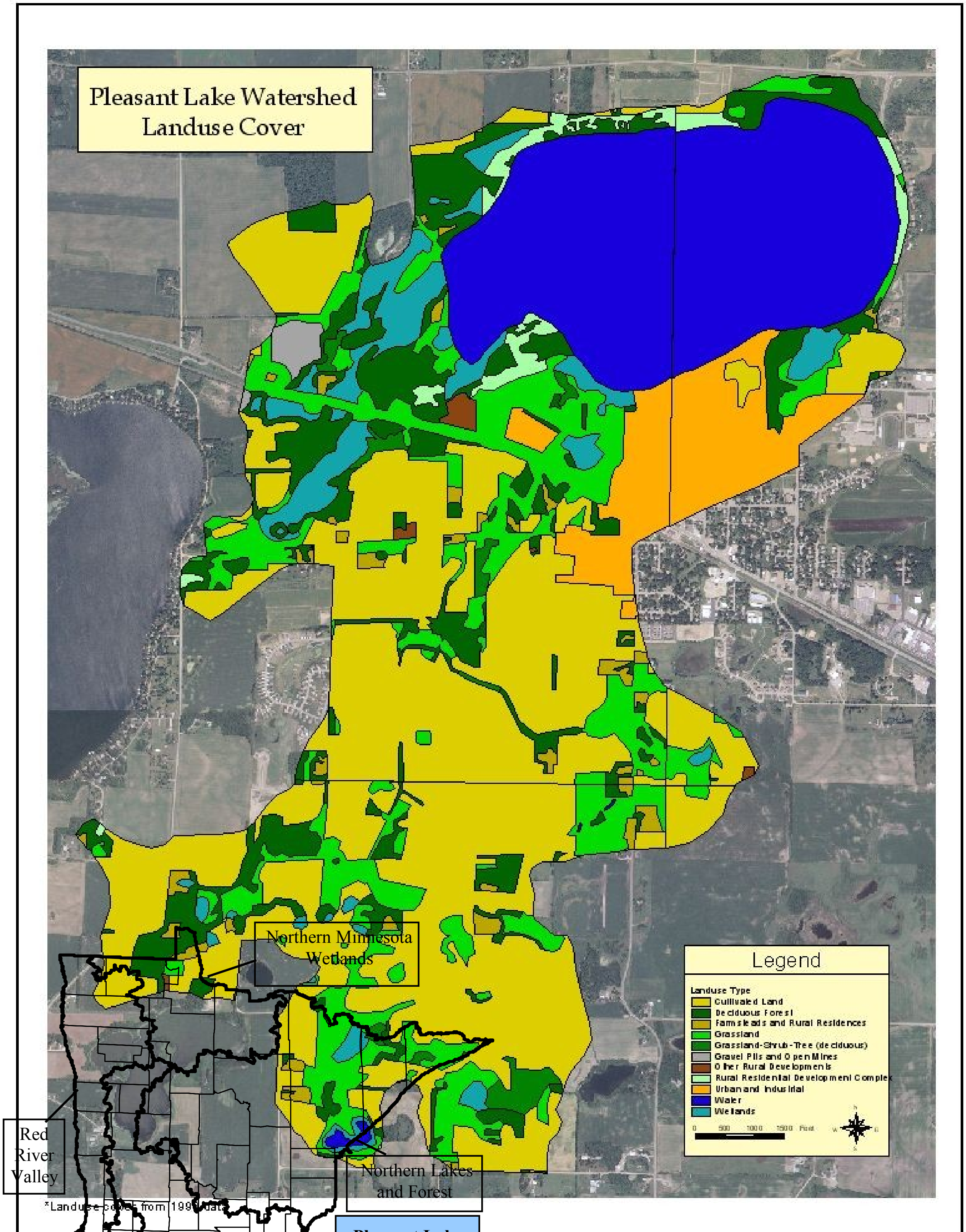
BACKGROUND

Pleasant Lake is located in the city of Annandale, Minnesota in Wright County. It has a surface area of 509 acres and a maximum depth of 74 feet. The watershed of Pleasant Lake is 2,543 acres (excludes the lake surface area) (Figure 1). The land uses observed in the watershed of Pleasant Lake are similar to the typical range for the NCHF ecoregion (Table 1). Cultivated uses represent the largest percentage present in the watershed (approximately 46 percent of the watershed); while water/marsh uses represent the smallest percentage (9 percent). These wetlands provide areas where pollutants in snowmelt and stormwater runoff can settle out and serve to slow the flow of nutrients which enter Pleasant Lake during periods of precipitation and runoff. Pasture/grassland uses account for 19 percent of the land use, followed by forested use (14 percent) and urban/residential use (12 percent) (Figure 1). Residents living within the city limits of Annandale are connected to city sewer, while the remaining lakeshore residents have individual septic treatment systems (Anderson, 2006).

Pleasant Lake was likely formed by an ice block basin in glacial outwash in the Keewatin Sheet of the lake Wisconsin Glaciation (Zumberge, 1952). Soils near the lake consist of the Estherville-Wadena-Hubbard series. This area is generally level with scattered rolling to hilly area with well to excessively drained soils. The Estherville-Wadena-Hubbard soils are dark in color and developed from calcareous gravel outwash (Arneman 1963).

Since land use affects water quality, it has proven helpful to divide the state into regions where land use and water resources are similar. Minnesota is divided into seven regions, referred to as ecoregions, as defined by soils, land surface form, natural vegetation and current land use. Data gathered from representative, minimally-impacted (reference) lakes within each ecoregion serve as a basis for comparing the water quality and characteristics of other lakes. Pleasant Lake is located in the North Central Hardwood Forests (NCHF) ecoregion (Figure 2).

Figure 1. Pleasant Lake Watershed & Land Use



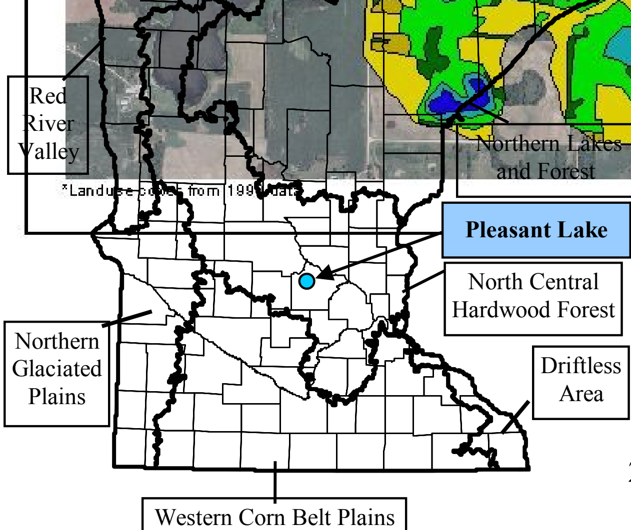


Figure 2. Pleasant Lake Location & Ecoregion Map

Septic System Survey - Minnesota Extension Service recommends pumping every one to three years for a 1,000 gallon tank serving a three-bedroom house and four occupants (assumes year-round use). The importance of septic system maintenance to Pleasant Lake should be emphasized to all lake residents that are not connected to the City of Annandale sewer system. The Association is encouraged to look into developing a program which encourages or arranges for the periodic pumping of septic tanks. The Association should inform its membership that poor septic system maintenance can lead to the contamination of shallow wells. Drain fields typically have a design lifetime of 20 to 30 years. Keep in mind that proper maintenance of the septic tank (regular pumping), protecting the drain field from compaction (keep vehicles and other heavy objects off), and water conservation in the home will all help to extend the useful lifetime of the drain field.

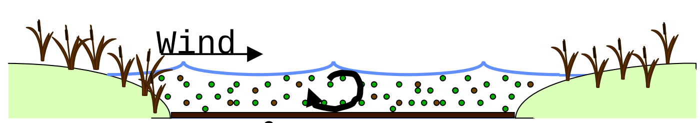
Fisheries - DNR fisheries managers utilize netting survey information to assess the well-being of fish communities and measure the efficacy of management programs. Presence, absence, abundance, physical condition of captured fishes, and community relationships among fish species within survey catch information also provide good indicators of current habitat conditions and trophic state of a lake (Schupp and Wilson, 1993). This long term fisheries survey database has also proven valuable in qualifying and quantifying changes in environmental and fisheries characteristics over time. This fishery of Pleasant Lake is managed by the Minnesota Department of Natural Resources Fisheries Office located in Montrose, Minnesota. A summary of Pleasant Lake's fishery as surveyed by the MDNR on June 30, 1997 is available in the appendix of this report or a current report can be found at:
www.dnr.state.mn.us/lakefind/showreport.html?downum=86025100

Lake Level - A summary of lake level information was drawn from the MDNR website: Pleasant Lake lake level period of record runs from January 1949 to April 1999, with a total of 118 readings. The highest recorded level was 1,042.1 feet on June 27, 1983; the lowest recorded level was 1,035 feet on January 1, 1949; and the average lake level for the period of record is 1,038.28 feet. Pleasant Lake's Ordinary High Water (OHW) elevation is established at 1,041 feet. A tabular summary of records for the most recent ten years can be found in Appendix IV.

