Four Township Recreational Carrying Capacity Study

Pine Lake
Upper Crooked Lake
Gull Lake
Sherman Lake

Prepared for:
Four Township Water Resources Council, Inc.
The Townships of Prairieville, Barry, Richland, and Ross

Prepared by:
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May 2001

Project No: 51830106

ProgressiveAE

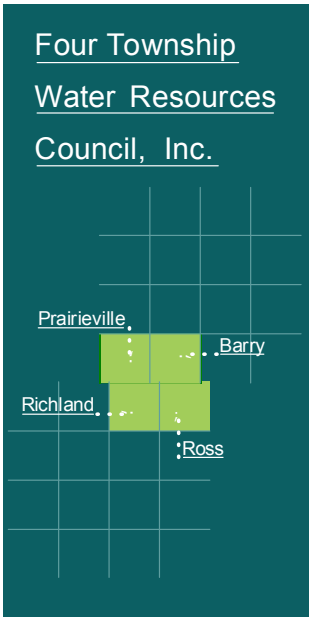

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Table of Contents

List of Tables

List of Figures

Introduction

Lakes are a finite resource with seemingly unlimited demand. As more development occurs around lakes and more lakeside cottages are converted from seasonal to year-round use, boating and other recreational activities on area lakes can be expected to increase accordingly. This fact, coupled with the tremendous increase in the number, size, and speed of today's watercraft, has brought the issue of lake access and overcrowding to the forefront in many communities.

The Four Township Water Resources Council is a volunteer, non-profit group dedicated to protecting water quality in Barry and Prairieville Townships in Barry County and Richland and Ross Townships in Kalamazoo County. The Council's mission is to *assist with the development and implementation of land use strategies that retain the rural environment currently enjoyed by township residents, protecting lakes, streams, drinking water, agriculture, and open space*. In 1998, the Council received a U.S. Environmental Protection Agency nonpoint source pollution control grant under Section 319 of the Federal Clean Water Act to implement the Four Township Water Resources Project. A component of the project is the issue of lake access and overcrowding, which this report will address.

One way to address lake access and overcrowding is to evaluate a lake's recreational carrying capacity. For the purposes of this report, recreational carrying capacity refers to the number of boats that can be operated on a lake without compromising safe recreational use, aesthetic enjoyment, and/or environmental quality. As part of the Four Township Water Resources Project, a recreational carrying capacity study was conducted on Pine Lake, Upper Crooked Lake, Gull Lake, and Sherman Lake (Figure 1). This study is proposed to be used as a guide to assist local governmental decision makers in formulating policies and regulations to help prevent overuse and environmental degradation of Four Township area lakes.

The Concept of Recreational Carrying Capacity

It should be recognized at the onset that the concept of recreational carrying capacity is as much perception as science (Mahoney and Stynes 1995). Although research shows that a higher density of boats increases the potential for negative impacts, there have been no conclusive studies that answer the question: How many boats is too many? (Wagner 1991). Each lake is different, and various lake users will have different perspectives on what constitutes congestion. Thus, there is no single boating density standard that will satisfy all lake users in all situations.

In light of these considerations, a recreational carrying capacity study should not be used as the sole determining factor limiting lake use or access. Rather, a recreational carrying capacity analysis should be used as a tool to evaluate the range of options that are available to help minimize multi-use conflicts, environmental concerns, and other problems associated with lake overcrowding. A recreational carrying capacity study can establish a framework for decision making and provide a basis for regulatory action.

At its core, the concept of recreational carrying capacity appears simplistic. The area of the lake that is suitable for boating is divided by the desired boating density. For example, if a lake is 100 acres, and the desired boat density is ten acres per boat, then the recreational carrying capacity would be a maximum of ten boats:

$$100 \text{ acres} \div 10 \text{ acres per boat} = 10 \text{ boats}$$

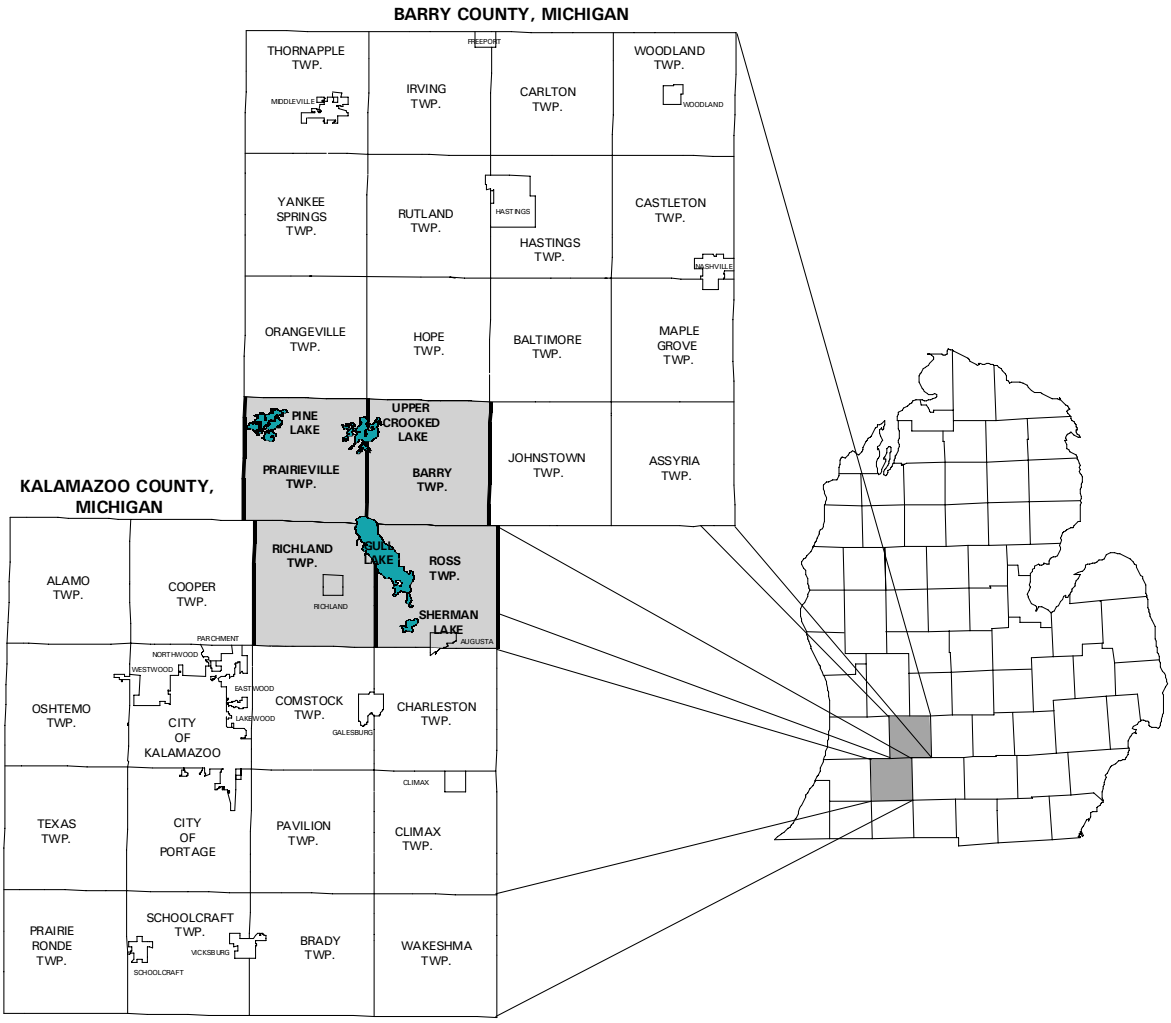

FIGURE 1
PROJECT LOCATION MAP

PRAIRIEVILLE AND BARRY TOWNSHIPS, BARRY COUNTY
RICHLAND AND ROSS TOWNSHIPS, KALAMAZOO COUNTY

N
No Scale

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However, in estimating recreational carrying capacity, a number of factors need to be considered. Key factors that should be evaluated include lake physical characteristics, use characteristics (i.e., the number of lakeside homes, moored boats, the number and type of access sites, and current boating activity), environmental impacts, useable lake area, boating density, and lake use rate. These factors are discussed in more detail in the body of the report.

Lake Physical Characteristics

Lake size, shape, and depth strongly influence recreational carrying capacity. As part of the study, an evaluation of the physical characteristics of each of the four study lakes was conducted (Table 1). Depth contour maps of each of the lakes are provided in Figure 2.

