UNIVERSITY OF MANITOBA

GRAND BEACH

A TEST OF GRAIN-SIZE DISTRIBUTION STATISTICS AS INDICATORS OF DEPOSITIONAL ENVIRONMENTS

A Dissertation

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Master of Science

by

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ABSTRACT

Sediments collected from the beach, aeolian, channel, lake delta and off-beach environments of Grand Beach, southern Lake Winnipeg, are used to test the ability of grain-size distribution statistics to determine depositional environments.

Five previously published techniques evaluated are:

(1) Diagram CM-Passega (1957).

(2) Graphical Parameters - Mason and Folk (1958).

(3) Moment Parameters - Friedman (1961).

(4) Discriminant Functions - Sahu (1964).

(5) Factor Analysis - Klovan (1966).

None of the five techniques reliably classified samples into the delineated environments. Factor analysis, however, gave results which reproduced energy conditions consistent with the known depositional environments.

The failure of every technique to classify samples into their correct depositional environments suggests that sediments of widely diverse environmental origin may have identical grain-size distributions. Thus, statistics cannot be used to differentiate between sediments from different environments if the grain-size distributions themselves are not different.

If the results observed for the recent sediments at Grand Beach are applicable to recent and ancient marine sediments, then grain-size distribution statistics cannot be used as indicators of specific depositional environments.

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CHAPTER I

INTRODUCTION

Statement of Problem

Several distinct methods of determining the depositional environment of clastic sediments through statistical analysis of grain-size distribution data have been published. This study has two primary objectives: first, to delineate the depositional environments of Grand Beach, an area of recent lacustrine sedimentation; and secondly, to evaluate the usefulness of several statistical techniques in determining depositional environments from grain-size distribution data using the Grand Beach area as a reference model.

Method of Study

Grand Beach was selected as a reference model because several contrasting depositional environments occur in a relatively small, easily accessible area.

Depositional environments at Grand Beach were first delineated according to topographic, sedimentologic, hydrographic and geographic criteria. Sediment samples collected from these environments were analyzed by sieve and pipette techniques to determine the weight percentages of sediment in standard size classes.

These data were then used to compute the depositional environments by means of five previously proposed statistical methods:

(1) CM Patterns, Passega (1957)

(2) Graphical Parameters, Masonand Folk (1958)

(3) Moment Parameters, Friedman (1961)

(4) Discriminant Functions, Sahu (1964)

(5) Factor Analysis, Klovan (1966)

The results of each of these methods were then compared to the reference model.

Method of Presentation

This dissertation is presented in two main parts.

The first part includes chapters describing field and laboratory studies of the Grand Beach recent sediments. Their minerology and provenance is also discussed.

The second part describes the results of five methods of statistical analysis of the grain-size data. Computer programs used to process the grain-size data are documented, and the progress made in the development of a system of multivariate statistical programs for the I.B.M. 360 computer is reported.

Acknowledgements

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CHAPTER II

DESCRIPTION OF THE STUDY AREA

Lake Winnipeg

Lake Winnipeg, a remnant of glacial Lake Agassiz (Davies, Bannatyne, Barry and McCabe, 1962), is a large freshwater lake entirely within the boundaries of Manitoba. The lake has a maximum length of 250 miles but is divided into two parts by a narrows (Figure 1) and several large islands.

The northern part of Lake Winnipeg receives water from many rivers, the largest being the Saskatchewan River. Lake Winnipeg is discharged by the Nelson River, flowing northward into Hudson Bay (Figure 1).

The southern part of Lake Winnipeg has a maximum length of 55 miles and a maximum width of 25 miles (Figure 2). This part of the lake has an average water depth of 40 feet (Government of Canada Bathymetric Map 6240, 1962). The Red and Winnipeg Rivers provide the main influx of water into the south part of Lake Winnipeg.