Lake Depth - Lake depth can have a significant influence on lake processes and water quality. One such process is *thermal stratification* (formation of distinct temperature layers), in which deep lakes (maximum depths of 30 - 40 feet or more) often stratify (form layers) during the summer months and are referred to as *dimictic*. These lakes full-mix or turn-over twice per year; typically in spring and fall. Shallow lakes (maximum depths of 20 feet or less) in contrast, typically do not stratify and are often referred to as *polymictic*. Some lakes, intermediate between these two, may stratify intermittently during calm periods. Measurement of temperature throughout the water column (surface to bottom) at selected intervals (e.g. every meter) can be used to determine whether the lake is well-mixed or stratified. It can also identify the depth of the thermocline (zone of maximum change in temperature over the depth interval). In general, the upper, well-mixed layer (epilimnion) is warm and has high oxygen concentrations. In contrast, the lower layer (hypolimnion) is much cooler and often has little or no oxygen. Most of the fish in the lake will be found in the epilimnion or near the thermocline. The combined effect of depth and stratification can influence overall water quality.

Diagram of Lake Layers for Deep and Shallow Lakes

Polymictic Lake
Shallow, No Layers,
Mixes Continuously
Spring, Summer &



Precipitation - Based on State Climatology records, precipitation averages 26 inches (0.66 meters) annually in this part of the state. Water-year precipitation near Pleasant Lake was above normal in 2005, with approximately 32 inches of precipitation recorded (Appendix II). Evaporation typically exceeds precipitation in this region of the state and averages about 36 inches (0.91 m) per year. Runoff averages for this area are about 5 inches with 1 in 10 year low and high values (low and high runoff values which might occur once in ten years) of 1.2 inches and 7.9 inches, respectively, for this area (Gunard, 1985).

Lake History – A brief history of events for Pleasant Lake was taken from MPCA lake files and historic records from the MPCA library.

- **1922** – City of Annandale constructs as wastewater treatment facility (WWTF); although the final disposal site at this time is unknown (MPCA, 1953 – 1987).
- **October 1952** – A severe blue-green algae bloom was reported on the lake.
- **1953** – According to MPCA records (MPCA, 1952 – 1987), City of Annandale WWTF final disposal site is Pleasant Lake until 1962.
- **Fall 1978** – Records from the Association indicate 61 members & 117 properties.
- **June 1979** – A meeting was held with MPCA and the Association. The primary concern at this meeting was high water levels and a lack of control outlet.
- **August 1990** – Pleasant Lake applies for CWP Phase-1 Diagnostic/Feasibility Study. The lake was not selected to participate.
- **Spring 2005** – Pleasant Lake participated in the LAP & CLMP+ programs with MPCA.

RESULTS AND DISCUSSION

Water quality data was collected on May 26, June 12, June 29, July 10, July 27, August 14, August 28, September 11, and September 29, 2005. One site was used: Site 101 (Figure 3). Lake surface samples were collected with an integrated sampler, which is a PVC tube 6.6 feet (2 meters) in length with an inside diameter of 1.24 inches (3.2 centimeters).

Sampling procedures were employed as described in the MPCA Quality Control Manual. Laboratory analyses were performed by the laboratory of the Minnesota Department of Health using

U.S. Environmental Protection Agency (EPA) approved methods. MPCA samples were analyzed for nutrients, color, solids, alkalinity, chloride and chlorophyll-*a* (Table 2). Temperature and dissolved oxygen profiles and Secchi transparency measurements were also taken. CLMP measurements from previous years were available for comparison. All MPCA data is stored in STORET, the EPA's national water quality data bank. The following discussion assumes that the reader is familiar with basic water quality terminology as used in the Guide to Lake Protection and Management (available at: http://www.pca.state.mn.us/water/lakeprotection.html).

Figure 3. Pleasant Lake Bathymetric Map and Monitoring Locations

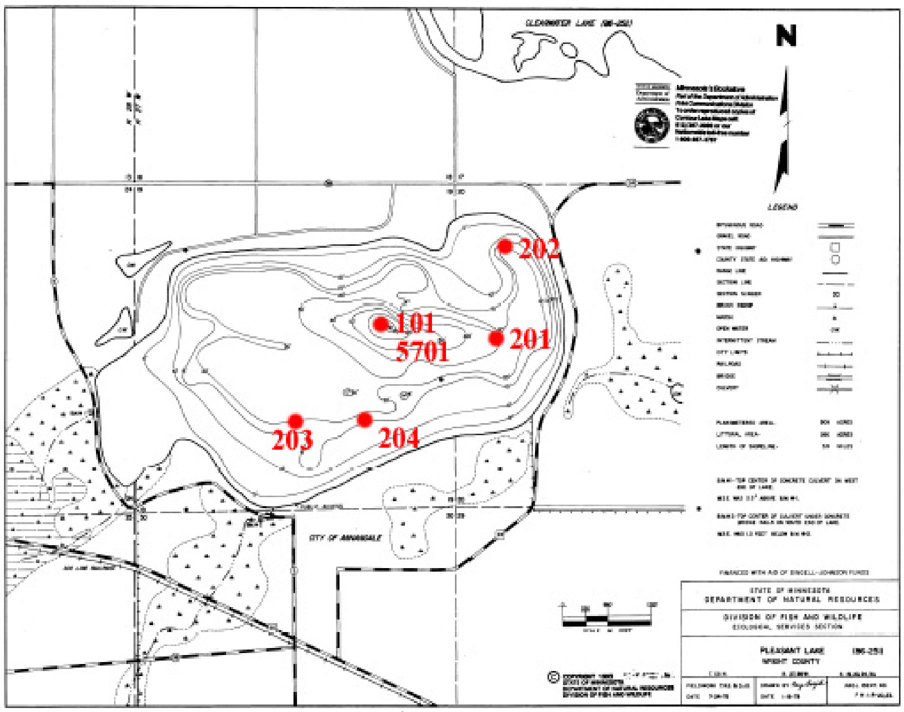


Table 1. Pleasant Lake (86-0251): Morphometric, Watershed, and Fishery Characteristics

Morphometry	Pleasant Lake
Area[1]	**509 acres (206 ha) (0.8 mi^2)**
Mean Depth[2]	**18 feet (5.5 meters)**
Maximum Depth[1]	**74 feet (22.6 meters)**
Volume[2]	**9,162 acre-feet (11.3 hm^3)**
Littoral Area[2]	**260 acres (51 %)**
Watershed area[3] *(excludes the lake)*	**2,543 acres (1,030 ha) (4.0 mi^2)**
Watershed:Lake[1]	**~ 5:1**
Estimated Water Residence Time	**~ 8 Years**
Fisheries[1] – Schupp's Lake class 1° Management Species 2° Management Species	**24** **Walleye-Northern pike** **Largemouth bass**
Public Access[1]	**2**
Inlets[4]: **Outlets[4]:**	**2** **1**

[1] MN Dept of Natural Resources [2] MN Pollution Control Agency [3] Wright County [4] Pleasant Lake Assoc.

Table 2: Pleasant Lake (86-0251) 2005 Summer-Average Water Quality

Parameter	Pleasant Lake 2005 Mean[1]	Typical Range for NCHF Ecoregion[1]
Total Phosphorus µg/L	**31**	**23 – 50**
Chlorophyll-*a* (µg/L) Mean **Chlorophyll-*a* (µg/L) Maximum**	**12** **33**	**5 – 22** **7 – 37**
Secchi disk (feet) **Secchi disk (meters)**	**7** **2.1**	**4.9 – 10.5** **1.5 – 3.2**
Total Kjeldahl Nitrogen (mg/L)	**0.7**	**< 0.60 – 1.2**
Alkalinity (mg/ l)	**160**	**75 – 150**
Color (Pt-Co Units)	**8**	**10 – 20**
Chloride (mg/L)	**32**	**4 – 10**
Total Suspended Solids (mg/L)	**3.5**	**2 – 6**
Total Suspended Inorganic Solids	**2.7**	**1 – 2**
Conductivity (µmhos/cm)	**382**	**300 – 400**
TN:TP Ratio	**23:1**	**25:0 – 33 :1**

Land Use	Forest	Wetlands or water	Pasture or grassland	Cultivated	Urban
Pleasant Lake (acres)	362	236	473	1,183	297
Pleasant Lake (%)	14	9	19	46	12
NCHF Ecoregion (%)	6 – 25	14 – 30	11 – 25	22 – 50	2 – 9

[1] Based on 2005 summer-mean eplilimnetic data for Pleasant Lake (86-0251).
[2] North Central Hardwood Forests as derived from Heiskary and Wilson (1990).