TABLE 1

FOUR TOWNSHIP STUDY LAKES PHYSICAL CHARACTERISTICS[1]

	Pine	Upper Crooked	Gull	Sherman
Lake Surface Area (acres)	660	645	2,047	153
Maximum Depth (feet)	34	48	110	36
Mean Depth (feet)	10.4	10.1	41.1	14.8
Lake Volume (acre-feet)	6,892	6,493	84.068	2,270
Shoreline Length (miles)	12.1	13.8	13.4	2.9
Shoreline Development Factor	3.4	3.9	2.1	1.7
Lake Elevation (feet)	892	924	880	851

With a surface area of 2,047 acres and maximum depth of 110 feet, Gull Lake is the largest and deepest of the study lakes. Gull Lake contains a volume of water more than five times the volume of the other three lakes combined. Although Sherman Lake has the smallest surface area, its mean or average depth is second only to Gull Lake.

Shoreline development factor is a measure of the degree of irregularity in the shape of the shoreline. A perfectly round lake would have a shoreline development factor of 1.0. The higher the shoreline development factor, the more convoluted the shoreline. Upper Crooked Lake and Pine Lake, with shoreline development factors of 3.9 and 3.4, respectively, have the potential to support more shoreland development per unit area of lake surface. In a study which assessed the impact of motorized watercraft on lakes, Wagner (1991) noted:

> The ratio of the length of shoreline around the lake to the circumference of a circle with the same area as the lake [shoreline development factor] provides a size-independent measure of lake shape and indicates much about how motorized watercraft could affect the water body. Higher ratios suggest irregular shorelines with more waterfront per unit area than smaller ratios. Numerous coves may serve to isolate impacts, but there is a greater potential for the shoreline to be affected. High ratios also imply greater safety risks as well as ecological consequences.

Use Characteristics

All of the study lakes provide fishing, boating, swimming and other recreational opportunities to both lake residents and the general public. The study lakes are all located within a 35-mile driving radius of the cities of Kalamazoo, Grand Rapids, and Battle Creek. Gull Lake is known state-wide for its exceptional cold and warm water fishery and sailing opportunities. In recent years, many of the orig-

[1] Shoreline length, lake elevation, and lake surface area were determined by examining a United States Geological Survey topographic map of the Four Township area (scale: 1″ = 2000′). Lake volume and maximum and mean depths were derived from Michigan Conservation Department depth contour maps of Gull, Pine, and Upper Crooked Lakes and a Michigan Department of Natural Resources depth contour map of Sherman Lake. Lake volume and shoreline development were calculated according to Lind (1974) using shoreline and contour areas derived from Microstation computer-aided design mapping.

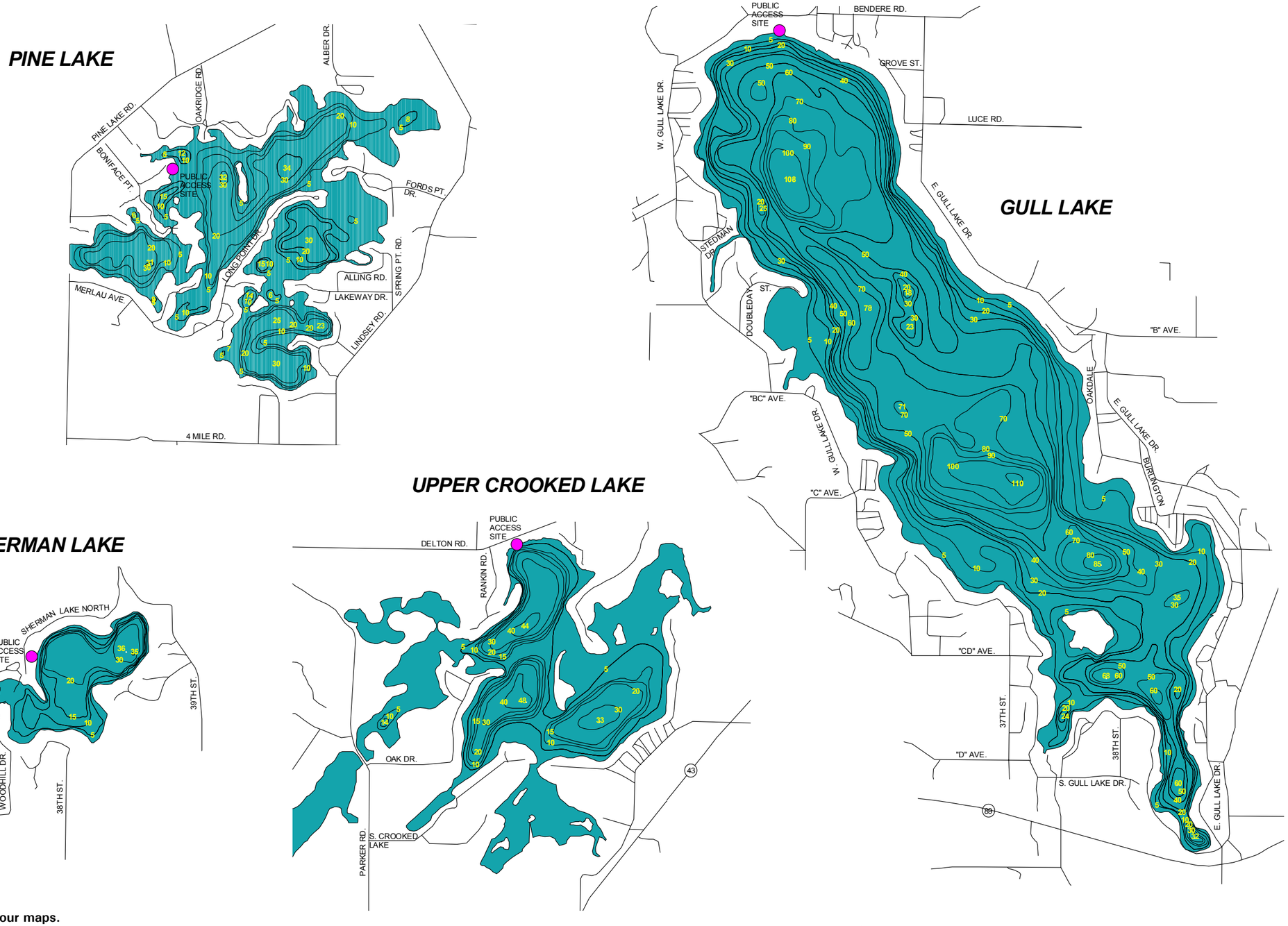

Figure 2. Lake depth contour maps.

inal seasonal cottages around the lakes were converted to year-round occupancy. Concurrent with this increase in residential occupancy, the number of boats appears to be on the rise as well. Boating registration statistics from the Michigan Secretary of State indicate that between 1978 and 1999, the number of boat registrations in Michigan increased by nearly 34% from 615,069 to 825,842.

To evaluate use characteristics on each of the lakes, field surveys were conducted to count the number of moored boats, lakeside homes, marinas, and other facilities. The numbers of the various types of boats moored on each of the lakes were tabulated individually. Moored boats included boats beached along the shore. Field count data are presented in Table 2 and Table 3 and moored boat data are shown in Figures 3 and 4.

TABLE 2
BUILDING COUNT DATA[1]

Lake	Houses	Marinas	Trailers	Other Buildings[2]	Total
Pine	545	2	30	1	578
Upper Crooked	250	1	27	1	279
Gull	719	8	0	2	729
Sherman	95	0	0	1	96

TABLE 3
BOAT COUNT DATA[3]

	Pine		Upper Crooked		Gull		Sherman	
Boats with Motors Greater Than 25 HP	389	36%	165	38%	961	58%	50	27%
Boats with Motors Less Than or Equal to 25 HP	200	18%	53	12%	48	3%	25	14%
Personal Watercraft	98	9%	30	7%	198	12%	6	3%
Sailboats	12	1%	11	2%	223	13%	11	6%
Non-Motorized Boats[4]	397	36%	178	41%	232	14%	92	50%
Total	1,096	100%	437	100%	1,662	100%	184	100%

[1] House counts were conducted on June 5, 2000, on Pine Lake and on June 29, 2000, on Upper Crooked Lake, Gull Lake, and Sherman Lake.

[2] Other buildings include the Michigan Career and Technical Institute on Pine Lake, the store on Upper Crooked Lake, MSU Kellogg Biological Station and the Bible Conference Fellowship Center on Gull Lake, and the YMCA Sherman Lake Outdoor Center on Sherman Lake.

[3] Boat counts on Sherman Lake, Upper Crooked Lake, and Pine Lake were conducted on June 29, 2000. The Boat count on Gull Lake was conducted on July 11, 2000.

[4] Non-motorized boats includes canoes, row boats, paddle boats, and other non-motorized watercraft, excluding sailboats.