Records maintained since 1913 indicate the average water level of Lake Winnipeg is 713 feet above mean sea level (Province of Manitoba Water Bulletin, May 1967). During 1965 and 1966 the Lake Winnipeg drainage basin has received greater than average amounts of precipitation. This additional runoff water has caused lake level to rise and remain about four feet above average.

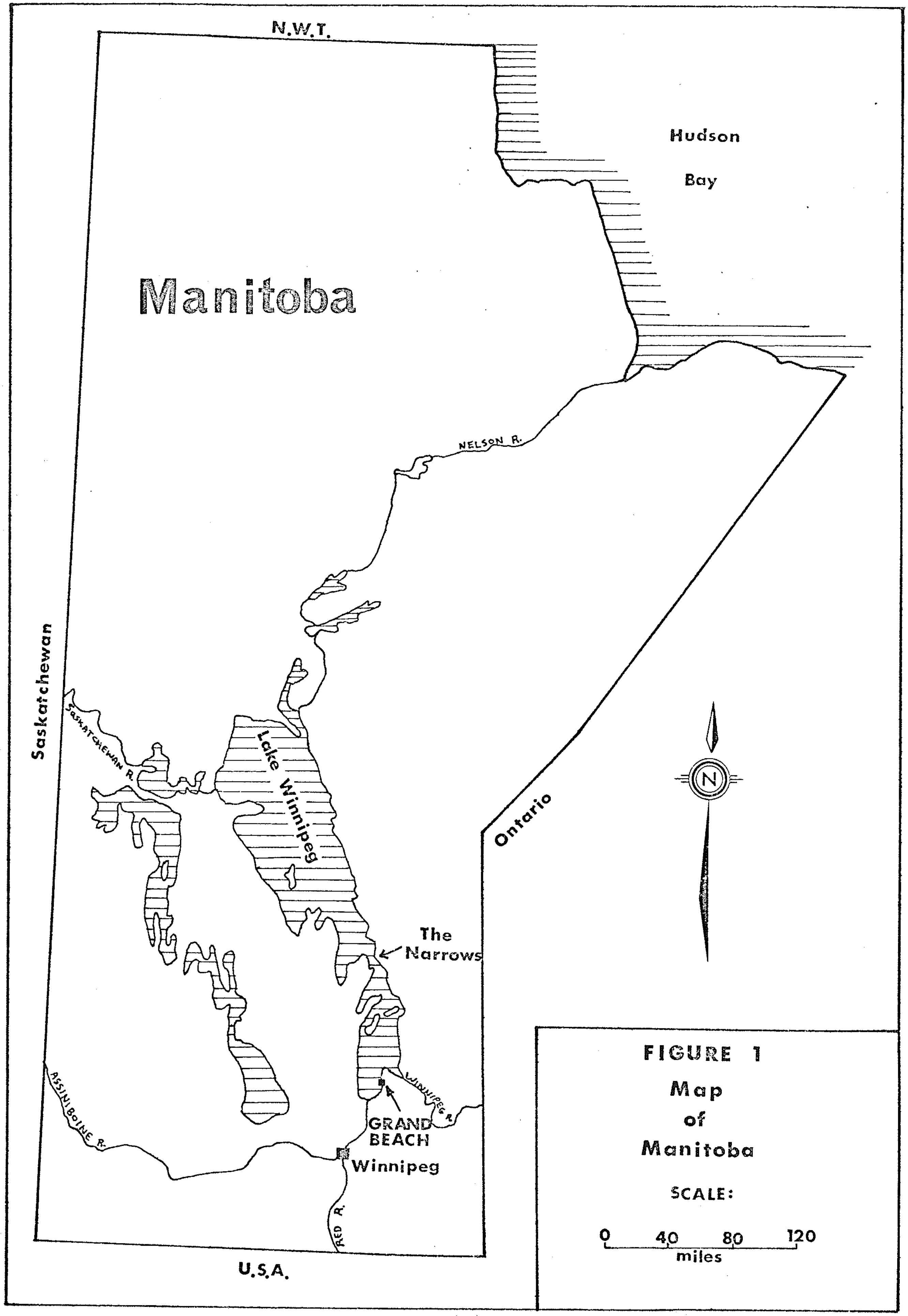

FIGURE 1
Map of Manitoba

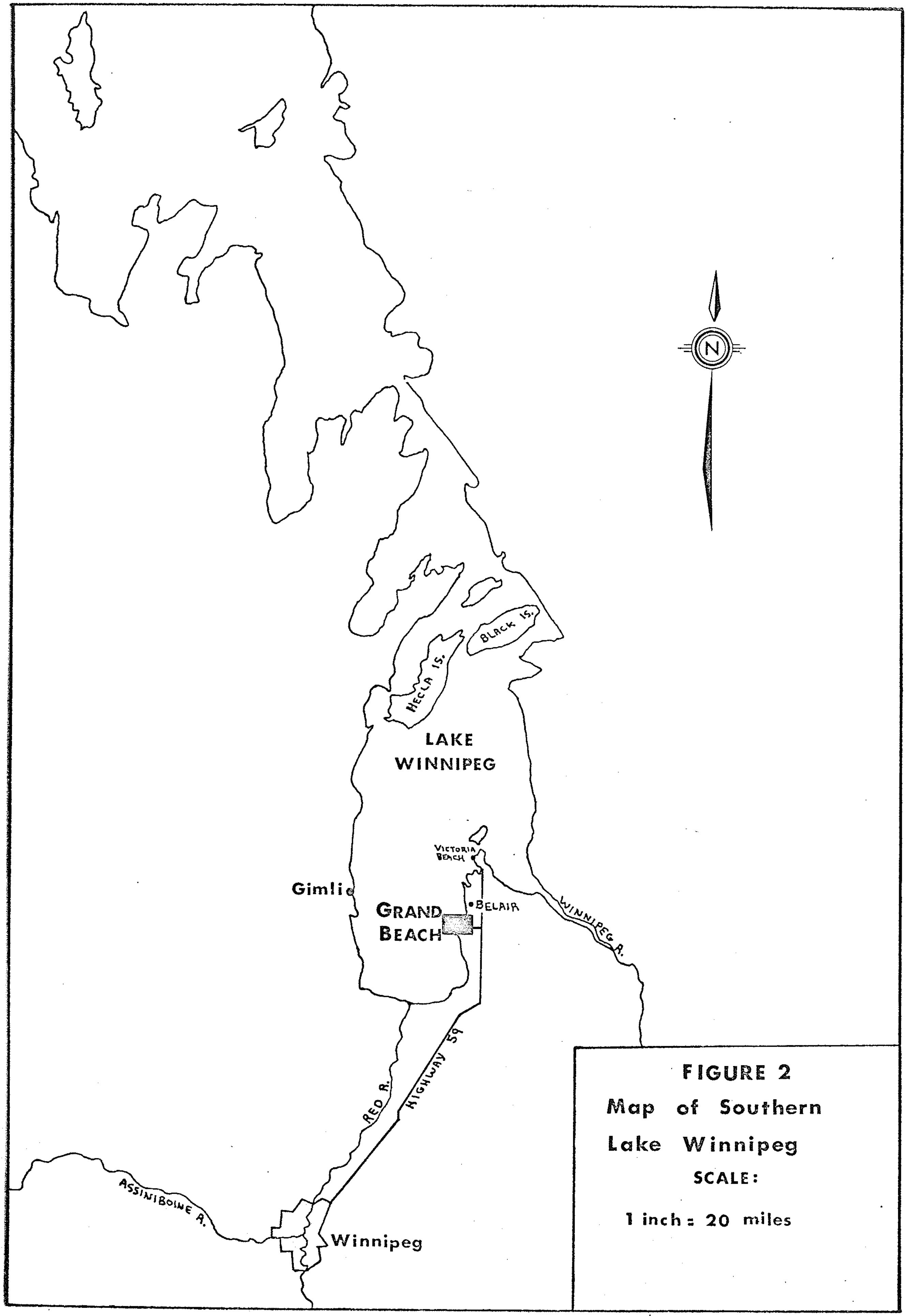

FIGURE 2
Map of Southern Lake Winnipeg
SCALE:
1 inch = 20 miles

Although Lake Winnipeg is not large enough to have noticeable lunar or solar tides, winds cause intermittent water level fluctuations in the order of several feet. Strong northerly winds pile up water at the south end of the lake; strong southerly winds generally have the opposite effect. Variations of Lake Winnipeg water level during the summer of 1966 are shown in Figure 3 (the dashed line is an estimate of lake level with wind effects removed and reflects the seasonal runoff cycle). Peak daily wind velocities for the South Lake Winnipeg region are listed in Table I. Wind velocities given are daily maximums, but undoubtedly reflect the directions and relative magnitudes of average wind forces during the summer of 1966. A comparison of these data indicates there is a strong correlation between peak wind velocity and water level and that there is often a lag of several hours between high winds and the resulting changes in lake level.

These intermittent fluctuations of lake level play a significant role in sediment transport and deposition along the south shore of Lake Winnipeg. A complete discussion of the effects of wind on sedimentation in the Grand Beach area is given in Chapter V.

Regional Geology and Physiography

Continental glaciation of the Pleistocene epoch has left the area along the east shore of southern Lake Winnipeg with a surficial covering of glacial drift. Because of this drift cover, Paleozoic bedrock rarely outcrops. A small subaqueous exposure of Paleozoic