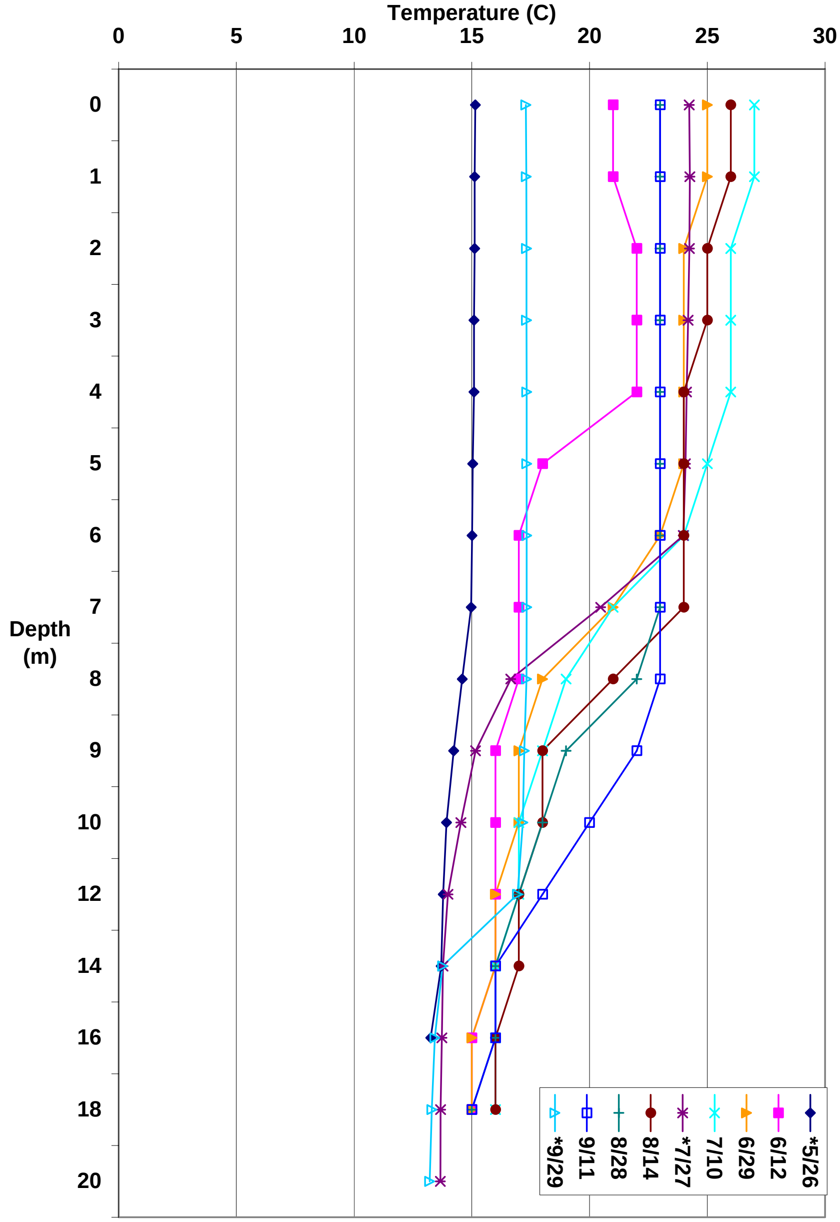
Table 3. Carlson's Trophic Status Indicators for Pleasant Lake 2005

Parameter	*TSI Value*
Total Phosphorus (TSIP)	54
Chlorophyll-*a* (TSIC)	55
Secchi (TSIS)	49
MEAN (TSI)	***53***

In-lake Conditions: 2005

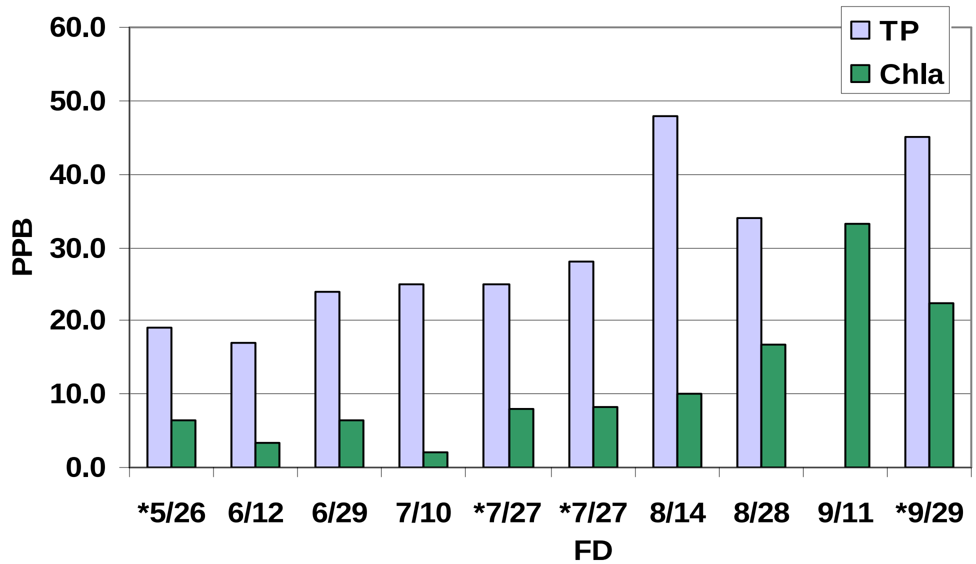
Dissolved oxygen and temperature profiles were taken at a point near maximum depth at site 101 from May through September. Pleasant Lake appeared to be well mixed on the first (May 26) sample date. The lake was well mixed on all of the remaining dates down to about 7 meters; with the exception of June 12, where the thermocline was noted at 4 – 5 meters and September 29 at 12 – 14 meters. Dissolved oxygen (DO) concentrations declined slightly with depth, but remained above 5 mg/L throughout the lake in May and down to 7 and 14 meters, respectively for July 27 and September 29 (Appendix I). DO levels of 5 mg/L or greater are preferred for game fish.

Figure 4. Pleasant Lake Temperature Profiles



Total phosphorus (TP) concentrations (an important nutrient for plant growth) ranged from 17 – 48 µg/L and averaged 31 µg/L (micrograms per liter or parts per billion) in the epilimnion during the summer of 2005. This average value is well within than the range of concentrations typically found in reference lakes in the North Central Hardwood Forests ecoregion (Figure 5 and Table 2). TP concentrations generally increased over the summer, with marked increases noted on June 29 and August 14. The June 29 increase is likely in response to runoff from a significant rain event of 2.5 inches, which occurred on the previous day (Appendix). In contrast, the August 14 increase was not in response to any recent rain events (Appendix); but rather, it was likely due to a release of nutrients from the die-back of curly-leaf pondweed in the lake. Curly-leaf pondweed (*Potamogeton crispus*) is a non-native aquatic plant that grows from the shore to depths of up to 15 feet. It starts growing before native species, giving it an edge on the growing season and in some cases, may actually crowds out native species. Its flowering stalks stick up above the surface in June; which can interfere with water recreation. Shortly after mid-summer, these plants die back, and as they decompose, they release nutrients into the water column. Dead plants will often form huge surface mats that often accumulate on downwind shorelands.