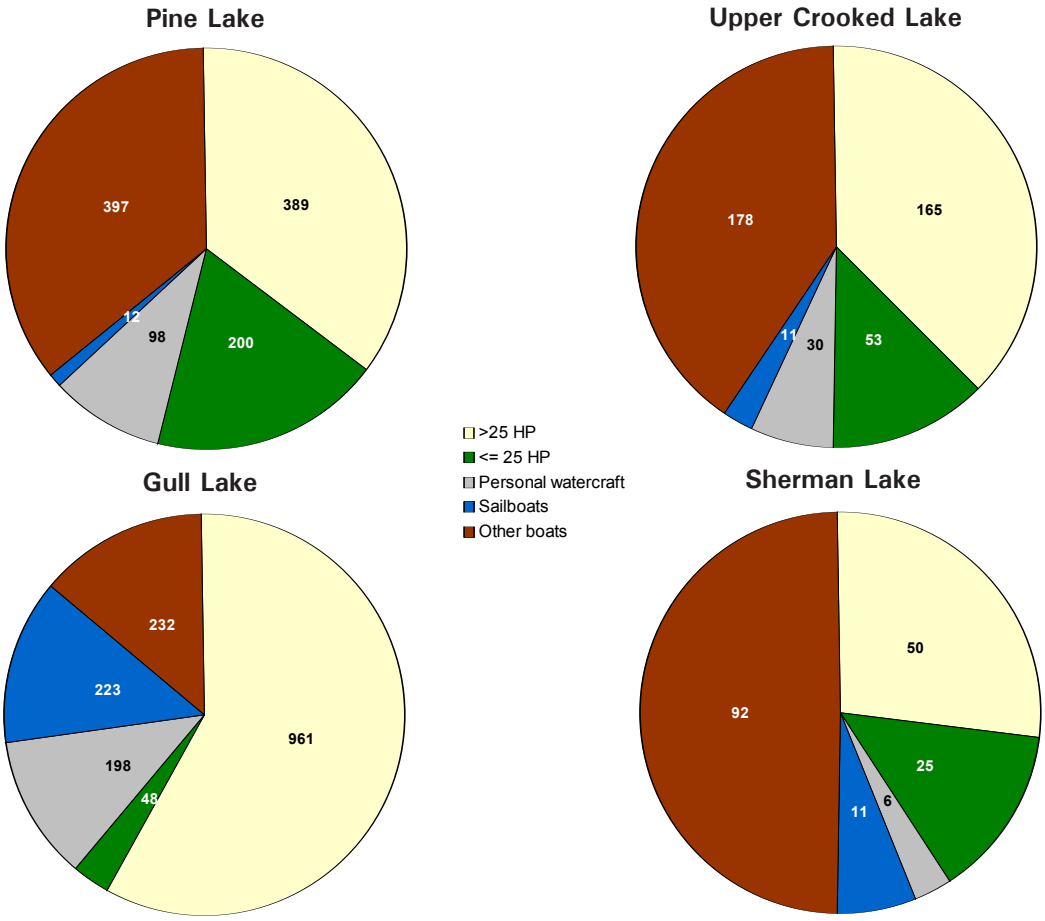

Figure 3. Moored boat counts (pie charts).

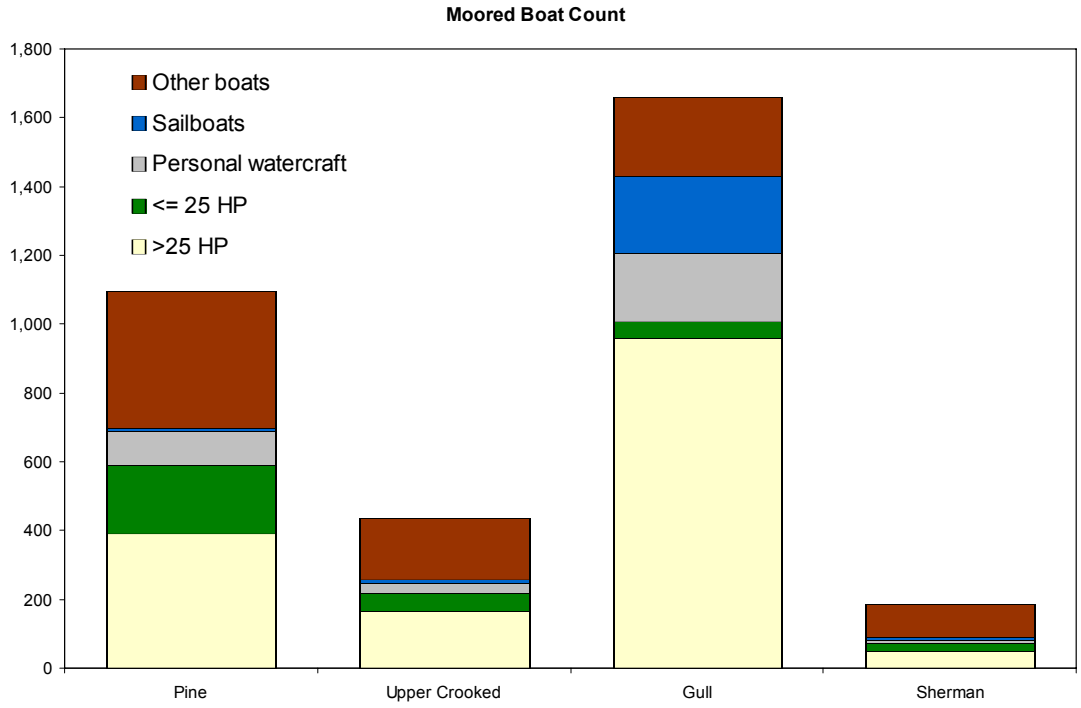

Figure 4. Moored boat counts (bar graph).

The average number of boats per household was estimated for each lake by deducting the number of boats moored at marina facilities and dividing the remaining riparian boats by the number of houses and trailers (Table 4). Most of the shoreline of each of the lakes has been developed for single-family residential use (Figure 5). Exceptions include the southeast shore of Sherman Lake where the YMCA Sherman Lake Outdoor Center is located, the Michigan State University Kellogg Biological Station on the east shore of Gull Lake, the Michigan Technical and Career Center on the northeast shore of Pine Lake, and portions of Pine Lake and Upper Crooked Lake where emergent wetlands exist.

TABLE 4
CURRENT NUMBER OF BOATS PER HOUSEHOLD

Lake	Average Number of Boats per Household
Pine	1.9
Upper Crooked	1.5
Gull	2.0
Sherman	1.9

