Pretty Lake Diagnostic Study

Marshall County, Indiana

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PRETTY LAKE DIAGNOSTIC STUDY
MARSHALL COUNTY, INDIANA

EXECUTIVE SUMMARY

Pretty Lake is a 97-acre (39.3 ha) natural lake that lies in the Yellow Creek (Kankakee) watershed near Plymouth, Indiana. Pretty Lake's watershed encompasses approximately 539 acres (218 ha) including the area of the lake. Slightly more than half of the area draining to the lake (230/442 acres or 93/179 ha) is utilized for row crops. Forested areas, grasslands, and wetlands cover approximately 68 acres (27 ha) or 12% of the entire watershed, while residential land uses account for less than 5% of the watershed's total acreage. Comparatively, the Country Club covers 22% and Pretty Lake itself covers 18% of the total watershed.

Pretty Lake has one "tributary" drainage that enters the lake through a drain tile on the north side of the lake. This tile drainage carries water from approximately 202 acres (82 ha) of the watershed. There is no legal name for this drainage as it is a privately installed tile and not regulated by any governmental agency. The maximum flow documented from this tile was 0.2 cubic feet per second after 0.5 inches of rainfall. The remainder of the water flowing to the lake comes directly from the 240 acres (97 ha) surrounding the lake.

Pretty Lake itself contains excellent water quality. Historical data for the lake suggest that Pretty Lake's water quality has remained relatively stable or declined only slightly over the past 33 years of occasional samples. The lake has better water clarity and lower nutrient levels than most Indiana lakes. Evaluating the lake using various trophic state indices suggest the lake is oligotrophic to mesotrophic in nature. However, Pretty Lake's phosphorus concentration has the potential to increase the lake's productivity. Pretty Lake supports a diverse submerged plant community that includes two state listed species.

The lake possesses a long hydraulic residence time of 3.0 years. Therefore, continued good water quality in Pretty Lake will require in-lake management and shoreline best management practices. Pretty Lake's relatively small watershed area to lake area ratio of 5.6:1 suggests near shore residents have substantial control over influencing the health of their lake.

Recommended management techniques include: cultivating near shore aquatic vegetation, phosphorus free fertilizer use, proper disposal of organic wastes, stormwater filtration, conversion of agricultural ground to wetland, grass, or forest land and purple loosestrife control, and intercepting the tile flow with a wetland filter or open water pond.

ACKNOWLEDGMENTS

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PRETTY LAKE DIAGNOSTIC STUDY
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1.0 INTRODUCTION

Pretty Lake is a 97-acre (39.3-ha) natural lake that lies in the west central portion of Marshall County, Indiana (Figure 1). Specifically, the lake is located in Section 11 of Township 33 North, Range 1 East in Marshall County. The Pretty Lake watershed stretches out to the north and west of the lake encompassing approximately 539 acres (218 ha or 0.84 square mile; Figure 2). Water discharges through the lake's outlet in the southeast corner. Water from Pretty Lake's outlet flows east into Dixon Lake and eventually reaches the Kankakee River and flows to the Gulf of Mexico.

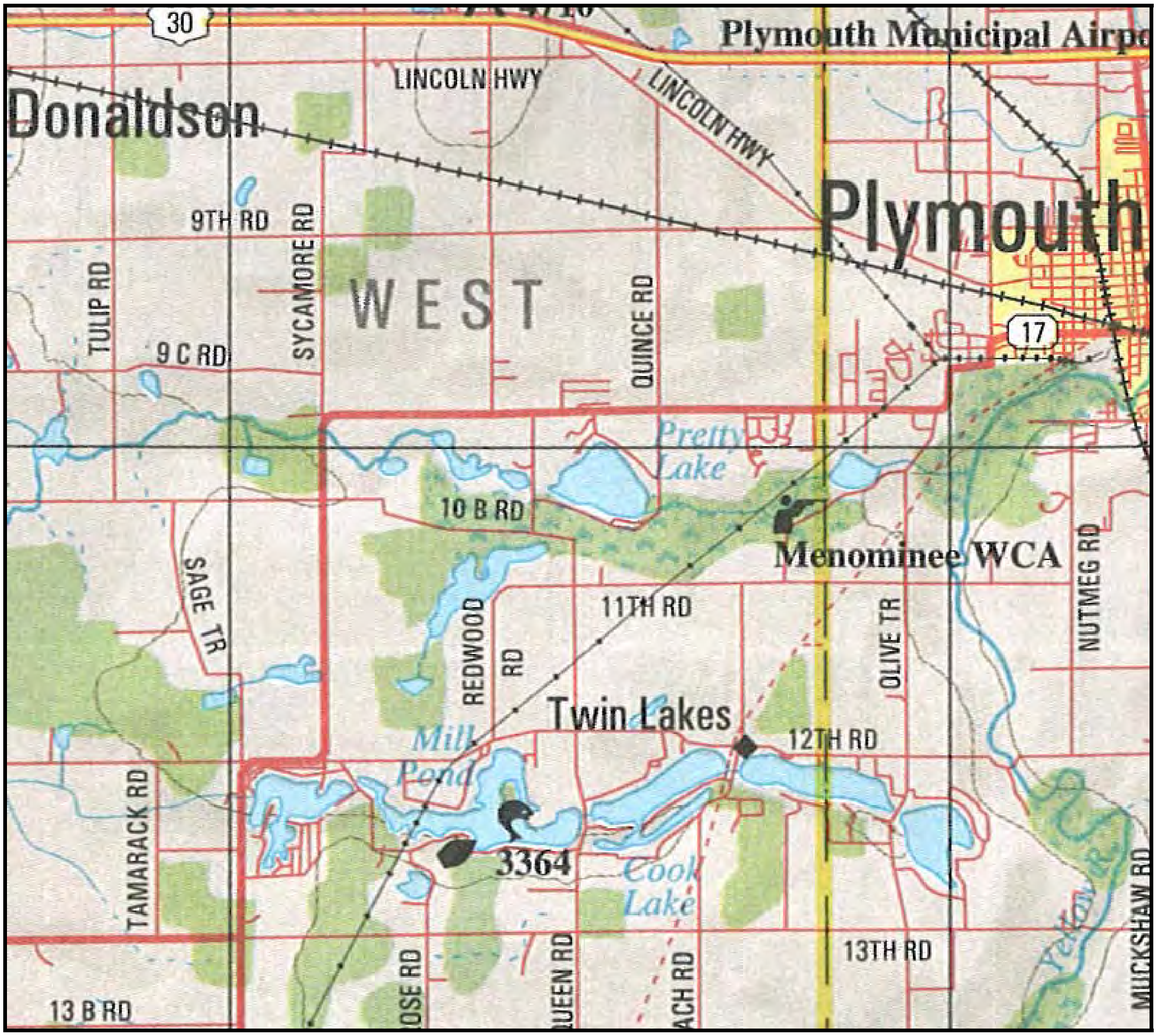

Figure 1. General location of the Pretty Lake watershed, Marshall County, Indiana
Source: DeLorme, 1998.

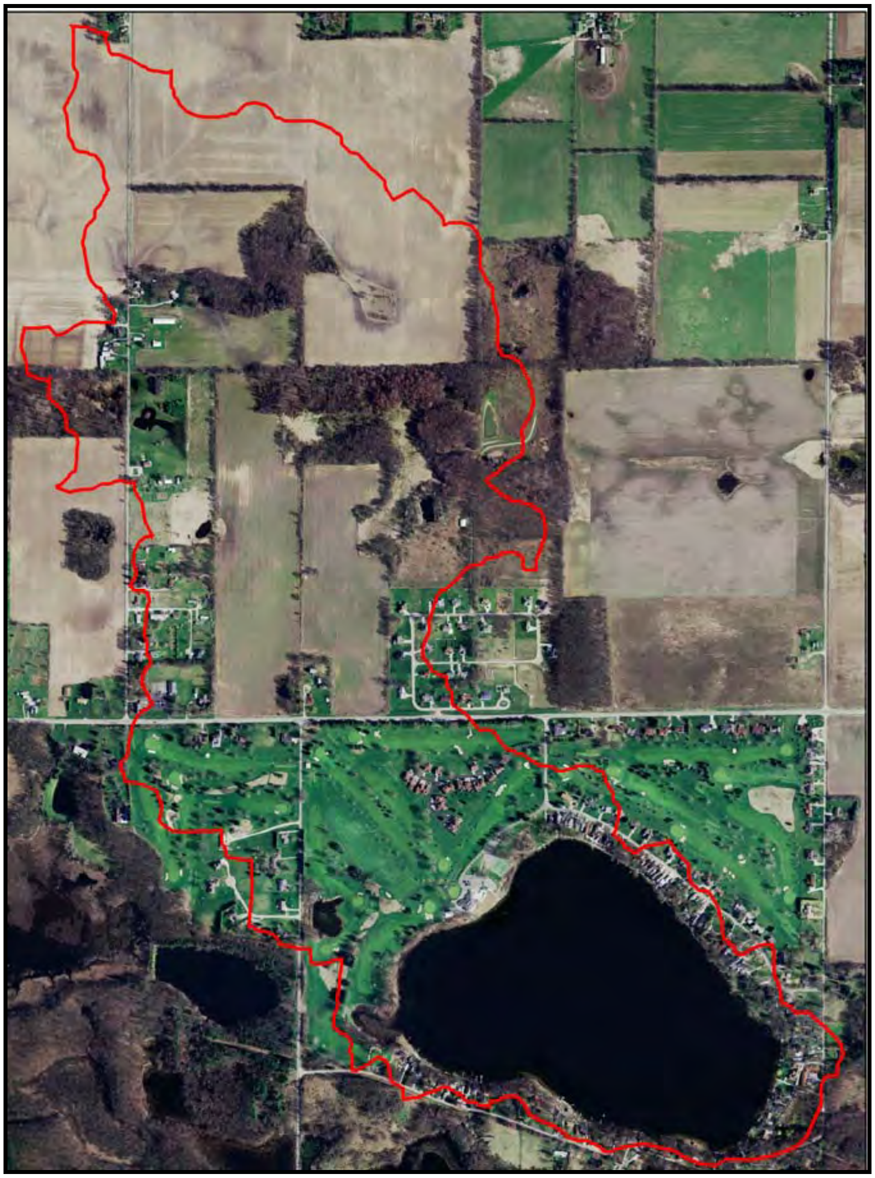

Figure 2. Pretty Lake watershed, Marshall County, Indiana

In comparison to other lakes in the region, Pretty Lake water quality has remained relatively stable. Historical records from the past twenty years show the lake's Secchi disk transparency (a measure of water clarity) has been consistently greater than 12 feet (3.7 m) compared to a regional median of less than 6.9 feet (2.1 m) (CLP, unpublished data). Nutrient levels have remained relatively low within Pretty Lake. Total phosphorus concentrations remain below the median values of surrounding lakes. Primary productivity of the lake (algae and plant growth) has been low as well. None of the chlorophyll *a* concentrations exceed the median concentration measured in Indiana lakes (12.9 g/L).

In addition to exhibiting good water quality, Pretty Lake possesses an extremely diverse aquatic plant community and continues to be a good lake for fishing. Nineteen aquatic plant species were identified in the lake during the most recent assessment (Aquatic Control, 2007). This is a reflection of Pretty Lake's good water clarity. However, three exotic species including Eurasian watermilfoil, curly-leaf pondweed, and purple loosestrife were identified within the confines of Pretty Lake.

Pretty Lake's fish community is typical of most Indiana Lakes with bluegill and largemouth bass being the dominate sport fishes. The last and only general fisheries survey occurred 40 years ago so very little is known about the current state of the fishery. Pretty Lake exhibits good water quality suggesting the fishery would be influenced most by the introduction of additional exotic plant and animal species, active reduction of existing exotic plant species, changes in angler harvest or pressure, or global climate change. A general fisheries survey would need to be completed to determine the current state of the Pretty Lake fishery.

Despite the lake's excellent water quality and its ability to provide good fishing, long-time residents have noticed changes in the lake's vegetation over the past several years. Specifically, emergent vegetation beds have decreased in size, while more nuisance vegetation, including Eurasian watermilfoil, appears to have expanded its coverage in the lake. Residents have also noted a decrease in the lake's water clarity in some portions of the lake following large rain events. These changes have negatively impacted the residents' enjoyment of the lake and increased their desire to protect the lake's health and future.

The purpose of the diagnostic study was to describe the conditions and trends in Pretty Lake and its watershed, identify potential problems, and make prioritized recommendations addressing these problems. The study consisted of a review of historical studies, interviews with lake residents and state/local regulatory agencies, the collection of current water quality data, pollutant modeling, and field investigations. In order to obtain a broad understanding of the water quality in Pretty Lake and the water entering the lake, the diagnostic study included an examination of the lake water chemistry and the tile inlet nutrients and bacteria entering the north side of the lake. This report documents the results of the study.

2.0 <u>WATERSHED CHARACTERISTICS</u>

2.1 Topography and Physical Setting

Pretty Lake is a headwaters lake in the Mississippi River Basin. Pretty Lake is part of the 14 digit 8,758-acre (3,544 ha) hydrologic unit code (HUC) 07120001060010 known as Yellow River-Dixon Lake Outlet. The lake and its 539-acre (218-ha) watershed lie south of the north-south continental divide. As part of the Mississippi River Basin, water exits Pretty Lake near the lake's southeast corner and flows east into Dixon Lake. Water from Dixon Lake flows east to the Yellow River, then to the Kankakee River, which empties into the Illinois River, ultimately reaching the Mississippi River in southwestern Illinois and flowing to the Gulf of Mexico.

The topography of the Pretty Lake watershed reflects the geological history of the watershed. The highest areas of the watershed lie along the watershed's southern and western edges. The rolling topography and depressions in the landscape are ice-marginal remnants of the Wisconsin age. In this region, glacial deposits from the Michigan and Erie Lobes of ice are present in end moraines, kettle lakes, scoured channels, and outwash plains. Along the watershed's western boundary, the elevation nears 830 feet above mean sea level. The ridges along the watershed's southern boundary are nearly as high (825 feet msl), and are equally as steep as the ridge along the western watershed boundary. Pretty Lake occupies the lowest point in the watershed (787 feet or 239.8 m msl). Figure 3 presents a topographical relief map of the Pretty Lake watershed.

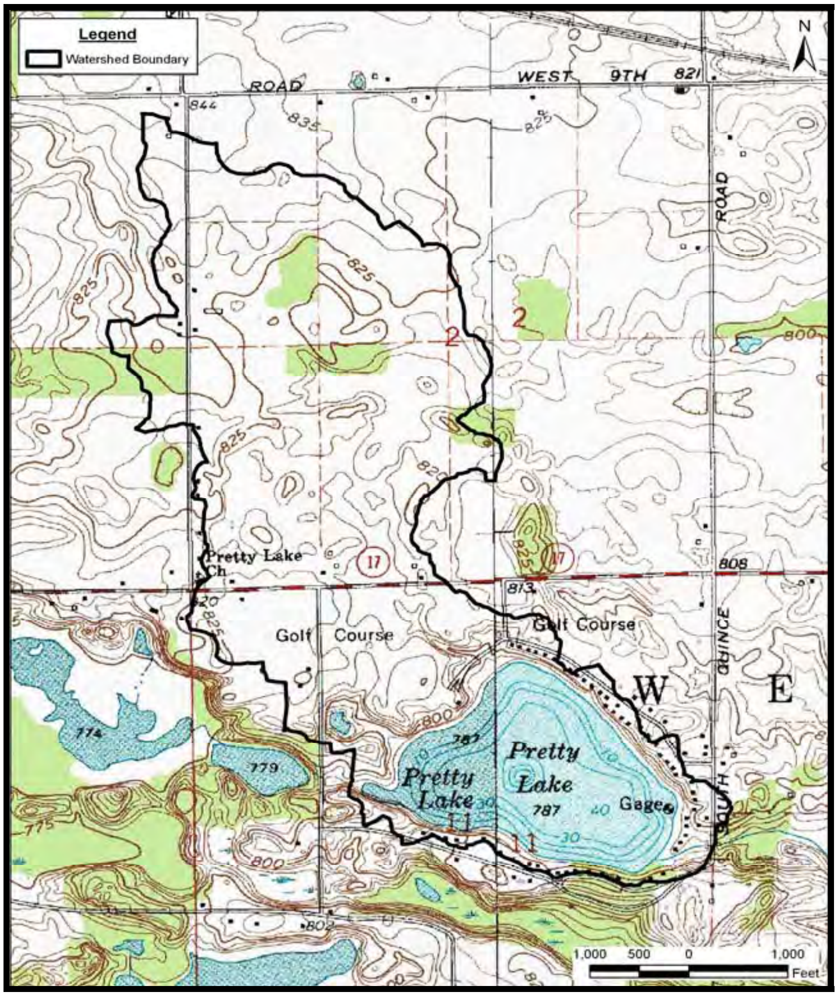

Figure 3. Topographical map of the Pretty Lake watershed, Marshall County, Indiana.

2.1.1 Pretty Lake watershed

Surface water drains to Pretty Lake via two primary routes: through an unnamed drainage tile, which enters the lake from the Plymouth County Club on the northwest shoreline, and via direct drainage from the surrounding landscape. The tile drain carries water from approximately 202 acres (81.7 ha or 37.5%) of the watershed north of Pretty Lake (Table 1). This drain is considered a private drainage tile and not a legal drain. The remaining 44.5% of the land in the Pretty Lake watershed (240 acres or 97.1 ha) drains directly to Pretty Lake (Figure 4).

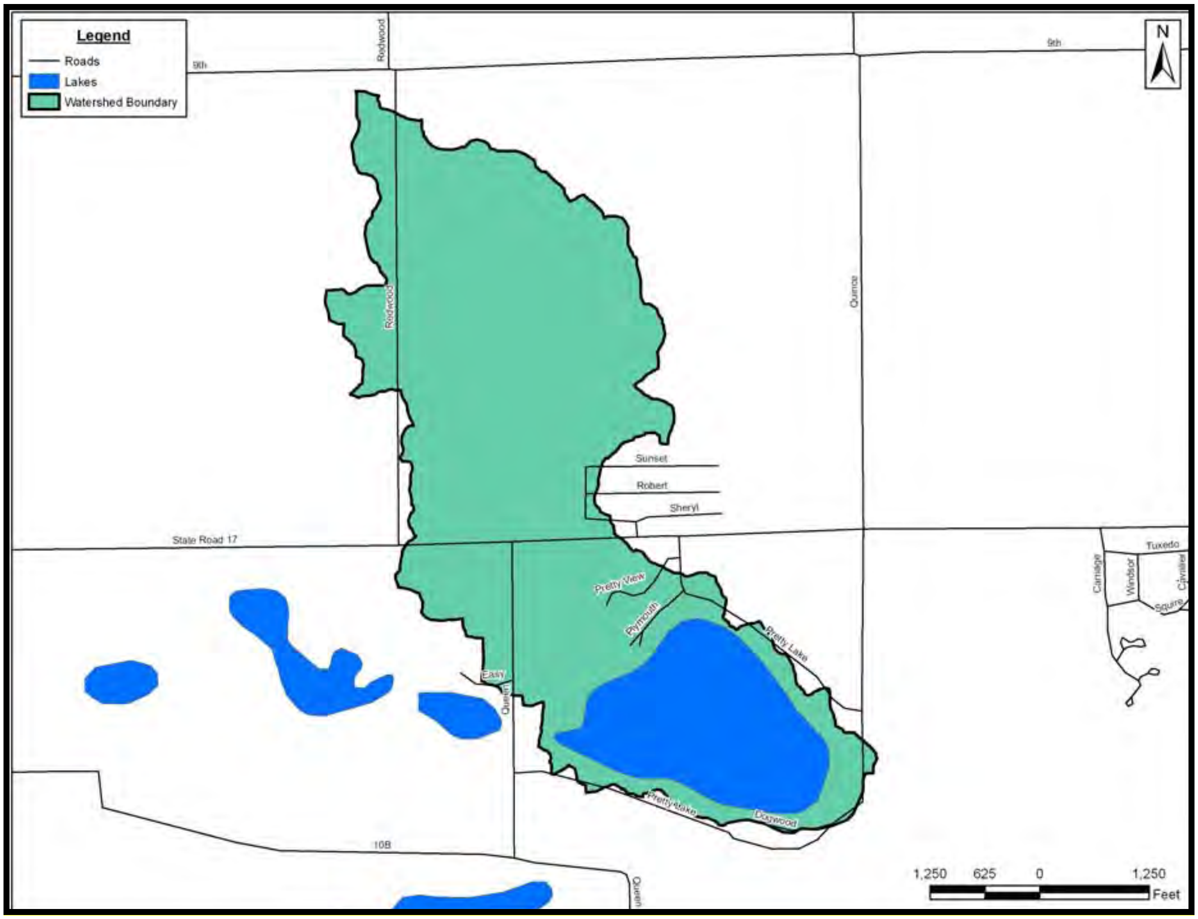

Figure 4. Pretty Lake watershed, Marshall County, Indiana.

Table 1. Watershed and subwatershed sizes for Pretty Lake, Marshall County, Indiana.

Subwatershed/Lake	Area (acres)	Area (hectares)	Percent of Watershed
Unnamed Tributary	202	81.7	37.5%
Area draining directly to Pretty Lake	240	97.1	44.5%
Watershed Draining to Lake	**442**	**178.9**	**82.0%**
Pretty Lake	97	39.3	18.0%
Total Watershed	**539**	**218.1**	**100%**
Watershed to Lake Area Ratio	5.6:1		

Table 1 also provides the watershed area to lake area ratio for Pretty Lake. Watershed size and watershed to lake area ratios can affect the chemical and biological characteristics of a lake. For example, lakes with large watersheds have the potential to receive greater quantities of pollutants (sediments, nutrients, pesticides, etc.) from runoff than lakes with smaller watersheds. For lakes with large watershed to lake ratios, watershed activities can potentially exert a greater influence on the health of the lake than lakes possessing small watershed to lake ratios. Conversely, for lakes with small watershed to lake ratios like Pretty Lake, shoreline activities and internal lake processes may have a greater influence on the lake's health than lakes with large watershed to lake ratios.

Pretty Lake possesses a watershed area to lake area ratio of approximately 5.6:1. This is a fairly low watershed area to lake area ratio for glacial lakes (Vant, 1987). This ratio is also relatively normal when compared to other lakes in northern Indiana. For example, Myers Lake in Marshall County, which is similar in size to Pretty Lake, has a watershed area to lake area ratio of approximately 8:1. In contrast, Lake Tippecanoe, Ridinger Lake, and Smalley Lake are glacial lakes in the Upper Tippecanoe River watershed in Kosciusko, Noble, and Whitley Counties that possess watershed area to lake area ratios of 93:1, 165:1, and 248:1, respectively. All of these lakes have extensive watersheds compared to Pretty Lake.

In terms of lake management, Pretty Lake's watershed area to lake area ratio indicates that near lake (i.e. shoreline) and in-lake activities and processes can potentially exert a significant influence on the health of the Lake. The relatively small watershed area to lake area ratio should be considered when prioritizing the use of limited funds for lake management. Implementing best management practices (BMP's) such as maintaining native vegetation along the lake's shoreline should be a high priority. BMP's in the near shore areas such as fertilizer management, stormwater treatment, proper disposal of organic wastes (leaves, lawn clippings, animal wastes) should also receive special attention.

2.2 Climate

Indiana Climate

Indiana's climate can be described as temperate with cold winters and warm summers. The National Climatic Data Center summarizes Indiana weather in its 1976 Climatology of the United States document no. 60: "Imposed on the well known daily and seasonal temperature fluctuations are changes occurring every few days as surges of polar air move southward or tropical air moves northward. These changes are more frequent and pronounced in the winter than in the summer. A winter may be unusually cold or a summer cool if the influence of polar air is persistent. Similarly, a summer may be unusually warm or a winter mild if air of tropical origin predominates. The action between these two air masses of contrasting temperature, humidity, and density fosters the development of low-pressure centers that move generally eastward and frequently pass over or close to the state, resulting in abundant rainfall. These systems are least active in midsummer and during this season frequently pass north of Indiana" (National Climatic Data Center, 1976). Prevailing winds in Indiana are generally from the southwest but are more persistent and blow from a northerly direction during the winter months.

Pretty Lake Watershed Climate

The climate of Marshall County is characteristic of northern Indiana exhibiting warm summers and cold and snowy winters. Winters in Marshall County typically provide enough precipitation, in the form of snow, to supply the soil with sufficient moisture to minimize drought conditions when the hot summers begin. Winters are cold in Marshall County, averaging 27º F (-2.8º C), while summers are warm, averaging 71º F (21.7º C). Marshall County's highest recorded temperature was 109º F (42.8º C) on June 20, 1953. Mild drought conditions occur occasionally during the summer when evaporation is highest. Historic data from 1951 to 1974 suggest that the growing season (defined as days with an air temperature higher than 40º F or 4.4º C) in Marshall County is typically 139 days long, although it can last as long as 164 days (Smallwood, 1980). The last day of freezing temperatures in spring usually occurs around May 6, while the first freezing temperature in the fall occurs around October 5. During summer, average relative humidity differs greatly over the course of a day averaging 80% at dawn and dropping to an average of 60% in mid-afternoon. The average annual precipitation is 39.76 inches (100.9 cm). Table 2 displays the average annual precipitation data for Marshall County as well as precipitation data for 2008. In 2008, approximately 46 inches (116.8 cm) of precipitation was recorded at Plymouth in Marshall County (Table 2). When compared with the 30-year average for the area, the 2008 annual rainfall exceeded the average by approximately 6.8 inches (17.2cm).

Table 2. Monthly rainfall data (in inches) for 2008 as compared to average rainfall.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2008	5.09	5.72	2.37	2.89	4.23	3.96	2.97	3.03	7.4	2.84	1.26	4.42	46.18
Average	2.16	1.86	2.85	3.96	4.27	4.48	3.74	3.35	3.58	3.19	3.19	2.78	39.41

All data were recorded at Plymouth Power Substation. Averages are 30-year normals based on available weather observations taken during the years of 1971-2000 (NOAA, 2008).

2.3 Geology

The advance and retreat of the glaciers in the last ice age (the Wisconsin Age) removed, shaped and reshaped much of the landscape found in Indiana today. In the northern portion of the state, ground moraines, end moraines, lake plains, outwash plains, and other geologically complex features dominate the landscape. Further, the interaction of three glacial lobes, (Michigan Lobe, Saginaw Lobe, and the Erie Lobe, respectively) left behind a vast array of deposits and landforms that changed the region’s hydrogeology. In comparison to the central portion of the state, surface water, groundwater and soils are more varied and complex. Large raised landforms including the Valparaiso Moraine, the Maxinkuckee Moraine, and the Packerton Moraine, indicate the glacial margins of these ice sheets in the northern portion of the state. Major rivers in northern Indiana cut through course grained outwash and transect these dominant topographical features, suggesting a drainage pattern that was established in an ice proximal and or subglacial environment. Later, outwash plains formed as the glacial melt waters flowed from retreating glaciers. This further altered the drainage of the landscape as dams between ice, morainal deposits and melt water pooled into lakes. As a result, lake plains and kettle lakes formed as stagnant water settled out and deposited silt and clay.

These processes and subsequent erosion shaped much of the Pretty Lake watershed. Sediments in these landforms contain remnants of bedrock from Michigan, Canada and local sources. The geology and resulting physiography of the Pretty Lake watershed are common in the Great Lakes and Upper Mississippi watershed. Pretty Lake Watershed lies in the Maxinkukee Moraine which is in the Plymouth Morainal complex (Gray, 2000) and situated in the Upper Mississippi Hydrologic Unit #07120001 (USGS, 1974).

Subsurficial geology indicates that glacial drift covers the Pretty Lake watershed to a depth of 300 to 400 feet (91.2 to 122 m; Wayne, 1966). The watershed’s surficial geology originates from silty clay loam and clay loam till materials. The bedrock underlying the watershed’s glacial deposits is Antrim shale (Gray, 1989). Shale was laid to a depth of 90 and 350 feet (27.4 to 106.7 m). The underlying bedrock is a broad lowland which possesses moderate relief, the Dekalb Lowland. This lowland formed on Upper Devonian and Lower Mississippian shales (Wayne, 1966; Gutschick, 1966).

2.4 Soils

Pretty Lake watershed’s geological history described in the previous section and the subsequent vegetative cover determined the soil types, which are reflected in the major soil association. Major soil associations are determined at the county level. Soil scientists review the soils, relief, and drainage patterns on the county landscape to identify distinct proportional groupings of soil units. The review process typically results in the identification of eight to fifteen distinct patterns of soil units. These patterns are the major soil associations in the county. Each soil association typically consists of two or three soil units that dominate the area covered by the soil association and several soil units that occupy only a small portion of the soil association’s landscape. Soil associations are named for their dominant components. For example, the Riddles-Metea-Wawasee soil association consists primarily of Riddles sandy loam, Metea loamy fine sand, and Wawasee sandy loam.

Smallwood (1980) maps one soil association in the Pretty Lake watershed: the Riddles-Metea-Wawasee association. This soil association is characteristic of morainal areas in Marshall County, such as the Maxinkuckee Moraine. Soils in this association developed from glacial till parent materials. In general, Riddles soils account for approximately 54% of the total soils in the association; Metea soils account for 22%, while Wawasee soils comprise 13% of the soil association. Much of the remaining portion of the soil association consists of hydric soil components which line drainageways and cover much of the watershed north of State Road 17. Riddles and Wawasee soils occupy moraine ridges, while Metea soils occur on low knolls and sides of moraines. Woodlands are the dominant native vegetation on the Riddles-Metea-Wawasee association. The soils' strong slopes may limit agricultural productivity. Steep slopes and moderately fine subsoil textures limit the usage of these soils for septic absorption fields.

Soils in the watershed, and in particular their ability to erode or sustain certain land use practices, can impact the water quality of lakes and streams in the watershed. The dominance of Riddles and Wawasee soils across the Pretty Lake watershed suggests much of the watershed is prone to erosion; common erosion control methods should be implemented when the land is used for agriculture or during residential development to protect waterbodies in the Pretty Lake watershed. Similarly, soils that are poorly suited to serve as septic system leach fields cover a large portion of the Pretty Lake watershed, including the heavily populated shorelines at Pretty Lake. The coupling of high density residential land use with soils that are poorly suited for treating septic tank effluent is of concern for water quality in the Pretty Lake watershed. More detailed discussion of highly erodible soils and soils used to treat septic tank effluent in the Pretty Lake watershed follows below.

2.4.1 Highly Erodible Soils

Soils that erode from the landscape are transported to waterways where they degrade water quality, interfere with recreational uses, and impair aquatic habitat and health. In addition, such soils can carry attached nutrients, which further impair water quality by increasing production of plant and algae growth. Soil-associated chemicals, like some herbicides and pesticides, can kill aquatic life and degrade water quality. Highly erodible and potentially highly erodible are classifications used by the Natural Resources Conservation Service (NRCS) to describe the potential of certain soil units to erode from the landscape. The NRCS examines common soil characteristics such as slope and soil texture when classifying soils. The NRCS maintains a list of highly erodible soil units for each county. Figure 5 displays and Table 3 lists the soil units in the Pretty Lake watershed that the NRCS considers to be highly erodible and potentially highly erodible.

Highly erodible (HES) and potentially highly erodible soil (PHES) units in the form of Chelsea fine sand; Martinsville loam; Metea loamy fine sand; Oshtemo loamy sand; Plainfield sand; and Riddles, Oshtemo, and Wawasee sandy loams cover more than half of the Pretty Lake watershed. Areas of the watershed that are mapped in these soil units and have gentle slopes are considered only slightly limited for agricultural production. As slope increases, the severity of the limitation increases. Some steeply sloped Oshtemo and Wawasee soils are considered unsuitable for agricultural production due to erosion hazard. The erosion hazard would also exist during residential development on these soils.

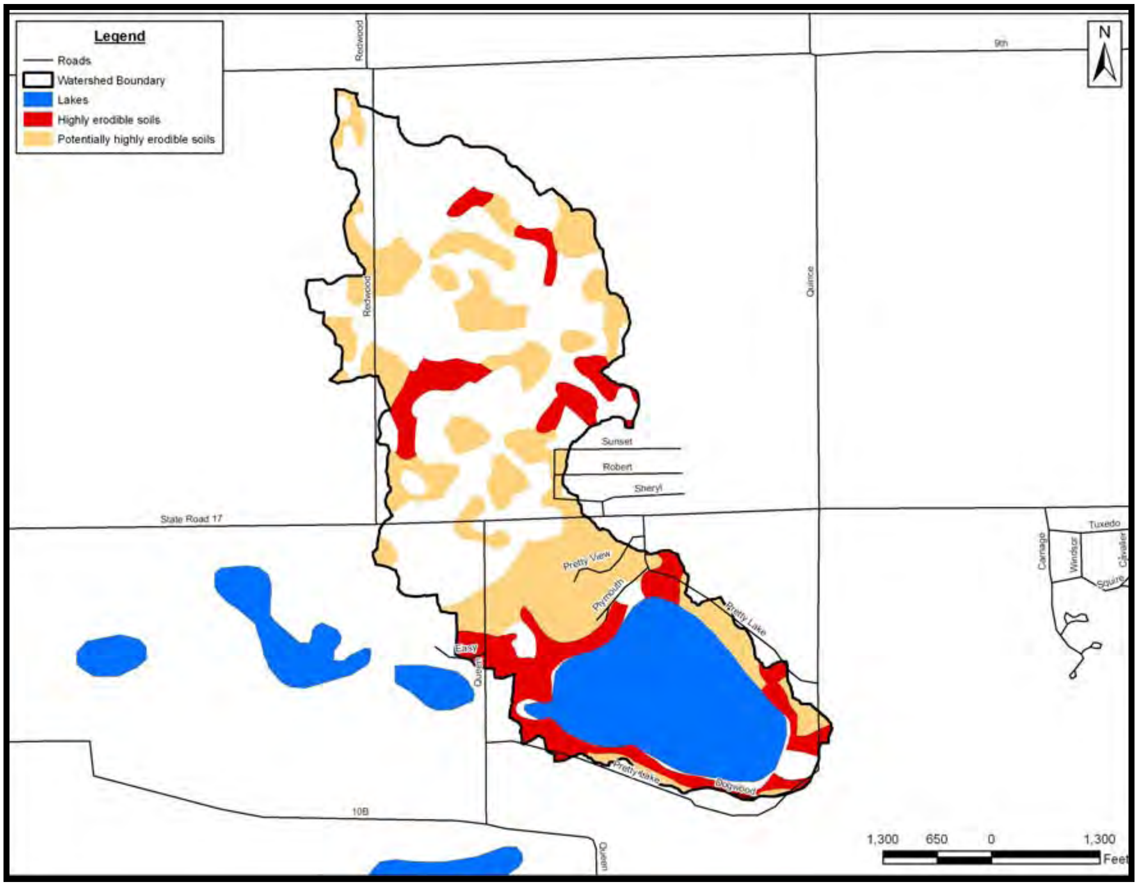

Figure 5. Highly erodible and potentially highly erodible soils within the Pretty Lake watershed, Marshall County, Indiana.

Table 3. Highly erodible and potentially highly erodible soil units in the Pretty Lake watershed.

Soil Unit	Status	Soil Name	Soil Description
ChB	PHES	Chelsea fine sand	2 to 6 percent slopes
MeB	PHES	Martinsville loam	2 to 6 percent slopes
MgB	PHES	Metea loamy fine sand	2 to 6 percent slopes
MgC	HES	Metea loamy fine sand	6 to 12 percent slopes
OsB	PHES	Oshtemo loamy sand	2 to 6 percent slopes
OsC	HES	Oshtemo loamy sand	6 to 12 percent slopes
OsD	HES	Oshtemo loamy sand	12 to 18 percent slopes
PsC	HES	Plainfield sand	3 to 10 percent slopes
RsB	PHES	Riddles sandy loam	2 to 6 percent slopes
RsC2	HES	Riddles sandy loam	6 to 12 percent slopes
WkC2	HES	Wawasee sandy loam	6 to 12 percent slopes, eroded

Note: PHES stands for potentially highly erodible soil and HES stands for highly erodible soil.

Erodible soils located on the most steeply sloped areas (HES) cover approximately 70.4 acres (28.5 ha) or 13.1% of the Pretty Lake watershed (Figure 5), while erodible soils on steep-sloped soils (PHES) cover approximately 155 acres (62.7 ha) or 28.8% of the watershed. Much of Pretty Lake's shoreline is also bordered by highly erodible soils (Figure 5).

2.4.2 Soils Used for Septic Tank Absorption Fields

Nearly half of Indiana's population lives in residences having private waste disposal systems. As is common in many areas of Indiana, septic tanks and septic tank absorption fields are utilized for wastewater treatment throughout the Pretty Lake watershed. The shoreline of Pretty Lake is one exception to this. Wastewater from all of the residences directly adjacent to Pretty Lake is treated by the wastewater treatment plant in Plymouth. Once treated, effluent is discharged to the Yellow River. Much of the wastewater from the remainder of the Pretty Lake watershed is still primarily treated by private waste disposal systems. Private waste disposal systems rely on the septic tank for primary treatment to remove solids and the soil for secondary treatment to reduce the remaining pollutants in the effluent to levels that protect surface and groundwater from contamination. The soil's ability to sequester and degrade pollutants in septic tank effluent will ultimately determine how well surface and groundwater is protected.

A variety of factors can affect a soil's ability to function as a septic absorption field. Seven soil characteristics are currently used to determine soil suitability for on-site sewage disposal systems: position in the landscape, slope, soil texture, soil structure, soil consistency, depth to limiting layers, and depth to seasonal high water table (Thomas, 1996). The ability of soil to treat effluent (waste discharge) depends on four factors: the amount of accessible soil particle surface area; the chemical properties of the soil particle's surface; soil conditions like temperature, moisture, and oxygen content; and the types of pollutants present in the effluent (Cogger, 1989).

The amount of accessible soil particle surface area depends both on particle size and porosity. Because they are smaller, clay particles have a greater surface area per unit volume than silt or sand; and therefore, a greater potential for chemical activity. However, soil surfaces only play a role if wastewater can contact them. Soils of high clay content or soils that have been compacted often have few pores that can be penetrated by water and are not suitable for septic systems because they are too impermeable. Additionally, some clays swell and expand on contact with water closing the larger pores in the profile. On the other hand, very coarse soils may not offer satisfactory effluent treatment either because the water can travel rapidly through the soil profile. Soils located on sloped land also may have difficulty in treating wastewater due to reduced contact time.

Chemical properties of the soil surfaces are also important for wastewater treatment. For example, clay materials have imperfections in their crystal structure which gives them a negative charge along their surfaces. Due to their negative charge, they can bond cations of positive charge to their surfaces. However, many pollutants in wastewater are also negatively charged and are not attracted to the clays. Clays can help remove and inactivate bacteria, viruses, and some organic compounds.

Environmental soil conditions influence the microorganism community which ultimately carries out the treatment of wastewater. Factors like temperature, moisture, and oxygen availability influence microbial action. Excess water or ponding saturates soil pores and slows oxygen transfer. The soil may become anaerobic if oxygen is depleted. Decomposition process (and therefore, effluent treatment) becomes less efficient, slower, and less complete if oxygen is not available.

Many of the nutrients and pollutants of concern are removed safely if a septic system is sited correctly. Most soils have a large capacity to hold phosphate. On the other hand, nitrate (the end product of nitrogen metabolism in a properly functioning septic system) is very soluble in soil solution and is often leached to the groundwater. Care must be taken in siting the system to avoid well contamination. Nearly all organic matter in wastewater is biodegradable as long as oxygen is present. Pathogens can be both retained and inactivated within the soil as long as conditions are right. Bacteria and viruses are much smaller than other pathogenic organisms associated with wastewater; and therefore, have a much greater potential for movement through the soil. Clay minerals and other soil components may adsorb bacteria and viruses, but retention is not necessarily permanent. During storm flows, bacteria and viruses may become resuspended in the soil solution and transported throughout the soil profile. Inactivation and destruction of pathogens occurs more rapidly in soils containing oxygen because sewage organisms compete poorly with the natural soil microorganisms, which are obligate aerobes requiring oxygen for life. Sewage organisms live longer under anaerobic conditions without oxygen and at lower soil temperatures because natural soil microbial activity is reduced.

Taking into account the various factors described above, the NRCS ranks each soil series in the Pretty Lake watershed in terms of its limitations for use as a septic tank absorption field. Each soil series is placed in one of three categories: slightly limited, moderately limited, or severely limited. Use of septic absorption fields in moderately or severely limited soils generally requires special design, planning, and/or maintenance to overcome the limitations and ensure proper function. Figure 6 displays the septic tank suitability of soils throughout the Pretty Lake watershed, while Table 4 lists the soils located within the watershed and their associated properties. Soils that are severely limited for use as septic systems cover 156.5 acres (63.3 ha or 29%) of the watershed. Severely limited soils cover much of Pretty Lake's watershed and are also located along the southern shoreline of the lake. Soils that are moderately limited cover an additional 49% or 263 acres (106.4 ha) of the Pretty Lake watershed. These soils border the remaining lakeshore including the western, northern, and eastern shorelines. Soils that are rated as slightly limited for septic system usage (5%) or soils that are not rated at all (17%), including Pretty Lake, cover the remaining 22% of the watershed.

Based on the above information, Pretty Lake residents made a good choice to complete the installation of the sewer system in 2006. While the immediate affects on water quality may not be witnessed, the experience of other lakes in northern Indiana has shown that water quality of an adjacent lake does improve within five to ten years after the completion of a sewer system.

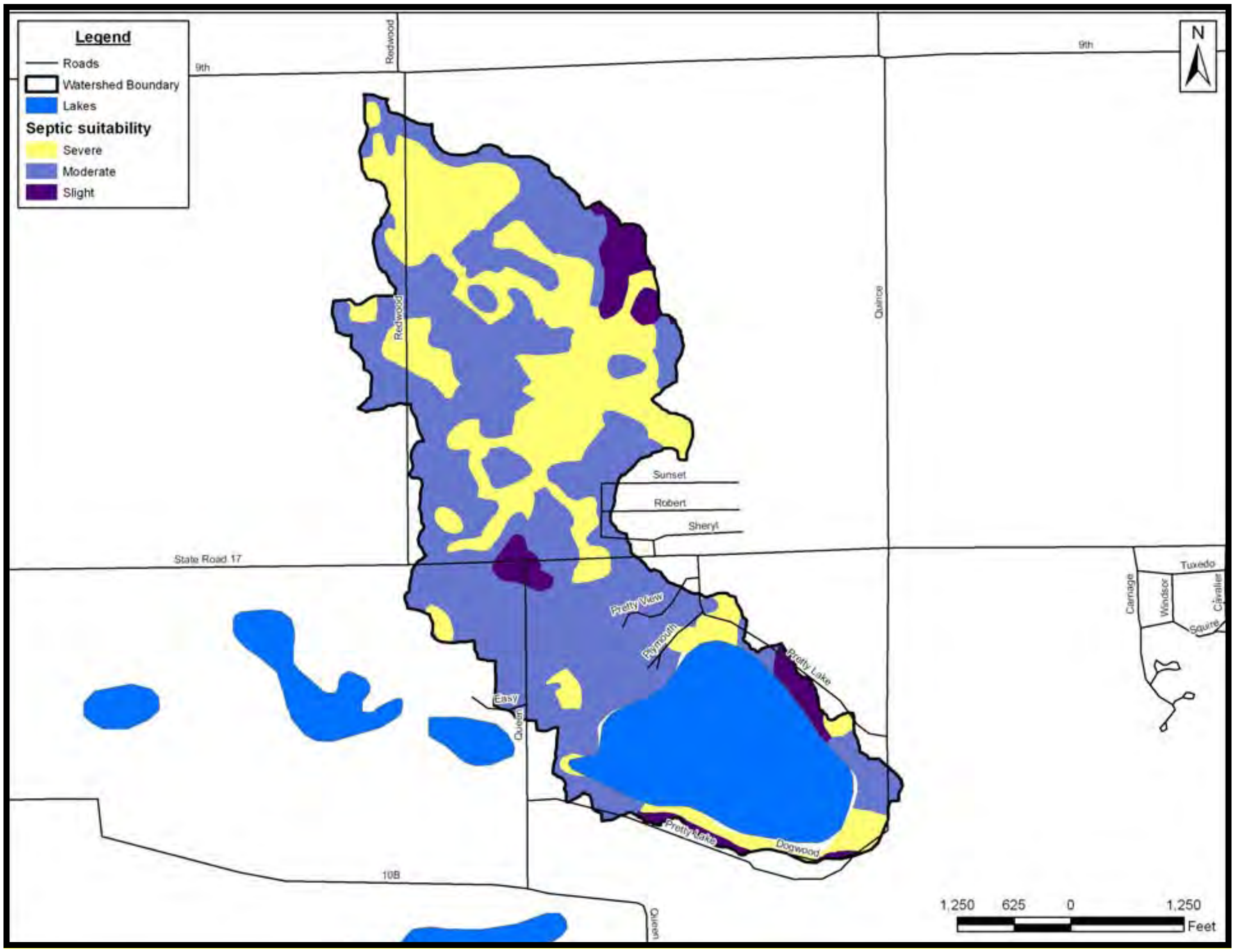

Figure 6. Soil septic tank suitability within the Pretty Lake, Marshall County, Indiana, watershed. Note: Residences directly adjacent to Pretty Lake's shoreline are treated by a sewer system maintained by the regional sewer district**.**

Table 4. Soil types in the Pretty Lake watershed and the features restrictive to their suitability to serve as a septic tank absorption field.

Soil Unit	Soil Name	Depth to High Water Table	Restrictive Features
AuA	Aubbeenaubbee sandy loam	1 to 3 feet	Wetness
Bd	Brady sandy loam	1 to 3 feet	Severe: Wetness, poor filter
Br	Brookston loam	+0.5 to 1.0 feet	Severe: Ponding
ChB, ChC	Chelsea fine sand	>6 feet	Severe: Poor filter
CtA	Crosier loam	1 to 3 feet	Severe: Percs slowly, wetness
Hp	Houghton muck	+2.0 to 0.5 feet	Severe: Ponding, percs slowly
MeA, MeB	Martinsville loam	>6 feet	Slight
MgB	Metea loamy fine sand	>6 feet	Moderate: percs slowly
MgC	Metea loamy fine sand	>6 feet	Moderate: percs slowly, slope
OsA, OsB	Oshtemo loamy sand	>6 feet	Slight
OsC, OsD	Oshtemo loamy sand	>6 feet	Moderate: slope
OwA	Owosso sandy loam	>6 feet	Severe: slope
PsA, PsC	Plainfield sand	>6 feet	Severe: poor filter
Re	Rensselaer loam	+0.5 to 1.0 feet	Severe: ponding, percs slowly
RsA, RsB	Riddles sandy loam	>6 feet	Moderate: percs slowly
RsC2	Riddles sandy loam	>6 feet	Moderate: percs slowly, slope
Wh	Washtenaw silt loam	+0.5 to 1.0 feet	Severe: ponding, percs slowly
WkC2	Wawasee sandy loam	>6 feet	Moderate: slope

2.5 Natural History

Geographic location, climate, topography, geology, soils, and other factors play a role in shaping the native floral (plant) and faunal (animal) communities in a particular area. Various ecologists (Deam, 1921; Petty and Jackson, 1966; Homoya et al., 1985; Omernik and Gallant, 1988) have divided Indiana into several natural regions or ecoregions, each with similar geographic history, climate, topography, and soils. Because the groupings are based on factors that ultimately influence the type of vegetation present in an area, these natural areas or ecoregions tend to support characteristic native floral and faunal communities. Under many of these classification systems, the Pretty Lake watershed lies at or near the transition between two or more regions. For example, the watershed lies at the western boundary separating Homoya's Northern Lakes Natural Area to the east from the Grand Prairie Natural Area to the west. Similarly, the Pretty Lake watershed lies in Omernik and Gallant's Eastern Corn Belt Plains Ecoregion (ECBP) immediately south of the point where the ECBP Ecoregion meets the Central Corn Belt Plains and Southern Michigan/Northern Indiana Till Plains Ecoregions. As a result, the native floral community of the Pretty Lake watershed likely consisted of components of neighboring natural areas and ecoregions in addition to components characteristic of the natural area and ecoregion in which it is mapped.

Homoya et. al (1985) noted that prior to European settlement, the region was a mixture of numerous natural community types including bog, fen, marsh, prairie, sedge meadow, swamp, seep spring, lake and deciduous forest. The dry to dry-mesic uplands were likely forested with red oak, white oak, black oak, shagbark hickory, and pignut hickory. More mesic areas probably harbored beech, sugar maple, black maple, and tulip poplar with sycamore, American elm, red elm, green ash, silver maple, red maple, cottonwood, hackberry, and honey locust dominating the floodplain forests. Historical records support the observation that prior to European settlement of West Township dense oak-hickory forests covered the Pretty Lake watershed (Historic Landmarks Foundation, 1990). Chamberlain (1849) described the area as being heavily timbered with oak openings or barrens covered by wet or dry prairies and lakes. White oak was the dominant component of the heavily timbered areas with shagbark hickory, maple, beech, elm, walnut, butternut, red oak, black oak, and bur oak as subdominants (McDonald, 1908; Petty and Jackson, 1966; Omernik and Gallant, 1988). Petty and Jackson (1966) list pussy toes, common cinquefoil, wild licorice, tick clover, blue phlox, waterleaf, bloodroot, Joe-pye-weed, woodland asters, woodland goldenrods, wild geranium, and bellwort as common components of the forest understory in the watershed's region.

Wet habitat (ponds, marshes, and swamps) intermingled with the upland habitat throughout the northern portion of Pretty Lake's watershed. The hydric soils map and an 1876 map of Marshall County (Baskins, Forster, and Company, 1876) indicate that wetland habitat existed throughout much of the area north of Pretty Lake. These wet habitats supported very different vegetative communities than the drier portions of the landscape. Swamp loosestrife, cattails, soft stem bulrush, marsh fern, marsh cinquefoil, pickerel weed, arrow arum, and sedges dominated the marsh habitat throughout the watershed. Swamp habitat likely covered most or all of the shallow depressions in the watershed. Typical dominant swamp species in the area included red and silver maple, green and black ash, and American elm (Homoya, 1985). Smallwood (1980) adds swamp white oak to the list of dominants in swamp habitat throughout the county.

2.6 Land Use

Just as soils, climate, and geology shape the native communities within the watershed, how the land in a watershed is used can impact the water quality of a waterbody. Different land uses have the potential to contribute different amounts of nutrients, sediment, and toxins to receiving water bodies. For example, Reckhow and Simpson (1980) compiled phosphorus export coefficients (amount of phosphorus lost per unit of land area) for various land uses by examining the rate at which phosphorus loss occurred on various types of land. (The Phosphorus Modeling Section of the report contains more detailed information on this work and its impact on Pretty Lake and its watershed.) Several researchers have also examined the impact of specific urban and suburban land uses on water quality (Bannerman et. al, 1993; Steuer et al., 1997; Waschbusch et al., 2000). Bannerman et al. (1993) and Steuer et al. (1997) found high mean phosphorus concentrations in runoff from residential lawns (2.33 to 2.67 mg/L) and residential streets (0.14 to 1.31 mg/L). These concentrations are well above the threshold at which lakes might begin to experience algae blooms. (Lakes with total phosphorus concentrations greater than 0.03 mg/L will likely experience algae blooms.) Finally, the Center for Watershed Protection has estimated the association of increased levels of impervious surface in a watershed with increased delivery of phosphorus to receiving waterbodies (Caraco and Brown, 2001). Land use directly affects the amount of impervious surface in a watershed. Because of the effect watershed land use has on water quality of the receiving lakes, mapping and understanding a watershed's land use is critical in directing water quality improvement efforts.

2.6.1 Pretty Lake Watershed Land Use

Figure 7 and Table 5 present current land use information for the Pretty Lake watershed. Like many Indiana watersheds, cultivated cropland dominates the Pretty Lake watershed, accounting for approximately 43% of the watershed. Most of the agricultural land in the Pretty Lake watershed and throughout Marshall County (USDA, 2002) is used for growing corn and soybeans. County-wide tillage transect data for Marshall County provides an estimate for the portion of cropland in conservation tillage for the Pretty Lake watershed. In Marshall County, corn producers utilize no-till methods on 11% of corn fields and some form of reduced tillage on 66% of corn fields (IDNR, 2004b). The percentage of corn fields on which no-till methods were used in Marshall County was below the statewide median percentage. Marshall County soybean producers used no-till methods on 36% of soybean fields and some form of reduced tillage on 59% of soybean fields in production (IDNR, 2004a).

Land uses other than agriculture account for the remaining 58% of the watershed. Natural landscapes, including forests and wetland, cover approximately 12.5% of the watershed. Most of the natural acreage in the watershed is associated with the forested uplands and forested and emergent wetland areas north of Pretty Lake. Additional smaller tracts are located adjacent to the lake's eastern and western shorelines. These natural areas consist of small tracts of wooded or emergent wetlands or deciduous forest, and are scattered along the shoreline. Open water, including Pretty Lake accounts for another 18.4% of the watershed. Most of the remaining 26.4% of the watershed is occupied by recreational or parkland, including the golf course and country club, or low intensity residential land. Much of the residential land lies directly adjacent to Pretty Lake.

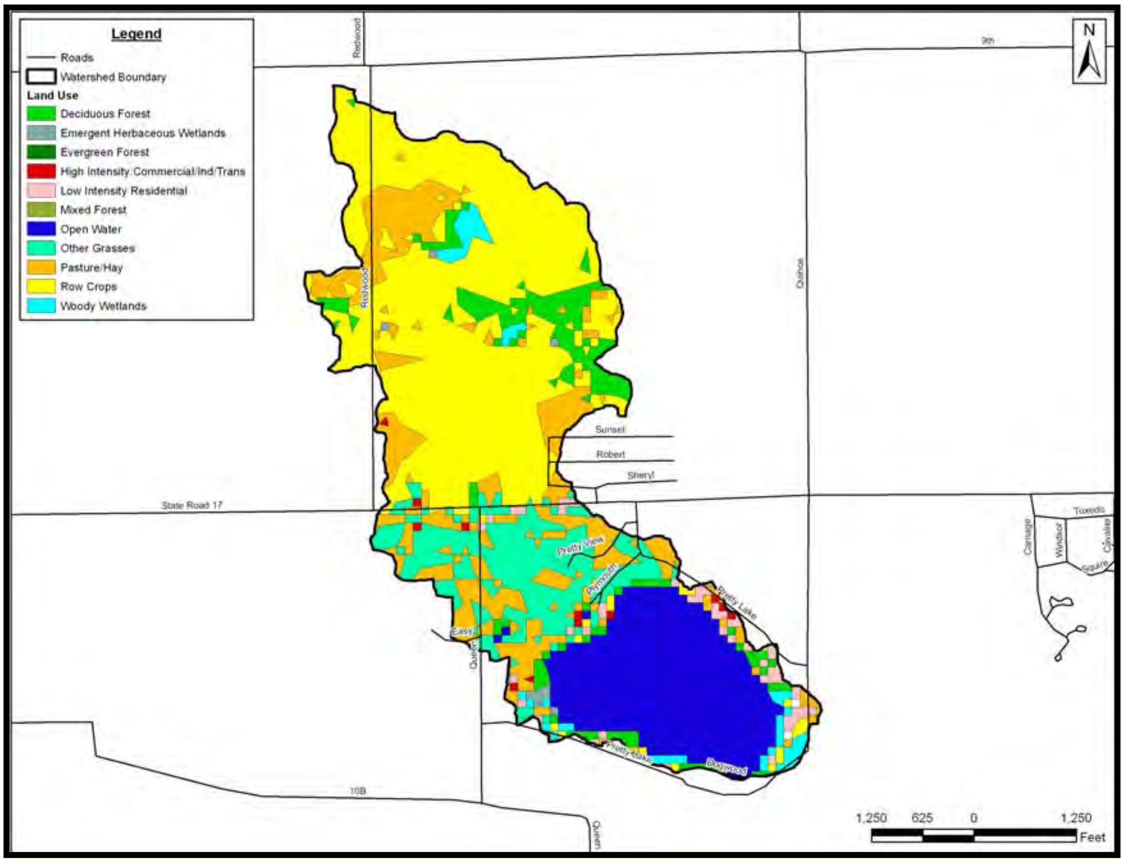

Figure 7. Land use in the Pretty Lake watershed, Marshall County, Indiana.

Table 5. Detailed land use in the Pretty Lake watershed, Marshall County, Indiana.

Land Use	Area (acres)	Area (hectares)	% of Watershed
Cultivated crops	230.1	93.2	42.7%
Developed open space	118.9	48.2	22.1%
Open water	99.4	40.2	18.4%
Deciduous forest	56.2	22.7	10.4%
Developed low intensity	23.2	9.4	4.3%
Grassland/herbaceous	7.4	3.0	1.4%
Emergent herbaceous wetland	4.0	1.6	0.7%
Evergreen forest	0.1	0.1	<0.1%
Entire Watershed	**539.4**	**218.4**	**100.0%**

Impervious surface coverage was calculated by using adapted impervious values for selected land used in Lee and Toonkel (2003), but does not include road surfaces. Impervious surfaces cover approximately 0.02% of the watershed. This estimate of impervious surface coverage is below the threshold at which the Center for Watershed Protection has found an associated decline in water quality. The land uses contributing to the impervious surface coverage in the Pretty Lake watershed are agricultural, residential, and developed parkland structures and parking areas.