Figure 3 - Lake Winnipeg Water Level

From 9:00 a.m. and 4:00 p.m. Readings at Gimli - Summer 1966

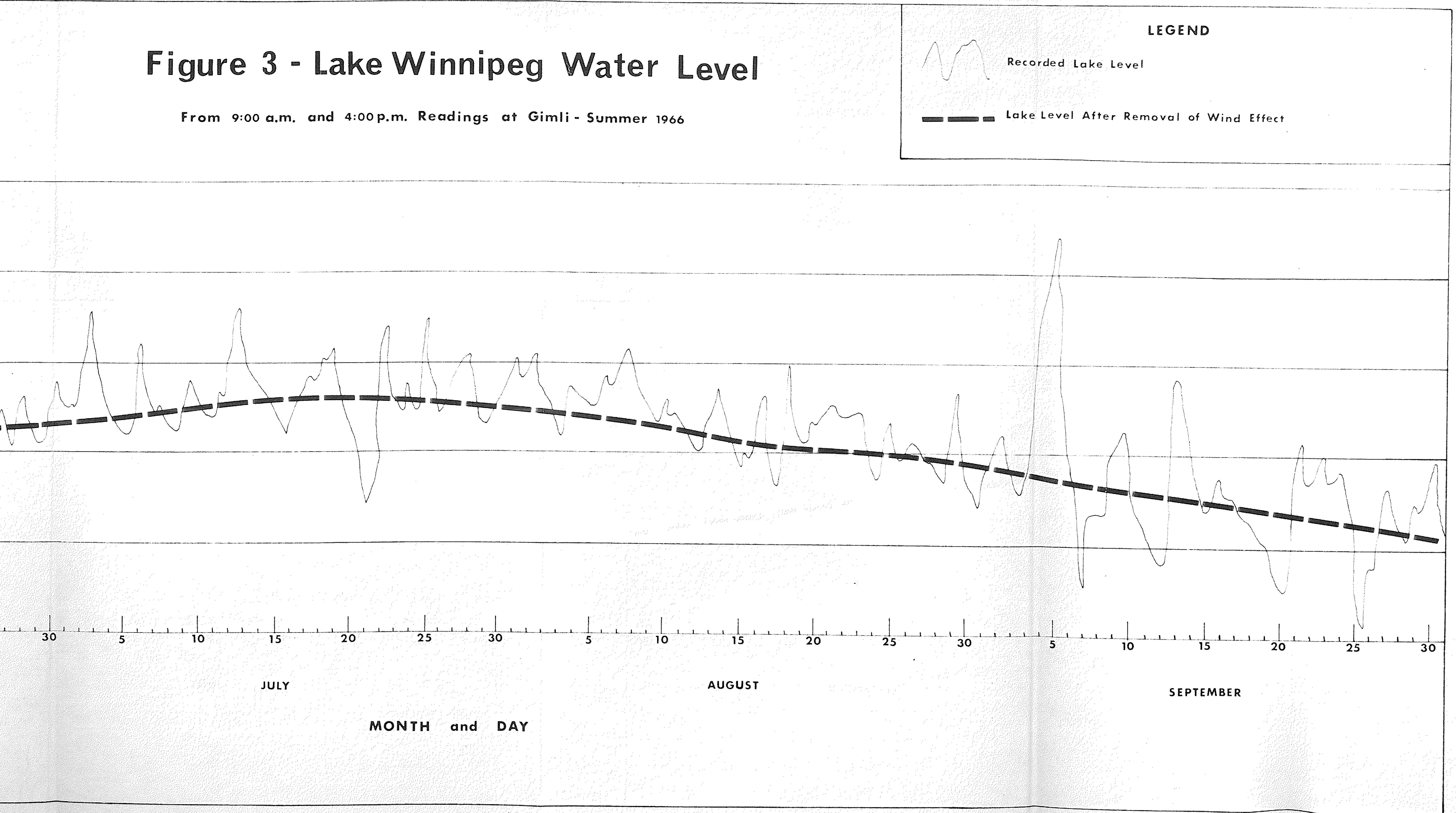

Figure 3

From 9:00

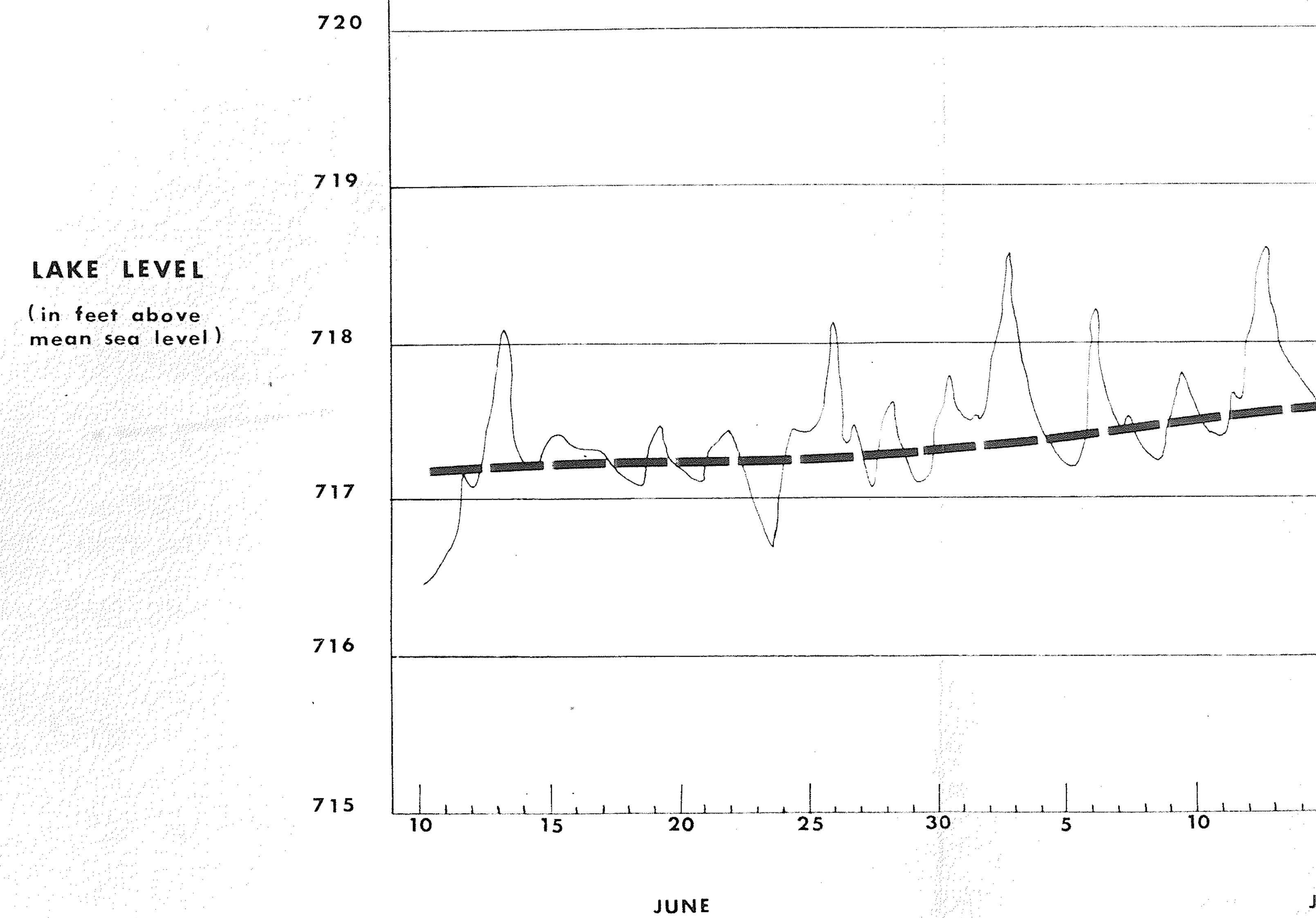

TABLE I

PEAK DAILY WIND VELOCITIES
RECORDED AT GIMLI - SUMMER 1966

DAY	MONTH							
	JUNE		JULY		AUGUST		SEPTEMBER	
	DIR.	VEL.	DIR.	VEL.	DIR.	VEL.	DIR.	VEL.
1	S	64	SW	70	------*		W	25
2	WNW	30	------		------		SSW	38
3	N	27	NE	34	NW	29	WNW	55