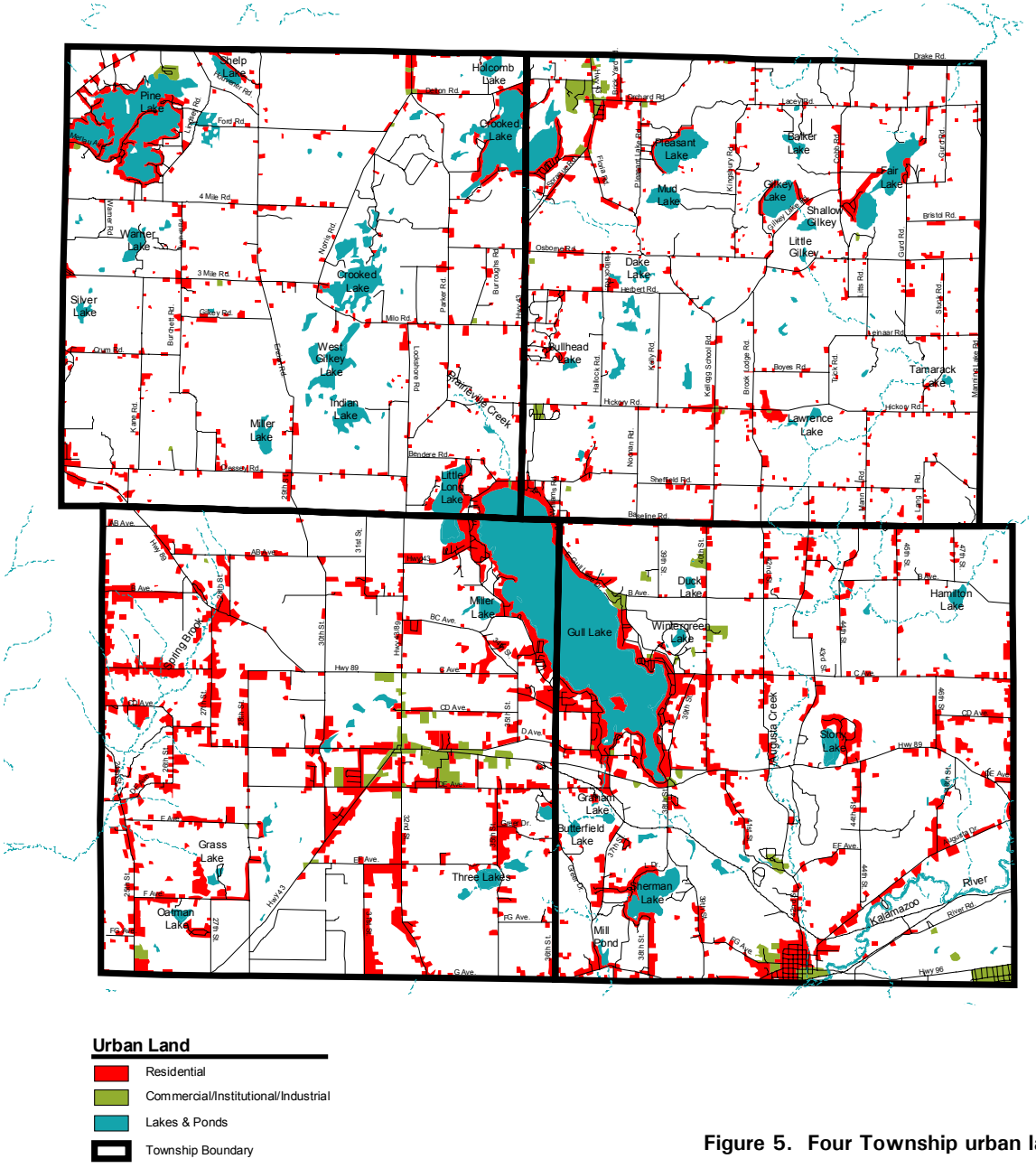

Figure 5. Four Township urban land map.

Gull Lake had the greatest number of shoreline buildings (729) and moored boats (1,662), and Sherman Lake had the least (96 shoreline buildings and 184 moored boats). Michigan Department of Environmental Quality (MDEQ) records indicate that as of August 2000, 12 marina-operating permits with a total of 182 boat slips on Gull Lake were pending or issued. (Marina operating permits must be renewed by the MDEQ every three years). MDEQ records listed one marina on Upper Crooked Lake with 12 boat slips and one marina on Pine Lake with no boat slips.

Motor boats greater than 25 horsepower and sailboats were most prevalent on Gull Lake while non-motorized boats were more prevalent on Pine Lake, Upper Crooked Lake, and Sherman Lake. Personal watercraft were most common on Gull Lake; however, personal watercraft account for only 12 percent or less of the boats on all the lakes. Gull Lake's size and expansive area of open water make it more conducive to sailing and high-speed boating activities. In 1999 and 2000, the Department of Natural Resources issued permits for sailboat races on Gull Lake on 51 dates each year. In contrast, the smaller surface areas of Pine Lake, Upper Crooked Lake, and Sherman Lake are less conducive to sail boating and support more small motorized and non-motorized boat usage. Although, by virtue of its size, Gull Lake has the ability to accommodate the greatest overall number of boats, a majority of lake residents responding to a recent survey conducted by the Gull Lake Quality Organization indicated boating activity on Gull Lake has become excessive. The vast majority of survey respondents indicated that boating traffic has increased and that boats have become larger, faster, and noisier over time.

Public access facilities exist on each of the study lakes. For a small fee, access to Gull Lake is provided through Prairieville Township Park at the north end of the lake. A 1983 circuit court consent judgement limited parking for cars with trailers to 70. In addition to Prairieville Township Park, limited access can be obtained off Baseline Road at the northeast end of Gull Lake.

Pine Lake has a public access site operated by the Prairieville Township Parks and Recreation Department, and Upper Crooked Lake and Sherman Lake each have Michigan Department of Natural Resources public access sites. Access to the lakes from these sites is somewhat limited by the availability of parking spaces to about 10 spaces on Pine Lake, 18 on Upper Crooked Lake, and 30 on Sherman Lake. (Figure 6).

Figure 6. Sherman Lake public access site.

In addition to the counts of moored boats, aerial fly-overs of each lake were conducted on Saturday, July 15, 2000, and Saturday, August 26, 2000, to estimate the total number of boats utilizing the lakes at these times. The number of boats launched from the public access sites versus riparian (i.e., lakefront properties) boats on the lakes was estimated by counting the number of vehicles with trailers at the various public access sites at the time of the fly-overs (Table 5). The flight on July 15th was conducted in the afternoon between 2 p.m. and 3 p.m. The weather on this date was partly sunny and the temperature was in the upper 70's. The second flight on August 26th was con-

ducted in late morning between 11 a.m. and noon. The weather on this date was overcast, with a trace of rain and temperatures in the upper 70's. With the exception of Pine Lake where most of the boats observed on the lake were riparian, about half of the boats observed on the other lakes at the time of the aerial fly-overs were from the public access sites. Public access utilization and the percent of riparian boats observed on the lakes during the fly-overs are presented in Table 6. It should be noted that the aerial fly-over data represents only a limited glimpse of use characteristics on each of the four lakes. Data compiled by the National Oceanographic and Atmospheric Administration indicates that temperatures in both July and August of 2000 were relatively cool. This fact, coupled with escalating fuel costs, may have contributed to less intensive use of the lakes than would normally occur during warmer weather. Based on field data collected from other lakes, it appears that the number of riparian boats normally in use on the lakes during peak use periods would be substantially greater than observed during the limited aerial fly-overs (Progressive Architecture Engineering 2001, Warbach *et al.* 1994, Threinen 1964).

TABLE 5
AERIAL FLY-OVER DATA

Lake	Date	Total Boats Counted On Lakes	Estimated Number of Boats Launched From Access Sites	Estimated Number of Riparian Boats on Lakes	Percentage of Public Access Boats On Lakes	Percentage of Riparian Boats on Lakes
Pine	7-15-00	42	7	35	16%	84%
Upper Crooked	7-15-00	9	5	4	56%	44%
Gull	7-15-00	116	66	50	57%	43%
Sherman	7-15-00	13	8	5	62%	38%
Pine	8-26-00	27	5	22	19%	81%
Upper Crooked	8-26-00	14	9	5	64%	36%
Gull	8-26-00	41	19	22	46%	54%
Sherman	8-26-00	11	6	5	55%	45%

Figure 7. Prairieville Township Park (July 15, 2000).

TABLE 6
PERCENT PUBLIC ACCESS AND RIPARIAN BOAT UTILIZATION

Lake	Date	Percent of Total Moored Boats In Use	Percent Utilization Of Public Access Sites
Pine	7-15-00	3%	70%
Upper Crooked	7-15-00	1%	28%
Gull	7-15-00	3%	94%
Sherman	7-15-00	3%	26%
Pine	8-26-00	2%	50%
Upper Crooked	8-26-00	1%	50%
Gull	8-26-00	1%	27%
Sherman	8-26-00	3%	20%

Environmental Impacts

Several studies have been conducted to evaluate environmental impacts associated with boating (Bouchard 2000, Warrington 1999, Asplund and Cook 1997, Asplund 1996, Wagner 1991). Environmental impacts most commonly associated with boating activity include fuel emissions from boat motors, suspension of bottom sediments, decreased water transparency, shoreline erosion, destruction of fish spawning areas, and loss of valuable fish and wildlife habitat.

Although fuel emissions from motor boats are often cited as major sources of pollution, recent technological advances have greatly reduced pollution inputs associated with outboard motor discharges. Wagner (1991) noted:

> Until the mid-1970s, two-cycle outboard engines were considered to be inefficient users of fuel and major contributors to water pollution. . . The fuel crisis in the 1970s and increasing environmental awareness resulted in a number of engineering advances that greatly reduced the discharge of fuel; recycling of fuel that accumulated in the crankcase became a standard feature in 1972. . . Fuel waste is typically less than 1 percent in a well-tuned modern engine.

Most hydrocarbons in outboard motor exhaust are biodegradable and many components of gasoline volatilize and evaporate rapidly (Bouchard 2000, Warrington 1999). In a study of the impacts of outboard motors conducted on lakes in British Columbia, Warrington (1999) found that there are few well-designed studies that have measured the effect of outboard exhaust on water quality and aquatic organisms. However, he tentatively concluded that there does not appear to be a significant detrimental effect on most aquatic organisms at normal recreational use levels. Warrington also observed that there is no evidence to suggest that lead from fuel was a serious problem for fish or other aquatic life under normal boating activity levels. Warrington further concluded that outboard motor use has not been shown to cause significant hydrocarbon pollution of the bulk water column. However, in localized areas of heavy boating traffic, such as marinas, the impacts of fuel emissions on the aquatic environment may be more pronounced (Warrington 1999, Wagner 1991). Bouchard (2000) concluded that acute (short term) toxicity from outboard exhaust was probably not a problem in most lakes, but chronic (long term) exposure of sensitive aquatic organisms to outboard exhaust is harmful.