2.7 Wetlands

Because wetlands perform a variety of functions in a healthy ecosystem, they deserve special attention when examining watersheds. Functioning wetlands filter sediments and nutrients in runoff, store water for future release, provide an opportunity for groundwater recharge, and serve as nesting habitat for waterfowl and spawning sites for fish. By performing these roles, healthy, functioning wetlands often improve the water quality and biological health of streams and lakes located downstream of the wetlands.

The United States Fish and Wildlife Service's (USFWS) National Wetland Inventory (NWI) Map shows that wetlands cover a 22.1% of the watershed (Figure 8). This is somewhat deceiving as the Lacustrine area (Pretty Lake) makes up 17.8% of the total "wetlands" labeled. Forested and herbaceous wetlands cover approximately 3.8% of the watershed. The largest contiguous tracts of wetland habitat lie north of State Road 17 in the northern portion of Pretty Lake's watershed. Ponds account for the remaining wetland acreage (0.5%).

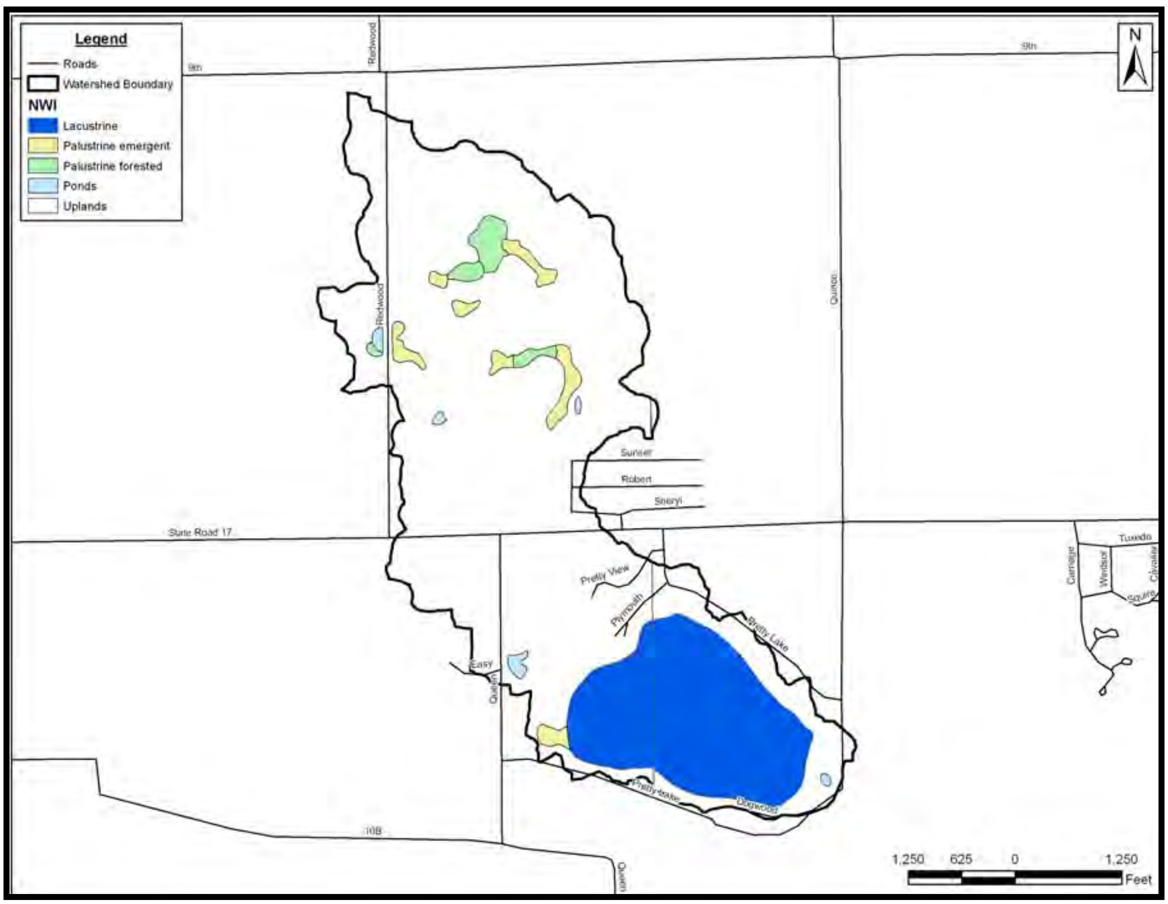

Figure 8. National wetland inventory (USFWS) in the Pretty Lake watershed, Marshall County, Indiana.

Table 6. Acreage and classification of wetland habitat in the Pretty Lake watershed.

Wetland Type	Area (acres)	Area (hectares)	Percent of Watershed
Lacustrine	95.7	38.7	17.8%
Palustrine emergent	12.4	5.0	2.3%
Palustrine forested	8.2	3.3	1.5%
Ponds	2.7	1.1	0.5%
Total	**119.0**	**48.1**	**22.1%**

Source: National Wetlands Inventory.

The USFWS NWI data differ in their estimate of wetland habitat acreage in the watershed from the USGS data presented in Figure 9. The primary difference between the NWI and the Land Cover Data sets is the acreage of emergent wetland. The USFWS reports over 12 acres of emergent wetland habitat exists in the Pretty Lake watershed compared to 4 acres of emergent wetland habitat reported by the USGS. The difference in reported wetland acreage is due to the differences in project goals and methodology used by the different agencies to collect land use data. The USGS land use data does not distinguish weather a forested area is wet or dry, and often does not distinguish whether grassland is upland or wetland, therefore it tends to under report wetland acreage.

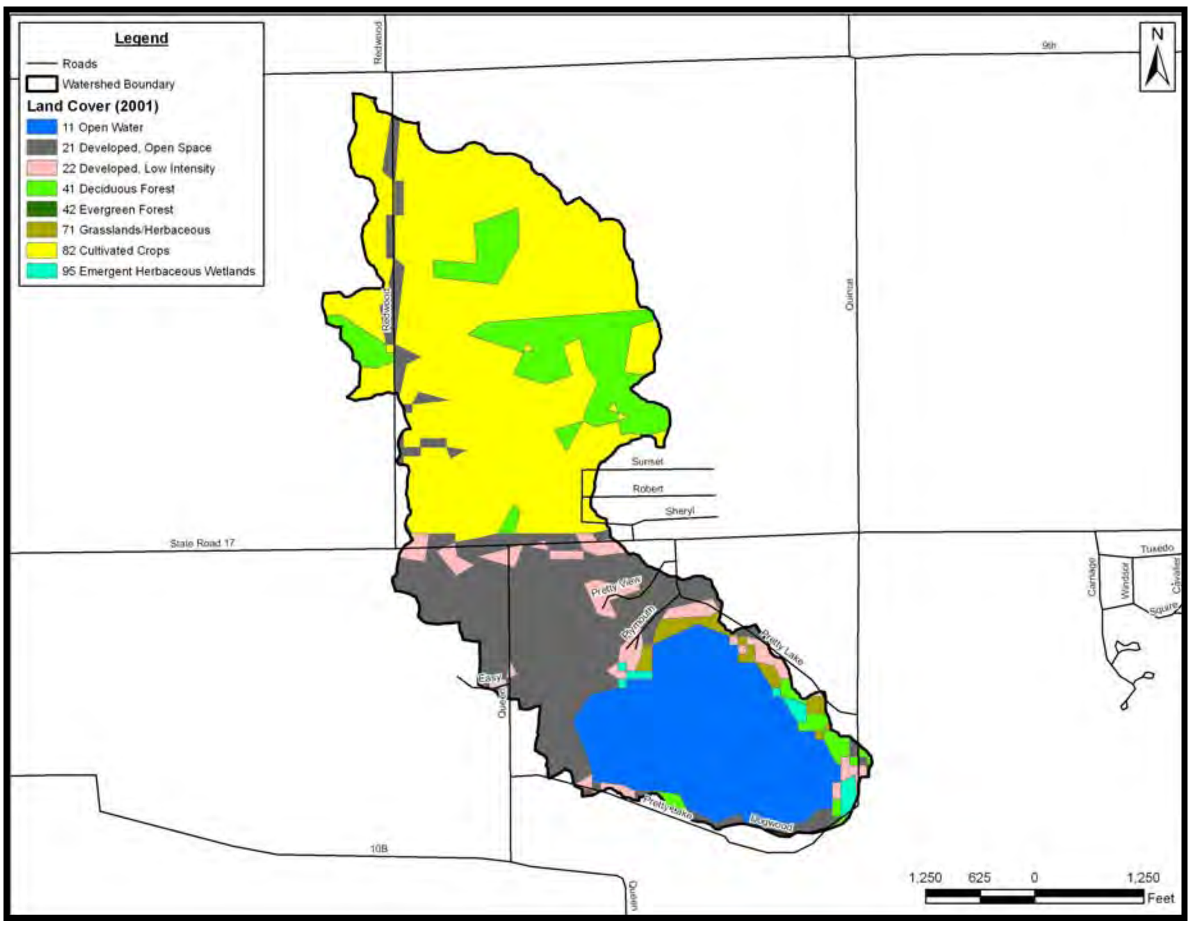

Figure 9: Land cover data from USGS in the Pretty Lake watershed, Marshall County, Indiana.

The U.S. Fish and Wildlife Service estimates an average of 2.6% of the nation's wetlands were lost annually from 1986 to 1997 (Zinn and Copeland, 2005). The IDNR estimates that approximately 85% of the state's wetlands have been filled (IDNR, 1996). The greatest loss has occurred in the northern counties of the state such as Marshall County. The last glacial retreat in these northern counties left level landscapes dotted with depressions that formed wetland and lake complexes. Development of the land in these counties for agricultural purposes altered much of the natural hydrology, eliminating many of the wetlands.

Development within the Pretty Lake watershed has undoubtedly reduced wetland acreage in the watershed as well. Hydric soils, which formed under wetland conditions, cover large areas of the watershed north of State Road 17 (Figure 10). Areas mapped in the wettest of hydric soils, such as Houghton muck, have largely remained undeveloped. Overall, hydric soils cover approximately 78.6 acres (31.8 ha or 17%) of the Pretty Lake watershed. When compared to the acreage of wetland mapped by the USFWS NWI map (20 acres or 8.1 ha), more than 73.8% of wetlands have been lost in the Pretty Lake watershed.

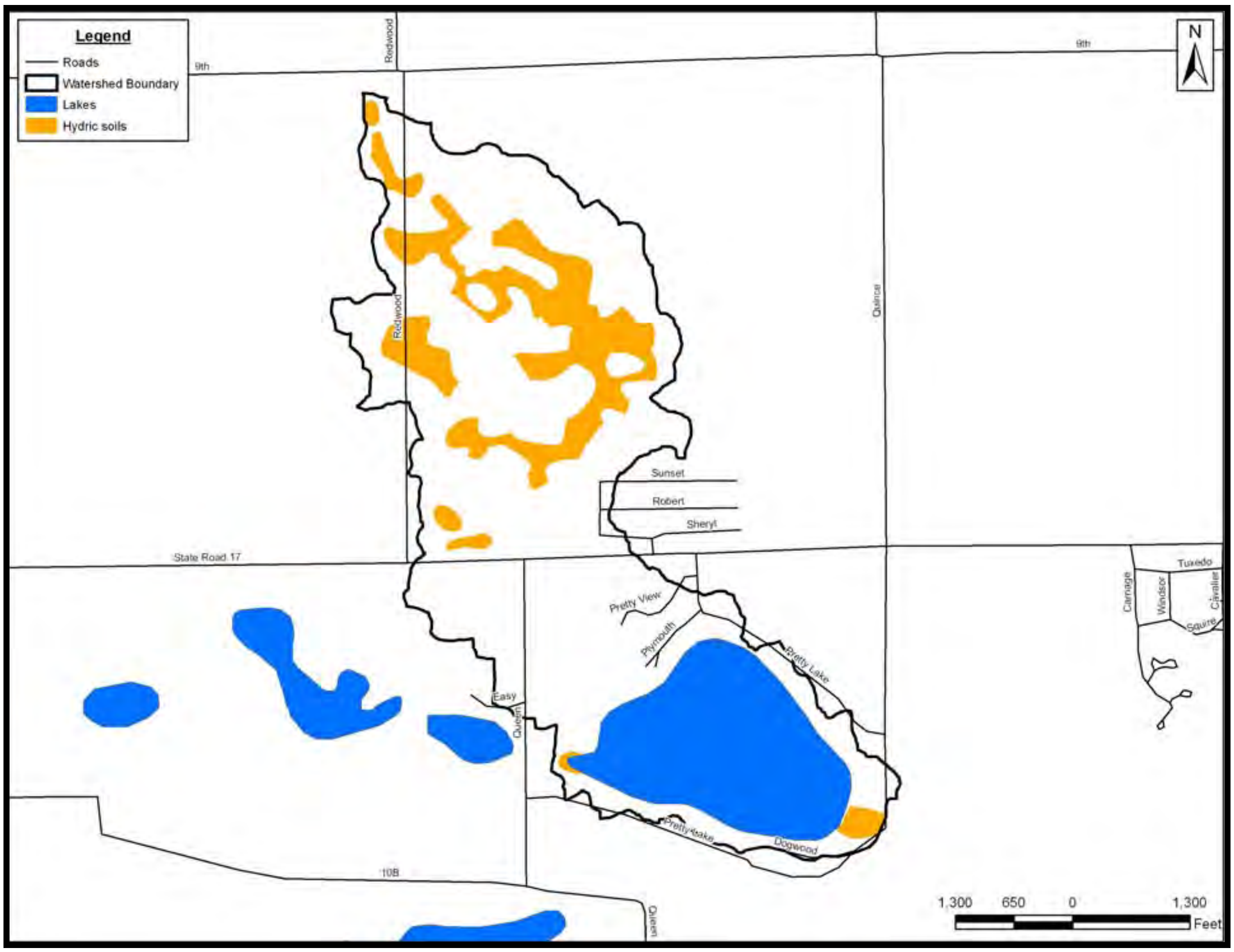

Figure 10. Hydric soils in the Pretty Lake watershed, Marshall County, Indiana.

2.8 Natural Communities and Endangered, Threatened, and Rare Species

The Indiana Natural Heritage Data Center database provides information on the presence of endangered, threatened, or rare species (ETR); high quality natural communities; and natural areas in Indiana. The IDNR developed the database to assist in documenting the presence of special species and significant natural areas and to serve as a tool for setting management priorities in areas where special species or habitats exist. The database relies on observations from individuals rather than systematic field surveys by the IDNR. Because of this, it does not document every occurrence of special species or habitat. At the same time, the listing of a species or natural area does not guarantee that the listed species is present or that the listed area is in pristine condition. To assist users, the database includes the date that the species or special habitat was last observed in a specific location. The following definitions clarify the labeling associated with this documentation.

- *Endangered*: Any species whose prospects for survival or recruitment with the state are in immediate jeopardy and are in danger of disappearing from the state. This includes all species classified as endangered by the federal government which occur in Indiana. Plants known to occur currently on five or fewer sites in the state are considered endangered.
- *Threatened*: Any species likely to become endangered within the foreseeable future. This includes all species classified as threatened by the federal government which occur in Indiana. Plants known to occur currently on six to ten sites in the state are considered threatened.
- *Rare*: Plants and insects known to occur currently on from eleven to twenty sites.

The results from the database search for the Pretty Lake watershed include a listing of the ETR species documented in Marshall County (Appendix A). The Indiana Natural Heritage Data Center database does not contain any records for the area encompassed by the Pretty Lake watershed. However, Marshall County supports a variety of endangered, threatened, and rare animals and plants as detailed by the Indiana Natural Heritage database listing for Marshall County, which was last updated in 2005. The listed animals include seven freshwater mussels (slippershell mussel, wavy-rayed lampmussel, black sandshell, round hickorynut, clubshell, kidneyshell, and purple lilliput), six reptiles (spotted turtle, Blanding's turtle, ornate box turtle, Butler's garter snake, Kirtland's snake, and eastern massasauga), and three fish (Ohio lamprey, cisco, and greater redhorse). More than ten birds and two mammals (Franklin's ground squirrel and American badger) have been documented in Marshall County. Fourteen plant species, many of which are hydrophytic (wetland or aquatic species), are also included in the database for Marshall County. The county also supports five high quality communities including mesic prairie, marl beach, acid bog, fen, and muck flats (but not within the Pretty Lake watershed).

2.9 State Owned Land and Easements

The State of Indiana DNR owns several hundred acres east and west of Pretty Lake but does not own any land adjacent to the lake or within the Pretty Lake watershed. The only public land within the watershed is the State Road 17 Right-of-Way and the county road easements. There is one public right-of-way easement (20 feet or 6 m wide) on the east end of the lake off Quince Road that is currently blocked. Public access to Pretty Lake has been through a fee only private access adjacent to this public right-of-way. Additional access has recently been created on the Country Club Property on the north side of the lake for use by members of the Association.

3.0 PRETTY LAKE DESCRIPTION AND HISTORICAL INFORMATION

3.1 Morphology

Figure 11 presents Pretty Lake's morphology. The lake is roughly triangular in shape and consists of relatively uniform gradients from the shoreline to a depth of 30 feet (9.1 m). Two deeper basins are separated by a sunken island in the center of the lake. The lake's deepest basin (40 feet or 12.2 m) lies slightly southeast of the center of the 97-acre (39.2-ha) lake. The other deep basin, which reaches 35 feet (10.7 m) in depth, lies in the southwestern portion of the lake. The sunken island in the center of the lake rises to within 5 feet (1.5 m) of the surface and is surrounded by water depths of 30 feet (9.1m).

Pretty Lake has a limited expanse of shallow water. According to its depth-area curve (Figure 12), nearly 22 acres (8.9 ha) of the lake is covered by water less than 5 feet (1.5 m) deep, while nearly 38 acres (15.4 ha) is covered by water less than 20 feet (6.1 m) deep. The shoal or drop-off between the shallow water and the deep water covers 16 acres (6.5 ha) of the lake. This translates into a very low shallowness ratio of 0.22 (ratio of area less than 5 feet deep to total lake area) and a moderately high shoalness ratio of 0.39 (ratio of area less than 20 feet deep to total lake area) (Table 7), as defined by Wagner (1990). A large portion of the lake's acreage (approximately 60 acres or 18.3 ha) has water deeper than 20 feet (6.1 m).

Pretty Lake holds approximately 2,103 acre-feet (2,594,012 m^3) of water. As illustrated in the depth-volume curve (Figure 13), most of the lake's volume is contained in the shallower areas of the lake. More than 70% of the lake's volume is contained in water that is less than 30 feet (9.1 m) deep. The lake's volume gradually increases with depth to a water depth of about 30 feet (9.1 m) before the rate of change increases. Below 30 feet (9.1 m), the steep curve indicates a greater change in depth per unit volume. This rate continues to the lakes maximum depth. The importance of this rate of increase will be discussed with regard to light penetration and the planktonic community in the **Discussion section**.

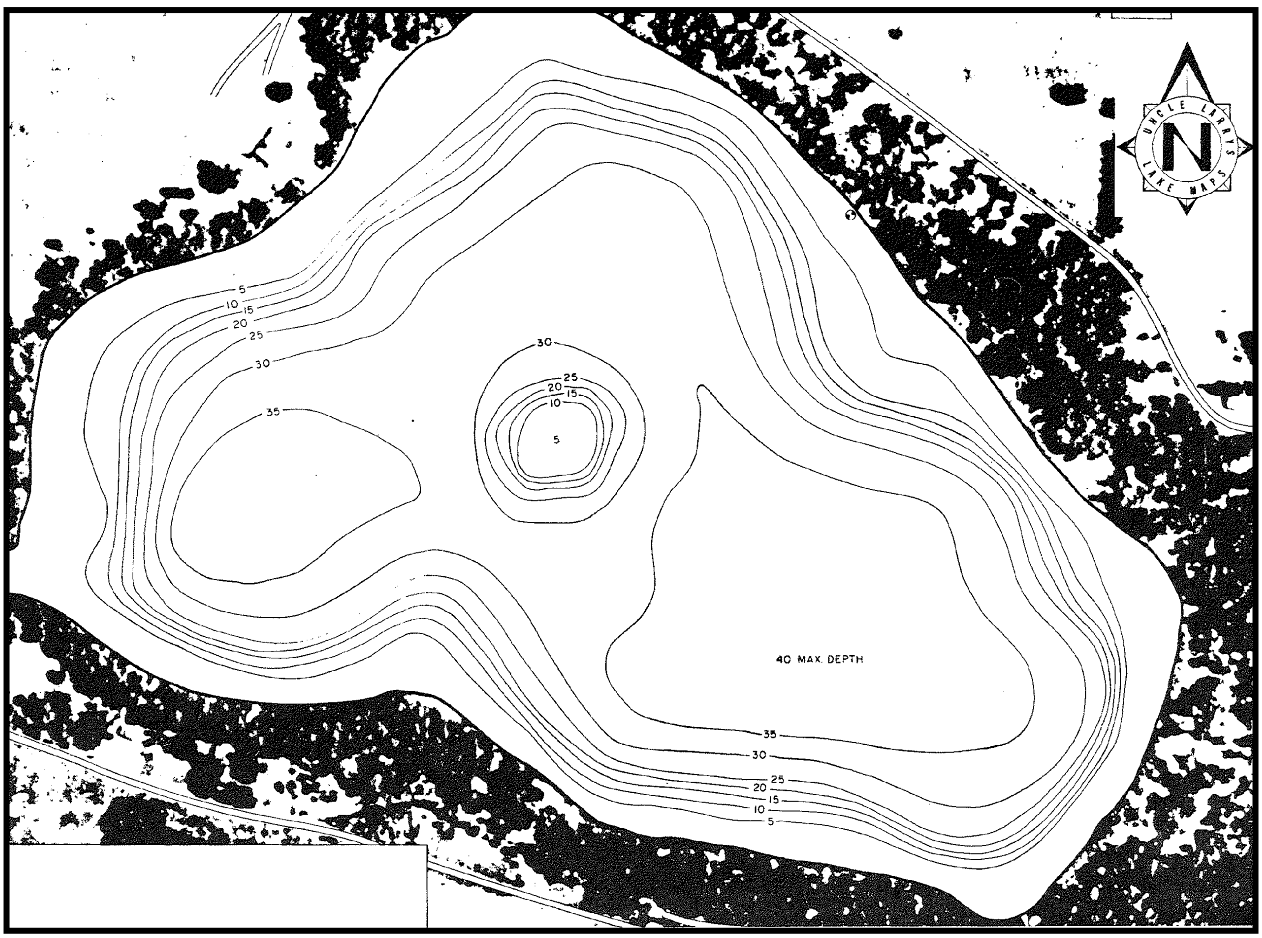

Figure 11. Pretty Lake bathymetric map. Source: Uncle Larry's Lake Maps (2000).

Table 7. Morphological characteristics of Pretty Lake.

Characteristic	Value
Surface Area	97 acres (39.2 ha)
Volume	**2,103 acre-feet (2,594,012 m^3)**
Maximum Depth	40 feet (12.2 m)
Mean Depth	21.7 feet (6.6 m)
Shallowness Ratio	0.22
Shoalness Ratio	0.39
Shoreline Length	8,720 feet (2,657.8 m)
Shoreline Development Ratio	1.2

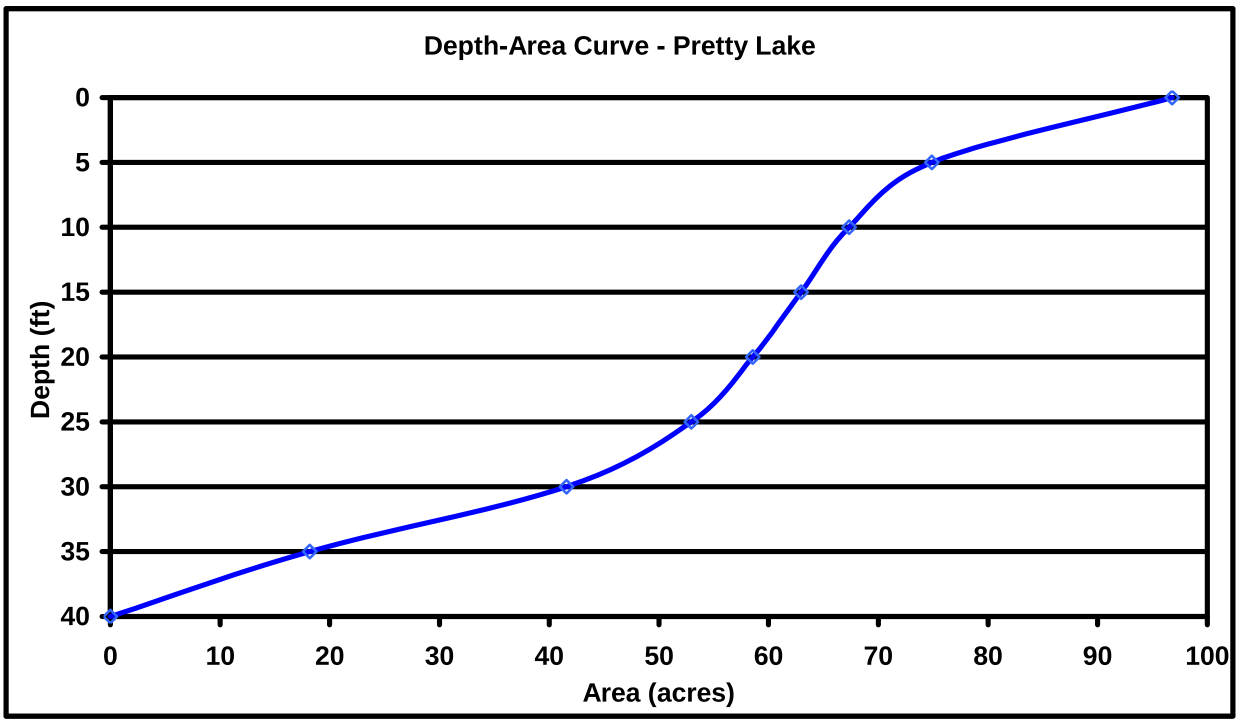

Figure 12. Depth-area curve for Pretty Lake, Marshall County, Indiana.

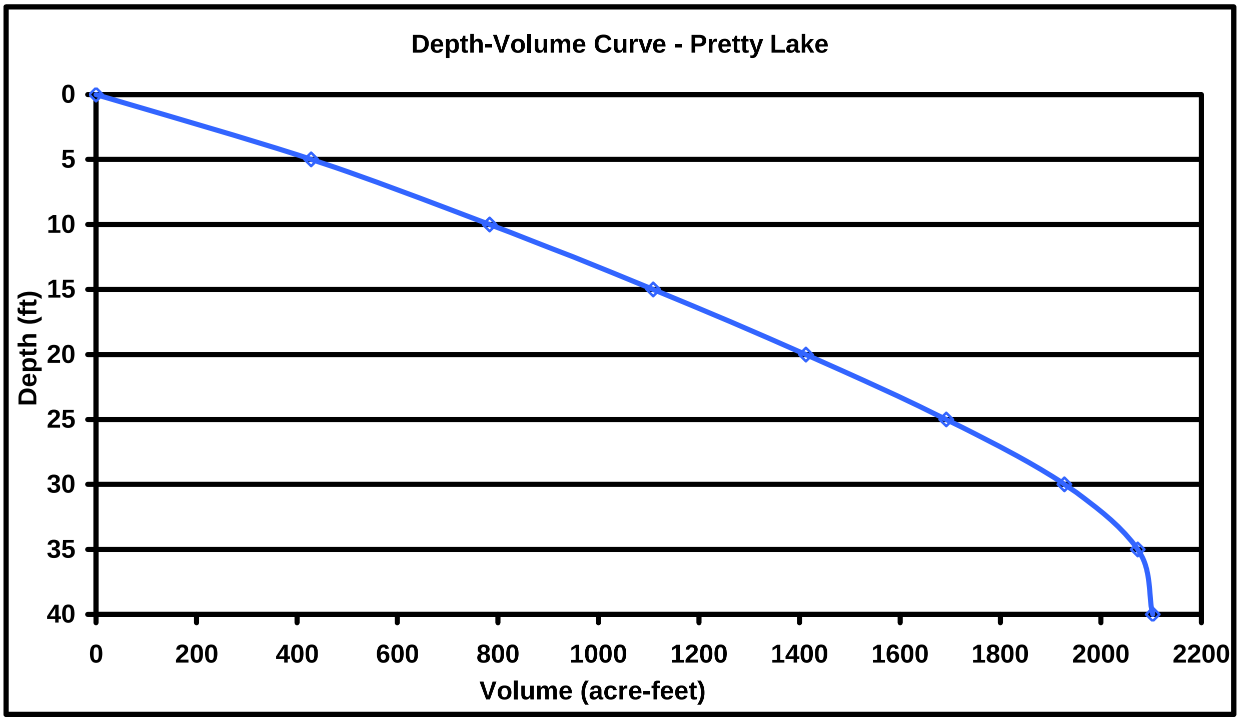

Figure 13. Depth-volume curve for Pretty Lake, Marshall County, Indiana.

A lake's morphology can play a role in shaping the lake's biotic communities. For example, Pretty Lake's moderately sized shallow area and wide, shallow shelf around much of the perimeter of the lake coupled with its better than average clarity suggests the lake is capable of supporting a quality rooted plant community. Based on the lake's average clarity (16.5 feet or 5.0 m), Pretty Lake's littoral zone (or the zone capable of supporting aquatic rooted plants and calculated by multiplying the transparency by a factor of three) could extend from the shoreline to a point past the maximum depth of the lake. The lake's 1% light level (or the depth at which only 1% of available surface light penetrates) may be a more realistic measure of the potential area for aquatic plants than the above method. Using the 1% light level, Pretty Lake's littoral zone reaches a depth of 16 to 24 feet (4.8 to 7.3 m) and covers 33 to 43 acres (13.4 to 17.4 ha) or 34 to 44% of the lakes surface area. This size littoral zone can impact other biotic communities in the lake such as fish that use the plant community for forage, spawning, cover, and resting habitat. Only a limited portion of Pretty Lake's surface has aquatic plant growth.

A lake's morphology can also influence water quality by influencing shoreline development. The shoreline development ratio is a measure of the development potential of a lake. It is calculated by dividing a lake's shoreline length by the circumference of a circle that has the same area as the lake. A perfectly circular lake with the same area as Pretty Lake (97 acres or 39.2 ha) would have a circumference of 7,286 feet (2,220 m). Dividing Pretty Lake's shoreline length (8,720 feet or 2,657 m) by 7,286 feet yields a ratio of 1.2:1. This ratio is relatively low due to the lack of valleys and artificial channeling observed on other popular Indiana lakes (see Figure 14) and the fact that the topography around the lake is fairly level (there are no deep bays associated with valley drainages into the lake). Given the immense popularity of lakes in northern Indiana, high shoreline development ratios are often highly developed with homes. Increased development around lakes often leads to decreased water quality. Since the shoreline development ratio is low for Pretty Lake, the potential negative impacts on water quality from lakeshore development are limited. Along with the low watershed to lake area ratio, the low human development of the shoreline helps explain why Pretty Lake's water quality is better than the majority of Indiana Lakes.

Figure 14. Aerial photograph of Pretty Lake, Marshall County, Indiana, circa spring 2005.

3.2 Shoreline Development and Erosion Issues

Development around Pretty Lake began early and by 1908, approximately 40 cottages were located around Pretty Lake (Wenino, 1997, Appendix B). A map drawn in 1927 showed 63 owners most of which were on the north and east side of the lake. By 1997, 96 cottages or owners were located along the north, east, and southern shorelines. Virtually all of the potentially developable shoreline has been developed for residential use at this time, with the exception of the frontage owned by the Plymouth Country Club on the west end of the lake.

Figure 15. Natural shoreline present along Pretty Lake's western shoreline.

Natural shoreline remains along approximately 40% of Pretty Lake's shoreline (3,460 feet or 1,055 m) where bands of aquatic and terrestrial vegetation are present (Figure 15). In these areas, the submerged, floating, emergent, and shoreline canopy layers all remain intact. The importance of a natural shoreline is discussed further in the aquatic macrophyte section of this report. The natural shoreline is especially important adjacent to shallow areas of Pretty Lake.

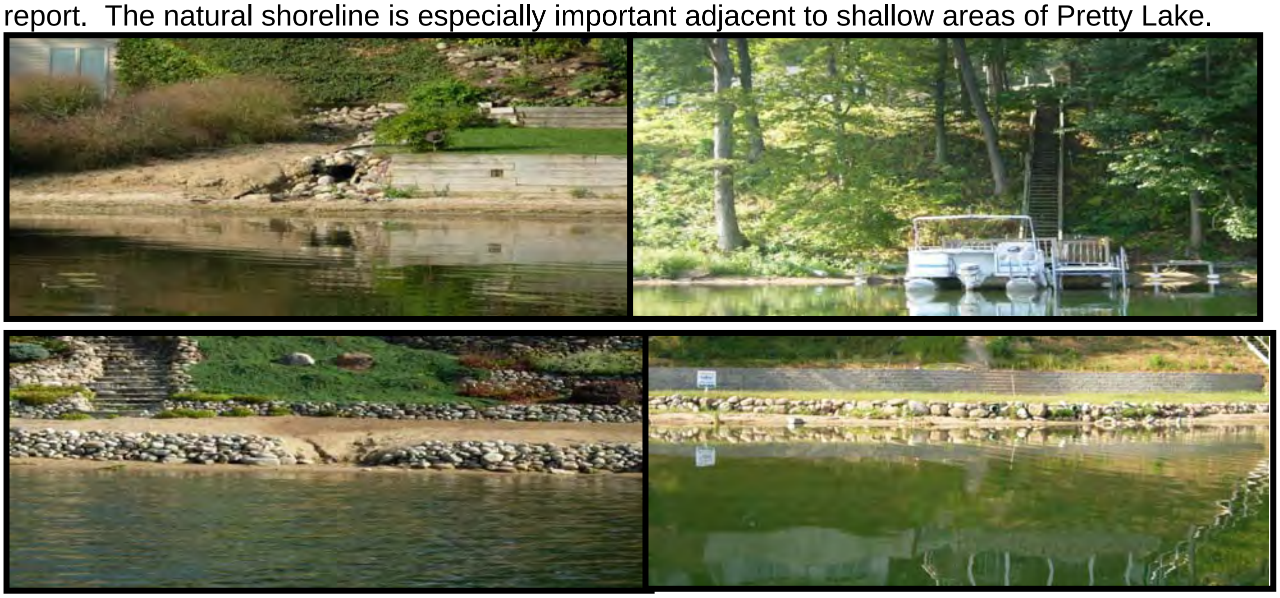

Figure 16. Moderate shoreline modifications observed at Pretty Lake.

Property owners typically modify their shorelines to reduce erosion or provide better lake access (Figure 16). Typical modifications include the removal of herbaceous vegetation from the waters edge and within the shallow water zone as well as protecting the immediate shoreline with rock or adding sand and gravel beaches. When the aquatic vegetation is removed the shoreline is less buffered from wave action and usually begins to erode. Placing rocks along the shoreline usually protects the shoreline in most areas and still allows for biotic interaction between the terrestrial and aquatic environment. The spaces in the rocks allow invertebrates to flourish, which serve as a food source for young fish. The spaces themselves also serve as refugia for the young fish when the rocks are under water. Approximately 32 percent (2780 feet or 847 m) of the Pretty Lake shoreline has been modified in some manner and approximately 10 percent of this modified shoreline remains to be protected from existing erosion issues.

Figure 17. Severely modified shorelines along Pretty Lake's shoreline.

In areas where concrete seawalls are present (Figure 17), waves from wind and boats strike the flat surface and reflect back into the lake. This creates an almost continuous turbulence in the shallow areas of the lake when boats are active or the wind is strong. When the waves reflect back into the lake and meet incoming waves, the wave height increases resulting in additional in-lake turbulence. This turbulence resuspends bottom sediments thereby increasing the transfer of nutrients from the sediment-water interface to the water column. Continuous disturbance in shallow areas can also encourage the growth of disturbance-oriented plants. Alternatively, shorelines vegetated with emergent or rooted floating vegetation will absorb more of the wave energy created by wind or boats. In these locations, wave energy will dissipate along the shoreline each time a wave reaches shallow water.

Approximately 22 percent (2,480 feet or 756 m) of Pretty Lake's shoreline has been severely modified to eliminate the natural transition from land to water. This percentage is lower than other Indiana Lakes; however, continuing this trend will result in decreased water clarity and quality.

Figure 18. Pretty Lake Shoreline erosion areas.

3.3 Macrophyte Inventory

3.3.1 Methods and Results

Aquatic Control (2007) conducted Tier I and Tier II inventories (IDNR protocol) of the aquatic vegetation during 2006 for the development of a five year Aquatic Vegetation Management Plan. Nineteen species were documented in the lake and were found within the entire littoral zone to a maximum depth of 23 feet (Aquatic Control, 2007). Eurasian watermilfoil was found at 87 percent of the sites sampled in the Tier II survey during August of 2006. Due to the extensive establishment of milfoil, Aquatic Control recommended a whole lake fluridone treatment during 2007 to eradicate this invasive and non-native plant. Curly-leaf pondweed and purple loosestrife were also documented and recommended for removal. The Fluridone treatment was not funded in 2007 as recommended. Aquatic Control did treat small areas of the lake with contact herbicides in order to relieve nuisance conditions for the short-term, which was funded by individual homeowners (Nathan Long, Personal communication). According to Mr. Long, there were no official surveys, with the exception of the treatment report completed for permit requirements.

During the late summer of 2008, JFNew found that between 40 and 50 percent of the shoreline had purple loosestrife present or was dominated by this invasive species. In 2008, Aquatic Control completed invasive species sampling in the early spring prior to fluridone treatment. A Tier II survey was completed in late summer. The spring survey documented 5.3 acres of Eurasian watermilfoil and curly-leaf pondweed was documented as occurring in 3.3 acres (Aquatic Control, unpublished data). Following the fluridone treatment in summer of 2008, the

Tier II survey conducted in late August documented seven species (all natives) of which the most dominant was eel grass (Aquatic Control, unpublished data). Aquatic Control also documented the presence of the ETR species, Richardson's pondweed in Pretty Lake for the first time (Aquatic Control, unpublished data). According to Aquatic Control, the fluridone treatment worked well to eliminate Eurasian watermilfoil but may have adversely affected five species of native plants including bur marigold (a state listed ETR species). There should be a concerted effort by the property owners and their contracted aquatic vegetation applicator to conserve and promote the native species present including Richardson's pondweed and bur marigold. Annual surveys for these species are recommended.

3.3.2 Discussion

There are many reasons to conduct an aquatic rooted plant survey as part of a complete assessment of a lake and its watershed. Like other biota in a lake ecosystem (e.g. fish, microscopic plants and animals, etc.), the composition and structure of the lake's rooted plant community often provide insight into the long term water quality of a lake. While sampling the lake water's chemistry (dissolved oxygen, nutrient concentrations, etc.) is important, water chemistry sampling offers a single snapshot of the lake's condition. Because rooted plants live for many years in a lake, the composition and structure of this community reflects the water quality of the lake over a longer term. For example, if one samples the water chemistry of a typically clear lake immediately following a major storm event, the results may suggest that the lake suffers from poor clarity. However, if one examines the same lake and finds that rooted plant species such as northern watermilfoil, white stem pondweed, and large-leaf pondweed, all of which prefer clear water, dominate the plant community, one is more likely to conclude that the lake is typically clear and its current state of turbidity is due to the storm rather than being its inherent nature.

The composition and structure of a lake's rooted plant community also help determine the lake's fish community composition and structure. Submerged aquatic vegetation provides cover from predators and is a source of forage for many different species of fish (Valley et al., 2004). However, extensive and dense stands of exotic aquatic vegetation can have a negative impact on the fish community. For example, a lake's bluegill population can become stunted because dense vegetation reduces their foraging ability, resulting in slower growth. Additionally, dense stands reduce predation by largemouth bass and other piscivorous fish on bluegill which results in increased intraspecific competition among both prey and predator species (Olsen et al., 1998). Vegetation removal can have variable results on improving fish growth rates (Cross et al., 1992, Olsen et al., 1998). Conversely, lakes with depauperate plant communities may have difficulty supporting some top predators that require emergent vegetation for spawning. In these and other ways, the lake's rooted plant community illuminates possible reasons for a lake's fish community composition and structure.

A lake's rooted plant community impacts the recreational uses of the lake. Swimmers and power boaters desire lakes that are relatively plant-free, at least in certain portions of the lake. In contrast, anglers prefer lakes with adequate rooted plant coverage, since those lakes offer the best fishing opportunity. Before lake users can develop a realistic management plan for a lake, they must understand the existing rooted plant community and how to manage that community. This understanding is necessary to achieve the recreational goals lake users may have for a given lake.

For the reasons outlined above, as well as several others, JFNew conducted a general macrophyte (rooted plant) survey on Pretty Lake as part of the overall lake and watershed diagnostic study. Before detailing the results of the macrophyte survey, it may be useful to outline the conditions under which lakes may support macrophyte growth. Additionally, an understanding of the roles that macrophytes play in a healthy, functioning lake ecosystem is necessary for lake users to manage the lake's macrophyte community. The following paragraphs provide some of this information.

Conditions for Growth

Like terrestrial vegetation, aquatic vegetation has several habitat requirements that need to be satisfied in order for the plants to grow or thrive. Aquatic plants depend on sunlight as an energy source. The amount of sunlight available to plants decreases with depth of water as algae, sediment, and other suspended particles block light penetration. Consequently, most aquatic plants are limited to maximum water depths of approximately 10-15 feet (3-4.5 m), but some species, such as Eurasian watermilfoil, have a greater tolerance for lower light levels and can grow in water deeper than 32 feet (10 m) (Aiken et al., 1979). Hydrostatic pressure rather than light often limits plant growth at deeper water depth (15-20 feet or 4.5-6 m).

Water clarity affects the ability of sunlight to reach plants, even those rooted in shallow water. Lakes with clearer water have an increased potential for plant growth. Pretty Lake possesses better water clarity than the average Indiana lake. The Secchi disk depth measured during the July 21, 2008 sampling was 8.9 feet (2.7 m). This measurement was significantly poorer than previous measurements (12.2 feet or 3.7 m) taken during Clean Lakes Program sampling in 1989, 1995, 1999, and 2004. As a general rule of thumb, rooted plant growth is restricted to the portion of the lake where water depth is less than or equal to 2 to 3 times the lake's Secchi disk depth. This holds mostly true in Pretty Lake, where rooted plants were observed in water to a depth of approximately 23 feet (7 m), which is more than two times the lake's average Secchi disk depth.

Aquatic plants also require a steady source of nutrients for survival. Many aquatic macrophytes differ from microscopic algae (which are also plants) in their uptake of nutrients. Aquatic macrophytes receive most of their nutrients from the sediments via their root systems rather than directly utilizing nutrients in the surrounding water column. Some competition with algae for nutrients in the water column does occur. The amount of nutrients taken from the water column varies for each macrophyte species. Because macrophytes obtain most of their nutrients from the sediments, lakes which receive high watershed inputs of nutrients to the water column will not necessarily have aquatic macrophyte problems.

A lake's substrate and the forces acting on the substrate also affect a lake's ability to support aquatic vegetation. Lakes that have organic, nutrient-rich (mucky) substrates have an increased potential for plant growth compared to lakes with gravel or rocky substrates. Sandy substrates that contain sufficient organic material typically support healthy aquatic plant communities. Lakes that have significant wave action that disturb the bottom sediments have decreased ability to support plants. Disturbance of bottom sediment may decrease water clarity, limiting light penetration, or may affect the availability of nutrients for the macrophytes. Wave action may also create significant shear forces prohibiting plant growth altogether.

Boating activity may affect macrophyte growth in conflicting ways. Rooted plant growth may be limited if boating activity regularly disturbs bottom sediments. Alternatively, boating activity in rooted plant stands of species that can reproduce vegetatively, such as Eurasian watermilfoil or coontail, may increase macrophyte density rather than decrease it. Herbicide treatment can also affect the presence and distribution of aquatic macrophytes within a lake. As species or areas are selectively treated, the density and diversity of plant present within those locations can, and typically do change. For example, continuing to treat a specific plant bed which contains Eurasian watermilfoil can result in the disappearance of Eurasian watermilfoil and the resurgence of a variety of native species. It should be noted, however, that non-native plants can regrow in these locations just as easily as native plants.

Ecosystem Roles
Aquatic plants are a beneficial and necessary part of healthy lakes. Plants stabilize shorelines holding bank soil with their roots. The vegetation also serves to dissipate wave energy, further protecting shorelines from erosion. Plants play a role in a lake's nutrient cycle by up-taking nutrients from the sediments. Like their terrestrial counterparts, aquatic macrophytes produce oxygen which is utilized by the lake's fauna. Many aquatic plants also produce flowers and unique leaf patterns that are aesthetically attractive.

Emergent and submerged plants provide important habitat for fish, insects, reptiles, amphibians, waterfowl, shorebirds, and small mammals. Fish utilize aquatic vegetation for cover from predators and for spawning and rearing grounds. Different species depend upon different percent coverages of these plants for successful spawning, rearing, and protection for predators. For example, bluegill require an area to be approximately 15-30% covered with aquatic plants for successful survival, while northern pike achieve success in areas where rooted plants cover 80% or more of the area (Borman et al., 1997).

Aquatic vegetation also serves as substrate for aquatic insects, the primary diet of insectivorous fish. Waterfowl and shorebirds depend on aquatic vegetation for nesting and brooding areas. Aquatic plants such as pondweed, coontail, duckweed, watermilfoil, and arrowhead, also provide a food source to waterfowl. Duckweed in particular has been noted for its high protein content and consequently has served as feed for livestock. Turtles and snakes utilize emergent vegetation as basking sites. Amphibians rely on the emergent vegetation zones as primary habitat.

3.4 Fisheries

A general fisheries survey was conducted by Rick Peterson on Pretty Lake in 1968 for the IDNR. The results of that survey are presented in Table 8. No subsequent surveys have been competed since that time because the public does not have good access to the lake. There has been only a private fee for access site at the east end of the lake to date.

Table 8: Results of fish sampling conducted by IDNR 1968 (Robertson, 1969).

Common Name	Scientific Name	#	%
Bluegill	*Lepomis macrochirus*	727	45.0%
Black Crappie	*Pomoxis nigromaculatus*	5	0.3%
Brook Silverside	*Labidesthes sicculus*	Abundant	
Brown Bullhead	*Ameiurus nebulosus*	57	3.5%
Grass Pickerel	*Esox americanus vermiculatus*	27	1.7%
Lake Chubsucker	*Erimyzon sucetta*	56	3.5%
Largemouth Bass	*Micropterus salmoides*	54	3.3.%
Longear Sunfish	*Lepomis megalotus*	40	2.5%
Pumpkinseed	*Lepomis gibbosus*	18	1.1%
Redear Sunfish	*Lepomis microlophus*	241	14.9%
Walleye	*Sander vitreum*	2	0.1%
Warmouth	*Lepomis gulosus*	179	11.1%
Yellow Bullhead	*Ameiurus natalis*	204	12.6%
Yellow Perch	*Perca flavescens*	5	0.3%
Total # Collected		**1615**	
Number Species		**14**	

The 1968 survey of Pretty Lake collected 14 species of fish (Robertson, 1969). Bluegill were the most abundant fish species collected by number (45%), followed by redear sunfish (15%), yellow bullhead (13%), and warmouth sunfish (11%). Sunfish species accounted for 75% the fish sampled by number. Bluegill exhibited below average growth and above average condition (length to weight relationship) in individuals up to 6.5 inches (16.5 cm) and below average condition in individuals over 6.5 inches (16.5 cm).

Proportional stock density (PSD) is an easily calculated statistic used by fisheries biologists to investigate balance within a species population. The PSD is generally applicable to water bodies less than 500 acres (Anderson 1976). PSD relates the number of individuals in a population stock size or larger to the number of those individuals that are of quality size or larger. Stock size is generally defined as the minimum size a species becomes available to anglers, while quality size is generally defined as the minimum size anglers consider the species harvestable. Generally, PSDs indicative of balance in a target species population are based on sustainable harvest of sizes preferred by anglers (Hubert and Kohler, 1999). Therefore, balance depends on the density of fish of various sizes in the population; both adequate numbers of catchable size fish and sufficient numbers of smaller fish to provide replacement (Hubert and Kohler, 1999). Ranges of PSD values indicating balanced populations have been developed for a number of different fish species. A balanced bluegill population and other sunfish species in general are recommended to have a PSD value of 20 to 40.

Bluegill had a calculated PSD value of 72 in the 1968 survey of Pretty Lake, suggesting there were a large number of individuals of harvestable size (≥ 6 in; 15.2 cm). Redear sunfish exhibited above average condition and below average growth. Redear sunfish had a PSD value of 29. Warmouth sunfish were in average condition and had a PSD value of 29. Largemouth bass accounted for 3.3% of the fish collected by number in 1968 and exhibited average condition and below average growth. Largemouth bass had a PSD value of 21, which is below the desired range of 40-70 for a balanced population. During the 1968 study the IDNR noted the density of aquatic vegetation was reaching a point where it was becoming a problem along the shoreline, although recent surveys of aquatic vegetation do not suggest this is still a problem (Aquatic Control, 2007).

According to the 1968 fishery management report, Pretty Lake was involved in a trout stocking program until 1965, and northern pike and walleye have been reportedly stocked by local residents (Robertson, 1969). Unfortunately, Pretty Lake has not been surveyed in 40 years, therefore the current structure of the fish community is not known. The scope of this diagnostic study did not allow for fish sampling. A general fisheries survey would need to be completed in order to evaluate the current state of the fish community in Pretty Lake and compare it to the historical information for trend analysis and specific management recommendations. The following general recommendations for improving the fishery of similar lakes are still applicable.

Anglers are encouraged to practice selective harvest of panfish (bluegill, redear, and crappie), by decreasing their harvest of large adults and increasing their harvest of younger, smaller fish. This would be beneficial to the panfish population for a couple of reasons: 1) the release of large adults will help develop a healthy stock of breeding individuals capable of producing many offspring, and 2) the increased harvest of smaller individuals would decrease the amount of intra-specific competition for space and food resources between young fish resulting in a healthy recruitment of individuals into the larger sized breeding population. The goal of selective harvest is to develop a distribution of sizes within the population that would allow for the harvest of quality size fish while ensuring the replacement of those individuals the following year.

Largemouth bass play an important role in controlling the population of desirable game-fish, such as bluegill, and undesirable fish species, such as gizzard shad. This occurs in two ways: 1) by helping to reduce intra-specific competition between young bluegill through limitation of their numbers; and 2) by reducing inter-specific competition of resources between young gizzard shad and young bluegill through the control of gizzard shad numbers. Catch and release of largemouth bass beyond that required by law is always encouraged.

It is recommended that the treatment for Eurasian watermilfoil continue on Pretty Lake as this is beneficial to the native plant community and the fish community. Controlling Eurasian watermilfoil is important in maintaining a diverse native plant community as it often outcompetes native species. Dense stands of Eurasian watermilfoil can have negative impacts on fish communities by decreasing predator (largemouth bass) foraging efficiency which often produces slow growth rates in both the predatory bass and the panfish prey species.

3.5 Zebra Mussels

Zebra mussels are an exotic species of concern for many lakes and rivers throughout the state and for Pretty Lake as well. Zebra mussels are small, fingernail-size, freshwater mollusks which are native to the Caspian, Black, and Aral Seas of Eastern Europe. Mature females can produce between 30,000 and 100,000 eggs per year which hatch into larvae, called veligers, the size of the period at the end of this sentence. Within two to three weeks of hatching the veliger shells begin to harden and become able to attach and detach from hard surfaces like rock, wood, glass, rubber, metal, gravel, other zebra mussels, and shellfish.

Zebra mussels are efficient filter-feeders and consume large amounts of phytoplankton (microscopic algae) which are food for zooplankton (small animals) that nourish small fish. Without the plants at the base of the food chain, zooplankton populations decline causing fish recruitment to decline as well. Additionally, mussels essentially filter out contaminants like PCB and other hazardous hydrocarbons from the water column and concentrate them in their tissues. The toxins may then be biomagnified in mussel predators higher in the food web. Filter-feeding also results in a rerouting of dissolved and particulate-bound contaminants from the water column to the sediments in the form of feces and pseudofeces where benthic or bottom-feeding invertebrates may ingest them. Fish consuming the invertebrates further biomagnify the toxins, and since zebra mussel introduction, PCB concentrations in top-predators have increased.

Zebra mussels also affect water quality by altering the sediments and the water column of infested water bodies. Colonies of mussels increase the amount of benthic organic matter through the production of waste products. A shift in the community composition of the invertebrates that inhabit the benthic sediments occurs, and invertebrates usually indicative of poorer water quality become dominant (like tubificid oligochaetes and chironomids). Zebra mussels are also associated with an increase in water clarity and light penetration which in turn may result in increased macrophytic vegetation growth. However, they selectively filter out small forms of phytoplankton (diatoms and cryptophytes), with no impact on colonial and filamentous cyanobacteria. Nutrient resources no longer used by the small members of the algal community become available to cyanobacteria causing noxious blooms. Zebra mussels also release large amounts of bioavailable nitrogen (ammonium, NH_4^+) which may be utilized by large, undesirable algae. Additionally, the invading mussels are associated with increasing fractions of dissolved, bioavailable toxins in the water column.

Because recreational boating is the primary mechanism for dissemination of adult and larval zebra mussels, following some simple precautions can help prevent the spread of this aquatic nuisance organism:

1. Remove visible vegetation from equipment and objects that were in the water.
2. Flush engine cooling system, live wells, and bilge with hot water or tap water. Water of 110°C and 140°C will kill veligers and adults respectively.
3. Rinse any other areas that get wet like trailers, boat decks, etc.
4. Air dry boat and equipment for two to five days before using in uninfested waters.
5. Examine boat exterior if it has been docked in mussel-infested waters. If mussels or large amounts of algae are found, clean the surfaces or dry the boat for at least five days.
6. Do not reuse bait or bait bucket water if they have been exposed to mussel-invaded waters.

Identify zebra mussels by:

1. Shell Appearance: zebra mussels look like small D-shaped clams of a yellow or brown color. The shell is characterized by light and dark striping resembling tiger stripes.
2. Size and Location: most zebra mussels are only the size of a fingernail but may be up to two inches long. They tend to grow in colonies of multiple individuals in shallow, productive waters.
3. Attachment: no other freshwater mussels can firmly attach themselves to solid substrates.

3.6 Historical Water Quality

The Indiana Department of Natural Resources, Division of Fish and Wildlife, the Indiana State Pollution Control Board, the Indiana Clean Lakes Program (CLP), and Volunteer Monitors have conducted various water quality tests on Pretty Lake. Table 9 presents some selected water quality parameters for these assessments of Pretty Lake.

Table 9. Summary of historic data for Pretty Lake, Marshall County, Indiana.

Date	Secchi (ft)	% Oxic	Epi pH	TP (mg/L)	Plankton (#/L)	Chl *a* (μg/L)	ITSI Score	Source
6/17/68	5.2	62.5%	9.5	--	--	--	--	Peterson and Robertson, 1969
7/22/75	--	70.0%	--	0.040*	--	--	28$^{\delta}$	ISPCB, 1986
1989	13.8	--	--	0.060	310	--	20	CLP, 1989
1990^{+}	18.5	--	--	--	--	--	--	Volunteer monitor, 1990
1991^{+}	22.2	--	--	--	--	--	--	Volunteer monitor, 1991
1992^{+}	20.1	--	--	--	--	--	--	Volunteer monitor, 1992
1993^{+}	23.5	--	--	--	--	--	--	Volunteer monitor, 1993
7/31/95	11.8	57.5%	8.6	0.067	1,997	1.3	11	CLP, 1995
7/19/99	10.5	65.0%	8.1	0.123	580	1.3	6	CLP, 1999
2000^{+}	12.2	--	--	--	--	--	--	Volunteer monitor, 2000
2001^{+}	13.4	--	--	--	--	--	--	Volunteer monitor, 2001
2002^{+}	16.7	--	--	--	--	--	--	Volunteer monitor, 2002
2003^{+}	14.8	--	--	--	--	--	--	Volunteer monitor, 2003
2004^{+}	14.0	--	--	--	--	--	--	Volunteer monitor, 2004
8/10/04	12.5	57.5%	8.6	0.034	3,127	1.4	18	CLP, 2004
2005^{+}	14.7	--	--	--	--	--	--	Volunteer monitor, 2005
6/6/06	14.0	--	--	--	--	--	--	Aquatic Control, 2007
8/18/06	15.0	--	--	--	--	--	--	Aquatic Control, 2007
2006^{+}	16.1	--	--	--	--	--	--	Volunteer monitor, 2006
2007^{+}	14.8	--	--	--	--	--	--	Volunteer monitor, 2007

*Water column average; all other values are means of epilimnion and hypolimnion values.
$^{+}$Volunteer monitoring data are average values for all samples collected in that calendar year.
$^{\delta}$Eutrophication Index (EI) score. The EI differs slightly but is still comparable to the TSI used today.

Based on the data presented in Table 9, water quality in Pretty Lake has remained stable or declined slightly over the past 40 years. Water clarity is relatively good for the region. Secchi disk transparency (a measure of water clarity) has ranged from a low of 5.2 feet (1.6 m) in June 1968 to a average high of 23.5 feet (8.2 m) in 1993. The June 1968 measurement is more than 5 feet less than any other measurements recorded for Pretty Lake. This could be attributed to an algae bloom at the time of the sampling, sampling occurring immediately following a rain event, or could result from an error in data recording. If this measurement is treated as an outlier and removed from the data set, then the lowest water clarity measurement in Pretty Lake is 11.8 feet (3.6 m) as measured in July 1995. Overall, water clarity in Pretty Lake is better than most lakes in Indiana. Pretty Lake has a median clarity of 16.6 feet (5.1 m) with average transparencies measuring 10 feet (3.1 m) greater than the median clarity measured for Indiana lakes. Figure 19 displays the variation in water clarity over time within Pretty Lake. The data suggests a decrease in water clarity (lower secchi disk reading); however, this may be due in part to variation in the amount of data collected per year and the period in the year in which the data was collected.