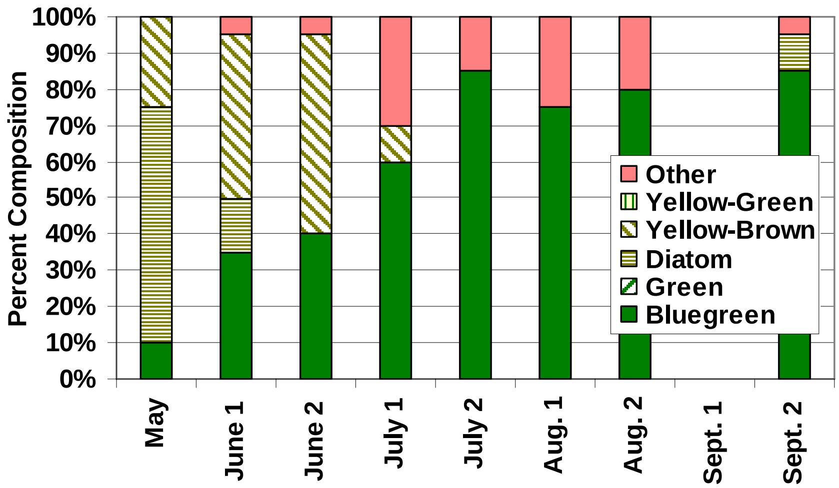
Figure 5. Pleasant Lake 2005 Total Phosphorus & Chlorophyll-*a* Concentrations



Chlorophyll-*a* concentrations provide an estimate of the amount of algal production in a lake. During the summer of 2005, chlorophyll-*a* concentrations ranged from 2 – 33 µg/L with an average of 12 µg/L (Figure 5 and Table 2). Concentrations from 10 - 20 µg/L are frequently perceived as a mild algal bloom, while concentrations greater than 30 µg/L may be perceived as a severe nuisance (Heiskary and Walker, 1988). Both the average and maximum chlorophyll-*a* concentrations for Pleasant Lake are well within the range of values for reference lakes from this ecoregion. Mild nuisance blooms were likely apparent in August, and would have reached severe nuisance levels by mid-September (Figure 5).

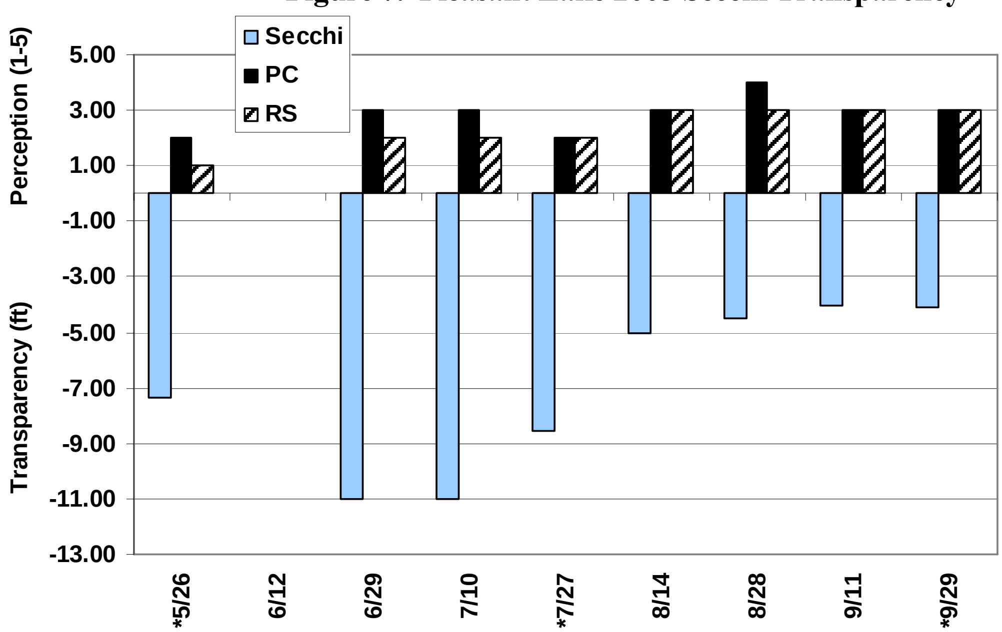
The composition of the phytoplankton (algae) population of Pleasant Lake is presented in Figure 6. Data are presented in terms of algal type. Samples were collected at Site 101. The yellow-browns and blue-greens were well represented throughout the summer, with blue-green algae dominating the algae population from early-July through September. The forms: *Dinobryon* (yellow-brown), and *Anabaena, Anacystis,* and *Aphanizomenon* (blue-greens) were the most common algae types found in 2005. The late-summer blooms were dominated by these blue-green forms that tend to float near the surface. A seasonal transition in algal types from diatoms to greens to blue-green is more typical for mesotrophic and eutrophic lakes in Minnesota.

Figure 6. Pleasant Lake 2005 Algal Composition



Secchi disk transparency is generally a function of the amount of algae in the water. Suspended sediments or color due to dissolved organics may also reduce water transparency. Color averaged 8 Pt-Co Units; while total suspended solids averaged 3.5 mg/L over the summer (Table 2). The color and total suspended solids values are comparable to reference lakes in this ecoregion and as such, should not appreciably limit water transparency in Pleasant Lake. Secchi transparency ranged from 4 – 11 feet and averaged 7 feet during the summer of 2005 (Figure 7). There were marked declines in transparency from early to late July as well as late July to August and September. The decline in July transparency is likely in response to increases in chlorophyll-*a* concentrations, where values were four times greater, increasing from 2 to 8 µg/L during the same time period (Figure 5). Likewise, chlorophyll-*a* concentrations more than doubled again in August, increasing from 8 to 17 µg/L, and then again in September, increasing from 17 to 33 µg/L; thus accounting for the marked declines in August and September transparency readings. Even with these declines over the summer, the average transparency is still within the typical range of values for reference lakes in this ecoregion (Table 2).

Figure 7. Pleasant Lake 2005 Secchi Transparency



The change in the transparency of Pleasant Lake over the course of the summer is fairly typical for mesotrophic-eutrophic lakes in Minnesota. Transparency is often highest in the spring when the water is cool and algae populations are low. As the summer progresses, the waters warm and algae make use of available nutrients. As algae become more abundant, the transparency declines. Later in the summer, surface blooms of algae may also appear. Long term monitoring of Secchi transparency at a consistent site in Pleasant Lake will yield the best data for performing water quality trend analysis.

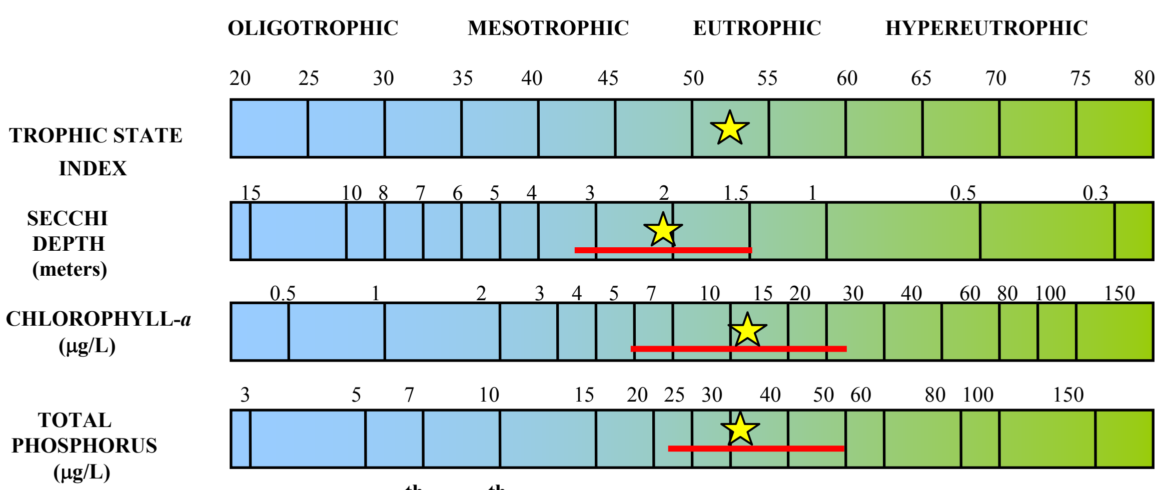
One means to evaluate the **trophic status** of a lake and to interpret the relationship between total phosphorus, chlorophyll-*a* and Secchi transparency is Carlson's Trophic State Index (TSI, Carlson 1977). This index was developed from the interrelationships of summer Secchi transparency and the concentrations of surface water chlorophyll-*a* and total phosphorus. TSI values are calculated as follows:

Total phosphorus TSI (TSIP) = (14.42 * [ln(TP)]) + 4.15
Chlorophyll-*a* TSI (TSIC) = (9.91 * [1n (Chl-*a*)]) + 30.6
Secchi disk TSI (TSIS) = 60 – (14.41 * [1n (SD)])

TP and chlorophyll-*a* values are in µg/L and Secchi transparency is in meters. TSI values range from 0 (ultra-oligotrophic) to 100 (hypereutrophic). In this index, each increase of 10 units represents a doubling of algal biomass. Average values for the trophic variables in Pleasant Lake and respective TSI's are presented in Table 3. Based on these values, Pleasant Lake is considered *eutrophic* in condition (Figure 8). The individual TSI values agree fairly well and therefore Secchi transparency should be a good predictor for overall water quality for Pleasant Lake.