In addition to fuel emissions, other environmental impacts associated with boating activity will vary widely depending on a number of factors such as lake size, depth, and level of boat use. In general, the shallower portions of lakes (i.e., areas less than 5 feet deep) are most susceptible to adverse environmental impacts associated with motor boat activities (Wagner 1991). This is especially true with regards to sediment resuspension, reduced water transparency, and impacts to fish and wildlife habitat. Wagner (1991) observed that the shallowness ratio, which compares the area of the lake less than 5 feet deep to the total lake area, is indicative of the lake bottom area likely to be directly affected by motorized watercraft. Shallowness ratios range from low (<0.10) for lakes unlikely to be impacted to high (>0.50) for lakes with a high potential for impact. Shallowness ratios for the study lakes are presented in Table 7. These data indicate that, due to the extent of shallow area, Pine Lake and Upper Crooked Lake will be more prone to environmental impacts from motor boat activity.

TABLE 7
LAKE SHALLOWNESS RATIOS

Lake	Total Lake Area (Acres)	Lake Area Less Than Five Feet Deep (Acres)	Shallowness Ratio
Pine	660	284	0.43
Upper Crooked	645	361	0.56
Gull	2,047	203	0.10
Sherman	153	28	0.18

A recent study of the effects of motor boats on aquatic plants concluded that motor boat activity significantly affects plant biomass, primarily through scouring of the sediment substrate and direct cutting (Asplund and Cook 1997). While most plant biomass is reduced by motor boat activities (Asplund and Cook 1997), some plants, particularly Eurasian milfoil (*Myriophyllum spicatum*), may spread by cutting. The spread of the exotic, nuisance plant species Eurasian milfoil is a concern on each of the study lakes. Eurasian milfoil has the ability to spread rapidly by vegetative propagation (small fragments of the plant break off, take root, and form new plants). This plant has the tendency to form a thick canopy at the lake surface that interferes with recreational utilization and shades out more desirable native plant species (Figure 8). Fragmentation and the spread of Eurasian milfoil can be greatly accelerated due to the "prop-chop" action of motor boats (Johnstone *et al.* 1985). Eurasian milfoil was observed in all the study lakes during the course of study and, in a recent survey of Pine Lake, over 100 acres were found to be infested with Eurasian milfoil (Progressive Architecture Engineering 2000).

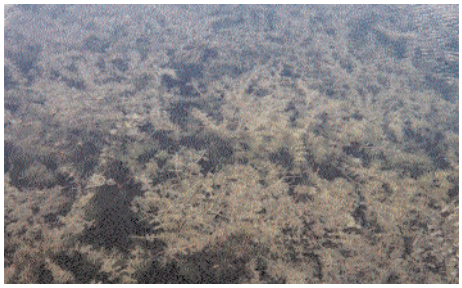

Figure 8. Eurasian Milfoil.

Impacts of motor boat activity will vary widely between lake systems. Direct environmental impacts associated with motor boat activity are often subtle and difficult to discern and measure quantitatively (Asplund 1996, Wagner 1991). Of the study lakes, the south end of Gull Lake, where a majority of the existing marina facilities are located, may be most prone to environmental degradation from exposure to hydrocarbons (Figure 9). Motor boat activity may also promote the spread of Eurasian milfoil in all the study lakes.

Figure 9. Gull Lake marina facilities (August 26, 2000).

Useable Lake Area

For every lake, there are portions of the lake where boating activity can create safety problems. Therefore, these areas should be subtracted from the total lake area and the remaining "useable lake area" should be retained for the carrying capacity calculation. In accordance with Part 801, Marine Safety, of the Natural Resources and Environmental Protection Act (PA 451 of 1994):

> A person shall not operate a motorboat on the waters of this state at a speed greater than slow no-wake speed or the minimum speed necessary for the motorboat to maintain forward movement *when within 100 feet of the shoreline where the water depth is less than 3 feet*, as determined by vertical measurement, except in navigable channels not otherwise posted (Section 80146 (3); emphasis added).
>
> Persons operating vessels on the waters of this state . . . *shall maintain a distance of 100 feet from any dock, raft, buoyed or occupied bathing area, or vessel moored or at anchor*, except when the vessel is proceeding at a slow-no wake speed or when water skiers are being picked up or dropped off . . . (Section 80149; emphasis added).

Pine Lake also has supplemental special watercraft controls adopted under Part 801 that require slow-no wake speed be maintained in all connecting channels and canals.

In addition to the state mandate that restricts high-speed boating activity in some shallow water and near-shore areas, periodic low water levels on Pine, Upper Crooked, and, to a lesser extent, Sherman Lake, directly impact navigability by reducing the areas of these lakes suitable for boating. Water level fluctuations of up to six feet have been documented in Pine Lake (Progressive Architecture

Engineering Planning 1996). Thus, during periods of low lake level, the useable lake area of each of these lakes may be reduced significantly.

In light of these considerations and the fact that most environmental problems associated with motor boating activity occur in shallow waters, a minimum width of 100 feet from the shoreline on each of the study lakes is recommended as a shoreline safety/environmental protection zone. These portions of the lakes would be excluded from the useable lake area for carrying capacity calculations. The remaining portion of the lakes would be suitable for boating activity and would constitute the useable lake area (Table 8).

TABLE 8
USEABLE LAKE AREA

Lake	Lake Area (Acres)	100-Foot-Wide Shoreline Safety/Environmental Protection Zone (Acres)	Useable Lake Area (Acres)
Pine	660	147	513
Upper Crooked	645	167	478
Gull	2,047	162	1,885
Sherman	153	35	118

Boating Density

Different types of boats have different spatial requirements. Despite widespread interest in lake carrying capacity, there have been very few scientific studies to determine optimum boating density (i.e., the number of acres of water surface required per boat). Most reported figures are based on the authors' personal opinions, though many may be considered expert (Table 9).

TABLE 9
SUMMARY OF OPTIMUM BOATING DENSITIES

Source	Suggested Density	Boating Uses
Ashton (1971)	5 to 9 acres/boat	All uses combined in Cass Lake
	4 to 9 acres/boat	All uses combined in Orchard Lake
	6 to 11 acres/boat	All uses combined in Union Lake
Kusler (1972)	40 acres/boat	Waterskiing - All uses combined
	20 acres/boat	Waterskiing
	15 acres/boat	Coordinated waterskiing
Jaakson *et al.* (1989)	20 acres/boat	Waterskiing and motorboat cruising
	10 acres/boat	Fishing
	8 acres/boat	Canoeing, kayaking, sailing
	10 acres/boat	All uses combined
Wagner (1991)	25 acres/boat	All recreational activities
Warbach *et al.* (1994)	30 acres/boat	All motorized (>5 HP) uses

In a study of carrying capacity controls for recreational water uses, Kusler (1972) noted:

> Water resource groups throughout the nation have prepared water space demand estimates for water sport uses based upon complex assumptions concerning acceptable limits for intrasport and intersport activity. However, these estimates vary widely and much work needs to be done to determine space demands of a particular use in isolation, or in combination with other uses, under particular conditions. For example, water skiing may require 40 acres per boat if the boat must run a complicated course around swimmers, power boaters, sailing craft, fisherman, and other ski craft moving at cross directions. However, only 20 acres of water might be required if other uses were excluded from the ski area. And perhaps only 15 acres would be needed if all ski boats were to move in the same direction, thereby preventing course conflicts.

In a study of carrying capacity and lake user attitudes for Cass, Orchard, and Union Lakes in Oakland County, Michigan, Ashton (1971) determined optimum boating density ranges of 5 to 9 acres per boat, 4 to 9 acres per boat, and 6 to 11 acres per boat for the three lakes, respectively. Jaakson *et al*. (1989) studied three lakes in north-central Saskatchewan and determined the following boating densities: 20 acres each for motorboat cruising and water skiing; 10 acres for fishing (from a boat); and 8 acres each for canoeing, kayaking, and sailing. Jaakson *et al*. (1989) assumed an average of 10 acres per boat for acceptable safe boating. Wagner (1991) reported that, based on the viewpoints of many boaters, one boat per 25 acres of water surface is considered sufficient for all recreational boating activities (racing, fishing, skiing). Racers and water skiers feel restricted at less that 10 acres per boat and nearly all motorized watercraft users feel crowded at less than 5 acres per boat. Warbach *et al*. (1994), concluded that approximately 30 acres per motor boat (greater than five horsepower) is an appropriate boat density.

