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**CARRYING CAPACITY**

**of**

**SOUTH LAKE LEELANAU**

**July 12, 2001**

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## SUMMARY AND CONCLUSIONS

Factual data of South Lake Leelanau were collected and employed to evaluate the *carrying capacity* of the lake. This study indicated that recreational quality (safety and satisfaction) requires 37 acres of lake surface for each boat and that environmental protection of the lake requires 35 acres of lake surface for each boat. Based on the slightly more stringent recreational quality requirement, no more than 118 boats should be in active use on South Lake Leelanau at any time.

Two counts of active boats were made in 1997 and one count in 2001. One of these counts (July, 12, 2001) found 125 active motor boats. The weather on this day was partly sunny and breezy. This number is greater than the maximum number recommended by the study. Additional boat counts should be made in the future.

This work suggests that South Lake Leelanau is being used above its prudent boat carrying capacity. Addition or enlargement of any boat launch sites, marinas, resorts, camp grounds or keyholing sites will further jeopardize recreational and environmental conditions of the lake. Several launch and marina facilities are already present that generate a localized concentration of watercraft which present some safety concerns.

## INTRODUCTION

Carrying capacity is the number of boats that can use a lake at any one time with minimal environmental damage to the lake and provide safe and enjoyable recreational use. The Planning & Zoning Center of Lansing, Michigan has developed a method of evaluating any lake to determine, objectively, its carrying capacity. That method is described in a manual entitled *Carrying Capacity Analysis & Ordinances Providing Lake Access Regulations* published in 1994 by that center.

The authors collected the information required to carry out the evaluation described in the manual and carried out the procedures described therein. The data used, calculations made and evaluation forms completed for the evaluation are presented in this report.

## LAKE CHARACTERISTICS

Lake Size	5370 acres
Lake area less than 5 feet deep	1015 acres
Lake volume	5356 million cubic feet
Shoreline length	25 miles
Number of shoreline properties	786

The lake morphology values were obtained by planimeter measurements of a bathymetric map of Lake Leelanau. The number of properties is found by review of tax maps in the County Equalization Department.

#### ACTIVE BOAT COUNT DATA

Date	08/09/97	09/01/97	07/22/01
Day	Saturday	Labor Day	Sunday
Time	16:00	16:15	15:45
Sun	overcast	ptly sunny	ptly sunny
Wind	breezy	breezy	sl breeze
Canoe/Kayak	0	1	4
Sail Boat	2	6	6
PWC	2	15	21
Pontoon Boat	5	10	18
Boat under 5 Hp	0	1	4
Boat over 5 Hp	49	72	86
Motor Boats	<b>56</b>	<b>97</b>	<b>125</b>
Total Boats	58	105	139

Active boats as reported above were determined by driving a boat from one end of the lake to the other at a speed whereby few, if any, boats overtook the counting boat. The boat traveled the approximate center line of the lake while two observers recorded the number and type of boats overtaken. Note was taken of any overtaking boat to avoid double counting that boat.

#### CALCULATIONS FOR MATRIX FORMS

$$\begin{aligned}\text{Lake Shape Factor} &= \text{Shore Length} / (2 * (3.14159 * \text{lake area})^{.5}) \\ &= 25 / (2 * (3.14159 * 8.46)^{.5}) \\ &= 2.43\end{aligned}$$

$$\begin{aligned}\text{Percent Lake less than 5 ft. deep} &= (1015/5370) * 100 \\ &= 19\end{aligned}$$

$$\begin{aligned}\text{Flushing Rate} &= \text{Lake Volume} / \text{Water outflow} \\ &= 5,356,000,000 / (132\text{cfs} * 3600 * 24) \\ &= 470 \text{ days}\end{aligned}$$

$$\begin{aligned}\text{Average frontage of building sites} \\ \text{Frontage} &= \text{Shoreline length} / \text{number properties} \\ &= 25 * 5280 / 786 \\ &= 168 \text{ feet}\end{aligned}$$

$$\begin{aligned}\text{Multi-boat Access Site Factor (MBASF)} \\ \text{BMBS} &= \text{average no. boats per multi-boat site} \\ &= 431/21 \\ &= 20.50\end{aligned}$$

## CALCULATIONS (Continued)

$$\begin{aligned} \text{RBE} &= \text{residential boat equivalent} \\ &= \text{number of boats at residential sites/Number sites} \\ &= 775/766 \\ &= 1.01 \end{aligned}$$

$$\begin{aligned} \text{MBASF} &= \text{BMBS} - \text{RBE} \\ &= 20.5 - 1.01 \\ &= 19.5 \end{aligned}$$

### Surface Area/Multi-boat Access Factor (SAMBAF)

$$\begin{aligned} \text{SAMBAF} &= \text{Multi-boat moorings per 20 acres useable surface} \\ &= 431 \times 20 / (5370 - 1015) \\ &= 1.98 \text{ boats per 20 acres} \end{aligned}$$

### Riparian Boat/Non-Riparian Factor (RNRF)

$$\begin{aligned} \text{RNRF} &= \text{Riparian owned boats/non-riparian owned boats} \\ &= 775/431 \\ &= 1.8 \end{aligned}$$

## ENVIRONMENTAL CARRYING CAPACITY MATRIX

Using data listed or calculated above along with known soil and topographical information, the attached 2 page environmental form was completed. This form indicated a minimum of 35 acres was desirable for each active motor boat.