Figure 8. Carlson's Trophic State Index. (Carlson 1977)

TSI < 30	Clear water, oxygen throughout the year in the hypolimnion, salmonid fisheries in deep lakes.
TSI 30 - 40	Deeper lakes, but some shallower lakes will become anoxic in the hypolimnion during the summer.
TSI 40 - 50	Water moderately clear, but increasing probability of anoxia in hypolimnion during summer.
TSI 50 - 60	Lower boundary of classical eutrophy: Decreased transparency, anoxic hypolimnia during the summer, macrophyte problems evident, warm-water fisheries only.
TSI 60 - 70	Dominance of blue-green algae, algal scums probable, extensive macrophyte problems.
TSI 70 - 80	Heavy algal blooms possible throughout the summer, dense macrophyte beds, but extent limited by light penetration. Often would be classified as hypereutrophic.
TSI > 80	Algal scums, summer fish kills, few macrophytes, dominance of rough fish.



NCHF Ecoregion Range, 25th – 75th percentile: ______ Pleasant Lake 2005: ☆

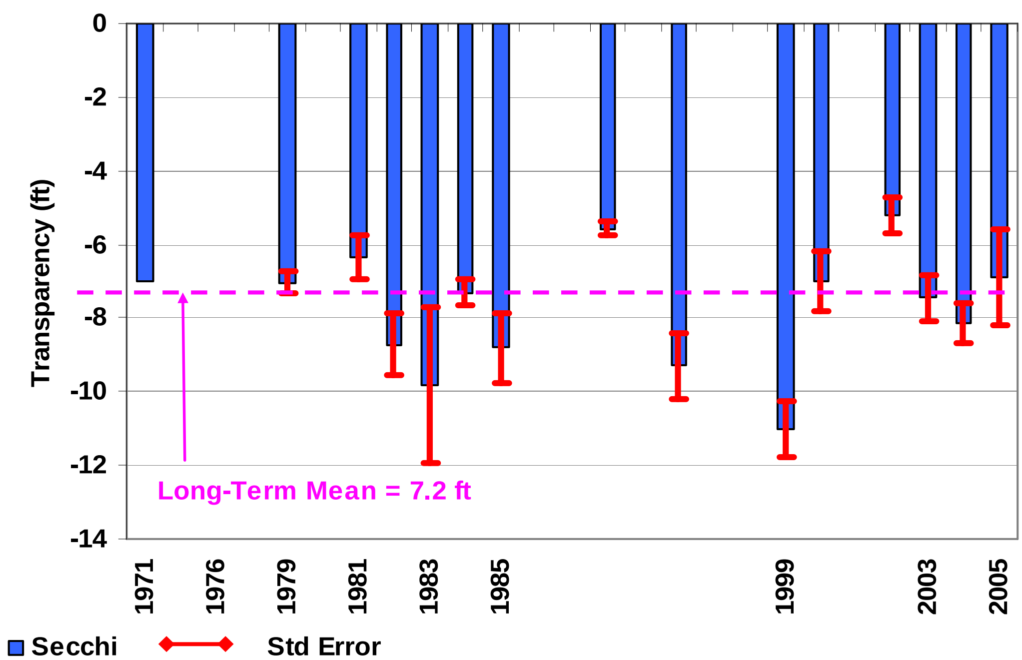
After Moore, L. and K. Thornton, [Ed.]1988. Lake and Reservoir Restoration Guidance Manual. USEPA>EPA 440/5-88-002.

The other water quality parameters measured, such as alkalinity, color and TSS are fairly typical as compared to reference lakes in the NCHF ecoregion (Table 2). Conversely, chloride is quite high compared to reference lakes in this ecoregion. This concentration is comparable to concentrations found in lakes in the Twin Cities Metro Area and is most likely a reflection of heavy road salt use and increased impervious surfaces (e.g. roads, rooftops, parking lots) within the watershed.

Water Quality Trends

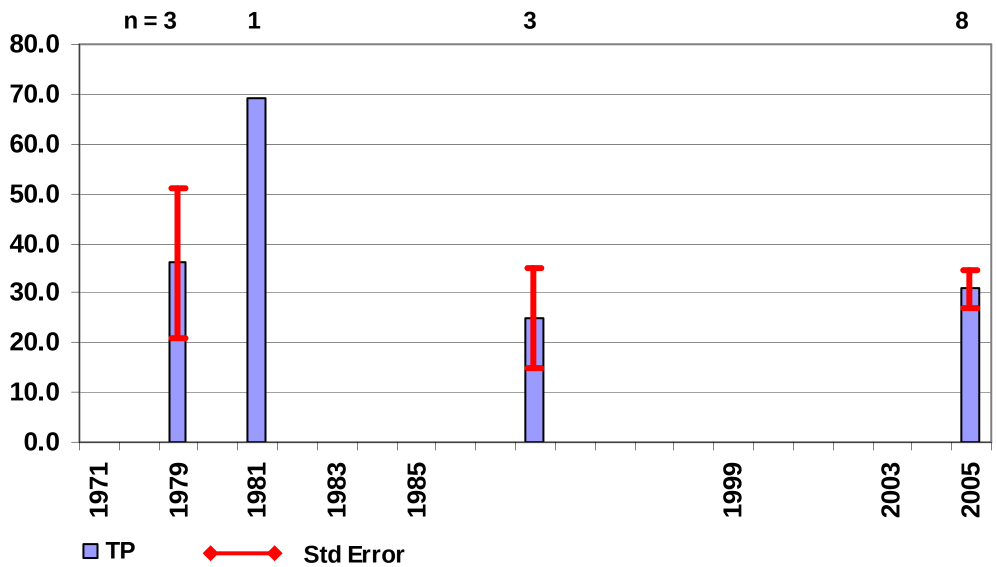
Fifteen years of Secchi data are available for Pleasant Lake; however, only 10 of those 15 years meet the criteria (four or more readings per year) to be available for determining trends in the transparency of Pleasant Lake. These data do not reveal a significant trend but do indicate that summer-mean transparency has varied between 5.3 and 11.2 feet (Figure 9). The long-term mean transparency is 7.2 feet. A slight decline in transparency in more recent years is noted as compared to data from the late 1990s; however, with such large gaps in the data, it is difficult to determine whether this constitutes a trend in transparency or is simply a reflection of year-to-year variability. Variability within the year, as noted by standard error, seems to be fairly large, particularly in 1983 and 2005. Continued and consistent monitoring will be essential for determining any future water clarity trends in Pleasant Lake.

Figure 9. Pleasant Lake Long-Term Secchi Transparency



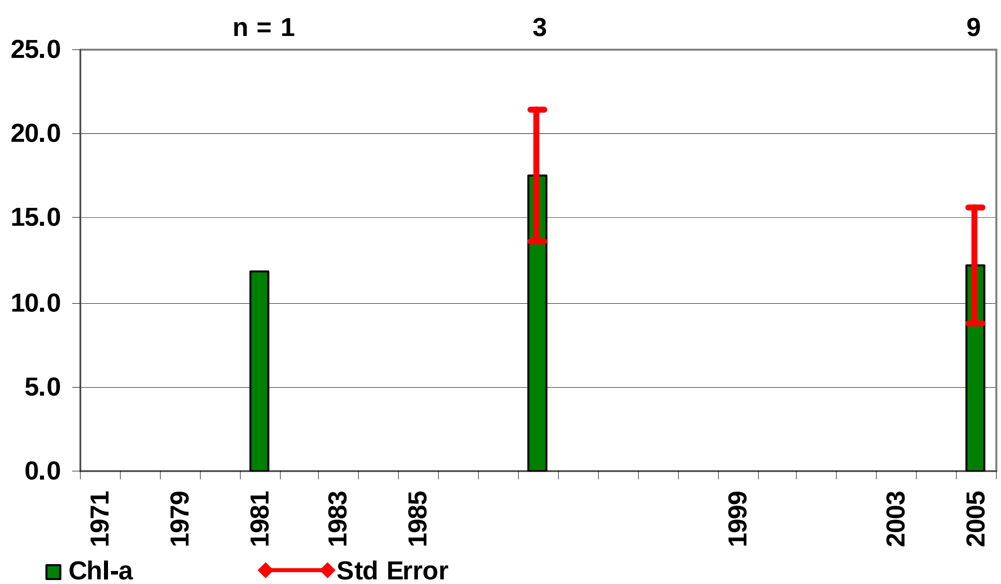
Phosphorus data has been collected during six summers in Pleasant Lake. Based on data from 1979 – 2005, the long-term average phosphorus for Pleasant Lake is 40 µg/L and readings ranged from a low of 25 µg/L in 1991 to a high of 69 µg/L in 1981 (Figure 10). Two single measurements in 1971 and 1976 were not included as they appear to be outlier values, relative to the other years, and we were unable to find further documentation for those sampling dates. Though there is insufficient data for a trend analysis, it appears TP has been relatively stable since 1979. Continued and consistent monitoring of phosphorus for this lake will be essential for augmenting the limited data for future trend assessments and determining compliance with lake eutrophication standards.