In recent years, increased use of personal watercraft has raised safety concerns statewide. The rate of injuries attributed to the use of personal watercraft was about 8.5 times higher than those from motorboats (Branche *et al.* 1997).

Based on these various criteria and considerations, 10 to 15 acres of water surface per boat is recommended as a conservative, aggregate density for all types of boating activities. A boating density greater than 10 to 15 acres per boat would create a potential for safety problems, multi-use conflicts, or environmental degradation. This would be especially true for high-speed boating activities such as water skiing or personal watercraft operation.

In assigning optimum boating densities to each of the study lakes, the percentage of high-speed watercraft (i.e., boats with motors greater than 25 horsepower and personal watercraft) was taken into account. The minimum boating density for each lake was 10 acres per boat and the maximum possible boating density would be 15 acres per boat (assuming all high-speed watercraft). The proportion of the 5-acre difference between the 10-acre minimum and the 15-acre maximum was allocated as a percentage of high-speed watercraft. For example, 45 percent of the watercraft on Pine Lake are high-speed (Table 3). Thus, the optimum boating density for Pine Lake was calculated by taking 45 percent of 5 acres, which equals 2.25 acres. The 2.25 acres was then added to the base 10-acre-per-boat density to get 12.25 acres per boat as the optimum boating density for Pine Lake. Optimum boating densities for each of the study lakes was determined in like fashion and break down as follows: Upper Crooked Lake - 12.25 acres per boat; Gull Lake - 13.5 acres per boat; and Sherman Lake - 11.5 acres per boat.

Lake Use Rate

Although it is possible to determine an optimum boating density, as described above, it is important to consider that only a fraction of moored boats are on the lake at any given time. For example, on peak use days, such as the Fourth of July, a large percentage of the boats moored at the lake may be on the lake at the same time. Or, on weekdays, the lake may be utilized by only a small fraction of boats at a given time. Thus, in evaluating carrying capacity, the lake use rate must be considered.

According to a 1987 study of Lake Charlevoix in Northern Michigan conducted by the Charlevoix County Planning Commission, an estimated 10 percent of the total number of riparian boats may be on the lake at any given time during high use periods such as summer weekends. Similarly, Threinen (1964) observed that a common level of use at a peak activity period is 10 percent of the boats present. An analysis of use rates on Lake Lansing in Ingham County, Michigan, found an overall use rate of about 8 percent of the moored boats (Progressive Architecture Engineering 2001). In the absence of empirical data to the contrary, Warbach *et al*. (1994) recommended that a peak use rate of 15 percent be used for planning purposes.

In light of these observations, a peak use rate of 10 percent has been assumed for the study lakes. Note, however, that this estimate does not take into account the number of boats launched from the public access sites during peak use periods. Therefore, it was assumed the various public access facilities would be at 50 percent capacity during peak use periods. An exception to this would be Gull Lake where Prairieville Township Parks and Recreation Department staff observations indicate a peak use rate of 100 percent at Prairieville Township Park. Based on these criteria and observations, the potential number of boats on each of the study lakes during peak use periods can be estimated (Table 10.)

TABLE 10
PEAK USE BOATING PROJECTIONS

Lake	10% of Moored Boats	Public Access Boats	Estimated Number Of Boats On Lake During Peak Use Periods
Pine	110	5	115
Upper Crooked	44	9	53
Gull	166	70	236
Sherman	18	15	33

The Recreational Carrying Capacity Calculation

It is now possible to determine if sufficient useable lake area is available to accommodate the number of boats anticipated on the study lakes during periods of peak use (Table 11). These data indicate that, under estimated peak use conditions, the recreational carrying capacity of each of the lakes has the potential to be exceeded.

TABLE 11
RECREATIONAL CARRYING CAPACITY RESULTS

Lake	Useable Lake Area (acres)	Carrying Capacity (# boats = Useable Lake Area/Optimum Boating Density)	Estimated Peak Use (# boats)	Percent of Carrying Capacity at Peak Use[1]
Pine	513	42	115	274%
Upper Crooked	478	39	53	136%
Gull	1,885	140	236	169%
Sherman	118	10	33	330%

Recommendations and Conclusions

Under estimated peak use conditions, the recreational carrying capacity of each of the lakes has the potential to be exceeded. Thus, at estimated peak use levels, the lakes are likely to experience lake overcrowding, multi-use conflicts, and/or environmental degradation as a result of boating activity. These problems have the potential to be most prevalent on Pine Lake and Sherman Lake.

Under Michigan law, there are a number of options that may be employed at the local and state level to address problems associated with lake congestion. A review of these options is included in Appendix A. Techniques that may be appropriate for the study lakes are listed in Table 12 and are discussed separately as follows.

Keyhole or Funnel Development Control Ordinances

Of primary concern on each of the study lakes is the issue of keyhole or funnel development. Funneling occurs when a waterfront lot is used to permit access to a larger development located away from the lake. Funneling allows a large number of individuals to gain access to the lake through a small corridor of lake property, thereby exceeding the natural limitation on access afforded by the existing shoreline. Given that the recreational carrying capacity of each of the study lakes is exceeded under estimated current peak use conditions, unregulated funnel development has the potential to create a number of problems, including land use conflicts; unsafe and inadequate access; boating accidents; noise; lake congestion; multi-use conflicts; and decreased property values. Keyhole development could have potential adverse environmental impacts as well, in that it tends to concentrate development in close proximity to the lakeshore which increases the amount of imperviousness and storm water runoff.

Currently, Prairieville Township and Ross Township have zoning provisions that regulate keyhole development. It is recommended that similar provisions be adopted in Richland Township and Barry Township as well.

Public Access Site Controls

Public access to each of the study lakes is provided through state public access sites or, in the case of Gull Lake, through a township park. It is recommended that, given the current level of use on the lakes, existing public access sites not be expanded and that no new sites be constructed.

[1] These numbers compare estimated peak use to estimated carrying capacity. For example, the carrying capacity of Pine Lake is estimated at 42 boats. If the peak use on Pine Lake was estimated at 42 boats as well, then Percent of Carrying Capacity at Peak Use would be 100%. As it is, estimated peak use on Pine Lake is 115, boats which is 115/42 or 274% of carrying capacity, or 174% over capacity.

At a use rate of only 50 percent, the public access site on Sherman Lake has the potential to exceed the carrying capacity of the lake. Current guidelines used by the Department of Natural Resources in sizing access sites require one car/trailer space for each 15 acres of lake surface area (on lakes up to 1,000 acres). Applying this general criteria to Sherman Lake would result in an access site with a total of 10 car/trailer parking spaces. The current site provides 30 spaces. Curtailing use of this site may be appropriate given the limited capacity of the lake to accommodate boat traffic.

Watercraft Control Ordinances

On lakes where there is an identified safety concern or problem associated with boating activity, watercraft control regulations can be adopted with assistance from the Michigan Department of Natural Resources (Appendix A). These types of ordinances often restrict the hours in which high-speed boating activity is allowed. Sherman Lake currently has a special watercraft control ordinance which limits hours for high-speed boating and water skiing to between 10 a.m. and 6:30 p.m. Gull Lake has a 40 mile per hour speed limit established by a waterecraft control ordinance, and both Pine Lake and Sherman Lake have slow, no wake controls in canals and channels.

It should be noted that special watercraft control regulations apply to all users of a lake, both riparian (i.e., waterfront property owners) and non-riparian. In the future, if the need can be documented from a safety perspective, a special watercraft regulation that limits hours of high-speed boating activity may be appropriate as a means of alleviating overcrowding and multi-use conflicts on Pine Lake. A time-share restriction on Pine Lake may be most effective if it only applied during periods of peak use such as summer weekends and holidays.

Marina Regulations

Pursuant to provisions of Part 301 of Michigan's Natural Resources and Environmental Protection Act, permits must be obtained from the Michigan Department of Environmental Quality (MDEQ) for both the construction and operation of marina facilities. Marina operating permits must be renewed every three years. As part of the permitting process, local units of government receive notification and are given an opportunity to provide comment to the department on the issuance of a construction permit or a marina operating permit. In issuing a permit, the MDEQ must consider the potential for congestion or safety problems, impacts to natural resources, and whether the facility is in compliance with local zoning ordinances.

Governmental decision makers in the four townships should avail themselves of the opportunity to review and comment on pending permit applications for the construction and operation of marina facilities. It may also be prudent for the townships to consider special land use regulations for marinas to help ensure the construction and operation of these facilities would not adversely impact area lakes.