## RECREATIONAL CARRYING CAPACITY MATRIX

The attached recreational capacity form was also completed using the above information. This form indicated a minimum of 37 useable acres was desirable for each active motor boat.

## CARRYING CAPACITY

Based on the recreational carrying capacity matrix requiring 37 acres of useable lake surface per boat and the measured useable surface area of 4355 acres, the lake has a carrying capacity of  $(4355/37)$  118 boats.

Based on the currently estimated use factor of 0.15, the lake should have a maximum of 787 (carrying capacity/use factor) boat moorings as compared to an actual count of 1206 moorings.

# ENVIRONMENTAL CARRYING CAPACITY MATRIX

Sheet 1 of 2

By: H. A. Farber and W. H. Nielsen

08/05/97

Lake Name:	South Lake Leelanau	Score toward	Score toward
County:	Leelanau	LESS restrictive	MORE restrictive
Township(s):	Leland, Suttons Bay, Bingham Elmwood, Solon, Centerville		

LAKE CHARACTERISTIC			
LAKE SIZE (acres)			
	< 50	+3	
	50 to <300	+2	
	300 to 1,000	+1	
5370 (8.4 sq mi)	>1,000		
Lake Shape Factor = Shore length/2 times sq rt(3.14159 times lake area)			
	Round LSF < 1.25	-2	
	Irregular LSF 1.25 to 1.75	-1	
	LSF 1.75 to 2.5	+2	2
2.43	LSF > 2.5	+4	
Percent lake less than 5 feet deep			
	<10%	-4	
19	10 to 30%	-2	2
	>30%	+4	
Bottom Soil Type			
	Mostly muck	+1	
	Sand and muck	+1	1
	Mostly sand	-1	
Bank Characteristics			
	High bluff	+2	
	Moderate bluff	+1	
	Low bluff	-1	1
Predominate Shoreline Soil Type			
	Silts, clays and loams	+1	
	Sands and gravel	-1	1
Option: Water Quality Protection			
	Minimize WQ damage from boating	+4	4
Flushing Rate			
	Less than 2 months	-2	
	2 months to 1 year	-1	
~470 days	Over 1 year	+1	1

# ENVIRONMENTAL CARRYING CAPACITY MATRIX

Sheet 2 of 2

Bv: H. A. Farber and W. H. Nielsen

08/05/97

Lake Name:	<b>South Lake Leelanau</b>	Score toward	Score toward
County:	<b>Leelanau</b>	LESS restrictive	MORE restrictive
Township(s):	<b>Leland, Suttons Bay, Bingham Elmwood, Solon, Centerville</b>		

LAKEFRONT LAND USE			
% Shoreline developed or developable = Developable/Shoreline length			
>80%	>70%	+2	<b>2</b>
	10 to 70%	+1	
	<30%	-1	
Average Frontage of Building Sites			
	up to 100 ft.	+1	
168	100 ft and greater	-1	<b>1</b>
Ownership Pattern			
+95%	Predominately individual	+1	<b>1</b>
	Over 25% owned in groups	-1	
Community Master Planning			
	Contributes to high intensity land use	+1	<b>1</b>
	Contributes to low intensity land use	-1	
Multi-Boat Access Site Factor (MBASF)			
19.5	<30 boats	-2	<b>2</b>
	30 to 60 boats	+1	
	>60 boats	+2	
Total Score		<b>7</b>	<b>12</b>
Difference between columns			<b>5</b>
Boat acreage= 30 +/- Difference			<b>35</b>

# RECREATIONAL CARRYING CAPACITY MATRIX

Sheet 1 of 1

By: H. A. Farber and W. H. Nielsen

08/05/97

Lake Name:	<b>South Lake Leelanau</b>	Score toward	Score toward
County:	<b>Leelanau</b>	LESS restrictive	MORE restrictive
Township(s):	<b>Leland, Suttons Bay, Bingham Elmwood, Solon, Centerville</b>		

LAKE CHARACTERISTIC					
LAKE SIZE (acres)					
	< 50		+4		
	50 to <300		+2		
	300 to 1,000		+1		
5370	>1,000				
Lake Shape Factor = Shore length/2 times sq rt(3.14159 times lake area)					
	Round	LSF < 1.25	-2		
	Irregular	LSF 1.25 to 1.75	-1		
		LSF 1.75 to 2.5	+3		<b>3</b>
2.43		LSF > 2.5	+4		
Percent lake less than 5 feet deep					
	<10%		-4		
19%	10 to 30%		-2	<b>2</b>	
	>30%		+4		
Option: Water Quality Protection					
	Minimize WQ damage from boating		+4		<b>4</b>
Surface Area/Multi-boat Access Factor (SAMBF)					
	up to 1 boat per 20 acres		-1		
1.98	over 1 boat per 20 acres		+1		<b>1</b>
Riparian Boat/Non-Riparian Factor (RNRF)					
1.80	up to 10 boats		+1		<b>1</b>
	Greater than 10		-1		
Total Score				<b>2</b>	<b>9</b>
Difference between columns					<b>7</b>
Boat acreage = 30 +/- Difference					<b>37</b>