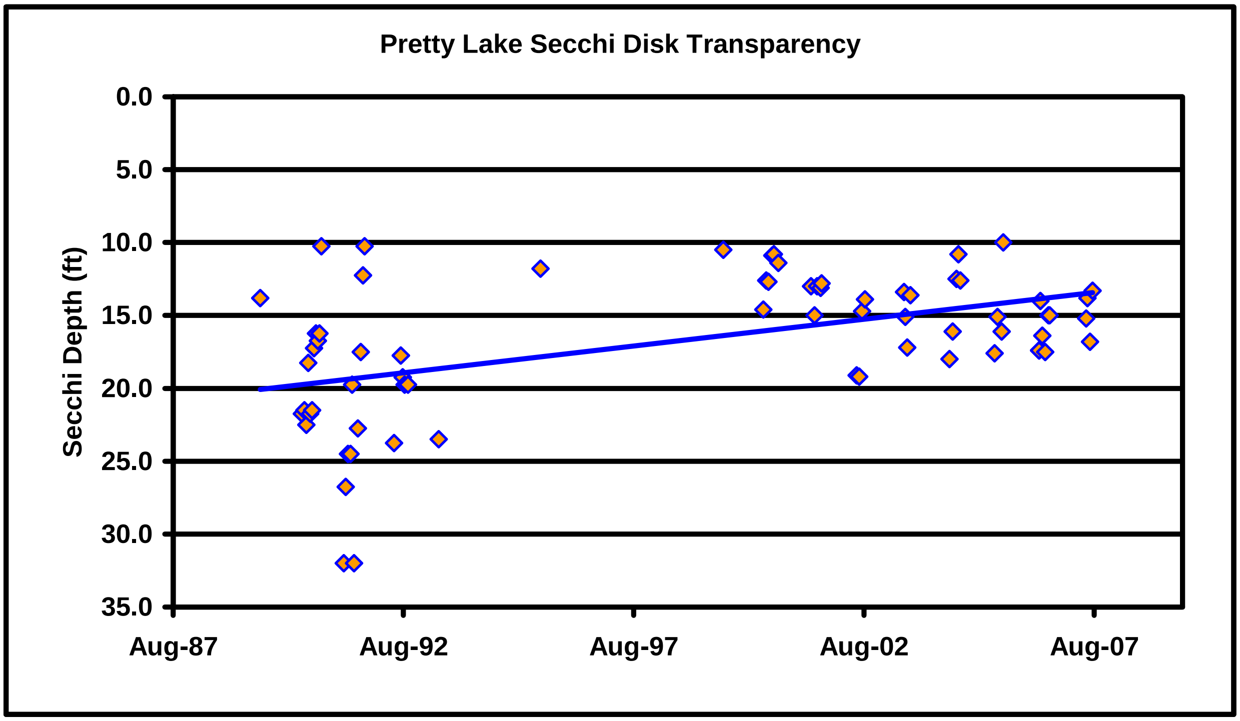

Figure 19. Historic Secchi disk transparency data - Pretty Lake, Marshall County, Indiana.
Source: Aquatic Control, 2007; CLP, 1989, 1995, 1999, 2004; ISPCB, 1986; Robertson, 1969;

Overall, water clarity measurements in Pretty Lake follow a pattern typically observed in Indiana lakes. Water clarity is generally better during the spring, early summer, and late fall than clarity measurements that occur during the middle of the summer and early fall (July to September). This trend is more apparent when individual monthly median and average Secchi disk transparencies are observed (Table 10). The best (highest) monthly average and median transparencies occur during May (32 feet or 9.7 m) and June (21.2 feet or 6.5 m), while the poorest (lowest) average and median transparencies occur during October (10.3 feet (3.1 m)). Additionally, it should be noted that more samples have been collected during the peak recreation season of July and August. For this reason, and due to the longer days, more sunlight, and higher temperatures, water clarity is typically poorer during this peak use season. Combined, these data suggest that water clarity within Pretty Lake may be declining; however, the variation over time is not a significant change from historic transparency levels.

Table 10. Median and average transparencies measured in Pretty Lake from 1965 to 2005.

Month	Average Clarity (ft)	Median Clarity (ft)	Number of Measurements
May	32.0	32.0	1
June	21.2	22.6	8
July	16.9	16.4	15
August	16.6	15.6	16
September	15.2	16.3	9
October	12.3	10.3	3

Source: Aquatic Control, 2007, 2008; CLP, 1989, 1995, 1999, 2004; ISPCB, 1986; Robertson, 1969.

Other data collected within Pretty Lake refute the idea that water quality may be declining within the lake. The 1% light level measurements (point at which only 1% of the surface ambient light is available underwater) suggests fluctuations in water clarity but neither support nor refute changes in water clarity over time. Overall, 1% light levels vary from 16.5 to 17 feet (5.0 to 5.2

m, respectively) in 1975 and 1995 to 26 feet (7.9 m) in 1999 before declining to 21 feet (6.4 m) in 2004.This means that light is available down to a zone from 16.5 to 26 feet (5.0 to 7.9 m), which is much better than median measurements for other Indiana lakes.

Total phosphorus concentrations have generally remained low within Pretty Lake with more recent data suggesting an increase in total phosphorus concentration (Figure 20). Total phosphorus concentrations ranged from 0.040 mg/L in July 1975 (ISPCB, 1986) to 0.123 mg/L in July 1999 (CLP). Despite the suggested increase in concentration, all of the total phosphorus measurements collected in Pretty Lake remain below the median concentration for Indiana lakes (0.17 mg/L).

Soluble reactive phosphorus concentrations follow a similar pattern with epilimnion concentrations as low as 0.01 mg/L measured in 1989 and increasing to 0.04 mg/L in August 2004. Soluble reactive phosphorus is the portion of phosphorus that is available to plankton and aquatic plants for uptake and usage in production. Therefore, increases in soluble phosphorus concentrations in Pretty Lake are of concern and suggest potential declines in water quality within Pretty Lake over the last 40 years. Despite increases in phosphorus, overall concentrations remain low compared with other lakes throughout the region and within Indiana.

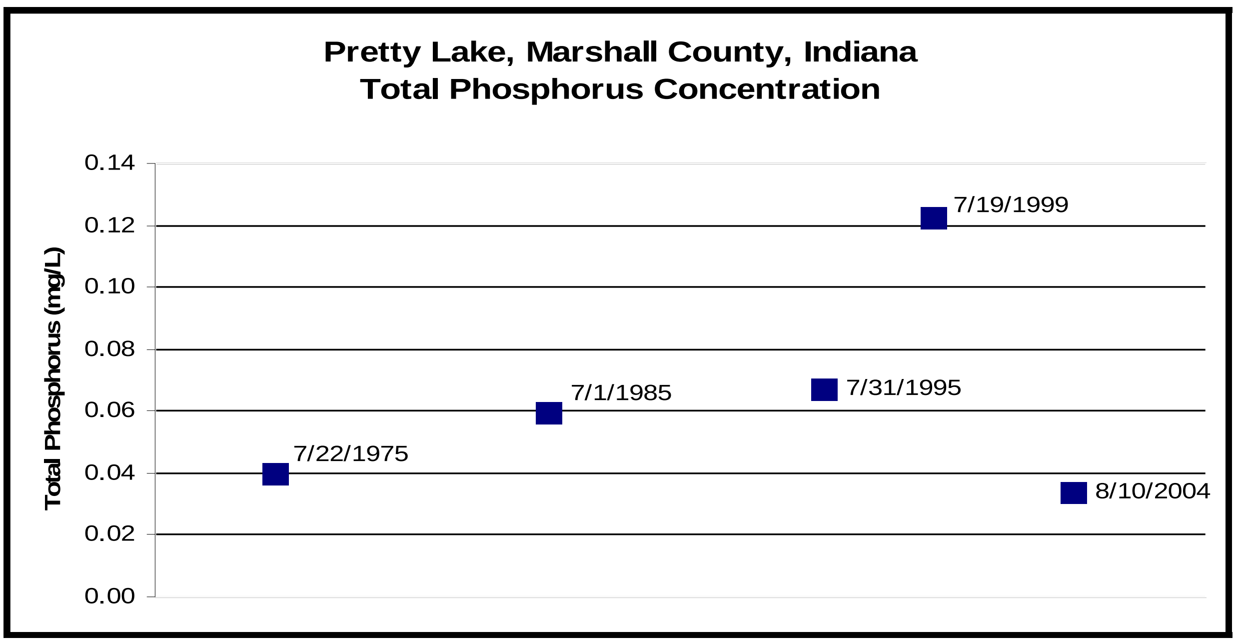

Figure 20. Historic total phosphorus concentrations measured in Pretty Lake, Marshall County, Indiana. Source: CLP, 1989, 1995, 1999, 2004; ISPCB, 1986.

The lake's algae (plankton) density reflects the relatively low nutrient levels typically present in Pretty Lake. Nutrients (nitrogen and phosphorus) promote the growth of algae and/or rooted plant populations. Thus, lakes with high nutrient levels are expected to support dense algae and/or rooted plants. Plankton densities are relatively low within Pretty Lake, reflecting the relatively low nutrient concentrations present within the lake. The lowest plankton density coincides with the lowest total phosphorus concentration measured in the lake; however, this relationship does not hold true for the other three plankton densities. This is likely due to the overall low density present in Pretty Lake. Low chlorophyll *a* concentrations also reflect the relatively low plankton densities and total phosphorus concentrations found in the lake. None of the chlorophyll *a* concentrations exceed the median concentration measured in Indiana lakes (12.9 μg/L or 0.0129 mg/l). The lake's overall Indiana Trophic State Index (ITSI) scores ranged from a high of 28 in 1975 to a low of 6 in 1999 before rising again to 18 in 2004. All of these scores suggest that the lake is oligotrophic to slightly mesotrophic. (Please see the following sections for more detailed discussion of lake water quality parameters and trophic state indices.)

Figure 21 displays the temperature profiles recorded during IDNR fisheries surveys and Indiana CLP assessments. All of the temperature profiles show that Pretty Lake was stratified at the time of the assessments. The developed hypolimnion (bottom water) present during the surveys is very typical of Indiana lakes. The metalimnion, or area of rapidly changing water temperature, typically extends from 5 feet (1.5 m) to approximately 30 feet (9.1 m). The epilimnion (surface water) is located above the metalimnion, while the hypolimnion (bottom water) is located below the metalimnion. Water within the epilimnion and hypolimnion are typically separated during the summer in stratified lakes and do not mix. This is the case during all assessments.

Much of the data presented above suggest that Pretty Lake is only moderately productive. The historical percent oxic results (Table 9) and dissolved oxygen profiles (Figure 22) support this idea. Dissolved oxygen data indicate that the lake possessed dissolved oxygen greater than 1 mg/L in less than 58% of the water column.

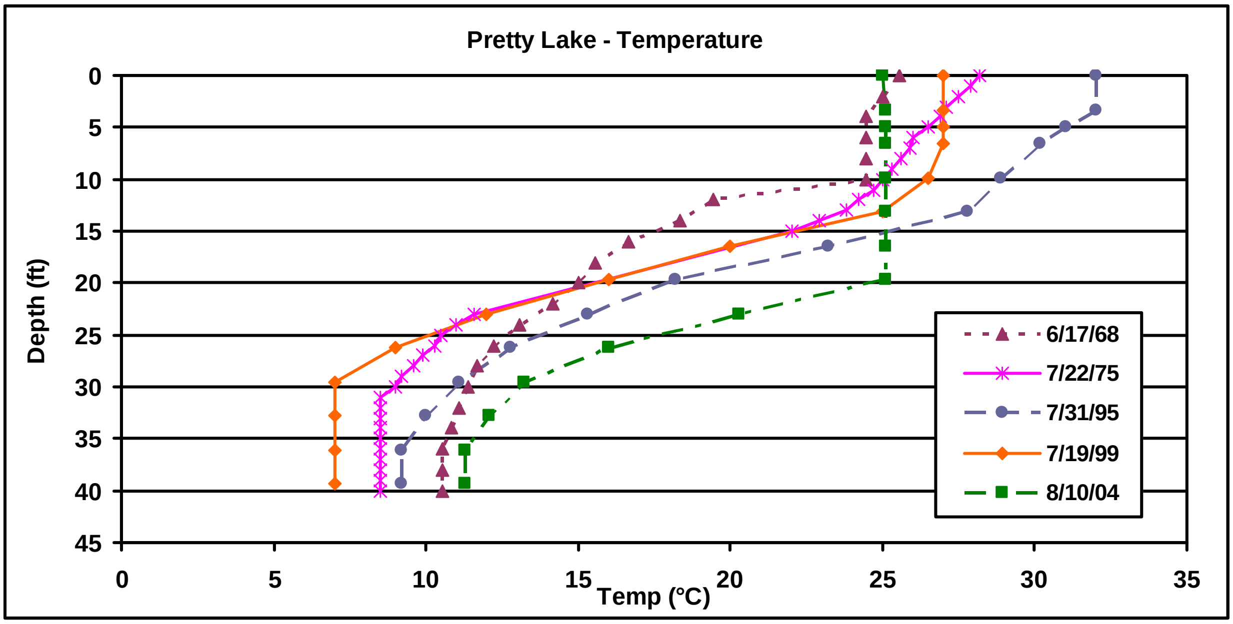

Figure 21. Historical temperature profiles for Pretty Lake. Source: CLP, 1995, 1999, 2004; ISPCB, 1986; Robertson, 1969.

The dissolved oxygen data also indicate that more than half of the water column is available for use by the lake's biota. However, low dissolved oxygen concentrations present at the lake bottom increases the potential for nutrient release from the lake's bottom sediments. Additionally, during each assessment, except the most recent (2004) assessment, there is a sharp increase in dissolved oxygen in the lake's metalimnion. This results in a positive-heterograde profile and a "Cisco Layer". Positive-heterograde profiles are characterized by a peak in oxygen concentration at a depth below the water surface, such as the peak in the 1999 profile beginning at 14 feet (4.2 m) below the water's surface. The peak is likely associated with a higher concentration in phytoplankton at that particular depth layer. Called a ***metalimnetic oxygen maximum***, the peak results when the rate of settling plankton slows in the denser waters of the metalimnion. At this depth, the plankton can take advantage of nutrients diffusing from the nutrient-enriched hypolimnion. As the plankton at this depth photosynthesize, they release oxygen into the water column, creating a peak in oxygen at that level. The "Cisco layer" is a layer of water with a temperature below 20 degrees C. and dissolved oxygen levels above 3 parts-per-million needed by this species of native whitefish for survival. As late summer and early fall stratification progress the cisco layer tends to become thinnest in response to increasing water temperatures above and oxygen deficits built by decomposing detritus (dead material) below (Frey, 1955). While Cisco have never been documented in Pretty Lake, a population did exist in nearby Lawrence Lake.

The 1975 assessment profile is also a great example of a metalimnetic oxygen maxima as are 1968 and 1995 assessments profiles, although in all of these cases, the peaks are much smaller than that present during the 1975 and 1999 assessments. During the most recent assessment, a peak is not present in the metalimnion. In fact, dissolved oxygen concentrations are uniform from the lake's surface to a depth of about 16 feet (4.8 m). As indicated by the temperature profile from the same date, the epilimnion (surface water) of Pretty Lake was mixing during this assessment. This results in relatively uniform conditions being present in the lake's upper waters. Decomposition of plant material undoubtedly occurs in the lake's deeper waters, removing oxygen from the water column.

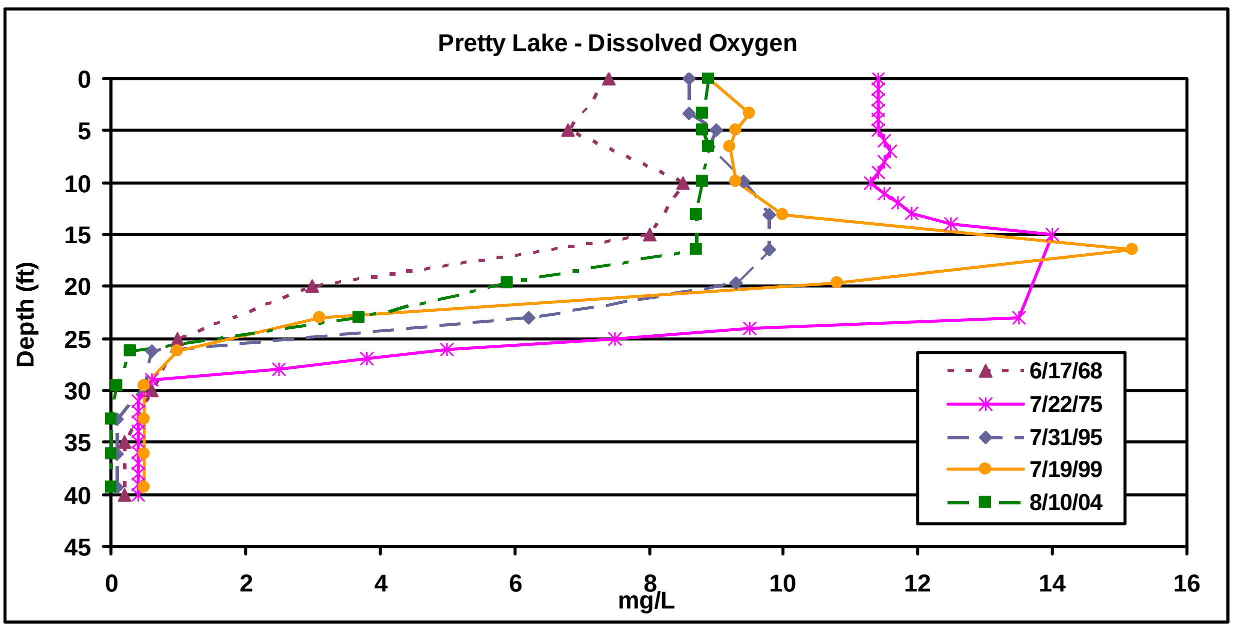

Figure 22. Historical dissolved oxygen profiles for Pretty Lake. Source: CLP1995, 1999, 2004; ISPCB, 1986; Robertson, 1969.

Higher hypolimnetic ammonia concentrations suggest decomposition has occurred in the lake's bottom waters during some points in the lake's history (Tables 11 to 14). The fact that the lake's hypolimnion is composed of several isolated basins may limit the complete mixing of the lake's deepest waters.

A similar situation occurs on Lake Maxinkuckee in Culver, Indiana. Lake Maxinkuckee possesses low nutrient levels and low productivity (lower than Pretty Lake), but Lake Maxinkuckee also exhibits anoxia in its hypolimnion. Historical documents show that Lake Maxinkuckee has always (at least prior to extensive settlement around the lake) lacked oxygen in its bottom waters (Evermann and Clark, 1920). Crisman (1986) suggests Lake Maxinkuckee's morphology prevents complete mixing of the lake during turnover periods. The lake's inability to completely mix prevents the reoxygenation of bottom waters in Lake Maxinkuckee. Thus, despite being a classified as an oligotrophic/mesotrophic lake, Lake Maxinkuckee experiences oxic conditions in the lower part of the water column more typical of eutrophic lakes.

Regardless of whether the lack of oxygen in Pretty Lake's hypolimnion is the result of its morphology or an indication of accelerated eutrophication of the lake, the lack of oxygen at any depth limits the use of the lake for aquatic organisms. Fish and other aquatic organisms require oxygen to live and; therefore, the lack of oxygen in the lake's hypolimnion reduces the amount of habitat available to fish. Fortunately, most of the lake's volume has oxygen levels sufficient to support fish. Based on the depth-volume curve (Figure 13), approximately 80% percent of the lake's volume is oxygenated. (The percent oxic parameter measures the vertical percent, not volumetric percent, of the water column with oxygen.)

The lack of oxygen in Pretty Lake's hypolimnion also affects the lake's chemistry. While mean total phosphorus concentrations are variable for the years displayed in Tables 11 through 14, a more detailed evaluation shows that hypolimnetic total phosphorus concentrations are typically higher than epilimnetic total phosphorus concentrations. Under anoxic conditions, the iron in iron phosphate, a common precipitate in lake sediments, is reduced, and the phosphate ion is released into the water column. This phosphate ion is readily available to algae, and can therefore spur algal growth. Further review of historical phosphorus data indicate that much of the total phosphorus was in the dissolved form of phosphorus (SRP). This indicates that Pretty Lake was releasing phosphorus from its bottom sediments. Additionally, Pretty Lake exhibited higher hypolimnetic ammonia concentrations than those observed in the lake's epilimnion during two of the four assessments, suggesting decomposition of organic matter was occurring in the lake's bottom waters. Overall, these data suggest that Pretty Lake was a mesotrophic to mildly eutrophic lake during the 1989, 1995, 1999, and 2004 assessments.

Table 11. Historical water quality characteristics of Pretty Lake, July 1, 1989.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
Secchi Depth Transparency	13.8 ft	--	0
Light Transmission @ 3 ft.	61%	--	2
Oxygen Saturation @ 5ft.	111%	--	0
% Water Column Oxic	81.8%	--	0
Nitrate-Nitrogen	0.819 mg/L	0.997 mg/L	3
Ammonia-Nitrogen	0.037 mg/L	0.024 mg/L	0
Organic Nitrogen	0.984 mg/L	1.034 mg/L	3
Soluble Reactive Phosphorus	0.010 mg/L*	0.010 mg/L*	0
Total Phosphorus	0.033 mg/L	0.086 mg/L	3
Plankton Density	310/L	--	0
Blue-Green Dominance	67%	--	10
		TSI Score	**21 Mesotrophic**

Table 12. Historical water quality characteristics of Pretty Lake, July 31, 1995.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
Secchi Depth Transparency	11.8 ft	--	0
Light Transmission @ 3 ft.	15%	--	4
1% Light Level	16.5ft	--	--
Oxygen Saturation @ 5ft.	121.1%	--	2
% Water Column Oxic	57%	--	2
pH	8.6	7.2	--
Conductivity	278 μmhos	216 μmhos	--
Alkalinity	90 mg/L	111 mg/L	--
Nitrate-Nitrogen	0.022 mg/L*	0.022 mg/L*	0
Ammonia-Nitrogen	0.037 mg/L	0.040 mg/L	0
Organic Nitrogen	0.399 mg/L	1.209 mg/L	2
Soluble Reactive Phosphorus	0.010 mg/L*	0.010 mg/L*	0
Total Phosphorus	0.017 mg/L	0.117 mg/L	3
Chlorophyll *a*	1.29 μg/L	--	--
Plankton Density	1,997/L	--	0
Blue-Green Dominance	40%	--	0
		TSI Score	**13 Oligotrophic**

*=Method detection level

Table 13. Historical water quality characteristics of Pretty Lake, July 19, 1999.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
Secchi Depth Transparency	10.5 ft	--	0
Light Transmission @ 3 ft.	75%	--	0
1% Light Level	26ft	--	--
Oxygen Saturation @ 5ft.	117%	--	1
% Water Column Oxic	65%	--	2
pH	8.1	7.2	--
Conductivity	275 μmhos	220 μmhos	--
Alkalinity	93 mg/L	148 mg/L	--
Nitrate-Nitrogen	0.022 mg/L*	0.022 mg/L*	0
Ammonia-Nitrogen	0.018 mg/L*	0.018 mg/L*	0
Organic Nitrogen	0.657 mg/L	1.077 mg/L	2
Soluble Reactive Phosphorus	0.017 mg/L	0.017 mg/L	0
Total Phosphorus	0.028 mg/L	0.217 mg/L	3
Chlorophyll *a*	1.34 μg/L	--	--
Plankton Density	580/L	--	0
Blue-Green Dominance	47%	--	0
		TSI Score	**8 Oligotrophic**

*=Method detection level

Table 14. Historical water quality characteristics of Pretty Lake, August 10, 2004.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
Secchi Depth Transparency	12.5 ft	--	0
Light Transmission @ 3 ft.	55%	--	2
1% Light Level	21ft	--	--
Oxygen Saturation @ 5ft.	107%	--	0
% Water Column Oxic	57%	--	2
pH	8.6	7.2	--
Conductivity	237 μmhos	211 μmhos	--
Alkalinity	85 mg/L	111 mg/L	--
Nitrate-Nitrogen	0.013 mg/L*	0.013 mg/L*	0
Ammonia-Nitrogen	0.029 mg/L	0.202 mg/L	0
Organic Nitrogen	0.260 mg/L	0.413 mg/L	1
Soluble Reactive Phosphorus	0.040 mg/L	0.211 mg/L	2
Total Phosphorus	0.024 mg/L	0.044 mg/L	1
Chlorophyll *a*	1.37 μg/L	--	--
Plankton Density	3,127/L	--	0
Blue-Green Dominance	82%	--	10
		TSI Score	**18** **Mesotrophic**

*=Method detection level

3.7 Boat Counts

In addition to swimming, birding, and other lake related activities, watercraft users are common in the warm season on Pretty Lake. Current policies enacted by the property owners allow high speed boating from 1-4 pm each day. A boat count was conducted by resident volunteers on June 19th, July 4th, and July 15, 2008 (Appendix C). The survey indicates that pontoons account for 47%; fishing boats represent 28%; speed boats 24%; and paddle boats, canoes, and kayaks less than 1% of the lake's boats. At any one time there was a maximum of 18 boats on the lake (this occurred on July 4th at 5pm) and 5 of those were speed boats. The average number of boats on Pretty Lake during a week day (Thursday, June 19th using 4 counting periods) was 1.5.

Carrying Capacity

Lakes are finite resources which are in high demand. As residential development increases around lakes, boating and other on-lake recreational activities increase as well. This increased use coupled with increases in boat size and speed has brought lake over-crowding to the forefront in many communities. Balancing lake use with ecological, economical, and aesthetic impacts is paramount in arriving at balanced, sustainable use levels.

Mahoney and Stynes (1995) noted that recreational carrying capacity is based as much on user perception as it is on science. Other researchers agree that every waterbody has a carrying capacity; however, what that capacity is determined to be depends on a number of factors including the waterbody's size, shape, depth, shoreline development, and most importantly the aesthetic preference of the lake's user group. Wagner (1990) suggests that there is not one true carrying capacity for each waterbody; rather each person has their own perception. This results in there being no single boating densities that will satisfy all users at all times. Jaakson et al. (1994) states "carrying capacity is more a value judgment than a technical decision".

Many factors influence the estimation of a lake's recreational carrying capacity. These include the physical characteristics of the lake; the lake's use characteristics (the number of lakeside homes, number of moored and off-lake boats, number of access sites and density of their use, etc.); environmental impacts such as those to the aquatic plant community or lake sediment; area of the lake available for boating; boat density (calculated and actual); and the lake use rate. As each of these include several factors, they will be discussed in more detail below with specifics for each of the lakes discussed in subsequent sections.

Lake Physical Characteristics

Many factors affect the recreational carrying capacity of a lake. However, the one factor that cannot be regulated is the lake's physical characteristics or morphology. The lake's surface area and maximum depth are important factors in determining the lake's use, aesthetic value, and environmental resource. Another important factor is the lake's fetch. The fetch represents the maximum open water distance across the lake. Finally, the shoreline development, or how convoluted the shoreline is, determines how much impact motorized craft will have on a waterbody. Wagner (1990) detailed the impact of high shoreline development ratios noting that as SDRs increase so does the potential for ecological consequence and safety risk. Wagner noted the following reasons for increased negative impacts: 1) more shoreline housing units and thus users per unit of surface area; 2) tighter and more confined recreational spaces; 3) additional shoreline subject to wake-induced erosion; and 4) greater probability for near-shore, shallow-water depths that are more vulnerable to motor boat impacts. Motorized watercraft impacts to waterbodies are directly correlated with the lake's physical characteristics; impacts to water clarity, shoreline erosion, and plant distribution increase as boat traffic increases, especially in shallow waters less than several feet deep (UWEX, 2002).

Use Characteristics

Jones (1996) identified the ability of waterbody to accommodate a variety of users attempting mixed uses as the predominant factor in determining a lake's use rate. As demands for the same space increase, so do the potential conflicts between users. During surveys completed on the Ririe River Reservoir, users noted that social and facility capacity were the two predominant factors in their use of the lake (USDI, 2004). Users typically stopped using the lake when they perceived that the lake was crowded, therefore the lake was limited by social capacity. Secondarily, users did not enter the lake when they were required to wait for access to the lake through the boat launch. User conflicts are typically based on speed, noise, or maneuverability (Klessig, 2001). Under crowded conditions, Kusler (1972) noted that users typically attempt one of the following:

- Tolerance of higher levels of interference or interruption from other users than that which they are comfortable;
- Engaging in riskier or more aggressive behavior than is their norm;
- Movement to less ideal or optimal locations within the same waterbody so that they may continue their activity; or
- Leaving the lake.

A lake's major use is determined both by its physical characteristics and by its users. Use levels can be determined in many ways including the number of shoreline dwellings, number of moored boats, number of boats launched daily at the lake's boat access points, or the number of boats in use. Additional factors that should be considered when assessing waterbody use include craft type, speed, and predominant movement pattern; operator behavior; and overall impacts to the environment. Mahoney and Stynes (1995) identified the following items as keys in determining a lake's carrying capacity: spatial and temporal use patterns; craft characteristics; and surrounding land use. The number of users and their use patterns are defined by the lake's social carrying capacity or the level of use where the social experience is negatively impacted.

Environmental Impacts

One of the most common impacts associated with motor boating is a decrease in water clarity. As motor boats travel through shallow water, the energy from movement of the boat propeller may be sufficient to resuspend sediment from the lake bottom, decreasing the lake's water clarity. Several researchers have documented either an increase in turbidity or a decrease in Secchi disk transparency during and following motor boat activity (Wagner, 1990; Asplund, 1996; Yousef et al., 1980). Crisman (1986) reports a decrease in Secchi disk transparency following holiday weekend use of Lake Maxinkuckee in Culver, Indiana. Asplund (1996) also observed poorer water clarity in his study of lakes following weekend boating and that this decrease in water clarity is more pronounced in lakes with generally better water clarity. This finding is particularly significant for many lakes throughout the watershed as they generally exhibit better water clarity than the typical Indiana lake.

The ability of a motor boat to resuspend sediment from the lake bottom depends on several factors. Some of these factors, such as boat length, motor size, and boat speed, are related to the boat itself and the boat's operator. Yousef et al. (1978) found that 10 horsepower (hp) motors were capable of mixing the water column to a depth of 6 feet (1.8 m), while 50 hp motors were capable of mixing the water column to a depth of 15 feet (4.6 m). While larger motor sizes have a greater potential to resuspend sediments than smaller motors, longer boats and higher speeds do not automatically translate to a greater ability to resuspend sediments. Boats that are 'planing' on the water actually have little impact on the lake's bottom. This is because the velocity of water at the lake bottom created by a motor boat depends on the boat's displacement, which is a function of boat length and speed. Beachler and Hill (2003) suggest that boat speeds in the range of 7 to 12 mph may have the greatest potential to resuspend sediment from the lake bottom. (This range is based on typical recreational boat length.)

Certain characteristics of lakes also influence the ability of motor boats to resuspend sediments. Shallow lakes are obviously more prone to water clarity degradation associated with motor boating than deeper lakes. Wagner (1990) suggests little impacts from motor boating are likely in water deeper than 10-15 feet (3.0-4.6 m). Lakes with soft fine sediments are more likely to suffer from sediment resuspension than lakes with coarser substrates. Lakes with extensive rooted plant coverage throughout the littoral zone are less prone to motor boat related resuspension problems than lakes with sparse vegetation since plants help hold the lake's bottom substrate in place.

It is important to note that the decrease in water clarity is not usually permanent. Once motor boating activity ceases, resuspended materials will sink to the lake bottom again. However, this process can take several days. Wagner (1990) found that while turbidity levels steadily decreased following boating activity in his shallow study lakes, the turbidity had not returned to baseline levels even two days after the activity. Crisman (1986) found similar lags on Lake Maxinkuckee.

In addition to a decrease in water clarity, several other potential ecological impacts from motor boating exist. Various researchers have documented increased phosphorus concentrations, damage to rooted plants, changes in rooted plant distribution, and increased shoreline erosion associated with motor boating activity (Asplund, 1996; Asplund and Cook, 1997; Schloss, 1990; Yousef et al., 1980). Less commonly studied concerns include potential increases in heavy metal and hydrocarbon pollution, changes in algal populations, and impacts to lake fauna.

Just as the potential impact of motor boating on a lake's water clarity depends in large part on the specific characteristics of the lake, the potential for other ecological impacts associated with motor boating often depend on characteristics of the specific lake (Wagner, 1990). For example, Yousef et al. (1980) found increases in total phosphorus concentrations associated with motor boating activity in all his study lakes. However, only one of Wagner's study lakes showed an increase in phosphorus concentrations associated with motor boating activity. This lake possessed a nutrient rich, fine particle substrate. Similarly, Schloss (1990) reported greater increases in phosphorus concentrations due to motor boat activities in those New Hampshire lakes with high levels of internal phosphorus loading. New Hampshire lakes with lower levels of internal phosphorus loading were less likely to see large increases in phosphorus concentration associated with motor boat activity.

Finally, boating activities can cause negative impacts to the aquatic plant community. Vermaat and Bruyne (1993) noted that boat-generated waves were the key factor in determining the distribution of aquatic plans. This is likely due to the potential impacts of boat motors through uprooting, dragging, and tearing of plant material. All of these factors lead to the ecological carrying capacity of a lake or the maximum level of use before an unacceptable or irreversible decline in the ecosystem occurs (Pigram, 1983).

Boating Density Options

Boating density is one of the most difficult pieces of information to obtain for a carrying capacity determination. This is also the most important factor used in the calculation of a waterbody's carrying capacity. Several studies have been completed that state what the optimum boating density, or the number of acres per boat by type, for a specific waterbody should be. The levels of expertise used in these decisions are varied. In fact, some are based on user opinion, on expert opinions designed with years of planning experience, or based solely on author opinions. As Kusler (1972) indicated, estimates of optimum boat density vary widely among sources. The first, and most important step, is to determine the optimal use in singular and in combination with other uses that the waterbody user group will tolerate. Additionally, Kusler noted the need to determine the activity of the boat in addition to its primary use. For instance, a ski boat is typically used for high speed boating activities, but can be used for fishing, slow-speed lake enjoyment, or as an anchor point for swimming or other off-boat activities. Each of these activities requires a different acreage and therefore ski boats in general should not be assigned a singular boat density. Rather, boats engaged in skiing or other high-speed boating activities should be assigned one density, while boats used for slow-speed boating should be assigned a separate density. Table 15 summarizes suggested maximum densities found by various researchers. More details on the local carrying capacity, including survey results of lake users, can be found in a LARE funded report "Wawasee Carrying Capacity Report" (JFNew, 2007).

Table 15. Summary of published optimum boating densities.

Source	Boating Use	Suggested Density
Ashton (1971)	All uses combined	4 to 11 acres/boat
Kusler (1972)	Water skiing combined with other uses	40 acres/boat
	Water skiing only	20 acres/boat
	Coordinated water skiing	15 acres/boat
Jaakson et al. (1989)	Waterskiing and motorboat cruising	20 acres/boat
	Fishing	10 acres/boat
	Canoeing, kayaking, or sailing	8 acres/boat
	All uses combined	10 acres/boat
Warren and Rea (1989)	Motor boat uses	9 acres/boat
	Canoeing, kayaking, or fishing	1.3 acres/boat
	Sail boating	4.3 acres/boat
Wagner (1990)	All uses combined	25 acres/boat
Warbach et al. (1994)	All motorized (>5 hp) uses	30 acres/boat
Aukerman et al. (2004)	All uses combined (urban lake)	1 to 10 acres/boat
	All uses combined (suburban lake)	10 to 20 acres/boat
	All uses combined (rural, developed lake)	20 to 50 acres/boat
Progressive AE (2005)	All uses combined	10 acres/boat
SCLC and LCLC (2006)	Water skiing only	4.6 acres/boat*SDI
	High speed boat only	3.9 acres/boat*SDI
	Pontoon boats (pleasure boating)	3.3 acres/boat*SDI
	Personal watercraft	4.0 acres/boat*SDI
	Manual-powered boat	2.9 acres/boat*SDI
LRMD (2003)	All uses: 100% idle	10 acres/boat
	All uses: 75% idle; 25% fast users	15 acres/boat
	All uses: 50% idle; 50% fast users	20 acres/boat
	All uses: 25% idle; 75% fast users	25 acres/boat
	All uses: 100% fast users	30 acres/boat

Determining Useable Lake Area

The first step in determining a lake's carrying capacity is to determine the area of the lake that is available for use by watercraft. Every lake contains a portion where boating activities cause safety issues or negative environmental impacts. Ideally, boating should not occur in these areas which results in these areas being subtracted from the overall lake area. The resulting acreage is then used as the available area for the carrying capacity calculation. There are many ways to determine this acreage, which results in a number of scenarios as described below. Specific acreages that result from each of these calculations are detailed in subsequent sections. The different lake areas and the calculations used to arrive at those areas are detailed as follows:

<u>Scenario 1</u>: The entire lake is useable. In Pretty Lake this is 97 acres which would allow from 3 to 10 boats to operate in relative comfort. The lower number is used if the boats are 100 percent high speed (water skiers or personal water craft) and the higher number is used for non-motorized or idle speed watercraft.

<u>Scenario 2</u>: Removing those areas of the lake where high-speed boating is already limited. According to the Indiana Code (IC 14-15-3-17):

> *A person may not pass within two hundred (200) feet of the shoreline of a lake or channel of the lake at a point where the lake or channel is at least five hundred (500) feet in width, except for the purpose of trolling or for the purpose of approaching or leaving a dock, pier, or wharf or the shore of the lake or channel.*

Using this section of the administrative code, all areas of the main lake that are within 200 feet of the shoreline are removed from the available boating area as are areas within channels. In Pretty Lake that means that only 61 acres are available for motor boat use allowing 2 to 6 boats.

<u>Scenario 3</u>: Remove shallow areas from boating. Studies indicate that shallow areas (0-10 feet) are extremely susceptible to negative impacts due to boating activities (Asplund, 1996); therefore, those areas that are less than 10 feet in depth were subtracted from the value obtained from Scenario 1. For Pretty Lake this results in the availability of 68 acres or a maximum comfort level of 2 to 7 boats on the lake.

Referencing the boat counts conducted by Pretty Lake property owners, the suggested carrying capacity of Pretty Lake was exceeded by a factor of three on July 4^{th} with 18 boats on the lake at one time and from 5 to 6 speed boats between 3:30 and 5:00 pm. There were 4 speed boats still using the lake at 9:00 pm. Although the count on July 15^{th} between 1 and 4 pm documented 7 speed boats, it is unknown whether they were on the lake simultaneously or took turns during this time period. It would be interesting to have interviewed lake users or lakeshore property owners at that time to document their perception of the lake use. While July 4^{th} probably represents one of the busiest days of the year, the other two boat counts represented an average of 1 and 4 boats respectively at any one time with speed boats mostly adhering to the 1 to 4 pm use policy. It appears that on most days that the suggested boat carrying capacity of Pretty Lake is not exceeded.

4.0 <u>WATER QUALITY ASSESSMENT</u>

4.1 Methods

The water sampling an analytical methods used for Pretty Lake were consistent with those used in IDEM's Indiana Clean Lakes Program and IDNR's Lake and River Enhancement Program. During most lake studies we sample tributary streams emptying into the lake, as well as the outfall to the lake, and the lake itself in order to assess inputs and outputs of nutrients from the lake. The only waterway entering Pretty Lake was not sampled because it is a drainage tile that has no consistent flow. The outfall from the lake on the eastern edge also had no noticeable flow on the day of sampling.

We collected Pretty Lake water samples on July 21, 2008 from the surface waters (***epilimnion***) and from the bottom waters (***hypolimnion***) at a location over the deepest water. The sampled parameters include total phosphorus (TP), soluble reactive phosphorus (SRP), nitrate-nitrogen (NO_3^-), ammonia-nitrogen (NH_4^+), total Kjeldahl nitrogen (TKN), and organic nitrogen (N). Other parameters such as Secchi disk transparency, light transmission, and oxygen saturation are single measurements made in the epilimnion. In addition, dissolved oxygen and temperature were measured at 3.3 foot (1 m) intervals from the surface to the bottom. Chlorophyll was determined only for the epilimnetic sample by using a tow to collect plankton from the 1% light level to the water surface. The net is pulled vertically towards the surface through this zone. Conductivity, alkalinity, turbidity, temperature, and dissolved oxygen were measured *in situ* at the lake sampling site with a HydroLab Model QD 0337 meter.

All lake samples were placed in the appropriate bottle (with preservative if needed) and stored in an ice chest until analysis at SPEA's laboratory in Bloomington. SRP samples were filtered in the field through a Whatman GF-C filter.

All sampling techniques and laboratory analytical methods were performed in accordance with procedures in *Standard Methods for the Examination of Water and* Wastewater, 21th Edition (APHA, 2005). Plankton counts were made using a standard Sedgewick-Rafter counting cell. Fifteen fields per cell were counted. Plankton identifications were made according to: Wehr and Sheath (2003), Prescott (1982), Ward and Whipple (1959) and Whitford and Schumacher (1984).

4.2 Results

4.2.1 Water Quality Parameters

Temperature and oxygen profiles for Pretty Lake show that the lake was thermally stratified at the time of sampling (Figure 23). Pretty Lake had abundant dissolved oxygen in the surface waters and, in fact, there was greater than 1 mg/L of dissolved oxygen throughout the lake. There was a *metalimnetic oxygen maximum* at 16.4 ft (5 m) when we sampled the lake. This supersaturated (107%) condition is usually symptomatic of intense phytoplankton photosynthesis. Although the lake never reached anoxic (D.O. < 1.0 mg/L) conditions, below 26 feet (8 m) there is little oxygen available to support fish. During thermal stratification, the bottom waters (*hypolimnion*) of the lake are isolated from the well-mixed epilimnion by temperature-induced density differences. The boundary between these two zones, where temperature changes most rapidly with depth is called the *metalimnion*. At the time of our sampling, the epilimnion was confined to the upper 10-13 feet (3 to 4 m) of water. The sharp decline in temperature between about 13 and 26 feet (4 and 8 m) defines the metalimnion or transition zone. The hypolimnion occupied water deeper than 26 feet (8 m).

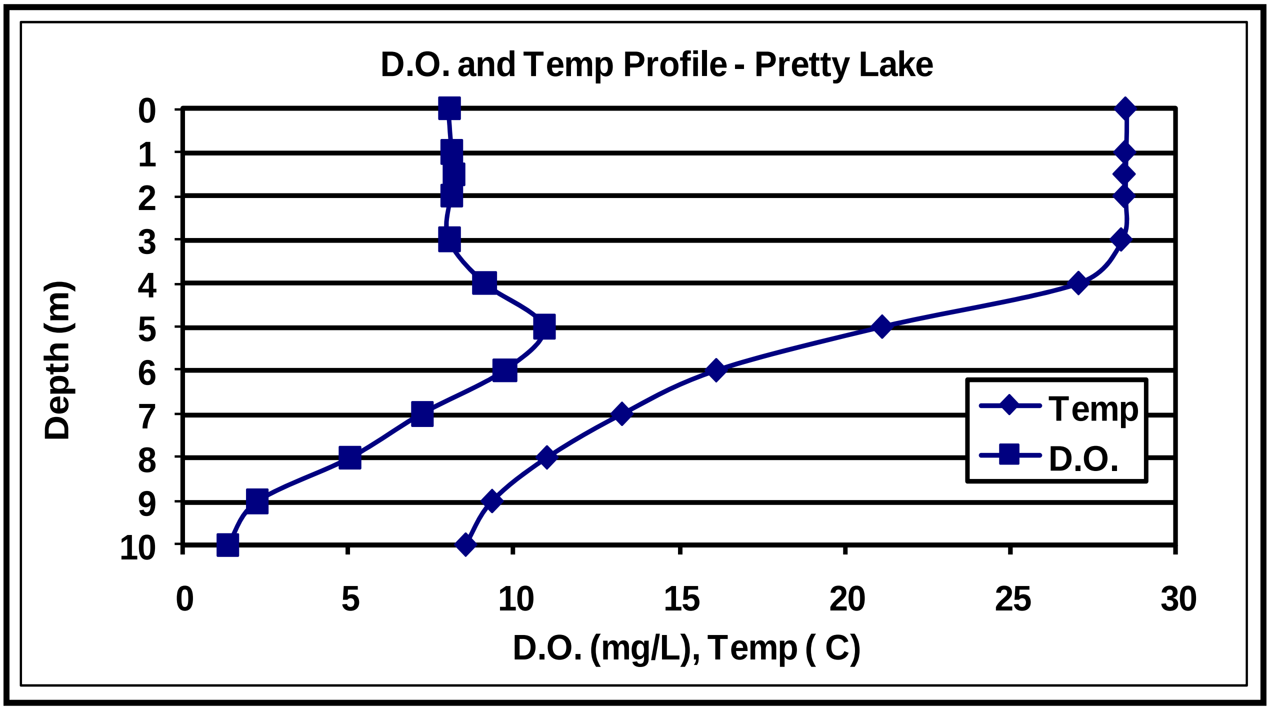

Figure 23. Temperature and dissolved oxygen profiles for Pretty Lake, Marshall County, Indiana on July 21, 2008.

The 1% light level, which limnologists use to determine the lower limit where photosynthesis can occur, extended to 21.5 ft (~7 m) (Table 14). Based on the depth-area curve (Figure 12) approximately 40% of lake bottom (59 acres or 23.9 ha) is shallower than 21.5 feet (6.5 m). This represents the area of the lake bottom with sufficient light to support rooted plants (*littoral zone*). Furthermore, based on the depth-volume curve (Figure 12), we see that a volume of greater than 1500 acre-feet of Pretty Lake (71% of total lake volume) lies above the 21.5-foot 1% light level. This area, referred to as the *photic zone*, represents the amount of water with sufficient light to support algae growth.

Phosphorus and nitrogen are the primary plant nutrients in lakes. At 0.010 mg/L, SRP phosphorus concentrations are at or below the detection limits of our analytical methods in the epilimnion and hypolimnion (Table 16). Because the hypolimnion is not anoxic we would not expect to see phosphorous release from the sediments. The low levels of phosphorous indicate that it could be the limiting nutrient in Pretty Lake.

Nitrate nitrogen was also at the detection limits (0.013 mg/L) of our analytical methods in the epilimnion and hypolimnion. Ammonia in the epilimnion was 0.036 mg/L and was at the detection limit of 0.018 mg/L in the hypolimnion. These values indicate that there is not excess nitrogen in Pretty Lake. Nitrogen could also be a limiting nutrient in the lake and could lead to blue-green algae dominance.

Values for pH are within the normal range for Indiana lakes, pH 8.2 for the epilimnion and pH 7.4 for the hypolimnion. Values of pH for most fresh waters fall between pH 6-9 (Kalff, 2002). The alkalinity values of 93 mg/L and 105 mg/L, for the epilimnion and hypolimnion, indicate that Pretty Lake is not a strongly buffered system.

Table 16. Results of Pretty Lake, Marshall County, Indiana sampling on July 21, 2008.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
pH	8.2	7.4	-
Alkalinity	93 mg/L	105 mg/L	-
Conductivity	242 μmhos	261 μmhos	-
Turbidity	1.6 NTU	3.6 NTU	-
Secchi Depth Transparency	2.7 meters	-	0
Light Transmission @ 3 ft.	20.0 %	-	-
1% Light Level	21.5 feet	-	4
Total Phosphorous	0.043 mg/L	0.043 mg/L	2
Soluble Reactive Phosphorous	0.010* mg/L	0.010* mg/L	0
Nitrate-Nitrogen	0.013* mg/L	0.013* mg/L	0
Ammonia-Nitrogen	0.036 mg/L	0.018* mg/L	0
Organic Nitrogen	0.432 mg/L	0.471 mg/L	4
Oxygen Saturation @ 5ft.	107.4 %	-	0
% Water Column Oxic	100.00 %	-	-
Plankton Density	1522/L	-	0
Blue-Green Dominance	78.6 %	-	10
Chlorophyll *a*	1.99 μg/L	-	0
*Method detection limit		**TSI Score**	**20**

Plankton enumerated from the sample collected from Pretty Lake are shown in Table 17. *Aphanizomenon*, a blue-green algae, was the most dominant genera found and accounted for over half the plankton density. In addition to this particular blue-green alga, other blue-green species contributed to the overall plankton dominance by blue-greens of 78.6%. Blue-greens are usually associated with degraded water quality. Blue-green algae are less desirable in lakes because they: 1) may form extremely dense nuisance blooms; 2) may cause taste and odor problems; and 3) are unpalatable as food for many zooplankton grazers.

Table 17. The plankton sample representing the species assemblage on July 21, 2008.

SPECIES	ABUNDANCE (#/l)
Blue-Green Algae (Cyanophyta)	
Anabaena	78
Aphanizomenon	925
Chroococcus	8
Lyngbya	163
Miscellaneous blue-green	23
Spirulina	8
Green Algae (Chlorophyta)	
Gomphosphaeria	93
Diatoms (Bacillariophyta)	
Fragilaria	16
Other Algae	
Ceratium	16
Dinobryon	47
Zooplankton	
Keratella	16
Bosmina	0.1
Daphnia	1.3
Diaphanosoma	0.2
Calanoid Copepod	0.6
Cyclopoid Copepod	1.6
Nauplius	3.2
Protozoa	31

4.2.2 Water Budget

Lake managers need to know how long water that enters a lake stays there in order to make good management decisions for the lake. In order to determine the amount of time it takes water that falls on or runs into the lake to theoretically leave the lake you first have to quantify sources of water (inputs) and the discharges of water (exports). Inputs of water to Pretty Lake are limited to:

1. direct precipitation to the lake
2. discharge from the inlet streams
3. sheet runoff from land immediately adjacent to the lake
4. groundwater

Water leaves the lake system from:

1. discharge from the individual lakes'
2. outlet channel
3. evaporation
4. groundwater

There are no discharge gages in the watershed to measure water inputs and the limited scope of this study did not allow us to determine quantitatively annual water inputs or outputs. Therefore we must estimate the water budget for lakes from other records.

- Direct precipitation to the lakes can be calculated from mean annual precipitation falling directly on the lakes' surface.
- Runoff from the lakes' watershed can be estimated by applying runoff coefficients. A runoff coefficient refers to the percentage of precipitation that occurs as surface runoff, as opposed to that which soaks into the ground. Runoff coefficients may be estimated by comparing discharge from a nearby gaged watershed of similar land and topographic features, to the total amount of precipitation falling on that watershed. The nearest gaged watershed is a U.S.G.S. gaging station on the Yellow River at Plymouth, Indiana (Morlock et al., 2004). The 58-year (1949–2006) mean annual discharge from this watershed is 268 cfs (cubic feet per second). With a mean annual precipitation for Marshall County of 36.78 inches (Smallwood, 1980), this means that on average, 33.6 % of the rainfall falling on this watershed runs off on the land surface.
- For the purposes of this study it was assumed that groundwater inputs equal outputs because of the limited budget allowed for this task. However; Pretty Lake has multiple "springs" according to the lake residents and therefore groundwater may play an important role in the nutrient cycling of the lake. Results from a comprehensive groundwater study would be useful for interpreting the lake water quality parameters measured during this study.
- We can estimate evaporation losses by applying evaporation rate data to the lakes. Evaporation rates are determined at six sites around Indiana by the National Oceanic and Atmospheric Administration (NOAA). The nearest site to the study lakes is located in Valparaiso, Indiana. Annual evaporation from a 'standard pan' at the Valparaiso site averages 28.05 inches per year. Because evaporation from the standard pan overestimates evaporation from a lake by about 30%, we correct the evaporation rate by this percentage, which yields an estimated evaporation rate from the lake surface of 19.95 inches per year. Multiplying this rate times the surface area of each lake yields an estimated volume of evaporative water loss from the study lakes.

The water budget for Pretty Lake, based on the assumptions discussed above, is shown in Table 18. When the volume of water flowing out of Pretty Lake is divided by the lake's volume, a hydraulic residence time of 3.0 years results. This means that on average, water entering the lake stays in the lake for 3 years before it flows out. This hydraulic residence time is longer than other glacial lakes in this part of the country. In a study of 95 north temperate lakes in the U.S., the mean hydraulic residence time for the lakes was 2.12 years (Reckhow and Simpson, 1980). Most glacial lakes have a watershed area to lake surface area ratio of around 10:1 (Vant, 1987). Pretty Lake, with a watershed area to lake surface area ratio of 5.6:1, has a smaller watershed than the average cited in Vant, and because of its mean depth of 21.7 feet, the relatively large volume of Pretty Lake contributes to its longer hydraulic residence time.

Table 18. Water budget calculations for Pretty Lake, Marshall County, Indiana.

Watershed	Pretty Lake - Marshall Co.
Watershed size (ac)	539.3
Mean watershed runoff (ac-ft/yr)	556
Lake volume (ac-ft)	2103
Closest gaged stream	Yellow River, Plymouth
Stream watershed (mi^2)	294
Stream watershed (acres)	188160
Mean annual daily Q (cfs)	268
Mean annual total Q (ac-ft/yr)	194023
Mean ppt (in/yr)	36.78
Mean watershed ppt (ac-ft/yr)	576710
Watershed C	0.33643
Pan evaporation (in/yr)	28.05
Pan evaporation coefficient	0.70
Lake surface area (acres)	97
Estimated lake evaporation (ac-ft)	158
Direct precipitation to lake (ac-ft)	297
(blue)	= input data
(yellow)	= output data
Water Budget Summary	
Direct precipitation to lake (ac-ft)	297
Runoff from watershed (ac-ft)	556
Evaporation (ac-ft)	158
TOTAL LAKE OUTPUT (ac-ft)	694
Hydraulic residence time (yr)	3.0

4.2.3 Phosphorus Modeling

The limited scope of this LARE study did not allow us to determine phosphorus inputs and outputs outright, which would have required direct measurements of phosphorus from all the sources of water entering the lake. Therefore, we have used a standard phosphorus model to estimate the phosphorus budget for Pretty Lake. Reckhow et al. (1980) compiled phosphorus loss rates from various land use activities as determined by a number of different studies, and from this, they calculated phosphorus export coefficients for various land uses. We used mid-range estimates of these phosphorus export coefficient values for all watershed land uses (Table 19). Phosphorus export coefficients are expressed as kilograms of phosphorus lost per hectare of land per year. The export coefficient for a particular land use was multiplied by the area of land in that land use category to derive an estimate of annual phosphorus export (as kg/year) for each land use (Table 19).

Table 19. Phosphorus export coefficients (units are kg/hectare except the septic category, which are kg/capita-yr).

Estimate Range	Agriculture	Forest	Precipitation	Urban	Septic
High	3.0	0.45	0.6	5.0	1.8
Mid	0.40-1.70	0.15-0.30	0.20-0.50	0.80-3.0	0.4-0.9
Low	0.10	0.2	0.15	0.50	0.3

Source: Reckhow and Simpson (1980)

We estimated direct phosphorus input via precipitation to the lakes by multiplying mean annual precipitation in Marshall County (36.8 in./yr) times the surface area of the lake times a typical phosphorus concentration in Indiana precipitation (0.03 mg/L). Because homes surrounding Pretty Lake are on sewer, there is likely no phosphorus input from septic systems.

The results, shown in Table 20, yielded an estimated 151 kg of phosphorus loading to Pretty Lake from its watershed and from precipitation annually. The greatest estimated source of phosphorus loading to the lake is from row crop agriculture in the watershed (67% of total).
We can examine the relationships among the primary parameters that affect a lake's phosphorus concentration by using a phosphorus-loading model such as the widely used Vollenweider (1975) model. Vollenweider's empirical model says that the concentration of phosphorus ([P]) in a lake is proportional to the areal phosphorus loading (L, in g/m^2 lake area - year), and inversely proportional to the product of mean depth ($\bar{z}$) and hydraulic flushing rate (ρ) plus a constant (10):

$$[P] = \frac{L}{10 + \bar{z}\rho}$$

Table 20. Phosphorus loading model for Pretty Lake, Marshall County, Indiana.