Public Road-End Ordinances

Road-ends on inland lakes dedicated to the use of the public have become a controversial issue on many lakes. Recent litigation over the issue of public road-ends on Higgins Lake in northern Michigan has resulted in two decisions by the state court of appeals. In these cases, the court essentially held that in subdivisions with roads dedicated to the "use of the public" the placement of one non-exclusive dock at each road end was permissible and that the public was entitled to the reasonable use of the water for boating, swimming, and fishing. However, this right did not extend to the placement of boat hoists and shore activities such as sunbathing, lounging, or picnicking.

To the extent that road-ends on lakes within the four townships may create the potential for use conflicts, the townships may wish to consider the adoption of ordinances to regulate road-end activities.

Information and Education

It should be noted that short of additional regulatory approaches, the dissemination of information about existing navigation laws coupled with aggressive enforcement may help alleviate many of the problems associated with lake overcrowding and congestion. Area lake associations, working in concert with the townships, should take steps to educate lake users about basic navigation law and ensure there is adequate marine patrol presence on the lakes to stem flagrant safety violations.

TABLE 12
LAKE CONGESTION CONTROL ALTERNATIVES

Technique	Lake
Keyhole or Funnel Development Control Ordinances	Pine, Upper Crooked, Gull, and Sherman
Public Access Site Controls	Sherman
Watercraft Control Ordinances	Pine
Marina Regulations	Pine, Upper Crooked, Gull, and Sherman
Public Road-End Ordinances	Gull
Information and Education	Pine, Upper Crooked, Gull, and Sherman

This study provides a benchmark from which to begin to monitor changes in use characteristics on the lakes. Clearly, additional empirical data would be helpful to better document peak use rates, multi-use conflicts, and changes in environmental conditions. This work could best be accomplished with technical assistance from local universities or private consultants with support from local lake users.

Both the state and local units of government have a role to play in attempting to balance the rights of the public and riparians to use our lake resources without creating public health, safety, or environmental problems. Decisions and actions taken today will dictate how area lakes fare in the future. When roads become congested, lanes can be added to increase capacity. This luxury doesn't exist on lakes. Recreational carrying capacity study findings will hopefully establish a framework for decision making and a basis for regulatory action to help ensure area lakes are used in a prudent and environmentally sound manner. To do otherwise will compromise the unique character and value of these resources.

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Appendix A
Lake Access and Overcrowding Regulatory Alternatives and Considerations

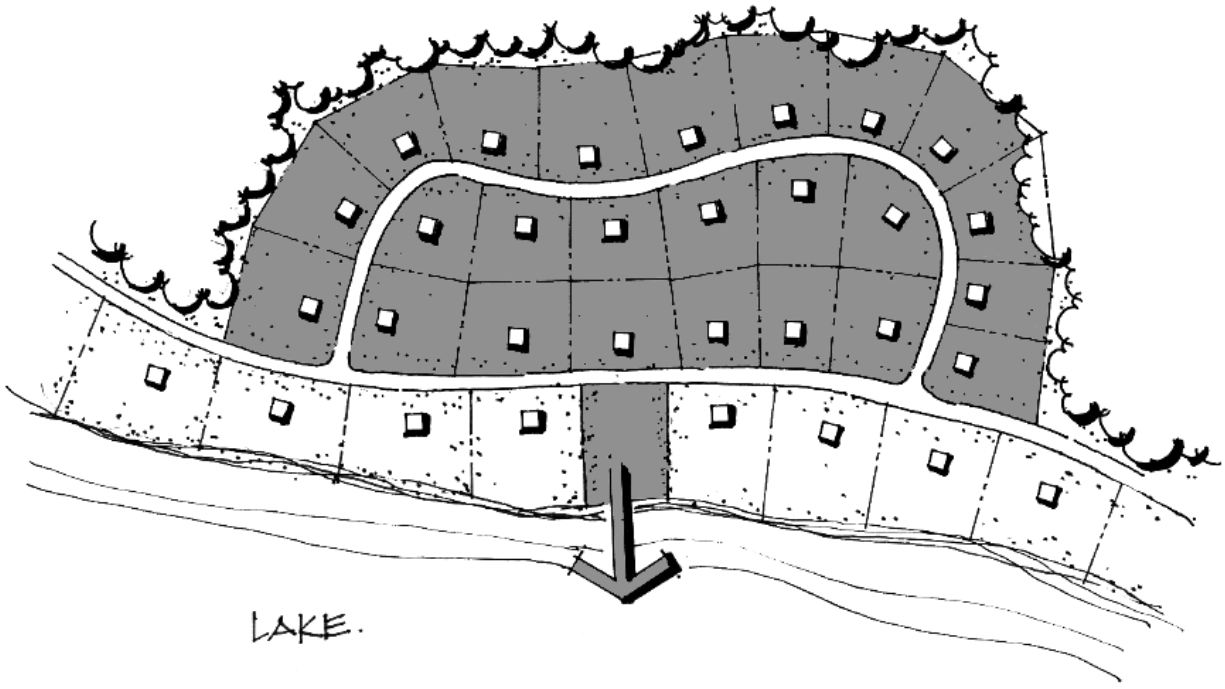
Lake Access and Overcrowding

Regulatory Alternatives and Considerations

Lakes are a finite resource with seemingly unlimited demand. As more development occurs around lakes and more lakeside cottages are converted from seasonal to year-round use, boating and other recreational activities on inland lakes can be expected to increase accordingly. This fact, coupled with the tremendous increase in the number, size, and speed of today's watercraft, has brought the issue of lake access and overcrowding to the forefront in many communities. Several recent court decisions and Michigan laws define the roles state and local government may play in addressing lake access and overcrowding issues.

Keyhole or Funnel Development

As lakefront property continues to be developed, the desire to provide direct lake access to property located off the lakes will continue to increase. Funnel or keyhole development occurs when a lakefront lot is used to provide lake access to a larger development located away from the lake. Funneling allows a large number of individuals to gain access to a lake through a small corridor of property. Unregulated funnel development has the potential to create a number of problems, including: Land use conflicts, unsafe and inadequate access, excessive noise, lake and shoreland congestion, multi-use conflicts, degradation of the environment, and decreased property values.



In response to concerns regarding lake overcrowding, many townships around the state adopted anti-funneling or keyhole ordinances in the 1970s and 1980s. However, in 1987, the Michigan Court of Appeals ruled in the *Fox and Associates, Inc.* v *Hayes Township* case that townships did not have the authority to regulate funnel development under the zoning enabling statute. Thus, for several years, Michigan townships were unable to regulate funnel development effectively. However, two more recent decisions by the Michigan Supreme Court shed new light on the issue. In 1991, the Michigan Supreme Court ruled in the case of *Square Lake Hills Condominium Association* v *Bloomfield Township,* "that townships have the authority to regulate by ordinance boat docking and launching for the protection of the health, safety, and welfare of persons and property within their communities under the Township Ordinance Act" (Public Act 246 of 1945).

In 1992, the Michigan Supreme Court ruled in the case *Hess* v *Charter Township of West Bloomfield,* "that the Township Zoning Act (Public Act 184 of 1943), permits townships to regulate riparian rights, such as dockage of boats, as part of their zoning power." This decision effectively overturned *Fox and Associates Inc.* v *Hayes Township*. In rendering its decision in the *Hess* case, the Court cited the Michigan constitution, which states that conservation and protection of natural resources shall constitute a paramount concern in the interest of the health, safety, and general welfare of the people of the State of Michigan. In addition, the Court found that the term "land" as used within the Township Zoning Act extends to riparian rights.

Thus, the Michigan Supreme Court has confirmed that townships have the ability to regulate boat docking under both the Township Ordinance Act and the Township Zoning Act. However, the two acts do not regulate existing and future uses in the same manner. Existing and future uses can be regulated under the township's general police power pursuant to the Township Ordinance Act, while zoning under the Township Zoning Act regulates future uses only. Thus, for a lake community that is experiencing problems as a result of existing uses, it may be wise to consider proceeding under the Township Ordinance Act, since an ordinance adopted under this act does not need to recognize non-conforming uses. On the other hand, if existing uses are not a major problem but future uses are a concern, then it may be more appropriate to proceed under the Township Zoning Act.

Although the courts have repeatedly stated that township ordinances carry an assumption of validity, townships must provide a logical basis for the ordinance, such as a carrying capacity study. Otherwise, a court may find an ordinance unreasonable or arbitrary and, therefore, invalid if challenged. Care must be taken in the drafting and application of a lake use regulation to ensure the ordinance would not be deemed unreasonable or confiscatory (i.e., constitute a "taking" of property without compensation). The ordinance should clearly articulate standards and address a specific, defined need.