Figure 10. Pleasant Lake Long-Term Total Phosphorus



Chlorophyll-*a* was sampled on two occasions prior to the 2005 study. There was not enough data to perform a trend analysis for this parameter and there was limited data per summer. No distinct pattern is noted as concentrations ranged from a low of 12 µg/L in 1981 to a high of 18 µg/L in 1991. The long-term average concentration was 14 µg/L (Figure 11). As with phosphorus, continued and consistent monitoring will be essential for augmenting the limited data for future trend assessments.

Figure 11. Pleasant Lake Long-Term Chlorophyll-*a*



Modeling Summary

Numerous complex mathematical models are available for estimating nutrient and water budgets for lakes. These models can be used to relate the flow of water and nutrients from a lake's watershed to observed conditions in the lake. To analyze the 2005 quality of Pleasant Lake, the model MINLEAP (Wilson, 1988) was used. MINLEAP was developed by MPCA staff based on an analysis of data collected from the ecoregion reference lakes. The model is described in greater detail in Wilson and Walker (1988). MINLEAP is intended to be used as a screening tool for estimating lake conditions with minimal input data including: lake area, mean depth, watershed area, and ecoregion in which the lake is located. However, for our modeling purposes on Pleasant Lake, no actual measure of water flow into or out of the lake was made. Rather, ecoregion-specific runoff coefficients, precipitation and evaporation data, and nutrient export coefficients were used in this modeling and mean depth was estimated by MPCA staff.

Known information such as lake and watershed areas, and mean depth are inputs to the model; which in turn, computes a "predicted" TP value. The predicted TP value is used to predict a chlorophyll value, which in turn, is used to predict a Secchi value. The predicted values can then compared to the observed values (summer means) for each lake to determine if the lake's condition is what would be expected – based on its size, depth and watershed area. The model has some limitations in that it cannot take into account groundwater influence and cannot account for TP-trapping or settling in large lakes that may be upstream of the lake being modeled.

A subroutine in the MINLEAP model provides an estimate of background TP concentration for each lake based on its mean depth and alkalinity. This estimate was derived from an equation developed by Vighi and Chiaudani (1985) and is based on the morphoedaphic index commonly used in fisheries science. This equation assumes that most of the phosphorus entering the lake arises from soil erosion in the watershed, and that phosphorus and other minerals, which contribute to alkalinity, are delivered in relatively constant proportions. In turn, the mean depth of the lake will moderate the in-lake phosphorus concentration (e.g. deep lakes settle material readily, which contributes to low phosphorus concentrations). This estimated "background" concentration helps place modern-day results and goal setting in perspective.

The **MINLEAP model** predicted a summer-mean total phosphorus (TP) concentration of 28 µg/L for Pleasant Lake (Table 4). This value is slightly lower than the observed summer-mean TP concentration (31 µg/L) for 2005. The model also predicted a lower chlorophyll-*a* value at 9 µg/L as compared to the 2005 observed value of 12 µg/L and subsequently predicted a higher Secchi at 2.2 meters as compared to the 2005 observed value of 2.1 meters. The Vighi-Chiaudani model predicted slightly lower TP concentration (23 µg/L) for the lake as compared to the 2005 observed value (Table 4). TP-loading for Pleasant Lake is estimated to be on the order of 260 kg P/yr. *(Note: there are 2.2 pounds of phosphorus per kilogram.)* The TP-retention coefficient was estimated to be 0.84. This means that roughly 84 percent of the TP that enters Pleasant Lake stays in the lake. Overall, model predictions compare favorably with observed results. It also suggests that Pleasant Lake is more nutrient rich than "background" conditions and an overall reduction in P-loading would be needed to achieve "background" conditions.

Table 4. MINLEAP Model Results

Parameter	Observed 2005	Predicted MINLEAP
TP (µg/L)	31 ± 4	28 ± 11
chl-*a* (µg/L)	12 ± 3	9 ± 6
Secchi (meters)	2.1 ± 0.4	2.2 ± 1.0
P-loading rate (kg/yr)	--	260
% P retention	--	84
P inflow conc. (µg/L)	--	183
water load (m/yr)	--	0.69
outflow volume (hm^3/yr)	--	1.42
Vighi-Chiaudani P (ie: background P)	--	23
residence time (years)	--	8

Goal Setting

For Pleasant Lake, it would be desirable to maintain or reduce the in-lake TP concentrations. The summer-mean P-concentration for Pleasant Lake was slightly higher than the MINLEAP-predicted P and Vighi and Chiaudani "background" estimate. Based on Tables 5 and 6, the lake should be fully supporting for designated uses as it is below the TP and chlorophyll-*a* criteria (threshold) values.

Continued efforts to protect this water body from any degradation are strongly recommended. Some important considerations for improving and protecting the water quality of the lake include implementation of BMP's in the shoreland area and ultimately through the watershed with a particular emphasis on the direct drainage area. A more comprehensive review of land use practices in the watershed may reveal opportunities for implementing BMPs in the watershed and reducing P-loading to the lake. Proper maintenance of buffers areas between lawns and the lakeshore, minimizing use of fertilizers, and minimizing the introduction of new significant sources of P-loading (e.g., stormwater from near-shore development in the watershed), will serve to minimize loading to the lake. Protection of the native aquatic plant community in this lake is important for fish and wildlife habitat as well as the overall ecology of the lake. It may also be desirable to try to reduce the extent of curly-leaf as it appears to be having a negative impact on water quality. These and other considerations will be important if the water quality of this Wright County lake is to be maintained over the long term.

Table 5. Nutrient & Trophic Status Thresholds for Determination of Use Support for Lakes.

Ecoregion	TP	Chl	Secchi	TP Range	TP	Chl	Secchi

(TSI)	(ppb)	(ppb)	(m)	(ppb)	(ppb)	(ppb)	(m)
305(b):	**Full Support**			**Partial Support**	**Non-Support**		
303(d):	**Not Listed**			**Review**	**Listed**		
NCHF	**< 40**	**< 15**	**≥ 1.2**	**40 - 45**	**> 45**	**> 18**	**< 1.1**
(TSI)	(< 57)	(< 57)	(< 57)	57 - 59	(> 59)	(> 59)	(> 59)

Derived from MPCA Guidance Manual for Assessing Minnesota Surface Waters for Determination of Impairment (MPCA 2003). *TSI* = Carlson's Trophic State Index; *Chl-a* = Chlorophyll-*a*, includes both pheophytin-corrected and non-pheophytin-corrected values; *ppb* = parts per billion or µg/L; *m* = meters

Table 6. Draft Eutrophication Criteria by Ecoregion & Lake Type with 2005 Observed (Heiskary and Wilson, 2005)

Ecoregion	**TP (ppb)**	**Chl-*a* (ppb)**	**Secchi (meters)**
NCHF – Stream trout (Class 2a)	< 20	< 6	> 2.5
NCHF – Aquatic Rec. Use (Class 2b)	< 40	< 14	> 1.4
NCHF – Aquatic Rec. Use (Class 2b) Shallow lakes	< 60	< 20	> 1.0
Lake: 2005 Observed (Ecoregion)	**TP (ppb)**	**Chl-a (ppb)**	**Secchi (meters)**
Pleasant Lake (NCHF)	31	12	2.1

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Appendix

Appendix I. Water Quality Data

2005 Water Quality Data for Pleasant Lake (86-0251) @ Site 101

Date	Depth (m)	TP (µg/L)	Chla (µg/L)	Pheo (µg/L)	Secchi (ft)	Secchi (m)	PC	RS	TSS (mg/L)	TSV (mg/L)	COL (cu)	Alk (mg/L)	CL (mg/L)	TKN (mg/L)	pH	Cond
*5/26	0	19.0	6.50	0.32 K	7.38	2.25	2	1	2.8	1.2	10.0	160.0	32.0	0.60	8.66	468
*5/26	19	18.0														
6/12	0	17.0 Q	3.23	0.50												
6/29	0	24.0	6.42	1.26	11.00	3.35	3	2								
7/10	0	25.0	1.99	0.35	11.00	3.35	3	2								
*7/27	0	25.0	7.89	0.81	8.53	2.60	2	2	2.8	2.8	5.0	160.0	33.0	0.77	8.53	309
*7/27 FD	0	28.0	8.25	0.96												
*7/27	19	123.0														
8/14	0	48.0	9.94	0.66	5.00	1.52	3	3								
8/28	0	34.0	16.80	1.44	4.50	1.37	4	3								
9/11	0		33.10	1.27	4.00	1.22	3	3								
*9/29	0	45	22.50	3.47	4.10	1.25	3	3	5.0	4.0	10.0	160.0	32.0	0.80	8.17	368
*9/29	21	243														