Phosphorus Loading - Lake Response Model

LAKE:	Pretty		**DATE:**	10/13/2008
COUNTY:				
STATE:	Indiana			
INPUT DATA		**Unit**		
Area, Lake	97	acres		-
Volume, Lake	2103	ac-ft		
Mean Depth	21.7	ft		
Hydraulic Residence Time	3.00			
Flushing Rate	0.33	1/yr		
Mean Annual Precipitation	0.93	m		
[P] in precipitation	0.03	mg/l		
[P] in epilimnion	0.043	mg/l		
[P] in hypolimnion	0.043	mg/l		
Volume of epilimnion	960	ac-ft		
Volume of hypolimnion	1143	ac-ft		
Land Use (in watershed)	**Area**		**P-export Coefficient**	
Deciduous Forest	47.80	hectare	0.2	kg/ha-yr
Emergent Herbaceous Wetlands	3.40	hectare	0.1	kg/ha-yr
Evergreen Forest	0.40	hectare	0.15	kg/ha-yr
High Intensity Residential	0.30	hectare	1.5	kg/ha-yr
High Intensity:Commercial/Ind	0.40	hectare	1.3	kg/ha-yr
Low Intensity Residential	6.0	hectare	0.8	kg/ha-yr
Mixed Forest	0.1	hectare	0.175	kg/ha-yr
Pasture/Hay	43.3	hectare	0.5	kg/ha-yr
Row Crops	101.2	hectare	1	kg/ha-yr
Woody Wetlands	15.2	hectare	0.1	kg/ha-yr

Septic Systems	--	-------	0.50	kg/ha-yr
	218.10			
Other Data				
Soil Retention coefficient	0.75	-------		
# Permanent Homes		homes		
Use of Permanent Homes	1.0	year		
# Seasonal Homes		homes		
Use of Seasonal Homes	0.25	year		
# Seasonal Homes		homes		
Use of Seasonal Homes	0.09	year		
Avg. Persons Per Home	3	persons		
OUTPUT				
P load from watershed	140.1	kg/yr		
P load from precipitation	10.96	kg/yr		
P load from septic systems	0.00	kg/yr		
Total External P load	151.08	kg/yr		
Areal P loading	0.385	g/m2-yr		
Predicted P from Vollenweider	0.032	mg/l		

Back Calculated L total	0.525	g/m2-yr
Estimation of L internal	0.140	g/m2-yr
% of External Loading	73.3	%
% of Internal Loading	26.7	%

4.3 Drain Tile Sampling

There was only one inlet to the lake that we were able to obtain a sample from during the course of the study. The inlet is overland flow from the golf course on the north side of the lake and a 12 inch diameter agricultural tile that has been exposed by surcharging (the tile is 3 feet below grade but the true outlet of the tile is buried somewhere at the edge of the lake. JFNew found at least two "blow holes" where water is forced to the surface creating an eroded crater because it has no where to escape from the tile). The sample was obtained March 9, 2009 from this water-filled blow-hole after 1.42 inches of rain had fallen the previous day and again on June 11, 2009 after 0.58 inches of rain within the previous 12 hours (underground Weather.com for Plymouth Indiana). Water was also sampled from a 12-inch diameter culvert under the private Country Club Drive on March 9, 2009, which represented overland flow off the course. The same culvert had no flowing water during the June 11, 2009 sample event. The rate of flow was not measured during the March sample event but was measured during the June sample event at 0.2 cubic feet (5.66 L) per second in a short section of defined channel approximately 50 feet from the edge of the lake. Table 21 summarizes the sample concentrations from both sample events. The Laboratory data sheets are located in Appendix F.

Table 21: Results of sampling at inlet on north side of Pretty Lake.

Sample date/description	*E. coli* Org/100ml	NO_3 (mg/L)	NH_4 (mg/L)	TKN (mg/L)	SRP (mg/L)	TP (mg/L)	TSS (mg/L)
3/09/2009 – Culvert	31	0.85	----	1.21	0.21	0.14	2
3/09/2009 - Tile	3	0.855	----	0.80	0.018	<0.1	6
6/11/2009 - Tile	2060	10.9	0.4	3.21	0.1	0.23	77

5.0 DISCUSSION

5.1 Background

The interpretation of a comprehensive set of water quality data can be quite complicated. Often, attention is directed at the important plant nutrients (phosphorus and nitrogen) and to water transparency (Secchi disk) since dense algal blooms and poor transparency greatly affect the health and use of lakes. Limnologists must compare data from the lake in question to standards, if they exist, to other lakes, or to criteria that most limnologists agree upon. There are no nutrient standards for Indiana lakes so we must compare the Pretty Lake results with data from other lakes and with generally accepted criteria. The following is a description of some of the parameters analyzed during the lake sampling efforts or included in the discussion.

Temperature. Temperature can determine the form, solubility, and toxicity of a broad range of aqueous compounds. For example, water temperature affects the amount of oxygen dissolved in the water column. Likewise, life associated with the aquatic environment in any location has its species composition and activity regulated by water temperature. Since essentially all aquatic organisms are 'cold-blooded' the temperature of the water regulates their metabolism and ability to survive and reproduce effectively (USEPA, 1976). The Indiana Administrative Code (327 IAC 2-1-6) sets maximum temperature limits to protect aquatic life for Indiana waters. For example, temperatures during the summer months should not exceed 90 ^{o}F (32.2 ^{o}C).

Dissolved Oxygen (DO). DO is the dissolved gaseous form of oxygen. It is essential for respiration of fish and other aquatic organisms. Fish need at least 3 to 5 mg/L of DO. Coldwater fish such as trout generally require higher concentrations of DO than warmwater fish such as bass or bluegill. The IAC sets minimum DO concentrations at 4 mg/L for warmwater fish, but all waters must have a daily average of 5 mg/L. DO enters water by diffusion from the atmosphere and as a byproduct of photosynthesis by algae and plants. Excessive algae growth can over-saturate (greater than 100% saturation) the water with DO. Conversely, dissolved oxygen is consumed by respiration of aquatic organisms, such as fish, and during bacterial decomposition of plant and animal matter.

Conductivity. Conductivity is a measure of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions: on their total concentration, mobility, and valence (APHA, 1998). Rather than setting a conductivity standard, the IAC sets a standard for dissolved solids (750 mg/L). Multiplying a dissolved solids concentration by a conversion factor of 0.55 to 0.75 μmhos per mg/L of dissolved solids roughly converts a dissolved solids concentration to specific conductance (Allan, 1995). Thus, converting the IAC dissolved solids concentration standard to specific conductance by multiplying 750 mg/L by 0.55 to 0.75 μmhos per mg/L yields a specific conductance range of approximately 1000 to 1360 μmhos. This report presents conductivity measurements at each site in μmhos.

Nutrients. Limnologists measure nutrients to predict the amount of algae growth and/or rooted plant (macrophyte) growth that is possible in a lake. Algae and rooted plants are a natural and necessary part of aquatic ecosystems. Both will always occur in a healthy lake. Complete elimination of algae and/or rooted plants is neither desirable nor even possible and should, therefore, never be the goal in managing a lake. Algae and rooted plant growth can, however, reach nuisance levels and interfere with the aesthetic and recreational uses of a lake. Limnologists commonly measure nutrient concentrations in aquatic ecosystem evaluations to determine the potential for such nuisance growth.

Like terrestrial plants, algae and rooted aquatic plants rely primarily on phosphorus and nitrogen for growth. Aquatic plants receive these nutrients from fertilizers, human and animal waste, atmospheric deposition in rainwater, and yard waste or other organic material that reaches the lake or stream. Nitrogen can also diffuse from the air into the water. This nitrogen is then "fixed" by certain algae species into a usable, "edible" form of nitrogen. Because of this readily available source of nitrogen (the air), phosphorus is usually the "limiting nutrient" in aquatic ecosystems. This means that it is actually the amount of phosphorus that controls plant growth in a lake or stream.

Phosphorus and nitrogen have several forms in water. The two common phosphorus forms are **soluble reactive phosphorus (SRP)** and **total phosphorus (TP)**. SRP is the dissolved form of phosphorus. It is the form that is "usable" by algae. Algae cannot directly digest and use particulate phosphorus. Total phosphorus is a measure of both dissolved and particulate forms of phosphorus. The most commonly measured nitrogen forms are **nitrate-nitrogen (NO_3)**, **ammonium-nitrogen (NH_4^+)**, and **total Kjeldahl nitrogen (TKN)**. Nitrate is a dissolved form of nitrogen that is commonly found in the upper layers of a lake or anywhere that oxygen is readily available. In contrast, ammonium-nitrogen is generally found where oxygen is lacking. ***Anoxia***, or a lack of oxygen, is common in the lower layers of a lake. Ammonium is a byproduct of decomposition generated by bacteria as they decompose organic material. Like SRP, ammonium is a dissolved form of nitrogen and the one utilized by algae for growth. The TKN measurement parallels the TP measurement to some extent. TKN is a measure of the **total organic nitrogen** (particulate) and ammonium-nitrogen in the water sample.

While the United States Environmental Protection Agency (USEPA) has established some nutrient standards for drinking water safety, it has not established similar nutrient standards for protecting the biological integrity of a lake. (The USEPA, in conjunction with the States, is currently working on developing these standards.) The USEPA has issued recommendations for numeric nutrient criteria for lakes (2000a). While these are not part of the Indiana Administrative Code, they serve as potential target conditions for which watershed managers might aim. Other researchers have suggested thresholds for several nutrients in lake ecosystems as well (Carlson, 1977; Vollenweider, 1975). Lastly, the IAC requires that all waters of the state have a nitrate concentration of less than 10 mg/L, which is the drinking water standard for the state.

With respect to lakes, limnologists have determined the existence of certain thresholds for nutrients above which changes in the lake's biological integrity can be expected. For example, Correll (1998) found that soluble reactive phosphorus concentrations of 0.005 mg/L are enough to maintain eutrophic or highly productive conditions in lake systems. For total phosphorus concentrations, 0.03 mg/L (0.03 ppm – parts per million or 30 ppb – parts per billion) is the generally accepted threshold. Total phosphorus concentrations above this level can promote nuisance algae blooms in lakes (Smith, 1982). The USEPA's recommended nutrient criterion for total phosphorus is fairly low at 0.01475 mg/L (2000a). This is an unrealistic target for many Indiana lakes. It is unlikely that IDEM will recommend a total phosphorus criterion this low for incorporation in the IAC. Similarly, the USEPA's recommended nutrient criterion for nitrate-nitrogen in lakes is low at 0.08 mg/L. This is below the detection limit of most laboratories. In general, levels of inorganic nitrogen (which includes nitrate-nitrogen) that exceed 0.3 mg/L may also promote algae blooms in lakes. High levels of nitrate-nitrogen can be lethal to fish. The nitrate LC_{50} is 5 mg/L for logperch, 40 mg/L for carp, and 100 mg/L for white sucker. (Determined by performing a bioassay in the laboratory, the LC_{50} is the concentration of the pollutant being tested, in this case nitrogen, at which 50% of the test population died in the bioassay.) The USEPA's recommended criterion for total Kjeldahl nitrogen in lakes is 0.56 mg/L.

It is important to remember that none of the threshold or recommended concentrations listed above are state standards for water quality. They are presented here to provide a frame of reference for the concentrations found in Pretty Lake. The IAC sets only nitrate-nitrogen and ammonia-nitrogen standards for waterbodies in Indiana. The IAC requires that all waters of the state have a nitrate-nitrogen concentration of less than 10 mg/L, which is the drinking water standard for the state. The IAC standard for ammonia-nitrogen depends upon the water's pH and temperature, since both can affect ammonia-nitrogen's toxicity. The Pretty Lake samples did not exceed the state standard for either nitrate-nitrogen or ammonia-nitrogen.

Secchi Disk Transparency. This refers to the depth to which the black and white Secchi disk can be seen in the lake water. Water clarity, as determined by a Secchi disk, is affected by two primary factors: algae and suspended particulate matter. Particulates (for example, soil or dead leaves) may be introduced into the water by either runoff from the land or from sediments already on the bottom of the lake. Many processes may introduce sediments from runoff; examples include erosion from construction sites, agricultural land, and riverbanks. Bottom sediments may be resuspended by bottom feeding fish such as carp, or in shallow lakes, by motorboats or strong winds. In general, lakes possessing Secchi disk transparency depths greater than 15 feet (4.5 m) have outstanding clarity. Lakes with Secchi disk transparency depths less than 5 feet (1.5 m) possess poor water clarity (ISPCB, 1976; Carlson, 1977). The USEPA recommended a numeric criterion of 10.9 feet (3.3 m) for Secchi disk depth in lakes (2000a).

Light Transmission. Similar to the Secchi disk transparency, this measurement uses a light meter (photocell) to determine the rate at which light transmission is diminished in the upper portion of the lake's water column. Another important light transmission measurement is determination of the 1% light level. The 1% light level is the water depth to which one percent of the surface light penetrates. This is considered the lower limit of algal growth in lakes. The volume of water above the 1% light level is referred to as the ***photic zone***.

Plankton. Plankton are important members of the aquatic food web. Plankton include the algae (microscopic plants) and the zooplankton (tiny shrimp-like animals that eat algae). Plankton are collected by towing a net with a very fine mesh (63-micron openings = 63/1000 millimeter) up through the lake's water column from the one percent light level to the surface. Of the many different planktonic species present in the water, the blue-green algae are of particular interest. Blue-green algae are those that most often form nuisance blooms and their dominance in lakes may indicate poor water conditions.

Chlorophyll *a*. The plant pigments in algae consist of the chlorophylls (green color) and carotenoids (yellow color). Chlorophyll *a* is by far the most dominant chlorophyll pigment and occurs in great abundance. Thus, chlorophyll *a* is often used as a direct estimate of algal biomass. In general, chlorophyll *a* concentrations below 2 mg/L are considered low, while those exceeding 10 mg/L are considered high and indicative of poor water quality. The USEPA recommended a numeric criterion of 2.6 mg/L as a target concentration for lakes in Aggregate Nutrient Ecoregion VII (2000a).

Vollenweider's Model. Results of studies conducted by Richard Vollenweider in the 1970's are often used as guidelines for evaluating concentrations of water quality parameters. Vollenweider relates the concentrations of selected water quality parameters to a lake's trophic state. The trophic state of a lake refers to its overall level of nutrition or biological productivity. Trophic categories include: oligotrophic, mesotrophic, eutrophic and hypereutrophic. Lake conditions characteristic of these trophic states are:

Oligotrophic - lack of plant nutrients keep productivity low, lake contains oxygen at all depths, clear water, deeper lakes can support trout.

Mesotrophic - moderate plant productivity, hypolimnion may lack oxygen in summer, moderately clear water, warm water fisheries only - bass and perch may dominate.

Eutrophic - contains excess nutrients, blue-green algae dominate during summer, algae scums are probable at times, hypolimnion lacks oxygen in summer, poor transparency, rooted macrophyte problems may be evident.

Hypereutrophic - algal scums dominate in summer, few macrophytes, no oxygen in hypolimnion, fish kills possible in summer and under winter ice.

The units in the table are either milligrams per liter (mg/L) or micrograms per liter (µg/L). One mg/L is equivalent to one part per million (PPM) while one microgram per liter is equivalent to one part per billion (PPB). Remember that these are only guidelines – similar concentrations in your lake may not cause problems if something else is limiting the growth of algae or rooted plants.

The Indiana TSI. The large amount of water quality data collected during lake water quality assessments can be confusing to evaluate. Because of this, Indiana and many other states use a trophic state index (TSI) to help evaluate water quality data. A TSI condenses water quality data into a single, numerical index. Different index (or eutrophy) points are assigned for various water quality concentrations. The index total, or TSI, is the sum of individual eutrophy points for a lake.

The Indiana TSI (IDEM, 1986) ranges from 0 to 75 total points. The TSI totals are grouped into the following three lake quality classifications:

TSI Total	Water Quality Classification
0-15	highest quality (oligotrophic)
16-30	intermediate quality (mesotrophic)
31-45	low quality (eutrophic)
46-60	lowest quality (hypereutrophic)

A rising TSI score for a particular lake from one year to the next indicates that water quality is worsening while a lower TSI score indicates improved conditions. However, natural factors such as climate variation can cause changes in TSI score that do not necessarily indicate a long-term change in lake condition. Parameters and values used to calculate the Indiana TSI are given in Table 22.

Table 22. The Indiana Trophic State Index

Parameter and Range			Eutrophy Points
I.	Total Phosphorus (ppm)		
	A.	At least 0.03	1
	B.	0.04 to 0.05	2
	C.	0.06 to 0.19	3
	D.	0.2 to 0.99	4
	E.	1.0 or more	5
II.	Soluble Phosphorus (ppm)		
	A.	At least 0.03	1
	B.	0.04 to 0.05	2
	C.	0.06 to 0.19	3
	D.	0.2 to 0.99	4
	E.	1.0 or more	5
III.	Organic Nitrogen (ppm)		
	A.	At least 0.5	1
	B.	0.6 to 0.8	2
	C.	0.9 to 1.9	3
	D.	2.0 or more	4
IV.	Nitrate (ppm)		
	A.	At least 0.3	1
	B.	0.4 to 0.8	2
	C.	0.9 to 1.9	3
	D.	2.0 or more	4
V.	Ammonia (ppm)		
	A.	At least 0.3	1
	B.	0.4 to 0.5	2
	C.	0.6 to 0.9	3
	D.	1.0 or more	4

Parameter and Range		Eutrophy Points
VI.	Dissolved Oxygen: Percent Saturation at 5 feet from surface	
	A. 114% or less	0
	B. 115% 50 119%	1
	C. 120% to 129%	2
	D. 130% to 149%	3
	E. 150% or more	4
VII.	Dissolved Oxygen: Percent of measured water column with at least 0.1 ppm dissolved oxygen	
	A. 28% or less	4
	B. 29% to 49%	3
	C. 50% to 65%	2
	D. 66% to 75%	1
	E. 76% 100%	0
VIII.	Light Penetration (Secchi Disk)	
	A. Five feet or under	6
IX.	Light Transmission (Photocell) : Percent of light transmission at a depth of 3 feet	
	A. 0 to 30%	4
	B. 31% to 50%	3
	C. 51% to 70%	2
	D. 71% and up	0
X.	Total Plankton per liter of water sampled from a single vertical tow between the 1% light level and the surface:	
	A. less than 3,000 organisms/L	0
	B. 3,000 - 6,000 organisms/L	1
	C. 6,001 - 16,000 organisms/L	2
	D. 16,001 - 26,000 organisms/L	3
	E. 26,001 - 36,000 organisms/L	4
	F. 36,001 - 60,000 organisms/L	5
	G. 60,001 - 95,000 organisms/L	10
	H. 95,001 - 150,000 organisms/L	15
	I. 150,001 - 5000,000 organisms/L	20
	J. greater than 500,000 organisms/L	25
	K. Blue-Green Dominance: additional points	10

The Indiana TSI has not been statistically validated. It tends to rely too heavily on algae and does not weigh poor transparency or nutrients high enough in the total score. For these reasons, the Carlson TSI may be more appropriate to use in evaluating Indiana lake data.

The Carlson TSI. The most widely used and accepted TSI is one developed by Bob Carlson (1977) called the Carlson TSI. Carlson analyzed summertime total phosphorus, chlorophyll *a*, and Secchi disk transparency data for numerous lakes and found statistically significant relationships among the three parameters. He developed mathematical equations for these relationships and these form the basis for the Carlson TSI. Using this index, a TSI value can be generated by one of three measurements: Secchi disk transparency, chlorophyll *a* or total phosphorus. Data for one parameter can also be used to predict a value for another. The TSI values range from 0 to 100. Each major TSI division (10, 20, 30, etc.) represents a doubling in algal biomass. As a further aid in interpreting TSI results Carlson's scale is divided into four lake productivity categories: oligotrophic (least productive), mesotrophic (moderately productive); eutrophic (very productive) and hypereutrophic (extremely productive).

Not all lakes have the same relationship between transparency, chlorophyll and total phosphorus as Carlson's lakes do. Other factors such as high suspended sediments or heavy predation of algae by zooplankton may keep chlorophyll concentrations lower than might otherwise be expected from the total phosphorus or chlorophyll concentrations. High suspended sediments would also make transparency worse than otherwise predicted by Carlson's index.

It is also useful to compare the actual trophic state points for a particular lake from one year to the next to detect any trends in changing water quality. While climate and other natural events will cause some variation in water quality over time (possibly 5-10 trophic points), larger point changes may indicate important changes in lake quality.

5.2. Data Analysis

A wide variety of conditions, including geography, morphometry, time of year, and watershed characteristics, can influence the water quality of lakes. To help place lake data into perspective, consider the following data for 456 Indiana lakes collected during July and August 1994-2004 under the Indiana Clean Lakes Program (Table 23). The set of data summarized in the table represents mean values of epilimnetic and hypolimnetic samples for each of the 456 lakes. Pretty Lake's values for these water quality parameters were all better than these median statewide values except for dominance by blue-green algae. However, overall algal densities were relatively low in Pretty Lake.

Table 23. Water quality characteristics of 456 Indiana Lakes sampled from 1994-2004 by the Indiana Clean Lakes Program (Epiliminion and hypolimnion data averaged).

	Secchi Disk (ft)	NO_3 (mg/L)	NH_4 (mg/L)	TKN (mg/L)	SRP (mg/L)	TP (mg/L)	Chl *a* (µg/L)	Plankton (NU/L)	Bl-Green Dominance (%)
Median	6.9	0.275	0.818	1.66	0.12	0.17	12.9	35,570	53.8
Maximum	32.8	9.4	22.5	27.05	2.84	2.81	380.4	753,170	100
Minimum	0.3	0.01	0.004	0.230	0.01	0.01	0.013	39	0.08

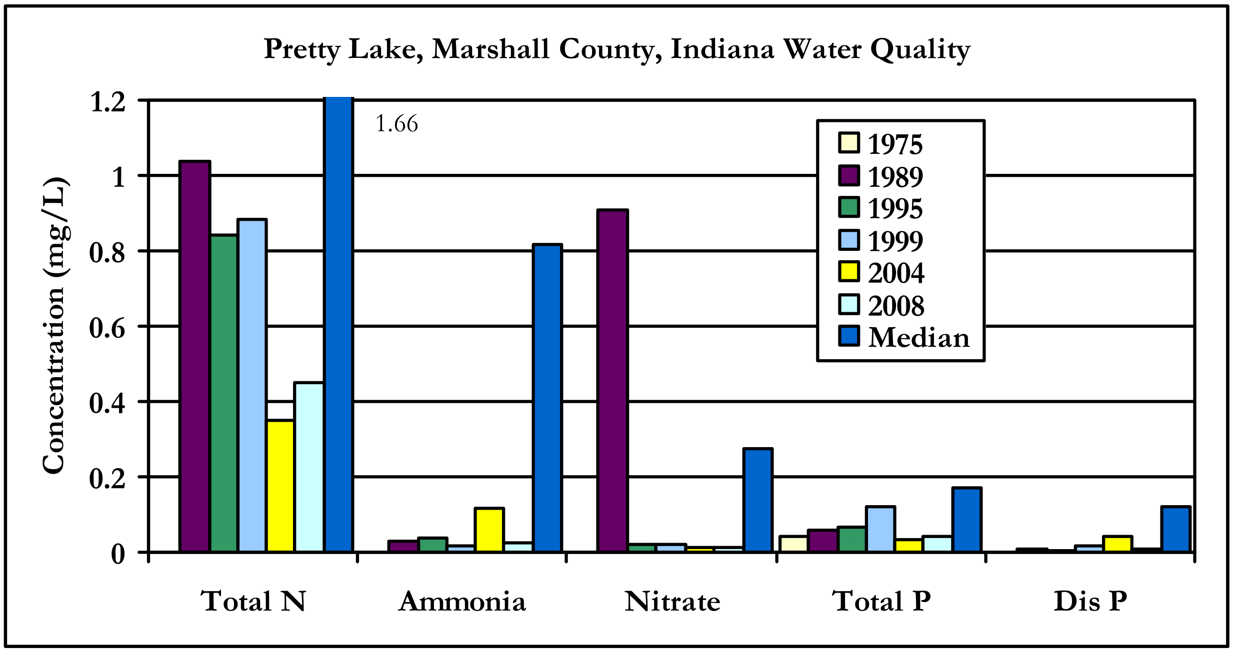

Figure 24: A comparison of nutrient levels in Pretty Lake, Marshall County, Indiana with the median nutrient levels from 456 Indiana Lakes sampled from 1994-2004.

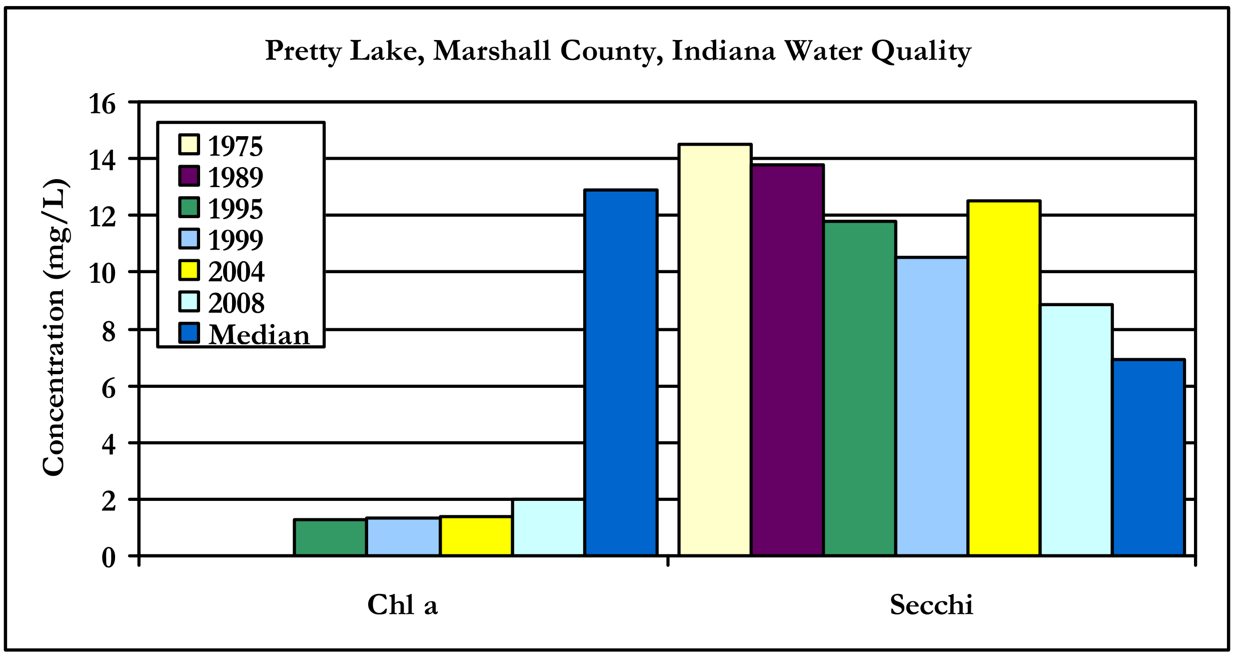

Figure 25. Chlorophyll *a* and Secchi disk readings from Pretty Lake, Marshall County Indiana, compared to median measurements from 456 Indiana Lakes sampled from 1994-2004. *Source: Indiana Department of Environmental Management. "Clean Lakes Program." 1989,1995, 1999, 2004.*

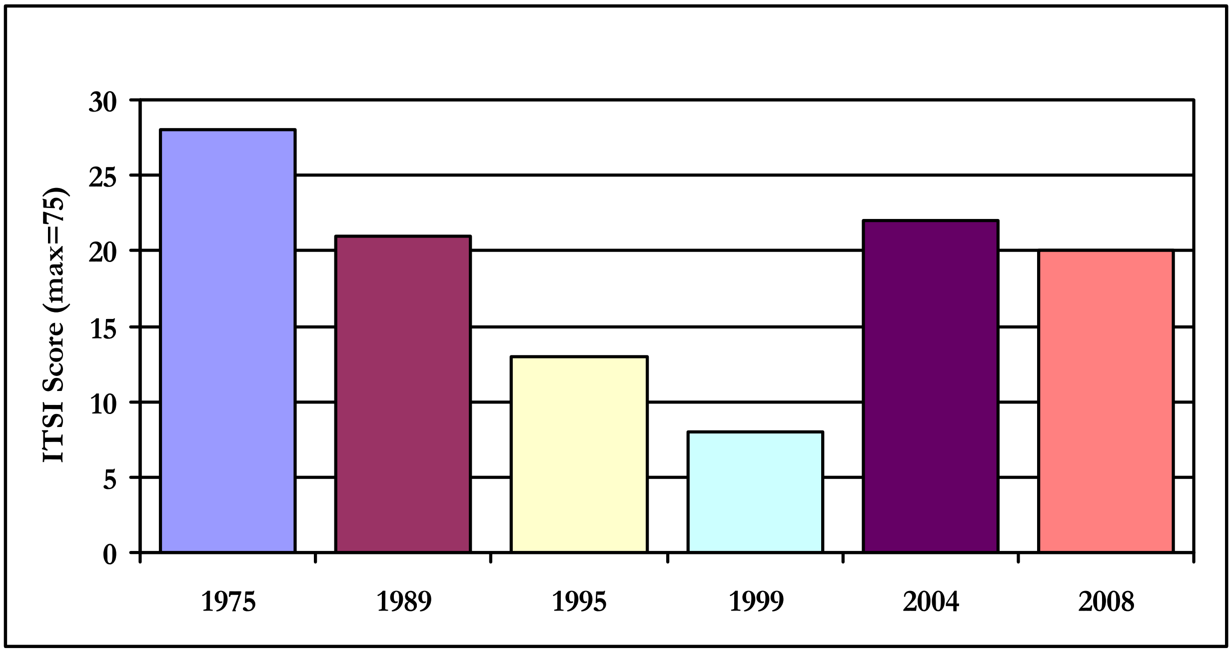

Figure 26. Indiana TSI scores from Pretty Lake, Marshall County, Indiana. *Source: Indiana Department of Environmental Management. "Clean Lakes Program." 1989,1995, 1999, 2004.*

Figures 24-26 compare the results of the 2008 sampling in Pretty Lake from all years to that of the Indiana Clean Lakes program median for all Indiana Lakes. Pretty Lake has significantly lower Total Nitrogen, Ammonia, and Nitrate concentrations than other Indiana Lakes. Total and dissolved phosphorus concentrations, average less than half the median concentration of other Indiana Lakes (Figure 24). Chlorophyll *a* concentrations at or below 2 mg/l are significantly less than the statewide median of nearly 13 mg/l and the corresponding secchi disk readings are nearly twice as deep as the state wide median measurement; however, the secchi disk reading do appear to be trending downward (getting worse) from 1975 to present (Figure 25). The Indiana TSI scores trend downward from 1975 to 1999 and then rise again in 2004 and 2008 (Table 23 and Figure 26) suggesting water quality was generally improving until 1999 and then the process was reversed.

Table 24. Pretty Lake: Indiana Trophic Index 1989, 1995, 1999, 2004 and 2008. *Source: Indiana Department of Environmental Management. "Clean Lakes Program." 1989,1995, 1999, 2004.*

	1989	**1995**	**1999**	**2004**	**2008**
Pretty Lake	21	13	8	22	20

The Indiana Trophic State Index values calculated for Pretty Lake from assessments conducted under the Indiana Clean Lakes Program are shown in Table 24. Pretty Lake was assessed in 1989, 1995, 1999, and 2004 by the Clean Lakes Program and in 2008 under the current study. The ITSI scores have been typically low for an Indiana lake, ranging from 8 in 1999 to a high of 22 in 2004. Pretty Lake's TSI scores for almost all measurements are better than most Indiana Lakes (Table 25).

Table 25. Comparison of Pretty Lake to the median for all Indiana Lakes for selected water parameters.

Lake	Secchi Disk	NO_3	NH_4	TKN	SRP	Total Phos.	Chl *a*	Plankton	Bl-green dominance
Pretty	better	better	better	better	better	better	better	better	worse

When compared to Carlson's Secchi Disk and Chlorophyll TSIs, Pretty Lake fell into the mesotrophic category for Secchi disk transparency and chlorophyll and into the eutrophic category for total phosphorous (Figure 27).

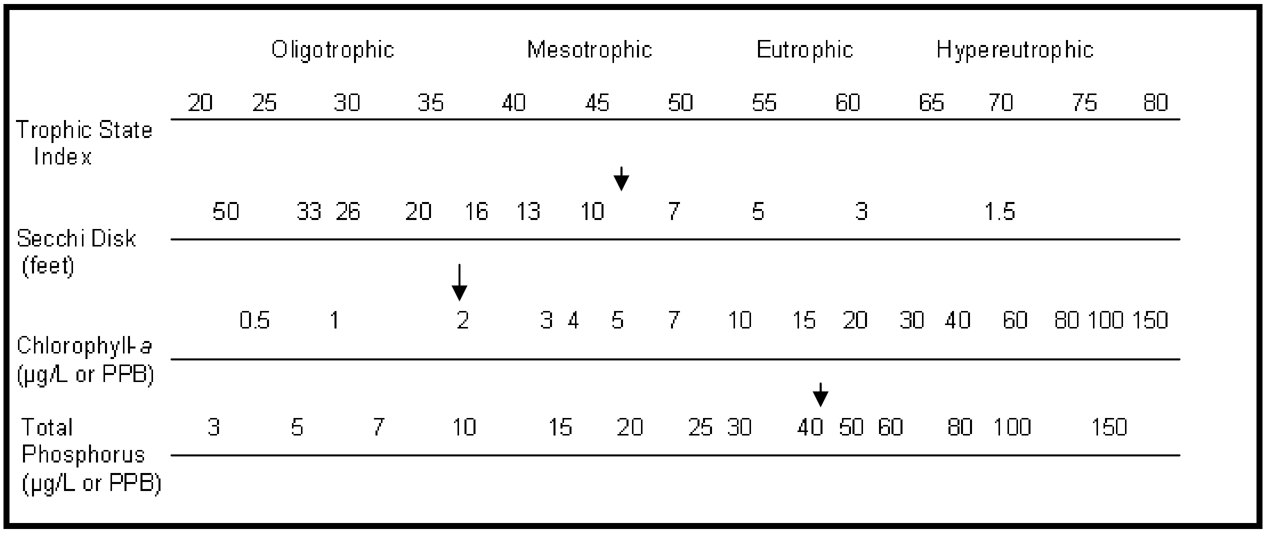

Figure 27. Carlson's Trophic State Index with Pretty Lake scores indicated with arrows.

Comparing the recent Pretty Lake sample results (Table 26) to mean values reported by Vollenweider (Table 27) shows mean concentrations of total nitrogen, and chlorophyll *a* occurring in the Oligotrophic range and the total phosphorus concentrations between the mesotrophic and eutrophic ranges. Pretty Lake also showed no indication of internal loading of phosphorus from the sediments.

Table 26. Summary of mean total phosphorus, total nitrogen, Secchi disk transparency, and Chlorophyll a results for Pretty Lake, Marshall County, Indiana

Parameter	Pretty
Total Phosphorus (mg/L or PPM)	0.043
Total Nitrogen (mg/L or PPM)	0.479
Secchi disk transparency (ft)	8.9
Chlorophyll *a* (µg/L or PPB)	1.99
Sediment phosphorus release factor	0

Table 27. Mean values of some water quality parameters and their relationship to lake production. (after Vollenweider, 1975).

Parameter	Oligotrophic	Mesotrophic	Eutrophic	Hypereutrophic
Total Phosphorus (mg/L or PPM)	0.008	0.027	0.084	>0.750
Total Nitrogen (mg/L or PPM)	0.661	0.753	1.875	-
Chlorophyll *a* (µg/L or PPB)	1.7	4.7	14.3	-

During our July 21, 2008 sampling of Pretty Lake, the mean volume weighted phosphorus concentration in the lake was 0.043 mg/L. Now it is useful to ask the question, "How much phosphorus loading from all sources is required to yield a mean phosphorus concentration of 0.043 mg/L in Pretty Lake?" By plugging this mean concentration along with the mean depth and flushing rate into Vollenweider's phosphorus loading model and solving for L, we get an estimated areal phosphorus loading rate (mass of phosphorus per unit area of lake) of 0.525 g/m^2-yr. This means that in order to get a mean phosphorus concentration of 0.043 mg/L in Pretty Lake, a total of 0.385 grams of phosphorus must be delivered to each square meter of lake surface area per year.

The phosphorus loading model (Reckhow et al. 1980) estimated that 0.385 g/m^2-yr of phosphorus is delivered to the lake from watershed sources each year. There are several possible explanations for the difference between the measured phosphorus concentration in the lake and the theoretical calculation of what should be in the lake based on the watershed :

1. The phosphorus loading model underestimated the watershed phosphorus delivery to the lake.
2. Groundwater inputs to the lake dilute the phosphorus concentrations.
3. The results of the July 21 2008 sampling of Pretty Lake were in error or were an anomaly.

Determining which of the above assumptions is important to explain the phosphorus dynamics in Pretty Lake. It is likely that the phosphorus model does not take into account the concentration of phosphorus that runs off the golf course as documented in recent sampling of the tile outlet on the north side of the lake. It is also likely that the lake has more dilutional capacity than accounted for in the model due to groundwater movement into and out of the lake. More likely is that both of these play a role in the existing phosphorus concentrations. Regardless of the reason for the difference in predicted versus actual lake phosphorus concentrations, reducing phosphorus from the watershed is still recommended to improve water quality in the lake.

Results of previous samples from Pretty Lake have also shown the same or slightly higher concentrations of phosphorus in the hypolimnion sample than in the epilimnion sample, like this present year (Table 28). For example, in 1989 hypolimnetic SRP concentration was 2 times that in the epilimnion. A large difference is strong evidence of substantial internal loading of phosphorus. Therefore, it is reasonable to assume that Pretty Lake's sediments are not a source of internal loading of phosphorus presently, but rather, are a sink for phosphorus. It is also reasonable to assume that the 2008 samples were not an error or an anomaly.

Table 28. Historic sediment phosphorus release from Pretty Lake (Hypo TP concentration/Epi TP concentration).

Year	Epilimnion (mg/L)	Hypolimnion (mg/L)	Sediment Phosphorus Release Factor
1989	0.005	0.010	2
1995	0.005	0.005	1
1999	0.017	0.017	1
2004	0.040	0.047	1.2
2008	0.010	0.010	1

Our experience on other lakes has shown that the runoff coefficient model of Reckhow et al. (1980) gives fairly accurate estimate of watershed loadings. The significance of areal phosphorus loading rates is better illustrated in Figure 28 in which areal phosphorus loading to Pretty Lake is plotted against the product of Pretty Lake's mean depth times flushing rate. Overlain on this graph is a curve, based on Vollenweider's model, which represent an acceptable loading rate that yields a phosphorus concentration in lake water of 30 µg/L (0.03 mg/L). The areal phosphorus loading rate for Pretty Lake lies slightly above the acceptable line.

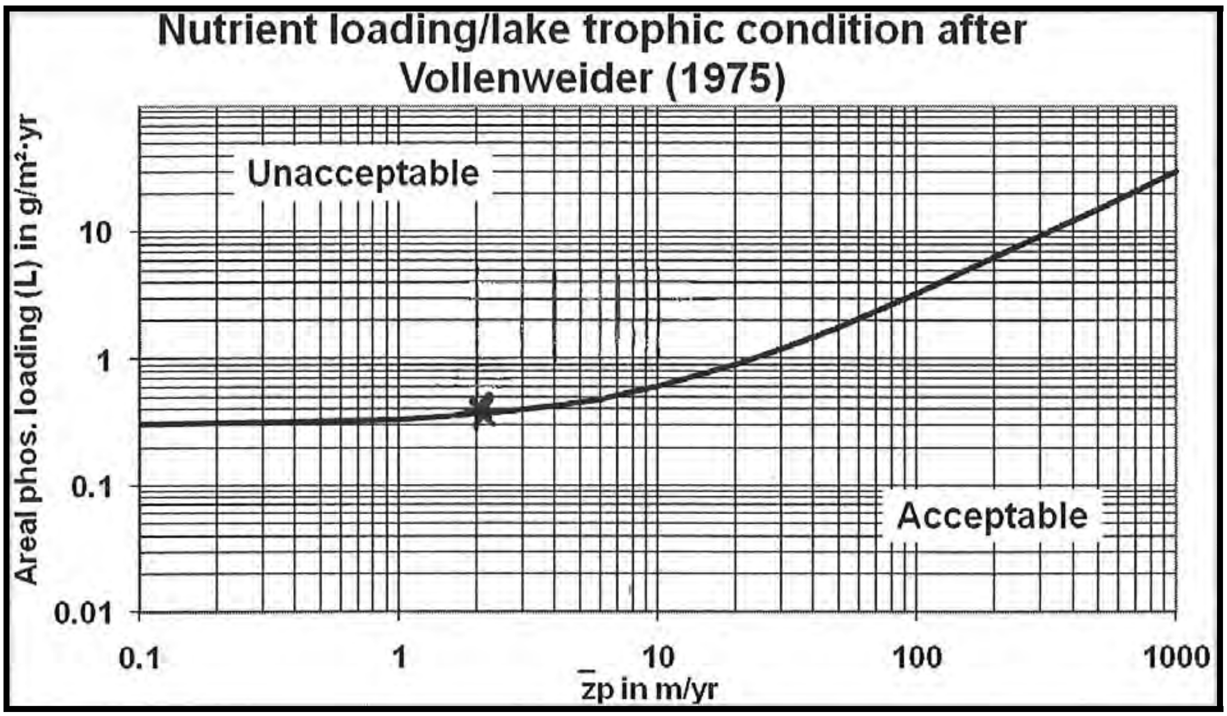

Figure 28. Estimated external phosphorus loadings from Reckhow and Simpson's runoff coefficients to Pretty Lake, Marshall County, Indiana, compared to acceptable loadings determined from Vollenweider's model. The dark line represents the upper limit for acceptable loading. The asterick is the estimated phosphorus loading.

Figure 28 can also be used to evaluate management needs. For example, areal phosphorus loading to Pretty Lake would have to be reduced from 0.385 g/m^2-yr to 0.370 g/m^2-yr (the downward vertical intercept with the line) to yield a mean lake water concentration of 0.030 mg/L. This represents a reduction in areal phosphorus loading of 0.015 g/m^2-yr to the lake, which is equivalent to a total phosphorus mass loading reduction of 7.4 kg P/yr or 5% of current estimated total phosphorus loading to the lake. Decisions by lake managers to improve lake water quality can now utilize the phosphorus load reduction estimate to target their available resources. In the case of Pretty Lake, reducing external phosphorus loading by 7.4 kg per year or 5% of the existing load (Table 29) will make a difference in water quality by preventing the build-up of excess phosphorus in Pretty Lake's sediments.

Table 29. Phosphorus reduction required to achieve an acceptable loading rate and a mean lake concentration of 0.03 mg/L in Pretty Lake, Marshall County, Indiana, based on Vollenweider's model.

Lake	Current External Total Areal P Loading (g/m^2-yr)	Acceptable Areal P Loading (g/m^2-yr)	Reduction Needed (kg P/yr and %)
Pretty	0.385	0.370	7.4 kg (4.9%)

5.3 Priority Areas for Conservation, Restoration and Acquisition

According to the phosphorus model, a five percent reduction would reduce the export of phosphorus below the 0.37g/m^2 per year threshold required to maintain the lake at a phosphorus concentration of 0.03 mg/l. There are several ways to obtain a five percent reduction in phosphorus loading to Pretty Lake:

1. Approximately 40 acres (16 ha) of existing agricultural land in the watershed north of Highway 17 could be converted to hay or just 20 acres (8 ha) could be converted to forest or wetland.
2. Eliminate the use of phosphorus on lawns and on the golf course adjacent to the lake.
3. Enhance and expand the use vegetated buffers at the edge of developed shorelines so that plants can utilize the phosphorus above and at the waters edge.

An area on the golf course adjacent to the lake and east of the tennis courts currently supports wetland vegetation and accepts the drainage from the majority of the golf course as well as a tile that flows from all the agricultural ground within the watershed. The drainage tile is a 12 inch clay tile. It is not a Legal Drain and therefore can be manipulated without permits. Caution is warranted though, as the agricultural landowners to the north of State Road 17 likely still rely on this tile to drain their fields. Any manipulation of the tile to create filters for pollutants should allow for unimpeded flow from the tile.

Wetland filters are known nutrient sinks. Nairn and Mitch (1999) found that two created wetlands, one vegetated and one unvegetated, significantly decreased turbidity (by 56%) in a flow through system, regardless of flow volume or duration and along with that decrease in suspended sediments they found a decrease in total phosphorus of 59% or more. Algal mats that develop in aquatic systems also utilize phosphorus in the dissolved form and then precipitate the phosphorus to the bottom of the system when they die (Nairn and Mitch (1999). It is likely that the existing vegetation at the outlet of the flows from the tile and the golf course are intercepting and trapping some of the nutrients and suspended solids measured during this study. However, it was apparent during the same storm events that a plume of suspended sediments does reach the lake and has undoubtedly created a more shallow environment at the shoreline (this is likely why the drain tile is plugged). No attempt was made during this study to document the depth and breath of this sediment plume in Pretty Lake due to the perceived lack of interest in dredging. From casual observation, the plume is no larger than ¼ acre and may be significantly smaller with a maximum depth of at most of 2 feet (0.6 m).

An interest by the Pretty Lake Property Owners Association was documented at both meetings (Appendix E) in somehow filtering the water that is coming through the tile system. Discussions based on early sample results (or lack of data early on) were muted by the fact that no cause for concern was firmly established. With the more recent (June 2009) samples it is documented that turbid water, high nitrogen, and high phosphorus concentrations are entering the lake from this tile system. Therefore, it is prudent to consider intercepting and treating this water using detention or a wetland filter system.

The easiest location to construct a sediment trap or filter is at the mouth of the existing drain, on country Club property east of the tennis courts. An adequate sized detention or wetland filter for this drainage should be at least an acre in size. The recommended maximum depth is three feet so that emergent vegetation can be supported in the filter. The cost to design, permit, and build a filter system is likely between $75,000 and $100,000.

5.4 Summary and Conclusions

Overall, the water quality of Pretty Lake is much better than most of Indiana's lakes. The lake can be considered as oligo-mesotrophic based upon the 2008 data. The relatively large volume of Pretty Lake helps to dilute nutrients washing into the lake from its watershed. While Pretty Lake enjoys very good water quality today, the concentration of total phosphorus in the lake suggests that the lake will degrade in the future if nothing is done to reduce phosphorus inputs.

1. The very deepest water contained diminished oxygen concentrations. This is due to the decomposition of organic matter on the sediments by bacteria that consume oxygen in the process. The sources of this organic matter are likely algae and rooted plants produced within the lake, and organic material washed into the lake from the watershed;
2. Estimated (modeled) phosphorus loadings to Pretty Lake from its watershed exceed suggested rates needed to maintain good water quality by only 5%. The lake's deep volume has mitigated excess phosphorus loadings in the past but for the long-term health of the lake, external phosphorus loadings should be reduced;
3. Pretty Lake's plankton was dominated by cyanobacteria, or blue-green algae. While these aren't the most desirable algae, their densities and resulting chlorophyll concentrations were low enough to not cause a discernable problem in the lake at the time of our sampling;
4. The 2008 Indiana TSI score for Pretty Lake is 20, rating the lake in the mesotrophic category, and the Carlson's Index also rates the lake as mesotrophic; however the measured phosphorus concentration are tending toward eutrophic conditions;
5. The lake is phosphorus limited with concentrations of total phosphorus greater than 10 times that of total nitrogen;
6. The phosphorus is not being released from the sediments;
7. Reducing the total phosphorus concentrations in the lake will result in better water quality.
8. The least expensive way to reduce the phosphorus concentration in the lake is to reduce the application of phosphorus in the watershed (phosphorus free fertilizer).
9. Additional phosphorus inputs can be reduced by conversion of cropland to grass, forest or wetland or by creating filters to intercept the drainage into the lake.

6.0 MANAGEMENT RECOMMENDATIONS

Pretty Lake has better water quality than most Indiana Lakes. However; the concentration of phosphorus in the lake indicates that water quality may be declining. The estimate produced in this report suggests a 5% reduction in Phosphorus loading. The watershed to lake ratio is low compared to most of these lakes, which means that processes and actions directly adjacent to the lake, and within the lake, may have a greater influence over the water quality than the watershed, when compared to other Indiana lakes. Therefore, the management recommendations provided below stress actions that can be performed on the lake by the PLPOA and by individuals homeowners all around the lake. None of the actions taken individually will result in noticeable lake water quality improvements. However, taken cumulatively, the actions below will add up to reduce the long term delivery or resuspension of phosphorus within and to the lake.

1) Promote or insist on the use of Phosphorus free fertilizer (middle number in three number fertilizer content label = 0) for all residents and businesses adjacent to the lake or adjacent to roads which have drains leading to the lake. Excess fertilizer washes to the lake during rain events and feeds algae as well as it feeds your lawn.
2) Reduce the direct discharge of stormwater to the lake from roof tops or roads. Rainwater off roofs and roads can and should be directed to rain barrels, rain gardens, or other storage areas to remove pollutants (including phosphorus) before it reaches the lake. The temporary storage and slow release of this water will remove many of the pollutants associated with storm water.
3) Pursue the design of a wetland filter for the tile or determine the source of pollution.
4) Insist that all disturbed land adjacent to the lakeshore, or to roads where runoff is directed to the lake through storm drains that lead to the lake, have adequate erosion control throughout the construction period. Several incidences were noted during the in-lake sampling for this study where significant erosion into the lake was occurring from home sites and private beaches.
5) Promote the use of native plants at the shoreline including emergent vegetation in the shallow waters. Even if ¼ of each lot were dedicated to a natural shoreline, the need for shoreline erosion protection would decrease on other areas due to the absorption of more wave energy. The resuspension of nutrients would decrease in the lake and fish would welcome the additional habitat. Where erosion is already occurring, consider a bioengineered or rock seawall over concrete and sheetpile walls.
6) Remove all pet waste from yards adjacent to the lake and dispose of the waste in a location where it will not decompose and add to the nutrients in the lake.
7) Pursue a program to reduce or eliminate purple loosestrife from the edges of the lakes. Purple loosestrife out competes native plants, thereby reducing the diversity of the food resource for aquatic biota in the critical near shore habitat.
8) Consider Conservation easements or purchase of the agricultural ground upstream of the lake. There are currently three owners which control almost 300 acres of the watershed (55%). If 20 acres (8 ha) of existing tilled agricultural ground is converted to wetland, prairie or woodland, the phosphorus delivery to the lake could be reduced to an acceptable level for maintaining a mesotrophic lake.

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APPENDIX A:

Endangered, Threatened, and Rare Species List

Pretty Lake Diagnostic Study
Marshall County, Indiana

JFNew

11/22/2005

Indiana County Endangered, Threatened and Rare Species List

County: Marshall

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Alasmidonta viridis	Slippershell Mussel			G4G5	S2
Lampsilis fasciola	Wavyrayed Lampmussel		SSC	G4	S2
Ligumia recta	Black Sandshell			G5	S2
Obovaria subrotunda	Round Hickorynut		SSC	G4	S2
Pleurobema clava	Clubshell	LE	SE	G2	S1
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Toxolasma lividus	Purple Lilliput		SSC	G2	S2
Mollusk: Gastropoda					
Campeloma decisum	Pointed Campeloma		SSC	G5	S2
Lymnaea stagnalis	Swamp Lymnaea		SSC	G5	S2
Fish					
Ammocrypta pellucida	Eastern Sand Darter			G3	S2
Coregonus artedi	Cisco		SSC	G5	S2
Ichthyomyzon bdellium	Ohio Lamprey			G3G4	S2
Reptile					
Clemmys guttata	Spotted Turtle		SE	G5	S2
Clonophis kirtlandii	Kirtland's Snake		SE	G2	S2
Emydoidea blandingii	Blanding's Turtle		SE	G4	S2
Sistrurus catenatus catenatus	Eastern Massasauga	C	SE	G3G4T3T4	S2
Terrapene ornata	Ornate Box Turtle		SE	G5	S2
Thamnophis butleri	Butler's Garter Snake		SE	G4	S1
Bird					
Accipiter striatus	Sharp-shinned Hawk	No Status	SSC	G5	S2B
Ardea herodias	Great Blue Heron			G5	S4B
Botaurus lentiginosus	American Bittern		SE	G4	S2B
Certhia americana	Brown Creeper			G5	S2B
Cistothorus palustris	Marsh Wren		SE	G5	S3B
Dendroica cerulea	Cerulean Warbler		SSC	G4	S3B
Ixobrychus exilis	Least Bittern		SE	G5	S3B
Rallus elegans	King Rail		SE	G4	S1B
Rallus limicola	Virginia Rail		SE	G5	S3B
Wilsonia citrina	Hooded Warbler		SSC	G5	S3B
Xanthocephalus xanthocephalus	Yellow-headed Blackbird		SE	G5	S1B
Mammal					
Spermophilus franklinii	Franklin's Ground Squirrel		SE	G5	S2
Taxidea taxus	American Badger			G5	S2
Vascular Plant					
Armoracia aquatica	Lake Cress		SE	G4?	S1
Aster borealis	Rushlike Aster		SR	G5	S2
Coeloglossum viride var. virescens	Long-bract Green Orchis		ST	G5T5	S2
Cypripedium candidum	Small White Lady's-slipper		WL	G4	S2
Eleocharis equisetoides	Horse-tail Spikerush		SE	G4	S1
Glyceria grandis	American Manna-grass		SX	G5	SH
Hypericum pyramidatum	Great St. John's-wort		ST	G4	S1
Platanthera orbiculata	Large Roundleaf Orchid		SX	G5	SX
Poa alsodes	Grove Meadow Grass		SR	G4G5	S2
Potamogeton friesii	Fries' Pondweed		ST	G4	S1
Potamogeton pusillus	Slender Pondweed		WL	G5	S2
Potamogeton strictifolius	Straight-leaf Pondweed		ST	G5	S1
Valeriana edulis	Hairy Valerian		SE	G5	S1
Zannichellia palustris	Horned Pondweed		SR	G5	S2
High Quality Natural Community					
Prairie - mesic	Mesic Prairie		SG	G2	S2

Indiana Natural Heritage Data Center
Division of Nature Preserves
Indiana Department of Natural Resources
This data is not the result of comprehensive county surveys.

Fed: LE = Endangered; LT = Threatened; C = candidate; PDL = proposed for delisting

State: SE = state endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SX = state extirpated; SG = state significant; WL = watch list

GRANK: Global Heritage Rank: G1 = critically imperiled globally; G2 = imperiled globally; G3 = rare or uncommon globally; G4 = widespread and abundant globally but with long term concerns; G5 = widespread and abundant globally; G? = unranked; GX = extinct; Q = uncertain rank; T = taxonomic subunit rank

SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

Indiana County Endangered, Threatened and Rare Species List

County: Marshall

Species Name	Common Name	FED	STATE	GRANK	SRANK
Wetland - beach marl	Marl Beach		SG	G3	S2
Wetland - bog acid	Acid Bog		SG	G3	S2
Wetland - fen	Fen		SG	G3	S3
Wetland - flat muck	Muck Flat		SG	G2	S2

Indiana Natural Heritage Data Center
Division of Nature Preserves
Indiana Department of Natural Resources
This data is not the result of comprehensive county surveys.