State Public Access Sites

Public access to many inland lakes is provided through access sites maintained and operated by the Michigan Department of Natural Resources. The authority for the Department of Natural Resources (DNR) to provide public access to the citizens of the state is contained in Part 5 of Act 451 of 1994, the Natural Resources and Environmental Protection Act, which states:

> The department shall protect and conserve the natural resources of this state [and] provide and develop facilities for outdoor recreation. The department has the power and jurisdiction over the management, control, and disposition of all land under the public domain, except for those lands under the public domain that are managed by other state agencies to carry out their assigned duties and responsibilities.

Until recently, it was assumed the DNR had exclusive jurisdiction over public access sites to the complete exclusion of township and county zoning interests. However, a recent decision by the Michigan Supreme Court (*Burt Township* v *Department of Natural*

Resources, decided June 1999), indicates that townships may have a role to play in the regulation of public access facilities on inland lakes. In this case, the Court held:

> The DNR, in the construction of its public-access boat launch, is subject to Burt Township's zoning ordinance. The Natural Resources and Environmental Protection Act and the Township Rural Zoning Act appear to provide coextensive statutory rights concerning the protection of natural resources in general and the development of recreation facilities, and other waterfront developments in particular. Nothing in the NREPA establishes a clear expression of legislative intent to exempt the DNR's activities in this case from the Burt Township Zoning Ordinance.
>
> 1. The Township Rural Zoning Act and the Township Planning Act provide townships with extensive authority to regulate the use and development of land within their borders, including waterfront property. There is nothing in the Natural Resources and Environmental Protection Act that suggests a clear expression of legislative intent to vest the DNR with exclusive jurisdiction over its subject matter and thus to exempt its activities in this case from the Burt Township zoning ordinance.
>
> 2. The Legislature, in directing that the DNR engage in certain governmental functions, did not intend that it be authorized to do so in any manner it chooses. According the DNR power and jurisdiction to manage land within its control is not the same as granting it exclusive jurisdiction. The fact that the DNR is mandated to create recreational facilities on public land it manages and controls does not indicate a legislative intent that it may do so in contravention of local zoning ordinances. Also, there is no particular significance in the fact that the TRZA does not expressly provide that state agencies are subject to zoning ordinances.

This decision should <u>not</u> be interpreted to mean that a local ordinance could be used to prohibit construction of necessary public access facilities. In fact, under Michigan law, a zoning ordinance may not totally exclude a lawful land use where there is a demonstrated need for the land use and the use is appropriate for the location. The Department of Natural Resources has a clear legislative mandate to provide lake access opportunities to the residents of the State of Michigan. However, in planning and designing public access facilities, it may be reasonable for a local ordinance to require that the carrying capacity of a particular lake and other factors of local importance be considered in determining the size, type, and number of boats that may ultimately use the facility.

Public "Road-Ends"

Road-ends on inland lakes dedicated to the use of the public have become a controversial issue. Two recent Appeals Court decisions provide insight into the discretion and latitude the courts may provide in road-end disputes. In the first case (*Jacobs* v *Lyon Township* [After Remand] 1993), the court held that in a subdivision with roads dedicated to the "use of the public," the placement of one non-exclusive dock at each road-end would be permissible and that the public was entitled to reasonable use of the water for boating, swimming, and fishing. The courts further determined that the erection of boat hoists and shore activities such as sunbathing, lounging, or picnicking was not within the scope of the plat dedication.

In a subsequent unpublished Appeals Court decision on a similar road-end dispute (*Higgins Lake Property Owners Association* v *Lyon Township, Roscommon County Road Commission, and Department of Environmental Quality*, May 30, 2000), the court revisited and reinforced the *Jacobs* decision as follows:

> The court interpreted the opaque dedication "to the use of the public" to include nothing more than the right to access the lake. We can discern no reason to interpret the similar dedication in the present case differently. Accordingly, we affirm the trial court finding that the scope of the dedication permitted the installation of one

nonexclusive dock at the end of each of the roads leading to the lake, and that the public was entitled to reasonable use of the water for boating, swimming, and fishing.

It should be noted individual situations involving public road-ends on inland lakes must be evaluated on their own merit and within the scope of the dedication in question. However, where road-ends are simply dedicated to the use of the public, the court decisions cited above may provide some insight into what uses and activities may be deemed appropriate by the courts. In communities where road-ends on inland lakes may create potential use conflicts, the adoption of ordinances to regulate activities at public road end may be appropriate.

Marinas

Proposals to construct marinas on inland lakes often promote considerable controversy and concern with regard to potential multi-use conflicts, congestion, and environmental problems. Permits for marina construction are issued by the Department of Environmental Quality (DEQ), but marina facilities may also be regulated through local zoning. In light of a recent Appeals Court decision, local zoning of marinas may be more important than ever.

The construction of marinas in Michigan is regulated under Part 301 of Act 451 of 1994, the Natural Resources and Environmental Protection Act. In acting upon an application for a marina-operating permit, Part 301 administrative rules require that the DEQ shall not issue a permit unless it is determined that the facility meets all the following criteria:

(a) The facility does not unreasonably affect the public trust or riparian interests.

(b) Ingress and egress are within the riparian owner's interest area or written authorization is secured from the adjacent owner whose riparian or property interest is or may be affected.

(c) The increased use brought about by the marina, and the increased use attributable to the marina will not create congestion, safety problems, or aggravate existing recognized congestion or safety problems.

(d) The construction and operation of the facility will not destroy or adversely impair the use of the waters or natural resources of the state.

(e) The facility is not aesthetically displeasing and conforms to similar structures and activities in the area on similar watercourses.

(f) The facility has adequate parking space to accommodate anticipated users.

(g) The facility is in compliance with local zoning ordinances. If the facility is not in compliance, and the local unit of government having proper jurisdiction notifies the department at the time of public notice objecting to the issuance of a permit, the department shall withhold permit issuance for 30 days from the date of the expiration of the public notice. If the local unit of government does not file an action to restrain operation of the facility in a public forum within the specified 30-day time frame, the department may issue a permit for marina operation if all other criteria are met.

(h) The structures do not constitute a safety or navigational hazard and are in good repair.

(i) The potential adverse environmental effects of operating a marina have been determined pursuant to R 281.814.

Rule 281.814 states:

> In each application for a permit, all existing and potential adverse environmental effects shall be determined and the department shall not issue a permit unless the department determines both of the following:

(a) That the adverse effects to the public trust, riparian rights, and the environment will be minimal.

(b) That a feasible and prudent alternative is not available.

Part 301 requires the Department of Environmental Quality to evaluate the potential for congestion, safety problems, and that marina facilities be in compliance with local zoning ordinances. However, a recent unpublished Appeals Court decision (*Attorney General of The State of Michigan, ex rel Michigan Department of Natural Resources* v *Chalet du Paw Paw Condominium Association and Beachfront Development, Inc., August 3, 1999),* may limit the authority of the Department of Environmental Quality to regulate marina facilities that are not clearly of a commercial nature, such as a yacht club.

In light of these considerations, it may be prudent for communities with lakes within their jurisdictions to draft special use regulations for marina facilities to help ensure the construction of such facilities would not adversely impact the lakes in question.

Watercraft Control Ordinances

On certain bodies of water, conflicts between anglers, high-speed boaters, swimmers, and various other lake users have necessitated the need for local watercraft ordinances. Watercraft ordinances are generally adopted in accordance with provisions of Part 801 of Act 451 of 1994, the Natural Resources and Environmental Protection Act, based on an identified safety concern or problem. Under this statute,

> The department may regulate the operation of vessels, water skis, water sleds, aquaplanes, surfboards, and other similar contrivances on the waters of this state. Where special regulations are determined necessary, the department may establish vessel speed limits; prohibit the use of vessels, water skis, water sleds, aquaplanes, surfboards, and other contrivances by day and hour, establish and designate areas restricted solely for boating, skin or scuba diving, fishing, swimming or water skiing, and prescribe any other regulations relating to the use or operation of vessels, water skis, water sleds, aquaplanes, surfboards or other contrivances, which will ensure compatible use of state waters and best protect the public safety. The department shall prescribe special local regulations in such a manner as to make the regulations uniform with other special local regulations established on other waters of this state insofar as is reasonably possible.

In considering the establishment of special rules for a lake, local governing bodies must, by formal resolution, request assistance from the Department of Natural Resources. In some instances, the department may initiate investigations to determine and document the need for special regulations. Prior to formal enactment of a watercraft control ordinance, a hearing must be held to obtain public input on the proposed ordinance. The ordinance is then presented to the local governing body that has 60 days to inform the department if it approves or disapproves of the proposed ordinance. If the governing body approves the proposed ordinance, the local ordinance shall be enacted identical to the local ordinance prepared by the department. Watercraft control ordinances generally take the form of regulations that restrict the hours of high-speed boating on inland lakes.