*Indicates MPCA staff monitoring

D = Depth of Sample
TP = Total Phosphorus in parts per billion
Chl*a* = Chlorophyll-*a* in parts per billion
Pheo = Pheophytin in parts per billion
Secchi = Secchi Transparency in feet or meters

PC = Physical condition
RS = Recreational Suitability
TSS = Total Suspended Solids in mg/L
TSV = Total Suspended Volatile Solids in mg/L
COL = Color in Pt-Co units

Alk = Alkalinity in mg/L
CL = Chloride in mg/L
TKN = Total Kjeldahl Nitrogen in mg/L
pH = pH of sample in SU
Cond = Conductivity in umhos/cm

Note: 1 ppb = 1 µg/L or microgram per Liter; ***Remark Codes for parameters (Q = sample held past holding time, K=less than the detection limit)***

2005 Temperature & Dissolved Oxygen Data for Pleasant Lake (86-0251) @ Site 101

Temperature (°C)

Depth (m)	*5/26	6/12	6/29	7/10	*7/27	8/14	8/28	9/11	*9/29
0	15.15	21	25	27	24.23	26	23	23	17.29
1	15.12	21	25	27	24.26	26	23	23	17.31
2	15.12	22	24	26	24.24	25	23	23	17.32
3	15.09	22	24	26	24.19	25	23	23	17.32
4	15.09	22	24	26	24.12	24	23	23	17.33
5	15.04	18	24	25	24.07	24	23	23	17.33
6	15.01	17	23	24	23.98	24	23	23	17.33
7	14.97	17	21	21	20.47	24	23	23	17.33
8	14.59	17	18	19	16.65	21	22	23	17.32
9	14.23	16	17	18	15.16	18	19	22	17.23
10	13.92	16	17	17	14.54	18	18	20	17.16
12	13.78	16	16	17	13.99	17	17	18	16.94
14	13.7	16	16	16	13.77	17	16	16	13.76
16	13.25	15	15	16	13.73	16	16	16	13.43
18		15	15	16	13.67	16	15	15	13.3
20					13.66				13.21

Dissolved Oxygen (mg/L)

Depth (m)	*5/26	*7/27	*9/29
0	16.35	7.35	9.19
1	13.86	7	8.68
2	12.76	6.84	8.71
3	12.27	6.68	8.41
4	11.76	6.61	8.33
5	11.41	6.66	8.21
6	11.15	6.3	8.26
7	10.86	0.41	8.1
8	10.69	0.29	8.1
9	10.45	0.24	8.07
10	9.44	0.21	7.95
12	8.93	0.21	7.89
14	8.74	0.18	4.07
16	8.03	0.17	0.79
18		0.21	0.49
20		0.19	0.36

Pleasant Lake (86-0251) Historic Water Quality Data

Year	TP	SEP	NTP	Pmin	Pmax	Chl-a	SEC	NC	Cmin	Cmax	SD	SES	NS	Col	Alk	CL	TKN	pH	Cond
1971											2.1		1		162		0.88	8.5	
1976															153	36		8.8	
1979	36.0	15.0	3	8.0	59.0						2.1	0.1	13	12			0.59		
1981	69.0		1	69.0	69.0	11.8		1	11.8	11.8	1.9	0.2	3	15	150		0.74	8.2	
1982											2.7	0.3	7						
1983											3.0	0.6	5						
1984											2.2	0.1	5						
1985											2.7	0.3	5						
1991	25.0	10.0	3	10.0	45.0	17.6	3.9	3	11.5	24.8	1.7	0.1	3	13	160	21	0.9	8.8	378
1993											2.8	0.3	3					8.7	347
1999											3.4	0.2	3						
2000											2.1	0.2	4						
2002											1.6	0.1	5						
2003											2.3	0.2	5						
2004											2.5	0.2	7						
2005	30.8	3.8	8	17.0	48.0	12.2	3.4	9	2	33.1	2.1	0.4	7	8.3	160	32.3	0.7	8.5	382

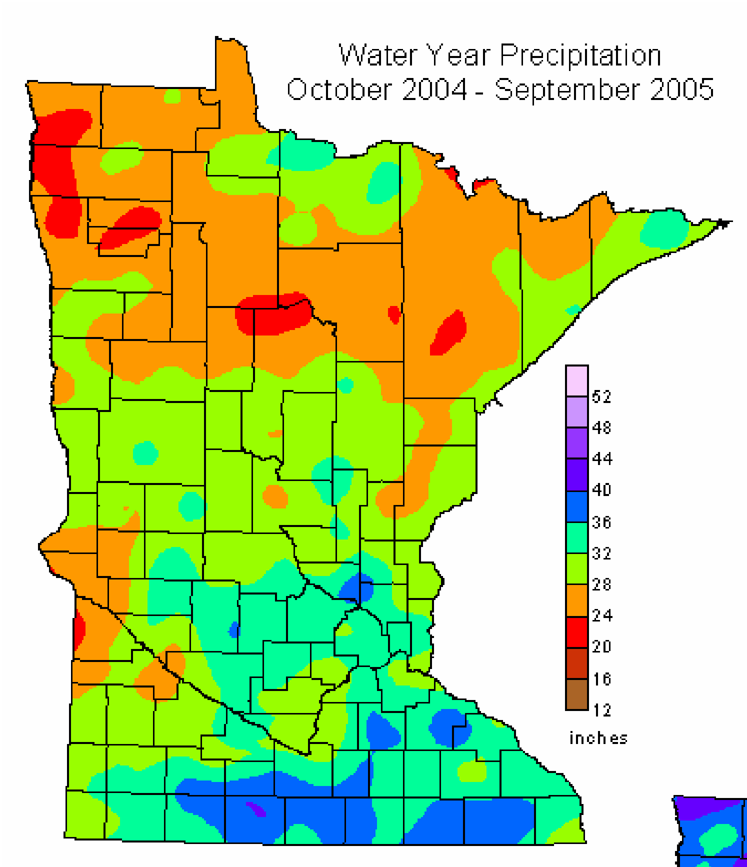
Year = Year Monitored
TP = Total Phosphorus (µg/L)
SEP = Standard Error for TP
NTP = # of TP Samples
Pmin = Minimum TP value
Pmax = Maximum TP value

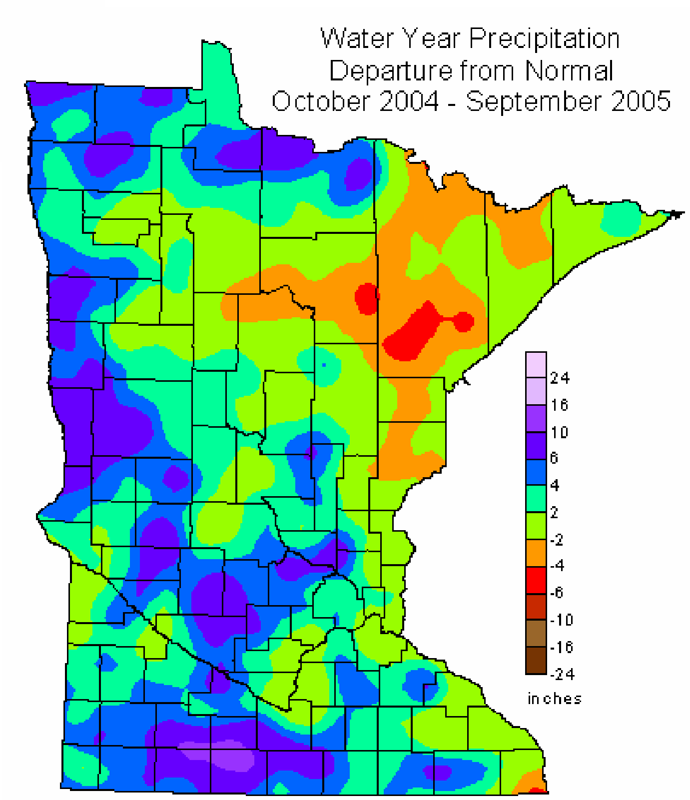
Chl-*a* = Chlorophyll-*a* (µg/L)
SEC = Standard Error for Chl-*a*
NC = # Chl-*a* samples/yr
Cmin = Minimum Chl-*a* value
Cmax = Maximum Chl-*a* value
SD = Secchi Transparency (meters)