Fed: LE = Endangered; LT = Threatened; C = candidate; PDL = proposed for delisting

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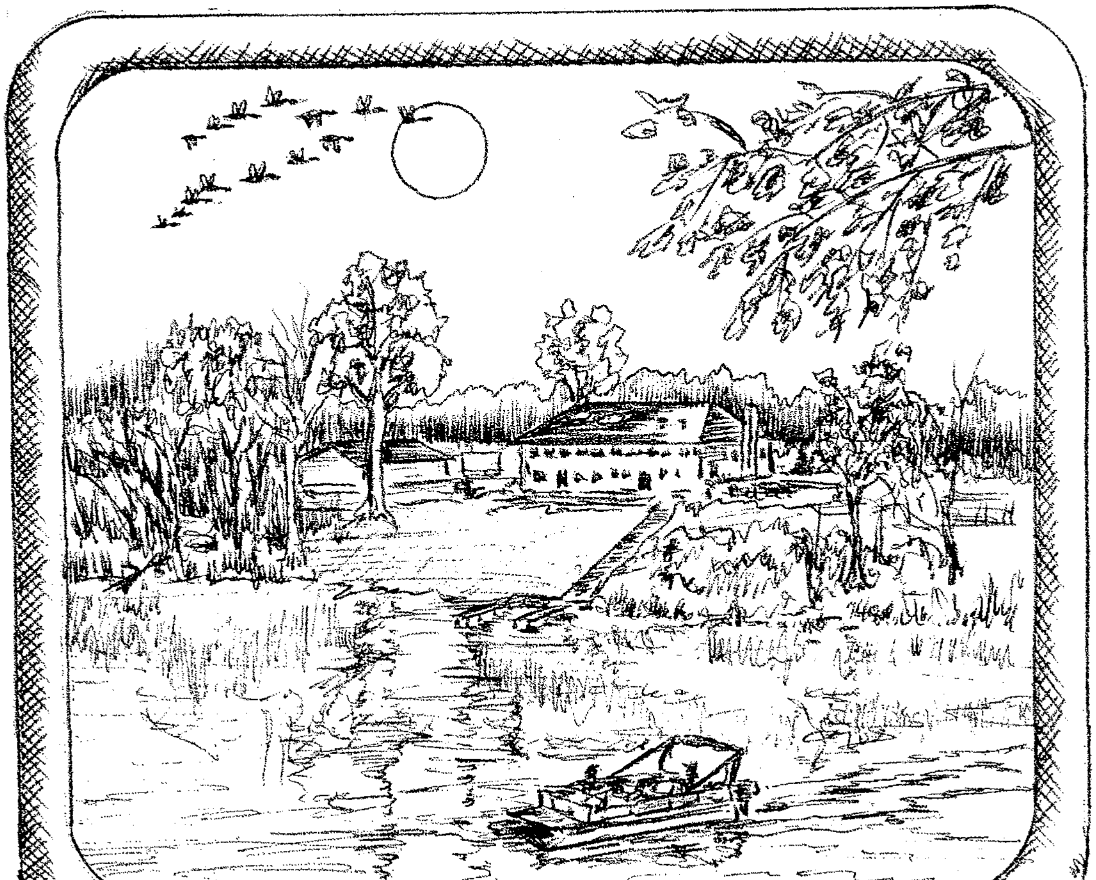
APPENDIX B:

Pretty Lake, Marshall County, History

Pretty Lake Diagnostic Study
Marshall County, Indiana

PRETTY LAKE



HISTORY

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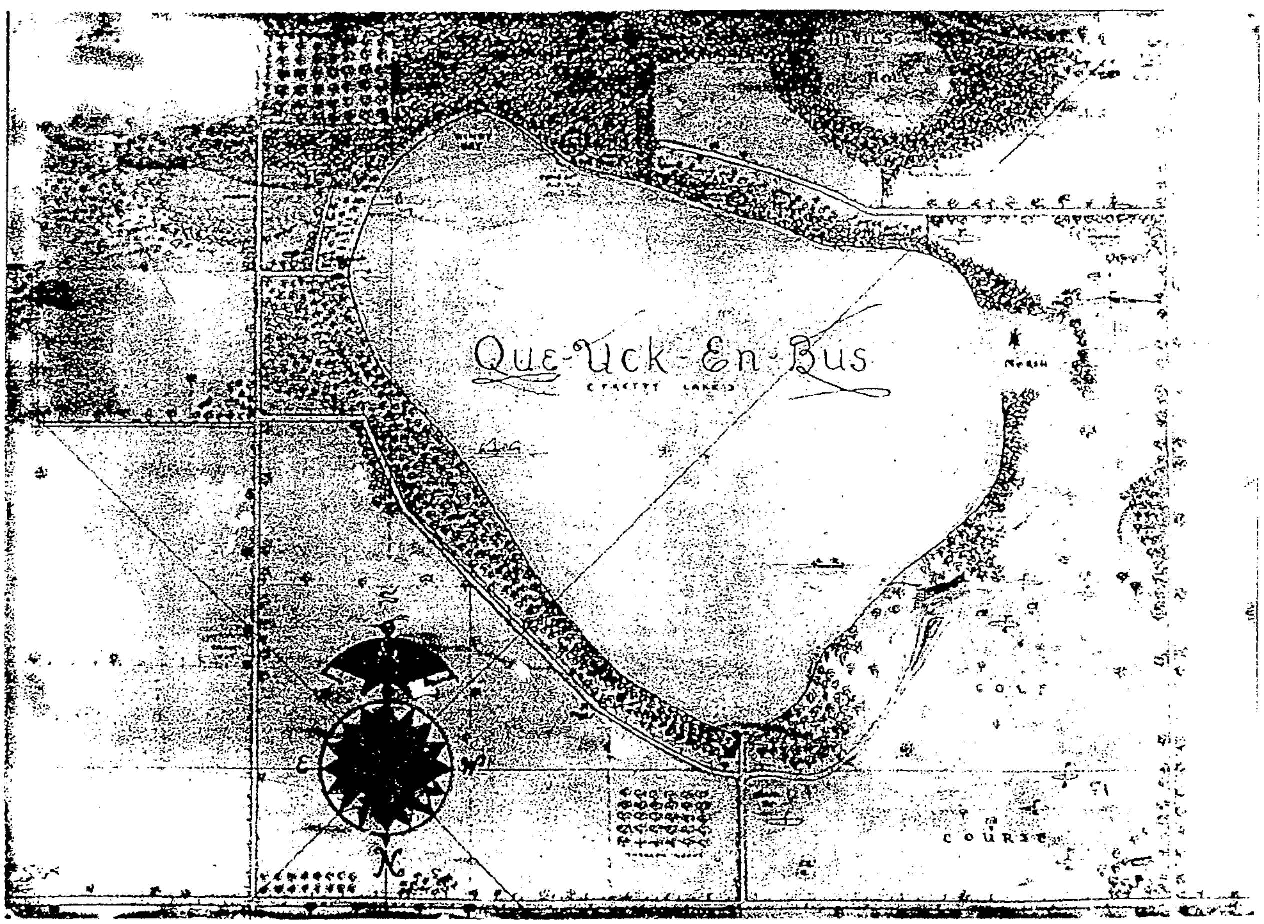
THE HISTORY OF PRETTY LAKE



Map drawn in the early 1920s by Arthur Jacoby

Indians around Pretty Lake

INDIAN TREATIES

Among the treaties made between the government and the various tribes of Indians then occupying this part of the Northwest Territory, a number of reservations were set off to various bands of the different tribes. Those who occupied the territory now known as Marshall County were the Pottawattomie tribe of Indians. They were divided into bands and governed by chiefs.

The largest reservation was called the "Me-'no-mi-nee Reserve." It was located beginning about a mile west and north of Plymouth, near where the Catholic cemetery is located. The east line ran directly south to a point about a mile south of Wolf Creek Mills, thence about three miles and a half west, thence north to the north line and east to the starting point. It contained twenty-two sections, or I4,080 acres in all, and embraced within its boundaries Pretty Lake, Twin Lakes, and a considerable portion of Yellow River southwest of Plymouth.

— From *A Twentieth Century History of Marshall County, Indiana;* Vol. I
by Daniel McDonald; 1908

Facts and Rememberances

The Indian name for Pretty Lake was "Qua-eck-eu-bus" (Que-Uck-En-Bus). Their name for Plymouth was "Aus-ka-nuk."

— From *History of Marshall County*
by Daniel McDonald (1836-1880)

The camping grounds for the "Gathering of Indians" is the current site of the McNeil, Burke and Smith homes (10431 - 10473 Pretty Lake Trail and 10411 - 10429 Quince Road.) Campfire deposits were dug into when digging to put in the septic tank.

— Edith Cullison Smith

"There were a lot of Indian hills [reservations] to the east of the lake. We found many arrowheads."

— Grace Engelhardt

An old man said that when he was a little boy fishing at Pretty Lake, he saw three Indians on horses ride into the lake. They were leading a riderless horse, which they took turns on until it was broken for riding. "Sometimes the Indians were on top, and sometimes the horse was. The water was really splashing!"

— Marshall County Historical Society

West Township

As we walk these trails of prehistoric times, we can only be amazed at the large forests, all the marshes, the many lakes, the many wild animals and the water fowl. Here, too, we could talk with them wherever we met them. Here lived the people of the woods, the Adena and Hopewell Cultures 300 to 1,000 years B.C. They left their presence known only by the shape of the arrow points which they made. It was probably a disease that wiped out their culture.

We walk the same trails of a new culture of the 16th and 17th centuries. We search and find their village sites, their burial grounds, their camp sites, their play grounds and work shops.

We need not wonder what happened to this last culture - we know. These, too, were taken down the Trail of Death in 1838.

Now, so that future generations may know, we will pinpoint our findings.

Pretty Lake is located in Marshall County, Indiana, West Township, Sec 11, T34N. On the south side of the lake, we find a trail-marker tree that points to a village and work shop site to the northeast in Sec 11. There, in the southeast quarter of the northwest quarter, we found four places, about 50 feet apart, where the natives made their stone work, leaving many artifacts and chips. This was a beautiful village site. This wooded acreage is now owned by Mr. and Mrs. George Unger, and they guard this spot religiously.

Mr. & Mrs. George Unger at the ancient village site on their farm. There are four chipping sites here, one-quarter mile east of Pretty Lake.

We now walk east past a few water holes. About one-fourth mile, we come to another wooded area with a ridge running diagonally through it from the northwest, located in the northeast quarter of the northwest quarter of Sec. 12. About in the center, we find two trenches of breastwork. These are about 50 feet apart, and nearly 100 feet long. They were probably made in the 1800s for protection.

George Unger's father told him there was an Indian burial on the flat part of the ridge. Using my test drill, I drilled many places until I found the burial site. In some places, the graves were close together; others were eight feet apart. My tests are based on topsoil mixed through the sub-soil, which is sand on that ridge.

George Unger on the ancient burial site which is one-half mile east of Pretty Lake in West township

— *The Incredible Wheel of Time*
by Ervin Stunty; 1983

How Pretty Lake Came to Be*

The title to all the lands in Indiana was obtained by the United States by cession from the State Of Virginia by Act of the General Assembly of the Commonwealth Of Virginia, December 20th, 1783.

Agreeably to the above recited Act, the whole territory Northwest of the Ohio River was on March 1st, 1784, transferred to the United States by Deed signed by Thomas Jefferson, Samuel Hardy, Arthur Lee, and James Monroe, then delegates in Congress from said Commonwealth. (See Vol. 1; page 472; U.S. Laws and Rev. Stat. Ind. 1843 pages 16 and 18.)

Upon the extinction of the Indians Title or rights of occupance Treaties with the various tribes of Indians, these lands were surveyed and sold to settlers and were commonly called Government Lands.

The treaties covering the lands in Marshall County are known as "Treaty at Tippecanoe, Oct. 26th and 27th, 1832": Treaty at Carey Mission Sept. 20th, 1828": "Treaty at Mississinewa, Oct. 16th, 1826" concerning the Michigan Road. The first named Treaty embraced all the land in the County except a small part in the Northeast corner which is covered by the second named Treaty, and the land South of the Tippecanoe River, which is covered by the third named Treaty.

The Government Surveys were made in December 1833 and January 1834: Michigan Road Land Sections were surveyed in 1832 as appears by the field notes on file in the Recorder's Office of Marshall County, Indiana.

For various purposes the United States ceded large tracts of land to the State of Indiana, and they were known as Canal Lands, Michigan Road Lands, Swamp Lands, Saline Lands, University Lands, Seminary Lands and School Lands. The State sold these lands under various acts of the General Assembly and Patents were issued to the purchasers in the name of the State. All of these patents are recorded in the Office of the Auditor of State except those for School lands which are recorded in the records of the Boards of Commissioners of the Counties in which the land is situated.

* From the original Abstract of Title by Cressner and Company of Plymouth, Indiana, for Lot Number Twenty-Eight (28) and the East Half of Lot Number Twenty-Nine (29) in Willis A. Koch's Second Addition to Koch's Lake Front at Pretty Lake, situated in Lot Number Two (2) of Section Number Eleven (11) Township Thirty-three (33) North, Range One (1) East.

Situated in Marshall County, Indiana.

President James K. Polk Grants Pretty Lake Area to State of Indiana

The United States of America By James K. Polk, President	)	PATENT
	)	
- to -	)	Deed Record 100, page 185
	)	
William Mason	)	Dated - July 1st, 1845
and to his heirs	)	Recorded - November 10th, 1927
	)	Consideration - Full Payment

By these presents do give, and grant the following described real estate in Marshall County, State of Indiana, towit:

The fractional Northeast Quarter of Section eleven, in township thirty three North, of Range One East of the Second Principal Meridian, in the district of lands subject to sale at Winimc (Winamac), Indiana, containing ninety two and seventy hundredths of an acre according to the official plat of the survey of said lands, returned to the General Land Office by the Surveyor General, which tract has been purchased by the said William Mason.

Founded on Certificate No. 14559 by which it appears that full payment has been made according to the provisions of the Act of Congress of the 24th of April, 1820, entitled "An Act making further provisions for the sale of the public lands."

In testimony whereof, I, James K. Polk, President of the United States of America have caused these letters to be made Patent and the seal of the General Land Office to be hereunto affixed.

Signed: "James K. Polk"
By Knox Walter, Secy.
(SEAL)

S.H. Laughlin Recorder of the General Land Office.

DEPARTMENT OF THE INTERIOR, GENERAL LAND OFFICE.
Washington D.C. November 8, 1927.

I hereby certify that this photograph is a true copy of the Patent record which is in my custody in this office.

M.P. LeRoy
Recorder
(SEAL)

* From the original Abstract of Title by Cressner and Company of Plymouth, Indiana, for Lot Number Twenty-Eight (28) and the East Half of Lot Number Twenty-Nine (29) in Willis A. Koch's Second Addition to Koch's Lake Front at Pretty Lake, situated in Lot Number Two (2) of Section Number Eleven (11) Township Thirty-three (33) North, Range One (1) East.
Situated in Marshall County, Indiana.

Pretty Lake

Located three and a half miles west of Plymouth in West Township, Pretty Lake is one of the coziest and pleasantest little lakes to be found in the state. The lake is rightly named. No one can stand on its banks and see its many beauties without being compelled to burst out with some such expression as, "My, but isn't this a pretty lake!"

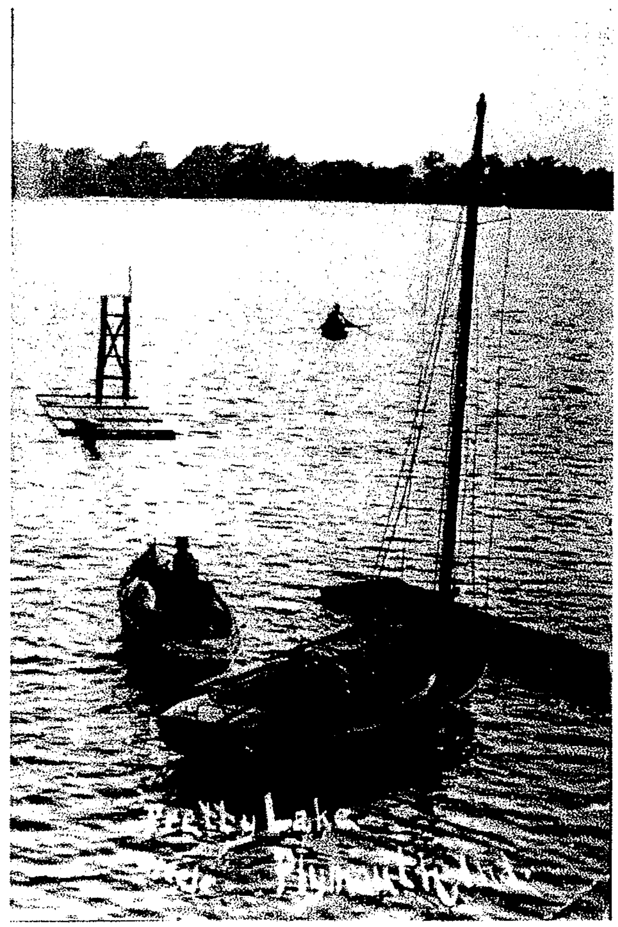
The lake is about a half mile wide and three fourths of a mile long. It has its length east and west, or nearly so, and has no outlet. It is doubtless one of the holes left during the glacial period, and is quite deep in many places, especially toward the south bank.

The north and east shores being nearest Plymouth, led to the building of cottages on this side of the lake.

— Marshall County Historical Society Archives

Pretty Lake is located in West Township, Marshall County, about four miles southwest of Plymouth in what were originally Pottawattomie Indian reserve lands. In early histories, it is described as the "prettiest lake of its size in all the region round about," and thus its name. McDonald, in his 1908 *History of Marshall County*, describes it at that time as "a fashionable summer resort area for Plymouth people and others, with about 40 summer cottages built in the last dozen years."

Among the people who lived close to the lake in the past 70 years was Irvin Broombaugh (Brumbaugh) who owned a great deal of land adjacent to the lake on the south side. Aaron Koch owned land on the east, north and west side of the lake, and Daniel Long and family had a small tract on the east side.

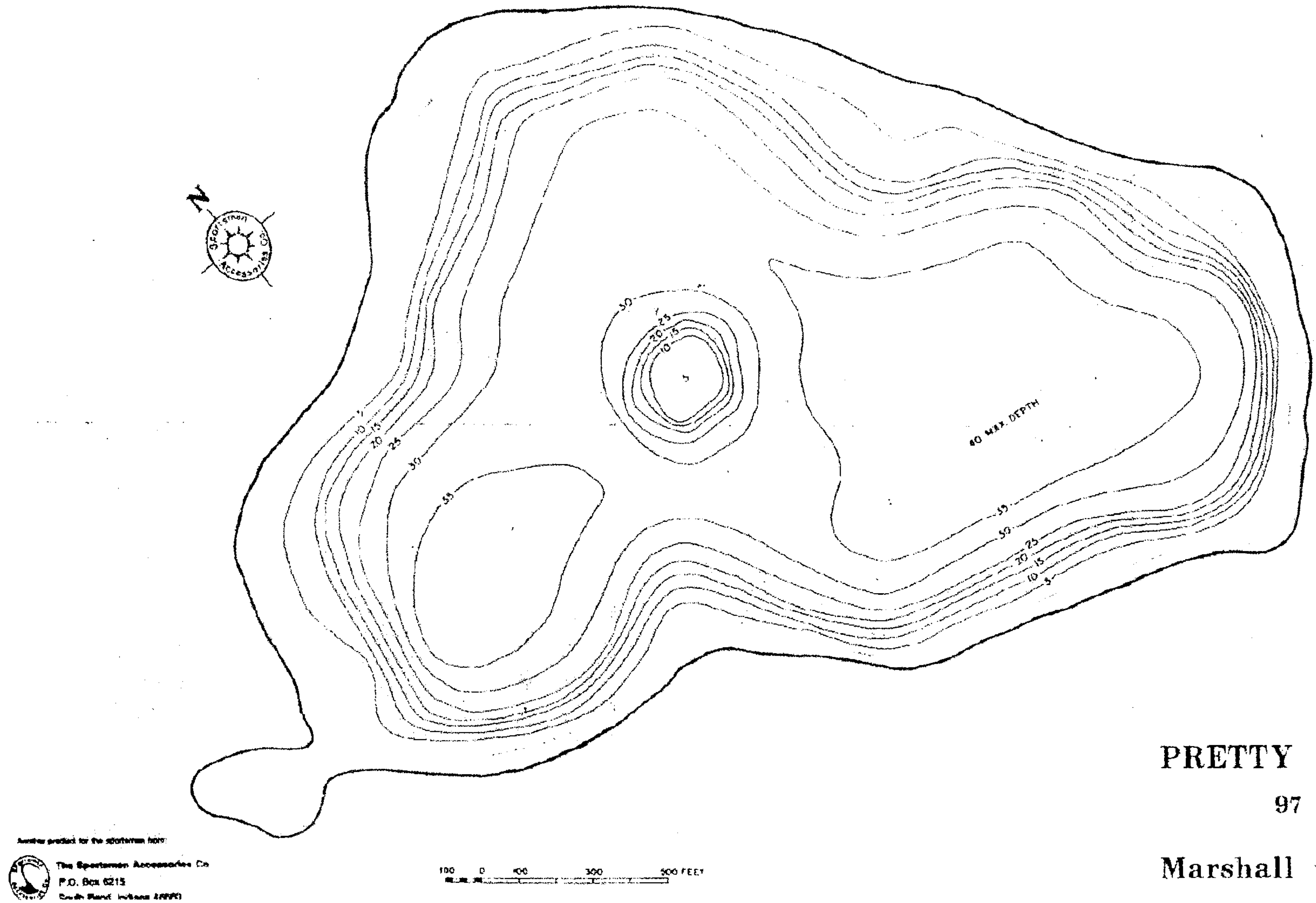


Written on back of card:
This is where we wanted you to come. Isnt it a pretty place? Sister

Sent to Louisville, KY
Original card was in color (1909).

Map showing the Depth of Pretty Lake

P - 160



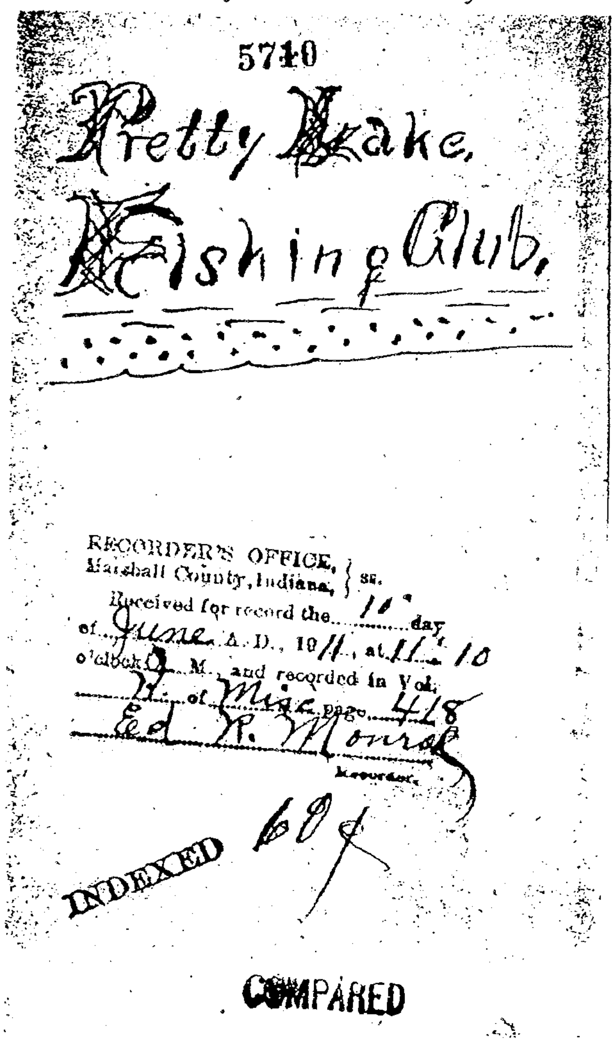
PRETTY LAKE

97 Acres

Marshall Co., Ind.

The Pretty Lake Fishing Club

In 1875, a number of Plymouth men organized the Marshall County Fish and Game Club, and purchased about four acres on the east side of the lake. No buildings were erected, and the owners sometimes camped there, weather permitting. This tract of land was later platted and became known as the Pretty Lake Club Grounds. The original June 1911 organizational papers are in the files of the Marshall County Historical Society.


5740

Pretty Lake Fishing Club.

RECORDER'S OFFICE, Marshall County, Indiana, } ss.
Received for record the 10 day of June A.D., 1911, at 11 10 o'clock A. M. and recorded in Vol. 2 of Misc. page 418
Ed. R. Monroe
Recorder.

INDEXED 684

COMPARED


A MORNING CATCH AT PRETTY LAKE

Highlights of Articles of Association for the Pretty Lake Fishing Club.

The persons whose names are subscribed herein shall be duly entered upon the records of the Association.

This organization to commence as soon as this certificate of organization is duly signed and acknowledged, and recorded in the Office of the County Recorder of Marshall County Indiana, and like-wise in the Office of the Secretary of State, at Indianapolis Indiana.

State of Indiana, Marshall County

J. Scott Sorey C. S. Vangilder
O. G. Baker
Grant Hanes
Guy Onstott
E. O. Tribbey

Personally appeared before me J.A. Molter a Notary Public in and for said County and State the 2nd day of June 1911.

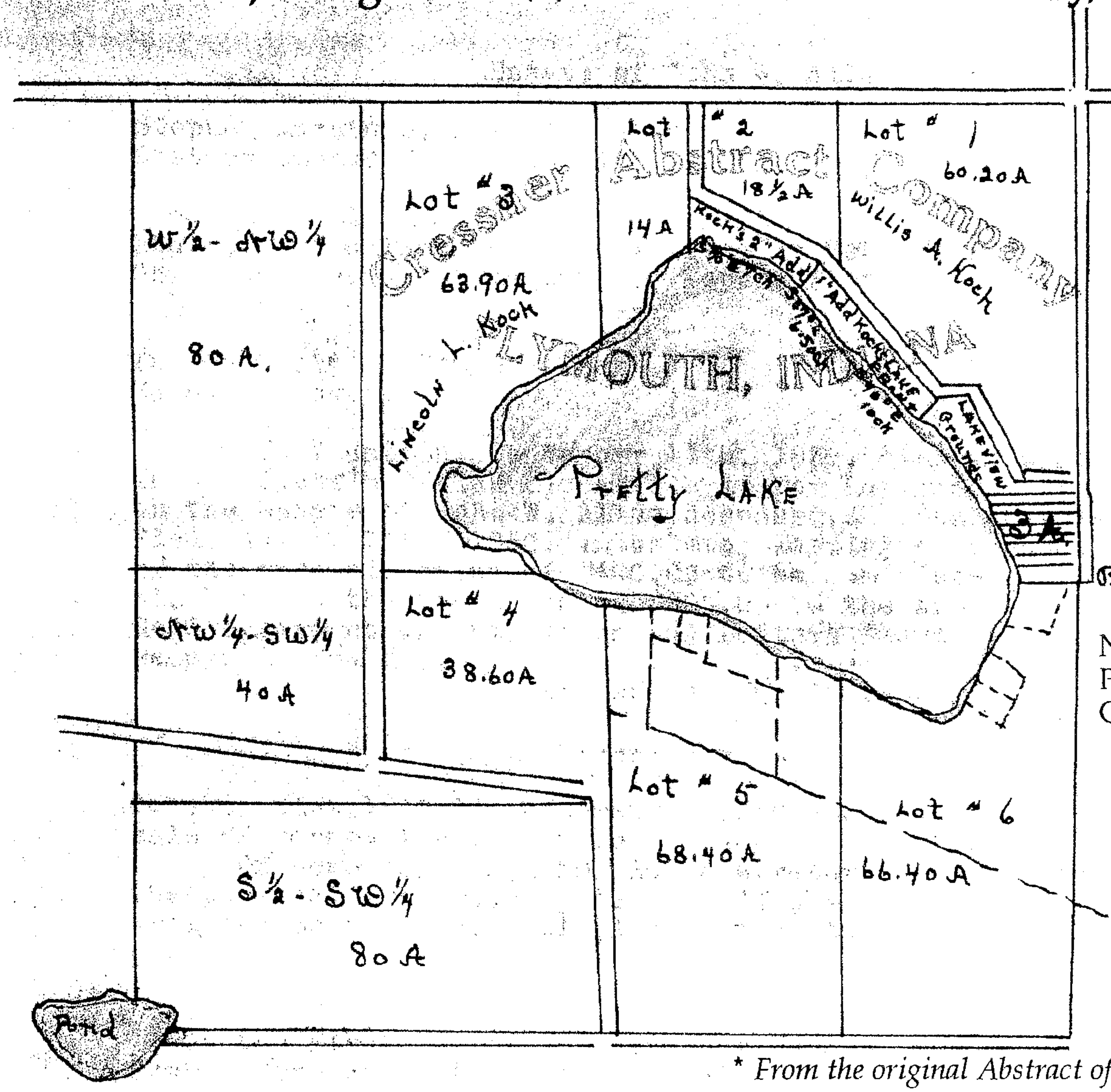
J. Scott Sorey
O. G. Baker
Grant Hanes
Guy Onstott
E. O. Tribbey
C. S. Vangilder

Whom duly acknowledged the above articles of Incorporation for the process therein set-forth.

J. A. Molter
Notary Public

COMMISSION EXPIRES
JANUARY 2ND, 1913

Map of Section Eleven (11) Township Thirty-three (33) North, Range One (1) East of Marshall County, Indiana*



Notice location of Pretty Lake Fishing Club

* *From the original Abstract of Title dated 1845*

DEMOCRAT, AUGUST 29, 1889

The new steamboat on Pretty Lake will be making regular trips around the lake on and after next Saturday.

Plymouth, Indiana
July 8 – 1968.

About two years ago during a conversation with Irene Shreve Ulrich I stated that I remembered well a steamboat on Pretty Lake. I was four or five years old at the time. To me as a child this boat belching black smoke looked like an ocean liner. It was probably twenty or less feet in length.

A few weeks ago Mrs. Shreve told me she had found the picture. – This is a photo taken from the original by "Hart Studio" in Plymouth – Mrs. Shreve expects to give the original to the Marshall County Historical Society.

This boat was probably built about 1891–92 and not later than 1895.

Fred N. Kuhn, Jr.
(Date of birth Dec. 25–1887.)

"Steam Boat on Pretty Lake."
Built by Peter Ulrich whose picture is shown with paint bucket in hand.

Written on back of postcard

A typical small-lake steamboat of the late 1800s

REPUBLICAN, JULY 16, 1896

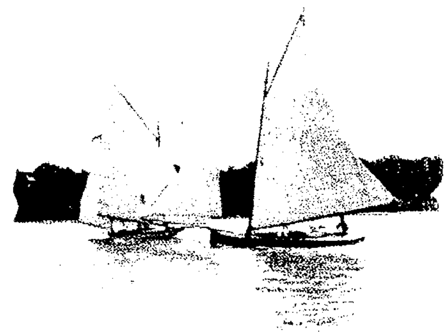
LAKE VIEW HOTEL HAPPENINGS

— Bowell & Lamson will give a social hop at the Lake View on the north shore of Pretty Lake, on this evening. The dance will be free to all, but no objectionable characters will be allowed to participate.

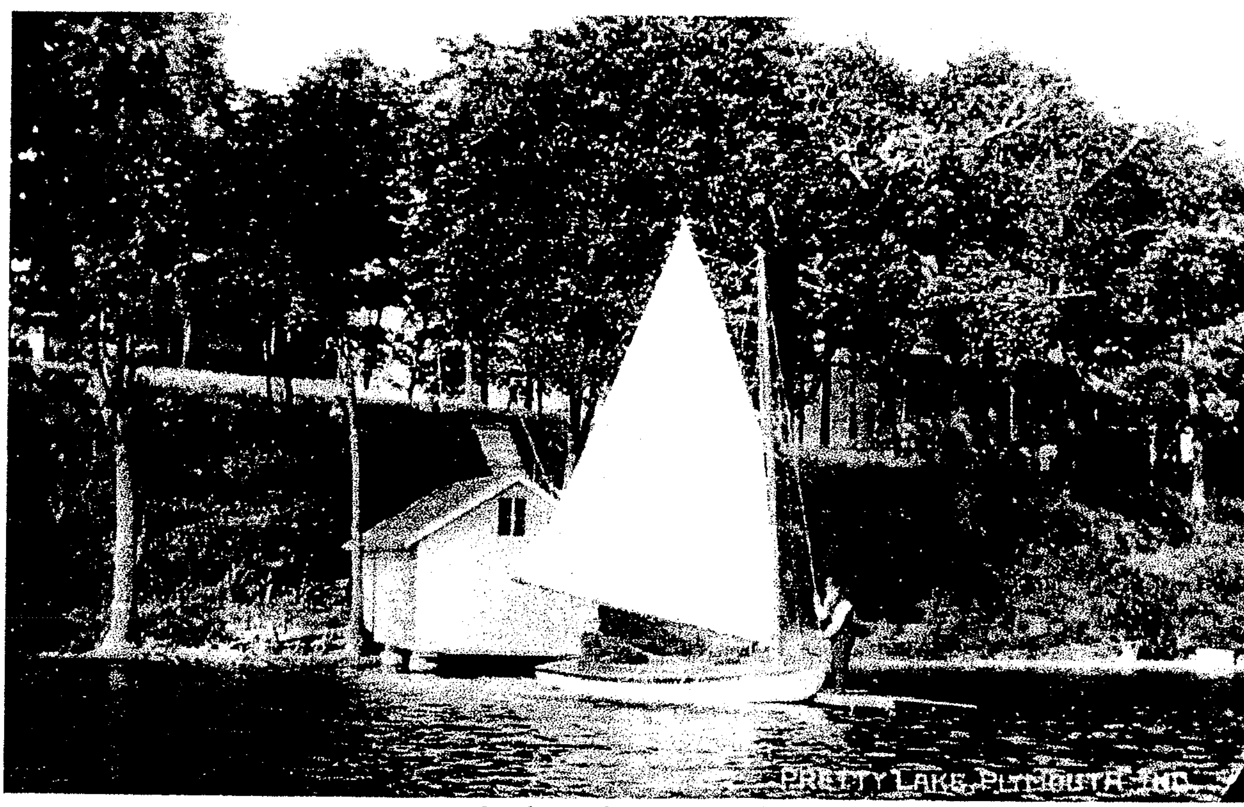
— E.D. Stansbury has purchased a lot at Pretty Lake and will erect a cottage thereon. It joins the Lake View property on the west.

— J.B. Bowell and family went out to Pretty Lake Monday, where they will remain all summer. Mr. Bowell says the "Lake View is the coolest spot in the county."

— The Episcopal Sunday school will picnic on the Lake View grounds at Pretty Lake today. The reformed Sunday school will also hold a picnic there today.



TYPICAL SCENE AT PRETTY LAKE.



Lake View Hotel

The Lake View Hotel was located on the Lake View grounds. The area is where the Holloway and Eckhart homes are today (10377–10389 Pretty Lake Trail.) The hotel building was later made into two cottages by Pansy Peterson and the Harpers.

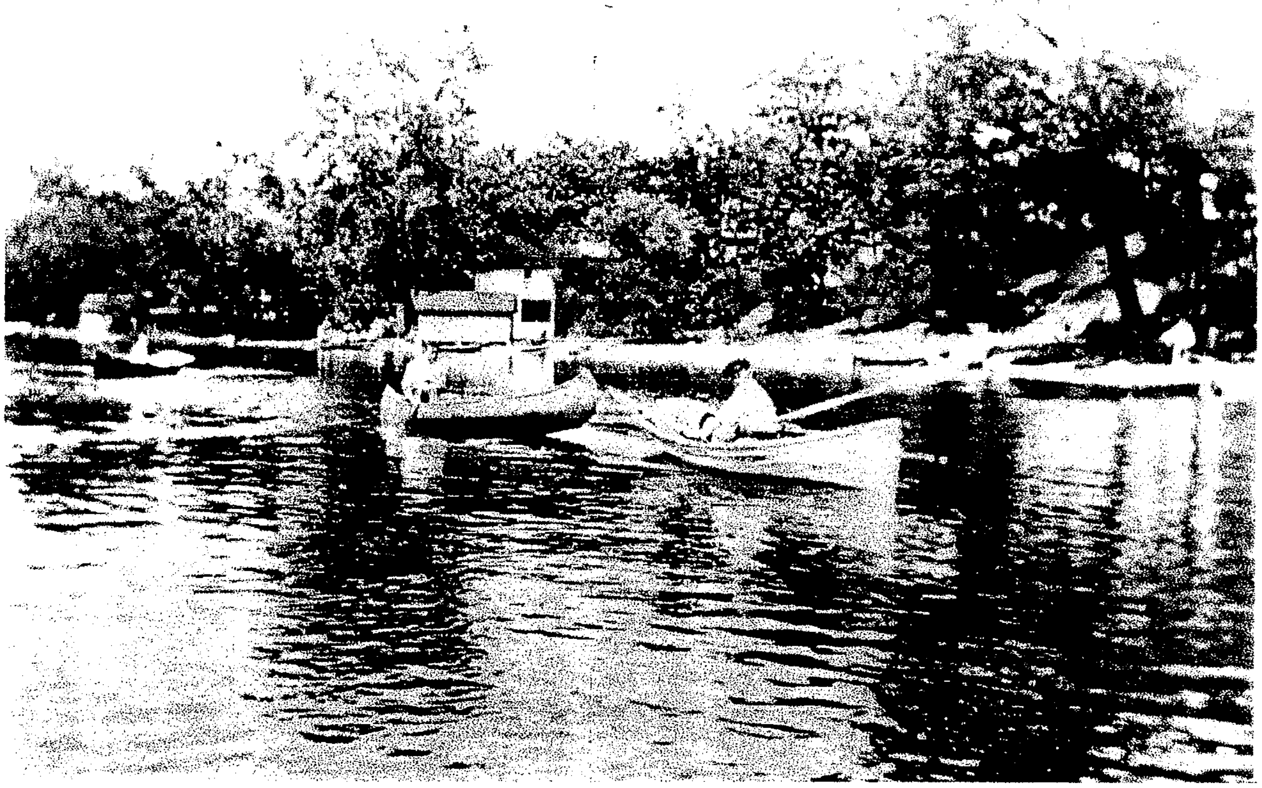
REPUBLICAN, JULY 9, 1896

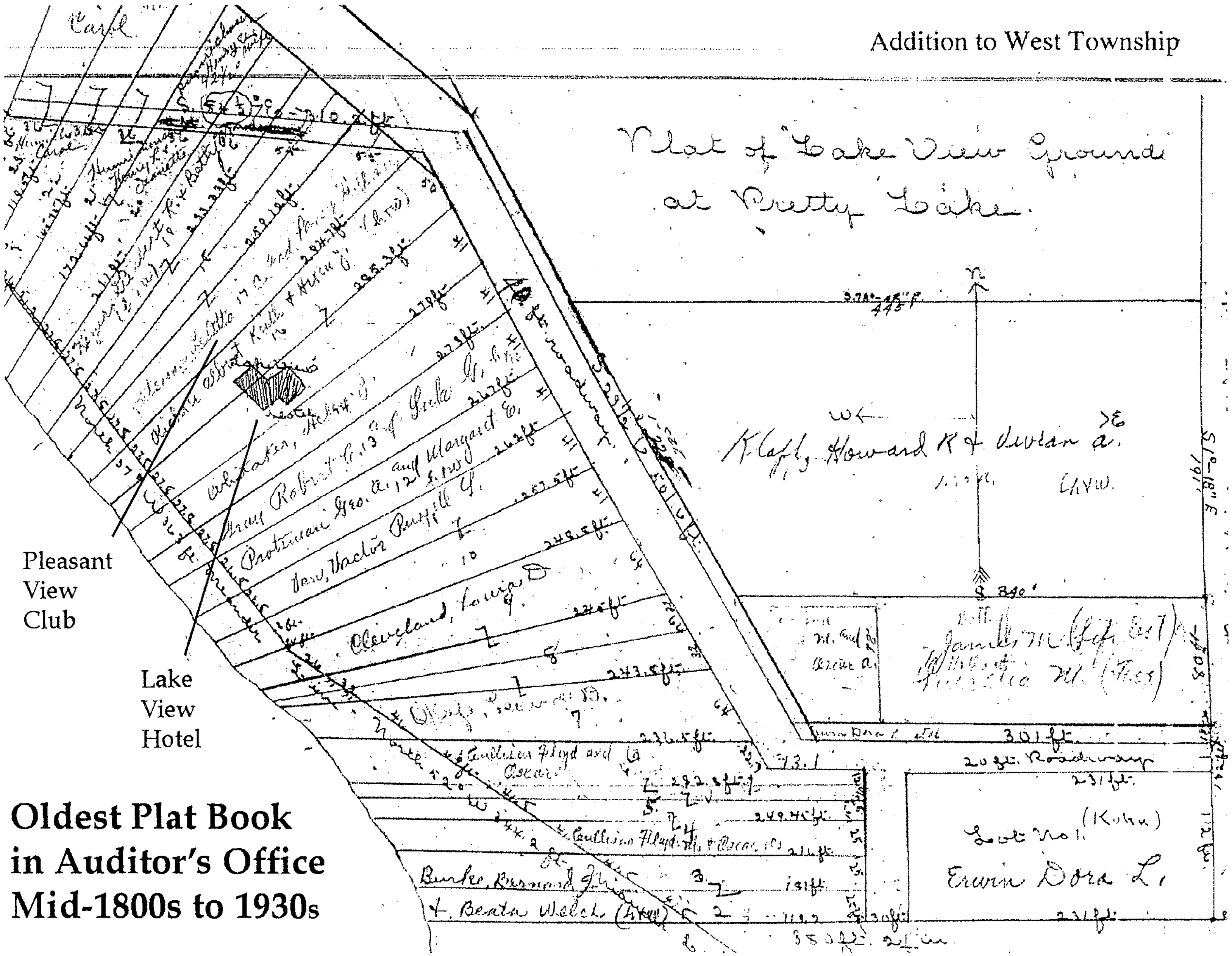
PLEASANT VIEW CLUB ORGANIZED

Pleasant View Club at Pretty Lake was formally open and dedicated yesterday, July 2, 1896, by electing Mrs. Dr. Jackson president of the cooking and baking department; Dr. Jackson president of the medical department; Mrs. D. Frank Redd president of the children's department; D. Frank Redd and Miss Ethel Wiltfong president of the milk, butter and cottage cheese department; Mrs. C. Firestone president of the grocery and provision department; C.O. Wiltfong president of the fishing and bathing department; J.W. Wiltfong president of the hammock, lounging and sleeping department; and Grandma Wade general boss of the whole kit and caboodle.

The dedication and election of officers was very friendly and harmonious, and the degrees were conferred by all the officers partaking of two square meals on the grounds. The general office of the club is on the north bank of Pretty Lake, first door west of the Lake View Hotel, and is one of the most beautiful places in Northern Indiana. Anyone wanting to see any or all of the above must call at our office during office hours which are from 3 a.m. to 10 p.m.

By order of
Kum & C Us.

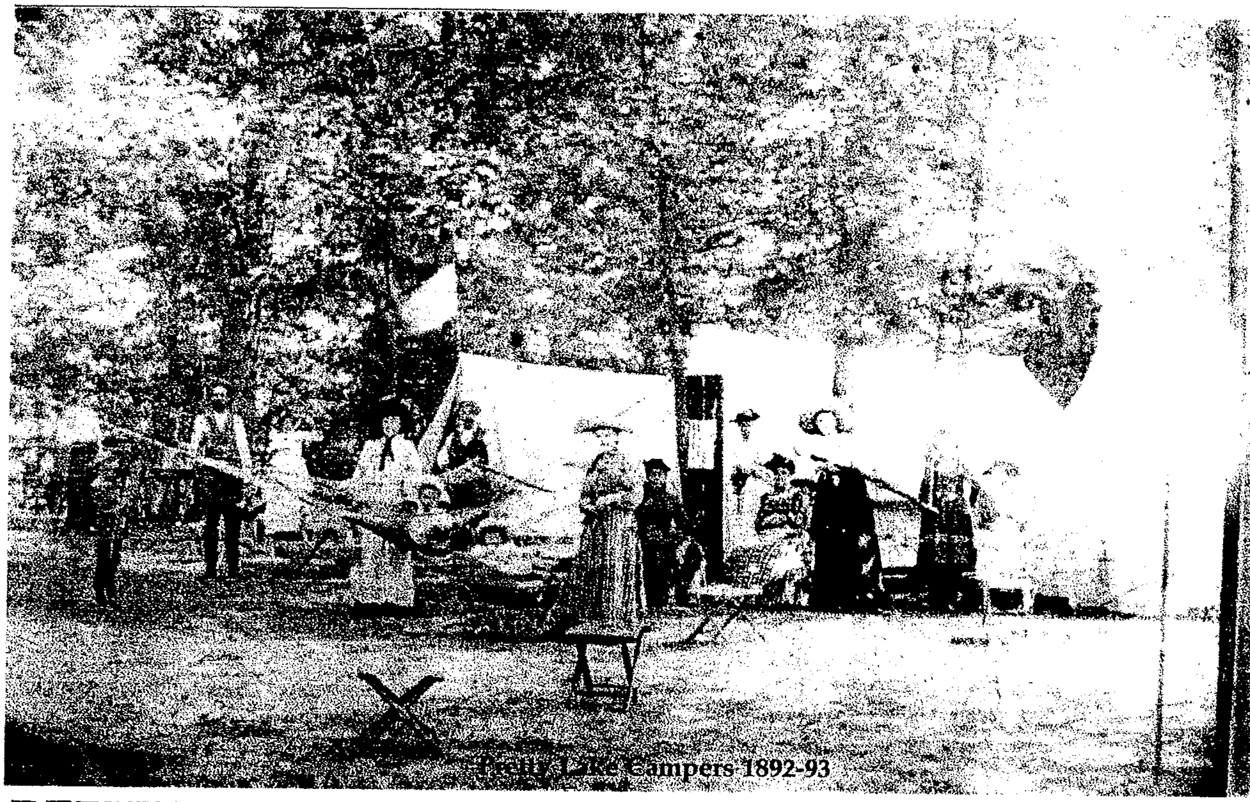




Oldest Plat Book in Auditor's Office Mid-1800s to 1930s

REPUBLICAN, APRIL 30, 1896

— Pretty Lake is beginning to be patronized quite freely by lovers of recreation and beauty. Among those there Sunday were Dr. Burket and family, C. Walls and family, Fred Kuhn and family, Al. Windbigler and Carl Strombeck.



Pretty Lake Campers 1892-93

REPUBLICAN, JULY 16, 1896

— Geo. Barkdoll, Elsie Barkdoll, Miss Philips, James Barkdoll, and others, of Rochester, are camping at Pretty Lake this week.

— A company of ten serenaders drove out to Pretty Lake last night, and charmed the campers and cottagers about that beautiful body of water with the melodious strains of the guitar, banjo, mandolin, and flute. They made a circle of the lake in boats.

— The families of F.H. Kuhn and C.J. Eich opened camp at Pretty Lake Monday morning and will remain during the remainder of the season.

— The U.B. Sunday school will hold their annual picnic next Thursday, July 16, at Pretty Lake. They will meet at the U.B. church at the ringing of the bell at 8 o'clock a.m., and expect to start for the lake by 8:30. Come friends and bring your children; also your baskets well filled with good things to eat and let's have a good time.

— Wm. Everly's new cottage at Pretty Lake was lifted entirely off its foundation by the tornado Saturday evening, but as luck would have it, it was dropped in almost the identical position it had occupied. Its occupants were certainly badly scared.

— Arrangements are being made, we understand, to abolish all drunken and indecent brawls at Pretty Lake in the future. Property owners will prosecute all trespassers and any bathers wearing no suits will not be allowed to frequent the swimming grounds. That nuisance of a "floating beer palace" will also be abolished. Pretty Lake will then be a right respectable place to go to.

Two groups of campers at Pretty Lake, 1893

Pretty Lake Champion "Sod Busters" ball team

Written on back of card: "*We are on the banks of no-place.*"
"No-place could have been in 'The Bowl' on the south side of the lake."

—Grace Engelhardt

REPUBLICAN, APRIL 30, 1896

A PIG ROAST AND A BIG ROAST

Lots of Fun and a Good Time Generally at Pretty Lake.

The cottagers who have been at Pretty lake this summer determined to close the season with a big dinner yesterday.

There were men of almost all professions there and all of them had good appetites. And there were cooks among the ladies and butchers and bakers among the men who have no rivals anywhere.

It is not therefore surprising that two large, finely roasted pigs headed the list of eatables for the long tables that had been arranged under the trees on E.C. Martindale's lot, where the ladies had brought out their rare old china and fixed places for sixty-five people. But roast pig was not all they had to eat. Oh no! They had oyster dressing, mashed potatoes, fried sweet potatoes, cole slaw, potato salad, apple sauce, pickles, olives, celery, jelly, pumpkin pie, coffee, lemonade, cake, rye and white bread, butter, tomato and grape catsup, mustard and popcorn.

The cottagers who sat down to that dinner were: J.V. Astley, family and guests, seven persons; O.G. Soice and family, five; Ed S. Hogarth and family, three; Wm. Everly and family, three; Theo. Cessner and seven; F.M. Burket and family, four; Chas. McLaughlin and family, four; E. Martindale and family, six; F.H. Kuhn and family, seven; E. Tucker and family, five; E. Stansbury and family, five; other guests, two; making sixty-seven all told.

After Fred Kuhn washed his hands in the lemonade he proceeded to give the crowd pointers in carving pigs and the banquet began in earnest. It was an occasion that will never be forgotten. There were no hungry people in the crowd when they arose from the table, and however widely the cottagers may be separated by the changes that a lifetime brings they will never forget the ties of friendship and hospitality that bound them together, while camping on the banks of Pretty Lake.

Fred Kuhn

HISTORICAL INCIDENTS ABOUT PRETTY LAKE AND AS A RESORT

Old Files of Plymouth Chronicle in 1910 Reveal Undeveloped Beauties

Some interesting incidents and facts about Pretty Lake, now a popular cottage location for people of Plymouth, are found in the old files of the Plymouth Chronicle published in 1910. Notes of the resorters, names of owners of 27 cottages on the lake then, wooded shores and property values are related in the account which follows:

Pretty Lake Resort in 1910.

Pretty Lake, the summer suburb of Plymouth, is altogether one of the coziest and pleasantest little resorts to be found in the state. There is an attractiveness, a charm and a beauty about it which bewitches all who see it, and creates a fond love in all who live on its banks for any length of time. Pretty Lake is three and a half miles west of Plymouth in West Township, and is reached only by wagon road. Like West Baden there is no highway leading past it. It is at the end of a by-road.

The north and east shores are especially fine, the banks being nicely wooded, clean and the water shallow at the edge on a gravel and sandy bottom which slopes gradually toward deep water.

It was perhaps these facts, as well as that of being nearest to Plymouth, which led to the building of cottages on the north side and east end of the lake. The west end is unfit for residence and the north side is yet without a cottage, save the lonely building at the water's edge known as the "Wilson's Cottage."

Though small, the general beauty of it, the fringe of woods about its border, widening at the east end, the clean banks, the gravel bottom, the quiet, the peace and repose which it instills into the human heart, make it a place longed for whenever the heat and weariness of summer drive people from the rush of everyday life.

It is fed by many springs cold as ice, which boil up from the bottom. There is no inlet nor outlet, so far as is known. The high banks and blue placid waters remind one of the famed mountain lakes of Italy.

The history of its development dates back to the time when Sheriff How, Bill Montgomery, the liveryman and Joe Westervelt made there the headquarters of the Plymouth Fishing Club. They bought about ten acres of ground for this purpose. Later, Fred Kuhn and Rolle Oglesbee put up a fishing shack which years later developed into the present Kuhn cottage "Idlewild". Soon afterward Mr. Kleepfer built "San Souci." Then followed the cottages of Dr. Burkett, Jacox, Vinall, Soice and Cressner. The last was the Linkenhelt cottage built in 1909.

Pretty Lake is not the ordinary summer resort. There is no place for the general excursion or picnic. They can't get in unless they are invited. All are private grounds. This fact maintains both the cleanliness and quiet of the resort.

Everybody here is acquainted with everybody else. It is more like a big family outing place, or a number of neighbors on a picnic. There are no grand residences occupied by nabobs from the city whose backs are stiff with style. All are on a level — all are neighbors and friends — all enjoy the companionship of all, the quiet and peacefulness of the lake, the bathing, the boating, the fishing — the rest of which creeps irresistably into the soul from this marvelous spot of mother nature.

Nearly all the lots are sold and values are steadily going upward as the convenience of this lake to Plymouth grows on the public. Beginning at the west end and following the lake around toward the east the cottages in 1910 are as follows:

1. L.J. Hess.
2. Mrs. Sarah Shakes

3. Miss Carrie Reeve, "Dreamworld Nest."

4. H.A. Armstrong, "Play Day."

5. Mrs. M.L. Linkenhelt, whose place reporters have jokingly named the "Pierless" because they have no pier.

6. Mrs. Harry Humrichouser, "Bird Center."

7. H.W. Bortree, of Chicago, "The Illinois."

8. Rev. W.S. Howard, "Kenwood Lodge."

9. J. Eich, "The Indiana."

10. Miss Anna Dorsey, "Bide-a-wee."

11. "Farmer's cottage", owned by several farmers among them being the Van Vactors, Pomeroys, Gibsons and Tachers.

12. Mayor C.S. Cleveland, "Grand View"

13. Dr. H.A. Deeds, "Restmore."

14. C.A. Reeve, "Seven Oaks."

15. R.C. Kloepfer, of Logansport, "Sans Souci."

16. Fred Kuhn, "Idlewild."

17. E.C. Martindale.

18. Frank Jacox.

19. George Vinalli, "Brotherless Inn."

20. Dr. F.M. Burkett.

21. Mrs. Theo Cressner.

22. Wm. Everly, "Lakeside Roost."

23. O.G. Soice and Ed Hogarth.

24. C.O. Tribbey.

At this point is where the road comes down to the lake. Here are located the store operated by Otis Williams and Tribbey's ice house.

25. Next after these is Mrs. Dibble's cottage.

26. John Astley.

27. The Shelley cottage, stands out by itself on the south side of the lake. It was built by Dr. Wilson, not many years ago, a prominent physician of Plymouth.

The Shelley Cottage owned by Dr. Wilson

Original Cottages
Listed in the 1922 Republican article

	Original Owner — 1910	Current Owner — 1997	1910 Names Still in Use
1.	L.J. Hess	Cottage gone	
2.	Mrs. Sarah Shakes	Gary Treat	
3.	Miss Carrie Reeve	Bud Treat	
4.	H.A. Armstrong	George Buday	"Play Day"
5.	Mrs. M.L. Linkenhelt	John Ritzenthaler	
6.	Mrs. Harry Humrichouser	Jim Meck	"Bird Centre"
7.	H.W. Bortree	Bob Kizer	
8.	Rev. W.S. Howard	Larry Holloway	
9.	J. Eich	Pete Eckhart	
10.	Miss Anna Dorsey	Jean Favorite	
11.	Owned by several farmers among them being the Van Vactors, Pomeroys, Gibsons and Tachers.	Harold Van Vactor	"Farmer's Cottage"
12.	Mayor C.S. Cleveland	Steve Van Vactor	
13.	Dr. H.A. Deeds	Chuck Glaub	"Restmore"
14.	C.A. Reeve	Edith Culbertson Smith	"Seven Oaks"
15.	R.C. Kloepfer, of Logansport	Betty Burke	"Sans Souci"
16.	Fred Kuhn	John McNeil	"Idlewild"
17.	E.C. Martindale	John McNeil (rental)	
18.	Frank Jacox	David Sexton	
19.	George Vinalli	Roberta Poore	
20.	Dr. F.M. Burkett	Kurt Kralavansky	
21.	Mrs. Theo Cressner	Bud & Belle Shemberger Henry	
22.	Wm. Everly	Joe Coury	
23.	O.G. Soice and Ed Hogarth	Dick Young	
24.	C.O. Tribbey	Chandler	
25.	Mrs. Dibble	Cottage gone	
26.	John Astley	Mike Thomas	
27.	Dr. Wilson	Cottage gone	

PRETTY LAKE BOOM ON BUILDING

SEVERAL NEW COTTAGES GOING UP THIS SEASON—PROSPECTS FOR BIG YEAR FOR POPULAR RESORT.

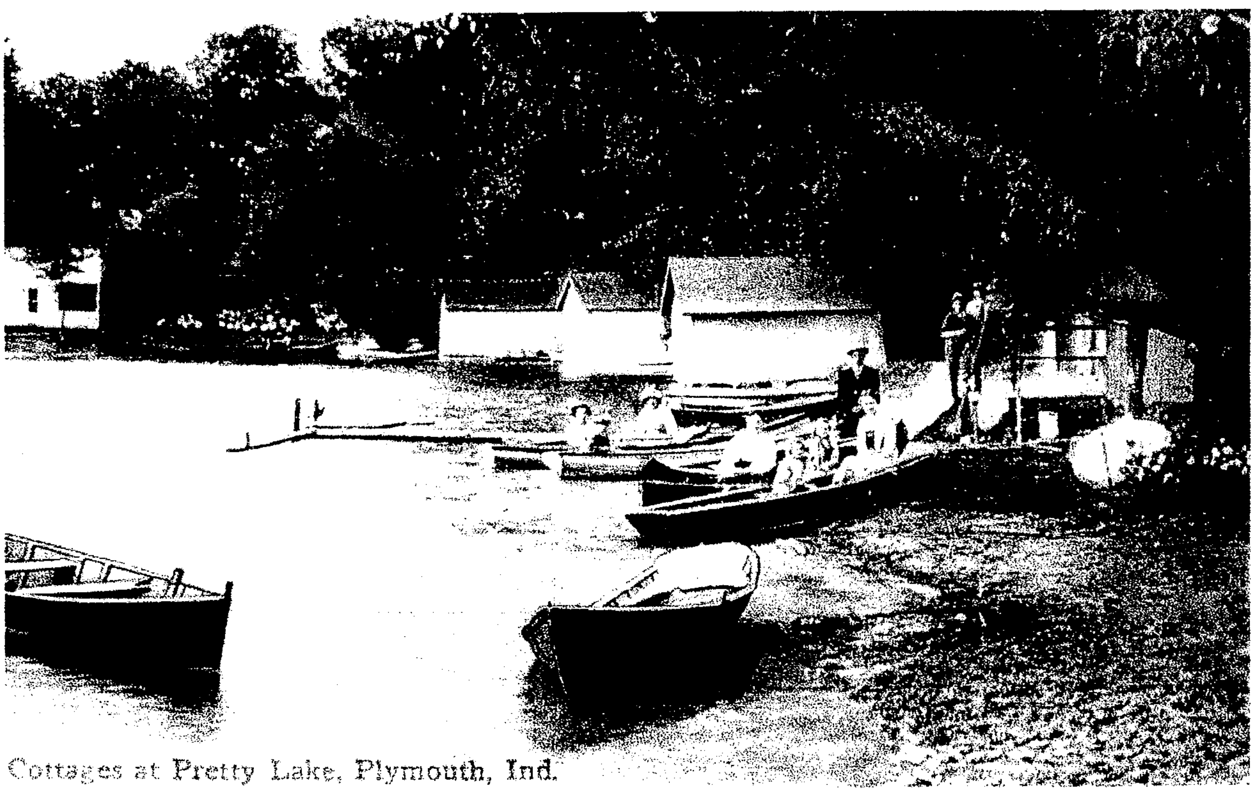
Indications point toward a big year for Pretty Lake, the popular summer resort for Plymouth people. A building boom is already in evidence continuing from last season.