4	------		WSW	70	------		NW	57
5	------		W	49	NE	20	NW	31
6	WNW	34	NW	21	ENE	60	S	27
7	NNW	30	------		NE	36	S	47
8	------		NW	55	NNE	21	S	26
9	S	26	WNW	26	------		W	46
10	S	50	S	21	------		ENE	22
11	S	39	WSW	32	------		SSE	29
12	WSW	41	NW	31	ESE	28	N	39
13	N	31	------		NNE	20	N	37
14	------		------		------		------	
15	N	42	S	44	SSW	30	WSW	31
16	NW	23	SSW	34	WNW	25	------	
17	W	36	SSW	25	NW	63	WSW	28
18	W	56	NW	29	NW	23	SSW	24
19	NW	40	------		------		S	32
20	SE	31	S	31	------		SSW	44
21	S	34	WSW	35	NNE	25	NNW	36
22	SW	35	WNW	24	N	23	N	42
23	SW	48	------		NNW	21	NNE	22
24	E	38	SW	30	WSW	34	NNE	27
25	WSW	36	NW	26	WSW	25	WNW	24
26	WNW	33	E	25	------		WSW	46
27	S	43	WNW	30	ESE	24	W	25
28	W	55	------		WSW	42	ENE	25
29	SE	40	SSW	29	NNW	32	------	
30	WSW	47	WNW	26	WSW	58	NNW	23
31			------		ESE	35		

*------ SIGNIFIES A PEAK WIND VELOCITY LESS THAN 18 MILES PER HOUR