SES = Standard Error for SD
NS = # Secchi Readings/yr
Col = Color in Pt-Co units
Alk = Alkalinity (mg/L)
CL = Chloride (mg/L)
TKN = Total Kjeldahl Nitrogen (mg/L)

pH = pH of sample in SU
Cond = Conductivity in umhos/cm

Appendix II. Precipitation Maps & Amounts





<u>Precipitation Records Near Annandale, Minnesota</u>

Date	Precip
Apr 1, 2005	0
Apr 2, 2005	0
Apr 3, 2005	0
Apr 4, 2005	0
Apr 5, 2005	0
Apr 6, 2005	.18
Apr 7, 2005	0
Apr 8, 2005	0
Apr 9, 2005	0
Apr 10, 2005	.07
Apr 11, 2005	.94
Apr 12, 2005	.70
Apr 13, 2005	.01
Apr 14, 2005	0
Apr 15, 2005	0
Apr 16, 2005	.07
Apr 17, 2005	.25
Apr 18, 2005	0
Apr 19, 2005	.05
Apr 20, 2005	0
Apr 21, 2005	0
Apr 22, 2005	0
Apr 23, 2005	0
Apr 24, 2005	0
Apr 25, 2005	0
Apr 26, 2005	.07
Apr 27, 2005	.05
Apr 28, 2005	0
Apr 29, 2005	0
Apr 30, 2005	0
May 1, 2005	0
May 2, 2005	.03
May 3, 2005	0
May 4, 2005	0
May 5, 2005	0
May 6, 2005	.07
May 7, 2005	0
May 8, 2005	.03
May 9, 2005	.17
May 10, 2005	.43
May 11, 2005	0
May 12, 2005	.05
May 13, 2005	.15
May 14, 2005	.10
May 15, 2005	0
May 16, 2005	.09
May 17, 2005	0
May 18, 2005	.80
May 19, 2005	.60
May 20, 2005	.01
May 21, 2005	.12
May 22, 2005	.04
May 23, 2005	0
May 24, 2005	0
May 25, 2005	.40
May 26, 2005	.71
May 27, 2005	.04
May 28, 2005	0
May 29, 2005	.01
May 30, 2005	.03
May 31, 2005	.03
Jun 1, 2005	.03
Jun 2, 2005	.07
Jun 3, 2005	0
Jun 4, 2005	.01
Jun 5, 2005	.90
Jun 6, 2005	.25
Jun 7, 2005	.16
Jun 8, 2005	.85
Jun 9, 2005	0
Jun 10, 2005	.81

Date	Precip
Jun 11, 2005	.01
Jun 12, 2005	.42
Jun 13, 2005	.19
Jun 14, 2005	.35
Jun 15, 2005	.08
Jun 16, 2005	0
Jun 17, 2005	0
Jun 18, 2005	0
Jun 19, 2005	0
Jun 20, 2005	0
Jun 21, 2005	.60
Jun 22, 2005	0
Jun 23, 2005	0
Jun 24, 2005	.09
Jun 25, 2005	0
Jun 26, 2005	0
Jun 27, 2005	.03
Jun 28, 2005	2.50
Jun 29, 2005	.57
Jun 30, 2005	.08
Jul 1, 2005	0
Jul 2, 2005	0
Jul 3, 2005	.40
Jul 4, 2005	0
Jul 5, 2005	0
Jul 6, 2005	0
Jul 7, 2005	0
Jul 8, 2005	0
Jul 9, 2005	0
Jul 10, 2005	0
Jul 11, 2005	0
Jul 12, 2005	0
Jul 13, 2005	.05
Jul 14, 2005	0
Jul 15, 2005	0
Jul 16, 2005	0
Jul 17, 2005	0
Jul 18, 2005	0
Jul 19, 2005	0
Jul 20, 2005	.61
Jul 21, 2005	0
Jul 22, 2005	0
Jul 23, 2005	0
Jul 24, 2005	.75
Jul 25, 2005	.05
Jul 26, 2005	.30
Jul 27, 2005	0
Jul 28, 2005	0
Jul 29, 2005	0
Jul 30, 2005	0
Jul 31, 2005	0
Aug 1, 2005	0
Aug 2, 2005	0
Aug 3, 2005	0
Aug 4, 2005	.10
Aug 5, 2005	0
Aug 6, 2005	0
Aug 7, 2005	0
Aug 8, 2005	.04
Aug 9, 2005	.01
Aug 10, 2005	0
Aug 11, 2005	0
Aug 12, 2005	0
Aug 13, 2005	0
Aug 14, 2005	0
Aug 15, 2005	0
Aug 16, 2005	0
Aug 17, 2005	.05
Aug 18, 2005	.07
Aug 19, 2005	0
Aug 20, 2005	.04

Date	Precip
Aug 22, 2005	0
Aug 23, 2005	0
Aug 24, 2005	0
Aug 25, 2005	0
Aug 26, 2005	2.45
Aug 27, 2005	.02
Aug 28, 2005	0
Aug 29, 2005	0
Aug 30, 2005	0
Aug 31, 2005	0
Sep 1, 2005	0
Sep 2, 2005	0
Sep 3, 2005	0
Sep 4, 2005	2.33
Sep 5, 2005	0
Sep 6, 2005	.43
Sep 7, 2005	0
Sep 8, 2005	.25
Sep 9, 2005	0
Sep 10, 2005	0
Sep 11, 2005	0
Sep 12, 2005	.13
Sep 13, 2005	3.12
Sep 14, 2005	0
Sep 15, 2005	0
Sep 16, 2005	0
Sep 17, 2005	0
Sep 18, 2005	.04
Sep 19, 2005	.53
Sep 20, 2005	0
Sep 21, 2005	0
Sep 22, 2005	.51
Sep 23, 2005	0
Sep 24, 2005	.02
Sep 25, 2005	.20
Sep 26, 2005	.23
Sep 27, 2005	0
Sep 28, 2005	.23
Sep 29, 2005	.03
Sep 30, 2005	0

Appendix III. Fisheries Status

From http://www.dnr.state.mn.us/lakefind/showreport.html?downum=86025100

Status of the Fishery (as of 06/30/1997): Pleasant Lake is a 509 acre lake located at the city of Annandale. The lake has 3.9 miles of shoreline and a maximum depth of 74 feet. During late June 1997, there was adequate dissolved oxygen for fish present to a depth of 25 feet. The lakeshore is highly developed with about 80% of the shoreline taken up by residential areas of the city of Annandale. Thirty aquatic plant species were identified in the 1997 survey. There is a county owned access on the north side of the lake in the county park as well as a city owned access on the south shore off CSAH 5.

Black crappie, bluegill, northern pike, yellow perch, largemouth bass and walleye are all present in the lake. In a lake survey conducted in the summer of 1997, test netting revealed the following information about the fish population.

Northern pike catch rate was 13.2/gill net, which is higher than expected for lakes similar to Pleasant. The average northern pike weighed 1.8 pounds and was 19.8 inches long, which was smaller than expected for the lake type. Pike growth was average compared to other populations in the state. Gill net catch of walleye (2.8/ gill net) was in the normal range for this lake type. Walleye averaged 3.0 pounds and 20.0 inches, which is larger than expected. Yellow perch catch rate was 0.3/gill net, which is lower than expected.

Trap net catch of black crappie (2.5/trap net) was in the expected range for the lake class. The average crappie was 4.6 inches long, and 88% of the black crappie sampled were less than 5 inches long. Bluegill catch rate (73.5/trap net) was higher than expected. The average size of bluegill was 5.5 inches and they ranged from 2.8-7.9 inches long. Growth rates of bluegill were average for the lake type, but this is still slow: typical bluegill did not reach 6 inches long until age 6. Young of the year bluegill were collected in shoreline seine hauls.

Largemouth bass were sampled by spring electrofishing. A total of 41 fish were sampled at a rate of 16.4 fish/hour of run-time, which is close to the area average. Largemouth bass averaged 1.7 pounds and 13.7 inches long. The bass population has a large proportion of fish over 12 inches long. Pleasant Lake has excellent spawning habitat and young largemouth bass were common in shoreline seine hauls.

Appendix IV. Lake Level Report

Water Level Data

Period of record: 01/01/1949 to 04/27/1999
\# of readings: 118
Highest recorded: 1042.1 ft (06/27/1983)
Highest known: 1042.1 ft (6/27/83)
Lowest recorded: 1035 ft (01/01/1949)
Recorded range: 7.1 ft
Average water level: 1038.28 ft
Last reading: 1039.63 ft (04/27/1999)
OHW elevation: 1041 ft
Datum: 1929 (ft)