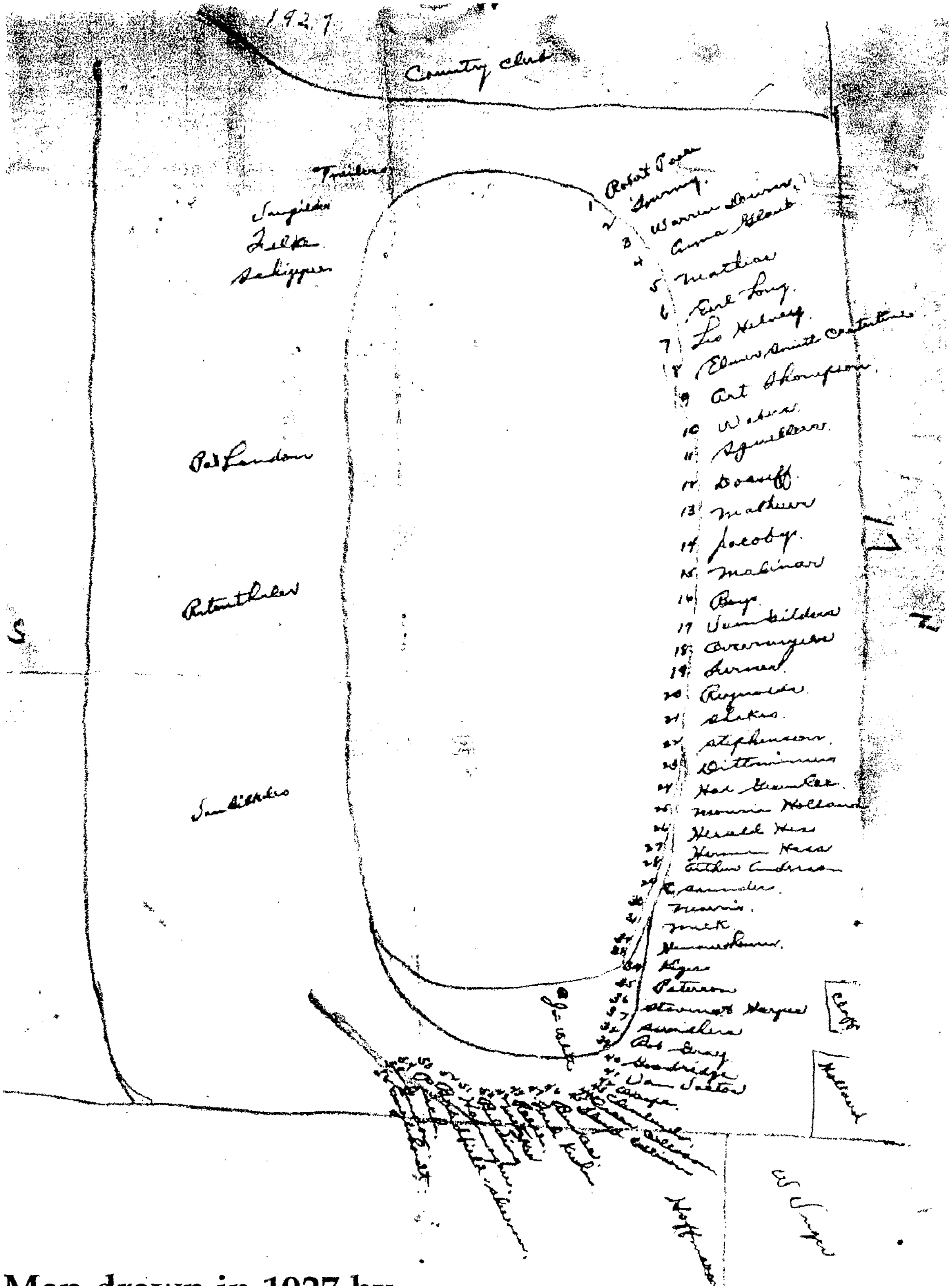
Among the new cottages now under construction is one for Frank Burns at the north end of the line of cottages on the northeast shore, one for Charles Drubert, one each for County Recorder Dan Bollinger and Earl Jacox on the south side where the old Wilson cottage was torn down, and one for Henry Humrichouser near his father's. Probably others will be built before the season is over.

Among the improvements this year is the extensive remodling of Dr. Harry Knott's cottage. An enclosed porch has been built on two sides and the size of the building considerably enlarged. His cottage will be one of the most complete on the lake.

Last year new cottages were built by Lloyd Morris, Eugene Beagles, V. Mathia, Alfred Sheetz, Mrs. Thomas Twomey, Wm. D. Giffen, Perry Marsh and a Chicago physician.

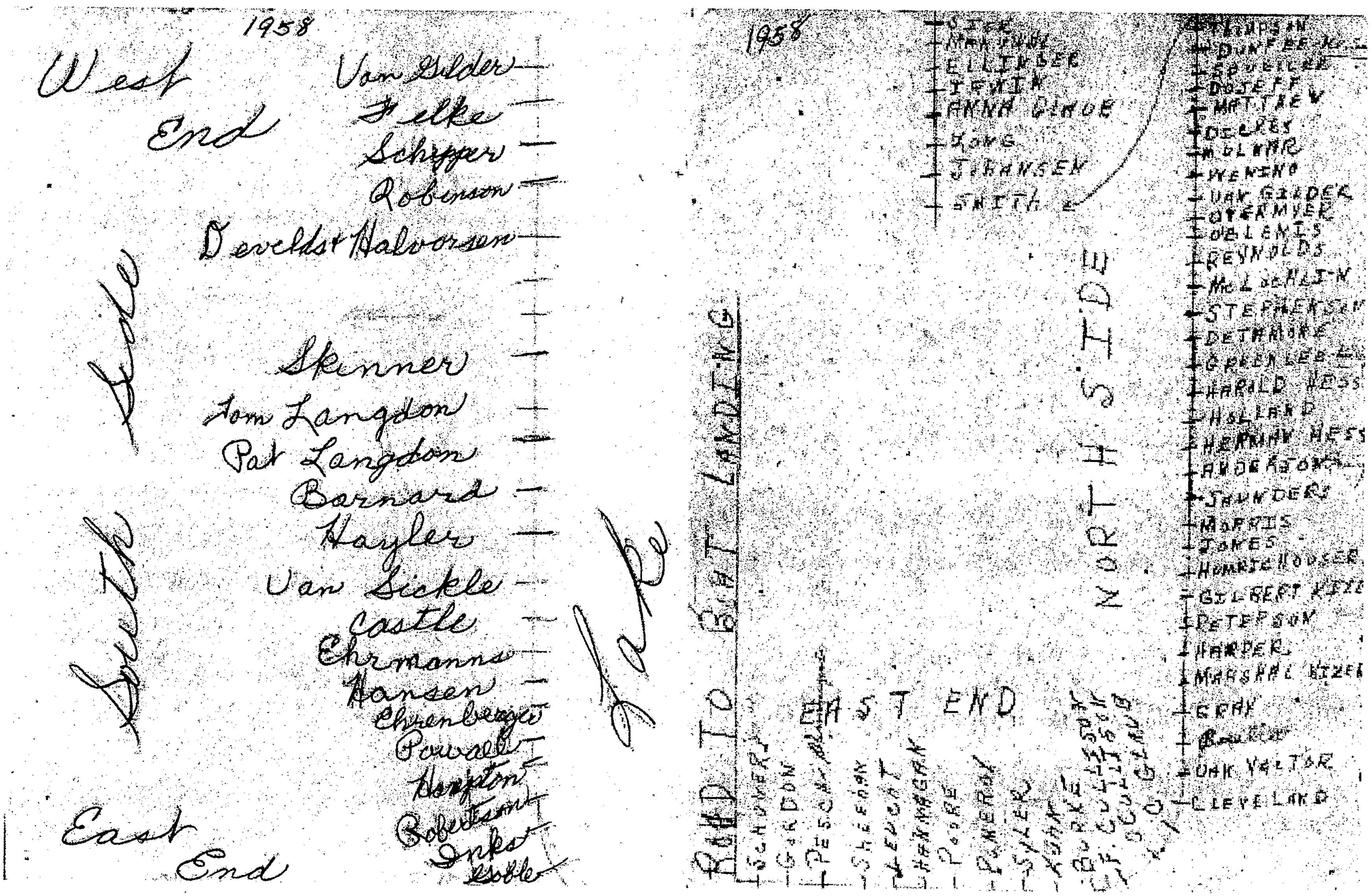
Prospects indicate that all cottages will be full this season. The Kuhn cottage, the Midway and the Chas. Miller cottage are already occupied. The "Shack" is to open Saturday with Harold Woodward and Sewell Falconbury in charge this year.


Cottages at Pretty Lake, Plymouth, Ind.



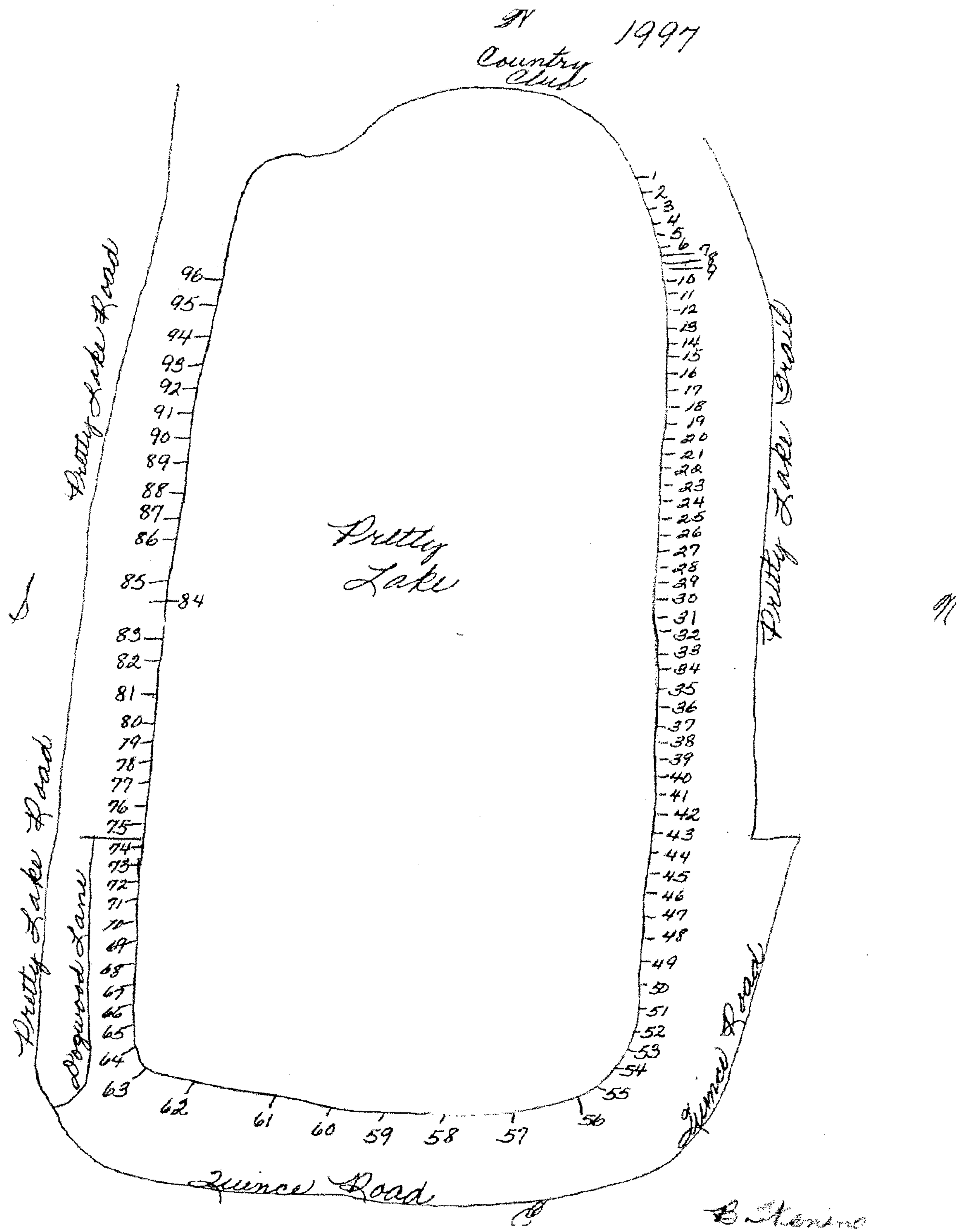
Map drawn in 1927 by Ralph Reynold's father

Hand-drawn Map from 1958 showing Pretty Lake residents



1997 Map of Pretty Lake

Key to map is on following page



Key to Map

1. Shuppert
2. Blum
3. Richmond
4. Carnahan
5. Berger
6. Roach
7. Long
8. Neidig
9. Neidig
10. Marohn
11. Bartlett
12. Isenbarger
13. Chamberlin
14. Yocum
15. Sjoquist
16. Flynn
17. Wenino
18. Moenck
19. Overmyer
20. Wenino
21. Reynolds
22. Treat
23. Landeen
24. Oliver
25. Kubley
26. Hess
27. Matthew
28. Treat
29. Buday
30. Ritzenthaler
31. Morris
32. Meck
33. Hilliard
34. Kizer
35. Holloway
36. Eckhart
37. Flynn
38. McClure
39. Favorite
40. Van Vactor
41. Van Vactor
42. Glaub
43. Smith
44. Smith
45. Burke
46. McNeil
47. McNeil
48. Sexton
49. Poore
50. Lindhjen
51. Kralovansky
52. Henry
53. Coury
54. Young
55. Chandler
56. Kimble
57. Day
58. Langdon
59. Sfura
60. Kralovansky
61. Estinos
62. Englehardt
63. Goble
64. Thomas
65. Banfich
66. Mear
67. Robertson
68. Holmes
69. Hampton
70. Dillingham
71. Langdon
72. Ehrenberger
73. Barbieri
74. Chamberlin
75. White
76. Ruggles
77. Langdon
78. Milner
79. Swain
80. Sexton
81. Alton
82. Langdon
83. Langdon
84. Miller
85. Skinner
86. Halvorsen
87. Wenino
88. Suesse
89. Beckham
90. Hueni
91. Thompson
92. Felke
93. Houin
94. Barnes
95. Starr
96. Schmelter

Residents

Pretty Lake

	Name(s) / *Occupation(s)*	Address / "House/Cottage Name"	Winter Home
1.	**Don & Loretts Shuppert** *Retired Teacher & Retired Elementary Teacher*	10099 Pretty Lake Trail	Sarasota, FL
2.	**Mike Blum** *Retired Chicago Fireman*	10105 Pretty Lake Trail	
3.	**Tom & Judy Richmond** *Carpenter & Secretary*	10107 Pretty Lake Trail	Goshen, IN
4.	**Larry & Stephanie Carnahan** *Yearly Rental*	10115 Pretty Lake Trail	
5.	**Bud & Lois Berger** *Retired High School Teacher/Coach & Retired Elementary Teacher*	10123 Pretty Lake Trail	
6.	**Ruth Ann Roach** *General Manager of Factories*	10131 Pretty Lake Trail	
7.	**Earl & Dolores Long** *Retired Engineer & Homemaker*	10139 Pretty Lake Trail	
8.	**Noble & Barbara Neidig** *Co-Owner of Indiana Tool and Die Company & Homemaker*	10147 Pretty Lake Trail	Plymouth, IN
9.	**Don & Dorothy Neidig** *Co-Owner of Indiana Tool and Die Company & Homemaker*	10155 Pretty Lake Trail	Plymouth, IN
10.	**Don & Chris Marohn** *Vice President of Manufacturing & Homemaker*	10163 Pretty Lake Trail	Naples, FL
11.	**Robert & Joan Bartlett** *Retired Newspaper Executive & Retired Manager of Group Insurance*	10171 Pretty Lake Trail	
	Helen Bartlett *Retired Secretary at Ad Agency*		
12.	**Tom & Cindy Isenbarger** *Teacher/Coach & Junior High School Teacher*	10179 Pretty Lake Trail	
13.	**Matt & Michelle Chamberlin** *Restaurant Owners & Junior High School Teacher*	10189 Pretty Lake Trail	

14.	**Paul & Debbie Yocum** *Retired Opthomologist & Homemaker*	10201 Pretty Lake Trail **"Edna-bill-t"**	Valparaiso, IN
15.	**James & Betty Sjoquist** *Project Engineering & Secretary*	10211 Pretty Lake Trail **"Breezy Bluff"**	
16.	**Mike & Barbara Flynn** *Yearly Rental*	10221 Pretty Lake Trail	
17.	**Jim & Joyce Wenino** *Feed and Seed Salesman & Housewife*	10227 Pretty Lake Trail	
18.	**Al & Judi Moenck** *Manufacturing Representative & Image and Color Consultant*	10237 Pretty Lake Trail	
19.	**Jack & Alberta Overmyer** *Retired from McCords & Retired from Plymouth City Office*	10243 Pretty Lake Trail	Mercedes, TX
20.	**Rachel Wenino** *Retired from Plymouth City Office*	10249 Pretty Lake Trail	
21.	**Ralph & Marjorie Reynolds** *Retired Mechanical Engineer & Retired Secretary in Indianapolis Schools*	10255 Pretty Lake Trail	
22.	**Gary Treat** *Clothing Merchant*	10265 Pretty Lake Trail	
23.	**Jean Landeen** *Homemaker*	10273 Pretty Lake Trail	Flossmoor, IL
24.	**Jack & Jana Oliver** *Owner of a New and Used Car Business & Homemaker*	10283 Pretty Lake Trail	
25.	**Katie Kubley** *Homemaker*	10293 Pretty Lake Trail	Plymouth, IN
26.	**Harold & Edith Hess** *Ret'd Route Salesman for LP Gas Co. & Ret'd from Pilgrim Farms Quality Control*	10299 Pretty Lake Trail	
27.	**Guy & Sharon Matthew** *Retired Radiologist & Homemaker*	10303 Pretty Lake Trail **"Away Sweet Away"**	Bloomington, IN
28.	**Budd & Ajean Treat** *Owners of Men's Clothing Store*	10307 Pretty Lake Trail	
29.	**George & Carolyn Buday** *Wholesale Plumbing and Heating Supplier & Line Supervisor*	10313 Pretty Lake Trail **"Play Day"**	
30.	**John & Evelyn Ritzenthaler** *Retired from Manufacturing of Homes and Mobile Homes & Homemaker*	10327 Pretty Lake Trail	

31.	**Hap & Rosalie Morris** *Retired Salesman for Lumber Company & Retired Nurse*	10335 Pretty Lake Trail **"Tumble Inn"**	Mishawaka, IN
32.	**Jim & Marty Meck** *Retired President of an Industrial Supply Company & Retired High School Teacher*	10343 Pretty Lake Trail **"Bird Centre"**	
33.	**George & Jean Hilliard** *Retired Project Manager for an Engineering Architect Firm & Homemaker*	10361 Pretty Lake Trail	Hazel Crest, IL
34.	**Robert & Ginger Kizer** *Carpenter & Teacher*	10369 Pretty Lake Trail	
35.	**Larry & Michelle Holloway** *Elementary School Principal & High School Teacher*	10377 Pretty Lake Trail	
36.	**Pete & Millie Eckhart** *Owner of Floor Coverings Company & Human Resources Director*	10389 Pretty Lake Trail	Columbus, OH
37.	**Dan & Sarah Flynn** *In Family Business of Manufacturing Mobile Homes & Homemaker and 7th Grade Basketball Coach*	10395 Pretty Lake Trail	
38.	**Mac & Carolyn McClure** *Semi-Retired Physician/Surgeon & Homemaker*	10401 Pretty Lake Trail	Ft. Lauderdale, FL
39.	**Jean Favorite** *Retired Waitress from Culver Inn*	10407 Pretty Lake Trail	
40.	**Harold & Marjorie Van Vactor** *Owners of Van Vactor Farms and Trucking*	10413 Pretty Lake Trail **"Farmers' Cottage"**	Plymouth, IN
41.	**Steve & Maria Van Vactor** *Operates Van Vactor Trucking Company & Works at Carport Factory in Bremen*	10417 Pretty Lake Trail	Plymouth, IN
42.	**Charles & Helen Glaub** *Mayor of Plymouth for 20 Years and Retired Grocery Store Owner & Homemaker*	10425 Pretty Lake Trail **"Restmore"**	
43.	**Edith Cullison Smith** *Yearly Rental*	10431 Pretty Lake Trail **"Seven Oaks"**	
44.	**Edith Cullison Smith** *Retired Home Economist*	10437 Pretty Lake Trail	
45.	**Betty Burke** *Retired Executive Secretary from Bendix*	10443 Pretty Lake Trail **"Sans Souci"**	
46.	**John & Linda McNeil** *Junior High School Principal & Teacher*	10411 Quince Road **"Idlewild"**	

47.	**John & Linda McNeil** *Yearly Rental*	10421 Quince Road	
48.	**David & Brenda Sexton** *Marriage and Family Counselor & Kindergarten Teacher*	10429 Quince Road	Valparaiso, IN
49.	**Roberta Poore** *Works for Lincoln Life Insurance Company*	10437 Quince Road	
50.	**Chris & Tim Lindhjen** (brothers) *Works for Environmental Agency in Michigan & Manufacturer's Representative*	10445 Quince Road	Ann Arbor, MI Indianapolis, IN
51.	**Kurt & Susie Kralovansky** *Electronic Technician & High School Librarian*	10455 Quince Road	
52.	**Bud and Marybelle Shemberger-Henry** *Semi-Retired Medical Doctor & Homemaker*	10465 Quince Road	Bonita Spgs, FL
53.	**Joe & Dorothy Coury** *Retired Executive of Aluminum Firm & Homemaker*	10475 Quince Road	Ft. Myers Bch, FL
54.	**Dick & Norma Young** *Retired Truck Driver & Retired Receptionist at Holiday Inn*	10485 Quince Road	
55.	**John Chandler** *Yearly Rental*	10493 Quince Road	
56.	**Roger & Billie Kimble** *Retired Service Engineer/Manager of Clark Equipment & Retired Medical Receptionist for General Surgeon*	10513 Quince Road	
57.	**Dick & Martha Day** *Building Contractor & Antique Dealer*	10549 Quince Road	Plymouth, IN
58.	**Tom & Kay Langdon** *Yearly Rental*	10561 Quince Road	
59.	**Ruth Sfura** *Homemaker*	10571 Quince Road	Highland, IN
60.	**Jerry & Mary Kralovansky** *Optometrist & Retired from Utility Company*	10581 Quince Road	Plymouth, IN
61.	**Benedict & Marian Estinos** *Banking & Homemaker*	10591 Quince Road	Downers Grv, IL
62.	**Grace Englehardt** *Nursing Home in Lamont, IL*	10609 Quince Road	

63. **Milt & Gloria Goble** 16066 Pretty Lake Road
Retired Owner of Wholesale Plumbing and Heating Supply Company & Retired Telephone Operator for Indiana Bell

64. **Mike & Vivian Thomas** 16086 Dogwood Lane
Plant Management & Secretary for Sears

65. **Peter & Marilyn Banfich** 16096 Dogwood Lane
Owner of Furniture Store & Interior Decorator

66. **Del & Phyllis Mear** 16126 Dogwood Lane
Owners of Import/Export Business

67. **Steve Robertson** 16150 Dogwood Lane
Owner of Dairy Queen

68. **Larry & Hildred Holmes** 16168 Dogwood Lane
Super at Locomotive Factory & Homemaker

69. **Gertrude "Rusty" Hampton** 16188 Dogwood Lane Avon Park, FL
Housewife

70. **Roy Dillingham** 16206 Dogwood Lane
Yearly Rental

71. **Tom & Kay Langdon** 16220 Dogwood Lane
Yearly Rental

72. **Dick Ehrenberger** 16228 Dogwood Lane
Retired General Sales Manager

73. **Brian & Ann Barbieri** 16238 Dogwood Lane **"Hosta Haven"** Ft. Wayne, IN
Door and Window Manufacturer & Homemaker

74. **John & Julie Chamberlin** 16258 Dogwood Lane
Yearly Rental

75. **John White** 16290 Pretty Lake Road
Retired President of Indiana Division of Hawthorne Melody Creamery Company

76. **Jim & Bev Ruggles** 16310 Pretty Lake Road
Musical Instrument Repair Technician & Owner of Hair Salon

77. **Tom & Kay Langdon** 16324 Pretty Lake Road
Yearly Rental

78. **Pat Milner** 16330 Pretty Lake Road
Comptroller

79. **Hilton & Suzie Swain** 16340 Pretty Lake Road
Car Salesman & Nurse

80.	**David & Brenda Sexton** Yearly Rental	16350 Pretty Lake Road	
81.	**Dan & Colleen Alton** *Attorney and President of Indiana Heat and Transfer Company & Special Ed. Teacher and Homemaker*	16360 Pretty Lake Road	Indianapolis, IN
82.	**Pat & Betty Langdon** *Retired Barber and Businessman & Retired Nurse*	16370 Pretty Lake Road	
83.	**Tom & Kay Langdon** *Catering and Restaurants & Carry-Out "Spirits Store"*	16392 Pretty Lake Road	
84.	**Duane & Cheryl Miller** *Financial Advisor & Customer Service Manager*	16386 Pretty Lake Road	
85.	**Mary Skinner** *Retired Co-Owner of Pharmacy*	16422 Pretty Lake Road	Gross Point, MI
86.	**William Halvorsen** *Works for Title and Trust Company*	16440 Pretty Lake Road	Chicago, IL
87.	**Lou & Betty Wenino** *Retired Owner of Service Station & Retired Elementary Teacher*	16450 Pretty Lake Road	
88.	**Bob & Caroline Suesse** *Retired from Mobil Corporation in Marketing & Semi-Retired Physical Education Instructor*	16510 Pretty Lake Road	
89.	**Jim & Sheryl Beckham** *Salesman of Fiberglass and Resin & Owner of Gymnastics Studio*	16516 Pretty Lake Road	
90.	**Jack & Marlene Hueni** *Part Owner of Foundry & Homemaker*	16522 Pretty Lake Road **"Hueni Haven"**	Bremen, IN
91.	**Tom & Sue Thompson** *President of Custom Home Company & Bookkeeper*	16540 Pretty Lake Road	Bremen, IN
92.	**Joe & Linda Felke** *Florists*	16556 Pretty Lake Road	
93.	**Ed & Linda Houin** *Yearly Rental*	16568 Pretty Lake Road	
94.	**Don & Gerry Barnes** *Retired from Indiana Bell Telephone Company & Homemaker*	16588 Pretty Lake Road	Indianapolis, IN
95.	**Jeff & Jan Starr** *Dentists*	16598 Pretty Lake Road	
96.	**Dan & Nancy Schmelter** *Investment Representative & Counselor/Educator*	16606 Pretty Lake Road	

Country Club Hills

	Name(s) *Occupation(s)*	Address	Winter Home
1.	**Arlene Staak** *Owner of KOA Campgrounds*	10010 Pretty Lake Trail	
2.	**Karen Boyle** *Manager/Representative*	8342 SR 17	
3.	**Del & Phyllis Mear** *Owners of Import/Export Business*	Lot, SR 17	
4.	**Jack & Mardell Druzik** *Retired Chicago Fire Engineer & Homemaker*	8300 SR 17	
5.	**Chuck Lienhart & Rene Williams** *Real Estate Appraisers*	8288 SR 17	
6.	**David & Chris Van Vactor** *Land Developer & Current Plymouth School Board Member and Elementary Teacher*	8262 SR 17	
7.	**Ed & Kathy Criswell** *Marshall County Sheriff & Dispatcher in Marshall County Sheriff's Office*	8256 SR 17	
8.	**Neil & Dorothy Chase** *Retired Trucking Executive & Homemaker*	Two Lots, SR 17	
9.	**Fred & Shirley Morrow** *Retired Owner of Morrow Insurance Agency and Former Plymouth Council Member for 17 Years & Elemenary School Teacher*	8162 SR 17	
10.	**Jay & Linda Wozniak** *Carpenter & Daycare Teacher*	8120 SR 17 *Yearly Rental*	
11.	**Don & Elaine Dick** *Retired High School Counselors*	8089 SR 17	
12.	**Frank Bauer** *Optometrist*	8068 SR 17	
13.	**John & Louise Parsons** *Retired from the Department of Agriculture and the Executive Branch & Retired from the Veteren's Administration in Washington D.C.*	8024 SR 17	
14.	**Bob "Butch" & Carole Kepler** *Manager of Sherwin Williams Paint Store & Vice President of Purchasing at U.S. Granules*	Lot, Quince Road	
16.	**Danny & Patty Bates** *Retired Superintendent of Plymouth Schools & Teacher*	10059 Quince Road	
15.	**Ned & Mary Shemberger** *Manufacturer's Representatives*	10065 Quince Road	

17. **Walter Dina Pental** 10111 Quince Road
Psychologist & Homemaker

18. **Jim & Peg Clevenger** 10139 Quince Road
Retired Auto Sales & Current County Council Member and Retired Marshall County Treasurer

19. **Frank & Joyce Howard** 10145 Quince Road
Insurance Marketing & Retired Elementary Teacher

20. **Wally & Rosemarie Wozniak** 10181 Quince Road
Retired Shoe Store Manager & Retired Owner of Interior Decorating Service

21. **Dick & Mary Klein** Lot Quince Road
Retired Businessman & Owner and Teacher of Nursury School

22. **Dean & Barbara Rager** 10267 Quince Road
Retired Elementary School Principal & Retired Elementary Teacher

23. **Doug & Jan Badell** 10337 Quince Road Mesa, AZ
Dentist & Office Manager

24. **Brad & Therese Bucher** 10400 Pretty Lake Trail
Commercial Banker & Assistant Director of Nursing in Nursing Home

25. **Merlin & Margot Jones** 10380 Pretty Lake Trail
Retired Owners of Office Products Store

26. **Marvin & Dorothy Kraft** 10372 Pretty Lake Trail Bonita Spgs, FL
Retired from Mobile Home Construction & Homemaker

27. **John & Dorothy Norris** 10350 Pretty Lake Trail
Retired from Air Force & Homemaker

28. **Guy and Sharon Matthew** Lot, Pretty Lake Trail
Retired Radiologist & Homemaker

29. **Wade & Dee Wyatt** 10320 Pretty Lake Trail
Retired from Shamrock Homes & Retired Insurance Salesperson

30. **Bob & Laura Lappin** Lot, Pretty Lake Trail
CPA & Speech Pathologist

31. **Wayne & Bonnie Frushour** 10286 Pretty Lake Trail Avon Park, FL
Insurance and Real Estate Agent & Retired Real Estate Salesperson and Antique Dealer

32. **Ron & Mary Gifford** 10280 Pretty Lake Trail
Attorney and Current Plymouth School Board Member & High School Teacher

33. **Greg & Sue Payne** 10240 Pretty Lake Trail
Salesman for American Containers & Homemaker

34. **Jim & Joyce Wenino** Lot, Pretty Lake Trail
Feed and Seed Salesman & Homemaker

35. **Bob & Carol Pendergast** 10200 Pretty Lake Trail
Owners of Pendy's Convenience Store and Former Owners of Dairy Queen

36. **Bob & Debbie Wise** 10186 Pretty Lake Trail
Assistant Director of Special Education & Special Ed. Teacher

37. **Jodie Kriscunas** 10180 Pretty Lake Trail
Elementary Teacher and Real Estate Salesperson

38. **Kevin & Donna Chaney** 10158 Pretty Lake Trail
Production Supervisor at Del Monte Foods & High School Teacher

39. **Don & Shirley Byrns** 10134 Pretty Lake Trail
Retired Postal Service & Retired from Banking

40. **Pat & Kay Flynn** 10106 Pretty Lake Trail
Retired Mobile Home Manufacturer & Artist - Enameling and Calligraphy

Homes Adjacent to Country Club Hills

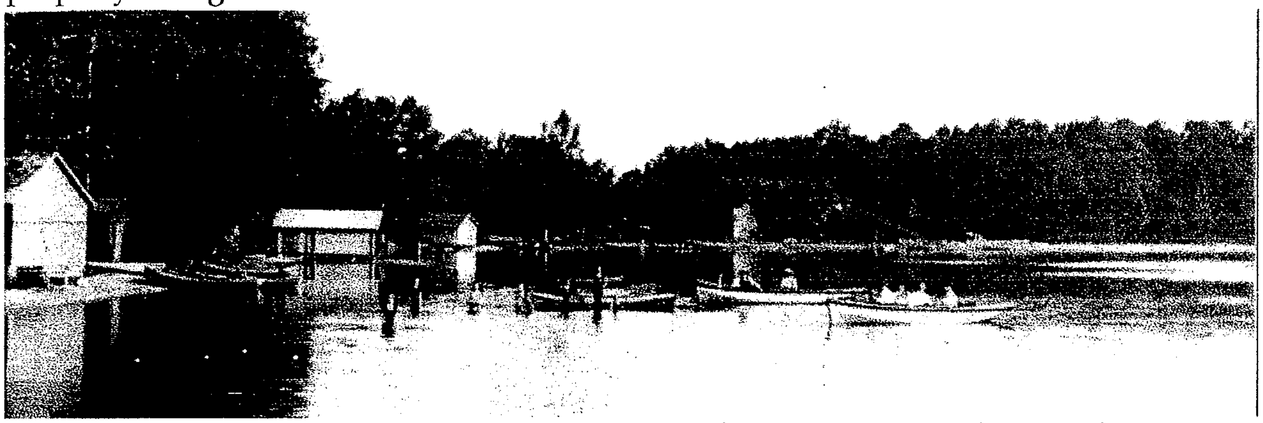
Name(s) *Occupation(s)*	Address	Winter Home
1. **Vivian Klapp** *Homemaker*	10371 Quince Road	
2. **Clyde & Helen Bick** *Both Retired from Variety Store*	10484 Pretty Lake Trail	Mission, TX
3. **Russell O. & Gretchen A.M. Henriksen** *Deceased 1993 & Retired R.N. and S.C.M.*	10448 Pretty Lake Trail	
4. **John & Mary Pat Glaub** *Both Self-Employed in Insurance*	10418 Pretty Lake Trail	

Ice Houses on Pretty Lake

Around 1890, Mr. Chaney built an ice house on the east side of Pretty Lake. He and his son Tom supplied Plymouth with ice in the summertime until the advent of commercailly-available ice.

The original Chaney house was soon replaced by a larger building. The Chaneys sold out the business to Ed Lacher, and in the next few years, the property changed hands several times. In 1924, Ed Engelhardt purchased the property, tore down the old ice house and erected three cottages on the site.

Herman Taber has also built an ice house on the north side of the lake. The harvesting of natural ice was, for many years, a source of winter cash for many of the surrounding farm families who hired out their teams for the work.



Postcard dated 1915. Notice the ramp for getting the ice into the ice house. This was the ice house that was torn down to make room for three cottages.

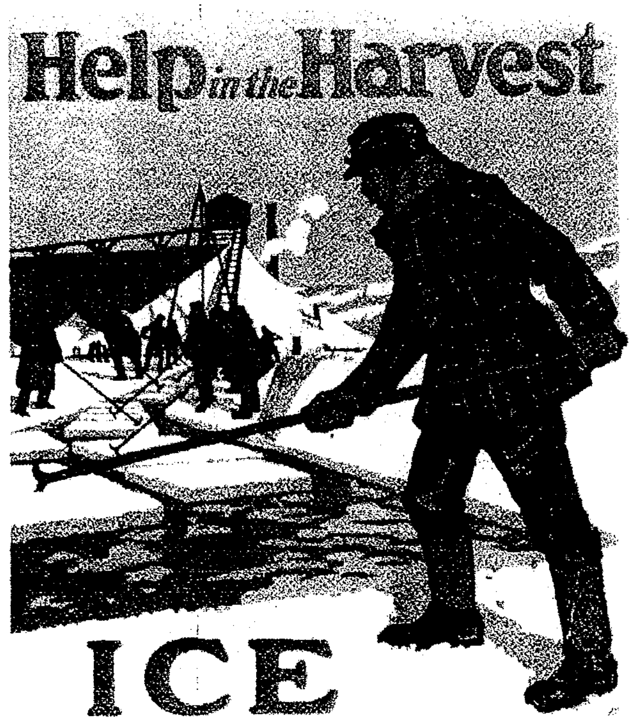
Thomas Chaney
Son and partner of original ice house owner

Ralph Reynolds said that when he was in school (1927—1930), he used to go into the Taber Ice House to cool off. He said that straw was used for insulation. This method worked well all summer.

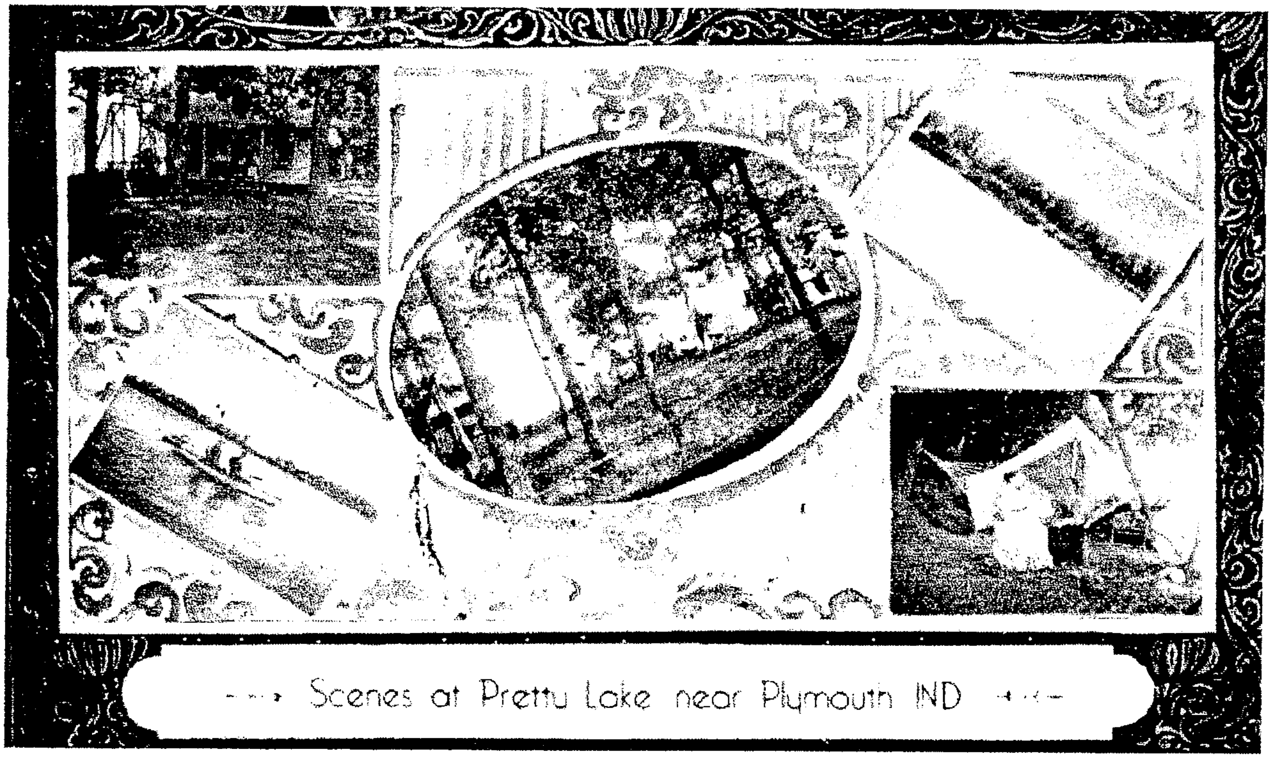
Edith Hess recalled that while harvesting ice, a team of horses went through the ice and drowned.Several ice house buildings were located where the Country Club Hills area has their access to the lake (10099 Pretty Lake Trail.)

Notes written in July of 1975, found in the Marshall County Historical Society Archives state that, "These buildings are still standing. The Taber ice houses have been owned successfully by the Artificial Ice Company and Syler & Syler, the present owners."

— *The Marshall County Historical Society Quarterly;* Vol. IV, No.3, July 1975



Odds & Ends



There was a Boy Scout camp in the area of the Kizer and Holloway homes (10369-10389 Pretty Lake Trail) from 1912 - 1917.
— Edith Culbertson Smith

The Boy Scout camp had to close when too many cottages were being built.
— The Marshall County Historical Society

The Plymouth High School football team would practice at football camp on the south side of the lake during the late 1920s.
— Chuck Glaub

There was an organization of Sea Scouts during the early 1930s. These boys were 14-15 years old. They remodeled a boathouse and decorated it in a nautical fashion, mast, flagpole, etc. They had a large rowboat that looked the same at both ends, and a large sailboat. The boathouse was in the area of the Kizer and Holloway homes (10369-10389 Pretty Lake Trail).
— Chuck Glaub & Hap Morris

Father Howard, an Episcopal priest at St. Thomas church in Plymouth, operated a boys' summer camp at Pretty Lake during his stay in Plymouth. The camp was in operation around 1900 - 1905.
—The Marshall County Historical Society Archives

Julia Work was the owner and superintendent of the orphans' home called Bright Side. The home was located about two miles north of the city of Plymouth. In January 1907, Ms. Work was deeded land where the Morris, Meck andHilliard homes are today. This land was to be used for a summer orphans' home. For whatever reason, a few years later, the land was sold to Winnie Humrichauser, wife of Harry.
— Jim Meck

Divers from the state came years ago to try to find the bottom of Devil's Hole. They never did.

— Gloria Unger

A horse sank into the quicksand in the swamp on the east side of the lake and couldn't be saved.

— Grace Englehardt
(as told to Wilma Wagoner)

In early days, the farmers used the lake to wash their sheep. Women used the lake to wash their clothes.

— The Marshall County
Historical Society Archives

Many baptisms have taken place at the east and north sides of the lake. Drubert's Beach was a very popular spot.

In 1890, Daniel Long built a small building on the east side of the lake, from which he sold pop and candy to summer visitors. Mr. Long also had a few boats which he rented to fishermen and others. This first store building was built of rough, unplaned boards and was never painted. It soon became known as the "Shack," and for over 50 years, it and the store buildings that followed on this location were commonly called "The Shack."

— The Marshall County Historical Society
Quarterly; Vol IV, No.3; July 1975)

The first cottage built on the lake was a very small building erected by F.H. Kuhn late in the 1890s on a lot platted from the old Pretty Lake Club.

— *The Marshall County Historical Society
Quarterly*; Vol IV, No.3; July 1975)

Dr. Wilson built the first real cottage on the south side of the lake. It was built before 1910, and known as the "Shelley Cottage." The Wilson cottage was torn down prior to 1922.

The Burke home (10443 Pretty Lake Trail) is the oldest structure on the lake. It was built in 1896.

The Van Vactor, Morris, Humrichauser, Meck, Felke and Yocum cottages have been owned by a family member since they were built.

William Matthew, my grandfather, was a lawyer in Plymouth. He was telling a friend how he built the cottage. The friend stayed for dinner and made a remark about what grandfather had said. The family all laughed and said, "Oh, no! Edna built the cottage!" They then decided to name the cottage "Edna-bill-t."

— Debbie Yocum

The last of the three cottages on the east side of the lake, built by Theodore Engelhardt in 1924, was torn down and burned in March 1997. It was located on the Kimble property (10513 Quince Road).

Many outhouses for the cottages on the lake were built in 1931 and 1932, during the Franklin D. Roosevelt administration by WPA labor. Some are still standing today.

— Chuck Glaub & Hap Morris

In 1958, Helen and Chuck Glaub had the first commercial pontoon boat on Pretty Lake, and in 1959, Bob Kizer's father Gibert had the first home-made pontoon boat on the lake.

The apartment complex on Quince Road was built in 1971.

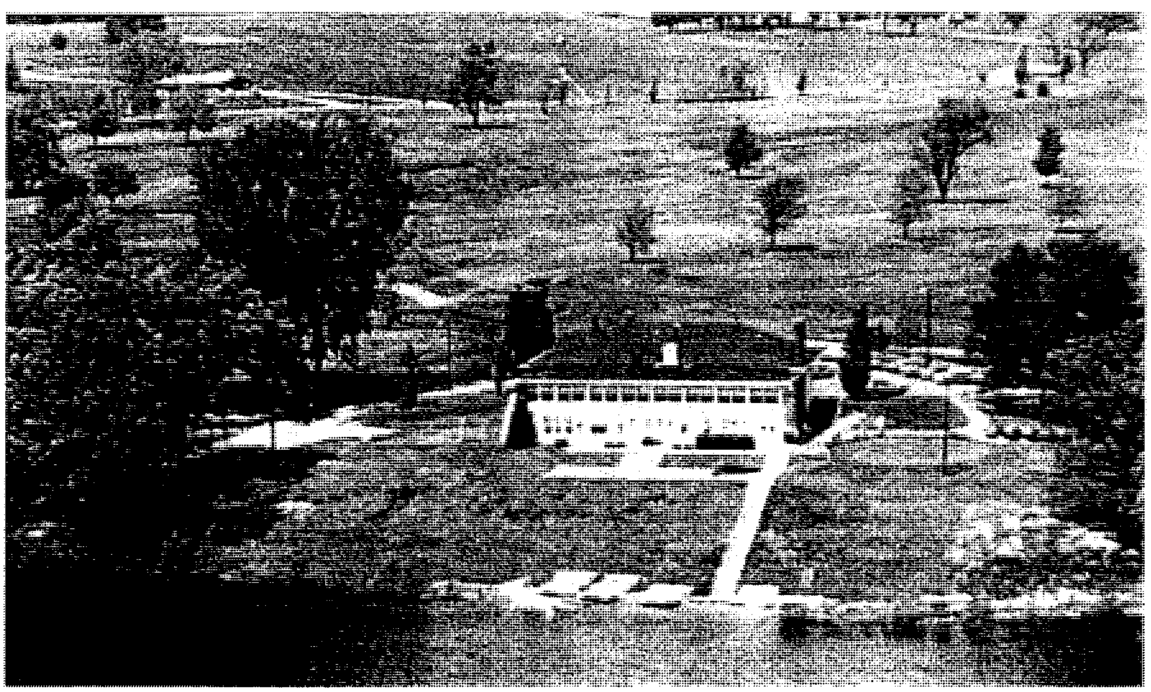
— Marshall County Assessors Office

Changes have occured around the shores of Pretty Lake also. Highly developed these days by its year around residents, it would hardly be recognized by those early campers who once enjoyed its quiet beauty. It remains, however, one of the jewels of Marshall County.

REPUBLICAN, THURSDAY, MAY 4, 1922

It is probable that a club house will be built for the Plymouth Country Club this summer on the new club grounds on the north side of the lake. The directors of that organization have not made definite plans for the season thus far but the building of a club house is only a question of a limited time. A golf course has been laid out and seeded to grass though a temporary course will probably be used this season. A roadway will probably be opened up in better shape from the main road directly to the country club buildings.

1922



1959

A BRIEF HISTORY OF THE PLYMOUTH COUNTRY CLUB

BY MERRITT L. SKINNER *(Written in 1985)*

On January 30, 1921 it was announced in the Plymouth Weekly Democrat newspaper that plans were being formulated by a group of business and professional people to organize a Plymouth Country Club. On July 14, 1921 the same newspaper printed an announcement that a sizable tract of land on the north and west banks of Pretty Lake had been purchased from Willis Koch with the intent of constructing thereon a nine hole golf course and club house. Elkhart architect Royal L. Simmons and Plymouth building contract boss O'Keefe and Thomson were selected.

At completion of the club house construction the following had been selected as Plymouth Country Club officers: A.M. Cleveland, president; Floyd Dunnell, vice president; Luther R. Cressner, secretary; O.G. Soice, treasurer. At this time there were approximately one hundred members in the Plymouth Country Club.

A "First Reception" event was planned by Dr. G.F. Hitchcock and his house committee to take place on December 29, 1922 which was to include, in addition to the reception and banquet, ice skating, card playing and dancing to a five piece orchestra. A.W. Gates, president of the Western Golf Association declared that the Plymouth Country Club had the finest club house and grounds of any city of 25,000 or less in the Central West.

In 1967 the members decided that it was time to expand the golf facilities to an 18 hole golf course. Land was acquired along State Road 17 both east and west of the original acreage to accomodate this desire.* Professional golf course architects were engaged to lay out the course. By May 17, 1968 the work was completed and the club golf professional Harley Drake planned the opening events which included two golf tournaments and a buffet dinner.

On May 1, 1973 Country Club President Frank Snead and the Board of Directors announced a $60,000 building program to include a swimming pool, three fenced and lighted tennis courts, a new golf shop with a bag storage area, and two additional buildings for housing golf carts.

In 1974, through a negotiation process with the Ladies Professional Golf Association, arrangements were made to include the Plymouth Country Club on the annual tour of the LPGA. Accordingly, for the next seven years the finest lady golfers of this country, as well as many representing foreign lands, visited the club for a week of golf activity highlighted by the annual Plymouth Country Club LPGA tournament. Each year the tournament drew thousands of golf fans and the favorable publicity to the Marshall County area was of national significance.

— *Courtesy of Country Club Archives*

* The land that is now holes 2-7 was donated by Jim Robertson and John Ritzenthaler, and the land that is now holes 11-14 was purchased from Pickles Smith

Plymouth Country Club

The Plymouth Country Club members opened their club house with a gala reception on December 29, 1922. At that time it was described as being "the finest clubhouse of any city of 25,000 or less in the midwest" by the president of the Western Golf Association, who inspected the facilities. The club grounds had been purchased from acreage of the early Koch farm. The clubhouse, designed by Alves O'Keefe, was built by contractors Art O'Keefe and Art Thompson. Many improvements and changes have been made to the building and grounds through the years.

FIRST
RECEPTION

of the

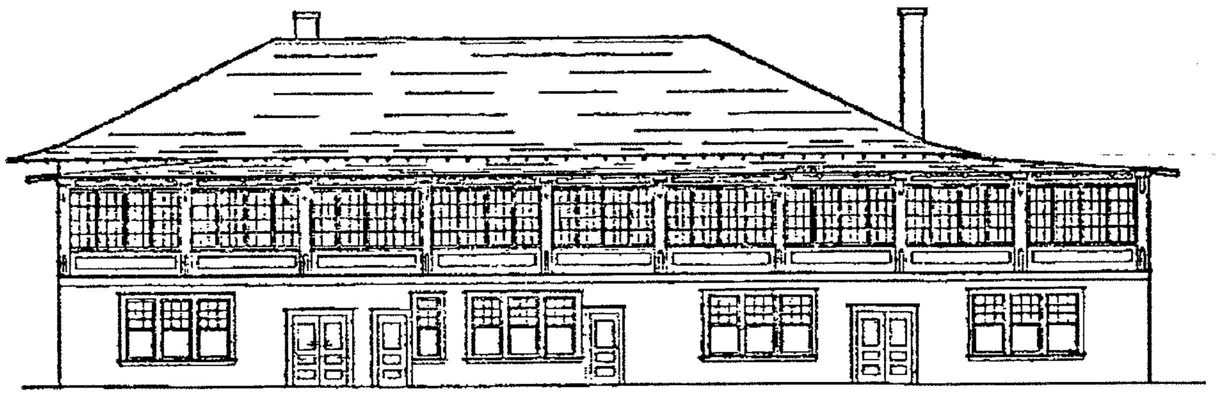
PLYMOUTH
COUNTRY CLUB

given to the members
and their families
at the

CLUB HOUSE

FRIDAY, DECEMBER 29, 1922
from 8:00 to 12:00 o'clock p. m.

First Officers and Committees of Plymouth Country Club — 1922



The Plymouth Country Club House on the banks of Pretty Lake, four miles west of Plymouth, Indiana

Committees

Building

A. W. O'Keefe
A. R. Clizbe
Sam Schlosser
W. B. Michel
D. L. McKesson
C. A. Bondurant
C. D. Snoeberger

House

G. F. Hitchcock
F. S. Southworth
Floyd Bunnell
L. M. Jackman
M. M. Lauer
S. E. Boys
A. J. Ball

Entertainment

Dr. C. F. Holtzendorff
J. C. Erwin
Ed. S. Kitch
Ed. N. Cook
Fred Wenzler
Lloyd Morris
Gray Murphy

Officers

President—A. M. Cleveland
Vice-President—Floyd Bunnell
Treasurer—O. G. Soice
Secretary—Luther R. Cressner

Reception Committee
The Officers and Heads of Committees

DANCING

CARDS

SKATING

Luncheon at Ten o'Clock

General good time

Orchestra

Committees

Grounds

Herbert Gibson
Arthur Thomson
H. P. Hoham
E. B. Milner
Sam Tomlinson

Greens

L. A. Shaffstall
A. M. Roth
Harry L. Unger
Dr. W. H. Fuller
J. A. Hanes
Rolland Metsker

Sports

Dr. R. C. Stephens
J. Lott Losey
Dr. C. W. Burkett
Glen Underwood
Claude Switzer
Wm. Hahn
Charles Miller

PLYMOUTH COUNTRY CLUB
OFFICERS, DIRECTORS AND COMMITTEES
FOR 1966-67

Robert M. Koch	President
Clarence Gay	Vice-Pres.
Edward L. Murfitt	Sec.-Treas.

DIRECTORS

Edver W. Coburn
Clarence Gay
Charles O. Glaub-
Robert M. Koch
Robert J, McDaniel
Edward L. Murfitt
Charles E. Robertson
George Towle
Robert Young

COMMITTEES

Beach and Junior Activities
Robert J. McDaniel, Chairman
Edver W. Coburn — Charles E. Robertson

Club House
Charles E. Robertson, Chairman
Charles O. Glaub — Robert Young

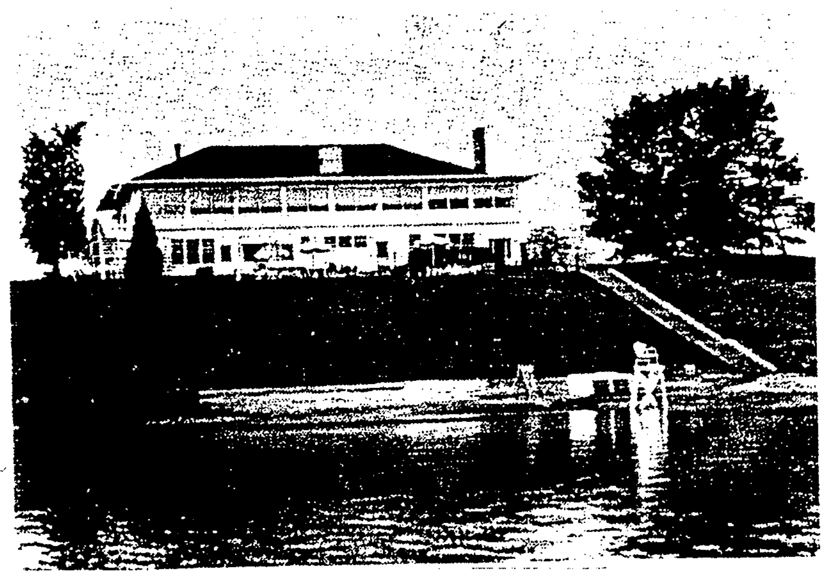
Entertainment and Publicity
Clarence Gay, Chairman
Robert Young — Charles O. Glaub

Finance
Robert Young, Chairman
Edward L. Murfitt — Clarence Gay

Golf Course and Grounds
George Towle, Chairman
Clarence Gay — Robert J. McDaniel

Golf Program
Edver Coburn, Chairman
Robert J. McDaniel — George Towle

Membership
Charles O. Glaub, Chairman
Charles E. Robertson — Edver Coburn



THE PLYMOUTH COUNTRY CLUB, INC.
MEMBERSHIP FEES
FOR 1966-67

Investing Membership Certificate		$ 100.00
Dues:		
Investing Family Members	per year	$ 180.00
Non-Resident Members	per year	$ 125.00
Non-Resident Members	per week	$ 25.00
Female Member		$ 60.00
Junior Members (Age to 25 inclusive)		$ 72.00
Senior Members		$ 60.00

New members accepted must also include membership certificate fee according to type of membership desired. (Transferred membership stock must be handled by the Secretary-Treasurer.)

Payment—Dues will be billed and collectible on not less than a quarterly basis. Other obligations of the membership will be payable on a thirty (30) day basis unless otherwise designated by the Board of Directors.

Charles Glaub
Membership Chairman

THE PLYMOUTH COUNTRY CLUB

PRETTY LAKE, PLYMOUTH, INDIANA

April 11, 1967

TAXES GOT YOU BROKE?

Come To Our Hard Times Dance

SATURDAY, APRIL 15, 1967

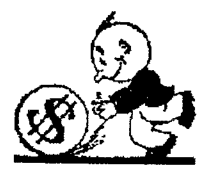
NO CHARGE

MULLIGAN STEW ONLY $1.25

ALSO REG. MENU FOR THE "FLUSH" ONES

PETE FREEHOLFS ORCHESTRA

All Hoboes Come in Casual Dress



Dear Country Club Member:

After a long, long winter, the golf season is again approaching. It is again time to assign lockers. Since there are not enough lockers to go around, it will be necessary for you to let us know what your desires are going to be.

Those of you who have had lockers in the past will be given preference and will receive the same lockers. You will have to let us know by April 25th if you want a locker. After May 1st those who have't had lockers in the past will be assigned lockers on a first come, first served, basis.

Locker rentals will again be $15.00 including towel service and will be billed by the club.

Please return the form below to Ed. Coburn, 408 Webster Ave., Plymouth, Ind.

Did you have a locker last year? ....

Do you wish a locker this year? ....

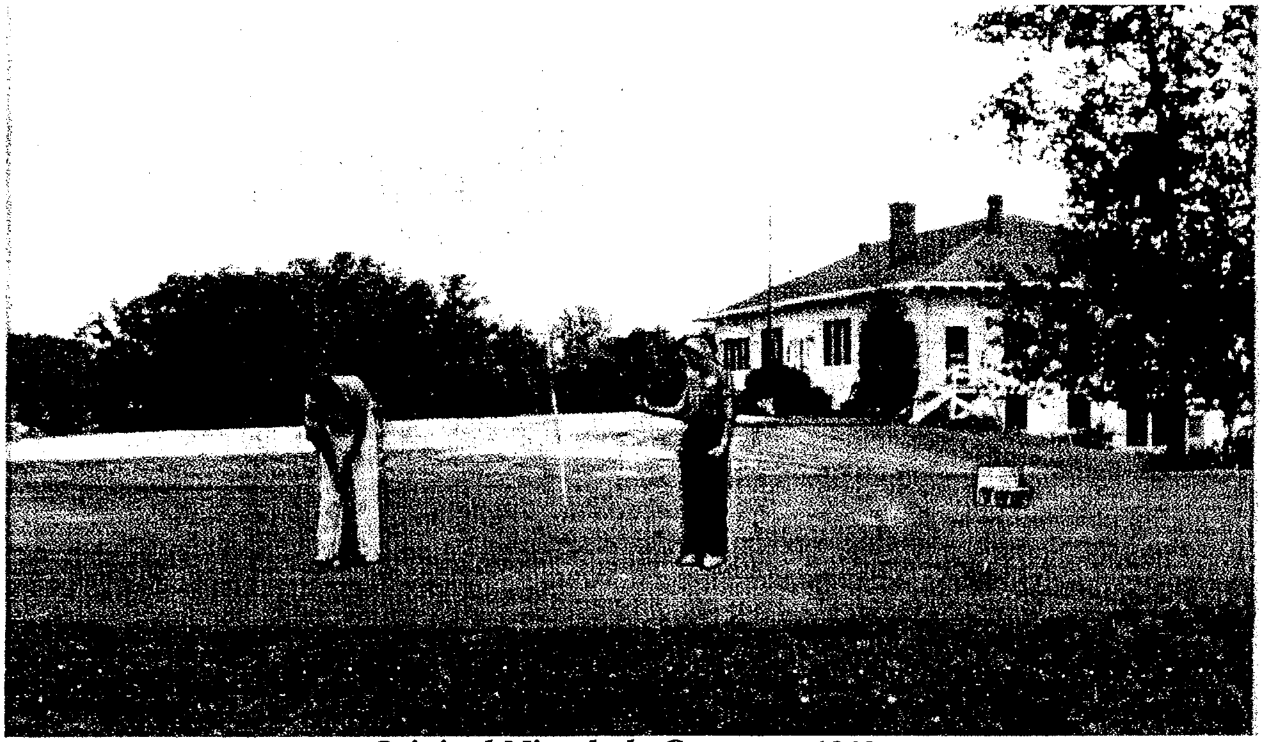
Indicate whether you want a lady's or man's or both. ....

Signed ....

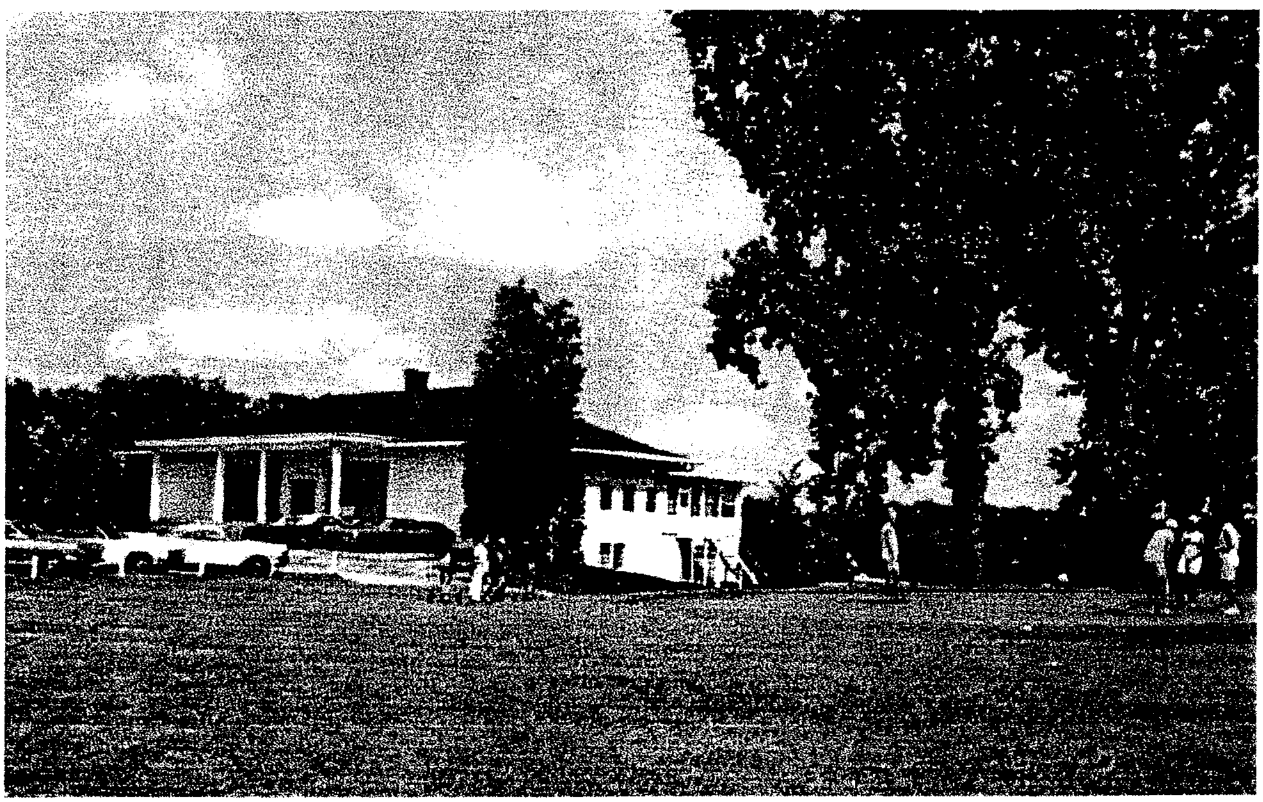
Welcome into membership the following:

Mr. and Mrs. Orin Treat
Mr. and Mrs. Wilbur A. McIntyre
Mr. and Mrs. Loren A. Schultz
Dr. and Mrs. Kenneth W. Reber
Mr. and Mrs. Donald Palbykin
Mr. and Mrs. John E. Parsons
Dr. and Mrs. Joseph D. Howard, M.D.
Dr. and Mrs. Harold B. Wackerle, D.O.
Mr. and Mrs. Willis Burroughs
Mr. and Mrs. Kenneth Crowel
Mr. and Mrs. David Scheetz
Mr. and Mrs. L. W. Bellamy
Mr. Tunnis Ross
Mr. and Mrs. Robert C. Danielson
Mr. and Mrs. C. Warren Edwards
Mr. and Mrs. James Hansen
Mr. and Mrs. Charles O. Heim
Dr. and Mrs. George Rosaro, M.D.
Dr. and Mrs. James M. Miley, Jr., D.O.
Mr. and Mrs. John Kumpf
Mr. and Mrs. Louis F. Baldoni, Jr.
Mr. and Mrs. William J. Skinner
Mr. and Mrs. Leonard D. Isban
Mr. and Mrs. Edward S. Quinn
Mr. and Mrs. Patrick J. Flynn
Mr. and Mrs. Richard L. Flagg
Mr. and Mrs. Raymond L. Borggren
Mr. and Mrs. Charles F. Cook
Mr. and Mrs. Richard W. Lewis
Mr. and Mrs. Thomas Houghton
Mr. and Mrs. Donald D. Schroeder
Mr. and Mrs. Russell Hartsough
Mr. and Mrs. Calvin L. Swing
Mr. and Mrs. Robert E. Urbin
Mr. and Mrs. Frank C. Martindale
Betty L. Engel

Golfing at Plymouth Country Club



Original Nine-hole Course — 1940s



The Same Green in 1962

The Country Club Pump House

The concrete building with a steel container on the top, located below the Country Club parking lot was used to pump water out of the lake in order to water the greens on the original golf course. Pipes led to each green and had to be opened individually. This water system started in 1922 and continued through 1967.

Perry Marsh Resort

1891 to the 1930s

Perry Marsh's resort area was where Dwayne and Cheryl Miller's home is now (16386 Pretty Lake Road.) Two cottages were on the shoreline along with a small building which sold groceries and fishing supplies, and rented rowboats for fishing or an afternoon outing on the lake.

Mr. Marsh lived in one of the cottages and rented out the other, along with two cottages above at the top of the hill. These cottages were located where Pat and Betty Langdon live now (16370 Pretty Lake Road.)

The resort had an exciting toboggan slide that ran into the water. The two pictures show the slide, which worked on a roller system. When Betty Langdon moved out to the lake in 1938, what was left of the slide was torn down, and her brothers made other toys out of the old parts.

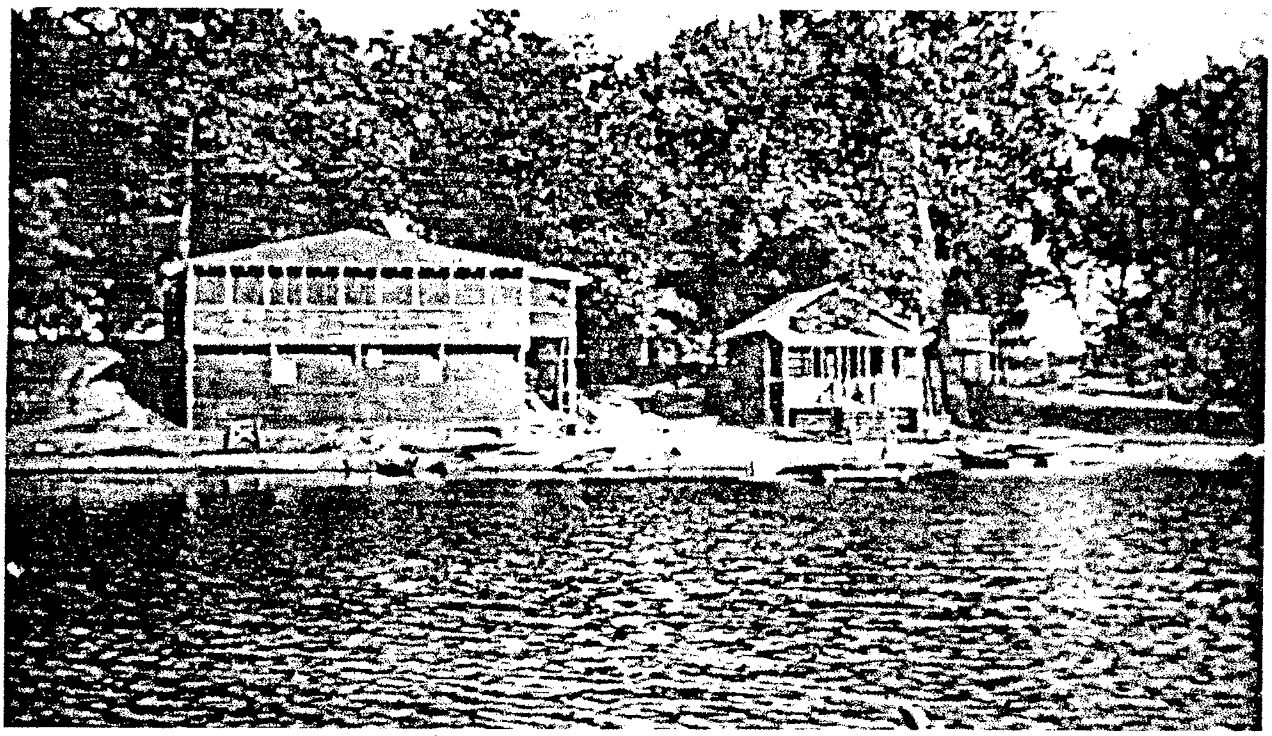
Where are the four cottages now?

After Mr. Marsh died, Omar Bixel and Walter Wise, two men from Plymouth, bought the property, and later sold it to Mr. Quillen, Betty Langdon's father. He tore down one cottage, and in 1941, started to build the house where Dwayne and Cheryl Miller now live. Pat and Betty Langdon bought the remaining property from her father, and tore down the other shoreline cottage in 1951. They lived in one of the upper cottages from 1951 to 1957. Then, they finished the house Betty's father had started uilding on thr shoreline. They remained in that house for 17 years. The other cottage was sold to Tom Langdon, who moved it more to the west. Tom and Kay Langdon currently live at that location (16392 Pretty Lake Road.)

Republican, May 11, 1922

"Dreamland" To Be Name of Pretty Lake Pavilion

In Tuesday's Republican an account was given of a dance pavilion being erected by local boys at Pretty Lake. It has since been decided to name the resort "Dreamland." The pavilion will be 48 by 36 feet in dimensions and will be of nifty appearance. Thomson & O'Keefe have the contract. May 30 is the opening date.



Pilot News, May 28, 1923

Dreamland Dancing to be Opened Again

Dreamland, the dancing pavilion at Pretty Lake, will be run again this season by Eugene S. Beagles, the owner. He has secured an orchestra of five pieces from Chicago to stay in Plymouth all season to furnish music for Dreamland. Mr. Beagles says that the five young men members are splendid musicians. There will be a big opening some time in June.

Pilot News, May 8, 1926

Pretty Lake Beach Is Improved for Season

Bathers at Pretty Lake beach, this summer will have a better beach than heretofore. T. Englehardt, who operates the store, beach and the dancing pavilion at the lake, has put wagon loads of sand on the beach, which has always been somewhat weedy and muddy, out from the shore. The beach will be in first class condition by the time for the first bathers to appear for the first sunburns.

The Dreamland dancing pavilion opens with the first dance tonight and before many weeks, the lake will take on the aspect of a lively village once more.

Many families are moving out to the lake within the next few weeks and some of the cottages are already opened up and the people living in them.

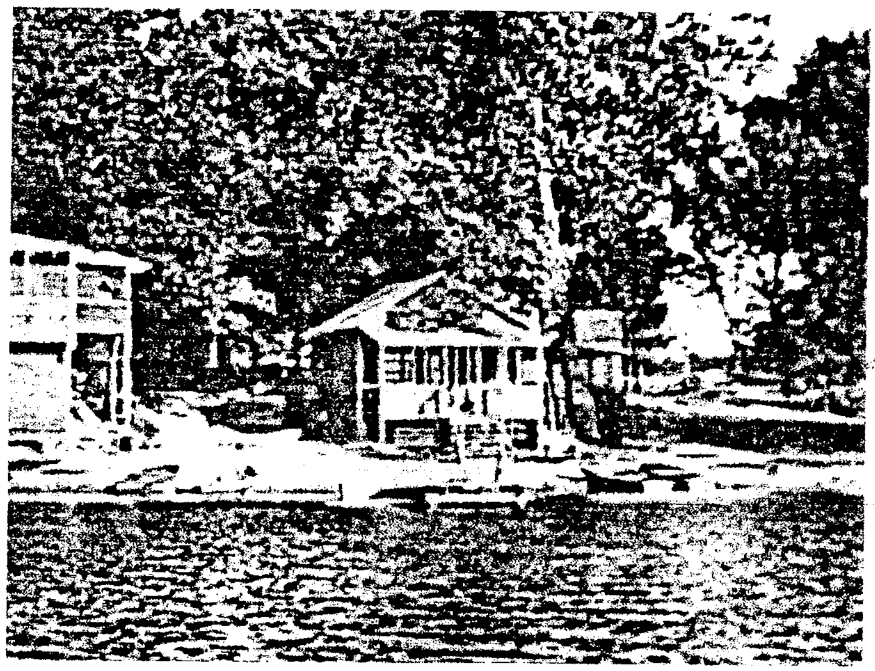
The House Beside Dreamland

The Englehardt's store had ten tables with chairs on the front porch. This was a very popular place for playing cards and drinking "home brew." Customers brought their own supply. Fishermen, townspeople and visitors from Chicago kept the place hopping. The smoke was so thick you could hardly see through the room. Of course, no children were allowed. A road ran between Dreamland and the Englehardt's store, so people could reach the entrance on the side.

Grace Englehardt sold sandwiches and candy, and had a soda fountain that used big glass glasses. She had a glass case displaying and selling wool bathing suits. There were one-piece black suits for the women and a trunk-style suit that tied for the men.

Ed Englehardt sold frog legs from all the frogs he caught under the docked rowboats.

— *Marilyn Panak*



The building next to Dreamland *(detail of photo on previous page)*

Many people from Chicago came to the lake to vacation. They would take the Pennsylvania Railroad to Plymouth and back to Chicago. The train came to Plymouth every day, so it made it very convenient. Many of these people worked for the Railroad. When arriving in Plymouth, friends would pick them up and take them to the lake or they would hire other transportation.

— *Ralph Reynolds*
Gloria Unger

Huge crowds came every weekend from Chicago. Many of them came because of Dreamland, which featured both square and round dancing.

— *Grace Englehardt*
as told to her daughter Marilyn Panak

Old Mr. Humrichouser said, "Just wait and see, somebody's going to bring out a lawnmower and spoil the lake!"

— *Debbie Yokum*

Drubert's Beach

1920s — 1940s

Charles Drubert built his cottage on the east (northeast) shore in 1922. By the late 1920s, they had opened their property to the public for swimming. People would drive down the narrow road, and park in an area in back of Drubert's cottage and the swamp. Also in this area, they had built a building with little rooms where people could change their clothes. Hattie Drubert used to sit on an outdoor swing by their cottage and watch over the beach activities.

Their store, which may have been the original "Shack," sold snacks and groceries. Lake residents could call in their grocery orders and have home delivery.

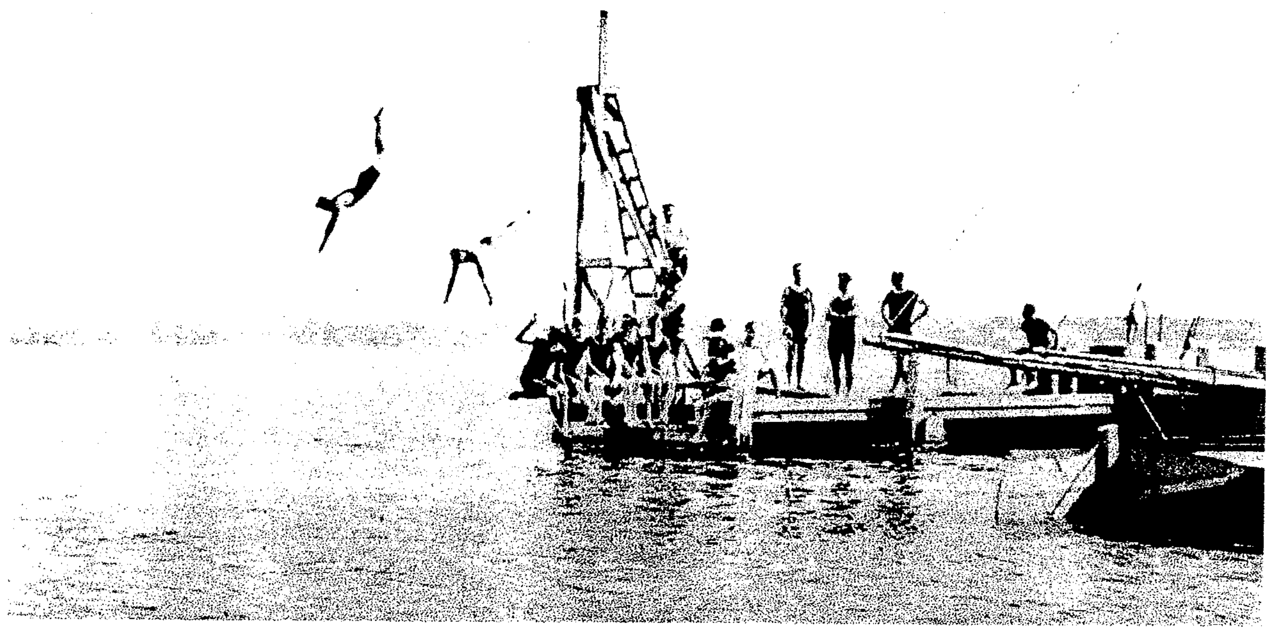
This was a very popular swimming spot for Plymouth residents, and many older people today remember it with fond memories.

The cottage and store were sold to Doc Keller in the mid-1940s. They kept the beach open to the public for one more year before closing it.

Jerry Kralovansky now owns "Drubert's cottage" location (10455 Quince Road), and Ruth Sfura owns the property where the store was (10571 Quince Road).

Drubert's Beach and Store

Notice the store (on the right-hand side of the photo) with the Coca Cola sign. In the trees, you can see two of the three cottages built by Theodore Engelhardt. The house by the store is now owned by Tom Langdon as a yearly rental (10561 Quince Road). At this time, the level of the lake was much lower, as you can see by the large beach area.



High Diving, Pretty Lake, Plymouth, Ind.

Two views of Drubert's Beach

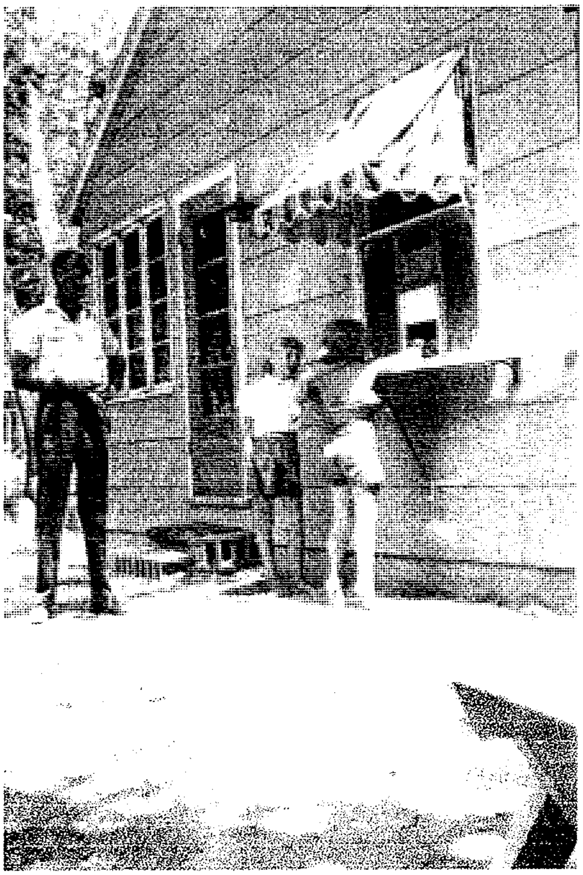
1945 — 1970s

The property known as the boat launch was purchased in 1945 by Albert "Bunk" and Elizabeth Weisjohn and Lola Sriver from Theodore Englehardt. They named this area the Pretty Lake Resort. At that time, it consisted of three small rental cottages and several metal rowboats. The small cottages were rented during the summer in one- and

Cottages and rowboats

two-week increments. They were rented at a cost of $21.00 per week, which included the use of a rowboat. The earliest records available date back to 1947. Although they had electricity, there was no running water. All water was obtained outside by a hand faucet, and heated on a gas stove. The outhouse was the only bathroom. There were three such "conveniences"; one for the ladies, one for the gentlemen, and one marked "Private" for the owners. Rowboats were rented for $1.00 per day.

During the summer months, the Weisjohns and Srivers took turns living in



The Lunch Box in the duplex

the "big cottage," which did have indoor plumbing and running water, and taking care of the boat rentals.

They also ran a hamburger stand. This building, called the Lunch Box, was located just south of the cottage, and was a most popular place. They sold hamburgers, hot dogs, candy, pop, ice cream and cigarettes.

In 1951, the two couples started building the duplex home which stands on the property today. It was completed in 1953. At one time, a road ran in front of the duplex, making a complete circle around the house.

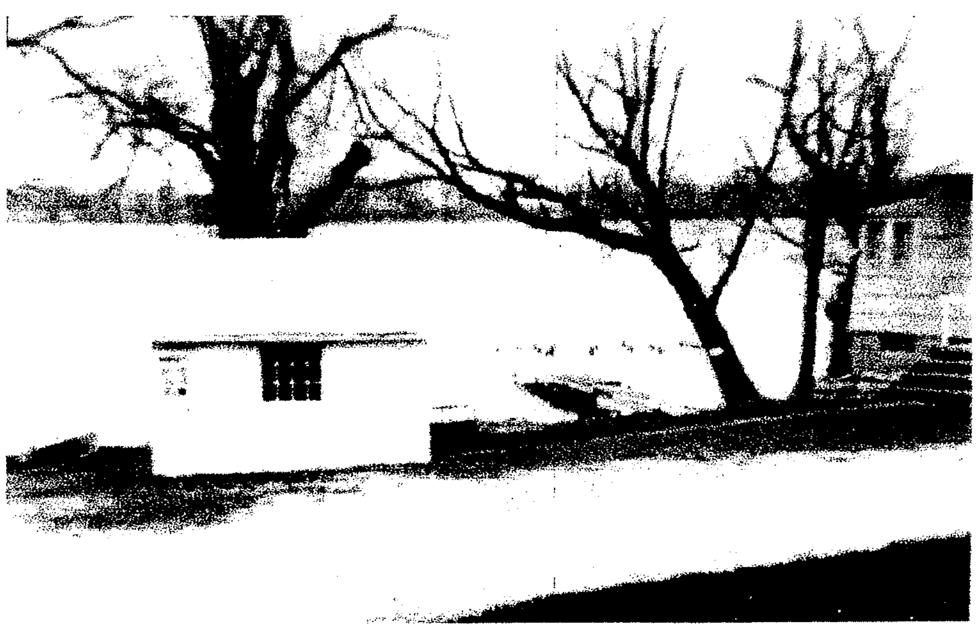
In 1950, they purchased the Drubert property at the south end of the lake from Doc Keller. They owned this for a little over one year, selling it to Howard Goss and Bill Goodman in 1951.

Eventually, after the duplex was built, the hamburger business was moved to the middle of the duplex. Part of each front porch was divided to accomodate the new store. This arrangement only lasted for one or two summers, and was eventually phased out.

The original hamburger stand became a bait house and storage shed for boating equipment. This building was torn down in 1992 because of severe damage from a tornado.

At the height of its popularity in the early 50s to mid-60s, there was a double T-shaped boat dock, which accomodated up to 30 rowboats.

After the death of Weisjohn, Sriver acquired ownership. Mr. Sriver died in 1973, and Mrs. Sriver continued the boat and cottage rentals until the late 1970s. Kimbles burned the big cottage down in 1993.



The Original Lunch Box building

FIRE DESTROYS SIX COTTAGES AT PRETTY LAKE

ALL NIGHT BOOZE PARTY IS BLAMED

FIRE DEPARTMENT IS UNABLE TO DO ANYTHING TO EXTINGUISH BLAZE—PREVENT IT FROM SPREADING.

ED KING LODGED IN JAIL

Officers Take List of Names of Other Men alleged to Have Been Connected With Liquor Party

An all-night booze party, Saturday night ended with the burning of six beautiful cottages on the north shore of Pretty Lake, about three o'clock Sunday morning. The fire destroyed the cottages of Ed. Cook, Rudolph Shakes, Ines Windbigler, Harry Paul, Mrs. T.J. Twomey and Ed. King.

The fire originated in Ed King's cottage. About three o'clock in the morning, the R.G. Groves family, occupying the Twomey cottage heard the call of "Fire" and, looking out, saw the King cottage in flames. They arose and Mrs. Groves called Mrs. Twomey in Plymouth, who called the fire department. Ed Cook was called and arrived on the scene ahead of the fire department. Other owners soon arrived but the fire was raging beyond control.

When the fire department arrived, it was impossible for them to connect the pump so that they could get water from the lake. They were practically helpless to do anything except to use chemical to prevent the fire from catching to the Holtzendorff cottage.

The Groves family lost all of their clothing in the fire, as well as other property. They estimated their loss at between $400 and $500.

Mrs. E.N. Cook had many heirlooms at their cottage which she valued very highly. They had prepared their cottage with the intention of going out to the lake to live in the near future. Everything in the cottage was burned, as well as the articles in all six of the cottages. Three of the cottages were occupied.

Harry Paul, whose home burned completely down, near the West High school about a year ago, occupied one of the cottages which was completely burned. Nearly all of the cottages were insured but not nearly high enough to cover the loss of the buildings. In addition to the large loss from the furnishings, the trees before the cottages were killed by the intense heat.

Occupants of cottages in the vicinity of the King cottage expressed the belief that the fire had started when King or someone else, in an intoxicated condition, had attempted to fill the kerosene stove. Loud voices were heard, cursing and asking where the kerosene can was. A few minutes afterwards the cottage was in flames.

Sheriff Falconbury and Prosecutor Hufsmith were called and when they arrived at the scene of the fire, they found King in a badly intoxicated condition. Hufsmith questioned him but was unable to learn anything definite from him. He said that he did not know how the fire had started.

He was brought to jail where he was later released under bond. His hearing will be held tonight in Justice court, on the charge of public intoxication. No other charge could be brought against him.

Officers also noted the names of other men, nearly all of whom have their names on the local court record in connection with liquor cases. However no charge could be made against them, as they were not intoxicated.

Whether an investigation will be conducted by the state fire marshal's office or not, is not known, but the belief was expressed by some of the property owners that such a probe would be made.

Note: The fire affected the area of 10237 - 10273 Pretty Lake Trail.

PLYMOUTH DEMOCRAT, THURSDAY, JULY 16, 1896

HE COULD NOT SWIM

WAYNE WILKINSON LOSES HIS LIFE

While Bathing in Pretty Lake last Evening,—Sank with Help Near.

The sad news of the drowning of Wayne Wilkinson, son of the proprietor of the Bargain Store, was brought to this city shortly after supper last evening.

Together with Lee Kendall and Frank Tanner, young Wilkinson had rowed into the middle of the lake in a row boat and from it they were diving and swimming and rolling off of it into the water, but keeping the boat near them. They were so much wrapped up in the sport, however, that at last they paid little attention to it and finally, when they had become very much exhausted from their violent exercise, it had drifted quite a ways from them. In their weak condition they swam for it but Wilkinson was not a good swimmer and seeing his peril, cried for help. M.C. Walls and J.A. Hoffman were fishing some distance away but struck out at once to help the unfortunates.

When half the distance had been made they saw Wilkinson sink for the last time and turned their attention to the other two who were taken from the water just in time, else they would probably also have drowned. The water is quite deep where the drowning occurred but every effort was made at once to recover the body.

PILOT NEWS, SUNDAY, JULY 26, 1925

FALLS IN WATER FROM BOAT NEAR THE SHORE

FRANK LIMMAR IS VICTIM OF SAD ACCIDENT YESTERDAY AFTERNOON ON SOUTH SIDE.

DROWNING WAS WITNESSED

Boy Could Have Been Restored If Immediate Attention Had Been Given.

Frank Limmar, aged nine of Chicago, drowned Tuesday afternoon at three o'clock near the south shore of Pretty Lake. The lad was in the care of his grandmother, Mrs. Krau of Chicago. They had been staying for three weeks at one of the Perry Marsh Resort cottages near the south shore bathing beach where the slide is situated.

The boy was in a boat fishing close to the shore. He must have lost his balance while standing in the boat. He was seen by his grandmother and Mrs. Lloyd Price clinging to the side of the boat. They hurried to his aid and the grandmother waded out into the water. She tripped and went under the water almost drowning. Mrs. Price got her out of the water and in the meantime the boy went down.

The lad was found in water about five feet deep and brought out within about four minutes after he had gone under. Few happened to be near and no one knew the resuscitation method of artificial respiration which would probably have brought recovery if used promptly. The boy lay perhaps 10 to 15 minutes while help was being summoned. Dr. Conroy Eley happened to be on the golf links across the lake and he was hurried to the scene. He and helpers worked for an hour and a half over the boy trying to restore heart action. Also hypodermic injections were used but no spark of life could be started. Dr. Eley is of the opinion that the boy must have had some physical weakness, such as heart trouble which may have caused his drowning and prevented his resuscitation.

Coroner R.E. Johnson held as inquest this morning and rendered a verdict of accidental drowning.

The parents of the lad were summoned from Chicago and arrived last night. The remains will be taken to Chicago for burial today.

Coroner Johnson is of the opinion that the life could have been saved if there had been a pulmotor as close as Plymouth and urges that such a device be secured for future emergencies.

PLYMOUTH DEMOCRAT, MONDAY, JULY 13, 1925

RULO MANN OF INWOOD DROWNS IN PRETTY LAKE

SANK IN 30 FEET OF WATER NEAR RAFT

MANN AND HIS COMPANION, WALTER DRAKE, WERE SWIMMING OUT TO RAFT AFTER DARK SATURDAY

BODY FOUND HOURS LATER

After Search of Three Hours and a Half, Grappling Hooks Brought Drowned Boy to Shore

Rulo D. Mann, son of Mr. and Mrs. John Mann of near Inwood, was drowned in Pretty Lake near the shack on Saturday night at about 8:45 o'clock.

Rulo and his companion, Walter Drake, also of near Inwood, were in swimming and had started for the raft about 50 yards away. Suddenly Rulo yelled to his companion that he was sinking. Drake went to his assistance and succeeded in reaching him. As he was trying to pull him up, however, his hold slipped loose and he was unable to get hold of him again.

Both boys were poor swimmers and it was all Drake could do to swim to a red boat anchored near and crawl into it. As he was swimming to the boat he called for help.

At the time it was about fifteen minutes until nine o'clock and darkness had just settled over the lake. The two boys were the only ones in swimming at that point.

On the shore were Gail Myers and Alfred Boys of Plymouth, who had just come out of the water and dressed to leave for home.

The boys heard Drake's call for help and saw him swim to the boat and get into it. Gail called to him, "Are you all right now?" thinking that Drake was the only one in trouble, as they could see no one else.

"Yes, I'm all right, but there is another man went down right out there," said Drake.

Both Boys Poor Swimmers.

Both Rulo and Walter were poor swimmers, said the relatives, and should not have attempted to swim out to the raft across the deep water. However, according to Walter Drake's story, Rulo had been out to the raft three or four times before and had dived from the raft.

Walter also said that they had not eaten supper or drank anything immediately before going into the water. They had eaten supper perhaps two hours before and then drove from Inwood to the lake, arriving about 8:30 or a little sooner. They had been splashing about the dock for several minutes before they started to swim out to the raft.

There seems to be no explanation as to why young Mann should have suddenly ceased to swim and gone down. He may have been very tired from a hard day's work on the farm and become exhausted and then got frightened, fearing he could not make the swim.

Big Crowd Gathers.

By this time a large crowd had gathered on the shore. Workers at once began dragging the lake with ice tongs to bring up the body. Later wire was attached to the electric light current along the shore and carried on boats out to the place where young Mann went down. A search boat was attached and the men in boats tried to help the search by this method.

To help in the lighting of the lake many cars were driven down along the beach and turned their spotlights on the water.

Word was telephoned to Culver and South Bend for divers and for grappling hooks for the search. It was after eleven o'clock when the South Bend men arrived. In the meantime many boats were out over the place of the drowning, doing what they could with the apparatus at hand to find the body. Among these were Thos. Roach of Chicago and Glenwood Beatty of Plymouth in one boat. Mr. Roach used some fishing tackle. Noble Kizer, Herman Taber, Mr. Otstot, formerly of Plymouth, were among the searchers in the boats.

Find the Body.

It was nearly twenty minutes after twelve o'clock when a murmur ran thru the crowd, "They've got him." The boats moved toward shore and soon the body of Rulo Mann, now stiff in death, but with a peaceful look on the boyish face, was brought to shore.

Dr. Harry Knott and several others took the body into one of the cottages underneath the Dreamland building to determine whether anything could possibly be done to bring back life. As the body was already stiff and cold after the three and a half hours in the cold water it was decided that there was no use trying to use the pulmotor.

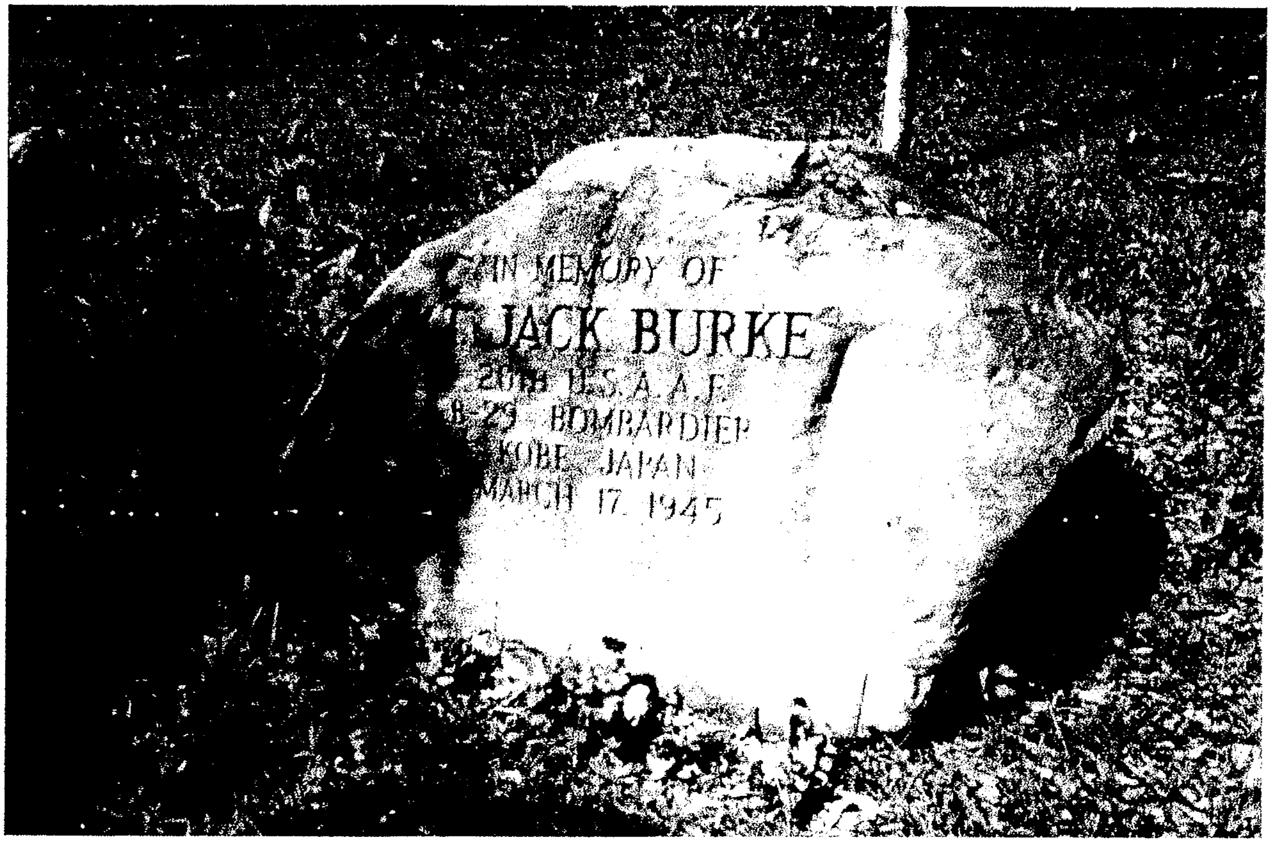
Drake, who was with Mann at the time is about 17 years old, and not a good swimmer. He was much frightened at the accident, but even tho he was a poor swimmer, went bravely to the assistance of his friend, knowing, perhaps, that there was a chance that he, too, might go down.

Drake was not very clear on just what happened, but says that when Rulo called for help he swam to him and was able to get hold of him. This hold was not secure enough, however, and Rulo slipped away from him and he was not able to reach him again before he went down. It was then he called for help and made for the boat nearby to save himself. Had the accident occurred in water much more shallow than at the point where it did, divers might easily have brought Rulo out and saved his life.

The body was taken to the Johnson undertaking parlors and cared for.

Memorial Stone on Lake Shore of Burke Property

This memorial stone is in memory of John (Jack) Burke, who was a B-29 bombadier in World War II. He was shot down on March 17, 1945 at Kobe, Japan. He was 21 years old. His parents found this stone while driving in the country, and had it engraved and brought to the lake in 1946. The Burke property is on the north shore of Pretty Lake.



Winter View from the north shore of Pretty Lake

Pretty Lake Roads

South Shoreline

The south shoreline dirt road was built in order to get to Dr. Wilson's cottage and the Perry Marsh resort area. This dirt road was constructed in the early 1890s. The road came down to the shoreline on the east side where Roger Kimble lives now (10513 Quince Road) going on around to the south side. It could only go as far as the swampy area in the southwest corner of the lake. The road was gone by the 1930s.

Pretty Lake Road

The road on the south side of the lake came in off of Queen Road as it does today. The road was more like a lane running very close to the back of the cottages which were there. It only went as far as the Tom Langdon rental is at 16340 Quince Road. Mr. Ray Welborn owned the land opposite the cottages. In the mid 1940s, when he decided to sell off the land for building lots, he straightened out the road to where it is now. This road too, only ran as far as 16340 Quince Road.

According to Betty Langdon, homeowners had the opportunity to buy the land behind their cottages, between the old road and the new. She also mentioned that at one time, all the land on the south sided of the lake was owned by Chicago people. There was no electricity along Pretty Lake Road until 1945. People travelling after dark had to use kerosene lamps.

In the mid 1950s, the road was constructed to go all the way around the lake as we know it today.

Dogwood Lane

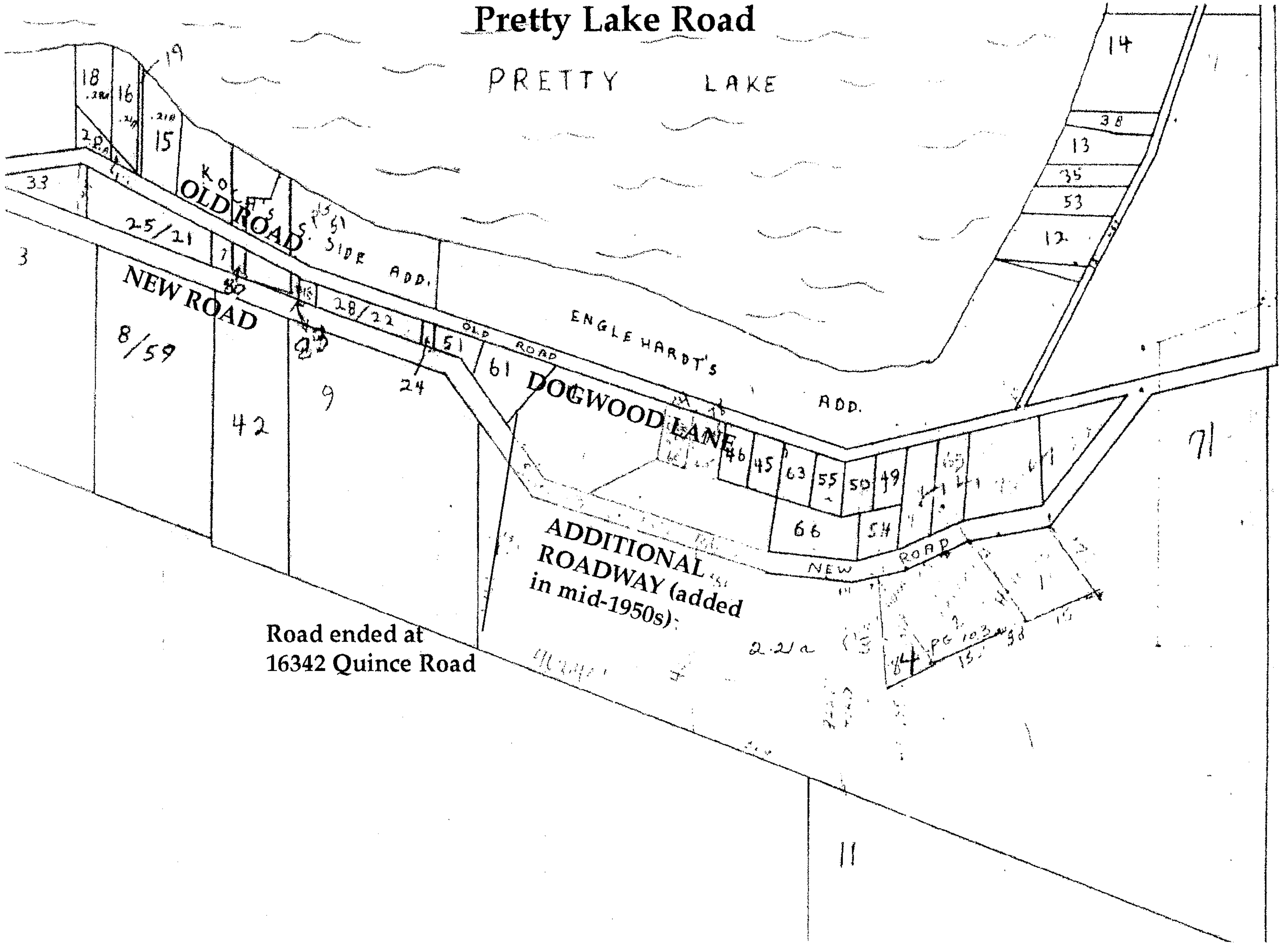
Edmond and Grace Engelhardt owned land on the south side of Pretty Lake. To get into this property, they had a small lane among the trees. They sold this property for building sites. Grace Engelhardt said the new owners were promised that this lane, later a wide road, would always remain a private road. The new residents, according to Mrs. Engelhardt, named the road Dogwood Lane because of the many Dogwood trees growing there as they do today.

Pretty Lake Trail

In the 1800s, people came from Plymouth by horse and buggy on a dirt lane. They turned off onto a dirt trail that ran to the lake. This trail is the road leading between the golf course. In the advent of cars in the 1920s, the roads were upgraded. The trail ran behind the cottages not curving out to Quince Road as it does today, but continued on behind the cottages built on the Pretty Lake Club grounds. The road leading behind Pretty Lake grounds cottages was closed by the late 1930s. To make the rest of Pretty Lake Trail a 40-foot right of way, land was purchased from Mr. Koch and the road was constructed where it is today.

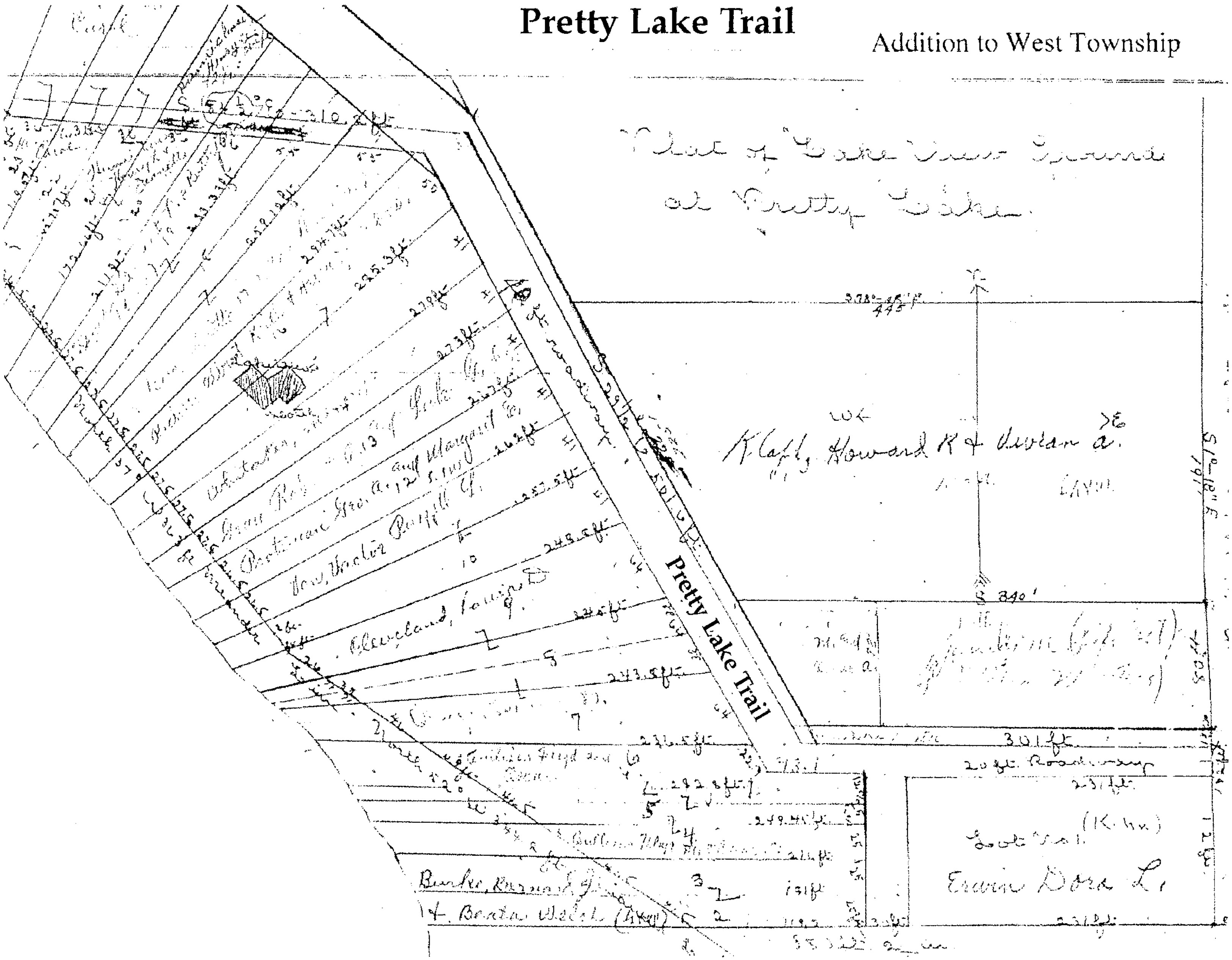
Road going around south shoreline of Pretty Lake — 1845

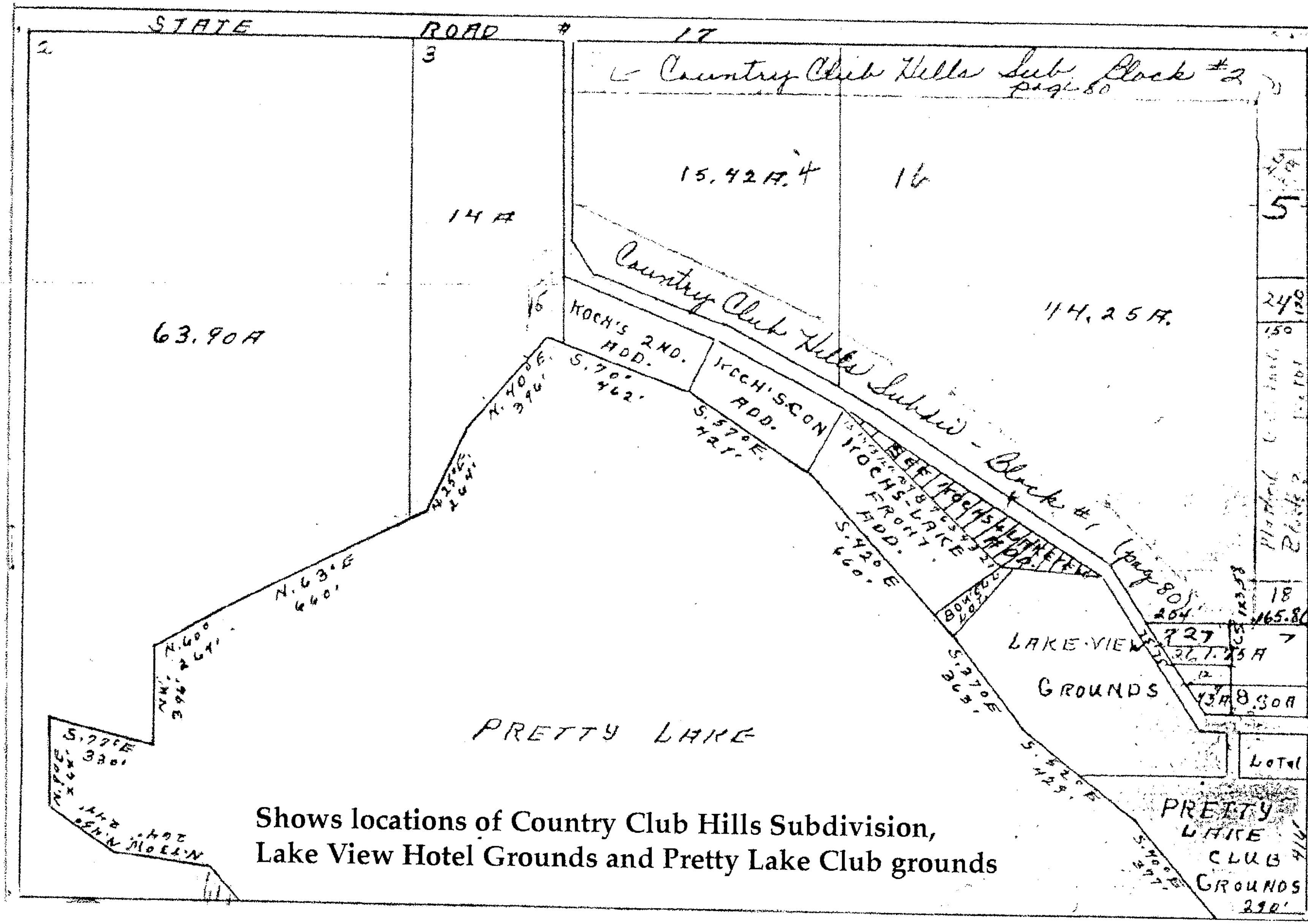
Pretty Lake Road



Pretty Lake Trail

Addition to West Township





Shows locations of Country Club Hills Subdivision, Lake View Hotel Grounds and Pretty Lake Club grounds

Pretty Lake Association — 1914

DEMOCRAT, MAY 7, 1914

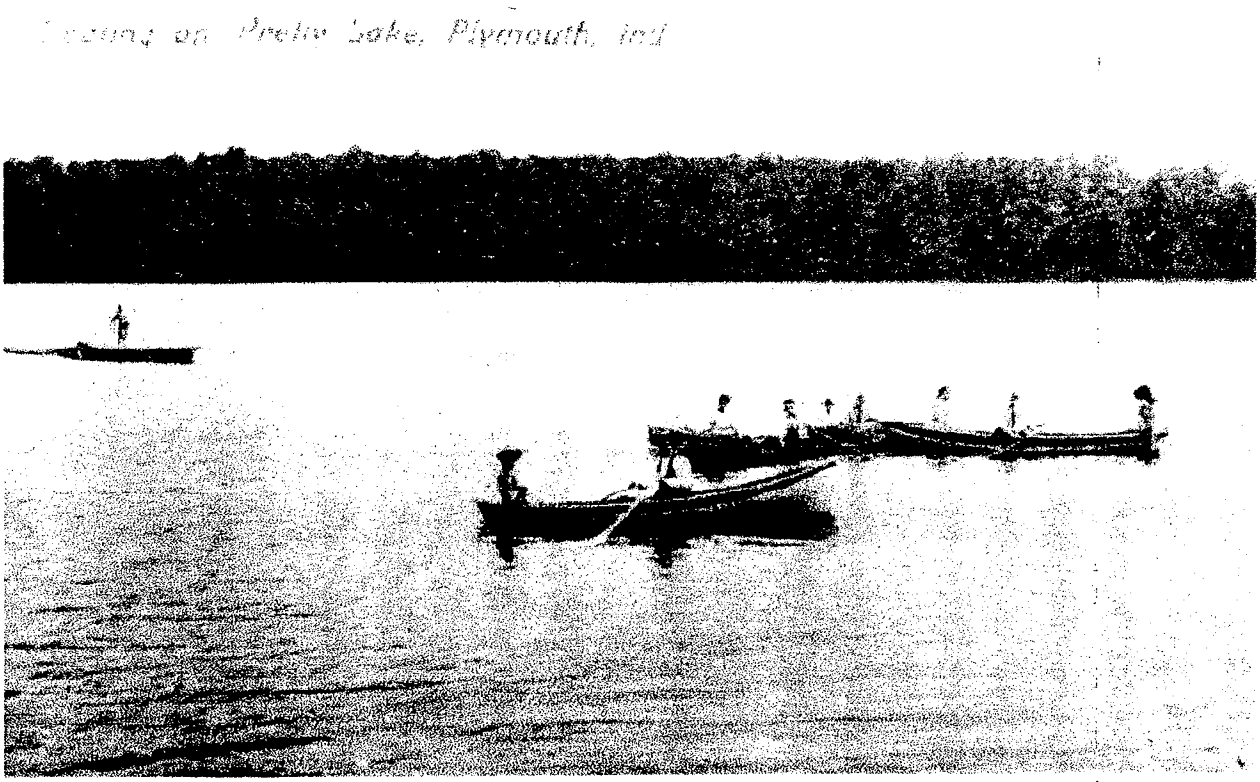
PRETTY LAKE ASSOCIATION ELECTS NEW OFFICERS

The owners of cottages at Pretty Lake have organized into an association for the better protection of their property. At the annual election of officers this week the following officers were elected: H.W. Borertree, president; F.M. Burkett, vice-president; O.G. Soice, treasurer; L.R. Cressner, secretary.

The members talked over plans for beautifying their property and it is the purpose to make this family resort as inviting as possible. The association will also guard the matter of illegal fishing.

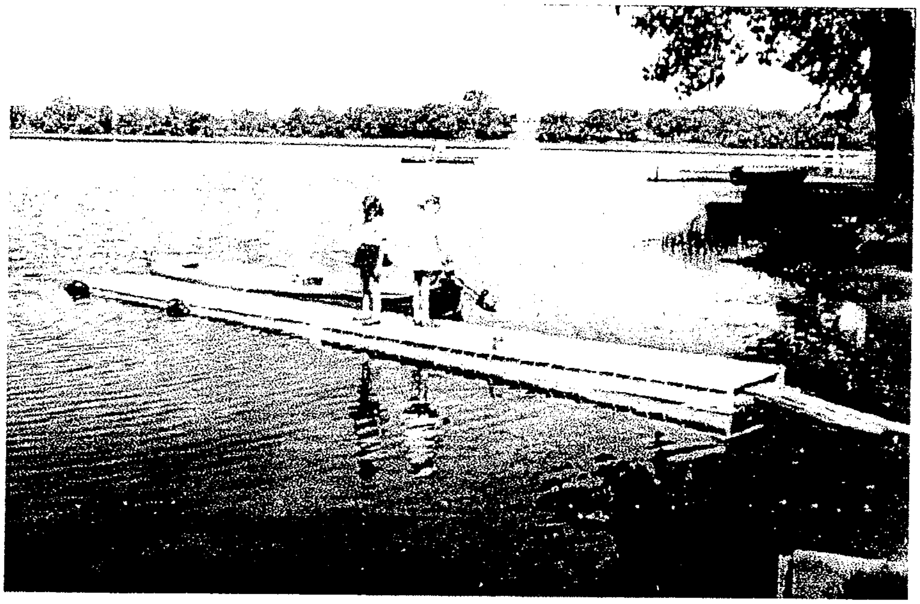
HALF MILLION PIKE IN PRETTY LAKE

Mr. George Berg of Indianapolis put one half million of wall-eyed pike in Pretty Lake Wednesday afternoon. He also will put the same amount in Bass Lake and Lake Manitau. These pike were hatched in the Columbia City hatchery. They were brought here in an auto truck. J.R. Losey accompanied Mr. Berg to Pretty Lake and saw that they were put into the lake. This action came about as a result of the Association of 1914.



Pretty Lake Association — 1970

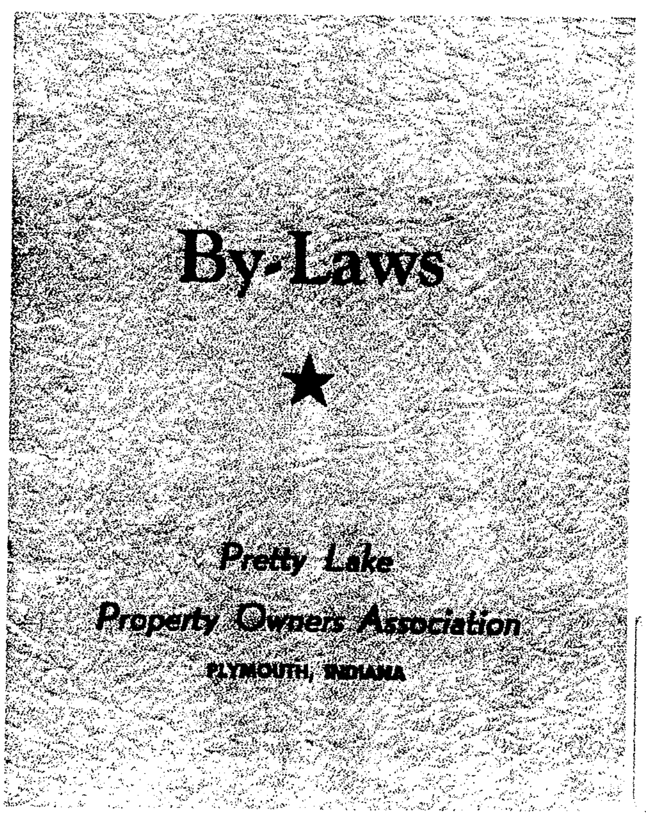
FROM THE
PRETTY LAKE PROPERTY OWNERS ASSOCIATION
BY-LAWS



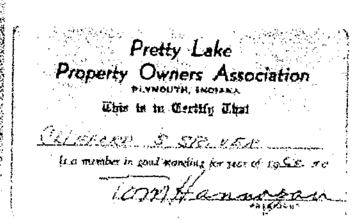
In 1970, the Association restocked the lake.

1. All persons of good character who as individuals own land on Pretty Lake, Indiana, or land with access to the Lake, shall be eligible for membership. The Country Club will be entitled to one membership authorized by the President or any officer of the Club.

2.Dues will be determined after a survey to determine the cost of providing services outlined in "Purposes", but not to exceed $10.00 per calendar year. Hereafter, dues will be fixed amount and can only be increased by a majority vote of the voting membership at any membership meeting. All dues are payable in advance.



3. For any special expense which the Association may not have funds on hand sufficient to meet at the time, the Board of Directors are authorized to levy an assessment, upon the membership, the amount of the assessment so levied by the Board of Directors shall in no event exceed $5.00 per year per property, unless a greater assessment shall be authorized by the vote of at least two-thirds of all the members of the Association present at a meeting.



4. Voting in membership meetings shall be limited to one vote per property.

Pretty Lake Association — 1991

Pretty Lake Property Owner's Association Meeting

Highlights — Reorganizational Meeting

July 21, 1991 - Plymouth Country Club

Acting Co-Chairpersons: Joan Bartlett, Chris Marohn

43 families represented

Association includes people who live on Pretty Lake and homes on Country Club Hills.*

New board elected:
Joan Bartlett, Chris Marohn, Jack Oliver, Ron Gifford, Joe Felke

A meeting of the Board of Directors and committee members of the Pretty Lake Association was held on August 1, 1991, at the home of Joan Bartlett. Those present were: Joan Bartlett, Chris Marohn. Board members: Earl Long - historical, Jim Meck - safety, Betty Wenino and Bob Bartlett - publicity/information, Helen Bartlett - social, Don and Loretta Schuppert - environment, Belle Shemberger - communications/calling.

Our primary purpose will be to keep people informed on lake issues and to promote cooperation and socialization among the lake users.

The time, work and money invested by Roger Kimble, Dick Day and Don Marohn in the lake level control installed at the east end of the lake was brought up. It was suggested that some repayment might be made at some future date. Lake level control in front of Dick Day's house (10549 Quince Road.) This eliminated the water problem written up in the March 27, 1991 article. Some discussion about helping Terry Smith with recycling of bottles and cans.

An announcement was made that the Social Committee is planning an Ice Cream Social for Sunday, August 25th.

* *Homes on Country Club Hills became eligible because of purchasing arrangement. The arrangement came about when Jim Robertson and John Ritzenthaler gave farm land to Country Club in 1967. They would sell building lots around outer edge of the property and the Country Club would have middle of property to expand golf course. A stipulation was added that the owners on Country Club Hills would have access to Pretty Lake across Plymouth Country Club property.*

High water upsets Pretty Lake residents

By YORK YOUNG
P N Staff Writer

High water levels have caused more problems in Marshall County over the last few months than the previous five years combined.

An overflow of Pretty Lake on the east end has caused some minor water problems, but a clogged culvert under Quince Rd., just south of Pretty Lake Trail, has contributed to the problem, according to local residents.

Mike Faylor, 10561 Quince Rd. and Dorothy Johnson and Donna Delph, both of whom live two houses to the south of Faylor, have taken requests to county officials, which have gone unheeded, they claim.

The homes are adjacent to the lake, but east of the homes and the driveway is a swampy area in which stands several feet of water. The area has been proclaimed a wetland by the Indiana Department of Natural Resources.

Between Pretty Lake and the swampy area is a 24-inch culvert which travels under Quince Road. West of the road, where the water enters, the tile is nearly covered, with one or two inches visible above the water. On east end, the water level is 18 inches below the top mark of the tile.

"The biggest problem is all the septic systems are covered by water," said Faylor. "Cleaning it (the culvert) wouldn't lower the lake level," said Faylor, "but it would get rid of the surface water at the back of the homes." Pretty Lake is a few inches higher than the dike on the east end.

Two summer cottages, one on east side of Faylor, and much smaller than his house, are nearly surrounded by water. The cottages are owned by Ruth Sfura and Richard Day. Faylor and the neighbors have tried to dig small trenches toward the wetlands to reduce the water levels. (Ed. note: This problem was solved by the lake level control system.)

Part of the Lake?

This summer cottage, owned by Ruth Sfura, looks from this angle to be part of Pretty Lake, on the east end of the lake, on Quince Rd. The lake is spilling over the dike on the east end of the lake, but some local residents claim a blocked culvert has contributed to high water problems. (See related story). photo by York Young

Pretty Lake Property Owner's Association Annual Meeting

Hignlights

July 21, 1992 - Plymouth Country Club
President: Joan Bartlett
Secretary: Ronald Gifford
42 people representing 28 memberships represented

Terry Smith addressed the meeting on the issue of recycling. It was suggested that the Association pay for a can crusher for Terry.

Sheriff Ed Croswell spoke about the MacGruff Safe House Program. The purpose is to protect children and also a deterrent to robberies, as thieves are aware that people are watching for unusual activities.

Committee Reports as follows:

Safety: Jim Meck was thanked for his rules and suggestions for lake safety.

Social: The garage sale will be an annual event. The Ice Cream Social was successful, and another is planned for this year. (probably August 23)

Chris Marohn thanked Lori Kohlmeyer and Mary Gifford for their work in planning and putting on these events. A regatta is being planned for Sunday, August 9th.

Thanks to Larry Holloway for designing the Association logo for sweatshirts. (See logo design below.)

Thanks to Belle Shemberger, Dorothy Coury, Shirley Morrow and Jane Oliver for doing a good job on the Calling Committee.

Pretty LAKE
PLYMOUTH, INDIANA

ATTENTION: Pretty Lake Residents or Visitors

We (Pretty Lake Association) want you to appreciate the unique experience of the most unusual lake in Indiana. We have quiet times and speed times — something for everyone! Some of us don't know the rules* — or have a lapse of memory.

<u>SPEEDS OF OVER 10 MPH from 1:00 P.M. to 4:00 P.M. ONLY</u>

The above regulation is allowed by the Conservation Department because we had a vote of home owners and over 51% voted YES. What the Conservation Department allows, it can rescind.

<u>BOATS WITHIN 200 FT. OF SHORE - IDLE SPEED — INCLUDES JET SKIS</u>

This is a state regulation for all lakes. We would hate to injure a swimmer or small boater. This includes dropping a skier.

<u>COUNTER-CLOCKWISE FAST TRAFFIC</u>

We do not know how this was started, but organized traffic patterns work in all other traffic and seem to work here.REMINDER OF PRIORITIES

1. Swimmers
2. Non-powered boats (canoes, rafts, fishing persons)
3. Sailboats
4. Small power-boats
5. Power boats

<u>REMINDER</u>

Watch for scuba divers and snorkelers. (Pontoon boats must also watch.)

All of us want a safe and sane lake. And we can, if we work together. Those of us who want to speed, must work extra hard to obey the rules, so we do not want to upset our neighbors or the Conservation Department.

<u>OTHER REQUESTS</u>

Do not drive cars in or on the Lake (oil and gas pollute).

Do not take glass on the Lake or ice (bad for feet).

Help remove cans and plastic from the Lake (fish don't like)

<u>ROADS</u>

We hope to reduce the road speed to 25 mph. At 30, people drive 35. Maybe at 25 they'll go 30. With all of our grandchildren and grandparents on the road hiking and walking, we must be careful.

<u>A TOWED PERSON</u>

A person is required to watch the towed person (state law).

* *Rules passed out in 1992 on Pretty Lake safety by Jim Meck*

PRETTY LAKE REMINDER

Boats going over 10 mph must be 200 ft. from shore
Step it off on land.

14 yrs. to 16 yrs. old may operate over 10 HP. after taking approved boating course. Younger than 14 may drive a motor under 10HP*.

WATCH OTHER BOATS

A. You must be 100 ft. from them.

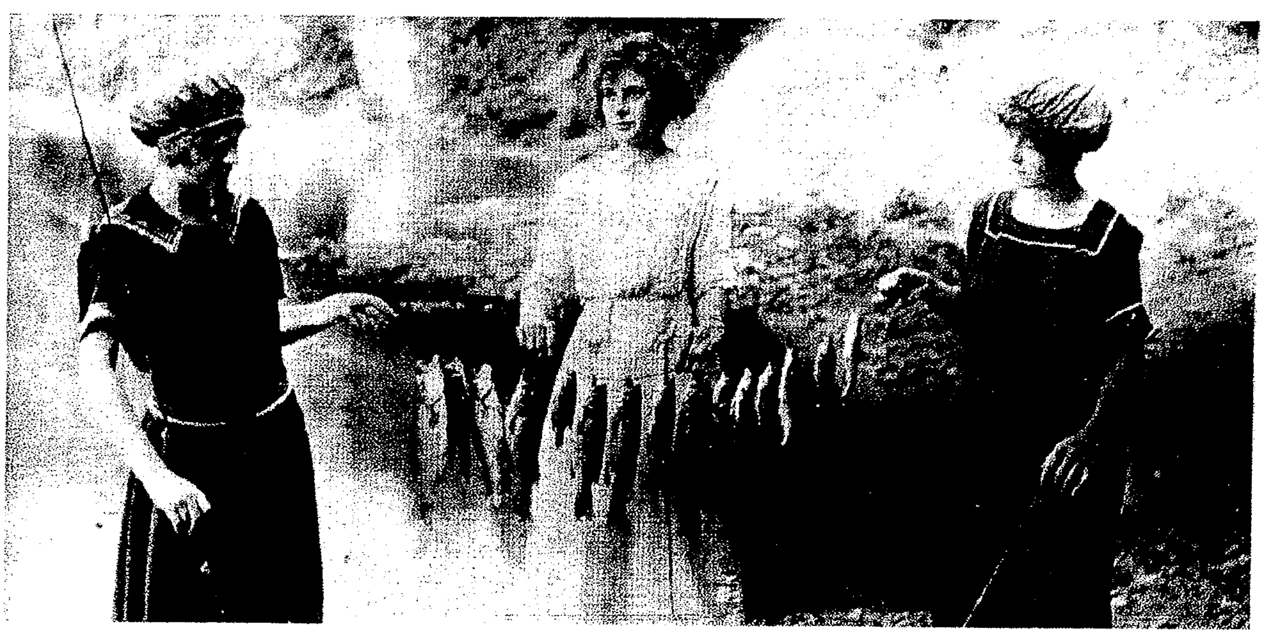
B. Do not cut in front.

C. Do not follow a tuber or skier ... they may fall.

Swimmers in the center of the Lake, please have a boat with you. Boat drivers are sometimes distracted by other boats — and by attractive people of the opposite sex.

To discuss the laws, stop at Jim Meck's — 10343 Pretty Lake Trail, or the blue Hydrodine on the Lake.

(Only friendly discussion allowed.)
I don't write the laws.



Pretty Lake Property Owner's Board Meeting

Highlights

September 22, 1992 - Office of Felke Florist

Present were: Joe Felke, Jr., Joan Bartlett, Jack Oliver and Ron Gifford

Joan reported $400 worth of orders for sweatshirts* was taken at the Ice Cream Social.

The Treasurer reported that the light has been installed at the intersection of Quince Road and State Road 17, at the price of $7.87 per month.

Tom Parsons** will be contacted to give a report on the water quality of the lake.

Pretty Lake Property Owner's Special Meeting

Highlights

October 11, 1992 - Plymouth Country Club

President: Joe Felke

Secretary: Ronald Gifford

Approximately 30 memberships represented

Members were told that the light at the corner of Quince Road and State Road 17 was done by Association.

Bob Bartlett introduced Jim Donahoe, owner and operator of Aquatic Weed Control. He explained about different ways to control weeds in the lake. He will talk to members in early spring in order to make decision on procedure.

Mr. Felke reported that Tom Parsons stated that Pretty Lake has been judged to have the best quality of any lake in Indiana for the last six years.

* *They were sold at cost for $15.75. Joan and Bob Bartlett tool the responsibility of ordering sweatshirts from Yoder's Sport Store. Members purchased them from their home.*

** *Tom parsons checks all the lakes in the county and works for the state.*

To: All Members of the Pretty Lake Property Owners Association
(Highlights)

From: Board of Directors

Date: August 19, 1993

Each of us, as Directors of the Pretty Lake Property Owners Association, have heard from several people who live on the lake with concerns over the recent advent of jet skis on the lake and some other boating practices which several members are concerned will lead to injury or death of someone attempting to enjoy Pretty Lake. Pretty Lake is a public lake and as such no one can adopt rules to ban the use of jet skis nor can any other rules be enforced with respect to the use of the lake. However, it is only good common sense that tells all of us that if we are to co-exist safely on the lake that we all must cooperate and work together so as to eliminate the possibility of death or injury.

The purpose of this letter is simply to bring to your attention the concerns of the Board as to some unsafe practices which have been observed by people who live on the lake and reported to the Board.

We look forward to discussing this with you at the annual meeting and ask all of you to bring your suggestions for solutions to what seems to be a growing problem with this matter.

Signed by: Joe Felke Budd Treat Ron Gifford Joan Bartlett Jack Oliver

Pretty Lake Property Owner's Association Annual Meeting

Highlights

September 19, 1993 - Plymouth Country Club

President: Joe Felke

Approximately 42 people present representing 30 memberships

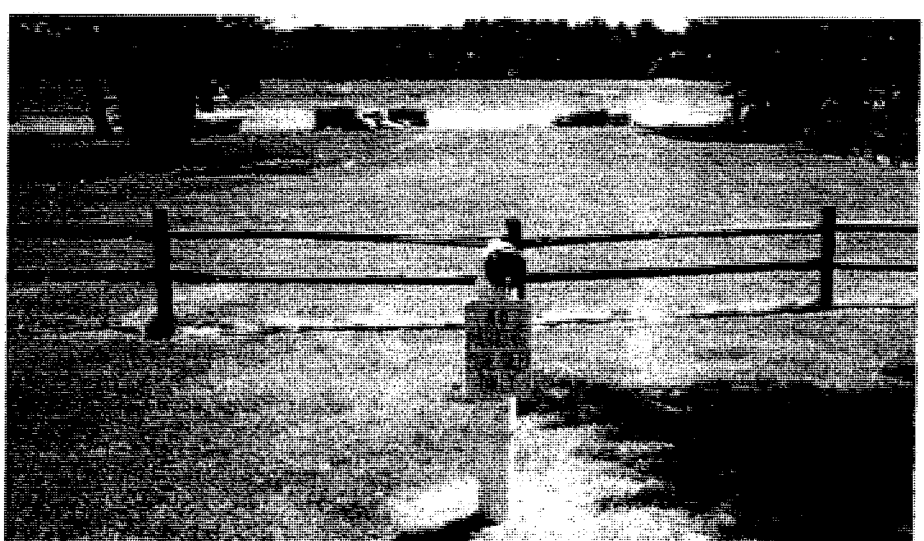
Mr. Felke announced that officers of the Association for the upcoming year would be Jack Oliver as President, Budd Treat as Vice President and Ron Gifford would continue as Secretary/Treasurer.

Mr. Blum explained the purpose of having a dry hydrant placed in the lake just off of the Country Club Hills access easement. At the present time it takes a tanker approximately ten to twenty minutes to fill up the tank to fight a fire and with the advent of the dry hydrant, it should take the same process only three to four minutes. The dry hydrant will be placed approximately thirty feet out into Pretty Lake at a fairly decent depth and would have a screen at the end of the pipe in order to pump into a six inch main with an actual hydrant being located off of the access road.

Mr. Felke reported on the aborted plans of Marshall County to develop access points on Pretty Lake and provide for public access to the same and thanked several members of the Association for having appeared at meetings to contest that possibility.

Mr. Felke thanks Bob and Joan Bartlett for handling the clothing and Bud Berger and Bob Bartlett for their efforts in weed control.

Dr. Guy Matthew reported that he had checked into the Illinois regulations on spraying of lakes and found that they are consistent with what Pretty Lake did this previous summer and that there was nothing improper in the way it was handled.



Dry Hydrant

Pretty Lake Property Owner's Association Annual Meeting

Highlights

May 28, 1995 - Plymouth Country Club

President: Jack Oliver

Present at said meeting were Board members Joan Bartlett, Jack Oliver, Budd Treat, Ron Gifford and Billie Kimble.

The annual garage sale will be held on June 9th and 10th and advertising would be placed in local papers.

Dr. Matthew moved that the membership take the position to discourage the use of jet skis and that signs be placed at both landings saying that the use of jet skis are discouraged. Larry Holloway will be asked to construct such signs to be placed at both the Country Club Hills access area and at Kimble's launching area, advising of other rules with respect to use of the lake by boats as well as discouraging the use of jet skis on the lake.

Upon motion by Bob Bartlett, seconded by Joe Coury and unanimously approved, an automatic $25.00 a year assessment per property owner was approved and dues notices will be sent out.

Bud Berger, Bob Bartlett, Larry Holloway and Lou Wenino were all placed in nomination for election to the Board of Directors to replace Budd Treat, Billie Kimble, Joe Felke and Joan Bartlett. Thereafter, upon motion being duly made and seconded, the above named individuals were elected by acclamation to serve a term of two years for Bud Berger and Bob Bartlett, and three year terms for Larry Holloway and Lou Wenino.

To: Pretty Lake/Country Club Hills Property Owners

YEAR-END REPORT — 1995

In May, the membership met, with President, Jack Oliver, presiding. Four new board members were elected: Larry Holloway, Lou Wenino, Bud Berger and Bob Bartlett. They joined Ron Gifford and Jack Oliver to form the new board.

The board has met several times, and is working towards forming committees to attempt to resolve various concerns of the membership.

Those committees are:

SAFETY	- To promote safety awareness on the lake and on our roads. Possibly a neighborhood watch program.
ENVIRONMENTAL	- This committee is concerned with developing an ongoing recycle program. Also is working on leaf disposal.
SOCIAL	- Nice people mixing with other nice people thru ice cream socials, boating events, annual garage sales, etc.
MEMBERSHIP	- Keeping everyone aware of what's going on, and maintaining strength thru strong 100% membership.
WEED CONTROL	- The ongoing battle the lakefront owners have with the weeds infesting our lovely lake. General satisfaction was expressed with last year's program.
SALES	- A selection of sweatshirts, T-shirts and caps with the Pretty Lake logo are available for men, women and kids at the Bartletts. Would make great Christmas gifts.
SEWERS	- A committee has been formed to determine the feasibility of a sewer system for our area. Visitation planned next Spring to existing systems in Rochester, IN. and Itasca, IL.

These are some concerns we are working on. We're sure there are others, and we want to hear what yours are. Also, these committees are looking for more members. If you're interested, give us a call.

To those of you who haven't sent in your annual dues of $25, please send them to Ron Gifford, 10280 Pretty Lake Trail, Plymouth 46563.

Thanks for your interest.

Credits

Material compiled and edited by:
Betty Wenino
1997
Cover by:
Larry Holloway

Material was obtained from the following sources
Conversations with:
Betty Burke
Joe Coury
Fred Drubert
Grace Englehardt
Chuck Glaub
Edith Hess
Merlin Jones
Billie Kimble
Bob Kizer
Betty Langdon
Sharon Matthew
Jim Meck
Hap Morris
Alberta Overmyer
Marilyn Panak
Ralph Reynolds
Gloria Unger
Wilma Wagoner
Rachael Wenino
Debbie Yocum
Files and Newspaper Articles:
The Assessor's Office at the Marshall County Building
The Marshall County Historical Society
The Plymouth Public Library
Photographs:
Bob Bartlett
Billie Kimble
Don Mahron
The Cressner Estate
The Marshall County Historical Society

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Judy Bartlett

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APPENDIX C:

Boat Count

Pretty Lake Diagnostic Study
Marshall County, Indiana

Boat Count

June 19, 2008

	6-10:30 AM	11-1 AM/PM	1-4 PM	4-8 PM
Fishing		1		
Pontoon			1	2
Speedboat			1	1
Kayak				
Canoe				
Paddle boat				

Boat Count

July 4, 2008

	7-9 AM	10:30 AM	Noon	2:00 PM	3:30 PM	5:00 PM	6:30 PM	9:00 PM
Fishing	5	5	5	3			1	1
Pontoon		1		3	7	13	7	8
Speedboat				1	6	5	3	4
Kayak								
Canoe		1						
Paddle boat								1

Boat Count

July 15, 2008

	6-8 AM	10-12 Noo	1-4 PM	6-9 PM
Fishing	2	4		1
Pontoon		1	4	
Speedboat			3	
Kayak				
Canoe				
Paddle boat				

APPENDIX D:

Pretty Lake Public Meeting Documentation

Pretty Lake Diagnostic Study
Marshall County, Indiana

Pretty Lake Public Meeting

October 3, 2007

Sara Peel from JFNew presented to a meeting of the Pretty Lake Property Owners Association. There were 23 people in attendance at the meeting. The topics covered included:

1) LARE program overview
2) Diagnostic Study components
3) The watershed boundaries of Pretty Lake
4) Bathymetry of Pretty lake
5) Highly Erodible and Potentially Highly Erodible watershed soils
6) Watershed land use
7) Watershed Wetlands (NWI map)
8) Watershed soils and septic limitations
9) Historic water quality parameters from Pretty Lake
10) The schedule for the project

The concerns brought up at the meeting and within a survey that was passed out (attached) were:

1) Sediment is accumulating in the NW corner of the lake (brown water after heavy rains)
2) Water levels – residents are concerned that the lake level may be dropping
3) Impacts from boating (boats and motors are getting larger and disturbing more sediment on the bottom)
4) Eurasian watermilfoil
5) Runoff from the golf course (they were supposed to have switched to phosphorus free fertilizer)
6) Impact of new sewer system on lake levels (this water is no longer returned to the lake)
7) More development with bigger homes
8) Educational tools they can use.

The responses to the survey were minimal but in general can be summarized as:

1) The biggest concern is the incoming drainage on the north side of the lake
2) The second largest concern was weed control
3) The next two concerns were boating impacts and lake education of homeowners
4) Flooding used to be a problem but now the lake is lower than normal
5) Limiting the size and horsepower of boats should be considered
6) Water clarity is good but gets worse after heavy boating use
7) Water clarity is worse on the north and west shorelines after heavy use
8) A new fish study of the lake would be helpful to compare to the original study
9) Most people fish for Bass, crappie, bluegill, and catfish in that order
10) From this study we hope to be able to solve the drain pipe issue on the north side of the lake and gain knowledge about the lake help manage the weeds.

Pretty Lake Diagnostic Study
Introductory Meeting
October 3, 2007

The following are questions to consider regarding Pretty Lake. The questions are only meant to stimulate thought and generate conversation. We do not need to address each question at the meeting. Some may not be relevant to Pretty Lake. Additionally, residents will have differing opinions on the severity of different problems. Each opinion is important to us. Our (JFNew's) goal with this introductory meeting is to learn about Pretty Lake from those who spend the most time on it (you!) and understand your perceptions of the lake.

Miscellaneous:

1. What is the #1 problem on the lake?

2. What are problems #2-5?

3. Were there any historical problems that are no longer problems?

4. If you could change one thing about your lake, what would it be?

Water Clarity/Quality:

1. In your opinion, has Pretty Lake's water clarity been improving, declining, or stayed the same over the past several years? Do you have any thoughts on why it has been improving or declining?

2. Is the lake's water clarity worse at certain times of the year (i.e. summer, fall, spring)? After rain storms? After heavy boating use?

3. Is the water clarity worse in certain parts of the lake?

Fishing:

1. Has the fishing in Pretty Lake been improving, declining, or stayed the same over the past several years? Do you have any thoughts on why the change has occurred?

2. Has there been any recent stocking? What has the residents' response to stocking been?

3. What do most people fish for (in your opinion)?

Pretty Lake Public Meeting

June 17, 2009

John Richardson from JFNew attended the annual Property Owners meeting and presented the results of the Diagnostic Study.

Approximately 21 people were in attendance.

The concerns addressed at the meeting included:

1) Goose control
2) Boat access
3) Invasive species control
4) Water quality of the lake

The samples taken on June 11 prior to the meeting had not yet been analyzed so they could not be discussed at the meeting.

APPENDIX E:

Annotated Bibliography of Previous Pretty Lake Studies

Pretty Lake Diagnostic Study
Marshall County, Indiana

JFNew

Annotated bibliography of previous reports on Pretty Lake, Marshall County, Indiana
The historical reports below were utilized within the current study to present and compare data collected and conclusions drawn in previous report with the recent efforts.

Aquatic Control. February 19, 2007. Pretty Lake Aquatic Vegetation Management Plan 2007-2011. Prepared for Pretty Lake Association. Plymouth, Indiana. Aquatic control completed a LARE sponsored aquatic vegetation management plan in 2007, with a follow up report in 2008 and an updated addendum in early 2009. The surveys involved Tier 1 and Tier II surveys which occur in spring and late summer respectively. The primary species of concern within Pretty Lake was the invasive plant Eurasian watermilfoil. Curlyleaf pondweed was another invasive submergent present in Pretty Lake. Purple loosestrife (Lythrum salicaria), is an invasive emergent species that appears to be spreading along the northwest shore of Pretty Lake. A sonar treatment was applied in 2008 to eradicate EWM.

Robertson, B. 1968. Pretty Lake, Marshall County: Fish Management Report. Indiana Department of Natural Resources, Division of Fish and Wildlife. Indianapolis, Indiana. This 1968 survey was the first and only IDNR fish survey of Pretty Lake. The work was conducted by Rick Peterson but written up by Bob Robertson. They found a good population of game fish on the lake at the time but did not return for additional surveys due to lack of public access to the lake.

William Jones, Indiana University Clean Lakes Program
Mr. Jones has been conducting Clean Lakes Program (CLP) data collection on Indiana Lakes since 1989 under contract with IDEM. Most of Indiana's lakes are sampled on a five year rotation including Pretty Lake. The sampling includes total and dissolved phosphorus, all forms of nitrogen, plankton counts, temperature and dissolved oxygen, conductivity, pH, Secchi disk, and light transmission. Annual reports are issued summarizing the lake data from the lakes sampled and comparing the recent data to historical data. Pretty Lake was sampled in 1989, 1994, 1999, and 2004.

Wenino, Betty, 1997. Pretty Lake History. This document was produced by Ms. Wenino and serves as a great resource for the owners around Pretty Lake and historians. It is collection of verbal and written stories, property records and sketches of the lake, activities of various groups around the lake and more recently PLOA's meeting minutes. The time period of history the document addresses spans from the 1800's through 1995.

APPENDIX F:

Data Sheets

Pretty Lake Diagnostic Study
Marshall County, Indiana

JFNew

SHERRY LABORATORIES
1701 North Ironwood Road
South Bend Indiana 46635
574-277-0707

TESTING TODAY, PROTECTING TOMORROW

WWW.SHERRYLABS.COM
Fax: 574-273-5699

CLIENT: J.F. New & Associates
Lab Order: E09030052 **Date Received:** 3/9/2009
Project: Pretty Lake Trail **Date Reported:** *20-Mar-09*

Lab ID: E09030052-02 **Collection Date: 3/9/2009** **Sample ID: Field tile**

Matrix: STORMWATER

Analyses	Result		Detection Limit	Qual	Units	Date Analyzed	Analyst
ECOLI BACTERIA BY MEMBRANE FILTRATION		**M9222 D**					**SS**
E.Coli Bacteria, MF	3.00		1.00		ORG/100ml	3/9/2009	
NITRATE/NITRITE		**E353.2**					**sub**
Nitrogen, Nitrate-Nitrite	0.855		0.500		ppm	3/12/2009	
ORTHOPHOSPHATE (PO4) AS P IN WATER		**M4500-P E**					**sub**
Ortho-Phosphate	0.018		0.010		ppm	3/11/2009 8:00:00	
TOTAL PHOSPHORUS		**M4500-P E**					**sub**
Total Phosphorus	< 0.100		0.10		ppm	3/17/2009 11:40:00	
TOTAL KJELDAHL NITROGEN IN WW		**E351.2**					**sub**
Nitrogen, Kjeldahl, Total	1.04		0.800		ppm	3/13/2009	
TOTAL SUSPENDED SOLIDS		**M2540 D**					**MS**
Suspended Solids (Residue, Non-Filterable)	6		2		mg/L	3/10/2009	

Qualifiers:

ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
B - Analyte detected in the associated Method Blank
* - Value exceeds MCL or Permit Limitation
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
MI+ - Matrix Interference
H - Exceeds Holding Time

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SHERRY LABORATORIES
1701 North Ironwood Road
South Bend Indiana 46635
574-277-0707

TESTING TODAY, PROTECTING TOMORROW

WWW.SHERRYLABS.COM

Fax: 574-273-5699

CLIENT: J.F. New & Associates
Lab Order: E09030052
Project: Pretty Lake Trail

Date Received: 3/9/2009
Date Reported: *20-Mar-09*

Lab ID: E09030052-01 **Collection Date: 3/9/2009 11:00:00 AM** **Sample ID: Culvert Water**

Matrix: STORMWATER

Analyses	Result		Detection Limit	Qual	Units	Date Analyzed	Analyst
ECOLI BACTERIA BY MEMBRANE FILTRATION		**M9222 D**					**SS**
E.Coli Bacteria, MF	31.0		1.00		ORG/100ml	3/9/2009	
NITRATE/NITRITE		**E353.2**					**sub**
Nitrogen, Nitrate-Nitrite	0.850		0.500		ppm	3/12/2009	
ORTHOPHOSPHATE (PO4) AS P IN WATER		**M4500-P E**					**sub**
Ortho-Phosphate	0.021		0.010		ppm	3/11/2009 8:00:00	
TOTAL PHOSPHORUS		**M4500-P E**					**sub**
Total Phosphorus	0.14		0.10		ppm	3/17/2009 11:40:00	
TOTAL KJELDAHL NITROGEN IN WW		**E351.2**					**sub**
Nitrogen, Kjeldahl, Total	1.21		0.800		ppm	3/13/2009	
TOTAL SUSPENDED SOLIDS		**M2540 D**					**MS**
Suspended Solids (Residue, Non-Filterable)	2		2		mg/L	3/10/2009	

Qualifiers:

ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
B - Analyte detected in the associated Method Blank
* - Value exceeds MCL or Permit Limitation
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
MI+ - Matrix Interference
H - Exceeds Holding Time

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Laboratory Report

Customer: 0030471
J. F. New & Associates

Mailing Address:
J. F. New & Associates
Tom Estrem
708 Roosevelt Rd
Walkerton, IN 46574

Billing Address:
J. F. New & Associates
Tom Estrem
708 Roosevelt Rd
Walkerton, IN 46574

Sample: W165522
Pretty Lake-Tile
Desc Code: STUDY
Date Sampled: 6/11/2009 Time: 11:15 AM
Date Received: 6/11/2009 4:13:46 PM
Date Reported: 6/24/2009
P.O. Number:
PWS_ID:
Status: Reported

SHERRY LABORATORIES
TESTING TODAY, PROTECTING TOMORROW
Certifications: IN# M-43-01, IN# C-02-02
IN#C-18-02, IN# C-03-02
USDA Laboratory Code #: 3659
560 S. Zimmer Road - P.O. Box 1849
Warsaw, Indiana 46581-1849
Voice: 574-267-3305 / Fax:574-269-6569

Test Description *Reference Method:*	Result	MDL	Units	Lab Method # QC-If Applicable	Batch #	Date and Time	Analyst
Ammonia Nitrogen *Ref: E350.3 Ammonia Selective Electrode*	0.4	0.03	ppm	4500NH3F Comments:	125292	6/15/2009 12:00:00 PM	SL
E Coli *Ref: QT 9223B E Coli*	2060		/100	9223B Comments:	125175	6/11/2009 4:30:00 PM	JP
Kjeldahl Nitrogen *Ref: E351.4 Nitrogen Macro-Kjeldahl Method*	3.21	0.06	ppm	4500NORGB Comments:	125312	6/16/2009 12:00:00 PM	SL
Nitrate-Nitrite/N *Ref: 4500 NO3 D Nitrate Nitrogen Electrode Method*	10.9	0.5	ppm	353.2 Comments:	125254	6/15/2009 12:00:00 PM	SL
Phosphorus Ortho *Ref: 4500 P E Ascorbic Acid*	0.1	0.01	ppm	4500PE Comments:	125313	6/12/2009 4:15:00 PM	SL
Phosphorus Total *Ref: 4500 P B 5 E H2SO4-HNO3, Ascorbic Acid*	0.23	0.1	ppm	4500PB5E Comments:	125311	6/17/2009 11:00:00 AM	SL
Suspended Solids *Ref: 2540 D Total Suspended Solids Dried at 103 C*	77	2	ppm	2540D Comments:	125310	6/15/2009 12:00:00 PM	SL

A result of "ND" indicates None Detected. For bacteriological results "ND" indicates negative. Zeros to the right of the decimal point and/or to the right of a digit are not significant. ie: 10.00 = 10; 1.00 = 1; 1.10 = 1.1 MDL - Minimum Detection Level concentration reportable >0 with 99% confidence in an aqueous matrix.

All testing is conducted in accordance with the following regulations as applicable: 40 CFR Part 136, 40 CFR Part 261, or PL 91-597.

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Approved By: Keith R. Klemm

APPENDIX G:

Pretty Lake Fact Sheet

Pretty Lake Diagnostic Study
Marshall County, Indiana

Understanding Your Watershed:

- ★ Pretty Lake lies in the Headwaters of the Mississippi River Basin. Water flows from Pretty Lake east to the Yellow River and then southwesterly to the Kankakee River, the Illinois River and then the Mississippi River.
- ★ Pretty Lake receives water from overland flows around the lake and from a tile system that drains approximately 200 acres north of the lake.
- ★ The Pretty Lake drainage area (watershed) encompass 539 acres (0.84 square miles) within Marshall County, most of it north of the lake.
- ★ The watershed of Pretty Lake is 4.5 times the size of the lake, smaller than most Indiana Lakes.
- ★ Land use within the watershed is:

Crop Land	43%	Open water	18%
Grassland	22%	Wetland	3%
Forest	10%	Residential	4%

- ★ The Riddles-Metea-Wawasee soil association dominates the watershed. The soils developed on glacial till and are general loams or fine sandy loams with clay loams in the drainages and muck soils in the low ground.
- ★ 78% of the soils in the watershed are moderately or severely limited for use as septic tank absorption fields, however, Pretty Lake now has a sewer system around the lake.
- ★ About 50% of the soils in the Pretty Lake watershed are highly erodible or potentially highly erodible

.

- ★ While Marshall County supports five high quality Natural communities and 40 Rare, Threatened, or Endangered species of plants and animals, there are no records from the Pretty Lake watershed.

For additional information on how to keep your lakes and watershed clean and healthy contact:

Lake and River Enhancement Program
Indiana Department of Natural Resources
(IDNR) Division of Fish & Wildlife
402 West Washington Street Room W273
Indianapolis, Indiana 46204
(317) 233-3871
http://www.in.gov/dnr/fishwild/2364.htm

Marshall County SWCD
2903 Gary Drive
Plymouth, IN 46563-8889
(574) 936-2024 ext 3
http://marshallcountyswcd.iaswcd.org/

This pamphlet was produced by:

JFNew

708 Roosevelt Road
Walkerton, Indiana 46574
(574) 586-3400

If you have any questions regarding the study or pamphlet, please contact JFNew.

Pretty Lake Diagnostic Study

Marshall County, IN

The study purpose was:

- ★ **Evaluate historical trends in the lake's water quality**
- ★ **Describe the existing condition of the lake and its watershed**
- ★ **Identify problems and make recommendations to address these problems**

Pretty Lake Facts:

- ★ Pretty Lake is a 97 acre natural Lake with relatively stable water clarity between 13 & 23 feet since 1989.
- ★ The lake has trophic index scores well within the mesotrophic lake category; however phosphorus concentrations are tending toward eutrophic levels.
- ★ Water that flows into Pretty Lake stays an average of 3 years before exiting. This is referred to as "residence time". This is longer than most Indiana Lakes due to the low watershed to lake ratio.
- ★ Pretty Lake's low watershed area to lake area ratio (4.5:1) suggests actions taken in and adjacent to the lake affect the health of the lake more than actions in the watershed.
- ★ Pretty Lake has a maximum depth of 40 feet and an average depth of 21.7 feet.
- ★ Approximately 22% or about 21 acres of Pretty Lake is less then 5 feet deep and supports rooted aquatic vegetation.
- ★ The rooted vegetation includes a diverse population (19 species) found at a maximum depth of 23 feet.
- ★ Eurasian Water milfoil has recently been controlled and at least temporarily eliminated from Pretty lake.
- ★ Purple Loosestrife is the most aggressive non-native invasive plant remaining around Pretty lake.
- ★ Natural shoreline remains along 40% of the Pretty lake shoreline
- ★ Due to lack of adequate public access, Pretty Lake's only IDNR fish survey was conducted in 1968; 14 species were documented.
- ★ Pretty Lake supports a healthy population of panfish including bluegill, redear sunfish and warmouth.

How to Manage the Lakes:

Both in-lake and watershed management will be necessary to improve the lakes' water quality. Focus on personal actions and activities and how they might influence the lake.

Management Actions:

In-Lake Recommendations:

- ★ Monitor and control invasive species.
- ★ Keep motorboat speeds low in shallow areas to prevent churning up bottom sediments.

Watershed Recommendations:

- ★ Encourage the use of phosphorus free fertilizer on the golf course
- ★ Provide agricultural producers Best Management Practices to utilize on their farms.
- ★ Restore wetland or woodland habitat by removing drain tile within inactive fields.
- ★ Implement a nutrient and sediment filter on the tile drain to the lake

What You Can Do:

Pretty Lake's residents have substantial control over the health of their lake!

- ★ Use phosphorus-free fertilizer
- ★ Use only rock or native vegetation to protect shorelines from erosion
- ★ Keep lawn clippings, leaves, and animal waste out of the water
- ★ Keep boat speeds low
- ★ Harvest only the necessary and legal area (625 sq. ft. without a permit) of aquatic plants for your enjoyment of the lake.

APPENDIX H:

Additional Resources

Pretty Lake Diagnostic Study
Marshall County, Indiana

JFNew

ADDITIONAL RESOURCES

The following agencies have staff members that may be useful for questions you may have about your lake and watershed or the environment in general:

Contacts:

LARE Program
Kent Tracey or Doug Nusbaum
Indiana Department of Natural Resources
1353 S Governors Drive
Columbia City, IN 46725
phone: (260) 244-7470
Fax: (260) 244-7247
ktracey@dnr.in.gov

Limnology Professor
and volunteer lake monitor coordinator
William Jones
IU-SPEA
1315 E. 10th Street
Bloomington, Indiana 47405
(812) 855-4556
joneswi@indiana.edu

Wanda Norris –Adminstrator
Lorena Kline – Water quality technicianMarshall County Soil and Water Conservation District (SWCD)
2903 Gary Drive, Plymouth, IN, 46563
Ph. 574/936-2024 ext. 3

USDA-Natural Resource Conservation Service
Troy Manges – District Conservationist
2903 Gary Drive
Plymouth, IN 46563
574-936-2024

Kosciusko County SWCD
Hosier Riverwatch training
Marci Zolman
217 East Bell Drive
Warsaw, IN 46580-9362
(219) 267-7445

319 Grant program
Andrew Pelloso - IDEM
Office of Water Quality
100 N. Senate Ave. N1255
Indianapolis, IN 46204
(317) 233-8488
apelloso@idem.IN.gov

There are several cost-share grants available from both state and federal government agencies specific to watershed management. Community groups and/or Soil and Water Conservation Districts can apply for the majority of these grants. The main goal of these grants and other funding sources is to improve water quality though the use of specific BMPs. As public awareness shifts towards watershed management, these grants will become more and more competitive. Therefore, any association interested in improving water quality through the use of grants must become active soon. Once an association is recognized as a “watershed management activist” it will become easier to obtain these funds repeatedly. The following are some of the possible major funding sources available to lake and watershed associations for watershed management.

Lake and River Enhancement Program (LARE)

LARE is administered by the Indiana Department of Natural Resources, Division of Fish and Wildlife. The program's main goals are to control sediment and nutrient inputs to lakes and streams and prevent or reverse degradation from these inputs through the implementation of corrective measures. Under present policy, the LARE program may fund Diagnostic, feasibility, and design studies with a local cost share of 10%, watershed improvement construction projects with a local cost share of 25%, Aquatic Plant management Plans at 25%, an sediment removal plans at 50%. Aquatic plant treatments and dredging projects require a local cost share of 25%. LARE also has a "watershed land treatment" component that can provide grants to SWCDs for multi-year projects. The funds are available on a cost-sharing basis with landowners who implement various BMPs. All of the LARE programs are recommended as a project funding source for your lakes's watershed. More information about the LARE program can be found at: http://www.in.gov/dnr/fishwild/3302.htm

Clean Water Act Section 319 Nonpoint Source Pollution Management Grant

The 319 Grant Program is administered by the Indiana Department of Environmental Management (IDEM), Office of Water Management, Watershed Management Section. 319 is a federal grant made available by the Environmental Protection Agency (EPA). 319 grants fund projects that target nonpoint source water pollution. Nonpoint source pollution (NPS) refers to pollution originating from general sources rather than specific discharge points (Olem and Flock, 1990). Sediment, animal and human waste, nutrients, pesticides, and other chemicals resulting from land use activities such as mining, farming, logging, construction, and septic fields are considered NPS pollution. According to the EPA, NPS pollution is the number one contributor to water pollution in the United States. To qualify for funding, the water body must meet specific criteria such as being listed in the state's 305(b) report as a high priority water body or be identified by a diagnostic study as being impacted by NPS pollution. Funds can be requested for up to $300,000 for individual projects. There is a 40% cash or in-kind match requirement. To qualify for implementation projects, there must be a watershed management plan for the receiving waterbody. This plan must meet all of the current 319 requirements. This diagnostic study serves as an n excellent foundation for developing a watershed management plan since it satisfies several, but not all, of the 319 requirements for a watershed management plan. More information about the Section 319 program can be obtained from:
http://www.in.gov/idem/water/planbr/wsm/319main.html.

Section 104(b)(3) NPDES Related State Program Grants

Section 104(b)(3) of the Clean Water Act gives authority to a grant program called the National Pollutant Discharge Elimination System (NPDES) Related State Program Grants. These grants provide money for developing, implementing, and demonstrating new concepts or requirements that will improve the effectiveness of the NPDES permit program that regulates point source discharges of water pollution. Projects that qualify for Section 104(b)(3) grants involve water pollution sources and activities regulated by the NPDES program. The awarded amount can vary by project and there is a required 5% match. For more information on Section 104(b)(3) grants, please see the IDEM website at:
http://www.in.gov/idem/water/planbr/wsm/104main.html.

Section 205(j) Water Quality Management Planning Grants

Funds allocated by Section 205(j) of the Clean Water Act are granted for water quality management planning and design. Grants are given to municipal governments, county governments, regional planning commissions, and other public organizations for researching point and non-point source pollution problems and developing plans to deal with the problems. According to the IDEM Office of Water Quality website: "The Section 205(j) program provides for projects that gather and map information on non-point and point source water pollution, develop recommendations for increasing the involvement of environmental and civic organizations in watershed planning and implementation activities, and implement watershed management plans. No match is required. For more information on and 205(j) grants, please see the IDEM website at: http://www.in.gov/idem/water/planbr/wsm/205jmain.html.

Other Federal Grant Programs

The USDA and EPA award research and project initiation grants through the U.S. National Research Initiative Competitive Grants Program and the Agriculture in Concert with the Environment Program.

Watershed Protection and Flood Prevention Program

The Watershed Protection and Flood Prevention Program is funded by the U.S. Department of Agriculture and is administered by the Natural Resources Conservation Service. Funding targets a variety of watershed activities including watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in small watersheds (250,000 or fewer acres). The program covers 100% of flood prevention construction costs or 50% of construction costs for agricultural water management, recreational, or fish and wildlife projects.

Conservation Reserve Program

The Conservation Reserve Program (CRP) is funded by the USDA and administered by the Farm Service Agency (FSA). CRP is a voluntary, competitive program designed to encourage farmers to establish vegetation on their property in an effort to decrease erosion, improve water quality, or enhance wildlife habitat. The program targets farmed areas that have a high potential for degrading water quality under traditional agricultural practices or areas that might make good wildlife habitat if they were not farmed. Such areas include highly erodible land, riparian zones, and farmed wetlands. Currently, the program offers continuous sign-up for practices like grassed waterways and filter strips. Participants in the program receive cost share assistance for any plantings or construction as well as annual payments for any land set aside.

Wetlands Reserve Program

The Wetlands Reserve Program (WRP) is funded by the USDA and is administered by the NRCS. WRP is a subsection of the Conservation Reserve Program. This voluntary program provides funding for the restoration of wetlands on agricultural land. To qualify for the program, land must be restorable and suitable for wildlife benefits. This includes farmed wetlands, prior converted cropland, farmed wet pasture, farmland that has become a wetland as a result of flooding, riparian areas which link protected wetlands, and the land adjacent to protected wetlands that contribute to wetland functions and values. Landowners may place permanent or

30-year easements on land in the program. Landowners receive payment for these easement agreements. Restoration cost-share funds are also available. No match is required.

Grassland Reserve Program

The Grassland Reserve Program (GRP) is funded by the USDA and is administered by the NRCS. GRP is a voluntary program that provides funding the restoration or improvement of natural grasslands, rangelands, prairies or pastures. To qualify for the program the land must consist of at least a 40 acre contiguous tract of land, be restorable, and provide water quality or wildlife benefit. Landowners may enroll land in the Grassland Reserve Program for 10, 15, 20, or 30 years or enter their land into a 30-year permanent easement. Landowners receive payment of up to 75% of the annual grazing value. Restoration cost-share funds of up to 75% for restored or 90% for virgin grasslands are also available.

Community Forestry Grant Program

The U.S. Forest Service through the Indiana Department of Natural Resources Division of Forestry provides three forms of funding for communities under the Community Forestry Grant Program. Urban Forest Conservation Grants (UFCG) are designed to help communities develop long term programs to manage their urban forests. UFCG funds are provided to communities to improve and protect trees and other natural resources; projects that target program development, planning, and education are emphasized. Local municipalities, not-for-profit organizations, and state agencies can apply for $2,000-20,000 annually. The second type of Community Forestry Grant Program, the Arbor Day Grant Program, funds activities which promote Arbor Day efforts and the planting and care of urban trees. $500-1000 grants are generally awarded. The Tree Steward Program is an educational training program that involves six training sessions of three hours each. The program can be offered in any county in Indiana and covers a variety of tree care and planting topics. Generally, $500-1000 is available to assist communities in starting a county or regional Tree Steward Program. Each of these grants requires an equal match.

Forest Land Enhancement Program (FLEP)

FLEP replaces the former Forestry Incentive Program. It provides financial, technical, and educational assistance to the Indiana Department of Natural Resources Division of Forestry to assist private landowners in forestry management. Projects are designed to enhance timber production, fish and wildlife habitat, soil and water quality, wetland and recreational resources, and aesthetic value. FLEP projects include implementation of practices to protect and restore forest lands, control invasive species, and preserve aesthetic quality. Projects may also include reforestation, afforestation, or agroforestry practices. The IDNR Division of Forestry has not determined how they will implement this program; however, their website indicates that they are working to determine their implementation and funding procedures. More information can be found at http://www.in.gov/dnr/forestry.

Wildlife Habitat Incentive Program

The Wildlife Habitat Incentive Program (WHIP) is funded by the USDA and administered by the NRCS. This program provides support to landowners to develop and improve wildlife habitat on private lands. Support includes technical assistance as well cost sharing payments. Those lands already enrolled in WRP are not eligible for WHIP. The match is 25%.

Environmental Quality Incentives Program
The Environmental Quality Incentives Program (EQIP) is a voluntary program designed to provide assistance to producers to establish conservation practices in target areas where significant natural resource concerns exist. Eligible land includes cropland, rangeland, pasture, and forestland, and preference is given to applications which propose BMP installation that benefits wildlife. EQIP offers cost-share and technical assistance on tracts that are not eligible for continuous CRP enrollment. Certain BMPs receive up to 75% cost-share. In return, the producer agrees to withhold the land from production for five years. Practices that typically benefit wildlife include: grassed waterways, grass filter strips, conservation cover, tree planting, pasture and hay planting, and field borders. Best fertilizer and pesticide management practices, innovative approaches to enhance environmental investments like carbon sequestration or market-based credit trading, and groundwater and surface water conservation are also eligible for EQIP cost-share.

Small Watershed Rehabilitation Program
The Small Watershed Rehabilitation Program provides funding for rehabilitation of aging small watershed impoundments that have been constructed within the last 50 years. This program is newly funded through the 2002 Farm Bill and is currently under development. More information regarding this and other Farm Bill programs can be found at http://www.usda.gov/farmbill.

Farmland Protection Program
The Farmland Protection Program (FPP) provides funds to help purchase development rights in order to keep productive farmland in use. The goals of FPP are: to protect valuable, prime farmland from unruly urbanization and development; to preserve farmland for future generations; to support a way of life for rural communities; and to protect farmland for long-term food security.

Debt for Nature
Debt for Nature is a voluntary program that allows certain FSA borrowers to enter into 10-year, 30-year, or 50-year contracts to cancel a portion of their FSA debts in exchange for devoting eligible acreage to conservation, recreation, or wildlife practices. Eligible acreage includes: wetlands, highly erodible lands, streams and their riparian areas, endangered species or significant wildlife habitat, land in 100-year floodplains, areas of high water quality or scenic value, aquifer recharge zones, areas containing soil not suited for cultivation, and areas adjacent to or within administered conservation areas.

Partners for Fish and Wildlife Program
The Partners for Fish and Wildlife Program (PFWP) is funded and administered by the U.S. Department of the Interior through the U.S. Fish and Wildlife Service. The program provides technical and financial assistance to landowners interested in improving native habitat for fish and wildlife on their land. The program focuses on restoring wetlands, native grasslands, streams, riparian areas, and other habitats to natural conditions. The program requires a 10-year cooperative agreement and a 1:1 match.

North American Wetland Conservation Act Grant Program

The North American Wetland Conservation Act Grant Program (NAWCA) is funded and administered by the U.S. Department of Interior. This program provides support for projects that involve long-term conservation of wetland ecosystems and their inhabitants including waterfowl, migratory birds, fish, and other wildlife. The match for this program is on a 1:1 basis.

National Fish and Wildlife Foundation (NFWF)

The National Fish and Wildlife Foundation is administered by the U.S. Department of the Interior. The program promotes healthy fish and wildlife populations and supports efforts to invest in conservation and sustainable use of natural resources. The NFWF targets six priority areas which are wetland conservation, conservation education, fisheries, neotropical migratory bird conservation, conservation policy, and wildlife and habitat. The program requires a minimum of a 1:1 match. More information can be found at http://www.nfwf.org/about.htm.

Bring Back the Natives Grant Program

Bring Back the Natives Grant Program (BBNG) is a NFWF program that provides funds to restore damaged or degraded riverine habitats and the associated native aquatic species. Generally, BBNP supports on the ground habitat restoration projects that benefit native aquatic species within their historic range. Funding is jointly provided by a variety of federal organizations including the U.S. Fish and Wildlife Service, Bureau of Land Management, and U.S. Department of Agriculture and the National Fish and Wildlife Foundation. Typical projects include those that revise land management practices to remove the cause of habitat degradation, provide multiple specie benefit, include multiple project partners, and are innovative solutions that assist in the development of new technology. A 1:1 match is required; however, a 2:1 match is preferred. More information can be obtained from http://www.nfwf.org.

Native Plant Conservation Initiative

The Native Plant Conservation Initiative (NPCI) supplies funding for projects that protect, enhance, or restore native plant communities on public or private land. This NFWF program typically funds projects that protect and restore of natural resources, inform and educate the surrounding community, and assess current resources. The program provides nearly $450,000 in funding opportunities annually awarding grants ranging from $10,000-50,000 each. A 1:1 match is required for this grant. More information can be found at http://www.nfwf.org/programs/grant_apply.htm.

Freshwater Mussel Fund

The National Fish and Wildlife Foundation and the U.S. Fish and Wildlife Service fund the Freshwater Mussel Fund which provides funds to protect and enhance freshwater mussel resources. The program provides $100,000 in funding to approximately 5-10 applicants annually. More information can be found at http://www.nfwf.org/programs/grant_apply.htm.

Non-Profit Conservation Advocacy Group Grants

Various non-profit conservation advocacy groups provide funding for projects and land purchases that involve resource conservation. Ducks Unlimited and Pheasants Forever are two such organizations that dedicate millions of dollars per year to projects that promote and/or create wildlife habitat.

U.S. Environmental Protection Agency Environmental Education Program
The USEPA Environmental Education Program provides funding for state agencies, non-profit groups, schools, and universities to support environmental education programs and projects. The program grants nearly $200,000 for projects throughout Illinois, Indiana, Michigan, Minnesota, Wisconsin, and Ohio. More information is available at http://www.epa.gov/region5/ened/grants.html.

Core 4 Conservation Alliance Grants
Core 4 provides funding for public/private partnerships working toward Better Soil, Cleaner Water, Greater Profits and a Brighter Future. Partnerships must consist of agricultural producers or citizens teaming with government representatives, academic institutions, local associations, or area businesses. CTIC provides grants of up to $2,500 to facilitate organizational or business plan development, assist with listserve or website development, share alliance successes through CTIC publications and other national media outlets, provide Core 4 Conservation promotional materials, and develop speakers list for local and regional use. More information on Core 4 Conservation Alliance grants can be found at http://www.ctic.purdue.edu/CTIC/GrantApplication.pdf.

Indianapolis Power and Light Company (IPALCO) Golden Eagle Environmental Grant
The IPALCO Golden Eagle Grant awards grants of up to $10,000 to projects that seek improve, preserve, and protect the environment and natural resources in the state of Indiana. The award is granted to approximately 10 environmental education or restoration projects each year. Deadline for funding is typically in January. More information is available at http://www.ipalco.com/ABOUTIPALCO/Environment/Golden_Eagle.html

Nina Mason Pulliam Charitable Trust (NMPCT)
The NMPCT awards various dollar amounts to projects that help people in need, protect the environment, and enrich community life. Prioritization is given to projects in the greater Phoenix, AZ and Indianapolis, IN areas, with secondary priority being assigned to projects throughout Arizona and Indiana. The trust awarded nearly $20,000,000 in funds in the year 2000. More information is available at www.nmpct.org